

## **TECHNICAL MEMORANDUM**

**From:** Peter Bemis & Walter Lewinski, PE.

**Date:** January 20, 2020

**Re:** EDC Project 3520

**SUBJECT:** TRAFFIC IMPACT ASSESSMENT  
555 HOPPING BROOK ROAD DEVELOPMENT  
HOLLISTON, MASSACHUSETTS

### **INTRODUCTION**

This memorandum provides an assessment of the traffic impacts of a proposed commercial warehouse development to be located at 555 Hopping Brook Road in Holliston, Massachusetts. The project is a proposed 800,000 square foot (sf) “high cube” warehouse. The assessment provides a description of existing conditions in the vicinity of the site, confirms travel speeds and existing traffic volumes, evaluates sight distances, and discusses the expected traffic generating characteristics and the access condition that will result at the intersection of Washington Street at Hopping Brook Road. With this project and along with two ongoing developments within the Park, the total park square footage will be approximately 1.5 million sf. An assessment rather than a full traffic impact & access study was completed since it is an existing park that is still in build out stages and the park, even with the proposed development, will remain well below the previously MEPA approved size, which is 3.0 million square feet of space. The existing Hopping Brook Road will continue to provide access for the industrial park.

### **BACKGROUND**

The industrial park was first conceived and underwent analysis as part of the Commonwealth’s MEPA project in the early 1980’s when 3.0 million sf was proposed. A Notice of Project Change was submitted in 2003 with a redesign of the park to reduce environmental impact while increasing the acreage. The Secretary issued a Certificate of the Supplemental Environmental Impact Report on August 9, 2003. The revised project did not change the original intent for 3.0 million sf, however, an updated traffic study was completed in 2003 as part of the supplemental filing.

## **EXISTING CONDITIONS**

### **Roadway & Intersection**

The proposed site has frontage along Hopping Brook Road, a two-way, two-lane, dead-end roadway servicing the Hopping Brook Industrial Park. Hopping Brook Road forms a T-type, three-way intersection with Washington Street, also designated as Massachusetts Route 16. It is under local jurisdiction. Hopping Brook Road, which become a local public roadway, extends south into the Hopping Brook Industrial Park. The project locus is shown in Figure 1.

Washington Street has a variable width right-of-way that changes width at the intersection with Hopping Brook Road. Washington Street has an 80-foot-wide layout for about 500 feet southwest of the intersection and then reduces to about a 70-foot-wide layout in the intersection and maintains that width for about 100 feet east of the intersections. It then reduces to a 60-foot-wide layout as the road continues east. The paved roadway surface is approximately 40-45 feet in width west of the intersection and is bounded by slopped granite curb on the southerly side of the road and by steel guardrails on both sides of the road. East of the intersection, the paved roadway surface is about 28-32 feet in width and has no curbing. The roadway alignment is straight and level, gaining about 6 feet in elevation over 1000 linear feet of roadway as traveled from east to west (starting 500 feet east and extending 500 feet west of the intersection) with an average slope of 0.6%. The Washington Street alignment enters a horizontal curve turning toward the east located about 400 feet east of the intersection with Hopping Brook Road. Pavement markings consist of a double yellow center line with white edge lines. Travel lanes are defined at 12 to 13 feet in width. Shoulders between Hopping Brook Road and South Street vary in width from about 6 to 8 feet while east of the industrial park, narrow shoulders (i.e. < 2 feet) are marked. Sidewalks do not exist along Washington Street in the project area. The posted speed limit along this section of Washington Street is 45 miles per hour.

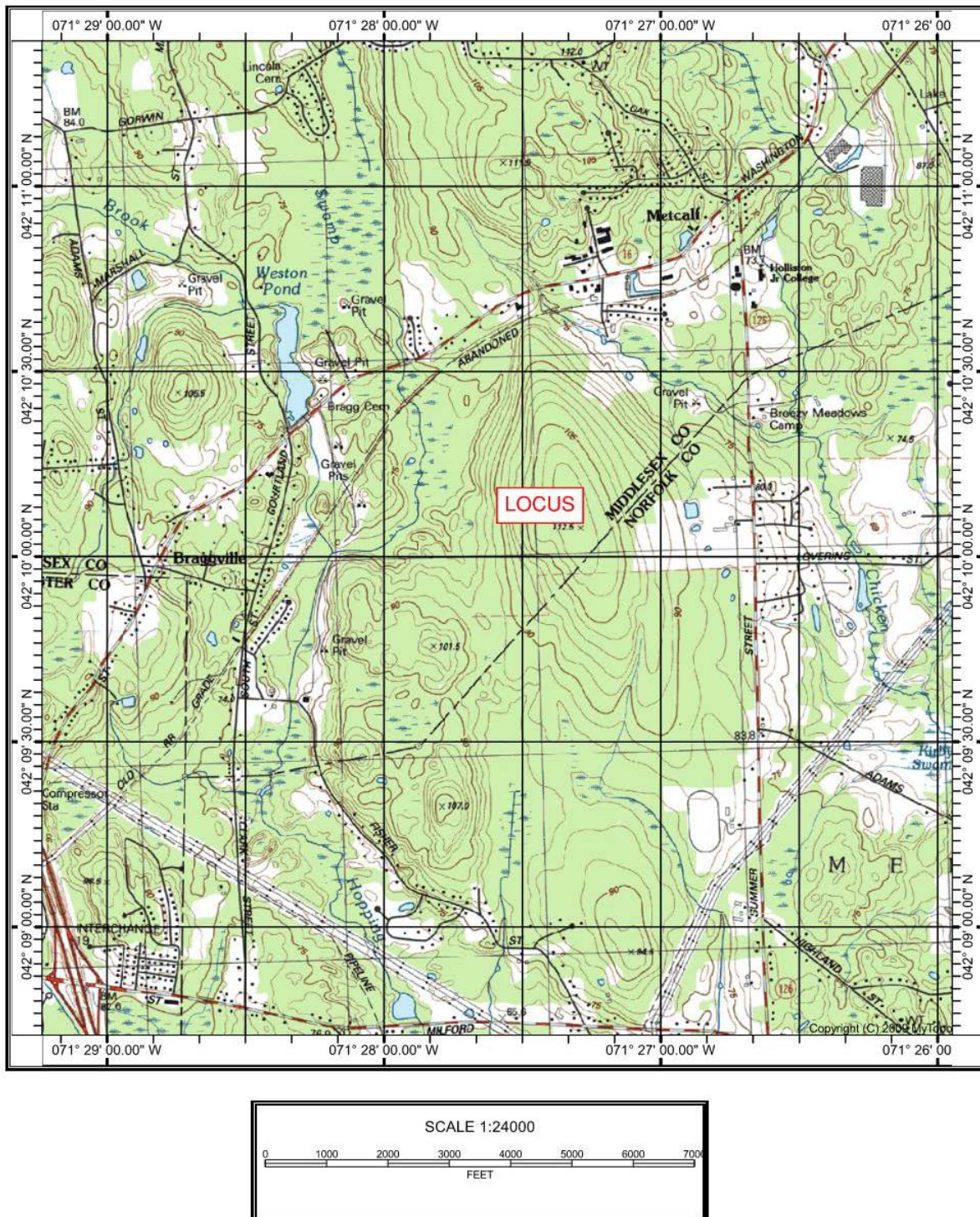


**Washington Street WB Approach**



**Washington Street EB Approach**





**Figure 1: USGS Locus Base Map**

Hopping Brook Road has a 60-foot-wide public right-of-way. The paved roadway surface is approximately 34-36 feet in width and is bounded by Cape Cod style bituminous berm with intermittent vertical granite curb elements at catch basin locations. In the general vicinity of the Washington Street intersection, the roadway alignment is straight and level, gaining 7 feet in elevation over 500 linear feet of roadway as traveled from south to north (starting 500 feet south of the intersection and terminating in the intersection) with an average slope of 1.5%. There is no posted speed limit along Hopping Brook Road. There are no sidewalks along Hopping Brook Road. There is, however, a crossing of the Upper Charles Rail Trail on the road, less than 1,400 feet from Washington Street. The crossing is marked (i.e. crosswalk) but in a less than desirable manner based on current practices.



Hopping Brook Road View South



Hopping Brook Road View North

The intersection of Washington Street at Hopping Brook Road is currently unsignalized with a STOP sign controlling the minor approach. The angle of the two roads is less than the preferred 90 degrees, however, the current geometry brings the immediate approach straight into Washington Street. The Hopping Brook Road approach is sufficiently wide to allow for separate left and right turn lanes at the intersection, while a small island separates entering and exiting flows. Washington Street is a two-lane roadway that has an east-west alignment at the intersection with Hopping Brook Road. The planimetric layout of Hopping Brook Road at the intersection with Washington Street is included as Figure 2.

Land use along Washington Street in the general project area is composed of a mix of small commercial and residential uses. Land use along Hopping Brook Road is exclusively comprised of the industrial park. A cemetery is located on the north side of Washington Street opposite Hopping Brook Road. The Weston Pond recreation area is also situated north of Washington Street in the project area.



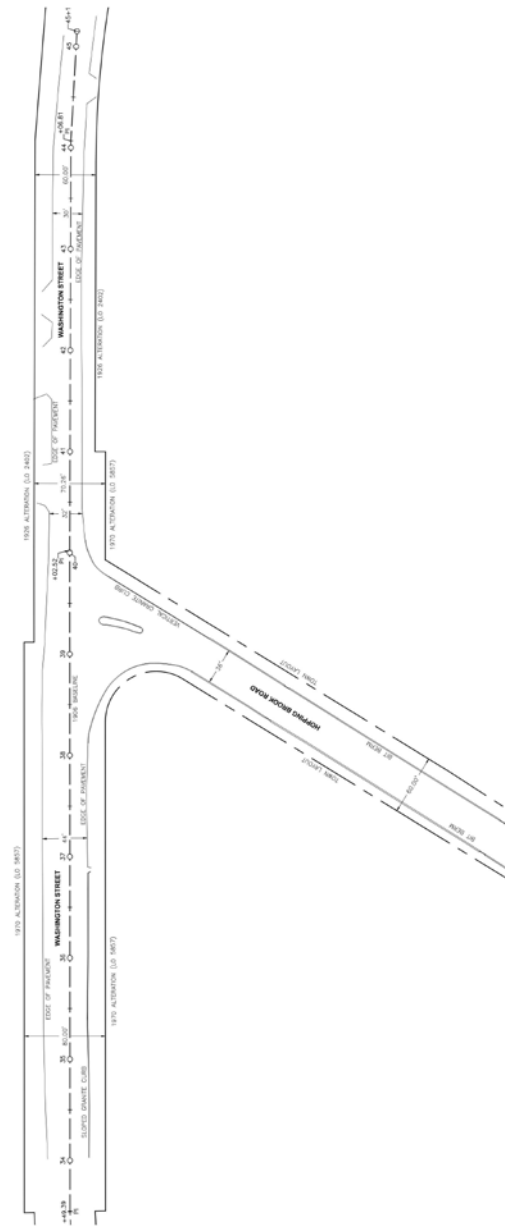
## **Traffic Volumes**

New traffic counts were performed along both Washington Street and Hopping Brook Road in December 2019 as well as at the intersection. The data was acquired by means of both peak hour manual turning counts and Automatic Traffic Recorders (ATRs). Peak hour manual turning counts (TMCs) were also performed between 7:00-9:00 AM on Wednesday December 18 and between 3:00-6:00 PM on Thursday December 12. The ATR counts were conducted from Monday, December 16 to Thursday, December 19 for a continuous total of ninety-six hours.

The Washington Street count location was approximately 500 feet east of Hopping Brook Road. The ATRs recorded both traffic volumes and travel speeds. The speed data was used in assessing sight distances at the Hopping Brook Road intersection in a later section of the memo. Volume data from the ATRs were used for examining traffic signal warrants at the intersection.



Hopping Brook Road Typical Queueing Pattern During Evening Peak Period



**Figure 2:** Planimetric Layout of the Hopping Brook Road Intersection at Washington Street

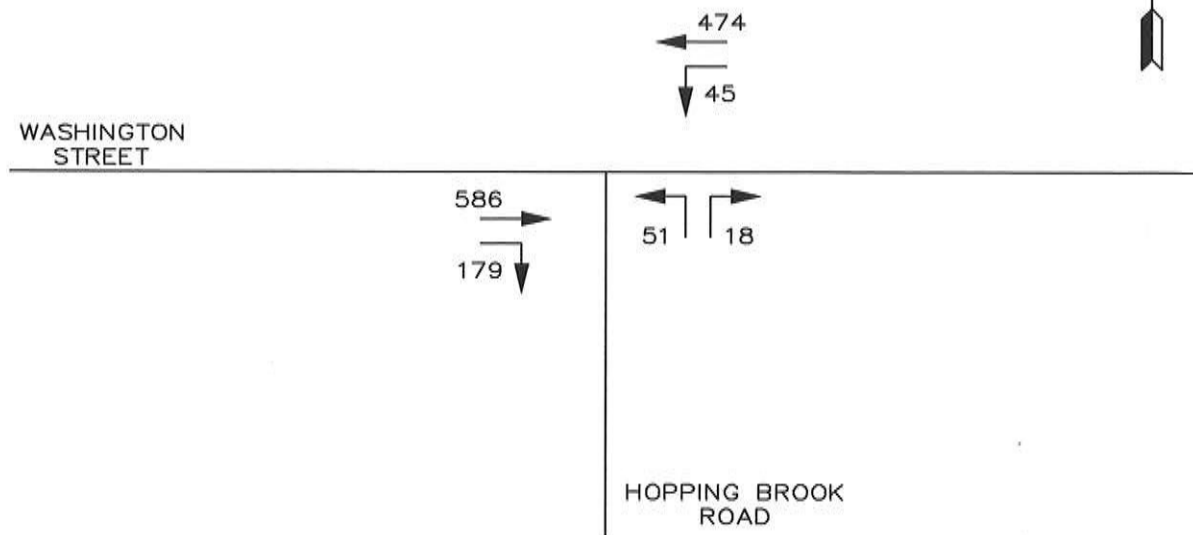
Based on the ATR data, Washington Street is carrying approximately 16,000 per day. Hopping Brook Road experienced weekday volumes of approximately 3,100 vehicles per day. The ATR data is in the appendix.

Based on the manual turning counts at the intersection, the peak hour volumes developed in the intersection between 7:30-8:30 AM in the morning and 4:30-5:30 PM in the evening. The TMCs formed the basis of the analysis at the intersection.

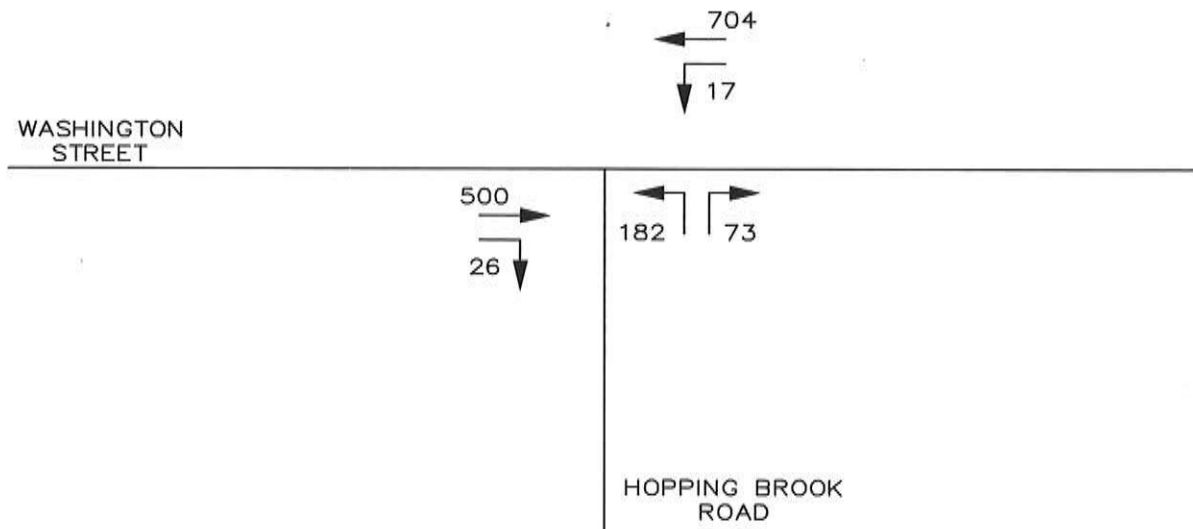
Since all the traffic data used in this analysis was collected in the month of December, it was necessary to evaluate the month of December 2019 to see how it related to annualized monthly averages and determined if the data represented reasonable analysis conditions or needed to be adjusted. Toward this end, monthly average daily traffic data was analyzed from MassDOT Count Station No. 307 on Route 9 in Westborough, the nearest permanent MassDOT traffic count station to the site on an arterial roadway. The data indicated that traffic during the month of December was, on average, slightly higher than the average monthly volumes. Despite the statistically higher flow in the month of December, for the purposes of this analysis, the on-the-ground data collected was not decreased and used as collected as a starting point in the analysis. It may reflect slightly conservative conditions. Figure 3 illustrates the estimated existing weekday peak hour traffic volume network for the morning and afternoon peak hours.

In addition to traffic volumes, the ATRs also documented travel speeds. The average speed on Washington Street in the vicinity of Hopping Brook Road, both eastbound and westbound, was 38 miles per hour, while the 85<sup>th</sup> percentile speed on Washington Street, both eastbound and westbound, was 43 miles per hour. The average speed on Hopping Brook Road was 30 miles per hour northbound and 31 miles per hour southbound, while the 85<sup>th</sup> percentile speed on Hopping Brook Road was 35 miles per hour northbound and 36 miles per hour southbound.

WEEKDAY  
AM



WEEKDAY  
PM



EXISTING PEAK HOUR  
TRAFFIC VOLUMES  
FIGURE 3





## **FUTURE CONDITIONS**

The focus of this section is to examine the anticipated future operational characteristics of the study intersection as a result of the proposed development. In addition to estimating the traffic to be expected, a level of service analysis was also completed later in the report. In conducting the future level of service analysis, traffic was projected to the year 2026 for the No-Build condition and considers background growth, site specific growth unrelated to the proposed projects and then Build conditions incorporating the proposed project.

### **1. No-Build Traffic Volume Analysis**

In order to properly assess the potential impact that the proposed development could have on the existing park access, the future No-Build traffic network at the intersection of Washington Street/Hopping Brook Road was developed. The No-Build condition projects the existing traffic network seven years into the future and includes expected background traffic growth and known site specific developments occurring in the vicinity of the project area and in this case, those occurring within the industrial park besides the proposed development at 555 Hopping Brook Road. Thus, the No-Build model forecasts the future traffic volumes as they would develop in absence of the proposed project.

### **Background Traffic Growth**

Based on socio-economic factors (i.e. population, employment), traffic rates have tended to increase throughout the region over time. As it relates to this analysis, this general background growth accounts for small residential growth nearby or more remote growth that may occur in the region, both of which could result in added traffic through the study area. To establish a traffic growth rate, historical traffic count data from the Massachusetts Department of Transportation (MassDOT) Traffic Count Reports were researched. Specifically, Stations #3307 (Westborough) and #4796 (located on Interstate 495) were evaluated to observe regional trends.

Based on the review of data from these stations, a traffic growth rate of 1% per year was selected and applied to the existing peak hour traffic volumes occurring along Washington Street to create an estimated future base traffic condition for use in the No-Build traffic network. Hopping Brook Road traffic changes would be directly affected by changes in the park and not general areawide growth.

### **Site Specific Development**

In addition to background growth, known site specific developments in the vicinity of the proposed project that are anticipated to be completed within the next seven years will also contribute increased traffic flow through the study area and affect the No-Build conditions. As it relates to this assessment, two projects are currently under construction within the industrial park and were taken into account. The first is the development at 56 Boynton Road, a 25,000 sf

single-story industrial building. The second is the development at 465 Hopping Brook Road, a 130,000 sf single-story cannabis growth and processing center. Trips from these sites directly affect traffic entering and exiting Hopping Brook Road. Future traffic volumes were estimated for both developments based on the trip model guidelines published by the Institute of Transportation Engineers (ITE) and applied to the background traffic volumes to result in the estimated No-Build traffic network. The calculations are in the appendix.

The Future No-Build Peak Hour Volumes are illustrated in Figure 4.

## **2. Site Generated Traffic Volumes**

With the Future No-Build Peak Hour Volume Network established, the Future Build Peak Hour Volume network was then created. This estimate builds off the No-Build condition by adding the anticipated site-specific traffic generated from the Locus 555 Hopping Brook development. Thus, the Build condition forecasts the estimated future traffic volumes as they are expected to develop once the proposed project is completed and the building is occupied and brought online. The following paragraphs describe the estimate of the project related traffic.

### **Trip Generation**

The proposed development entails the construction of 800,000 square feet of high cube type warehouse space with significant technology systems. Our understanding of the proposed project is that the facility will serve one or two tenants. In developing trip estimates for the proposed development included a review of the tenth (latest) edition, of the informational report entitled **Trip Generation**<sup>1</sup> published in 2017 by the Institute of Transportation Engineers (ITE). The proposed use falls into the overall category of “high cube warehousing” and the current ITE edition further breaks these types of warehouses beyond the 9<sup>th</sup> edition into subgroups such as “cold storage”, “fulfillment centers” and “parcel hub facilities”. The modern warehouses include significant automation as well as may become a central point for the last part of delivery for retail related products. Of the alternative types of defined warehouses, it was determined that the ITE Land Use Codes *#155 Fulfillment Centers* and *#156, High-Cube Parcel Hub Warehouse* are most reasonable to consider for analysis purposes and provide a reasonable basis for assessment the effect of the project. However, in review of the current ITE data base, it was noted that a limited amount of data is available and there is substantial variation in the data. Consequently, additional research was completed and as described below, recent findings from sources including Florida Department of Transportation (FDOT) studies<sup>2</sup> and the Rajappan et al study<sup>3</sup>.

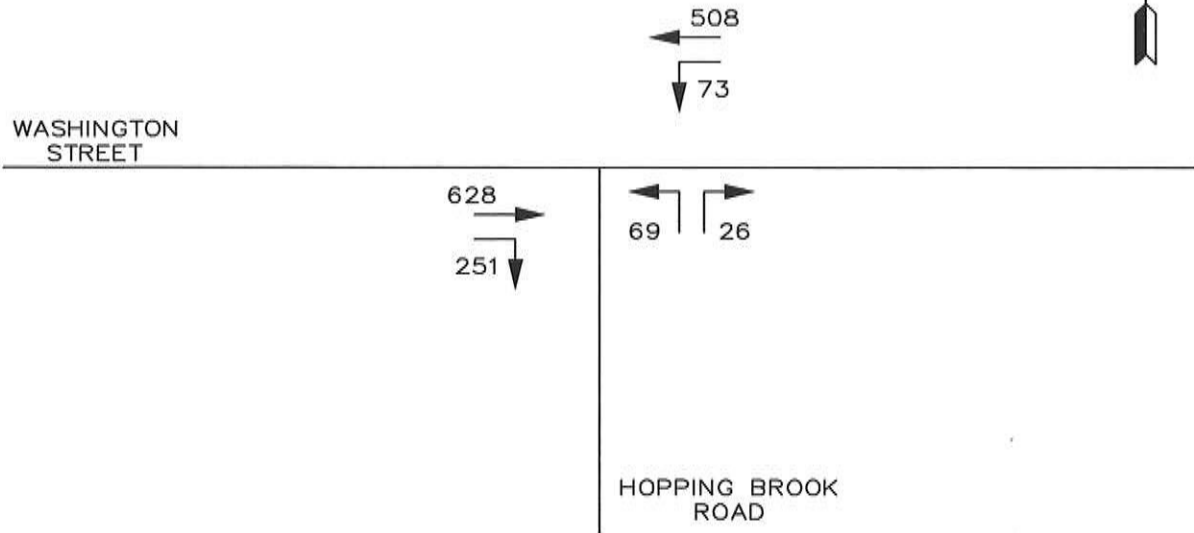
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<sup>1</sup> Institute of Transportation Engineers, Trip Generation, An Informational Report, Washington, D.C., 2017

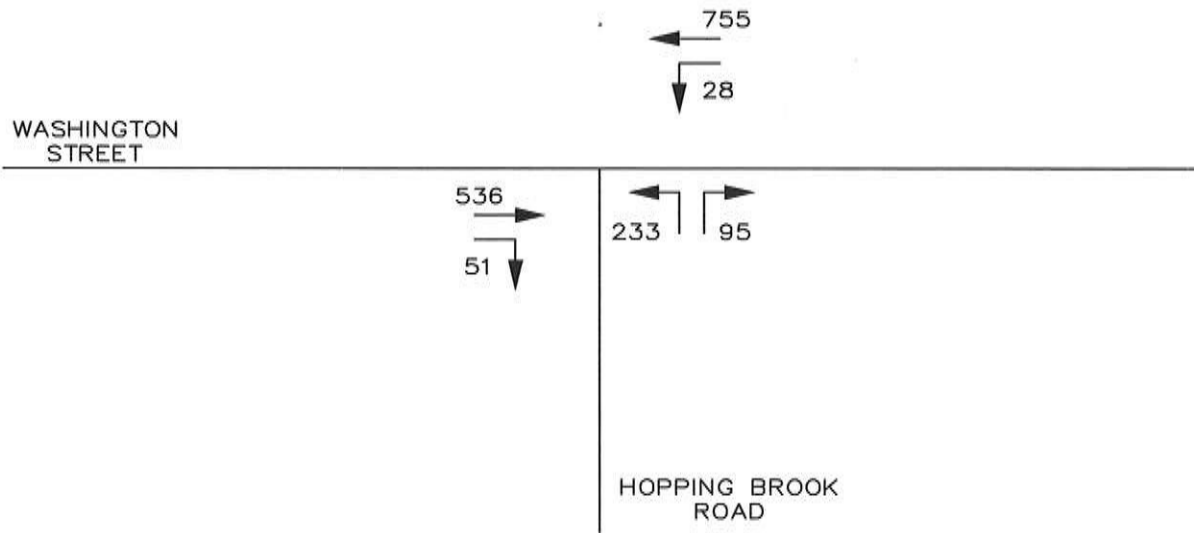
<sup>2</sup> Florida Department of Transportation, Trip Generation Recommendations, prepared by Kimley Horn Associates, Inc., October 2014

<sup>3</sup> *Fulfillment Center Trip Generation*, prepared by Rajappan B., Taubeneck, L., and Patil, S., ITE Journal, pages 23-26, published July 2019.

WEEKDAY  
AM



WEEKDAY  
PM



**FUTURE NO-BUILD  
TRAFFIC VOLUME NETWORKS  
FIGURE 4**



The recent research completed by Rajappan et al as well as the FDOT research study provides additional data that provide a basis for estimating traffic for the proposed new warehouse use. The article and the FDOT information are included in the Appendix as well as information from the ITE Trip Generation guide. Trip estimates were completed using this information and the resulting vehicle trip estimates for weekday and the peak hours are summarized in Table 1 below. The 24 trip rate was taken from the FDOT research while the peak hours were taken from the Rajappan research.

