Transportation Impact Assessment

Proposed Baldwin 2 Section Pk-8 School

Brookline, Massachusetts

Prepared for:

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TRANSPORTATION IMPACT ASSESSMENT

PROPOSED BALDWIN 2 SECTION PK-8 SCHOOL
BROOKLINE, MASSACHUSETTS

Prepared for:

Jonathan Levi Architects
Boston, Massachusetts

December 2018

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EXECUTIVE SUMMARY

VAI has completed a detailed assessment of the potential impacts on the transportation infrastructure associated with the proposed Baldwin 2 Section PK-8 School to be located off Heath Street in Brookline, Massachusetts. The proposed School will accommodate up to 453 students with 86 staff. The school size has been reduced from 800 students to the current 453 students which will significantly reduce the overall impact to the area. In addition, critical measures have been recommended to facilitate traffic flow in the area and to manage peak conditions, which were not considered in prior studies. These include: crossing guard control at Heath Street at Oak Street (School Drive), new phasing and timing at Heath Street and Hammond Street with a crossing guard; and a recommended Earlier Start Time. These new measures are designed to improve area safety conditions and reduce the school traffic during the area peak periods. Prior opinions with respect to this project were without benefit of a full traffic study and these recommendations. This assessment has been completed in accordance with State and Town standards and those of the Traffic Engineering and Transportation Planning professions for the preparation of such reports. The following specific areas have been evaluated as they relate to the Project: i) access requirements; ii) potential off-site improvements; and iii) safety considerations; under existing and future conditions, both with and without the Project. Based on this assessment, we have concluded the following with respect to the Project:

- Based upon a safety assessment of the area, the school can be safely accommodated with the design as planned.

- The impact of the proposed school will be very similar to conditions experienced at other schools in Brookline. Impacts are limited to a short 15-20-minute period during parents' drop-off and pick-up times.

- The school is expected to generate approximately 340 vehicle trips (207 entering/ 133 exiting) during the weekday morning peak-hour and 174 vehicle trips (82 entering/ 92 exiting) during the weekday afternoon peak-hour.

- During the peak period in the morning, only 71 vehicles turn left from the school driveway onto Heath Street over a one-hour period.

- The proposed driveway off Oak Street has adequate sight distances for safe and efficient operations.

- Safe conditions can be achieved with sidewalks, crosswalks and crossing guards at appropriate locations for students walking to school. The town will implement safety improvements to the area sidewalks.

- The Project will increase traffic in the morning and afternoon periods with increased delays and queues at locations within the study area. These delays and queues will be confined to limited and distinct periods during the morning drop-off and afternoon pick-up periods (15-20 minutes at peaks) and these periods are non-coincident with the peak periods of the adjacent roadways.

In summary, the proposed site is a good location for a new school and a safe environment can be maintained with traffic conditions at manageable levels. While the school can be safely accommodated, there will be delays and queues during limited period of the day, and improvements will be necessary to minimize the impacts and enhance safety conditions.

RECOMMENDATIONS

A detailed transportation improvement program has been developed that is designed to maintain safe and efficient access to the school and address any deficiencies identified at off-site locations evaluated in conjunction with this study. The following improvements have been recommended as a part of this evaluation and will be completed in coordination with the Town.

School Start Time

Based upon observations of area traffic it is recommended that the school start time begin prior to 8:00 AM in advance of peak traffic volumes. Even a 15-minute adjustment to a 7:45 AM start will significantly improve conditions.

Project Access and Circulation

The school driveways were planned such that traffic impacts to the area are minimized and safe and efficient access and egress is provided. As currently planned, an entrance driveway will be located along Heath Street at Dunster Street with an exit driveway at Oak Street. The on-site circulation includes a 650-foot drop-off area for queuing.

The following recommendations are offered with respect to the design and operation of the school site driveways:

- The main entrance driveway should have a minimum 24-foot entrance and will be illuminated. The driveway will provide two lanes with a drop-off/pick-up lane and a separate by-pass lane.

- The Oak Street driveway will be a minimum of 24-feet wide accommodating two-way traffic and will be under stop control and illuminated. During peak drop-off and pick-up periods this location will be placed under crossing guard control.

- A bus pull-off area is recommended off Heath Street and shall be designed such that buses pull-off from Heath Street to safely drop-off and pick-up students.

- School Zone signs, pavement markings and traffic control devices (i.e., flashing school speed limit signs) should be provided along Heath Street.

- All signs and other pavement markings to be installed within the Project site shall conform to the applicable standards of the current Manual on Uniform Traffic Devices (MUTCD).[1]

- Signs and landscaping adjacent to the Project site driveway intersections should be designed and maintained so as not to restrict lines of sight.

Pedestrian Improvements

New crosswalks are proposed along Heath Street and Hammond Street. The new Heath Street crosswalk is located near Oak Street where the sight lines are better. Sidewalks entering the site will be provided along the bus pull-off area and entering the site. In addition, all of the identified existing pedestrian deficiencies should be addressed by the Town including all pedestrian routes which are anticipated to accommodate teacher parking. ADA-complaint sidewalks should be provided in the area. The desirable sidewalk minimum width is five (5) feet and a 3-foot clearance at point objects. Further review of the pedestrian improvements will be required.

Proposed Rectangular Rapid Flashing Beacon (RRFB) signs are proposed along Route 9 at Dunster Road in the both directions and Hammond Street to alert drivers of the crossings and enhance safety for the school children. A pedestrian traffic signal is also proposed at Route 9 and Norfolk Road.

Off-Site

Hammond Street at Route 9 and Hammond Street at Heath Street

The Heath Street and Hammond Street signalized intersections will be retimed to include an exclusive pedestrian phase and reallocated green time to Heath Street approach to better facilitate peak traffic movements associated with the school. The new phasing and timing can better serve the peak school demand in comparison to the current signal timing and phasing. The Heath Street approach to Hammond Street will operate at LOS D, an acceptable peak condition. Hammond Street at Boylston Street (Route 9) will remain unchanged.

Traffic Enforcement

Increased traffic enforcement along Heath Street is recommended to enforce the school speed zone.

Parking

Designated teacher parking on local street must be approved by the Transportation Board. In addition, existing Heath Street on-street parking should be considered for 15-minute parking during parent drop-off and pick-up times. A minimum of 10 parking spaces should be provided on-site for visitors and handicap parking. An EV installation should be considered. Similar to other schools in Brookline, off-site parent parking can be found on local residential streets a short walking distance from the school.

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[1] *Manual on Uniform Traffic Control Devices (MUTCD); Federal Highway Administration; Washington, D.C.; 2009*

Bicycle Considerations

The following should be incorporated into the site plan.

- Bicycle racks should be provided proximate to the building entrance in a visible location.
- Interior bicycle storage and shower facilities should be provided.
- Bicycle enhancements by the Town should be reviewed for both Heath Street and Woodland Road.

Transit Usage

While public transit usage will be limited to staff, the school should actively promote staff usage of public transportation to the school. This should be incorporated into a school Travel Demand Management Plan.

School Drop-Off and Pick-Up Traffic Management Plan

A central feature of the Project is the implementation of a traffic and parking management plan for school drop-off and pick-up activities. The Project site and the site access and off-site improvements detailed herein have been developed to facilitate access to the school campus for pedestrians, bicyclists, school buses and parents/caregivers in a safe and efficient manner. The traffic and parking management plan has been designed to build-upon this created infrastructure and will consist of the following major elements, all of which are overseen by school staff:

- A crossing guard should be located at the Oak Street school driveway in order to manage the flow of vehicles exiting the school and pedestrian crossings.
- School staff should be stationed at the drop-off areas to manage traffic within the site and along the driveway, as well as to facilitate the safety of pedestrians and bicyclists.
- A designated drop-off/pick-up area should be designed to facilitate these movements.
- A lane along the entryway should remain unobstructed during student drop-off and pick-up times.
- Parents and caregivers should be given information on school drop-off and pick-up times and procedures at the beginning of the school year, with periodic updates and reminders provided as may be necessary.

The elements of the traffic and parking management plan for school drop-off and pick-up activities should be reviewed and updated as may be necessary in order to ensure the safety of students.

Regional Traffic in the Area

Regional traffic was observed to utilize Heath Street to access Route 9 and contribute to area delays. While not required for this project, neighborhood conditions can be improved with the following considerations:

- Implement peak hour on-way flow on Heath Street in the westbound direction.
- Closure of Dunster Road

These measures can be considered by the Town to reduce regional impacts to the immediate area.

Construction Management Plan

A detailed Construction Management Plan should be prepared and reviewed by the Town.

Traffic Monitoring

Within three months after school opening, a traffic monitoring study should be completed to review traffic counts at the school driveways and evaluate the traffic condition within the area.