**TABLE 1**  
**SUMMARY OF TRIP GENERATION ESTIMATES**  
**FOR PROPOSED DEVELOPMENT**

	<u>Entering</u>	<u>Exiting</u>	<u>Total</u>
Weekday	744	744	1,488
AM Peak Hour	52	52	104
PM Peak Hour	49	23	72

Under this land use, the 800,000 square foot warehouse is expected to generate an estimated 1,488 trips per day that includes 744 entering vehicle trips and 744 exiting trip over the course of a full 24 hour weekday. During the morning peak hour, a total of 104 vehicle trips is estimated with 52 entering vehicle trips and 52 exiting vehicle trips. It was estimated that 72 vehicle trips will be generated during the evening peak hour with 49 entering vehicle trips and 23 exiting trips.

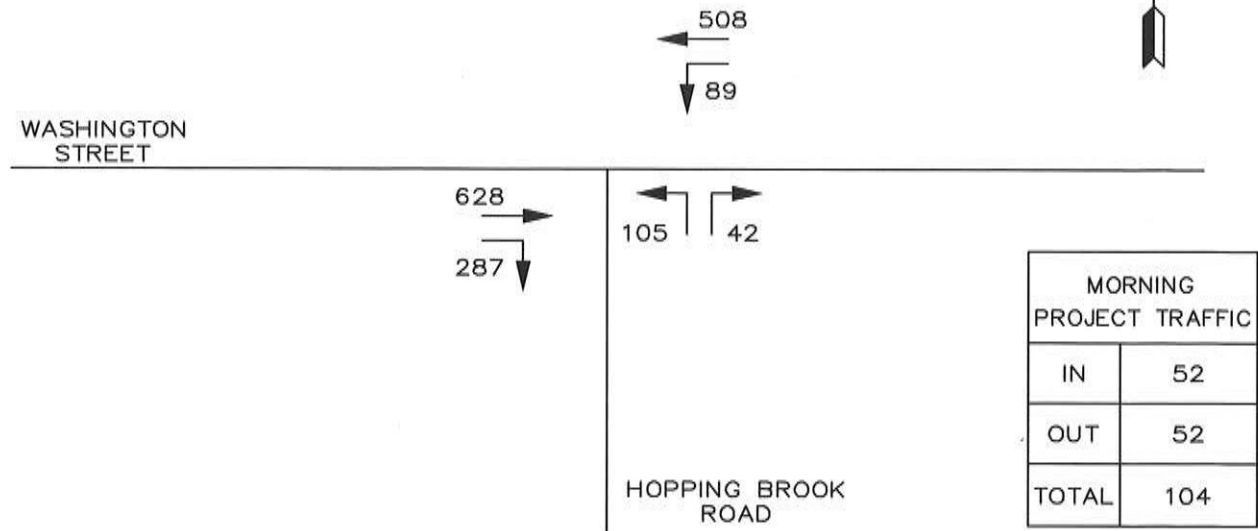
### **Directional Distribution**

With the trip generation established, it then becomes necessary to assign the new trips to the roadway system and create the Build Peak Hour Volume Networks. For the purposes of this study, it was assumed that the future trip patterns will be similar as those of the current existing conditions. As it concerns the intersection of Hopping Brook Road with Washington Street, the additional trips generated by the proposed development will only affect those movements of the intersection associated with traffic entering and exiting the Hopping Brook Industrial Park. Based on overall current patterns and for this study's purposes, it has been estimated that 70% of the new traffic would be oriented to and from the west while 30% would be to and from the east.

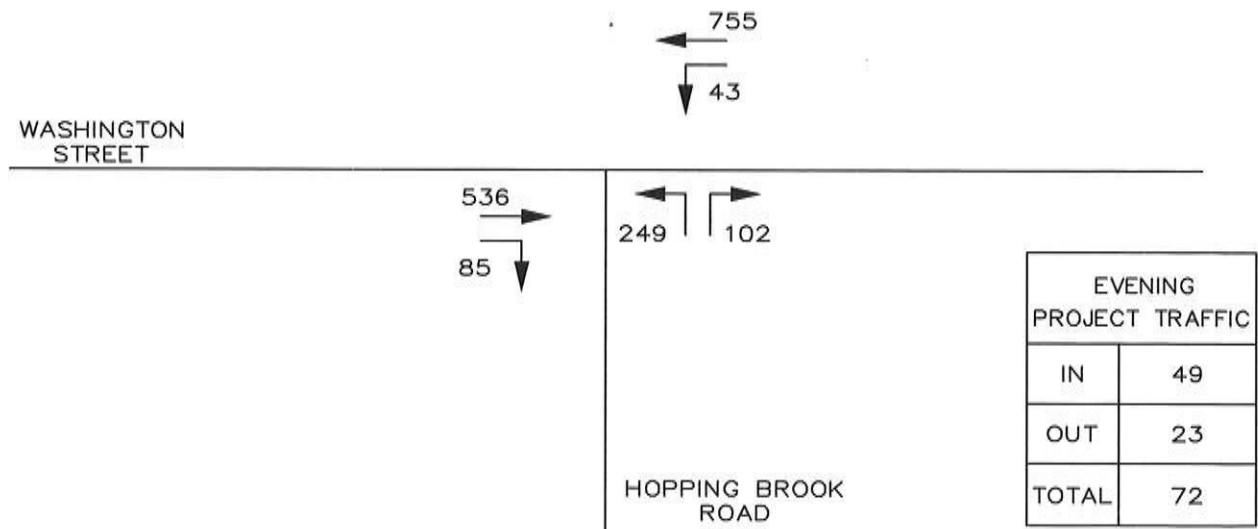
The future traffic volumes estimated for the development at 555 Hopping Brook Road were applied to the No-Build network to define the Future Build Peak Hour Volume networks, which is illustrated in Figure 5.



WEEKDAY  
 AM



WEEKDAY  
 PM



**FUTURE BUILD  
 TRAFFIC VOLUME NETWORKS  
 FIGURE 5**



## **ANALYSIS**

As indicated by the trip generation estimates, the proposed new warehouse project would result in a relatively small number of vehicle trips despite its size. The estimates show that additional peak hour trips due to the project would be between 1 to 1.8 additional vehicle trips per minute. At this rate, the effect would not necessarily result in a noticeable difference in conditions from the No-Build Condition. However, the impact of the project on the intersection operations is important to evaluate and a level of service analysis was completed as described in the following section. In addition, the sight distances in relation to the Washington Street intersection with Hopping Brook Road were verified in the subsequent section.

### **Level of Service (LOS) Analysis**

The study intersection was examined with regard to flow rates, capacity, and delay characteristics to determine the Level of Service (LOS), using the methodology defined in the Highway Capacity Manual (HCM)<sup>4</sup> for the existing, future No-Build and Build traffic conditions. Level of Service is an indicator of operating conditions which occur on a given roadway feature while accommodating varying levels of traffic volumes. It is a qualitative measure that accounts for several operational factors including roadway geometry, speed, traffic composition, peak hour factors, travel delay, freedom to maneuver and driver expectation. When all these measures are assessed, and a level of Service is assigned to a roadway or intersection, it is equivalent to presenting an “index” to the operational qualities of the section under study, Level of Service is classified into set levels that are designated ‘A’ through ‘F’ based on the control delay ranges they fall under. Additionally, a movement with a volume-to-capacity (v/c) ratio of over 1.00 would be designated as LOS of ‘F’, regardless of delay. These criteria are presented in Table 2 for both signalized and unsignalized intersections.

In practice, any given roadway/intersection may operate at a wide LOS range depending upon time of day, day of week or period of year. It should be noted that for unsignalized intersections, the Level of Service is not computed for the intersection as a whole. Instead, the Level of Service is determined by the computed or measured control delay for each individual critical movement (typically, the side street movements).

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<sup>4</sup> Transportation Research Board of the National Academies, Highway Capacity Manual 6<sup>th</sup> Edition, Washington, D.C., 2017

**TABLE 2**  
**LEVEL OF SERVICE CRITERIA FOR**  
**UNSIGNALIZED AND SIGNALIZED INTERSECTIONS**

LEVEL OF SERVICE	UNSIGNALIZED INTERSECTIONS CONTROL DELAY RANGE (SEC)	SIGNALIZED INTERSECTIONS CONTROL DELAY RANGE (SEC)
A	≤10	≤10
B	>10 and ≤15	>10 and ≤20
C	>15 and ≤25	>20 and ≤35
D	>25 and ≤35	>35 and ≤55
E	>35 and ≤50	>55 and ≤80
F	>50 or v/c >1.00	>80 or v/c >1.00

The intersections were analyzed based on the HCM using the HCS computer software. Using existing roadway features and the intersection controls, traffic operations at the study intersection was evaluated for existing as well as the estimated 2026 conditions. Analysis results are presented in Table 3 for the morning and afternoon peak hours.

**TABLE 3**  
**SUMMARY OF LEVEL OF SERVICE ANALYSIS**  
**Washington Street at Hopping Brook Road**

	EXISTING CONDITIONS				2026 NO-BUILD CONDITIONS				2026 BUILD CONDITIONS			
	DELAY	V/C	LOS	95 <sup>TH</sup> % QUEUE (FT.)	DELAY	V/C	LOS	95 <sup>TH</sup> % QUEUE (FT.)	DELAY	V/C	LOS	95 <sup>TH</sup> % QUEUE (FT.)
<b>WEEKDAY MORNING PEAK HOUR</b>												
Washington St WB LT	9.7	0.06	A	5	10.4	0.10	B	8	10.8	0.88	B	12
Hopping Br NB LT	38.4	0.33	E	32	78.0	0.63	F	80	163.8	1.01	F	165
Hopping Br NB RT	13.7	0.04	B	2	15.0	0.07	C	5	15.8	0.12	C	10
Northbound Approach Overall	31.9	-	D	-	60.8	-	F	-	-	-	C	-
<b>WEEKDAY AFTERNOON PEAK HOUR</b>												
Washington St WB LT	8.6	0.02	A	2	8.9	0.03	A	2	9.1	0.05	A	5
Hopping Br NB LT	166.0	1.14	F	250	>200	1.80	F	462	>200	2.13	F	547
Hopping Br NB RT	12.7	0.14	B	12	13.8	0.20	B	18	14.3	0.22	B	20
Northbound Approach Overall	122.1	-	F	-	317.8	-	F	-	425.0	-	F	-

The LOS analysis has shown the following:

- The left turn exiting movement from Hopping Brook Road is constrained under current conditions with long delays and queuing occurring, particularly during the PM peak hour.
- Conditions worsen in the future No-Build regardless of the proposed development project as volumes increase on Hopping Brook Drive and are anticipated to also grow on Washington Street. The left turn exit movement from Hopping Brook Road is expected to experience poor levels of service and long delays during both the AM and PM peak hours.
- The addition of the project will add to the delays, and queuing for this movement. Once the unsignalized intersection and this particular movement experiences difficulty in entering the major street traffic flow, additional demands will substantially increase
- The other critical movements including the right turn exit from Hopping Brook Road and the left turn entering movement from Washington Street currently operate relatively well and will continue to do so in the future under both No-Build and Build conditions.

**As a result of the LOS analysis and taking into consideration the fact that in the EIR prepared for the Park, a preliminary evaluation of a traffic signal at the intersection of Washington Street and Hopping Brook Drive was completed. The EIR stated that at some point, a signal would be justified and installed.**

When considering the installation of a traffic signal, a series of criteria also known as “warrants” are reviewed. Traffic signal warrants have been developed over the years to guide the analyst in determining whether or not a traffic signal should be installed at a particular location. The warrants most relevant to this project are based on volumes are defined in the MUTCD<sup>5</sup>. Other warrants may examine crash history, school locations, pedestrians and signal coordination factors. It should be noted that care and judgment needs to be taken in any decision related to installing new signals and simply satisfying one or more of the warrant criteria does not mean that a traffic signal must be installed. In summary, the three key warrants for this project are described as follows:

- Warrant 1, Eight Hour Vehicular Volume

In order to meet the warrant, vehicle volume, in each of any eight (8) hours of an average day, on the major street in both directions and the minor street with higher volume in one direction need to meet or exceed a certain level of volumes. There are two conditions: Condition A and Condition B. Condition B takes in to consideration the effect of a lower volume side street could have as volumes increase on the major street. The volume criteria can also be reduced in each condition by 30% if the travel speed on the major street exceed 40 mph, which that is the case in

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<sup>5</sup> U.S. Department of Transportation, Federal Highway Administration, Manual on Uniform Traffic Control Devices (MUTCD), Washington, D.C., 2009



this situation. The following cites the minimum volumes with respect to approach lanes for both Conditions A and B for this project:

<u>Condition A.</u>	<u>No. of Approach Lanes</u>	<u>Volume</u>
	Major street (1)/minor street (2 or more)	major street (350)/minor street (140)

<u>Condition B.</u>	<u>No. of Approach Lanes</u>	<u>Volume</u>
	Major street (1)/minor street (2 or more)	major street (525)/minor street (70)

- Warrant 2, Four Hour Vehicular Volume

Vehicular volumes per hour each of any four (4) hours of an average day on major street in both directions and minor street in one direction (with higher volume) are plotted on a standard graph provided in MUTCD. If the intersecting point falls above the respective curve in terms of number of approach lanes, the warrant is met.

- Warrant 3, Peak Hour

Vehicular volumes one (1) hour of any average weekday on major street in both direction and minor street in one direction (with higher volume) are plotted on a standard graph provided in MUTCD. If the intersecting point falls above the respective curve in terms of number of approach lanes, the warrant is met.

## **2. Signal Warrant Analysis Results**

A signal warrant analysis was performed for study intersection in accordance with the procedures and criteria described in MUTCD. The results of analysis, which was based on projected future volumes, is summarized in Table 4. Criteria were adjusted for high travel speeds. The focus of the analysis was on Warrants 1, 2 and 3. As indicated, Warrants 1 under Condition B is satisfied at this location for 9 hours. Condition A criteria was met for \_ hours as well. The warrants were also satisfied for the 4 Hour Warrant and the Peak Hour Warrant. Details pertaining to signal warrant analysis for Warrants 2 and 3 are included in the Appendix. Traffic signals are warranted if one or more warrants are satisfied.

And while it was indicated above that simply meeting warrants does not equate to installing them, based on the current and future anticipated levels of service, considering the industrial park has a more substantial amount of truck traffic and that the warrants are adequately satisfied, it would be recommended in this case to install a traffic signal at the intersection for operational and safety purposes as a result of this project.

**TABLE 4**  
**SUMMARY OF SIGNAL WARRANT ANALYSIS**  
**Washington Street (Route 16) at Hopping Brook Road**

<b>Warrant Hours</b>	<b>Major Road: (Total of both approaches)</b>	<b>Minor Road: (Max. volume approach)</b>	<b>Condition A - Minimum Vehicular Volume</b>		<b>Condition B - Interruption of Continuous Traffic</b>	
<b>Hour Begin:</b>	<b>Washington Street</b>	<b>Hopping Brook Road</b>	<b>&gt;= 350 vehs.</b>	<b>&gt;= 140 vehs.</b>	<b>&gt;= 525 vehs.</b>	<b>&gt;= 70 vehs.</b>
7:00 AM	1047	65	Y		Y	
8:00 AM	1077	66	Y		Y	
9:00 AM	890	63	Y		Y	
10:00 AM	852	92	Y		Y	Y
11:00 AM	877	119	Y		Y	Y
12:00 Noon	949	214	Y	Y	Y	Y
1:00 PM	970	128	Y		Y	Y
2:00 PM	1115	150	Y	Y	Y	Y
3:00 PM	1209	225	Y	Y	Y	Y
4:00 PM	1267	266	Y	Y	Y	Y
5:00 PM	1326	279	Y	Y	Y	Y
6:00 PM	971	81	Y		Y	Y
7:00 PM	643	31	Y		Y	
<b>Hours Warranted:</b>			<b>5</b>		<b>9</b>	
<b>Signal Warranted?</b>			<b>NO</b>		<b>YES</b>	

Note: criteria has been reduced to 70% due to the 85<sup>th</sup> speeds on Washington Street exceeding 40 miles per hour.

While a design of the signal is beyond the scope of this study, a preliminary LOS analysis was completed for the intersection if it came under signal control. The detailed results are included in the appendix and they indicated that with a traffic signal, the intersection would operate at LOS B or better in the morning and evening peak hours under future Build conditions.

### **Sight Distance Analysis**

This section considers whether sight distances are adequate to meet federal standards. The basis for determining if sight distances are adequate is the research and guidelines provided by the American Association of State Highway and Transportation Officials (AASHTO). The criteria are presented in the latest publication, **A Policy on Geometric Design of Highways and Streets**, 2018 edition<sup>6</sup>. While the study intersection is existing, a verification of adequate sight distances was completed.

<sup>6</sup> American Association of State Highway and Transportation Officials, A Policy on Geometric Design of Highways and Streets, Washington, D.C., 2018.

Adequate sight distance is an important safety consideration at intersections and driveways. Sight distances were reviewed at the proposed site drive location. Stopping sight distance (SSD) is the distance required for an approaching driver (with an eye height of 3.5 feet) to perceive and stop in time to avoid a collision with an object 2 feet high in the roadway. The values are based on a perception and reaction time of 2.5 seconds and braking distance required under wet, level pavements. Corner or intersection sight distance (ISD) is based upon the time required to perceive, react, and complete desired exiting maneuver from a driveway once the driver decides to execute the maneuver. Adjustments for the grade of the roadway are applied to both SSD and ISD.

Value for ISD represent the time to (1) turn left or right, in addition to accelerating to the operating speed of the roadway, without causing approaching vehicles to reduce speed by more than 10 mph, and (2) upon turning left, to clear the near half of the intersection without conflicting with the vehicles approaching from the left. ISD is more related to operations and to some degree, the convenience or inconvenience of oncoming motorist. The minimum criteria are defined by the AASHTO. SSD relates specifically to safety. As indicated by AASHTO, if available ISD meets or exceeds the minimum SSD criteria, then there is adequate safe sight distance available for motorist to avoid collisions. A criterion for calculating minimum required sight distances can be established based on operating speed, the speed at or under which most motorist (85<sup>th</sup> percentile) actually travel along a particular portion of roadway.

As noted previously, the 85<sup>th</sup>-percentile speeds are used in evaluating sight distances. In this case, the eastbound and westbound 85<sup>th</sup>-percentile speeds of Washington Street are both 43 miles per hour. Using 45 mph for analysis purposes, the required SSD would be 360 feet for both eastbound and westbound approaching traffic. The ISD would need to be at least at that distance for safe movement. Measurements along Washington Street found that the visibility is more than 500 feet to and from Hopping Brook Road in both the west and the east directions. Based on the above information, the requirements for Stopping Sight Distances and Intersection Sight Distances are exceeded in both directions. In addition, the intersection will be more visible to oncoming motorists under signal control.

## **CONCLUSIONS & RECOMMENDATIONS**

This memorandum has provided a review and traffic assessment of the proposed warehouse development (555 Hopping Brook Road) within Hopping Brook Industrial Park off Washington Street in Holliston. Included were estimates of project related traffic and the evaluation of the intersection of Washington Street at Hopping Brook Road that provides the access to the industrial park.

While Washington Street itself has the capacity to accommodate additional traffic and the specific project is expected to be a moderate generator of new traffic, the unsignalized intersection with Hopping Brook Road has existing operational deficiencies in terms of the left turn exiting movement delays that will continue to worsen in the future as the industrial park

continues to increase in size. The industrial park was originally envisioned for 3.0 million square feet and a traffic signal was eventually going to be required at the Park's primary access point.

As a result of the findings, a set of recommendations as part of the approval for the proposed warehouse development. These include the following:

- A traffic signal installation be accomplished prior to the proposed development being occupied and operational. The layout of the signal will be determined in the design phase but will need to take into account the cemetery and wetlands abutting the intersection.
- The designation of left and right turn lanes on Hopping Brook Road will need to be clearly defined and marked. The lengths should be at least 150 feet not including any taper.
- The existing median island on Hopping Brook Road should be modified including removing park sign but making the island longer and clearly visible to traffic through standard MUTCD signage. It is also suggested that it be set further back but a flush island possibly using serrated concrete extend from the raised island towards the Washington Street layout. Final configuration and materials can be determined during design.
- A preliminary review of a potential left turn lane in the westbound direction on Washington Street indicated that while not essential, could be beneficial. However, the environmental constraints abutting the intersection may prevent the incorporation. This will be examined in more detail during the signal design phase.
- Pavement markings need to be maintained on Hopping Brook Road to include a double yellow centerline as well as white edge lines. To be more accommodating to bicycle travel for employees, it would be beneficial to try and provide 4 to 5 foot shoulders even if 11 foot travel lanes need to exist.
- The signage and advance warning treatment including markings of the trail crossing of Hopping Brook using current best practices.



Traffic Impact Assessment  
555 Hopping Brook Road Development  
Holliston, Massachusetts  
January 20, 2020  
-21-

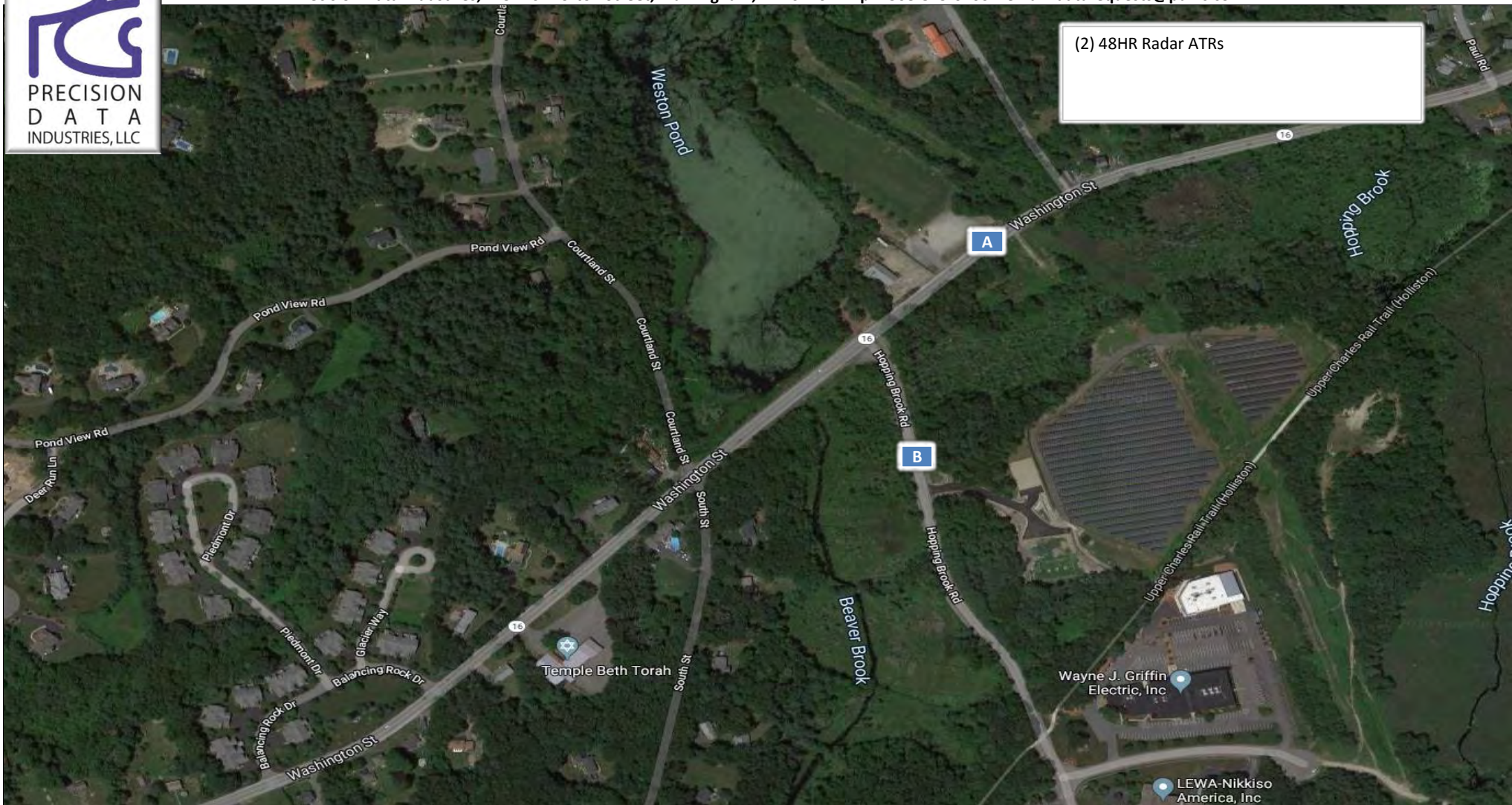
## **APPENDIX**



PRECISION  
DATA  
INDUSTRIES, LLC

## Location Map: 197374 Holliston, MA

Precision Data Industries, LLC 46 Morton Street, Framingham, MA 01702 ph: 508-875-0100 email: [datarequests@pdillc.com](mailto:datarequests@pdillc.com)



Client:  
EDC

Engineer:  
P. Bemis

Site Code:  
TBA

Date:  
Mon 12/16 thru Thurs 12/19/2019

PDI Job #  
197374

City, State:  
Holliston, MA

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Volume  
Site Code: TBA  
Date Start: 12/16/19  
Date End: 12/19/19

Start Time	12/16/19		12/17/19		12/18/19		12/19/19		12/20/19		12/21/19		12/22/19		Week Average	
	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB
12:00 AM	19	18	17	18	35	16	29	28	*	*	*	*	*	*	25	20
01:00	16	12	13	20	22	20	22	16	*	*	*	*	*	*	18	17
02:00	4	13	5	16	12	20	5	17	*	*	*	*	*	*	6	16
03:00	6	18	14	25	21	30	13	24	*	*	*	*	*	*	14	24
04:00	16	44	30	68	28	61	25	42	*	*	*	*	*	*	25	54
05:00	89	312	80	284	93	268	81	296	*	*	*	*	*	*	86	290
06:00	244	620	225	502	238	573	249	590	*	*	*	*	*	*	239	571
07:00	426	609	368	507	434	574	416	575	*	*	*	*	*	*	411	566
08:00	489	577	394	446	502	624	426	560	*	*	*	*	*	*	453	552
09:00	457	428	345	330	409	487	429	434	*	*	*	*	*	*	410	420
10:00	438	443	311	333	412	423	410	408	*	*	*	*	*	*	393	402
11:00	465	421	303	332	464	426	457	405	*	*	*	*	*	*	422	396
12:00 PM	509	466	356	293	530	437	486	465	*	*	*	*	*	*	470	415
01:00	504	457	371	376	533	444	492	441	*	*	*	*	*	*	475	430
02:00	607	534	472	339	615	493	597	503	*	*	*	*	*	*	573	467
03:00	705	496	542	375	699	536	687	472	*	*	*	*	*	*	658	470
04:00	670	567	570	408	681	564	681	591	*	*	*	*	*	*	650	532
05:00	694	612	572	412	704	637	706	612	*	*	*	*	*	*	669	568
06:00	590	412	354	226	587	418	596	438	*	*	*	*	*	*	532	374
07:00	318	302	214	189	447	262	365	304	*	*	*	*	*	*	336	264
08:00	221	222	161	130	265	242	257	221	*	*	*	*	*	*	226	204
09:00	182	142	122	83	232	165	211	183	*	*	*	*	*	*	187	143
10:00	91	106	81	72	107	145	119	132	*	*	*	*	*	*	100	114
11:00	62	49	82	32	88	69	104	66	*	*	*	*	*	*	84	54
Total Day	7822	7880	6002	5816	8158	7934	7863	7823	0	0	0	0	0	0	7462	7363
	15702		11818		16092		15686		0		0		0		14825	
AM Peak	08:00	06:00	08:00	07:00	08:00	08:00	11:00	06:00	-	-	-	-	-	-	08:00	06:00
Vol.	489	620	394	507	502	624	457	590	-	-	-	-	-	-	453	571
PM Peak	15:00	17:00	17:00	17:00	17:00	17:00	17:00	17:00	-	-	-	-	-	-	17:00	17:00
Vol.	705	612	572	412	704	637	706	612	-	-	-	-	-	-	669	568

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Volume  
Site Code: TBA  
Date Start: 12/16/19  
Date End: 12/19/19

Start	WB				EB				Combin ed		12/16/19	
Time	A.M.		P.M.		A.M.		P.M.		A.M.		P.M.	Mon
12:00	8		124		4		103		12		227	
12:15	5		111		6		119		11		230	
12:30	2		128		7		122		9		250	
12:45	4	19	146	509	1	18	122	466	5	37	268	975
01:00	6		118		5		117		11		235	
01:15	4		120		3		122		7		242	
01:30	4		143		3		102		7		245	
01:45	2	16	123	504	1	12	116	457	3	28	239	961
02:00	0		139		0		130		0		269	
02:15	3		150		5		150		8		300	
02:30	1		153		6		118		7		271	
02:45	0	4	165	607	2	13	136	534	2	17	301	1141
03:00	0		166		1		134		1		300	
03:15	1		174		4		121		5		295	
03:30	2		183		5		111		7		294	
03:45	3	6	182	705	8	18	130	496	11	24	312	1201
04:00	3		189		3		124		6		313	
04:15	5		151		7		147		12		298	
04:30	3		178		8		136		11		314	
04:45	5	16	152	670	26	44	160	567	31	60	312	1237
05:00	16		181		24		176		40		357	
05:15	18		164		60		143		78		307	
05:30	22		188		89		133		111		321	
05:45	33	89	161	694	139	312	160	612	172	401	321	1306
06:00	44		149		126		121		170		270	
06:15	53		166		170		116		223		282	
06:30	58		139		162		81		220		220	
06:45	89	244	136	590	162	620	94	412	251	864	230	1002
07:00	81		95		167		94		248		189	
07:15	92		93		156		75		248		168	
07:30	125		61		131		72		256		133	
07:45	128	426	69	318	155	609	61	302	283	1035	130	620
08:00	131		52		161		54		292		106	
08:15	107		67		175		58		282		125	
08:30	128		57		129		75		257		132	
08:45	123	489	45	221	112	577	35	222	235	1066	80	443
09:00	119		40		110		36		229		76	
09:15	112		40		117		39		229		79	
09:30	117		51		106		27		223		78	
09:45	109	457	51	182	95	428	40	142	204	885	91	324
10:00	109		26		103		29		212		55	
10:15	115		23		106		29		221		52	
10:30	112		23		108		30		220		53	
10:45	102	438	19	91	126	443	18	106	228	881	37	197
11:00	111		23		100		17		211		40	
11:15	110		14		104		8		214		22	
11:30	113		10		108		13		221		23	
11:45	131	465	15	62	109	421	11	49	240	886	26	111
Total	2669		5153		3515		4365		6184		9518	
Percent	43.2%		54.1%		56.8%		45.9%					
Day Total			7822				7880				15702	
Peak	07:45	-	03:15	-	06:15	-	04:15	-	07:45	-	05:00	-
Vol.	494	-	728	-	661	-	619	-	1114	-	1306	-
P.H.F.	0.943		0.963		0.972		0.879		0.954		0.915	



Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Volume  
Site Code: TBA  
Date Start: 12/16/19  
Date End: 12/19/19

Start	WB			EB			Combin ed		12/17/19			
Time	A.M.		P.M.		A.M.		P.M.		A.M.		P.M.	Tue
12:00	10		86		10		87		20		173	
12:15	3		81		3		67		6		148	
12:30	2		104		3		73		5		177	
12:45	2	17	85	356	2	18	66	293	4	35	151	649
01:00	2		95		4		93		6		188	
01:15	7		97		5		102		12		199	
01:30	2		88		7		100		9		188	
01:45	2	13	91	371	4	20	81	376	6	33	172	747
02:00	2		101		3		78		5		179	
02:15	0		113		3		76		3		189	
02:30	0		109		4		97		4		206	
02:45	3	5	149	472	6	16	88	339	9	21	237	811
03:00	4		131		4		73		8		204	
03:15	3		149		0		90		3		239	
03:30	3		138		9		101		12		239	
03:45	4	14	124	542	12	25	111	375	16	39	235	917
04:00	7		164		5		96		12		260	
04:15	7		117		11		98		18		215	
04:30	5		158		20		106		25		264	
04:45	11	30	131	570	32	68	108	408	43	98	239	978
05:00	13		152		33		117		46		269	
05:15	19		152		59		108		78		260	
05:30	22		140		87		92		109		232	
05:45	26	80	128	572	105	284	95	412	131	364	223	984
06:00	37		102		131		69		168		171	
06:15	48		107		119		70		167		177	
06:30	67		85		120		55		187		140	
06:45	73	225	60	354	132	502	32	226	205	727	92	580
07:00	71		64		136		59		207		123	
07:15	88		57		128		46		216		103	
07:30	111		42		112		48		223		90	
07:45	98	368	51	214	131	507	36	189	229	875	87	403
08:00	125		37		112		36		237		73	
08:15	99		53		123		35		222		88	
08:30	81		36		113		38		194		74	
08:45	89	394	35	161	98	446	21	130	187	840	56	291
09:00	79		34		93		26		172		60	
09:15	108		32		78		23		186		55	
09:30	81		32		80		12		161		44	
09:45	77	345	24	122	79	330	22	83	156	675	46	205
10:00	75		22		82		21		157		43	
10:15	83		23		88		21		171		44	
10:30	74		23		89		18		163		41	
10:45	79	311	13	81	74	333	12	72	153	644	25	153
11:00	72		20		75		6		147		26	
11:15	68		20		91		9		159		29	
11:30	74		21		86		12		160		33	
11:45	89	303	21	82	80	332	5	32	169	635	26	114
Total	2105		3897		2881		2935		4986		6832	
Percent	42.2%		57.0%		57.8%		43.0%					
Day Total			6002				5816				11818	
Peak	07:30	-	04:30	-	06:30	-	04:30	-	07:30	-	04:30	-
Vol.	433	-	593	-	516	-	439	-	911	-	1032	-
P.H.F.	0.866		0.904		0.949		0.938		0.961		0.959	

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Volume  
Site Code: TBA  
Date Start: 12/16/19  
Date End: 12/19/19

Start		WB		EB		Combin ed		12/18/19	
Time	A.M.	P.M.		A.M.	P.M.	A.M.	P.M.	Wed	
12:00	10	119		4	101	14	220		
12:15	13	133		6	103	19	236		
12:30	6	139		4	129	10	268		
12:45	6	139	530	2	104	8	243	967	
01:00	3	140		5	105	8	245		
01:15	5	123		3	113	8	236		
01:30	9	145		8	117	17	262		
01:45	5	125	533	4	109	9	234	977	
02:00	4	133		4	135	8	268		
02:15	1	149		6	101	7	250		
02:30	4	175		4	120	8	295		
02:45	3	158	615	6	137	9	295	1108	
03:00	4	191		4	125	8	316		
03:15	7	173		5	132	12	305		
03:30	6	166		8	135	14	301		
03:45	4	169	699	13	144	17	313	1235	
04:00	4	183		8	137	12	320		
04:15	8	185		12	121	20	306		
04:30	8	159		16	151	24	310		
04:45	8	154	681	25	155	33	309	1245	
05:00	25	168		28	158	53	326		
05:15	14	178		44	176	58	354		
05:30	21	174		88	171	109	345		
05:45	33	184	704	108	132	141	316	1341	
06:00	50	165		114	108	164	273		
06:15	42	132		166	116	208	248		
06:30	65	148		144	101	209	249		
06:45	81	142	587	149	93	230	235	1005	
07:00	80	133		160	62	240	195		
07:15	77	121		140	70	217	191		
07:30	134	90		127	60	261	150		
07:45	143	103	447	147	70	262	173	709	
08:00	154	77		167	62	321	139		
08:15	109	64		172	65	281	129		
08:30	115	50		147	51	262	101		
08:45	124	74	265	138	64	242	138	507	
09:00	93	73		148	44	241	117		
09:15	130	61		126	43	256	104		
09:30	87	48		112	42	199	90		
09:45	99	50	232	101	487	36	86	397	
10:00	97	31		120	31	217	62		
10:15	99	31		113	46	212	77		
10:30	97	24		99	30	196	54		
10:45	119	21	107	91	423	38	59	252	
11:00	117	23		117	15	234	38		
11:15	98	30		103	16	201	46		
11:30	118	21		95	20	213	41		
11:45	131	14	88	111	426	18	32	157	
Total	2670	5488		3522	4412	6192	9900		
Percent	43.1%	55.4%		56.9%	44.6%				
Day Total		8158			7934		16092		
Peak	07:30	-	05:00	-	07:45	-	07:45	-	05:00
Vol.	540	-	704	-	633	-	1154	-	1341
P.H.F.	0.877		0.951		0.920		0.899		0.947

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Volume  
Site Code: TBA  
Date Start: 12/16/19  
Date End: 12/19/19

Start	WB				EB				Combin ed		12/19/19		
Time	A.M.		P.M.		A.M.		P.M.		A.M.		P.M.		Thu
12:00	11		109		11		120		22		229		
12:15	8		140		7		114		15		254		
12:30	5		124		6		117		11		241		
12:45	5	29	113	486	4	28	114	465	9	57	227	951	
01:00	5		123		3		109		8		232		
01:15	8		132		2		118		10		250		
01:30	5		121		9		105		14		226		
01:45	4	22	116	492	2	16	109	441	6	38	225	933	
02:00	2		132		8		109		10		241		
02:15	2		125		2		123		4		248		
02:30	0		152		2		122		2		274		
02:45	1	5	188	597	5	17	149	503	6	22	337	1100	
03:00	3		196		7		122		10		318		
03:15	7		145		0		116		7		261		
03:30	2		160		11		112		13		272		
03:45	1	13	186	687	6	24	122	472	7	37	308	1159	
04:00	4		163		4		133		8		296		
04:15	4		188		9		133		13		321		
04:30	6		173		10		153		16		326		
04:45	11	25	157	681	19	42	172	591	30	67	329	1272	
05:00	10		174		31		180		41		354		
05:15	12		155		51		146		63		301		
05:30	24		182		84		149		108		331		
05:45	35	81	195	706	130	296	137	612	165	377	332	1318	
06:00	42		150		139		118		181		268		
06:15	52		173		156		134		208		307		
06:30	62		149		150		96		212		245		
06:45	93	249	124	596	145	590	90	438	238	839	214	1034	
07:00	64		112		153		83		217		195		
07:15	99		82		149		72		248		154		
07:30	126		86		133		71		259		157		
07:45	127	416	85	365	140	575	78	304	267	991	163	669	
08:00	115		69		160		61		275		130		
08:15	102		56		138		65		240		121		
08:30	101		64		130		47		231		111		
08:45	108	426	68	257	132	560	48	221	240	986	116	478	
09:00	126		41		116		43		242		84		
09:15	103		63		121		57		224		120		
09:30	85		55		108		43		193		98		
09:45	115	429	52	211	89	434	40	183	204	863	92	394	
10:00	100		32		119		43		219		75		
10:15	99		32		107		44		206		76		
10:30	116		35		88		17		204		52		
10:45	95	410	20	119	94	408	28	132	189	818	48	251	
11:00	131		35		102		20		233		55		
11:15	107		25		109		20		216		45		
11:30	120		21		105		11		225		32		
11:45	99	457	23	104	89	405	15	66	188	862	38	170	
Total	2562		5301		3395		4428		5957		9729		
Percent	43.0%		54.5%		57.0%		45.5%						
Day Total			7863				7823				15686		
Peak	07:30	-	03:45	-	06:15	-	04:30	-	07:15	-	04:15	-	-
Vol.	470	-	710	-	604	-	651	-	1049	-	1330	-	-
P.H.F.	0.925		0.944		0.968		0.904		0.954		0.939		

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

WB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/16/																
19	0	0	0	0	2	3	11	2	2	0	0	0	0	20	46	42
01:00	0	0	0	0	1	3	9	3	0	0	0	0	0	16	45	41
02:00	0	0	0	0	0	0	2	0	2	0	0	0	0	4	52	47
03:00	0	0	0	0	0	2	0	3	1	0	0	0	0	6	49	45
04:00	0	0	0	0	1	1	6	6	1	0	0	0	0	15	47	44
05:00	0	0	0	0	2	17	49	16	3	0	0	0	0	87	45	42
06:00	0	0	2	11	29	90	79	25	2	0	0	0	0	238	43	39
07:00	0	0	0	7	51	130	199	38	3	1	0	0	0	429	43	40
08:00	1	0	5	5	24	175	230	45	1	1	0	0	0	487	43	40
09:00	0	0	1	5	22	139	238	47	2	2	0	0	0	456	43	40
10:00	0	1	3	1	25	131	229	50	2	0	1	0	0	443	43	40
11:00	5	6	5	24	33	162	180	42	3	0	0	0	0	460	43	38
12 PM	0	18	21	13	36	149	220	50	4	0	0	0	0	511	43	38
13:00	0	0	3	16	50	232	170	32	0	0	0	0	0	503	42	38
14:00	1	5	10	24	65	246	214	36	3	0	0	0	0	604	42	38
15:00	0	12	14	31	77	264	268	33	1	0	0	0	0	700	42	38
16:00	2	6	10	29	103	252	233	43	1	0	0	0	0	679	42	38
17:00	0	0	0	26	140	357	143	23	0	0	0	0	0	689	41	37
18:00	0	1	7	3	87	266	213	20	1	0	0	0	0	598	42	38
19:00	0	0	0	0	17	124	137	38	1	1	0	0	0	318	43	40
20:00	0	0	0	0	13	54	120	33	4	0	0	0	0	224	44	41
21:00	0	0	0	0	4	70	71	27	7	3	0	0	0	182	45	41
22:00	0	0	0	0	2	31	35	19	4	0	0	0	0	91	46	42
23:00	0	0	0	0	1	14	28	15	4	0	0	0	0	62	47	43
Total	9	49	81	195	785	2912	3084	646	52	8	1	0	0	7822		
%	0.1%	0.6%	1.0%	2.5%	10.0%	37.2%	39.4%	8.3%	0.7%	0.1%	0.0%	0.0%	0.0%			
AM Peak	11:00	11:00	08:00	11:00	07:00	08:00	09:00	10:00	05:00	09:00	10:00			08:00		
Vol.	5	6	5	24	51	175	238	50	3	2	1			487		
PM Peak	16:00	12:00	12:00	15:00	17:00	17:00	15:00	12:00	21:00	21:00				15:00		
Vol.	2	18	21	31	140	357	268	50	7	3				700		

Stats  
15th Percentile : 34 MPH  
50th Percentile : 38 MPH  
85th Percentile : 43 MPH  
95th Percentile : 46 MPH

Mean Speed(Average) : 39 MPH  
10 MPH Pace Speed : 35-44 MPH  
Number in Pace : 5996  
Percent in Pace : 76.7%  
Number of Vehicles > 35 MPH : 6121  
Percent of Vehicles > 35 MPH : 78.2%

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

WB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean)
12/17/																
19	0	0	0	0	3	3	6	4	2	0	0	0	0	18	48	42
01:00	0	0	0	0	0	6	3	4	0	0	0	0	0	13	46	41
02:00	0	0	0	0	1	1	3	0	0	0	0	0	0	5	42	39
03:00	0	0	0	0	1	3	4	2	<b>3</b>	<b>1</b>	0	0	0	14	52	44
04:00	1	0	2	0	1	12	11	2	1	0	0	0	0	30	43	38
05:00	0	0	2	2	11	35	21	<b>8</b>	0	0	0	0	0	79	43	38
06:00	0	0	0	6	53	115	40	8	0	1	0	0	0	223	40	37
07:00	1	4	14	28	51	160	<b>96</b>	6	2	0	0	0	0	362	41	36
08:00	0	0	<b>20</b>	<b>58</b>	<b>133</b>	157	30	1	0	0	0	0	0	<b>399</b>	38	34
09:00	<b>28</b>	<b>32</b>	17	56	109	85	10	1	0	0	0	0	0	338	36	29
10:00	0	0	2	15	98	162	38	2	1	0	0	0	0	318	38	36
11:00	0	0	4	15	56	<b>163</b>	63	4	0	0	0	0	0	305	40	37
12 PM	0	2	10	41	127	146	24	3	0	0	0	0	0	353	38	34
13:00	0	0	<b>26</b>	46	158	122	18	1	<b>1</b>	0	0	0	0	372	37	33
14:00	0	0	4	65	192	184	15	1	0	0	0	0	0	461	37	34
15:00	<b>7</b>	2	23	74	217	200	25	1	0	0	0	0	0	549	37	33
16:00	6	<b>12</b>	21	<b>75</b>	<b>276</b>	159	14	1	0	0	0	0	0	564	36	32
17:00	2	3	3	62	264	<b>223</b>	22	0	0	0	0	0	0	<b>579</b>	37	34
18:00	4	7	15	25	120	158	27	1	0	0	0	0	0	357	38	34
19:00	0	0	13	5	43	103	<b>42</b>	4	1	0	0	0	0	211	40	36
20:00	0	0	0	8	36	86	27	6	1	0	0	0	0	164	40	37
21:00	0	0	0	5	32	59	23	<b>7</b>	0	0	0	0	0	126	41	37
22:00	0	0	5	1	26	34	12	2	0	0	0	0	0	80	39	35
23:00	0	0	0	2	20	31	26	4	0	0	0	0	0	83	42	38
Total	49	62	181	589	2028	2407	600	73	12	2	0	0	0	6003		
%	0.8%	1.0%	3.0%	9.8%	33.8%	40.1%	10.0%	1.2%	0.2%	0.0%	0.0%	0.0%	0.0%			
AM Peak	09:00	09:00	08:00	08:00	08:00	11:00	07:00	05:00	03:00	03:00				08:00		
Vol.	28	32	20	58	133	163	96	8	3	1				399		
PM Peak	15:00	16:00	13:00	16:00	16:00	17:00	19:00	21:00	13:00					17:00		
Vol.	7	12	26	75	276	223	42	7	1					579		

Stats

15th Percentile :	29 MPH
50th Percentile :	34 MPH
85th Percentile :	38 MPH
95th Percentile :	42 MPH

Mean Speed(Average) :	34 MPH
10 MPH Pace Speed :	30-39 MPH
Number in Pace :	4435
Percent in Pace :	73.9%
Number of Vehicles > 35 MPH :	2613
Percent of Vehicles > 35 MPH :	43.5%

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

WB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean)
12/18/19	0	0	0	4	9	16	6	0	0	0	0	0	0	35	39	35
01:00	0	0	0	2	8	6	5	1	0	0	0	0	0	22	41	36
02:00	0	0	0	0	4	8	0	0	0	0	0	0	0	12	37	35
03:00	0	0	0	0	3	9	6	1	1	0	0	0	1	21	43	39
04:00	0	0	0	2	7	15	3	1	0	0	0	0	0	28	38	36
05:00	0	0	0	4	16	34	30	6	0	0	0	0	0	90	42	38
06:00	0	0	1	12	46	111	59	7	0	0	0	0	0	236	41	37
07:00	0	0	0	7	61	231	125	11	2	0	0	0	0	437	41	38
08:00	0	4	0	6	90	213	162	22	2	0	0	0	0	499	42	38
09:00	0	0	7	16	60	146	154	27	0	0	0	0	0	410	42	38
10:00	0	1	1	1	31	179	166	29	2	0	0	0	0	410	43	39
11:00	0	0	0	8	42	148	215	47	3	0	0	0	0	463	43	40
12 PM	0	0	4	10	54	209	214	40	1	0	0	0	0	532	43	39
13:00	0	19	6	9	27	258	186	27	0	0	0	0	0	532	42	38
14:00	0	0	0	3	54	284	250	22	0	0	0	0	0	613	42	39
15:00	16	7	8	44	125	299	170	21	0	0	1	1	0	692	41	36
16:00	0	3	7	38	126	362	145	4	0	1	0	0	0	686	40	36
17:00	0	15	27	79	223	283	73	7	0	0	0	0	0	707	38	34
18:00	1	0	2	14	90	314	153	13	1	0	0	0	1	589	41	37
19:00	0	0	3	14	87	243	91	10	0	0	0	0	0	448	40	37
20:00	0	0	0	0	25	125	93	22	1	0	0	0	0	266	43	39
21:00	0	0	0	0	14	101	106	12	0	1	0	0	0	234	42	40
22:00	0	0	0	0	6	35	55	9	2	0	0	0	0	107	43	40
23:00	0	0	0	0	4	37	29	15	4	0	0	0	0	89	45	41
Total	17	49	66	273	1212	3666	2496	354	19	2	1	1	2	8158		
%	0.2%	0.6%	0.8%	3.3%	14.9%	44.9%	30.6%	4.3%	0.2%	0.0%	0.0%	0.0%	0.0%			
AM Peak		08:00	09:00	09:00	08:00	07:00	11:00	11:00	11:00				03:00	08:00		
Vol.		4	7	16	90	231	215	47	3				1	499		
PM Peak	15:00	13:00	17:00	17:00	17:00	16:00	14:00	12:00	23:00	16:00	15:00	15:00	18:00	17:00		
Vol.	16	19	27	79	223	362	250	40	4	1	1	1	1	707		

Stats

15th Percentile :	32 MPH
50th Percentile :	37 MPH
85th Percentile :	42 MPH
95th Percentile :	43 MPH

Mean Speed(Average) :	38 MPH
10 MPH Pace Speed :	35-44 MPH
Number in Pace :	6162
Percent in Pace :	75.5%
Number of Vehicles > 35 MPH :	5808
Percent of Vehicles > 35 MPH :	71.2%

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

WB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/19/																
19	0	0	0	0	0	15	7	4	1	2	0	0	0	29	47	41
01:00	0	0	0	1	1	8	10	1	0	1	0	0	0	22	43	40
02:00	0	0	0	0	1	2	1	0	1	0	0	0	0	5	50	40
03:00	0	0	0	0	0	3	10	0	0	0	0	0	0	13	43	41
04:00	0	0	0	0	0	8	12	4	0	0	0	0	0	24	44	41
05:00	0	0	0	0	2	31	40	7	1	0	1	0	0	82	43	41
06:00	0	0	0	4	33	110	86	6	3	0	0	0	0	242	42	38
07:00	1	1	4	14	32	171	156	35	2	0	0	0	0	416	43	39
08:00	0	0	1	11	34	134	200	41	4	1	0	0	0	426	43	40
09:00	0	0	0	0	33	144	200	40	3	0	0	0	0	420	43	40
10:00	0	0	2	15	31	154	178	42	2	1	0	0	0	425	43	39
11:00	0	0	0	3	31	181	206	31	2	0	0	0	0	454	43	40
12 PM	0	3	9	9	46	173	202	38	8	0	0	0	0	488	43	39
13:00	0	0	2	5	46	187	202	43	5	0	0	0	0	490	43	39
14:00	16	4	5	35	89	230	194	23	0	0	0	0	0	596	42	37
15:00	22	6	33	20	95	285	187	33	3	0	0	0	0	684	42	36
16:00	0	0	7	30	106	315	193	25	2	0	0	0	0	678	42	37
17:00	0	2	1	23	157	356	157	11	0	0	0	0	0	707	40	37
18:00	0	0	0	10	83	294	192	16	1	0	0	0	0	596	42	38
19:00	0	0	0	1	33	168	150	19	3	0	0	0	0	374	42	39
20:00	0	0	0	0	12	94	122	23	3	0	0	0	0	254	43	40
21:00	0	0	0	0	18	94	75	22	1	1	0	0	0	211	43	40
22:00	0	0	0	0	6	36	58	19	1	0	0	0	0	120	44	41
23:00	0	0	0	0	2	30	57	13	3	1	0	0	0	106	44	41
Total	39	16	64	181	891	3223	2895	496	49	7	1	0	0	7862		
%	0.5%	0.2%	0.8%	2.3%	11.3%	41.0%	36.8%	6.3%	0.6%	0.1%	0.0%	0.0%	0.0%			
AM Peak	07:00	07:00	07:00	10:00	08:00	11:00	11:00	10:00	08:00	00:00	05:00			11:00		
Vol.	1	1	4	15	34	181	206	42	4	2	1			454		
PM Peak	15:00	15:00	15:00	14:00	17:00	17:00	12:00	13:00	12:00	21:00				17:00		
Vol.	22	6	33	35	157	356	202	43	8	1				707		

Stats  
15th Percentile : 33 MPH  
50th Percentile : 38 MPH  
85th Percentile : 42 MPH  
95th Percentile : 45 MPH

Mean Speed(Average) : 38 MPH  
10 MPH Pace Speed : 35-44 MPH  
Number in Pace : 6118  
Percent in Pace : 77.8%  
Number of Vehicles > 35 MPH : 6026  
Percent of Vehicles > 35 MPH : 76.7%



Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean)
12/16/19	0	0	0	0	1	5	6	3	3	0	0	0	0	18	49	43
01:00	0	0	0	0	1	2	7	2	0	0	0	0	0	12	44	41
02:00	0	0	1	0	0	3	7	2	0	0	0	0	0	13	44	40
03:00	0	0	0	0	1	3	4	7	3	0	0	0	0	18	49	44
04:00	0	0	0	0	1	5	23	11	2	0	0	0	0	42	47	43
05:00	0	0	0	0	2	41	170	91	5	1	0	0	0	310	46	43
06:00	0	0	0	2	16	224	270	91	8	4	0	0	0	615	44	41
07:00	0	0	0	8	18	226	270	72	7	0	0	0	0	601	43	40
08:00	0	0	1	2	34	267	240	40	3	1	0	0	0	588	43	39
09:00	0	0	3	0	26	142	187	64	5	1	0	0	0	428	44	40
10:00	0	0	0	4	12	151	224	42	4	0	0	0	0	437	43	40
11:00	0	0	0	12	38	141	198	34	7	0	0	0	0	430	43	40
12 PM	0	0	1	1	60	187	168	41	3	0	0	0	0	461	43	39
13:00	1	0	0	1	39	236	159	26	0	0	0	0	0	462	42	39
14:00	0	0	0	3	86	246	167	26	3	1	0	0	0	532	42	38
15:00	0	0	0	7	62	189	209	26	2	0	0	0	1	496	42	39
16:00	0	0	0	5	54	205	233	59	4	1	1	0	0	562	43	40
17:00	0	0	0	6	51	314	216	26	1	0	0	0	0	614	42	39
18:00	0	0	0	11	33	163	168	43	1	0	0	0	0	419	43	39
19:00	0	0	0	0	14	110	142	29	2	1	0	0	0	298	43	40
20:00	0	0	0	0	13	68	111	27	7	1	0	0	0	227	44	41
21:00	0	0	0	0	5	43	63	26	5	0	0	0	0	142	45	41
22:00	0	0	0	0	1	29	51	17	5	0	0	0	0	103	45	42
23:00	0	0	0	0	2	12	15	18	2	0	0	0	1	50	47	43
Total	1	0	6	62	570	3012	3308	823	82	11	1	0	2	7878		
%	0.0%	0.0%	0.1%	0.8%	7.2%	38.2%	42.0%	10.4%	1.0%	0.1%	0.0%	0.0%	0.0%			
AM Peak			09:00	11:00	11:00	08:00	06:00	05:00	06:00	06:00				06:00		
Vol.			3	12	38	267	270	91	8	4				615		
PM Peak	13:00		12:00	18:00	14:00	17:00	16:00	16:00	20:00	14:00	16:00		15:00	17:00		
Vol.	1		1	11	86	314	233	59	7	1	1		1	614		