Annually, the school should assess conditions and evaluate pedestrian safety, crossing guards, and evaluate the level of student busing and make adjustments, as necessary.

CONCLUSION

Overall, a safe environment to the school can be maintained and the increased traffic conditions with respect to delays and queues will be limited to short periods in the morning and afternoon.

INTRODUCTION

Vanasse & Associates, Inc. (VAI) has prepared this Transportation Impact Assessment (TIA) in order to identify the potential traffic impacts associated with the proposed Baldwin 2 Section PK-8 School to be located off Heath Street in Brookline, Massachusetts. As typical with school traffic in Brookline, there is a relatively short peak period of impacts between 15 and 20 minutes as drop-off and pick-up occur at the school. Generally, the morning peak is more pronounced than the afternoon peak, as after school programs reduce the afternoon impacts. The focus of this study is to provide a safe environment for the school children, while minimizing the impacts to the surrounding neighborhood. This report identifies and analyzes existing and future traffic conditions both with and without the school and reviews access requirements, potential off-site improvements, and safety considerations.

PROJECT DESCRIPTION

The Baldwin Elementary School will consist of a 453-student elementary school with 86 staff to be located on Heath Street in Brookline, Massachusetts. Careful consideration has been made with respect to site access and egress. The school will be serviced by two driveways onto Heath Street (Entrance only) and Oak Street (exit only). The primary school driveway entrance is located opposite Dunster Road. This enter only driveway will service mostly parent drop-off and pick-ups and limited parking. The second driveway is an exit only and will be located off Oak Street. The site will accommodate at a minimum 10 parking spaces for visitor and Handicap parking.

STUDY METHODOLOGY

The scope of the Transportation Assessment was reviewed with Town officials. This study was prepared in general accordance with the state and town guidelines for Transportation Impact Assessments (TIA); and was conducted in three distinct stages.

The first stage involved an assessment of existing conditions in the study area and included an inventory of roadway geometrics; observations of traffic flow; and collection of daily and peak period traffic counts.

In the second stage of the study, future traffic conditions were projected and analyzed. Specific travel demand forecasts for the school were assessed along with future traffic demands due to expected traffic growth independent of the project. A seven-year time horizon was selected for analyses consistent with state guidelines for the preparation of TIA. The traffic analysis conducted in stage two identifies existing or projected future roadway capacity, traffic safety, and site access issues.

The third stage of the study presents and evaluates measures to address traffic and safety issues, if any, identified in stage two of the study.

EXISTING CONDITIONS

A comprehensive field inventory of traffic conditions on the study area roadways was conducted. The field investigation consisted of an inventory of existing roadway geometrics, traffic volumes, and operating characteristics, as well as posted speed limits and land use information within the study area. The study area for the project was selected to contain the major roadway providing access to the project site, Heath Street, as well as 12 intersections located near the site:

1. Boylston Street at Hammond Street
2. Hammond Street at Heath Street
3. Hammond Street at Soule Recreation Drive and Private Drive
4. Hammond Street at Woodland Road
5. Heath Street at Oak Street
6. Heath Street at Dunster Road
7. Boylston Street at Dunster Road
8. Heath Street at Cary Road and Soule Recreation Drive
9. Heath Street at Woodland Road
10. Heath Street at Randolph Road
11. Heath Street at Warren Street
12. Horace James Circle: Newton Street at Hammond Street, Hammond Pond Parkway and LaGrange Street

The following describes the study area roadways and intersections. Figure 1 provides a Study Location Map and the study area intersections.

GEOMETRY

Roadways

Heath Street

Heath Street, in the vicinity of the site, is a roadway under local jurisdiction that generally travels in an east/west orientation in Brookline Massachusetts. Heath Street accommodates a two-lane roadway in each direction with travel separated by a double yellow centerline. Concrete sidewalks are generally provided along Heath Street within the study area. Land use along Heath Street consists primarily of residential, school and recreational properties. There is no posted speed limit on Heath Street in the vicinity of the site.

Figure 1

Site Location and Study Area Map

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Intersections

Figures 2 and 3 summarizes lane use and lane widths at the study area intersections as observed in November 2018.

EXISTING TRAFFIC VOLUMES

In order to determine existing traffic-volume demands and flow patterns within the study area, automatic traffic recorder (ATR) counts, manual turning movement counts (TMCs) and vehicle classification counts were completed in September 2018. The ATR counts were conducted on Heath Street in the vicinity of the Project site in order to record weekday daily traffic conditions over an extended period, with weekday morning (7:00 to 9:00 AM) and weekday afternoon (1:00 to 4:00 PM) peak period manual TMCs performed at the study intersections. These time periods were selected for analysis purposes as they are representative of the peak traffic volume hours for the school.

Traffic Volume Adjustments

In order to evaluate the potential for seasonal fluctuation of traffic volumes within the study area, historical traffic data collected by MassDOT were examined. Based on a review of seasonal adjustment factors collected by MassDOT for urban arterials and collectors, October traffic volumes are typically 3 percent higher than average monthly conditions and, therefore, were not adjusted downward in order to provide a conservative (above-average) analysis condition. For purposes of the study, the weekday morning peak hour of the school generally occurs between 7:00 and 8:00 AM while the weekday afternoon peak hour of the school generally occurs between 1:30 and 2:30 PM. In all instances, these peak hours of the school were utilized for analysis purposes.

The 2018 Existing traffic volumes are summarized in Table 1 and graphically depicted on Figures 4 and 5, respectively.

Table 1
EXISTING ROADWAY TRAFFIC-VOLUME SUMMARY

		Weekday Morning Peak Hour (7:00 - 8:00 AM)			Weekday Afternoon Peak Hour (1:30-2:30 PM)		
Location	Daily Volume (vpd)[a]	Volume (vph)[b]	Percent of Daily Traffic[c]	Predominant Flow	Volume (vph)	Percent of Daily Traffic	Predominant Flow
Heath Street, west of Dunster Road	3,400	369	10.6	53% EB	237	6.9	54% WB
Hammond Street North of Woodland Road	12,500	1,071	8.6	60% NB	729	5.8	55% SB

[a]Two-way daily traffic expressed in vehicles per day; from ATR Counts October 2018.
[b]Manual turning movement counts conducted in September 2018
[c]The percent of daily traffic that occurs during the peak hour.
SB = southbound; EB = eastbound; WB = westbound;

As can be seen in Table 1, Heath Street was found to accommodate approximately 3,400 vehicles per day (vpd) with 369 vehicles per hour (vph) during the weekday morning school peak hour and

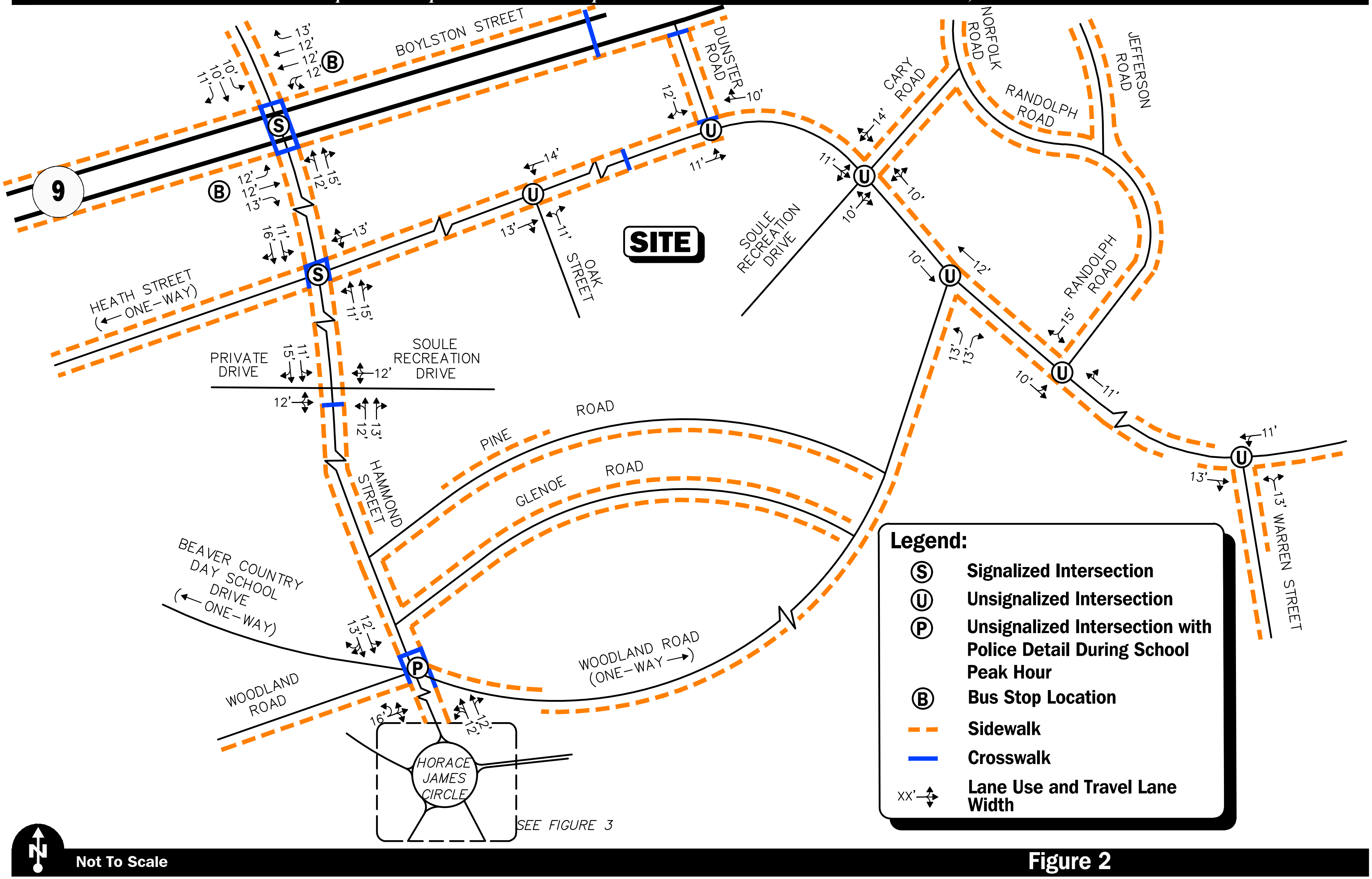

Figure 2

Existing Intersection Lane Use, Travel Lane Width and Pedestrian Facilities

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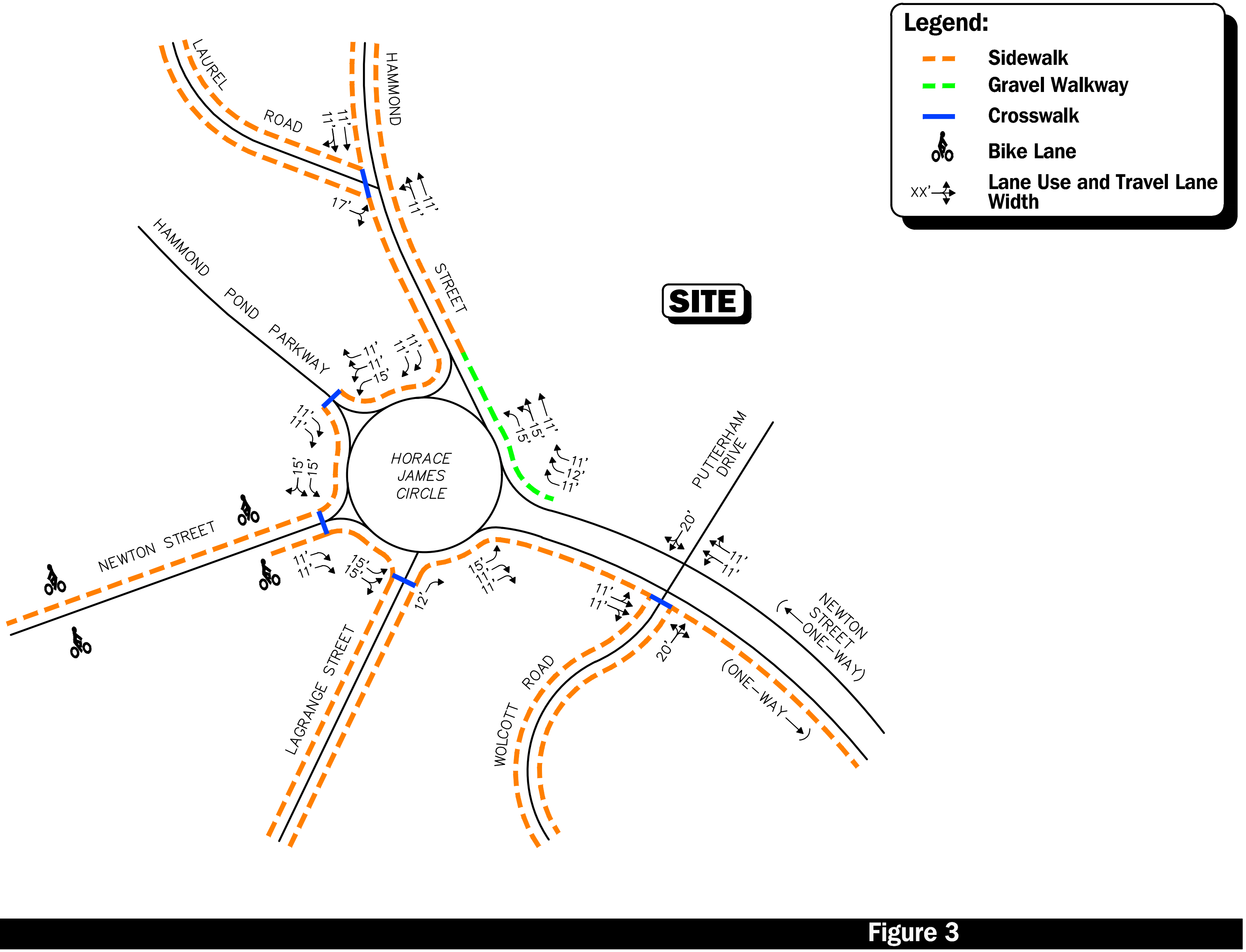

Figure 3

Existing Intersection Lane Use, Travel Lane Width and Pedestrian Facilities

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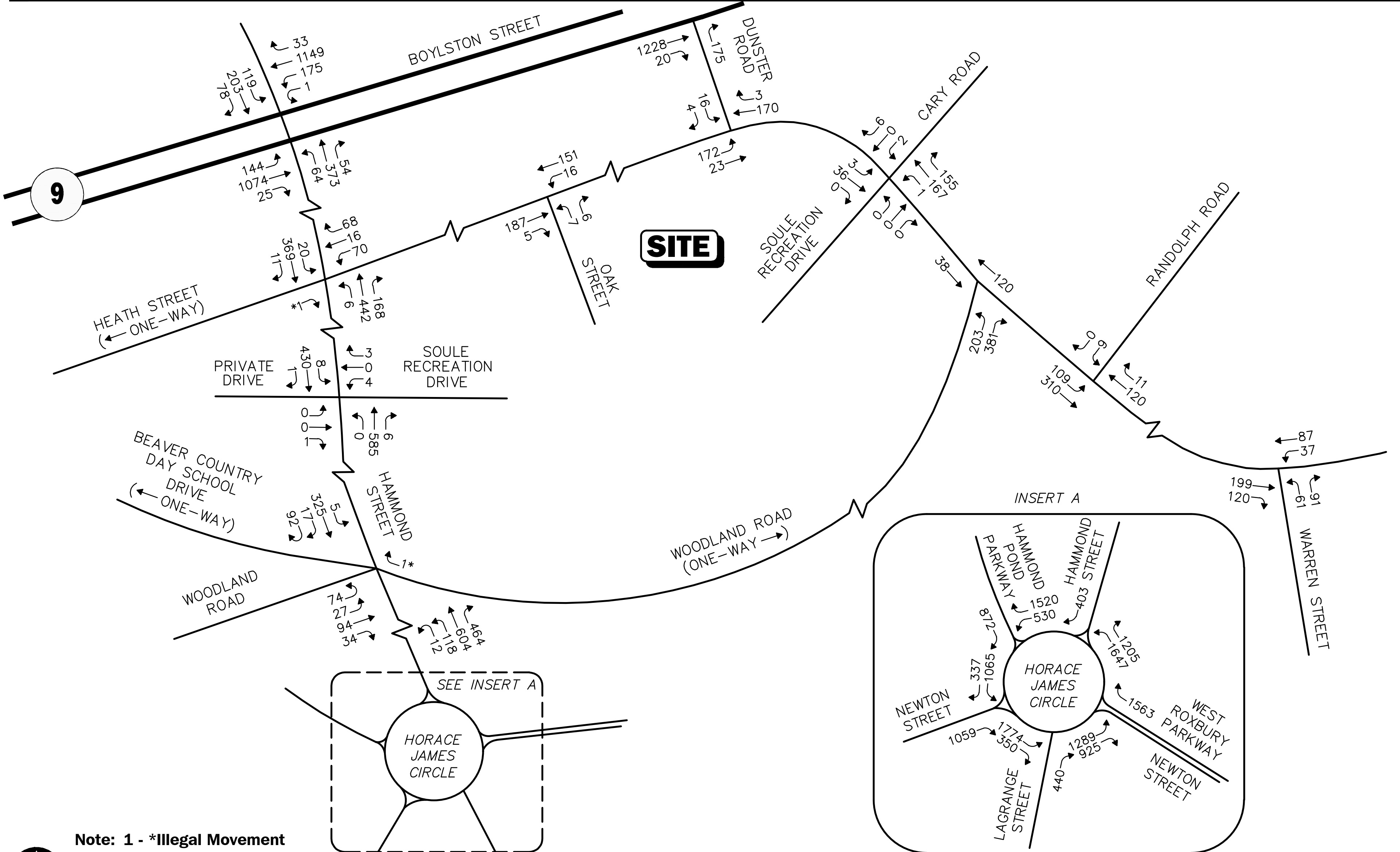

Note: 1 - *Illegal Movement

2 - Imbalances exist due to numerous curb cuts and side streets that are not shown.