Stats  
15th Percentile : 34 MPH  
50th Percentile : 39 MPH  
85th Percentile : 43 MPH  
95th Percentile : 47 MPH

Mean Speed(Average) : 40 MPH  
10 MPH Pace Speed : 35-44 MPH  
Number in Pace : 6320  
Percent in Pace : 80.2%  
Number of Vehicles > 35 MPH : 6637  
Percent of Vehicles > 35 MPH : 84.2%

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

EB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/17/																
19	0	0	0	0	0	2	9	8	1	0	0	0	0	20	47	44
01:00	0	0	0	0	2	6	9	2	1	0	0	0	0	20	44	41
02:00	0	0	0	0	0	4	5	3	1	0	0	0	0	13	47	42
03:00	0	0	0	0	1	4	15	4	4	0	0	0	0	28	48	43
04:00	0	0	0	0	4	12	26	20	3	0	0	1	0	66	47	43
05:00	0	0	0	1	14	111	111	<b>38</b>	<b>5</b>	0	0	<b>2</b>	0	282	44	41
06:00	0	0	5	17	77	261	<b>115</b>	19	1	0	0	0	0	495	41	37
07:00	0	0	0	20	81	<b>304</b>	95	10	0	0	<b>1</b>	0	0	<b>511</b>	40	37
08:00	0	0	1	<b>44</b>	<b>164</b>	196	44	3	0	0	0	0	<b>1</b>	453	38	35
09:00	0	0	<b>13</b>	34	130	134	13	1	0	0	0	0	0	325	37	34
10:00	0	0	3	38	113	141	38	1	0	0	0	0	0	334	38	35
11:00	0	0	6	9	84	166	63	3	0	0	0	0	1	332	40	36
12 PM	0	0	0	24	124	123	23	0	0	0	0	0	0	294	38	34
13:00	0	0	9	51	171	130	10	1	0	<b>1</b>	0	0	1	374	37	33
14:00	0	0	<b>18</b>	41	169	104	8	1	0	0	0	<b>1</b>	0	342	37	33
15:00	0	0	1	41	168	134	29	1	0	0	0	0	0	374	38	34
16:00	0	1	11	<b>80</b>	<b>175</b>	123	9	1	0	0	0	0	<b>2</b>	402	36	32
17:00	0	3	11	31	167	<b>173</b>	28	2	0	0	0	0	0	<b>415</b>	38	34
18:00	0	0	14	10	72	102	30	2	0	0	0	0	0	230	38	35
19:00	0	<b>4</b>	1	3	42	93	<b>39</b>	<b>8</b>	0	0	0	0	0	190	41	37
20:00	0	0	0	3	25	69	25	4	<b>2</b>	0	0	0	0	128	41	37
21:00	0	0	0	4	15	44	20	3	0	0	0	0	0	86	41	37
22:00	0	0	2	3	22	28	14	3	0	0	0	0	0	72	41	36
23:00	0	0	0	3	6	15	7	1	0	0	0	0	0	32	41	37
Total	0	8	95	457	1826	2479	785	139	18	1	1	4	5	5818		
%	0.0%	0.1%	1.6%	7.9%	31.4%	42.6%	13.5%	2.4%	0.3%	0.0%	0.0%	0.1%	0.1%			
AM Peak			09:00	08:00	08:00	07:00	06:00	05:00	05:00		07:00	05:00	08:00	07:00		
Vol.			13	44	164	304	115	38	5		1	2	1	511		
PM Peak		19:00	14:00	16:00	16:00	17:00	19:00	19:00	20:00	13:00		14:00	16:00	17:00		
Vol.		4	18	80	175	173	39	8	2	1		1	2	415		

Stats  
15th Percentile : 29 MPH  
50th Percentile : 35 MPH  
85th Percentile : 39 MPH  
95th Percentile : 43 MPH

Mean Speed(Average) : 35 MPH  
10 MPH Pace Speed : 30-39 MPH  
Number in Pace : 4305  
Percent in Pace : 74.0%  
Number of Vehicles > 35 MPH : 2936  
Percent of Vehicles > 35 MPH : 50.5%

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

EB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/18/ 19	0	0	2	1	1	4	5	3	0	0	0	0	0	16	45	38
01:00	0	0	0	1	2	13	2	2	0	0	0	0	0	20	41	38
02:00	0	0	0	4	4	4	5	1	0	0	0	0	0	18	42	36
03:00	0	0	0	2	6	15	6	1	0	0	0	0	0	30	41	37
04:00	0	0	3	0	10	19	24	6	1	0	0	0	0	63	43	39
05:00	0	0	0	3	23	96	109	28	3	1	0	0	0	263	43	40
06:00	0	0	0	15	115	301	117	20	0	0	0	0	0	568	41	37
07:00	0	1	0	14	86	251	197	25	0	0	0	0	0	574	42	38
08:00	0	0	3	3	103	289	195	32	3	1	0	0	0	629	42	38
09:00	0	0	0	11	30	197	207	39	1	0	0	0	0	485	43	39
10:00	1	3	0	4	43	169	181	25	1	0	0	0	0	427	42	39
11:00	0	0	0	1	41	212	140	26	3	0	0	0	0	423	42	39
12 PM	0	0	3	7	41	172	177	37	1	0	1	0	0	439	43	39
13:00	0	0	0	1	34	195	172	36	2	1	0	0	0	441	43	39
14:00	0	0	0	1	43	197	193	48	6	0	0	0	0	488	43	40
15:00	0	1	2	33	69	229	177	30	3	0	0	0	0	544	42	38
16:00	0	0	0	8	72	293	169	19	0	0	0	3	0	564	42	38
17:00	0	0	0	11	166	353	93	9	0	0	0	0	1	633	39	36
18:00	0	1	1	0	45	221	129	24	1	0	0	0	0	422	42	39
19:00	0	0	0	11	39	123	79	7	1	0	0	0	0	260	42	38
20:00	0	0	0	4	57	105	54	22	1	0	0	0	0	243	42	38
21:00	0	0	0	0	13	59	82	12	2	0	0	0	0	168	43	40
22:00	0	0	0	1	14	58	58	15	1	0	0	0	0	147	43	40
23:00	0	0	0	0	1	21	35	10	2	0	0	0	0	69	44	41
Total	1	6	14	136	1058	3596	2606	477	32	3	1	3	1	7934		
%	0.0%	0.1%	0.2%	1.7%	13.3%	45.3%	32.8%	6.0%	0.4%	0.0%	0.0%	0.0%	0.0%			
AM Peak	10:00	10:00	04:00	06:00	06:00	06:00	09:00	09:00	05:00	05:00				08:00		
Vol.	1	3	3	15	115	301	207	39	3	1				629		
PM Peak		15:00	12:00	15:00	17:00	17:00	14:00	14:00	14:00	13:00	12:00	16:00	17:00	17:00		
Vol.		1	3	33	166	353	193	48	6	1	1	3	1	633		

Stats  
15th Percentile : 33 MPH  
50th Percentile : 37 MPH  
85th Percentile : 42 MPH  
95th Percentile : 45 MPH

Mean Speed(Average) : 38 MPH  
10 MPH Pace Speed : 35-44 MPH  
Number in Pace : 6202  
Percent in Pace : 78.2%  
Number of Vehicles > 35 MPH : 6000  
Percent of Vehicles > 35 MPH : 75.6%

Washington Street (Route 16)  
approx 500' east of Hopping Brook Road  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 A Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

EB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/19/ 19	0	0	0	0	2	13	10	2	0	0	0	0	0	27	42	39
01:00	0	0	0	1	2	7	5	1	1	0	0	0	0	17	43	39
02:00	0	0	0	1	6	5	5	0	0	0	0	0	0	17	41	36
03:00	0	0	0	0	2	4	11	3	4	0	0	0	0	24	49	43
04:00	0	0	0	0	1	4	22	10	1	0	0	0	0	38	46	43
05:00	0	0	0	0	9	92	146	42	5	3	0	0	0	297	44	41
06:00	0	0	0	3	84	247	211	35	3	0	0	0	1	584	42	39
07:00	0	0	0	0	27	247	257	32	2	0	0	0	0	565	43	40
08:00	0	0	0	0	35	261	231	43	6	0	0	0	0	576	43	40
09:00	0	0	0	6	49	182	156	31	4	1	0	0	0	429	43	39
10:00	0	0	1	6	48	144	183	23	5	0	0	0	2	412	43	39
11:00	0	0	0	4	35	162	173	28	0	1	0	0	0	403	43	39
12 PM	1	0	4	6	54	194	177	28	1	0	0	0	0	465	42	39
13:00	0	0	0	2	47	183	165	42	2	0	0	0	0	441	43	39
14:00	0	0	0	6	61	227	165	39	1	0	0	0	0	499	42	39
15:00	0	0	6	5	49	197	183	34	4	1	0	0	1	480	43	39
16:00	0	0	2	3	72	296	181	24	2	0	0	0	0	580	42	38
17:00	0	0	0	2	89	326	171	32	2	0	0	0	0	622	42	38
18:00	0	0	0	7	28	186	185	27	1	1	0	0	0	435	43	39
19:00	0	0	0	5	19	126	117	35	3	0	0	0	0	305	43	40
20:00	0	0	0	0	16	65	115	26	2	0	0	0	0	224	43	41
21:00	0	0	0	0	7	57	82	35	2	0	0	0	0	183	45	41
22:00	0	0	0	1	2	35	70	24	1	0	0	0	0	133	45	41
23:00	0	0	0	1	1	18	30	14	1	1	0	0	0	66	46	42
Total	1	0	13	59	745	3278	3051	610	53	8	0	0	4	7822		
%	0.0%	0.0%	0.2%	0.8%	9.5%	41.9%	39.0%	7.8%	0.7%	0.1%	0.0%	0.0%	0.1%			
AM Peak			10:00	09:00	06:00	08:00	07:00	08:00	08:00	05:00			10:00	06:00		
Vol.			1	6	84	261	257	43	6	3			2	584		
PM Peak	12:00		15:00	18:00	17:00	17:00	18:00	13:00	15:00	15:00			15:00	17:00		
Vol.	1		6	7	89	326	185	42	4	1			1	622		

Stats  
15th Percentile : 34 MPH  
50th Percentile : 38 MPH  
85th Percentile : 43 MPH  
95th Percentile : 46 MPH

Mean Speed(Average) : 39 MPH  
10 MPH Pace Speed : 35-44 MPH  
Number in Pace : 6329  
Percent in Pace : 80.9%  
Number of Vehicles > 35 MPH : 6348  
Percent of Vehicles > 35 MPH : 81.2%

Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Volume  
Site Code: TBA  
Date Start: 12/16/19  
Date End: 12/19/19

Start Time	12/16/19		12/17/19		12/18/19		12/19/19		12/20/19		12/21/19		12/22/19		Week Average	
	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
12:00 AM	0	0	6	0	3	2	5	0	*	*	*	*	*	*	4	0
01:00	2	1	12	1	8	2	8	0	*	*	*	*	*	*	8	1
02:00	2	1	4	2	13	0	8	2	*	*	*	*	*	*	7	1
03:00	1	1	2	1	2	6	1	1	*	*	*	*	*	*	2	2
04:00	1	17	1	17	4	22	1	18	*	*	*	*	*	*	2	18
05:00	7	84	16	95	15	102	13	90	*	*	*	*	*	*	13	93
06:00	20	239	34	237	45	256	41	241	*	*	*	*	*	*	35	243
07:00	52	263	39	260	59	240	48	219	*	*	*	*	*	*	50	246
08:00	54	184	60	169	43	195	40	179	*	*	*	*	*	*	49	182
09:00	53	102	27	91	41	106	43	97	*	*	*	*	*	*	41	99
10:00	52	74	51	59	62	69	75	95	*	*	*	*	*	*	60	74
11:00	96	67	61	60	93	69	97	85	*	*	*	*	*	*	87	70
12:00 PM	175	128	92	79	193	143	211	145	*	*	*	*	*	*	168	124
01:00	86	138	79	84	106	139	99	140	*	*	*	*	*	*	92	125
02:00	128	100	104	73	101	115	122	101	*	*	*	*	*	*	114	97
03:00	189	56	218	53	174	64	176	53	*	*	*	*	*	*	189	56
04:00	221	45	224	38	232	32	212	38	*	*	*	*	*	*	222	38
05:00	231	27	194	28	260	32	223	27	*	*	*	*	*	*	227	28
06:00	52	21	67	21	69	23	58	26	*	*	*	*	*	*	62	23
07:00	34	6	26	9	11	10	26	15	*	*	*	*	*	*	24	10
08:00	20	5	12	12	15	6	10	3	*	*	*	*	*	*	14	6
09:00	8	5	10	1	5	2	6	4	*	*	*	*	*	*	7	3
10:00	7	4	6	4	11	6	10	4	*	*	*	*	*	*	8	4
11:00	5	1	4	0	4	1	6	1	*	*	*	*	*	*	5	1
Total Day	1496	1569	1349	1394	1569	1642	1539	1584	0	0	0	0	0	0	1490	1544
	3065		2743		3211		3123		0		0		0		3034	
AM Peak	11:00	07:00	11:00	07:00	11:00	06:00	11:00	06:00	-	-	-	-	-	-	11:00	07:00
Vol.	96	263	61	260	93	256	97	241	-	-	-	-	-	-	87	246
PM Peak	17:00	13:00	16:00	13:00	17:00	12:00	17:00	12:00	-	-	-	-	-	-	17:00	13:00
Vol.	231	138	224	84	260	143	223	145	-	-	-	-	-	-	227	125

Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Volume  
Site Code: TBA  
Date Start: 12/16/19  
Date End: 12/19/19

Start	NB			SB			Combin ed		12/16/19			
Time	A.M.		P.M.		A.M.		P.M.	A.M.		P.M.	Mon	
12:00	0		57		0		21	0		78		
12:15	0		50		0		19	0		69		
12:30	0		44		0		36	0		80		
12:45	0	0	24	175	0	0	52	128	0	0	76	303
01:00	0		28		0		47		0		75	
01:15	0		16		0		29		0		45	
01:30	2		16		1		30		3		46	
01:45	0	2	26	86	0	1	32	138	0	3	58	224
02:00	0		57		0		28		0		85	
02:15	0		14		0		19		0		33	
02:30	0		41		1		23		1		64	
02:45	2	2	16	128	0	1	30	100	2	3	46	228
03:00	0		58		1		13		1		71	
03:15	1		24		0		26		1		50	
03:30	0		69		0		12		0		81	
03:45	0	1	38	189	0	1	5	56	0	2	43	245
04:00	0		63		1		16		1		79	
04:15	0		43		3		7		3		50	
04:30	0		65		6		15		6		80	
04:45	1	1	50	221	7	17	7	45	8	18	57	266
05:00	0		91		12		4		12		95	
05:15	1		53		12		5		13		58	
05:30	1		44		21		7		22		51	
05:45	5	7	43	231	39	84	11	27	44	91	54	258
06:00	5		20		36		5		41		25	
06:15	4		16		56		4		60		20	
06:30	7		11		62		7		69		18	
06:45	4	20	5	52	85	239	5	21	89	259	10	73
07:00	10		13		77		2		87		15	
07:15	19		4		58		2		77		6	
07:30	9		12		63		2		72		14	
07:45	14	52	5	34	65	263	0	6	79	315	5	40
08:00	17		7		65		1		82		8	
08:15	14		3		44		3		58		6	
08:30	9		4		38		0		47		4	
08:45	14	54	6	20	37	184	1	5	51	238	7	25
09:00	16		1		34		1		50		2	
09:15	13		1		16		2		29		3	
09:30	10		2		27		2		37		4	
09:45	14	53	4	8	25	102	0	5	39	155	4	13
10:00	14		3		18		1		32		4	
10:15	12		1		22		1		34		2	
10:30	14		2		19		1		33		3	
10:45	12	52	1	7	15	74	1	4	27	126	2	11
11:00	27		2		13		0		40		2	
11:15	14		0		16		1		30		1	
11:30	33		3		22		0		55		3	
11:45	22	96	0	5	16	67	0	1	38	163	0	6
Total	340		1156		1033		536		1373		1692	
Percent	24.8%		68.3%		75.2%		31.7%					
Day Total			1496				1569				3065	
Peak	11:00	-	04:30	-	06:45	-	00:30	-	06:45	-	12:00	-
Vol.	96	-	259	-	283	-	164	-	325	-	303	-
P.H.F.	0.727		0.712		0.832		0.788		0.913		0.947	

Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Volume  
Site Code: TBA  
Date Start: 12/16/19  
Date End: 12/19/19

Start Time	NB		SB		Combined		12/17/19	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	Tue	
12:00	3	34	0	11	3	45		
12:15	2	15	0	17	2	32		
12:30	1	24	0	20	1	44		
12:45	0	19	0	31	0	50	171	
01:00	2	28	0	37	2	65		
01:15	4	16	1	20	5	36		
01:30	3	23	0	11	3	34		
01:45	3	12	0	16	3	28	163	
02:00	3	34	0	17	3	51		
02:15	0	25	0	16	0	41		
02:30	1	23	1	16	2	39		
02:45	0	22	1	24	1	46	177	
03:00	2	51	0	14	2	65		
03:15	0	45	0	15	0	60		
03:30	0	71	0	11	0	82		
03:45	0	51	1	13	1	64	271	
04:00	1	47	1	9	2	56		
04:15	0	52	3	13	3	65		
04:30	0	59	6	6	6	65		
04:45	0	66	7	10	7	76	262	
05:00	1	63	18	2	19	65		
05:15	3	58	8	9	11	67		
05:30	5	43	28	10	33	53		
05:45	7	30	41	7	48	37	222	
06:00	4	23	52	6	56	29		
06:15	10	19	50	4	60	23		
06:30	10	17	56	9	66	26		
06:45	10	8	79	2	89	10	88	
07:00	10	3	72	4	82	7		
07:15	9	9	56	2	65	11		
07:30	5	7	69	2	74	9		
07:45	15	7	63	1	78	8	35	
08:00	18	2	66	1	84	3		
08:15	15	2	35	6	50	8		
08:30	17	4	37	3	54	7		
08:45	10	4	31	2	41	6	24	
09:00	4	6	23	0	27	6		
09:15	6	2	27	0	33	2		
09:30	9	1	20	1	29	2		
09:45	8	1	21	0	29	1	11	
10:00	13	1	18	3	31	4		
10:15	17	2	13	1	30	3		
10:30	10	3	17	0	27	3		
10:45	11	0	11	0	22	0	10	
11:00	15	0	17	0	32	0		
11:15	14	0	11	0	25	0		
11:30	13	1	20	0	33	1		
11:45	19	3	12	0	31	3	4	
Total	313	1036	992	402	1305	1438		
Percent	24.0%	72.0%	76.0%	28.0%				
Day Total		1349		1394		2743		
Peak	07:45	-	04:30	-	00:30	-	04:30	-
Vol.	65	-	246	-	108	-	273	-
P.H.F.	0.903	-	0.932	-	0.730	-	0.832	-



Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Volume  
Site Code: TBA  
Date Start: 12/16/19  
Date End: 12/19/19

Start	NB				SB				Combined		12/18/19	
Time	A.M.		P.M.		A.M.	P.M.			A.M.	P.M.	Wed	
12:00	1		78		0	20			1	98		
12:15	0		45		0	40			0	85		
12:30	2		44		1	30			3	74		
12:45	0	3	26	193	1	53	143		1	79	336	
01:00	2		37		0	34			2	71		
01:15	1		32		1	38			2	70		
01:30	1		20		1	37			2	57		
01:45	4	8	17	106	0	30	139		4	47	245	
02:00	8		46		0	30			8	76		
02:15	2		21		0	38			2	59		
02:30	2		19		0	23			2	42		
02:45	1	13	15	101	0	24	115		1	39	216	
03:00	0		57		0	19			0	76		
03:15	0		22		1	20			1	42		
03:30	0		51		2	17			2	68		
03:45	2	2	44	174	3	8	64		5	52	238	
04:00	1		70		2	7			3	77		
04:15	1		41		4	10			5	51		
04:30	1		62		11	9			12	71		
04:45	1	4	59	232	5	6	32		6	65	264	
05:00	3		96		18	9			21	105		
05:15	1		59		12	6			13	65		
05:30	6		69		28	9			34	78		
05:45	5	15	36	260	44	8	32		49	44	292	
06:00	5		33		43	13			48	46		
06:15	8		18		52	0			60	18		
06:30	19		12		90	5			109	17		
06:45	13	45	6	69	71	5	23		84	11	92	
07:00	5		2		56	4			61	6		
07:15	14		5		65	2			79	7		
07:30	20		2		65	2			85	4		
07:45	20	59	2	11	54	2	10		74	4	21	
08:00	20		6		72	1			92	7		
08:15	10		2		44	4			54	6		
08:30	7		0		49	0			56	0		
08:45	6	43	7	15	30	1	6		36	8	21	
09:00	10		3		33	0			43	3		
09:15	13		1		28	2			41	3		
09:30	8		1		23	0			31	1		
09:45	10	41	0	5	22	0	2		32	0	7	
10:00	15		2		16	3			31	5		
10:15	17		1		18	2			35	3		
10:30	17		7		15	1			32	8		
10:45	13	62	1	11	20	0	6		33	1	17	
11:00	21		0		19	0			40	0		
11:15	14		1		14	0			28	1		
11:30	34		0		13	0			47	0		
11:45	24	93	3	4	23	1	1		47	4	5	
Total	388		1181		1069	573			1457	1754		
Percent	26.6%		67.3%		73.4%	32.7%						
Day Total			1569			1642				3211		
Peak	11:00	-	04:45	-	06:30	-	00:45	-	06:30	-	12:00	-
Vol.	93	-	283	-	282	-	162	-	333	-	336	-
P.H.F.	0.684		0.737		0.783		0.764		0.764		0.857	

Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Volume  
Site Code: TBA  
Date Start: 12/16/19  
Date End: 12/19/19

Start	NB				SB				Combined		12/19/19	
Time	A.M.		P.M.		A.M.		P.M.		A.M.	P.M.	Thu	
12:00	1		74		0		21		1	95		
12:15	1		48		0		42		1	90		
12:30	2		55		0		44		2	99		
12:45	1	5	34	211	0	0	38	145	1	72	356	
01:00	2		37		0		35		2	72		
01:15	0		28		0		37		0	65		
01:30	4		14		0		34		4	48		
01:45	2	8	20	99	0	0	34	140	2	54	239	
02:00	4		41		1		34		5	75		
02:15	3		26		0		22		3	48		
02:30	0		26		0		18		0	44		
02:45	1	8	29	122	1	2	27	101	2	56	223	
03:00	0		58		0		12		0	70		
03:15	0		24		1		13		1	37		
03:30	0		59		0		15		0	74		
03:45	1	1	35	176	0	1	13	53	1	48	229	
04:00	0		56		0		13		0	69		
04:15	0		30		2		11		2	41		
04:30	1		75		6		6		7	81		
04:45	0	1	51	212	10	18	8	38	10	59	250	
05:00	0		93		9		6		9	99		
05:15	0		55		14		9		14	64		
05:30	4		53		24		4		28	57		
05:45	9	13	22	223	43	90	8	27	52	30	250	
06:00	6		19		41		8		47	27		
06:15	7		16		63		6		70	22		
06:30	16		13		62		4		78	17		
06:45	12	41	10	58	75	241	8	26	87	18	84	
07:00	10		8		59		3		69	11		
07:15	9		6		51		4		60	10		
07:30	7		7		51		2		58	9		
07:45	22	48	5	26	58	219	6	15	80	11	41	
08:00	17		3		65		0		82	3		
08:15	6		4		33		2		39	6		
08:30	11		1		43		1		54	2		
08:45	6	40	2	10	38	179	0	3	44	2	13	
09:00	10		1		33		3		43	4		
09:15	10		2		28		0		38	2		
09:30	11		1		18		0		29	1		
09:45	12	43	2	6	18	97	1	4	30	3	10	
10:00	18		3		25		2		43	5		
10:15	19		0		27		1		46	1		
10:30	18		6		17		0		35	6		
10:45	20	75	1	10	26	95	1	4	46	2	14	
11:00	20		3		16		1		36	4		
11:15	29		1		19		0		48	1		
11:30	22		1		21		0		43	1		
11:45	26	97	1	6	29	85	0	1	55	1	7	
Total	380		1159		1027		557		1407	1716		
Percent	27.0%		67.5%		73.0%		32.5%					
Day Total		1539			1584				3123			
Peak	11:00	-	04:30	-	06:15	-	00:15	-	06:15	-	12:00	-
Vol.	97	-	274	-	259	-	159	-	304	-	356	-
P.H.F.	0.836		0.737		0.863		0.903		0.874		0.899	

Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

NB

Start Time	14	15	20	25	30	35	40	45	50	55	60	65	70	Total	85th Perce	Avera (Mean
	14	19	24	29	34	39	44	49	54	59	64	69	9999			
12/16/19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
01:00	0	0	0	1	0	1	0	0	0	0	0	0	0	2	37	32
02:00	0	0	0	0	1	1	0	0	0	0	0	0	0	2	37	35
03:00	0	0	0	0	1	0	0	0	0	0	0	0	0	1	33	32
04:00	0	0	0	0	1	0	0	0	0	0	0	0	0	1	33	32
05:00	0	0	0	3	4	0	0	0	0	0	0	0	0	7	32	30
06:00	0	0	2	7	8	3	0	0	0	0	0	0	0	20	34	30
07:00	0	0	5	<b>18</b>	22	6	1	0	0	0	0	0	0	52	33	30
08:00	0	1	<b>11</b>	15	19	5	3	0	0	0	0	0	0	54	33	29
09:00	0	0	5	11	20	12	3	2	0	0	0	0	0	53	37	32
10:00	<b>1</b>	0	5	8	19	16	3	0	0	0	0	0	0	52	37	32
11:00	0	<b>3</b>	10	16	<b>37</b>	<b>23</b>	<b>4</b>	<b>3</b>	0	0	0	0	0	<b>96</b>	37	32
12 PM	0	0	6	42	63	<b>56</b>	7	1	0	0	0	0	0	175	37	33
13:00	0	0	5	13	41	22	4	1	0	0	0	0	0	86	37	33
14:00	6	8	24	34	38	15	3	0	0	0	0	0	0	128	33	28
15:00	5	2	10	55	<b>70</b>	36	7	<b>4</b>	0	0	0	0	0	189	36	31
16:00	1	4	<b>25</b>	<b>78</b>	70	29	<b>14</b>	0	0	0	0	0	0	221	35	30
17:00	<b>27</b>	<b>17</b>	14	77	67	27	2	0	0	0	0	0	0	<b>231</b>	33	26
18:00	0	0	1	17	16	16	2	0	0	0	0	0	0	52	37	32
19:00	0	0	2	10	13	6	2	1	0	0	0	0	0	34	37	32
20:00	0	0	0	4	11	4	1	0	0	0	0	0	0	20	36	32
21:00	0	1	0	3	2	2	0	0	0	0	0	0	0	8	36	29
22:00	0	0	0	3	3	1	0	0	0	0	0	0	0	7	33	31
23:00	0	0	0	3	1	0	0	1	0	0	0	0	0	5	45	32
Total	40	36	125	418	527	281	56	13	0	0	0	0	0	1496		
%	2.7%	2.4%	8.4%	27.9%	35.2%	18.8%	3.7%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	10:00	11:00	08:00	07:00	11:00	11:00	11:00	11:00						11:00		
Vol.	1	3	11	18	37	23	4	3						96		
PM Peak	17:00	17:00	16:00	16:00	15:00	12:00	16:00	15:00						17:00		
Vol.	27	17	25	78	70	56	14	4						231		