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Figure 4

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2018 Existing
Weekday Morning
School Peak Hour Traffic Volume
(7:00 - 8:00 AM)

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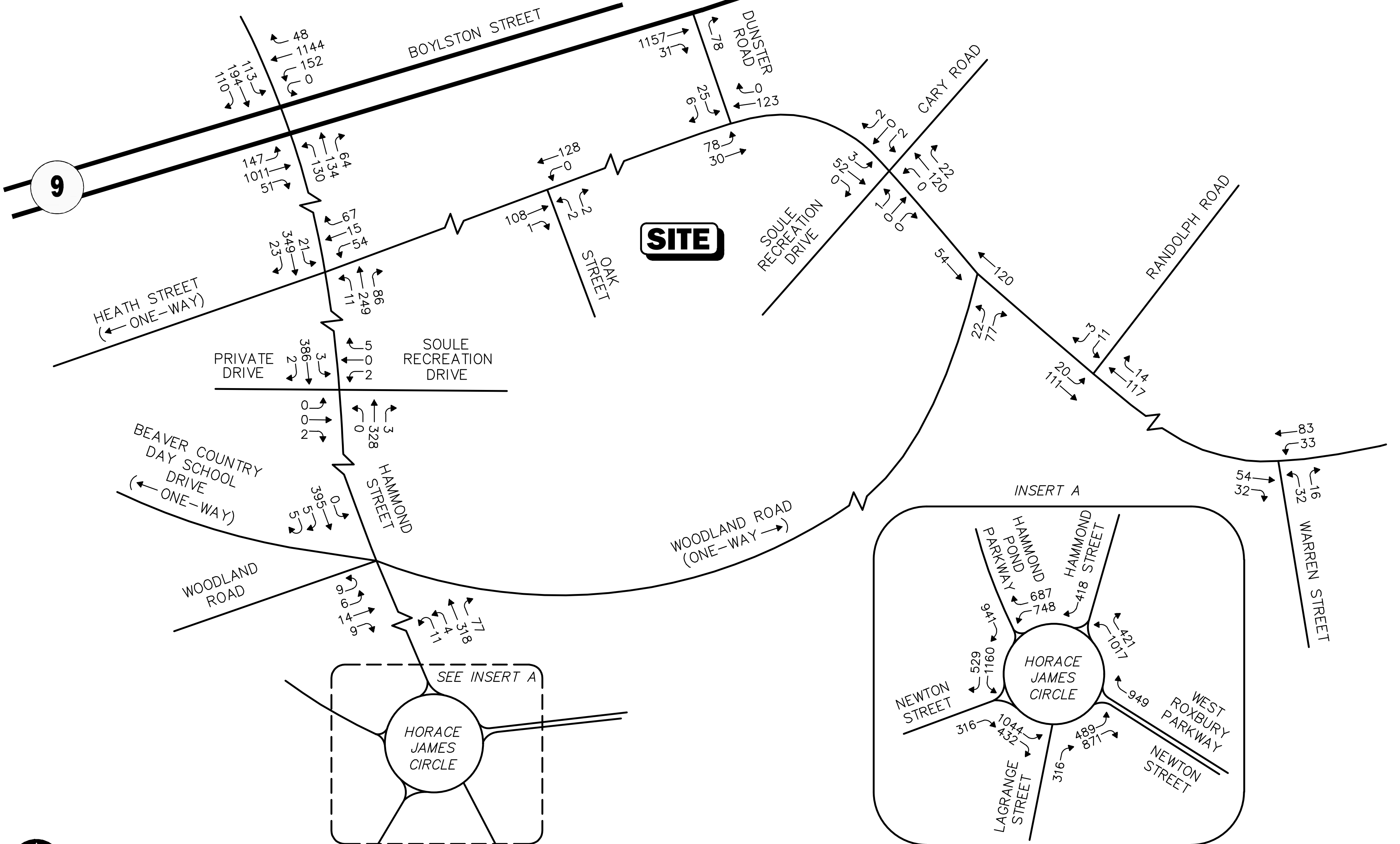

Note: Imbalances exist due to numerous curb cuts and side streets that are not shown.

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Figure 5

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2018 Existing
Weekday Afternoon
School Peak Hour Traffic Volume
(1:30 - 2:30 PM)

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237 vph during the weekday afternoon school peak hour. Directional traffic during the morning period is in the eastbound direction and during afternoon periods is in the westbound direction.

Figure 6 graphically depicts hourly traffic volumes along Heath Street between 6:00 AM and 11:00 AM and 1:00 PM and 7:00 PM. As shown, the highest hour of traffic occurs between 8:00 and 9:00 AM and 5:00 and 6:00 PM. It is important to note that the school traffic will occur prior to these peak periods and as such minimizes the impact of the school traffic in the area.

Figures 7 and 8 depict observed queues along Heath Street from Hammond Street for 5 minutes intervals for the anticipated peak school hours. During the morning period, queues increase between 7:35 and 8:00 AM, and the longest queues were observed after 8:00 AM. During the afternoon period, Heath Street queues peaked at 2:25 PM.

Based upon several observations of traffic conditions along Heath Street, it was concluded that a slightly earlier start time would be very beneficial to traffic flow entering and exiting the school.

PEDESTRIAN AND BICYCLE FACILITIES

A comprehensive field inventory of pedestrian and bicycle facilities within the study area was undertaken in October 2018. The field inventory consisted of a review of the location of sidewalks and pedestrian crossing locations along the study roadways and at the study intersections, as well as the location of bicycle facilities. Sidewalks are provided along both sides of Boylston Street, Hammond Street and Heath Street in the vicinity of the site. Marked crosswalks are provided along each approach to the Boylston Street at Hammond Street intersection and at the Heath Street at Hammond Street intersection, and along Hammond Street at the Soule Recreation Drive. No bicycle facilities were noted in the area. Figures 9 and 10 graphically depict the pedestrian volumes recorded in the area during the weekday morning and weekday afternoon school peak hours.

As part of the study, an inventory of existing deficiencies was completed in the immediate area of the proposed school. Figure 11 depicts existing deficiencies along the pedestrian routes within the study area. Deficiencies included non-ADA compliant ramps, utilities in sidewalks, non-compliant sidewalks and missing crosswalks. All existing area pedestrian routes including areas where teacher parking is planned, will be upgraded by the Town.

PUBLIC TRANSPORTATION

Public transportation services are provided within the study area by the Massachusetts Bay Transit Authority (MBTA). The MBTA operates fixed-route bus services in the vicinity. Bus Route 60 – Chestnut Hill – Kenmore Station via Brookline Village and Cypress Street stops at the intersection of Boylston Street at Hammond Street. The MBTA Green Line D Branch Chestnut Hill Station is located off of Hammond Street approximately 0.3 miles north of the Project site, less than a ten minute walk. The Town will actively promote staff-use of public transportation to the new school.