Stats  
15th Percentile : 24 MPH  
50th Percentile : 30 MPH  
85th Percentile : 36 MPH  
95th Percentile : 38 MPH

Mean Speed(Average) : 30 MPH  
10 MPH Pace Speed : 25-34 MPH  
Number in Pace : 945  
Percent in Pace : 63.2%  
Number of Vehicles > 30 MPH : 772  
Percent of Vehicles > 30 MPH : 51.6%

Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

NB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/17/																
19	0	0	0	1	3	2	0	0	0	0	0	0	0	6	36	33
01:00	0	0	1	1	6	3	1	0	0	0	0	0	0	12	37	33
02:00	0	0	0	0	2	1	1	0	0	0	0	0	0	4	41	36
03:00	0	0	0	0	2	0	0	0	0	0	0	0	0	2	33	32
04:00	0	0	0	0	0	0	1	0	0	0	0	0	0	1	43	42
05:00	0	1	1	5	8	1	0	0	0	0	0	0	0	16	33	29
06:00	0	0	8	18	7	1	0	0	0	0	0	0	0	34	31	27
07:00	0	1	11	18	7	2	0	0	0	0	0	0	0	39	31	27
08:00	0	5	9	31	13	2	0	0	0	0	0	0	0	60	31	27
09:00	0	5	7	10	5	0	0	0	0	0	0	0	0	27	29	25
10:00	1	9	17	16	8	0	0	0	0	0	0	0	0	51	29	24
11:00	1	1	15	22	18	3	1	0	0	0	0	0	0	61	32	27
12 PM	1	2	14	41	27	7	0	0	0	0	0	0	0	92	32	28
13:00	0	4	36	30	8	1	0	0	0	0	0	0	0	79	28	25
14:00	5	11	24	51	11	2	0	0	0	0	0	0	0	104	28	25
15:00	54	26	57	65	13	3	0	0	0	0	0	0	0	218	27	20
16:00	20	36	68	75	22	3	0	0	0	0	0	0	0	224	28	23
17:00	2	33	76	68	14	1	0	0	0	0	0	0	0	194	27	24
18:00	2	3	18	25	17	1	1	0	0	0	0	0	0	67	31	26
19:00	0	2	4	15	4	1	0	0	0	0	0	0	0	26	30	27
20:00	0	2	2	4	3	1	0	0	0	0	0	0	0	12	32	27
21:00	0	1	2	4	3	0	0	0	0	0	0	0	0	10	31	26
22:00	0	0	2	0	4	0	0	0	0	0	0	0	0	6	32	29
23:00	0	0	1	2	0	0	1	0	0	0	0	0	0	4	41	29
Total	86	142	373	502	205	35	6	0	0	0	0	0	0	1349		
%	6.4%	10.5%	27.7%	37.2%	15.2%	2.6%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	10:00	10:00	10:00	08:00	11:00	01:00	01:00							11:00		
Vol.	1	9	17	31	18	3	1							61		
PM Peak	15:00	16:00	17:00	16:00	12:00	12:00	18:00							16:00		
Vol.	54	36	76	75	27	7	1							224		

Stats  
15th Percentile : 18 MPH  
50th Percentile : 24 MPH  
85th Percentile : 30 MPH  
95th Percentile : 33 MPH

Mean Speed(Average) : 24 MPH  
10 MPH Pace Speed : 20-29 MPH  
Number in Pace : 875  
Percent in Pace : 64.9%  
Number of Vehicles > 30 MPH : 205  
Percent of Vehicles > 30 MPH : 15.2%

Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

NB

Start Time	14	15	20	25	30	35	40	45	50	55	60	65	70	Total	85th Perce	Avera (Mean
12/18/19	0	1	1	0	1	0	0	0	0	0	0	0	0	3	31	24
01:00	0	1	2	4	1	0	0	0	0	0	0	0	0	8	28	25
02:00	1	1	3	5	3	0	0	0	0	0	0	0	0	13	30	25
03:00	0	0	0	1	1	0	0	0	0	0	0	0	0	2	32	30
04:00	0	0	1	1	2	0	0	0	0	0	0	0	0	4	32	28
05:00	0	0	3	7	5	0	0	0	0	0	0	0	0	15	31	28
06:00	0	<b>2</b>	<b>10</b>	21	12	0	0	0	0	0	0	0	0	45	31	27
07:00	1	1	8	20	24	4	1	0	0	0	0	0	0	59	33	29
08:00	0	2	6	15	13	7	0	0	0	0	0	0	0	43	34	29
09:00	0	1	6	9	21	2	2	0	0	0	0	0	0	41	33	30
10:00	<b>2</b>	0	5	17	26	7	5	0	0	0	0	0	0	62	35	30
11:00	0	1	6	<b>24</b>	<b>32</b>	<b>20</b>	<b>10</b>	0	0	0	0	0	0	<b>93</b>	38	32
12 PM	9	10	7	34	78	<b>40</b>	<b>14</b>	<b>1</b>	0	0	0	0	0	193	37	31
13:00	1	1	6	29	47	19	3	0	0	0	0	0	0	106	35	31
14:00	3	2	5	34	35	20	2	0	0	0	0	0	0	101	35	30
15:00	<b>34</b>	12	18	39	54	14	0	1	<b>2</b>	0	0	0	0	174	33	25
16:00	2	9	19	68	<b>101</b>	29	3	1	0	0	0	0	0	232	33	30
17:00	0	<b>20</b>	<b>71</b>	<b>96</b>	55	17	1	0	0	0	0	0	0	<b>260</b>	32	27
18:00	0	0	3	27	25	11	2	1	0	0	0	0	0	69	35	31
19:00	0	0	0	1	8	2	0	0	0	0	0	0	0	11	34	32
20:00	0	0	2	3	7	1	1	1	0	0	0	0	0	15	37	32
21:00	0	0	1	1	1	1	1	0	0	0	0	0	0	5	40	32
22:00	0	0	2	4	4	1	0	0	0	0	0	0	0	11	33	29
23:00	0	0	0	1	3	0	0	0	0	0	0	0	0	4	33	31
Total %	53 3.4%	64 4.1%	185 11.8%	461 29.4%	559 35.6%	195 12.4%	45 2.9%	5 0.3%	2 0.1%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1569		
AM Peak	10:00	06:00	06:00	11:00	11:00	11:00	11:00							11:00		
Vol.	2	2	10	24	32	20	10							93		
PM Peak	15:00	17:00	17:00	17:00	16:00	12:00	12:00	12:00	15:00					17:00		
Vol.	34	20	71	96	101	40	14	1	2					260		

Stats  
15th Percentile : 22 MPH  
50th Percentile : 29 MPH  
85th Percentile : 34 MPH  
95th Percentile : 38 MPH

Mean Speed(Average) : 29 MPH  
10 MPH Pace Speed : 25-34 MPH  
Number in Pace : 1020  
Percent in Pace : 65.0%  
Number of Vehicles > 30 MPH : 694  
Percent of Vehicles > 30 MPH : 44.2%

Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

NB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/19/ 19	0	0	1	0	3	1	0	0	0	0	0	0	0	5	35	31
01:00	0	0	0	2	5	1	0	0	0	0	0	0	0	8	33	31
02:00	0	0	0	1	5	2	0	0	0	0	0	0	0	8	36	33
03:00	0	0	0	0	1	0	0	0	0	0	0	0	0	1	33	32
04:00	0	0	0	0	1	0	0	0	0	0	0	0	0	1	33	32
05:00	0	0	4	5	2	0	2	0	0	0	0	0	0	13	39	29
06:00	0	0	4	20	12	5	0	0	0	0	0	0	0	41	33	29
07:00	2	2	3	14	26	1	0	0	0	0	0	0	0	48	32	28
08:00	1	3	3	9	18	3	3	0	0	0	0	0	0	40	33	30
09:00	0	0	3	8	21	11	0	0	0	0	0	0	0	43	36	32
10:00	0	1	2	19	32	14	6	0	0	0	0	1	0	75	37	32
11:00	0	0	4	20	48	20	4	1	0	0	0	0	0	97	36	32
12 PM	4	3	7	53	87	46	9	2	0	0	0	0	0	211	36	31
13:00	0	0	9	24	34	28	4	0	0	0	0	0	0	99	37	32
14:00	0	7	12	30	38	27	8	0	0	0	0	0	0	122	37	31
15:00	29	17	24	33	42	25	5	1	0	0	0	0	0	176	34	25
16:00	0	3	16	42	106	33	11	1	0	0	0	0	0	212	35	31
17:00	13	15	22	80	69	21	3	0	0	0	0	0	0	223	33	27
18:00	0	0	0	15	24	16	3	0	0	0	0	0	0	58	37	33
19:00	0	0	0	1	15	8	2	0	0	0	0	0	0	26	37	34
20:00	0	0	2	2	1	2	2	1	0	0	0	0	0	10	42	34
21:00	0	0	1	1	2	2	0	0	0	0	0	0	0	6	36	31
22:00	0	0	0	1	7	0	0	1	1	0	0	0	0	10	46	35
23:00	0	0	0	1	4	1	0	0	0	0	0	0	0	6	34	32
Total	49	51	117	381	603	267	62	7	1	0	0	1	0	1539		
%	3.2%	3.3%	7.6%	24.8%	39.2%	17.3%	4.0%	0.5%	0.1%	0.0%	0.0%	0.1%	0.0%			
AM Peak	07:00	08:00	05:00	06:00	11:00	11:00	10:00	11:00				10:00		11:00		
Vol.	2	3	4	20	48	20	6	1				1		97		
PM Peak	15:00	15:00	15:00	17:00	16:00	12:00	16:00	12:00	22:00					17:00		
Vol.	29	17	24	80	106	46	11	2	1					223		

Stats  
15th Percentile : 24 MPH  
50th Percentile : 30 MPH  
85th Percentile : 36 MPH  
95th Percentile : 38 MPH

Mean Speed(Average) : 30 MPH  
10 MPH Pace Speed : 25-34 MPH  
Number in Pace : 984  
Percent in Pace : 63.9%  
Number of Vehicles > 30 MPH : 820  
Percent of Vehicles > 30 MPH : 53.3%

Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

SB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/16/ 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
01:00	0	0	0	0	0	1	0	0	0	0	0	0	0	1	38	37
02:00	0	0	0	0	0	1	0	0	0	0	0	0	0	1	38	37
03:00	0	0	0	0	1	0	0	0	0	0	0	0	0	1	33	32
04:00	0	<b>3</b>	0	3	8	3	0	0	0	0	0	0	0	17	34	29
05:00	0	0	1	8	42	29	4	0	0	0	0	0	0	84	37	34
06:00	0	0	1	34	127	67	<b>7</b>	<b>2</b>	0	0	<b>1</b>	0	0	239	37	33
07:00	0	0	<b>14</b>	26	<b>147</b>	<b>68</b>	7	0	0	0	1	0	0	<b>263</b>	36	33
08:00	<b>1</b>	0	12	<b>40</b>	80	44	7	0	0	0	0	0	0	184	36	32
09:00	0	0	1	27	42	26	5	1	0	0	0	0	0	102	37	32
10:00	0	0	5	23	33	10	2	0	0	<b>1</b>	0	0	0	74	34	31
11:00	0	0	8	18	25	11	2	1	<b>1</b>	1	0	0	0	67	36	31
12 PM	0	0	3	15	70	<b>31</b>	5	<b>1</b>	<b>2</b>	0	<b>1</b>	0	0	128	37	33
13:00	0	0	3	28	<b>71</b>	30	<b>6</b>	0	0	0	0	0	0	<b>138</b>	36	32
14:00	<b>2</b>	0	<b>9</b>	<b>39</b>	38	11	1	0	0	0	0	0	0	100	33	29
15:00	0	0	2	13	23	18	0	0	0	0	0	0	0	56	36	32
16:00	0	0	3	9	19	13	0	0	0	0	0	0	<b>1</b>	45	36	32
17:00	0	0	2	9	9	6	1	0	0	0	0	0	0	27	36	31
18:00	0	<b>1</b>	2	11	2	4	1	0	0	0	0	0	0	21	36	29
19:00	0	0	0	5	1	0	0	0	0	0	0	0	0	6	29	28
20:00	0	0	0	1	1	3	0	0	0	0	0	0	0	5	37	34
21:00	0	0	0	0	4	1	0	0	0	0	0	0	0	5	35	33
22:00	0	0	0	1	2	0	0	1	0	0	0	0	0	4	46	34
23:00	0	0	0	0	0	1	0	0	0	0	0	0	0	1	38	37
Total	3	4	66	310	745	378	48	6	3	2	3	0	1	1569		
%	0.2%	0.3%	4.2%	19.8%	47.5%	24.1%	3.1%	0.4%	0.2%	0.1%	0.2%	0.0%	0.1%			
AM Peak	08:00	04:00	07:00	08:00	07:00	07:00	06:00	06:00	11:00	10:00	06:00			07:00		
Vol.	1	3	14	40	147	68	7	2	1	1	1			263		
PM Peak	14:00	18:00	14:00	14:00	13:00	12:00	13:00	12:00	12:00		12:00		16:00	13:00		
Vol.	2	1	9	39	71	31	6	1	2		1		1	138		

Stats  
15th Percentile : 26 MPH  
50th Percentile : 31 MPH  
85th Percentile : 36 MPH  
95th Percentile : 38 MPH

Mean Speed(Average) : 32 MPH  
10 MPH Pace Speed : 30-39 MPH  
Number in Pace : 1123  
Percent in Pace : 71.6%  
Number of Vehicles > 30 MPH : 1037  
Percent of Vehicles > 30 MPH : 66.1%



Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

SB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/17/																
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
01:00	0	0	0	0	1	0	0	0	0	0	0	0	0	1	33	32
02:00	0	0	0	0	1	1	0	0	0	0	0	0	0	2	37	35
03:00	0	0	0	0	0	0	1	0	0	0	0	0	0	1	43	42
04:00	0	0	1	6	7	2	1	0	0	0	0	0	0	17	35	31
05:00	0	0	5	18	50	22	0	0	0	0	0	0	0	95	35	32
06:00	0	0	5	73	128	30	1	0	0	0	0	0	0	237	33	31
07:00	0	0	11	95	132	19	3	0	0	0	0	0	0	260	33	30
08:00	1	0	16	67	73	11	0	0	0	0	1	0	0	169	33	29
09:00	0	4	21	43	20	3	0	0	0	0	0	0	0	91	31	27
10:00	0	1	9	31	11	5	0	1	0	0	0	1	0	59	33	29
11:00	0	3	3	23	25	5	1	0	0	0	0	0	0	60	33	29
12 PM	0	5	11	34	22	4	1	0	0	0	2	0	0	79	32	29
13:00	5	2	20	30	24	3	0	0	0	0	0	0	0	84	32	26
14:00	0	1	14	36	20	2	0	0	0	0	0	0	0	73	31	28
15:00	0	0	14	20	17	2	0	0	0	0	0	0	0	53	32	28
16:00	1	1	6	16	10	4	0	0	0	0	0	0	0	38	33	28
17:00	0	1	4	11	7	5	0	0	0	0	0	0	0	28	34	29
18:00	0	0	4	11	6	0	0	0	0	0	0	0	0	21	31	27
19:00	0	1	1	5	2	0	0	0	0	0	0	0	0	9	30	26
20:00	0	0	4	2	6	0	0	0	0	0	0	0	0	12	32	28
21:00	0	0	0	0	1	0	0	0	0	0	0	0	0	1	33	32
22:00	0	0	0	3	1	0	0	0	0	0	0	0	0	4	31	28
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
Total	7	19	149	524	564	118	8	1	0	0	3	1	0	1394		
%	0.5%	1.4%	10.7%	37.6%	40.5%	8.5%	0.6%	0.1%	0.0%	0.0%	0.2%	0.1%	0.0%			
AM Peak	08:00	09:00	09:00	07:00	07:00	06:00	07:00	10:00			08:00	10:00		07:00		
Vol.	1	4	21	95	132	30	3	1			1	1		260		
PM Peak	13:00	12:00	13:00	14:00	13:00	17:00	12:00				12:00			13:00		
Vol.	5	5	20	36	24	5	1				2			84		

Stats  
15th Percentile : 24 MPH  
50th Percentile : 28 MPH  
85th Percentile : 33 MPH  
95th Percentile : 36 MPH

Mean Speed(Average) : 29 MPH  
10 MPH Pace Speed : 25-34 MPH  
Number in Pace : 1088  
Percent in Pace : 78.0%  
Number of Vehicles > 30 MPH : 582  
Percent of Vehicles > 30 MPH : 41.8%

Hopping Brook Road  
Approx 450' south of Washington Street  
City, State: Holliston, MA  
Client: EDC/ P. Bemis



197374 B Speed  
Site Code: TBA  
Date Start: 16-Dec-19  
Date End: 19-Dec-19

SB

Start Time	14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/18/19	0	0	0	1	0	1	0	0	0	0	0	0	0	2	37	32
01:00	0	1	0	1	0	0	0	0	0	0	0	0	0	2	27	22
02:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
03:00	0	0	4	1	1	0	0	0	0	0	0	0	0	6	29	24
04:00	0	<b>3</b>	4	12	2	0	0	0	0	<b>1</b>	0	0	0	22	28	27
05:00	0	1	4	27	49	21	0	0	0	0	0	0	0	102	35	31
06:00	0	1	<b>10</b>	<b>64</b>	<b>137</b>	40	3	<b>1</b>	0	0	0	0	0	<b>256</b>	34	31
07:00	0	0	10	56	120	<b>48</b>	2	1	0	0	<b>3</b>	0	0	240	35	32
08:00	0	0	2	37	99	48	<b>9</b>	0	0	0	0	0	0	195	36	33
09:00	<b>1</b>	0	7	14	57	23	1	1	<b>1</b>	1	0	0	0	106	36	32
10:00	1	2	3	21	23	17	2	0	0	0	0	0	0	69	36	31
11:00	0	0	3	12	31	21	2	0	0	0	0	0	0	69	37	33
12 PM	<b>2</b>	<b>2</b>	<b>9</b>	<b>38</b>	56	32	<b>4</b>	0	0	0	0	0	0	<b>143</b>	36	31
13:00	0	0	4	29	<b>72</b>	<b>33</b>	1	0	0	0	0	0	0	139	35	32
14:00	0	0	6	38	44	24	3	0	0	0	0	0	0	115	36	31
15:00	0	0	7	19	23	11	2	<b>2</b>	0	0	0	0	0	64	36	31
16:00	0	0	2	10	13	6	0	0	0	<b>1</b>	0	0	0	32	35	32
17:00	0	0	0	14	14	3	0	1	0	0	0	0	0	32	33	31
18:00	0	0	1	8	12	2	0	0	0	0	0	0	0	23	33	30
19:00	0	0	2	1	6	1	0	0	0	0	0	0	0	10	33	30
20:00	0	0	0	2	4	0	0	0	0	0	0	0	0	6	32	30
21:00	0	0	0	2	0	0	0	0	0	0	0	0	0	2	28	27
22:00	0	1	2	2	0	0	0	0	0	0	<b>1</b>	0	0	6	59	30
23:00	0	0	0	0	0	1	0	0	0	0	0	0	0	1	38	37
Total	4	11	80	409	763	332	29	6	1	3	4	0	0	1642		
%	0.2%	0.7%	4.9%	24.9%	46.5%	20.2%	1.8%	0.4%	0.1%	0.2%	0.2%	0.0%	0.0%			
AM Peak	09:00	04:00	06:00	06:00	06:00	07:00	08:00	06:00	09:00	04:00	07:00			06:00		
Vol.	1	3	10	64	137	48	9	1	1	1	3			256		
PM Peak	12:00	12:00	12:00	12:00	13:00	13:00	12:00	15:00		16:00	22:00			12:00		
Vol.	2	2	9	38	72	33	4	2		1	1			143		

Stats  
15th Percentile : 25 MPH  
50th Percentile : 31 MPH  
85th Percentile : 35 MPH  
95th Percentile : 38 MPH

Mean Speed(Average) : 31 MPH  
10 MPH Pace Speed : 25-34 MPH  
Number in Pace : 1172  
Percent in Pace : 71.4%  
Number of Vehicles > 30 MPH : 985  
Percent of Vehicles > 30 MPH : 60.0%

Hopping Brook Road  
 Approx 450' south of Washington Street  
 City, State: Holliston, MA  
 Client: EDC/ P. Bemis



197374 B Speed  
 Site Code: TBA  
 Date Start: 16-Dec-19  
 Date End: 19-Dec-19

SB

Start Time	1 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69	70 9999	Total	85th Perce	Avera (Mean
12/19/ 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*
02:00	0	0	0	0	2	0	0	0	0	0	0	0	0	2	33	32
03:00	0	0	0	0	0	1	0	0	0	0	0	0	0	1	38	37
04:00	0	0	1	0	14	2	1	0	0	0	0	0	0	18	34	33
05:00	0	0	0	11	45	31	2	1	0	0	0	0	0	90	37	34
06:00	0	0	6	22	<b>126</b>	<b>76</b>	<b>11</b>	0	0	0	0	0	0	<b>241</b>	37	33
07:00	0	0	3	<b>23</b>	117	65	8	1	<b>2</b>	0	0	0	0	219	37	33
08:00	0	0	2	17	96	52	11	1	0	0	0	0	0	179	37	34
09:00	0	0	<b>9</b>	7	46	28	6	1	0	0	0	0	0	97	37	33
10:00	0	0	4	20	43	24	3	0	0	0	0	0	<b>1</b>	95	36	32
11:00	0	<b>2</b>	2	20	37	18	5	0	0	0	0	0	1	85	36	32
12 PM	1	<b>5</b>	4	16	<b>69</b>	38	<b>10</b>	0	<b>1</b>	0	0	0	<b>1</b>	<b>145</b>	37	33
13:00	0	0	3	28	56	<b>50</b>	3	0	0	0	0	0	0	140	37	33
14:00	1	2	<b>8</b>	<b>34</b>	35	20	0	<b>1</b>	0	0	0	0	0	101	35	30
15:00	<b>2</b>	2	2	11	19	14	3	0	0	0	0	0	0	53	37	31
16:00	0	0	1	8	19	6	3	1	0	0	0	0	0	38	37	33
17:00	0	0	0	11	13	3	0	0	0	0	0	0	0	27	33	31
18:00	0	0	2	3	13	5	3	0	0	0	0	0	0	26	38	33
19:00	0	1	0	5	6	2	1	0	0	0	0	0	0	15	35	31
20:00	0	0	0	3	0	0	0	0	0	0	0	0	0	3	28	27
21:00	0	0	0	0	2	2	0	0	0	0	0	0	0	4	37	35
22:00	0	0	0	1	1	2	0	0	0	0	0	0	0	4	37	33
23:00	0	0	0	0	1	0	0	0	0	0	0	0	0	1	33	32
Total	4	12	47	240	760	439	70	6	3	0	0	0	3	1584		
%	0.3%	0.8%	3.0%	15.2%	48.0%	27.7%	4.4%	0.4%	0.2%	0.0%	0.0%	0.0%	0.2%			
AM Peak		11:00	09:00	07:00	06:00	06:00	06:00	05:00	07:00				10:00	06:00		
Vol.		2	9	23	126	76	11	1	2				1	241		
PM Peak	15:00	12:00	14:00	14:00	12:00	13:00	12:00	14:00	12:00				12:00	12:00		
Vol.	2	5	8	34	69	50	10	1	1				1	145		

Stats  
 15th Percentile : 27 MPH  
 50th Percentile : 32 MPH  
 85th Percentile : 37 MPH  
 95th Percentile : 38 MPH

Mean Speed(Average) : 33 MPH  
 10 MPH Pace Speed : 30-39 MPH  
 Number in Pace : 1199  
 Percent in Pace : 75.7%  
 Number of Vehicles > 30 MPH : 1129  
 Percent of Vehicles > 30 MPH : 71.3%

# TURNING MOVEMENT COUNT REDUCTION WORKSHEET

INTERSECTION: Washington Street at Hopping Brook Drive  
COUNT DATE: 7AM-9AM Wednesday 12/18/19 3PM-6PM Thursday 12/12/19

Counted By: ZRB  
Weather Conditions: Clear 20-30 deg F

TIME:	Washington Street WB				Washington Street EB					Hopping Brook Drive NB					SB				TOTAL (15 Min.)	TOTAL (Hour)
	L	T	R	Total	L	T	R	RR	Total	L	T	R	RR	Total	L	T	R	Total		
6:30 - 6:45				0					0					0				0	0	
6:45 - 7:00				0					0					0				0	0	
7:00 - 7:15	9	72		81		90	44		134	3		2		5				0	220	
7:15 - 7:30	9	68		77		129	59		188	8		4		12				0	277	497
7:30 - 7:45	9	119		128		114	52		166	22		7		29				0	323	820
7:45 - 8:00	15	130		145		151	43		194	12		1		13				0	352	1172
8:00 - 8:15	13	122		135		149	54		203	13		6		19				0	357	1309
8:15 - 8:30	8	103		111		172	30		202	4		4		8				0	321	1353
8:30 - 8:45	7	106		113		147	40		187	5		3		8				0	308	1338
8:45 - 9:00	7	113		120		130	25		155	3		7		10				0	285	1271
9:00 - 9:15				0					0					0				0	0	914
9:15 - 9:30				0					0					0				0	0	593
				0					0					0				0	0	
TOTAL	77	833	0	910	0	1082	347	0	1429	70	0	34	0	104	0	0	0	0	2443	
15:00 - 15:15	7	136		143		90	18		108	46		18		64				0	315	
15:15 - 15:30	4	129		133		87	8		95	20		9		29				0	257	
15:30 - 15:45	9	169		178		105	8		113	63		22		85				0	376	
15:45 - 16:00	4	178		182		117			117	39		12		51				0	350	1298
16:00 - 16:15	2	165		167		104	5		109	51		14		65				0	341	1324
16:15 - 16:30	3	180		183		114	9		123	28		9		37				0	343	1410
16:30 - 16:45	6	185		191		124	7		131	42		19		61				0	383	1417
16:45 - 17:00	3	156		159		113	13		126	45		17		62				0	347	1414
17:00 - 17:15	5	178		183		126	5		131	57		26		83				0	397	1470
17:15 - 17:30	3	185		188		137	1		138	38		11		49				0	375	1502
17:30 - 17:45	1	175		176		110	3		113	33		4		37				0	326	1445
17:45 - 18:00	2	149		151		116	2		118	16		8		24				0	293	1391
TOTAL 4:00 - 6:00	49	1985	0	2034	0	1343	79	0	1422	478	0	169	0	647	0	0	0	0	4103	