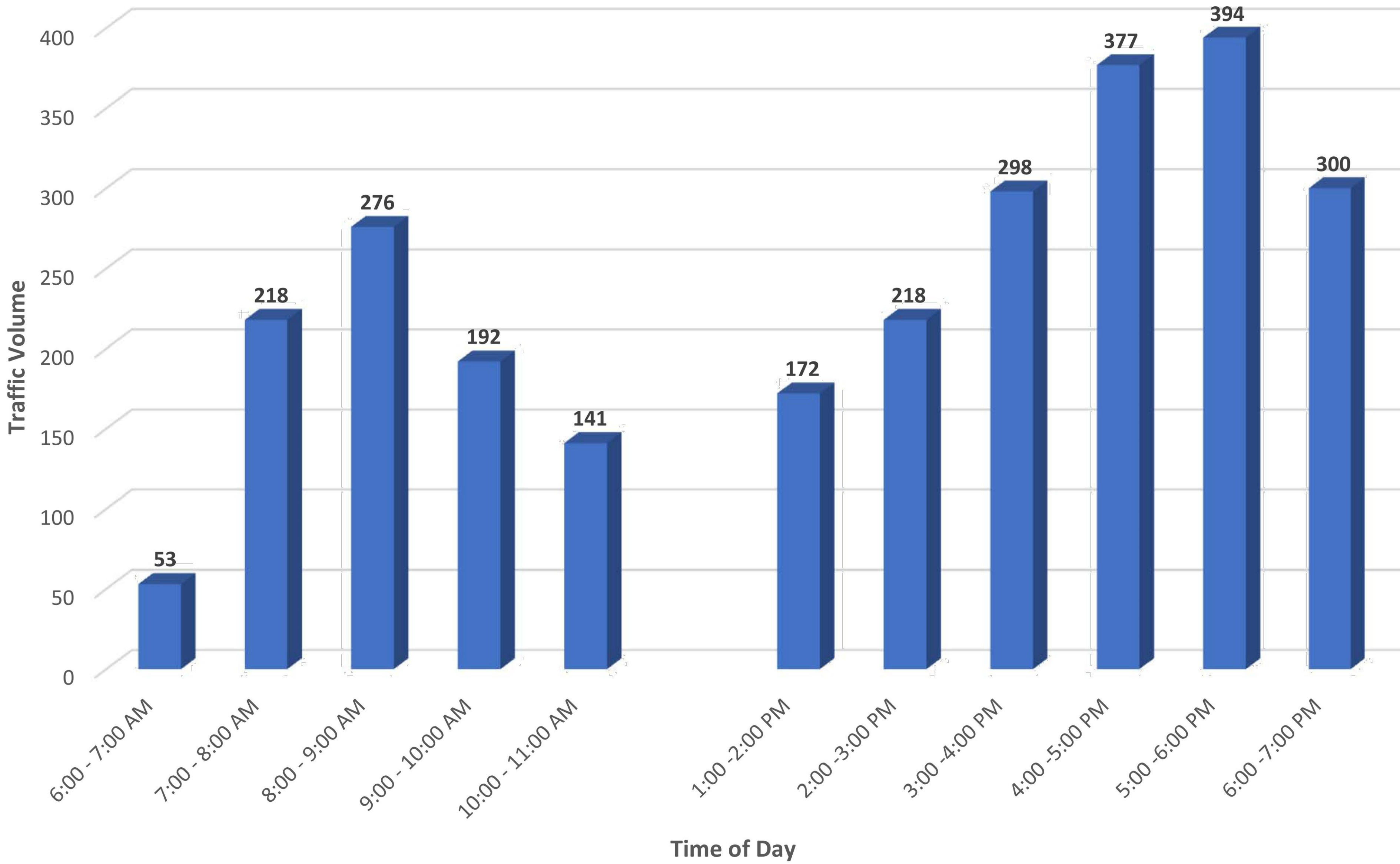

Figure 6

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Existing Heath Street Traffic Count October 01 , 2018