## PEAK HOUR VOLUMES:

TIME: MORNING PEAK PERIOD	Washington Street WB				Washington Street EB					Hopping Brook Drive NB					SB				TOTAL (Hour)	
	L	T	R	Total	L	T	R	RR	Total	L	T	R	RR	Total	L	T	R	Total		
7:30 - 7:45	9	119		128		114	52		166	22		7		29				0	323	
7:45 - 8:00	15	130		145		151	43		194	12		1		13				0	352	
8:00 - 8:15	13	122		135		149	54		203	13		6		19				0	357	
8:15 - 8:30	8	103		111		172	30		202	4		4		8				0	321	
	45	474	0	519	0	586	179	0	765	51	0	18	0	69	0	0	0	0	1353	

PHF 0.89 0.94 0.59 0.95 PHF

TIME: EVENING PEAK PERIOD	Washington Street WB				Washington Street EB					Hopping Brook Drive NB					SB				TOTAL (Hour)	
	L	T	R	Total	L	T	R	RR	Total	L	T	R	RR	Total	L	T	R	Total		
16:30 - 16:45	6	185		191		124	7		131	42		19		61				0	383	383
16:45 - 17:00	3	156		159		113	13		126	45		17		62				0	347	730
17:00 - 17:15	5	178		183		126	5		131	57		26		83				0	397	1127
17:15 - 17:30	3	185		188		137	1		138	38		11		49				0	375	1502
	17	704	0	721	0	500	26	0	526	182	0	73	0	255	0	0	0	0	1502	

PHF 0.94 0.95 0.77 #### 0.95 PHF

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**TRIP GENERATION WORKSHEET**LAND USE: *Manufacturing*

LAND USE CODE: 140

Independent Variable---Trips per 1000 square feet

LOCATION: 465 Hopping Brook Road

JOB NUMBER:

Gross Floor Area (KSF):

113

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***WEEKDAY***

RATES:

	Total Trip Ends			Directional Dist.		Number of Studies	Avg Size (ksf)
	Average	Low	High	Enter	Exit		
DAILY	3.82	0.5	52.05	50%	50%	62	349
AM PEAK	0.73	0.1	8.75	78%	22%	51	293
PM PEAK	0.73	0.07	7.85	36%	64%	56	318
PK GEN AM	0.78	0.1	8.75	68%	32%	50	370
PK GEN PM	0.75	0.09	7.85	52%	48%	50	370

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	432	216	216	418	209	209
AM PEAK	82	64	18	64	50	14
PM PEAK	82	30	52	72	26	46
PK GEN AM	88	60	28	76	52	24
PK GEN PM	85	44	41	81	42	39

***SATURDAY***

RATES:

	Total Trip Ends			Directional Dist.		Number of Studies	Avg Size (ksf)
	Average	Low	High	Enter	Exit		
DAILY	1.49	0.88	6.42	50%	50%	2	483
GEN PEAK HR	0.28	0.2	0.94	NA	NA	2	483

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	168	84	84	*** Not Given ***		
PEAK HR	32	*** Not Given ***		*** Not Given ***		

***SUNDAY***

RATES:

	Total Trip Ends			Directional Dist.	
	Average	Low	High	Enter	Exit
DAILY	0.62	0.07	5.09	50%	50%
PEAK HR	0.09	0.01	0.75	NA	NA

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	70	35	35	*** Not Given ***		
PEAK HR	10	*** Not Given ***		*** Not Given ***		

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**TRIP GENERATION WORKSHEET**LAND USE: *General Light Industrial*

LAND USE CODE: 110 Independent Variable---Trips per 1000 square feet

LOCATION: 56 Boyton Road

JOB NUMBER: Gross Floor Area (KSF): 25

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***WEEKDAY***

RATES:	Total Trip Ends			Directional Dist.		Number of Studies	Avg Size (ksf)
	Average	Low	High	Enter	Exit		
DAILY	6.97	1.58	16.88	50%	50%	18	203
AM PEAK	0.92	0.17	4.00	88%	12%	29	336
PM PEAK	0.97	0.8	4.50	12%	88%	27	345
PK GEN AM	1.01	0.27	4.00	90%	10%	27	358
PK GEN PM	1.08	0.36	4.5	14%	86%	27	364

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	174	87	87	85	42	42
AM PEAK	23	20	3	-60	-53	-7
PM PEAK	24	3	21	-122	-15	-107
PK GEN AM	25	23	3	-31	-28	-3
PK GEN PM	27	4	23	-90	-13	-77

***SATURDAY***

RATES:	Total Trip Ends			Directional Dist.		Number of Studies	Avg Size (ksf)
	Average	Low	High	Enter	Exit		
DAILY	1.32	0.69	5.78	50%	50%	6	351
GEN PEAK HR	0.14	0.08	0.94	47%	53%	5	410

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	33	17	17	184	92	92
PEAK HR	4	2	2	*** Not Given ***		

***SUNDAY***

RATES:	Total Trip Ends			Directional Dist.	
	Average	Low	High	Enter	Exit
DAILY	0.68	0.28	5.00	50%	50%
PEAK HR	0.10	0.05	0.69	48%	52%

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	17	9	9	*** Not Given ***		
PEAK HR	3	1	2	*** Not Given ***		



# Fulfillment Center Trip Generation

A large commercial development, spanning 700 acres, within a city in western San Joaquin County, CA, USA was approved after completion of the Environmental Impact Report in 2013. The development adjoins a number of collector distributor roads, and is in close proximity to two Interstate freeways 580 and 205, both running east to west at this location. International Parkway, a major collector road—slated to be improved to a major arterial—runs north to south between the two interstate freeways. An environmental document proposed several improvements to International Parkway interchanges at I-205 and I-580. Two scoping documents were completed in 2016 by R&M Consulting Engineers Inc., and were approved by the California Department of Transportation (Caltrans) District 10 within four months to assist in the planning and funding of these improvements.

Consistent with Caltrans project development procedures, the city has embarked on preparation of the next level of approval documents for the interchanges. These documents require updated traffic forecasts for up to 20-years post-construction completion. Current scheduling calls for construction to begin in 2020 and end by the conclusion of 2022 for both interchange improvements. Consequently, traffic forecasts are necessary for the year 2042.

The business uses planned for this development at the time of approval of the environmental document included light industrial, general office, retail commercial, and a small percentage of high cube warehouses. However, over the lengthy period of environmental document preparation, review, and approval, the demand for high cube warehouses such as fulfillment centers had increased significantly. Consequently, after the approval of the environmental document and the specific plan, the very first set of buildings constructed and opened for use were fulfillment centers. The infrastructure construction to support this development such as roadways, water, sewer, electrical, etc. was rapidly completed based on business uses considered in the environmental document.

## Initial Field Observations

As the first four buildings opened for business and were fully operational, driveway and intersection

traffic observed were significantly lower traffic than anticipated. Three of these buildings were fulfillment centers, and the other was a parcel hub. Given the extraordinary demand for fulfillment centers, the next set of buildings designed and permitted were also all fulfillment centers. Consequently, there was an urgent need to reanalyze the trip generation characteristics of this entire development. An attempt was made to use trip rates from the *ITE Trip Generation Manual*, 10th Edition. The ITE edition, however, has only two points in the data set, 155—High Cube Warehouse, with big differences in rates between the two points. It seemed the authors had more data with the three that are already in operation, and a few more within the city in close proximity. The authors therefore decided to collect driveway and intersection traffic volume data to forecast trips for the remaining fulfillment centers.

The purpose of this paper is to present the results of trip generation characteristics of fulfillment centers that are in operation within this commercial development and some of those in close proximity to this area.

## Fulfillment Center Development Phases

This development was divided into 17 Traffic Analysis Zones (TAZs). Each TAZ was assigned a unique three-digit number. Given the projected duration of subdivision buildout, it was appropriate to forecast traffic numbers for three separate time periods: existing, 2022, and 2042. The first period coincides with fulfillment centers which are in operation, about 2.8 million square feet (ft.) (260,128 square meters [m]). The second period, corresponds to completion of Interim Phase 2 construction with about 6 million square ft. (557,418 square m) of fulfillment centers. The third period corresponds to full build out of the development, with an additional 11.8 million square ft. (1,096,255 square m) of fulfillment centers. Figure 1 shows a collage of existing fulfillment centers layouts and their driveway movements.

The fulfillment centers were fully operational as of April 2018 and are shown in Figure 2. In addition, there is also one parcel hub in full operation.

*By Bala Rajappan, P.E., T.E., ENV SP (F), Lee Taubeneck, P.E., and Sushil Patil*



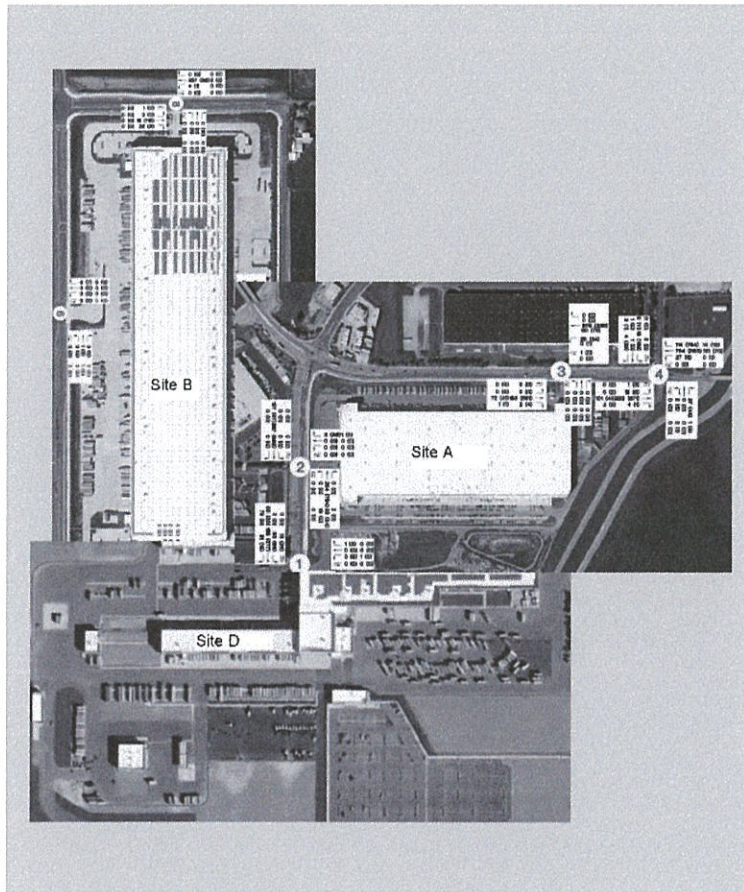


Figure 1. A collage of existing fulfillment centers layouts and their driveway movements.

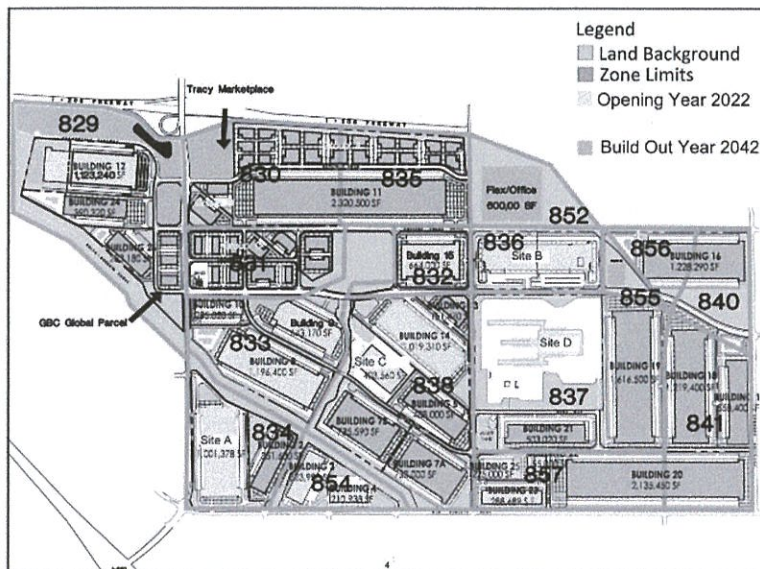


Figure 2. Build Out Year (2042) Building and Zone Map.

## Traffic Count Data

Traffic volumes at operational intersections and drive-ways across the development were counted in June and December 2017, and April 2018. All counts included trucks. Counts were taken for morning and afternoon/evening 3-hour peak periods in 15-minute intervals. The AM peak period was between 5:00–8:00 a.m. and PM period was between 3:00–6:00 p.m.

Raw data were summarized in tabular form and intersection movements were then broken down by direction (through, left, and right) and peak hours (AM and PM). Peak of adjacent street intersections was determined by selecting four peak 15-minute intervals. The adjacent street intersection peak hours were between 7:00–8:00 a.m. in the morning, and 5:00–6:00 p.m. in the evening. Traffic volumes for all driveways for each building were summed for time period corresponding to adjacent street peak hour to arrive at total facility trips. Total trips for each building were then divided by facility area to arrive at trip generation rates per 1,000 square ft. (93 square m). The building area was obtained from the development construction plans.

## Updated Fulfillment Center Trip Generation Rates

As of February 2017, two fulfillment centers and the parcel hub had been in operation for more than two years. The most recent tenant began operations as a third fulfillment center in February 2017, and has been in full capacity since the opening. Current peak-hour traffic volumes generated by buildings in operation are shown in Table 1.

Traffic counts at the three operational fulfillment centers were supplemented with two rounds of additional counts, and counts at similar facilities nearby. These additional data are shown in Table 2. It includes count data from two separate Amazon facilities.

In Table 2, the authors used the highest trip data for each peak from June and December 2017 and April 2018 counts for each location as the final selected data points to calculate the average trip rate and were able to estimate the generation rates for fulfillment centers corresponding to peak hour of adjacent street. The AM average is estimated at 0.13 trips per 1,000 square ft. (93 square m) and PM average of 0.09 trips per 1,000 square ft. (93 square m). These rates could represent a majority of newer fulfillment centers. The Table 2 averages exclude the Site I data.



Site I, an older facility located within the city but outside of this development, clearly seemed to be an outlier with much higher rates of 1.45 during the AM peak hour and 0.89 during the PM peak hour. The other sites were generating between 0.03 and 0.51 during the AM peak hour and between 0.01 and 0.24 during the PM peak hour. Upon further investigation, the authors determined that Site I is a sort facility (i.e., a fulfillment center that ships out smaller items and that requires extensive sorting, potentially manual). The rest of the Sites in Table 2 are in the non-sort category (i.e., fulfillment center that ships large box items with a higher automation level).

Although more research and data are needed to verify sort vs. non-sort category of fulfillment center trip generation characteristics, we could say that fulfillment centers in this development in general are generating much lower trips.

## Comparison to ITE Rates

The lower end of rate range presented in the *ITE Trip Generation Manual*, 10th Edition, for land use 155 (High-Cube Fulfillment Center Warehouse) with 0.15 for AM and 0.27 for PM peak hour trip generation rates seem to represent fulfillment centers with characteristics closer to rates in Table 2 with average of 0.13 for AM and 0.09 for PM peak hours. The higher data point in the ITE data set of 0.84 for AM and 1.98 for PM peak hours seem closer to the sort Site 5 facility with rates of 1.45 and 0.89 for AM and PM peak hour, respectively.

The trip generation rates presented here require further research with data from fulfillment centers from various parts of the state and country. There are a few observations that can be made about the centers studied here.

The newer fulfillment centers utilize a significant amount of automation for efficiency and cost reduction. The automation reduces the number of workers and therefore trips during the peak hours.

The centers operate trucks and other commercial vehicles outside the AM and PM peak hours/periods. Fleet operations of this kind avoid delays due to local street as well as freeway/interchange traffic congestion.

**Conclusion.** Results from the study of fulfillment centers in the western portion of San Joaquin County closely support the significantly lower traffic volumes observed after completion of the first three. These trip generation rates were documented at 0.13 and 0.09 trips per 1,000 square ft. (93 square m) for AM and PM peak hours, respectively. These averages matched closer to

Table 1 – Traffic Volumes from Buildings in Operation (April 2018).

Zone Number	Development	Gross Square Feet (GSF)	April 2018 Counts	
			AM	PM
			Total Trips (Truck Trips)	Total Trips (Truck Trips)
834	Site A (Fulfillment Center)	1,001,378	188 (13)	180 (12)
836	Site B (Fulfillment Center)	1,005,500	101 (22)	69 (11)
838	Site C (Fulfillment Center)	403,560	41 (20)	20 (7)
837	Site D (Parcel Hub)	385,000	169 (55)	286 (46)
Total		2,795,438	499 (110)	555 (86)

Table 2 - Trip Generation Rate for Study Fulfillment Centers (June and December 2017 and April 2018 Counts).

Development	GSF	AM		PM	
Fulfillment Centers		Total Trips (Truck)	Trip Rates	Total Trips (Truck)	Trip Rates
Site B, Tracy (June 2017)	1,005,500	49 (14)	0.05	28 (7)	0.03
Site B, Tracy (December 2017)		56 (16)	0.06	36 (9)	0.04
Site B, Tracy (April 2018)		<b>101 (22)</b>	<b>0.10</b>	<b>69 (11)</b>	<b>0.07</b>
Site C, Tracy (June 2017)	403,560	25 (6)	0.06	17 (5)	0.04
Site C, Tracy (December 2017)		24 (6)	0.06	12 (4)	0.03
Site C, Tracy (April 2018)		<b>41 (20)</b>	<b>0.10</b>	<b>20 (7)</b>	<b>0.05</b>
Site E, Lathrop (April 2018)	440,000	<b>11 (5)</b>	<b>0.03</b>	<b>4 (4)</b>	<b>0.01</b>
Site F (December 2017)	390,280	40 (29)	0.10	13 (9)	0.03
Site F (April 2018)		<b>42 (17)</b>	<b>0.11</b>	<b>35 (21)</b>	<b>0.09</b>
Site G (December 2017)	1,225,680	<b>67 (6)</b>	<b>0.05</b>	16 (3)	0.01
Site G (April 2018)		59 (9)	0.05	<b>29 (12)</b>	<b>0.02</b>
Site H (December 2017)	283,603	<b>144 (35)</b>	<b>0.51</b>	<b>69 (11)</b>	<b>0.24</b>
Site A, Project Site (June 2017)	1,001,378	182 (11)	0.18	<b>206 (11)</b>	<b>0.21</b>
Site A, Project Site (May 2018)		<b>188 (13)</b>	<b>0.19</b>	180 (12)	0.18
Site I, Nearby Project Site (December 2017)	1,111,029	1,611 (39)	1.45	992 (58)	0.89
Avg. Trip rate	5,861,030	2640 (249)	0.36	1726 (199)	0.23
Average Trip Rate	4,750,001	<b>594 (118)</b>	<b>0.13</b>	<b>432 (77)</b>	<b>0.09</b>

Note: Average Trip Rate is calculated from highest trip data for each peak from June and December 2017 and April/May 2018 counts (shown in bold).



the low point of the two-point data set used in the (155 – High Cube Fulfillment Center Warehouse) *ITE Trip Generation Manual*, 10th Edition trip rates, at 0.15 and 0.27 for AM and PM peak hours, respectively.

The sort facility was clearly an outlier with generation of 1.45 and 0.89 trips per 1,000 square ft. (93 square m) for AM and PM peak hours, respectively. This data point is closer to the higher point of the two-point data set used in the (155 – High Cube Fulfillment Center Warehouse) *ITE Trip Generation Manual*, 10th Edition trip rates, at 0.84 for AM and 1.98 for PM peak hours.

Other observations made include extensive automation with newer fulfillment centers and fleet scheduling to avoid adjacent street peak hour congestion. With time, additional automation including autonomous fleets and flexible employee work shifts could continue to reduce trips during adjacent street peak hour congestion. **itej**



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improvement projects for cities, counties, and Caltrans. Mr. Rajappan is also a co-owner of MSPhitect Inc., a big data platform solution provider, which specializes in the application of Urban Observatory (Mi-Flash) big data analytics in transportation planning.



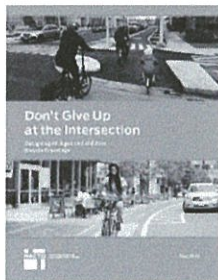
**Lee Taubeneck, P.E.** is a project manager and civil engineer with more than 30 years of professional experience in the development of highways and freeways in the State of California. Currently, he acts as principal project manager for R&M Consulting Engineers Inc. He was formerly deputy district director for Caltrans through eight annual budget cycles for the nine-county San Francisco, CA, USA, Bay Area.



**Sushil Patil** has more than five years of experience in civil and traffic engineering projects. His responsibilities include preparation of project plans, cost estimates, schedule and freeway traffic analysis, and simulation. He currently works as assistant transportation engineer with R&M Consulting Engineers Inc.

## INDUSTRY NEWS

### NACTO Releases Best Practices for Next-Generation Street Intersection Design



The National Association of City Transportation Officials (NACTO) has released best practices for next-generation intersection designs that save lives and make walking and biking more comfortable for people of all ages and abilities. Intersections are the place where the most vehicle-bike conflicts occur. In 2017, 43 percent of urban bicyclist fatalities occurred at intersections. On

many streets, large turn radii and wide lanes encourage drivers to make sweeping, fast turns. These design decisions increase exposure and risk for people walking and biking, reduce the safety and comfort of the bike network, and discourage cycling. As cities work to make streets safer and more welcoming for bicyclists of all ages and abilities, intersection design is key. The new guidance, *Don't Give Up at the Intersection*, expands the groundbreaking NACTO *Urban Bikeway Design Guide* with new diagrams detailing intersection design treatments and signal strategies that reduce vehicle-bike and vehicle-pedestrian conflicts. *Don't Give Up at the Intersection* is available for free online at [www.nacto.org/saferintersections](http://www.nacto.org/saferintersections). **itej**

## WHERE IN THE WORLD?

Can you guess the location of the "Where in the World?" photo in this issue? The answer is on page 50. Feel free to send in your own photos to [hstowell@ite.org](mailto:hstowell@ite.org). Good luck! **itej**





specified in ITE's data. In an effort to assess the trip generation characteristics of large single-retailer distribution centers, data was collected at nine sites throughout the state that varied in size from just under 500,000 square feet to just under 1.5 million square feet GFA.

#### *Analysis of Results*

The weighted average rate for the weekday daily period was determined to be 1.86 trips per 1,000 square feet GFA and the PM peak hour of the adjacent street was determined to be 0.14 trips per 1,000 square feet GFA. Since the study, the ITE *Trip Generation Manual*, 9<sup>th</sup> Edition, has revised Land Use 152 to include Distribution Center in both the title and definition of the land use. The revised land use includes the data from the FDOT study, as well as other distribution center data collected by the Texas Transportation Institute (TTI). **Table 8** below shows the rate from this study and how it compares to the ITE High Cube Warehouse/Distribution Center rate, as well as rates determined in a 2006 study performed by Putnam County and FDOT Districts 2 and 5 and a 2009 Polk County study.

**Table 8: Trip Generation Rate Comparisons for Distribution Centers**

Trip Generation Rate Source	Rate per 1,000 ft <sup>2</sup> Gross Floor Area			
	Weekday Daily		PM Peak Hour of Adjacent Street	
	Rate	% Difference from ITE LU 152 (9th Edition)	Rate	% Difference from ITE LU 152 (9th Edition)
ITE LU 152 -High Cube Warehouse <sup>1</sup>	1.68	-	0.10	-
2010 FDOT Statewide Study	1.86	+11%	0.14	+40%
Putnam County/FDOT District 2 & 5 Study <sup>2</sup>	1.98	+18%	0.12	+18%
Polk County Study	1.95	+16%	-	-
<b>Sources:</b>				
<sup>1</sup> 9 <sup>th</sup> Edition <i>Trip Generation Manual</i> , ITE				
<sup>2</sup> <i>Trip Generation for the South Putnam Distribution Warehouse Special Planning Area (SPA) Transportation Analysis</i>				

#### *Recommendations*

As seen in the table above, the weekday daily and PM peak hour of adjacent street rates from the study are higher than the average ITE rates for High Cube Warehouse/Distribution Center. This shows that the average rates in Florida are generally higher than the average rates for all of the data included by ITE. The data collected in this study has since been included in ITE LU 152 – High Cube Warehouse in the ITE *Trip Generation Manual*, 9<sup>th</sup> Edition. **However, since the rates determined in this study were found to be higher than those for ITE LU 152 – High Cube Warehouse, it is recommended that the FDOT 2011 study rates be used for Large Single-Retailer Distribution Centers in Florida.**

#### *Home Improvement Superstores*

##### *Introduction*

In an effort to estimate the trip generation of home improvement superstores in Florida, ten sites ranging from 100,000 square feet to 138,000 square feet GFA studied were chosen from around the state. The data collected most closely relates to ITE LU 862 - **Home Improvement Superstore** in ITE's *Trip Generation Manual*, 9<sup>th</sup> Edition.



# 027 Houston

✓

ITE Trip Gen - 10th Ed

limited data for LUC 155, 156

LUC 155 - full/h/hat  
156 - Parcel 1/b/b } similar or related

FDET sub study in 2011-2012  
post 9th Ed - doesn't look like in  
10th Ed - (at least in LUC 155 & 156)

R & M. Lenahy  
Rajaguru et al study - CA -  
Full/h/hat Center & like LUC 155  
cited unitation of ITE data  
2017/2018 data collection

AM 0.13/kcf PM 0.09/kcf

FDET - 1.86/kcf - weekly  
0.14/kcf PM peak

LUC 152 - 9th edition  
1.44/kcf which  
0.10/ AM  
0.09/ PM



2/

Foot study - shows PM pk = 7.5% of wkdy

WE152 - shows AM pk = 6.9% of wkdy  
PM pk = 6.2% of wkdy

- R & M study seems to make legitimate & concrete comments/observations - more data -

Decision -

use R & M study for AM & PM pks  
estimate daily using 7% AM pk of wkdy

• Rates

Wkdy 1.88 / Ksf  
AM 0.13 / Ksf  
PM 0.09 / Ksf

@ 80 Ksf

		IN	OUT	Split Assuming
Wkdy	1488	744	744	50/50
AM	104	52	52	50/50
PM	72	49	23	68/32

---

**TRIP GENERATION WORKSHEET**LAND USE: *High Cube Parcel Hub Warehouse*

LAND USE CODE: 156 Independent Variable---Trips per 1000 square feet

LOCATION: 555 Hopping Brook Road

JOB NUMBER: Gross Floor Area (KSF): 800

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***WEEKDAY***

RATES:	Total Trip Ends			Directional Dist.		Number of Studies	Avg Size (ksf)
	Average	Low	High	Enter	Exit		
DAILY	1.86			50%	50%		
AM PEAK	0.13			50%	50%		
PM PEAK	0.09			68%	32%		
PK GEN AM							
PK GEN PM							

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	1488	744	744	*** Not Given ***		
AM PEAK	104	52	52	*** Not Given ***		
PM PEAK	72	49	23	*** Not Given ***		
PK GEN AM	*** Not Given ***			*** Not Given ***		
PK GEN PM	*** Not Given ***			*** Not Given ***		

***SATURDAY***

RATES:	Total Trip Ends			Directional Dist.	Number	Avg
	Average	Low	High	Enter	Exit of Studies	Size (ksf)
DAILY	*** Not Given ***					
GEN PEAK HR						

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	*** Not Given ***			*** Not Given ***		
PEAK HR	*** Not Given ***			*** Not Given ***		

***SUNDAY***

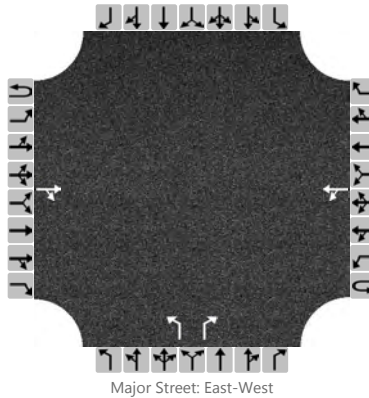
RATES:	Total Trip Ends			Directional Dist.	
	Average	Low	High	Enter	Exit
DAILY	*** Not Given ***				
PEAK HR					

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	*** Not Given ***			*** Not Given ***		
PEAK HR	*** Not Given ***			*** Not Given ***		

# HCS 2010 Two-Way Stop Control Summary Report

General Information		Site Information	
Analyst		Intersection	Washington at Hopping Bro
Agency/Co.		Jurisdiction	Holliston
Date Performed	1/11/2020	East/West Street	Washington Street
Analysis Year	2019	North/South Street	Hopping Brook Road
Time Analyzed	AM Peak Hour	Peak Hour Factor	0.95
Intersection Orientation	East-West	Analysis Time Period (hrs)	0.25
Project Description	555 Hopping Brook		

## Lanes



## Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		1	0	1		0	0	0
Configuration				TR		LT				L		R				
Volume (veh/h)			586	179		45	474			51		18				
Percent Heavy Vehicles						2				5		2				
Proportion Time Blocked																
Right Turn Channelized	No				No				No				No			
Median Type	Undivided															
Median Storage																

## Delay, Queue Length, and Level of Service

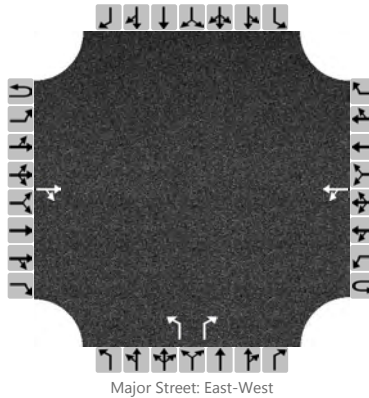
Flow Rate (veh/h)						546					54		19			
Capacity						819					165		433			
v/c Ratio						0.67					0.33		0.04			
95% Queue Length						0.2					1.3		0.1			
Control Delay (s/veh)						9.7					37.2		13.7			
Level of Service (LOS)						A					E		B			
Approach Delay (s/veh)					1.5				31.1							
Approach LOS									D							



# HCS 2010 Two-Way Stop Control Summary Report

General Information		Site Information	
Analyst		Intersection	Washington at Hopping Bro
Agency/Co.		Jurisdiction	Holliston
Date Performed	1/11/2020	East/West Street	Washington Street
Analysis Year	2019	North/South Street	Hopping Brook Road
Time Analyzed	PM Peak Hour	Peak Hour Factor	0.95
Intersection Orientation	East-West	Analysis Time Period (hrs)	0.25
Project Description	555 Hopping Brook		

## Lanes



## Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		1	0	1		0	0	0
Configuration				TR		LT				L		R				
Volume (veh/h)			500	26		17	704			182		73				
Percent Heavy Vehicles						0				2		2				
Proportion Time Blocked																
Right Turn Channelized	No				No				No				No			
Median Type	Undivided															
Median Storage																

## Delay, Queue Length, and Level of Service

Flow Rate (veh/h)						759					192		77			
Capacity						1027					171		542			
v/c Ratio						0.74					1.12		0.14			
95% Queue Length						0.1					9.9		0.5			
Control Delay (s/veh)						8.6					160.6		12.7			
Level of Service (LOS)						A					F		B			
Approach Delay (s/veh)					0.5				118.3							
Approach LOS									F							

# HCS7 Two-Way Stop-Control Report

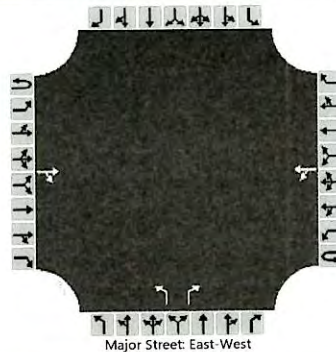
## General Information

Analyst	
Agency/Co.	
Date Performed	1/11/2020
Analysis Year	2026
Time Analyzed	AM Peak Hour
Intersection Orientation	East-West
Project Description	555 Hopping Brook <b>NO BUILD</b>

## Site Information

Intersection	Washington at Hopping Bro
Jurisdiction	Holliston
East/West Street	Washington Street
North/South Street	Hopping Brook Road
Peak Hour Factor	0.95
Analysis Time Period (hrs)	0.25

## Lanes



## Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		1	0	1		0	0	0
Configuration				TR		LT				L		R				
Volume (veh/h)			628	251		73	508			69		26				
Percent Heavy Vehicles (%)						2				5		3				
Proportion Time Blocked																
Percent Grade (%)									0							
Right Turn Channelized									No							
Median Type   Storage	Undivided															

## Critical and Follow-up Headways

Base Critical Headway (sec)						4.1				7.1		6.2				
Critical Headway (sec)						4.12				6.45		6.23				
Base Follow-Up Headway (sec)						2.2				3.5		3.3				
Follow-Up Headway (sec)						2.22				3.54		3.33				

## Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						77				73		27				
Capacity, c (veh/h)						738				116		387				
v/c Ratio						0.10				0.63		0.07				
95% Queue Length, Q <sub>95</sub> (veh)						0.3				3.2		0.2				
Control Delay (s/veh)						10.4				78.0		15.0				
Level of Service (LOS)						B				F		C				
Approach Delay (s/veh)					2.7				60.8							
Approach LOS									F							



# HCS7 Two-Way Stop-Control Report

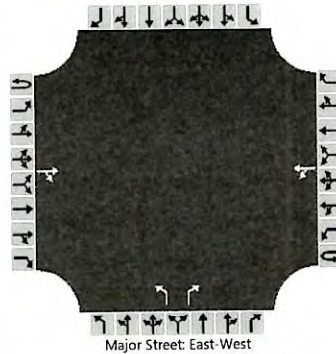
## General Information

Analyst	
Agency/Co.	
Date Performed	1/11/2020
Analysis Year	2026
Time Analyzed	PM Peak Hour
Intersection Orientation	East-West
Project Description	555 Hopping Brook NO BUILD

## Site Information

Intersection	Washington at Hopping Bro
Jurisdiction	Holliston
East/West Street	Washington Street
North/South Street	Hopping Brook Road
Peak Hour Factor	0.95
Analysis Time Period (hrs)	0.25

## Lanes



## Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		1	0	1		0	0	0
Configuration				TR		LT				L		R				
Volume (veh/h)			536	51		28	755			233		95				
Percent Heavy Vehicles (%)						2				3		2				
Proportion Time Blocked																
Percent Grade (%)									0							
Right Turn Channelized									No							
Median Type   Storage	Undivided															

## Critical and Follow-up Headways

Base Critical Headway (sec)						4.1				7.1		6.2				
Critical Headway (sec)						4.12				6.43		6.22				
Base Follow-Up Headway (sec)						2.2				3.5		3.3				
Follow-Up Headway (sec)						2.22				3.53		3.32				

## Delay, Queue Length, and Level of Service

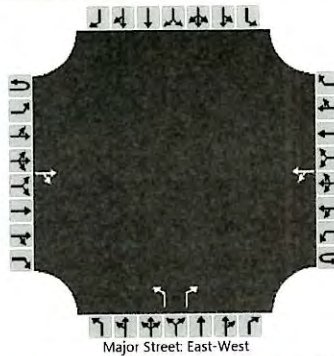
Flow Rate, v (veh/h)						29				245		100				
Capacity, c (veh/h)						962				137		507				
v/c Ratio						0.03				1.80		0.20				
95% Queue Length, Q <sub>95</sub> (veh)						0.1				18.5		0.7				
Control Delay (s/veh)						8.9				441.7		13.8				
Level of Service (LOS)						A				F		B				
Approach Delay (s/veh)					0.8				317.8							
Approach LOS									F							



# HCS7 Two-Way Stop-Control Report

General Information		Site Information	
Analyst		Intersection	Washington at Hopping Bro
Agency/Co.		Jurisdiction	Holliston
Date Performed	1/11/2020	East/West Street	Washington Street
Analysis Year	2026	North/South Street	Hopping Brook Road
Time Analyzed	AM Peak Hour	Peak Hour Factor	0.95
Intersection Orientation	East-West	Analysis Time Period (hrs)	0.25
Project Description	555 Hopping Brook BUILD		

## Lanes



## Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		1	0	1		0	0	0
Configuration				TR		LT				L		R				
Volume (veh/h)			628	287		89	508			105		42				
Percent Heavy Vehicles (%)						2				5		3				
Proportion Time Blocked																
Percent Grade (%)									0							
Right Turn Channelized									No							
Median Type   Storage	Undivided															

## Critical and Follow-up Headways

Base Critical Headway (sec)						4.1				7.1		6.2				
Critical Headway (sec)						4.12				6.45		6.23				
Base Follow-Up Headway (sec)						2.2				3.5		3.3				
Follow-Up Headway (sec)						2.22				3.54		3.33				

## Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						94				111		44				
Capacity, c (veh/h)						714				103		377				
v/c Ratio						0.13				1.08		0.12				
95% Queue Length, Q <sub>95</sub> (veh)						0.5				7.0		0.4				
Control Delay (s/veh)						10.8				189.2		15.8				
Level of Service (LOS)						B				F		C				
Approach Delay (s/veh)					3.3				139.7							
Approach LOS									F							



# HCS7 Two-Way Stop-Control Report

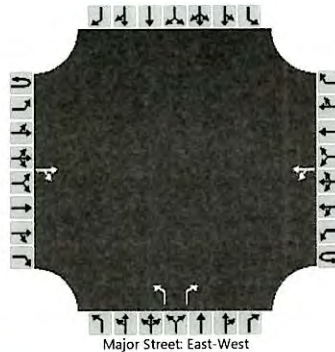
## General Information

Analyst	
Agency/Co.	
Date Performed	1/11/2020
Analysis Year	2026
Time Analyzed	PM Peak Hour
Intersection Orientation	East-West
Project Description	555 Hopping Brook BUILD

## Site Information

Intersection	Washington at Hopping Bro
Jurisdiction	Holliston
East/West Street	Washington Street
North/South Street	Hopping Brook Road
Peak Hour Factor	0.95
Analysis Time Period (hrs)	0.25

## Lanes



## Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		1	0	1		0	0	0
Configuration				TR		LT				L		R				
Volume (veh/h)			536	85		43	755			249		102				
Percent Heavy Vehicles (%)						2				3		2				
Proportion Time Blocked																
Percent Grade (%)									0							
Right Turn Channelized									No							
Median Type   Storage	Undivided															

## Critical and Follow-up Headways

Base Critical Headway (sec)						4.1				7.1		6.2				
Critical Headway (sec)						4.12				6.43		6.22				
Base Follow-Up Headway (sec)						2.2				3.5		3.3				
Follow-Up Headway (sec)						2.22				3.53		3.32				

## Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						45				262		107				
Capacity, c (veh/h)						932				123		495				
v/c Ratio						0.05				2.13		0.22				
95% Queue Length, Q <sub>95</sub> (veh)						0.2				21.9		0.8				
Control Delay (s/veh)						9.1				593.3		14.3				
Level of Service (LOS)						A				F		B				
Approach Delay (s/veh)					1.2				425.0							
Approach LOS									F							



**Standard:**

- 04 The need for a traffic control signal shall be considered if an engineering study finds that one of the following conditions exist for each of any 8 hours of an average day:

- A. The vehicles per hour given in both of the 100 percent columns of Condition A in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection; or
- B. The vehicles per hour given in both of the 100 percent columns of Condition B in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection.

In applying each condition the major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of these 8 hours.

**Option:**

- 05 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 70 percent columns in Table 4C-1 may be used in place of the 100 percent columns.

**Guidance:**

- 06 The combination of Conditions A and B is intended for application at locations where Condition A is not satisfied and Condition B is not satisfied and should be applied only after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems.

**Standard:**

- 07 The need for a traffic control signal shall be considered if an engineering study finds that both of the following conditions exist for each of any 8 hours of an average day:

- A. The vehicles per hour given in both of the 80 percent columns of Condition A in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection; and
- B. The vehicles per hour given in both of the 80 percent columns of Condition B in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection.

These major-street and minor-street volumes shall be for the same 8 hours for each condition; however, the 8 hours satisfied in Condition A shall not be required to be the same 8 hours satisfied in Condition B. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours.

**Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume**

**Condition A—Minimum Vehicular Volume**

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>	100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

**Condition B—Interruption of Continuous Traffic**

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>	100% <sup>a</sup>	80% <sup>b</sup>	70% <sup>c</sup>	56% <sup>d</sup>
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

<sup>a</sup> Basic minimum hourly volume

<sup>b</sup> Used for combination of Conditions A and B after adequate trial of other remedial measures

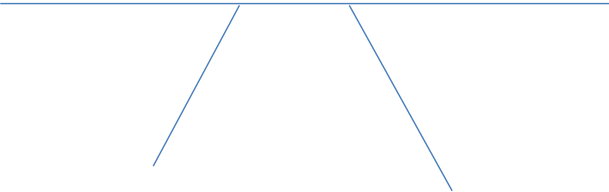
<sup>c</sup> May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

<sup>d</sup> May be used for combination of Conditions A and B after adequate trial of other remedial measures when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

EXISTING CONDITIONS

Warrant Set 1- Washington Street & Hopping Brook Road

Start Time	Washington Street (Route 16) From East		Hopping Brook Road From South		Washington Street (Route 16) From West		Int Total	Wash Total
	Left	WB Thru	NB Total		EB Thru	Right		
6:00:00		239	35		571		845	810
7:00:00		411	50		566		1027	977
8:00:00		453	49		552		1054	1005
9:00:00		410	41		420		871	830
10:00:00		393	60		402		855	795
11:00:00		422	87		396		905	818
12:00:00		470	168		415		1053	885
13:00:00		475	92		430		997	905
14:00:00		573	114		467		1154	1040
15:00:00		658	189		470		1317	1128
16:00:00		650	222		532		1404	1182
17:00:00		669	227		568		1464	1237
18:00:00		532	62		374		968	906
19:00:00		336	24		264		624	600



FUTURE CONDITIONS

Warrant Set 1- Washington Street & Hopping Brook Road

	0		0		0			
	From East		From South		From West			Wash St Total
Start Time	Left	WB Thru	NB Total		EB Thru	Right	Int Total	
6:00:00		256	42		612		911	868
7:00:00		441	65		607		1113	1047
8:00:00		486	66		592		1144	1077
9:00:00		440	63		450		953	890
10:00:00		421	92		431		945	852
11:00:00		452	119		425		996	877
12:00:00		504	214		445		1163	949
13:00:00		509	128		461		1099	970
14:00:00		614	150		501		1265	1115
15:00:00		705	225		504		1435	1209
16:00:00		697	266		570		1534	1267
17:00:00		717	279		609		1606	1326
18:00:00		570	81		401		1053	971
19:00:00		360	31		283		675	643
7173			1827		6890			

Est 56 Boyton	Est 455 Hopping
NB	NB
3	5
5	5
5	10
5	20
5	20
15	24
5	24
5	24
5	24
13	24
21	24
0	12
0	0
87	216
87	216

Warrant 1 Condition A		Warrant 1 Condition B	
Major Road	Minor Road	Major Road	Minor Road
>350	>140	>525	>70
√		√	
√		√	
√		√	
√		√	
√		√	√
√	√	√	√
√	√	√	√
√	√	√	√
√	√	√	√
√	√	√	√
√		√	
√		√	

Warrant Set 2- Main Street & Maple Street

5 Hours 9 Hours



Option:

- 08 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 56 percent columns in Table 4C-1 may be used in place of the 80 percent columns.

### **Section 4C.03 Warrant 2, Four-Hour Vehicular Volume**

Support:

- 01 The Four-Hour Vehicular Volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

**Standard:**

- 02 **The need for a traffic control signal shall be considered if an engineering study finds that, for each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) all fall above the applicable curve in Figure 4C-1 for the existing combination of approach lanes. On the minor street, the higher volume shall not be required to be on the same approach during each of these 4 hours.**

Option:

- 03 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-2 may be used in place of Figure 4C-1.

### **Section 4C.04 Warrant 3, Peak Hour**

Support:

- 01 The Peak Hour signal warrant is intended for use at a location where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street.

**Standard:**

- 02 **This signal warrant shall be applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.**
- 03 **The need for a traffic control signal shall be considered if an engineering study finds that the criteria in either of the following two categories are met:**
- A. If all three of the following conditions exist for the same 1 hour (any four consecutive 15-minute periods) of an average day:**
    - 1. The total stopped time delay experienced by the traffic on one minor-street approach (one direction only) controlled by a STOP sign equals or exceeds: 4 vehicle-hours for a one-lane approach or 5 vehicle-hours for a two-lane approach; and**
    - 2. The volume on the same minor-street approach (one direction only) equals or exceeds 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes; and**
    - 3. The total entering volume serviced during the hour equals or exceeds 650 vehicles per hour for intersections with three approaches or 800 vehicles per hour for intersections with four or more approaches.**
  - B. The plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4C-3 for the existing combination of approach lanes.**

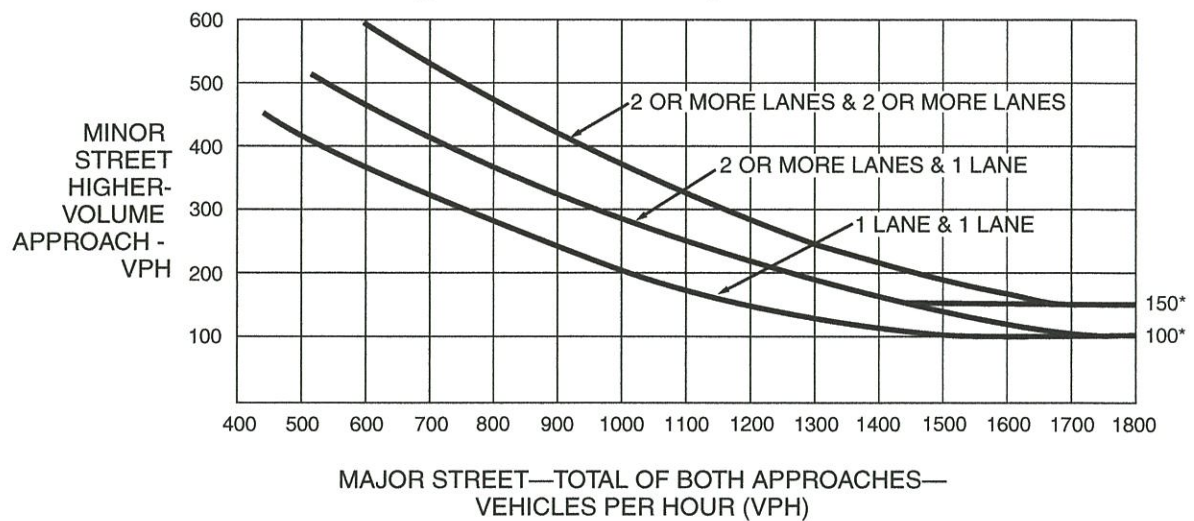
Option:

- 04 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-4 may be used in place of Figure 4C-3 to evaluate the criteria in the second category of the Standard.
- 05 If this warrant is the only warrant met and a traffic control signal is justified by an engineering study, the traffic control signal may be operated in the flashing mode during the hours that the volume criteria of this warrant are not met.

**Guidance:**

- 06 *If this warrant is the only warrant met and a traffic control signal is justified by an engineering study, the traffic control signal should be traffic-actuated.*

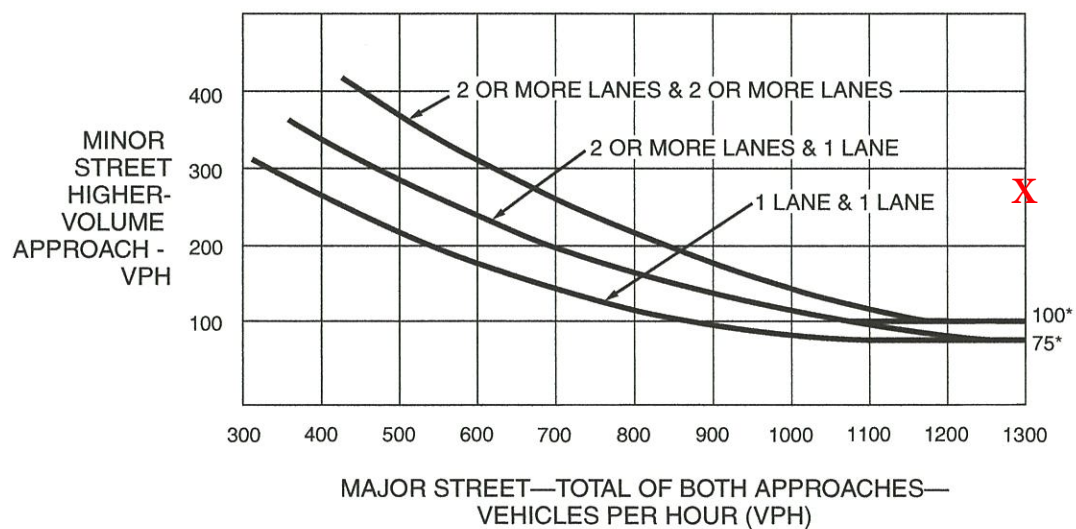


**Figure 4C-3. Warrant 3, Peak Hour**

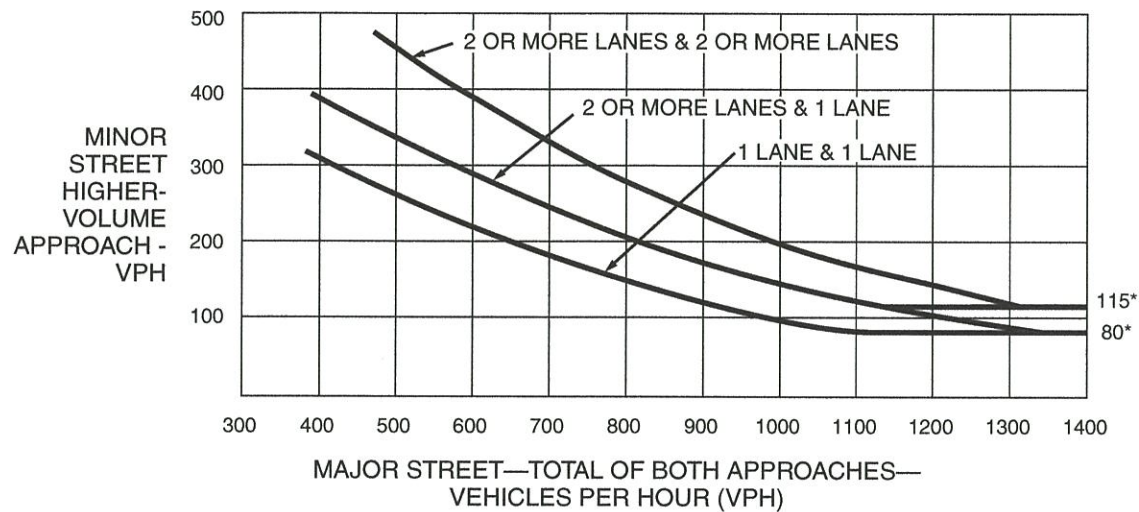
\*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.

**Figure 4C-4. Warrant 3, Peak Hour (70% Factor)**

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



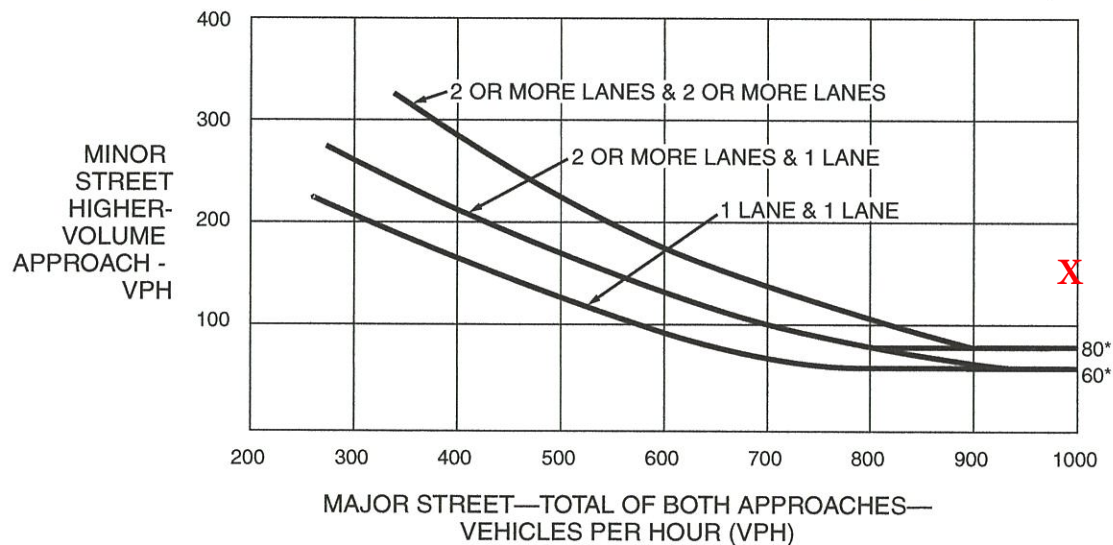
\*Note: 100 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor-street approach with one lane.

**Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume**

\*Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.

**Figure 4C-2. Warrant 2, Four-Hour Vehicular Volume (70% Factor)**

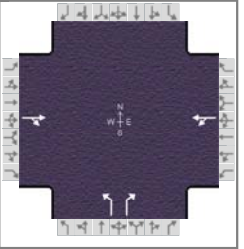
(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



\*Note: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane.