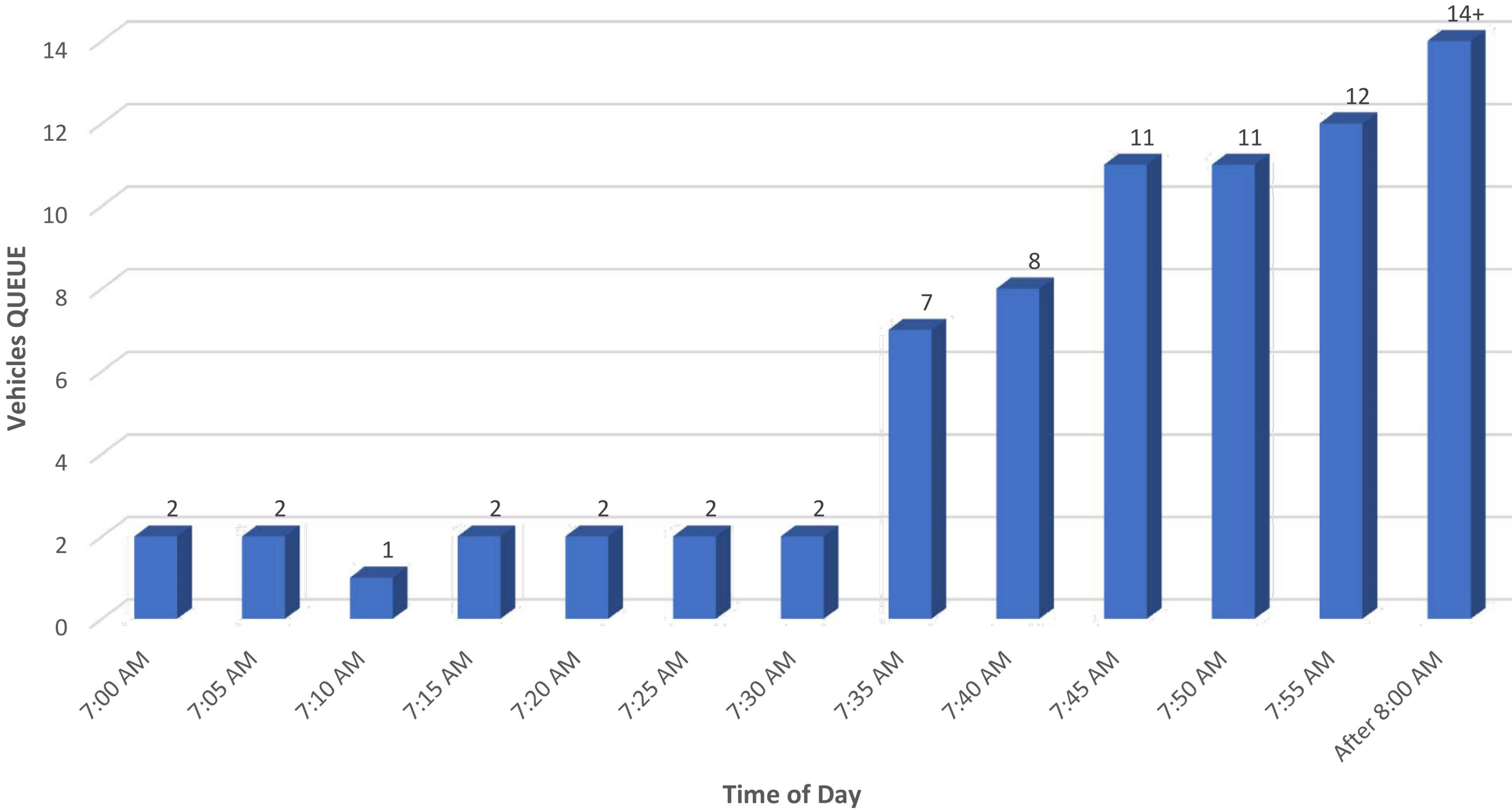

Figure 7

Vehicle Queue on Heath Street Weekday Morning October 16 , 2018

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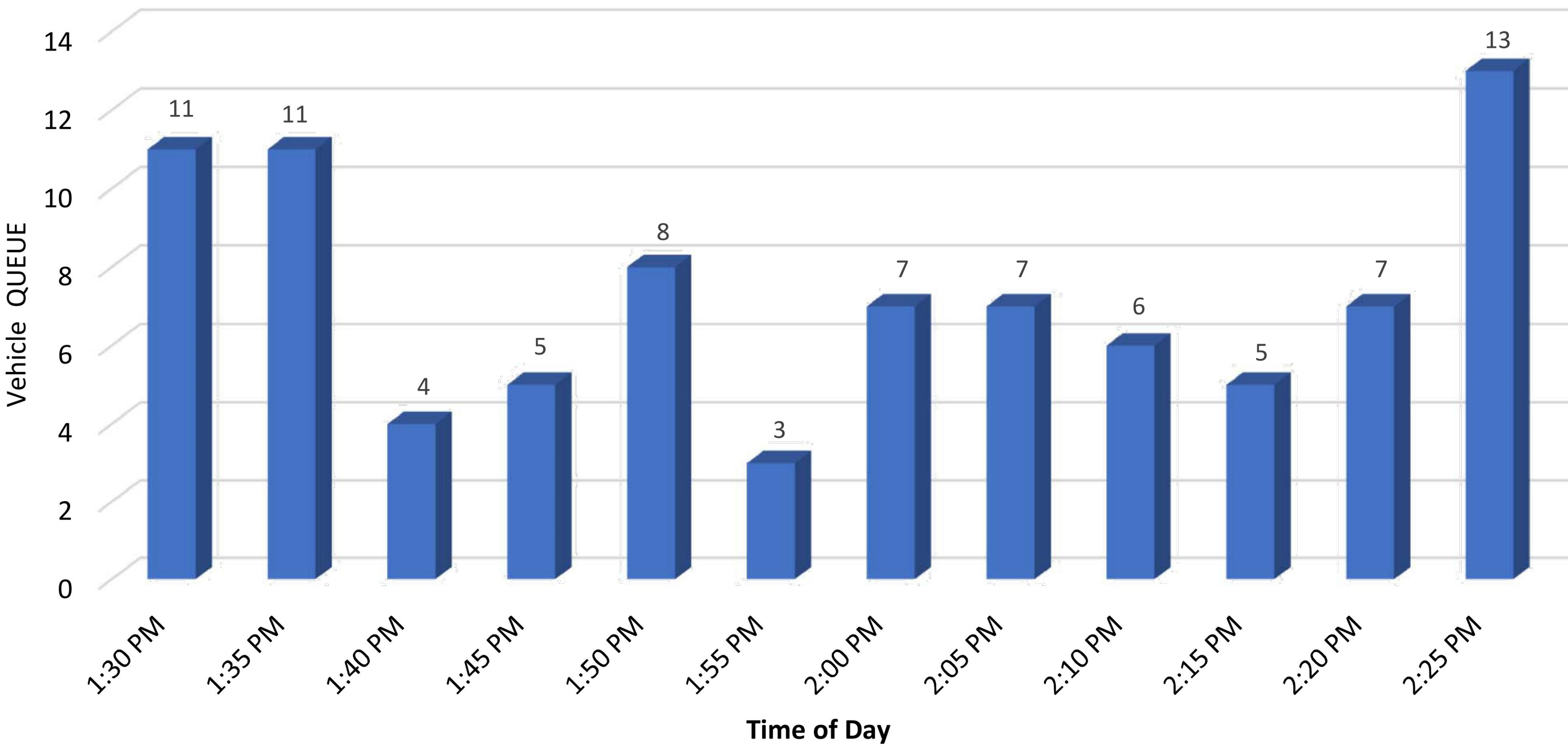

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Figure 8

Vehicle Queue
Heath Street
Weekday Afternoon
October 16 , 2018

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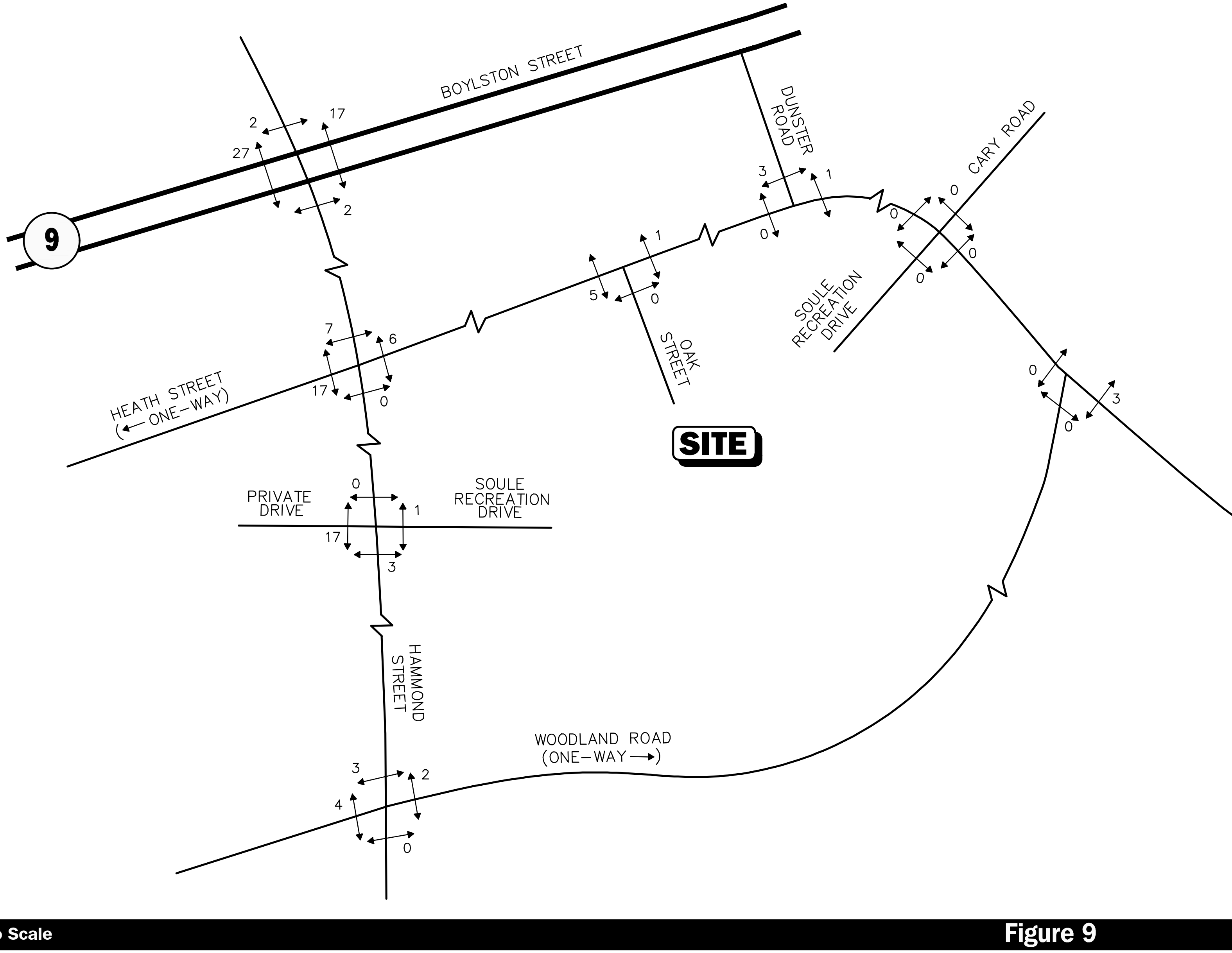

Figure 9

2018 Existing Weekday Morning School Peak Hour Pedestrian Volume (7:00 - 8:00 AM)

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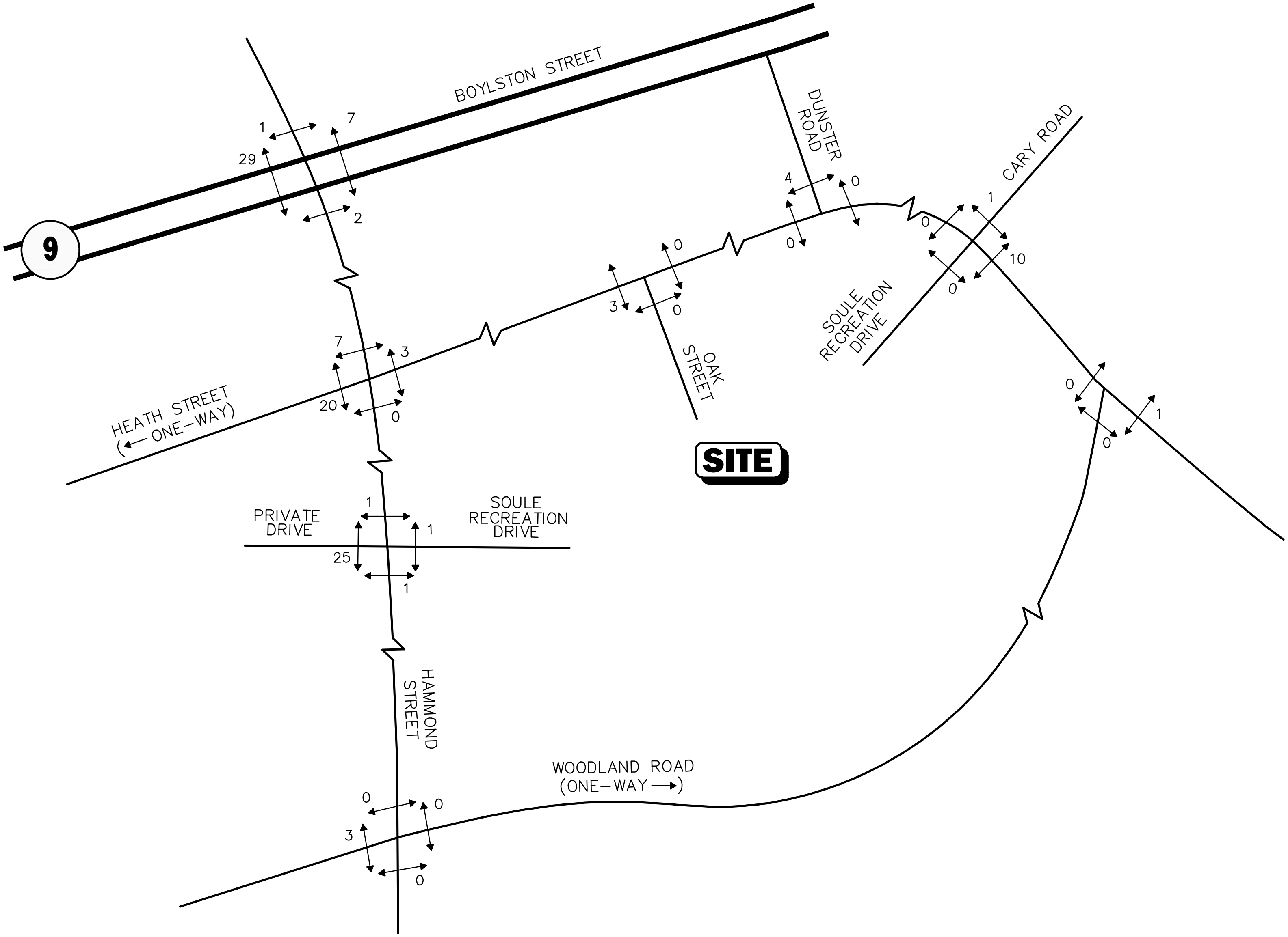

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Figure 10

2018 Existing Weekday Afternoon School Peak Hour Pedestrian Volume (1:30 - 2:30 PM)

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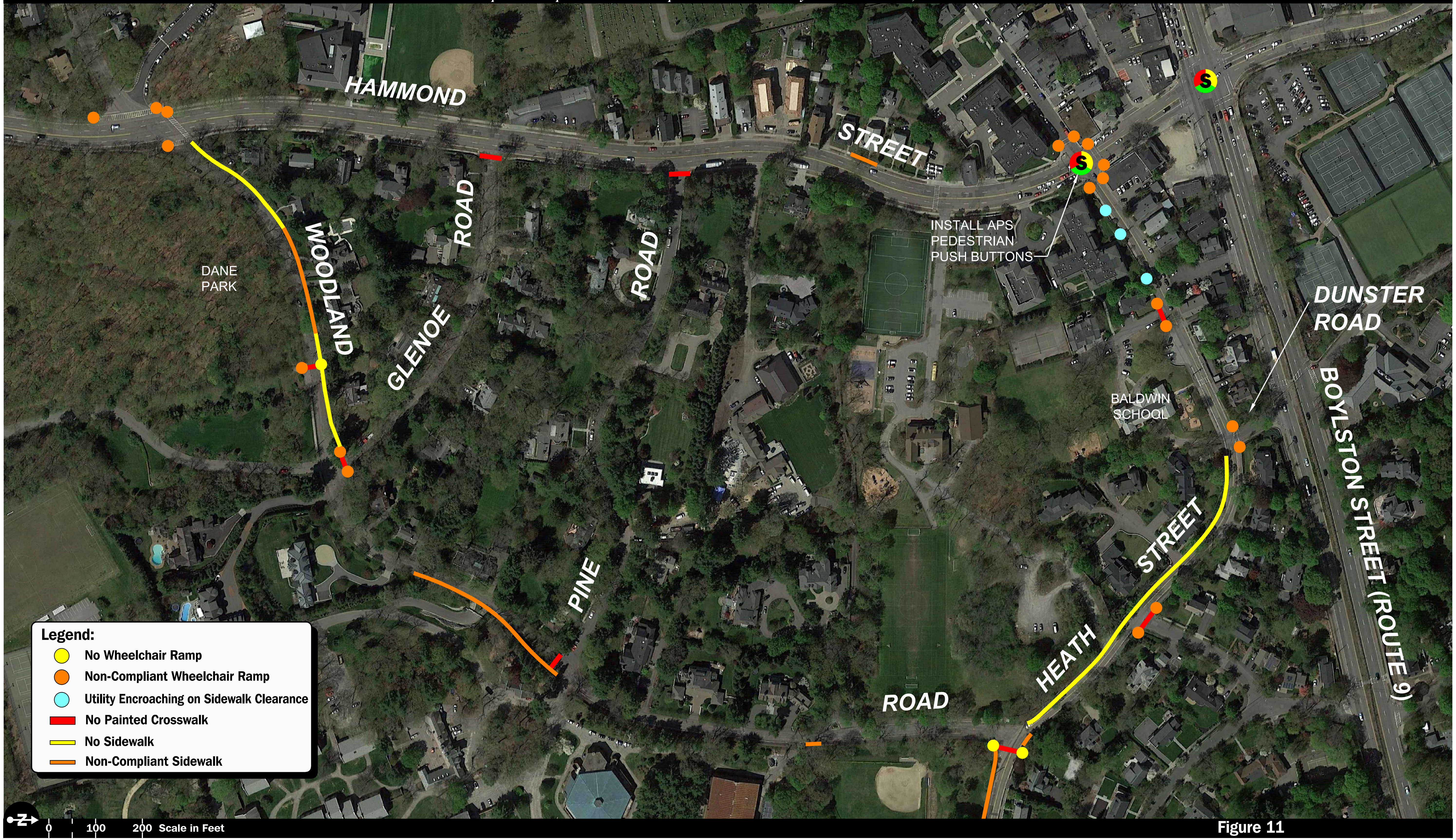

Figure 11

**Pedestrian Facility Deficiencies
Hammond Street, Heath Street
and Woodland Road**

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SPOT SPEED MEASUREMENTS

Vehicle travel speed measurements were performed on Heath Street in the vicinity of the Project site in conjunction with the ATR counts. Table 2 summarizes the vehicle travel speed measurements.

Table 2
VEHICLE TRAVEL SPEED MEASUREMENTS

	Heath Street	
	Eastbound	Westbound
Mean Travel Speed (mph)	27	28
85^{th} Percentile Speed (mph)	30	32
Speed Limit (mph)	25*	25*

mph = miles per hour.
*Unposted

As can be seen in Table 2, the mean (average) vehicle travel speed along Heath Street in the vicinity of the proposed school was found to be approximately 27 mph in the eastbound direction and 28 mph in the westbound direction. The measured 85^{th} percentile vehicle travel speed, or the speed at which 85^{th} percent of the observed vehicles traveled at or below, was found to be 30 mph in the eastbound direction and 32 mph in the westbound direction. The 85^{th} percentile speed is used as the basis of engineering design and in the evaluation of sight distances, and is often used in establishing posted speed limits.

SIGHT DISTANCE EVALUATION

Sight distance measurements were performed at the proposed school driveway exit with Heath Street in accordance with MassDOT and American Association of State Highway and Transportation Officials (AASHTO)[2] standards. In brief, Stopping Sight Distance (SSD) is the distance required by a vehicle traveling at the design speed of a roadway, on wet pavement, to stop prior to striking an object in its travel path. In accordance with AASHTO and MassDOT standards, at a minimum, sufficient stopping sight distances must be provided at an intersection. Table 3 presents the measured sight distances at Oak Street where the school traffic will exit.

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[2] *A Policy on Geometric Design of Highway and Streets,* 6^{th} Edition; American Association of State Highway and Transportation Officials (AASHTO); 2011.

Table 3
STOPPING SIGHT DISTANCE

	Required Minimum (Feet) [a]		
Intersection/Sight Distance Measurement	30 mph	35 mph	Measured (Feet)
Oak Street at Heath Street Exiting Sight Distance:			
Looking to the east from the driveway	200	250	360
Looking to the west from the driveway	200	250	240

[a]Recommended minimum values obtained from *A Policy on Geometric Design of Highways and Streets,* Fifth Edition; American Association of State Highway and Transportation Officials (AASHTO); 2011.

As shown in Table 3, the proposed school driveway has acceptable sight distances for over 35 mph indicating that safe operation can exist based upon the existing geometrics. It should be noted that existing vegetation to the west will need to be trimmed and maintained.

MOTOR VEHICLE CRASH DATA

Motor vehicle crash information for the study area intersections was provided by the MassDOT Safety Management/Traffic Operations Unit for the most recent five-year period available (2012 through 2016) in order to examine motor vehicle crash trends occurring within the study area. The data is summarized by intersection, type, pavement condition and severity in Table 4. Figure 12 graphically depicts the Accident Data at each study area intersection, by number of accidents, accidents per year and crash rate.