# HCS7 Signalized Intersection Input Data

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	1/20/2020	Area Type	Other
Jurisdiction		Time Period		PHF	0.95
Urban Street	Washinton Street	Analysis Year	2020	Analysis Period	1> 7:00
Intersection	Hoppng Brook Road	File Name	027 Holliston Build AM.xus		
Project Description	Build with Improvement				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand ( $v$ ), veh/h		628	287	89	508		105		42			

Signal Information											
Cycle, s	45.6	Reference Phase	2								
Offset, s	0	Reference Point	End								
Uncoordinated	Yes	Simult. Gap E/W	On	Green	30.5	5.1	0.0	0.0	0.0	0.0	
Force Mode	Fixed	Simult. Gap N/S	On	Yellow	4.0	4.0	0.0	0.0	0.0	0.0	
				Red	1.0	1.0	0.0	0.0	0.0	0.0	

Traffic Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand ( $v$ ), veh/h		628	287	89	508		105		42			
Initial Queue ( $Q_0$ ), veh/h		0	0	0	0		0		0			
Base Saturation Flow Rate ( $s_0$ ), veh/h		1900	1900	1900	1900		1900		1900			
Parking ( $N_m$ ), man/h		None			None			None				
Heavy Vehicles ( $P_{HV}$ ), %		0			0		0		0			
Ped / Bike / RTOR, /h	0	0	0	0	0		0	0		0	0	
Buses ( $N_b$ ), buses/h	0	0	0	0	0	0	0	0	0			
Arrival Type ( $AT$ )		3	3	3	3		3		3			
Upstream Filtering ( $I$ )		1.00	1.00	1.00	1.00		1.00		1.00			
Lane Width ( $W$ ), ft		12.0			12.0		12.0		12.0			
Turn Bay Length, ft		0			0		150		150			
Grade ( $P_g$ ), %		0			0			0			0	
Speed Limit, mi/h		45	45	45	45		45		45			

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green ( $G_{max}$ ) or Phase Split, s		45.0		45.0	20.0	30.0		
Yellow Change Interval ( $Y$ ), s		4.0		4.0	4.0	4.0		
Red Clearance Interval ( $R_c$ ), s		1.0		1.0	1.0	1.0		
Minimum Green ( $G_{min}$ ), s		6		6	6	6		
Start-Up Lost Time ( $l_t$ ), s		2.0	2.0	2.0	2.0			
Extension of Effective Green ( $e$ ), s		2.0	2.0	2.0	2.0			
Passage ( $PT$ ), s		2.0		2.0	2.0	2.0		
Recall Mode		Min		Min	Off	Off		
Dual Entry		Yes		Yes	No	Yes		
Walk ( $Walk$ ), s		0.0				0.0		0.0
Pedestrian Clearance Time ( $PC$ ), s		0.0				0.0		0.0

Multimodal Information	EB			WB			NB			SB		
85th % Speed / Rest in Walk / Corner Radius	0	No	25				0	No	25	0	No	25
Walkway / Crosswalk Width / Length, ft	9.0	12	0				9.0	12	0	9.0	12	0
Street Width / Island / Curb	0	0	No	0		No	0	0	No		0	
Width Outside / Bike Lane / Shoulder, ft	12	5.0	2.0	12	5.0	2.0	12	5.0	2.0			
Pedestrian Signal / Occupied Parking	No		0.50			0.50	No		0.50	No		

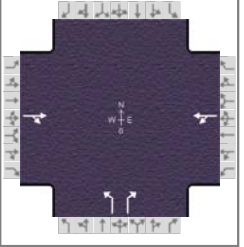
# HCS7 Signalized Intersection Results Summary

## General Information

Agency		Analysis Date	1/20/2020	Duration, h	0.25
Analyst		Area Type	Other	PHF	0.95
Jurisdiction		Analysis Year	2020	Analysis Period	1 > 7:00
Urban Street	Washinton Street	File Name	027 Holliston Build AM.xus		
Intersection	Hoppng Brook Road				
Project Description	Build with Improvement				

## Intersection Information

Duration, h	0.25
Area Type	Other
PHF	0.95
Analysis Period	1 > 7:00



## Demand Information

	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand ( v ), veh/h		628	287	89	508		105		42			

## Signal Information

Cycle, s	45.6	Reference Phase	2									
Offset, s	0	Reference Point	End									
Uncoordinated	Yes	Simult. Gap E/W	On	Green	30.5	5.1	0.0	0.0	0.0	0.0		
Force Mode	Fixed	Simult. Gap N/S	On	Yellow	4.0	4.0	0.0	0.0	0.0	0.0		
				Red	1.0	1.0	0.0	0.0	0.0	0.0		

## Timer Results

	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		
Case Number		8.0		8.0		9.0		
Phase Duration, s		35.5		35.5		10.1		
Change Period, ( Y+R <sub>c</sub> ), s		5.0		5.0		5.0		
Max Allow Headway ( MAH ), s		3.2		3.2		3.1		
Queue Clearance Time ( g <sub>s</sub> ), s		19.4		26.7		4.6		
Green Extension Time ( g <sub>e</sub> ), s		4.5		4.2		0.2		
Phase Call Probability		1.00		1.00		0.86		
Max Out Probability		0.03		0.09		0.00		

## Movement Group Results

	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement		2	12	1	6		3		18			
Adjusted Flow Rate ( v ), veh/h		963			628		111		44			
Adjusted Saturation Flow Rate ( s ), veh/h/ln		1798			1178		1810		1610			
Queue Service Time ( g <sub>s</sub> ), s		17.4			6.6		2.6		1.1			
Cycle Queue Clearance Time ( g <sub>c</sub> ), s		17.4			24.7		2.6		1.1			
Green Ratio ( g/C )		0.67			0.67		0.11		0.11			
Capacity ( c ), veh/h		1198			876		204		182			
Volume-to-Capacity Ratio ( X )		0.804			0.717		0.542		0.244			
Back of Queue ( Q ), ft/ln ( 50 th percentile)		40.3			17.3		23.4		8.9			
Back of Queue ( Q ), veh/ln ( 50 th percentile)		1.6			0.7		0.9		0.4			
Queue Storage Ratio ( RQ ) ( 50 th percentile)		0.00			0.00		0.16		0.06			
Uniform Delay ( d <sub>1</sub> ), s/veh		5.4			5.2		18.9		18.3			
Incremental Delay ( d <sub>2</sub> ), s/veh		0.9			0.4		0.8		0.3			
Initial Queue Delay ( d <sub>3</sub> ), s/veh		0.0			0.0		0.0		0.0			
Control Delay ( d ), s/veh		6.3			5.6		19.8		18.5			
Level of Service ( LOS )		A			A		B		B			
Approach Delay, s/veh / LOS	6.3	A		5.6	A		19.4	B		0.0		
Intersection Delay, s/veh / LOS	7.2						A					

## Multimodal Results

	EB			WB			NB			SB		
Pedestrian LOS Score / LOS	1.61	B		0.64	A		1.71	B		1.71	B	
Bicycle LOS Score / LOS	2.08	B		1.52	B			F				

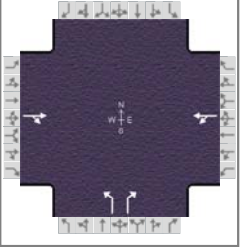
# HCS7 Signalized Intersection Intermediate Values

## General Information

Agency		Analysis Date	1/20/2020	Duration, h	0.25
Analyst		Area Type	Other	PHF	0.95
Jurisdiction		Analysis Year	2020	Analysis Period	1 > 7:00
Urban Street	Washinton Street	File Name	027 Holliston Build AM.xus		
Intersection	Hoppng Brook Road				
Project Description	Build with Improvement				

## Intersection Information

Duration, h	0.25
Area Type	Other
PHF	0.95
Analysis Period	1 > 7:00



## Demand Information

	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand ( v ), veh/h		628	287	89	508		105		42			

## Signal Information

Cycle, s	45.6	Reference Phase	2									
Offset, s	0	Reference Point	End	Green	30.5	5.1	0.0	0.0	0.0	0.0		
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	4.0	4.0	0.0	0.0	0.0	0.0		
Force Mode	Fixed	Simult. Gap N/S	On	Red	1.0	1.0	0.0	0.0	0.0	0.0		

## Saturation Flow / Delay

	L	T	R	L	T	R	L	T	R	L	T	R
Lane Width Adjustment Factor ( $f_w$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Heavy Vehicles and Grade Factor ( $f_{HVg}$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Parking Activity Adjustment Factor ( $f_p$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000
Bus Blockage Adjustment Factor ( $f_{bb}$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000
Area Type Adjustment Factor ( $f_a$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Lane Utilization Adjustment Factor ( $f_{LU}$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Left-Turn Adjustment Factor ( $f_{LT}$ )	1.000	0.947		0.620	0.620		0.952	0.000				
Right-Turn Adjustment Factor ( $f_{RT}$ )		0.000	0.947		0.000	0.620		0.000	0.847			
Left-Turn Pedestrian Adjustment Factor ( $f_{LPB}$ )	1.000			1.000			1.000					
Right-Turn Ped-Bike Adjustment Factor ( $f_{RPB}$ )			1.000			1.000			1.000			
Work Zone Adjustment Factor ( $f_{WZ}$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
DDI Factor ( $f_{DDI}$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Movement Saturation Flow Rate (s), veh/h	0	1234	564	176	1003	0	1810	0	1610			
Proportion of Vehicles Arriving on Green (P)	0.00	0.67	0.67	0.67	0.67	0.00	0.11	0.00	0.11	0.00	0.00	0.00
Incremental Delay Factor (k)		0.07			0.04		0.04		0.04			

## Signal Timing / Movement Groups

	EBL	EBT/R	WBL	WBT/R	NBL	NBT/R	SBL	SBT/R
Lost Time ( $t_L$ )		5.0		5.0		5.0		
Green Ratio (g/C)		0.67		0.67		0.11		
Permitted Saturation Flow Rate ( $s_p$ ), veh/h/ln		884		592		1810		
Shared Saturation Flow Rate ( $s_{sh}$ ), veh/h/ln		1900		0				
Permitted Effective Green Time ( $g_p$ ), s		0.0		30.1		25.0		
Permitted Service Time ( $g_u$ ), s		0.0		12.0		0.0		
Permitted Queue Service Time ( $g_{ps}$ ), s				6.6				
Time to First Blockage ( $g_r$ ), s		30.1		9.6		0.0		
Queue Service Time Before Blockage ( $g_{ts}$ ), s				7.5				
Protected Right Saturation Flow ( $s_R$ ), veh/h/ln						0		
Protected Right Effective Green Time ( $g_R$ ), s						0.0		

## Multimodal

	EB		WB		NB		SB	
Pedestrian $F_w / F_v$	0.972	0.000	0.000	0.000	0.972	0.000	0.972	0.000
Pedestrian $F_s / F_{delay}$	0.000	0.037	0.000	0.037	0.000	0.135	0.000	0.134
Pedestrian $M_{corner} / M_{cw}$								
Bicycle $c_b / d_b$	1337.46	2.50	1337.46	2.50	-262.97	29.21	-219.14	28.09
Bicycle $F_w / F_v$	-3.64	1.59	-3.64	1.04	-3.64		-3.64	



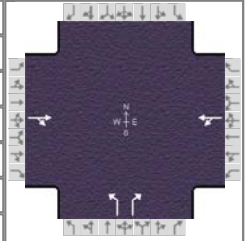
# HCS7 Signalized Intersection Results Graphical Summary

## General Information

Agency	
Analyst	
Jurisdiction	
Urban Street	Washinton Street
Intersection	Hoppng Brook Road
Project Description	Build with Improvement

## Intersection Information

Duration, h	0.25
Area Type	Other
PHF	0.95
Analysis Period	1 > 7:00



## Demand Information

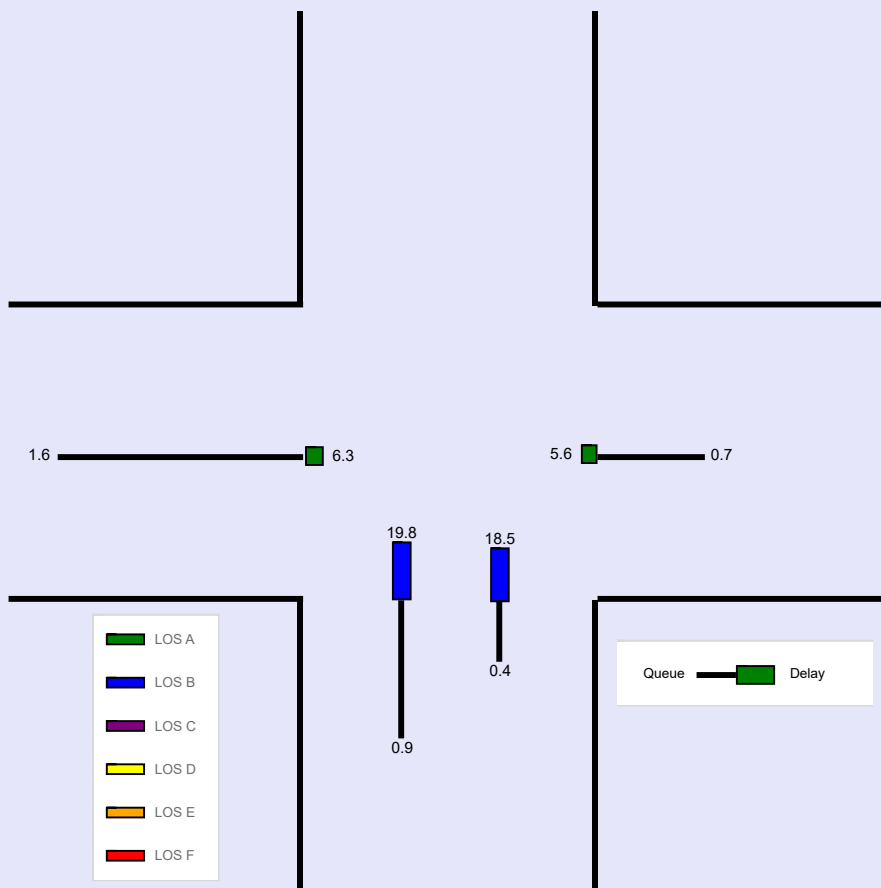
	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand ( v ), veh/h		628	287	89	508		105		42			

## Signal Information

Cycle, s	45.6	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

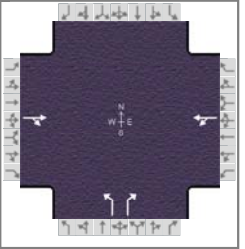
## Movement Group Results

	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Back of Queue ( Q ), ft/ln ( 50 th percentile)		40.3			17.3		23.4		8.9			
Back of Queue ( Q ), veh/ln ( 50 th percentile)		1.6			0.7		0.9		0.4			
Queue Storage Ratio ( RQ ) ( 50 th percentile)		0.00			0.00		0.16		0.06			
Control Delay ( d ), s/veh		6.3			5.6		19.8		18.5			
Level of Service (LOS)		A			A		B		B			
Approach Delay, s/veh / LOS	6.3		A	5.6		A	19.4		B	0.0		
Intersection Delay, s/veh / LOS	7.2						A					



# HCS7 Signalized Intersection Input Data

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	1/20/2020	Area Type	Other
Jurisdiction		Time Period		PHF	0.95
Urban Street	Washinton Street	Analysis Year	2020	Analysis Period	1> 7:00
Intersection	Hoppng Brook Road	File Name	027 Holliston Build PM.xus		
Project Description	Build with Improvement				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand ( $v$ ), veh/h		536	85	43	755		249		102			

Signal Information											
Cycle, s	38.9	Reference Phase	2								
Offset, s	0	Reference Point	End								
Uncoordinated	Yes	Simult. Gap E/W	On	Green	20.9	8.0	0.0	0.0	0.0	0.0	
Force Mode	Fixed	Simult. Gap N/S	On	Yellow	4.0	4.0	0.0	0.0	0.0	0.0	
				Red	1.0	1.0	0.0	0.0	0.0	0.0	

Traffic Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand ( $v$ ), veh/h		536	85	43	755		249		102			
Initial Queue ( $Q_0$ ), veh/h		0	0	0	0		0		0			
Base Saturation Flow Rate ( $s_0$ ), veh/h		1900	1900	1900	1900		1900		1900			
Parking ( $N_m$ ), man/h		None			None			None				
Heavy Vehicles ( $P_{HV}$ ), %		2			2		5		0			
Ped / Bike / RTOR, /h	0	0	0	0	0		0	0		0	0	
Buses ( $N_b$ ), buses/h	0	0	0	0	0	0	0	0	0			
Arrival Type ( $AT$ )		3	3	3	3		3		3			
Upstream Filtering ( $I$ )		1.00	1.00	1.00	1.00		1.00		1.00			
Lane Width ( $W$ ), ft		12.0			12.0		12.0		12.0			
Turn Bay Length, ft		0			0		150		150			
Grade ( $P_g$ ), %		0			0			0			0	
Speed Limit, mi/h		45	45	45	45		45		45			

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green ( $G_{max}$ ) or Phase Split, s		45.0		45.0	20.0	30.0		
Yellow Change Interval ( $Y$ ), s		4.0		4.0	4.0	4.0		
Red Clearance Interval ( $R_c$ ), s		1.0		1.0	1.0	1.0		
Minimum Green ( $G_{min}$ ), s		6		6	6	6		
Start-Up Lost Time ( $l_t$ ), s		2.0	2.0	2.0	2.0			
Extension of Effective Green ( $e$ ), s		2.0	2.0	2.0	2.0			
Passage ( $PT$ ), s		2.0		2.0	2.0	2.0		
Recall Mode		Min		Min	Off	Off		
Dual Entry		Yes		Yes	No	Yes		
Walk ( $Walk$ ), s		0.0				0.0		0.0
Pedestrian Clearance Time ( $PC$ ), s		0.0				0.0		0.0

Multimodal Information	EB			WB			NB			SB		
85th % Speed / Rest in Walk / Corner Radius	0	No	25				0	No	25	0	No	25
Walkway / Crosswalk Width / Length, ft	9.0	12	0				9.0	12	0	9.0	12	0
Street Width / Island / Curb	0	0	No	0		No	0	0	No		0	
Width Outside / Bike Lane / Shoulder, ft	12	5.0	2.0	12	5.0	2.0	12	5.0	2.0			
Pedestrian Signal / Occupied Parking	No		0.50			0.50	No		0.50	No		

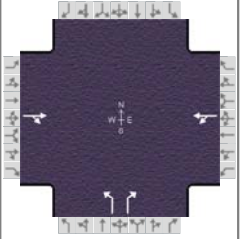
# HCS7 Signalized Intersection Results Summary

## General Information

Agency		Analysis Date	1/20/2020
Analyst		Time Period	
Jurisdiction		Analysis Year	2020
Urban Street	Washinton Street	File Name	027 Holliston Build PM.xus
Intersection	Hoppng Brook Road		
Project Description	Build with Improvement		

## Intersection Information

Duration, h	0.25
Area Type	Other
PHF	0.95
Analysis Period	1> 7:00



## Demand Information

	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand ( v ), veh/h		536	85	43	755		249		102			

## Signal Information

Cycle, s	38.9	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

## Timer Results

	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		
Case Number		8.0		8.0		9.0		
Phase Duration, s		25.9		25.9		13.0		
Change Period, ( Y+R <sub>c</sub> ), s		5.0		5.0		5.0		
Max Allow Headway ( MAH ), s		3.0		3.0		3.1		
Queue Clearance Time ( g <sub>s</sub> ), s		12.1		17.4		7.5		
Green Extension Time ( g <sub>e</sub> ), s		3.4		3.4		0.7		
Phase Call Probability		1.00		1.00		0.98		
Max Out Probability		0.00		0.01		0.00		

## Movement Group Results

	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement		2	12	1	6		3		18			
Adjusted Flow Rate ( v ), veh/h		654			840		262		107			
Adjusted Saturation Flow Rate ( s ), veh/h/ln		1825			1802		1739		1610			
Queue Service Time ( g <sub>s</sub> ), s		10.1			5.3		5.5		2.2			
Cycle Queue Clearance Time ( g <sub>c</sub> ), s		10.1			15.4		5.5		2.2			
Green Ratio ( g/C )		0.54			0.54		0.21		0.21			
Capacity ( c ), veh/h		980			1065		360		333			
Volume-to-Capacity Ratio ( X )		0.667			0.789		0.729		0.322			
Back of Queue ( Q ), ft/ln ( 50 th percentile)		39.4			60.1		43.1		14.9			
Back of Queue ( Q ), veh/ln ( 50 th percentile)		1.6			2.4		1.7		0.6			
Queue Storage Ratio ( RQ ) ( 50 th percentile)		0.00			0.00		0.29		0.10			
Uniform Delay ( d <sub>1</sub> ), s/veh		6.5			7.6		14.5		13.2			
Incremental Delay ( d <sub>2</sub> ), s/veh		0.3			0.5		1.1		0.2			
Initial Queue Delay ( d <sub>3</sub> ), s/veh		0.0			0.0		0.0		0.0			
Control Delay ( d ), s/veh		6.8			8.1		15.5		13.4			
Level of Service ( LOS )		A			A		B		B			
Approach Delay, s/veh / LOS	6.8	A		8.1	A		14.9	B		0.0		
Intersection Delay, s/veh / LOS	9.0						A					

## Multimodal Results

	EB			WB			NB			SB		
Pedestrian LOS Score / LOS	1.63	B		0.66	A		1.70	B		1.70	B	
Bicycle LOS Score / LOS	1.57	B		1.87	B			F				



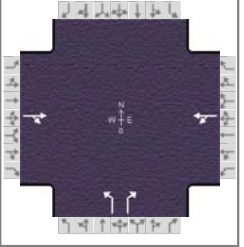
# HCS7 Signalized Intersection Intermediate Values

## General Information

Agency		Analysis Date	1/20/2020	Duration, h	0.25
Analyst		Area Type	Other	PHF	0.95
Jurisdiction		Analysis Year	2020	Analysis Period	1 > 7:00
Urban Street	Washinton Street	File Name	027 Holliston Build PM.xus		
Intersection	Hoppng Brook Road				
Project Description	Build with Improvement				

## Intersection Information

Duration, h	0.25
Area Type	Other
PHF	0.95
Analysis Period	1 > 7:00



## Demand Information

	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand ( $v$ ), veh/h		536	85	43	755		249		102			

## Signal Information

Cycle, s	38.9	Reference Phase	2									
Offset, s	0	Reference Point	End	Green	20.9	8.0	0.0	0.0	0.0	0.0		
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	4.0	4.0	0.0	0.0	0.0	0.0		
Force Mode	Fixed	Simult. Gap N/S	On	Red	1.0	1.0	0.0	0.0	0.0	0.0		

## Saturation Flow / Delay

	L	T	R	L	T	R	L	T	R	L	T	R
Lane Width Adjustment Factor ( $f_w$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Heavy Vehicles and Grade Factor ( $f_{HVg}$ )	1.000	0.984	1.000	1.000	0.984	1.000	0.961	1.000	1.000	1.000	1.000	1.000
Parking Activity Adjustment Factor ( $f_p$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000
Bus Blockage Adjustment Factor ( $f_{bb}$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000
Area Type Adjustment Factor ( $f_a$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Lane Utilization Adjustment Factor ( $f_{LU}$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Left-Turn Adjustment Factor ( $f_{LT}$ )	1.000	0.976		0.964	0.964		0.952	0.000				
Right-Turn Adjustment Factor ( $f_{RT}$ )		0.000	0.976		0.000	0.964		0.000	0.847			
Left-Turn Pedestrian Adjustment Factor ( $f_{LPB}$ )	1.000			1.000			1.000					
Right-Turn Ped-Bike Adjustment Factor ( $f_{RPB}$ )			1.000			1.000			1.000			
Work Zone Adjustment Factor ( $f_{WZ}$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
DDI Factor ( $f_{DDI}$ )	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Movement Saturation Flow Rate ( $s$ ), veh/h	0	1576	250	97	1705	0	1739	0	1610			
Proportion of Vehicles Arriving on Green ( $P$ )	0.00	0.54	0.54	0.54	0.54	0.00	0.21	0.00	0.21	0.00	0.00	0.00
Incremental Delay Factor ( $k$ )		0.04			0.04		0.04		0.04			

## Signal Timing / Movement Groups

	EBL	EBT/R	WBL	WBT/R	NBL	NBT/R	SBL	SBT/R
Lost Time ( $t_L$ )		5.0		5.0		5.0		
Green Ratio ( $g/C$ )		0.54		0.54		0.21		
Permitted Saturation Flow Rate ( $s_p$ ), veh/h/ln		694		791		1739		
Shared Saturation Flow Rate ( $s_{sh}$ ), veh/h/ln		1870		0				
Permitted Effective Green Time ( $g_p$ ), s		0.0		21.0		25.0		
Permitted Service Time ( $g_u$ ), s		0.0		11.0		0.0		
Permitted Queue Service Time ( $g_{ps}$ ), s				5.3				
Time to First Blockage ( $g_r$ ), s		21.0		10.1		0.0		
Queue Service Time Before Blockage ( $g_{ts}$ ), s				10.1				
Protected Right Saturation Flow ( $s_R$ ), veh/h/ln						0		
Protected Right Effective Green Time ( $g_R$ ), s						0.0		

## Multimodal

	EB			WB			NB			SB		
Pedestrian $F_w / F_v$	0.972	0.000	0.000	0.000	0.000	0.000	0.972	0.000	0.000	0.972	0.000	0.000
Pedestrian $F_s / F_{delay}$	0.000	0.057	0.000	0.057	0.000	0.000	0.000	0.131	0.000	0.000	0.129	0.000
Pedestrian $M_{corner} / M_{cw}$												
Bicycle $c_b / d_b$	1073.11	4.18	1073.11	4.18	-308.33	25.92	-256.94	24.78				
Bicycle $F_w / F_v$	-3.64	1.08	-3.64	1.39	-3.64		-3.64			-3.64		

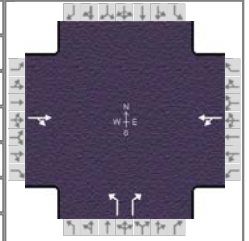
# HCS7 Signalized Intersection Results Graphical Summary

## General Information

Agency		Analysis Date	1/20/2020
Analyst		Time Period	
Jurisdiction		Analysis Year	2020
Urban Street	Washinton Street	File Name	027 Holliston Build PM.xus
Intersection	Hoppng Brook Road		
Project Description	Build with Improvement		

## Intersection Information

Duration, h	0.25
Area Type	Other
PHF	0.95
Analysis Period	1> 7:00



## Demand Information

	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand ( v ), veh/h		536	85	43	755		249		102			

## Signal Information

Cycle, s	38.9	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

## Movement Group Results

	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Back of Queue ( Q ), ft/ln ( 50 th percentile)		39.4			60.1		43.1		14.9			
Back of Queue ( Q ), veh/ln ( 50 th percentile)		1.6			2.4		1.7		0.6			
Queue Storage Ratio ( RQ ) ( 50 th percentile)		0.00			0.00		0.29		0.10			
Control Delay ( d ), s/veh		6.8			8.1		15.5		13.4			
Level of Service (LOS)		A			A		B		B			
Approach Delay, s/veh / LOS	6.8		A	8.1		A	14.9		B	0.0		
Intersection Delay, s/veh / LOS	9.0						A					