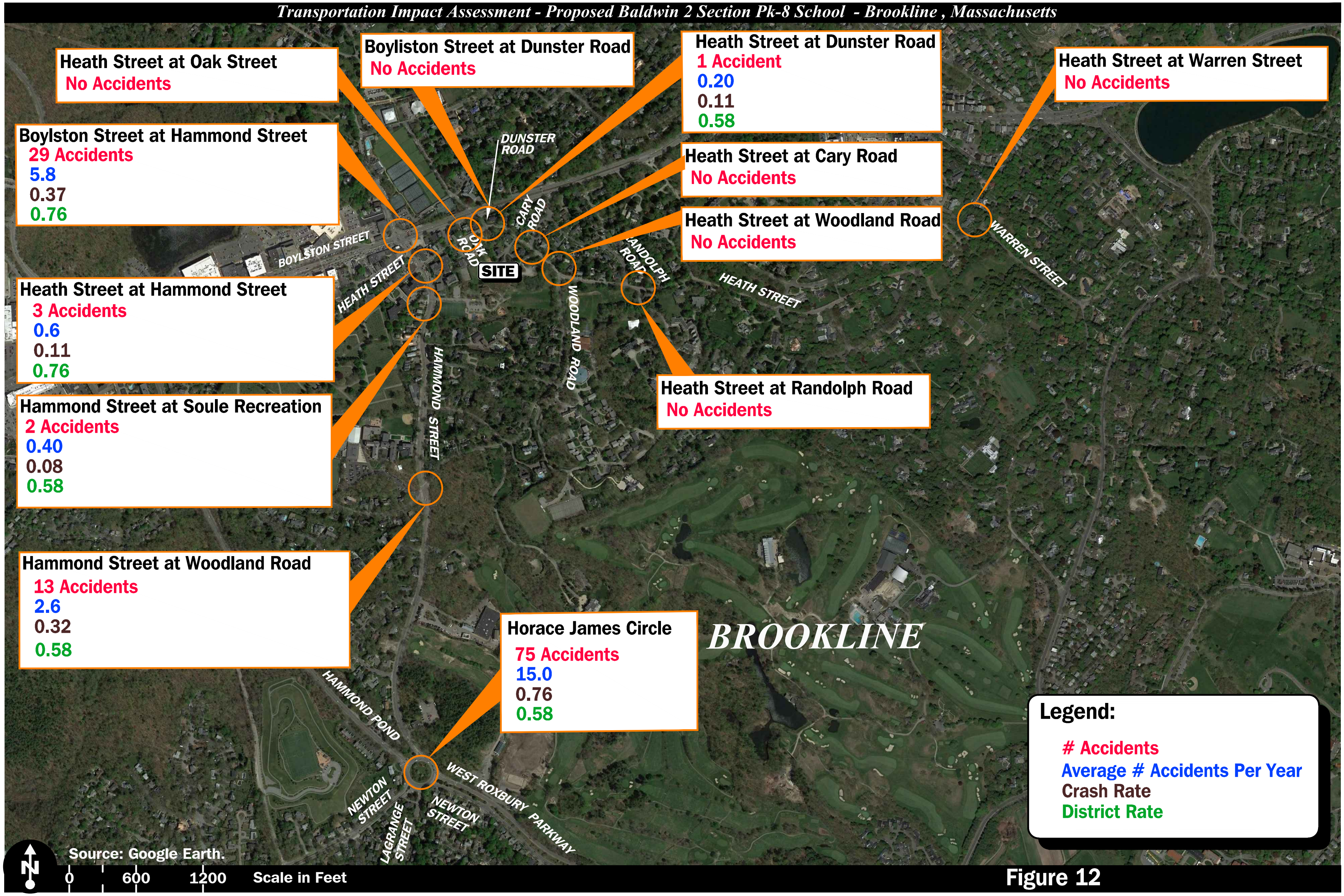

Figure 12

Accident Data

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Table 4
MOTOR VEHICLE CRASH DATA SUMMARY[a]

Scenario	Boylston Street (Route 9) at Hammond Street	Hammond Street at Heath Street	Hammond Street at Soule Rec Drive	Hammond Street at Woodland Road	Heath Street at Dunster Road	Horace James Circle
Year:						
2012	5	0	0	3	0	7
2013	4	1	0	1	0	11
2014	5	0	1	5	1	14
2015	3	1	1	2	0	15
2016	12	1	0	2	0	28
Total	29	3	2	13	0	75
Average[a]	5.80	0.60	0.40	2.60	0.20	15.0
Crash Rate[b]	0.37	0.11	0.08	0.32	0.11	0.76
Significant	No	No	No	No	No	Yes
Type:						
Angle	8	2	1	8	0	29
Rear-End	12	0	0	1	0	22
Head-On	2	0	0	1	0	0
Sideswipe	4	1	1	0	0	17
Fixed Object	2	0	0	2	1	7
Other	1	0	0	1	0	0
Total	29	3	2	13	1	75
Pavement Conditions:						
Dry	23	3	1	10	0	64
Wet	5	0	1	3	0	9
Snow/Ice	1	0	0	0	1	1
Unknown/ Other	0	0	0	0	0	1
Total	29	3	2	13	1	75
Severity:						
Property Damage Only	16	2	1	9	1	47
Personal Injury	12	1	1	4	0	27
Fatality	0	0	0	0	0	1
Unknown	1	0	0	0	0	0
Total	29	3	2	13	1	75

[a]Average crash over five-year period.
[b]Crash rate per million entering vehicles (mev).
Source: MassDOT Crash Data, 2012 through 2016.

As can be seen in Table 4, the intersection of Horace James Circle experienced a total of 75 accidents reported at the intersection over the five-year review period, averaging 15 accidents per year. All other intersections experienced less than 6 crashes per year. All of the study intersections were found to have a motor vehicle crash rate below the MassDOT average for the District 6 (0.71 for signalized intersections and 0.52 for unsignalized intersections), with the exception of Horace James Circle which had a crash rate of 0.76, which is slightly above the District average. This is typical of traffic circles with many conflict points within the circle. Pedestrian accidents were also reported at Boylston Street at Hammond Street (2), Hammond Street at Woodland Street (1), and the Horace James Circle (4). Based upon a review of the accident data, it can be concluded that safe conditions currently exist in the area of the proposal school.

FUTURE CONDITIONS

To determine the impact of school traffic volumes on the roadway network under future conditions, baseline traffic volumes in the study area were projected to the year 2025. Traffic volumes on the roadway network at that time, in the absence of the project (that is, the No-Build condition), would include existing traffic, new traffic due to general background traffic growth, and traffic related to specific development by others expected to be completed by 2025. Inclusion of these factors resulted in the development of 2025 No-Build traffic volumes. Anticipated site-generated traffic volumes were then superimposed upon these No-Build traffic-flow networks to develop the 2025 Build traffic-volume conditions.

FUTURE TRAFFIC GROWTH

Traffic growth on area roadways is a function of the expected land development in the immediate area, as well as the surrounding region. Several methods are used to estimate this growth. A procedure frequently employed estimates an annual percentage increase in traffic growth and applies that percentage to all traffic volumes under study. The drawback to such a procedure is that some turning volumes may actually grow at either a higher or a lower rate at particular intersections.

An alternative procedure identifies the location and type of planned development, estimates the traffic to be generated, and assigns it to the area roadway network. This produces a more realistic estimate of growth for local traffic. However, the drawback of this procedure is that the potential growth in population and development external to the study area would not be accounted for in the traffic projections.

To provide a conservative analysis framework, both procedures were used.

General Background Growth

Traffic-volume data compiled by MassDOT from permanent count stations and historic traffic counts in the area were reviewed in order to determine general background traffic growth trends. Based on a review of this data and other area traffic studies, a 1.0 percent per year compounded annual background traffic growth rate was used in order to conservatively account for future traffic growth and presently unforeseen development within the study area. This is consistent with previous traffic studies conducted for the area[3].

Specific Development by Others

The Town of Brookline and the City of Newton were contacted in order to determine if there are any planned or approved specific development projects within the area that would have an impact on future traffic volumes at the study intersections. Based on these discussions two projects were identified:

1180 Boylston Street. This project consists of the development of 45 age-restricted (55+) apartments and 7,000 sf of retail. The Site Generated volumes from the traffic study were added to the No-Build volumes (see distribution in appendix). This project has Route 9 access only and will not impact Hammond Street or Heath Street.

Life Time Center – 300 Boylston Street, Newton. This project is a 265,000-sf reuse of retail space to a Wellness Center including a health club and medical offices. Traffic volumes were estimated and incorporated for peak school peak times.

No other background developments were identified within the study area.

Planned Roadway Improvements

The Town of Brookline was contacted in order to determine if there are any planned roadway improvement projects expected to be completed within the study area. Based on these discussions, two projects were identified:

- ***Hammond Street at Woodland Road Intersection Improvement Study.*** Intersection alternatives have been evaluated by the team and their consultant. The preferred alternative is traffic signalization.

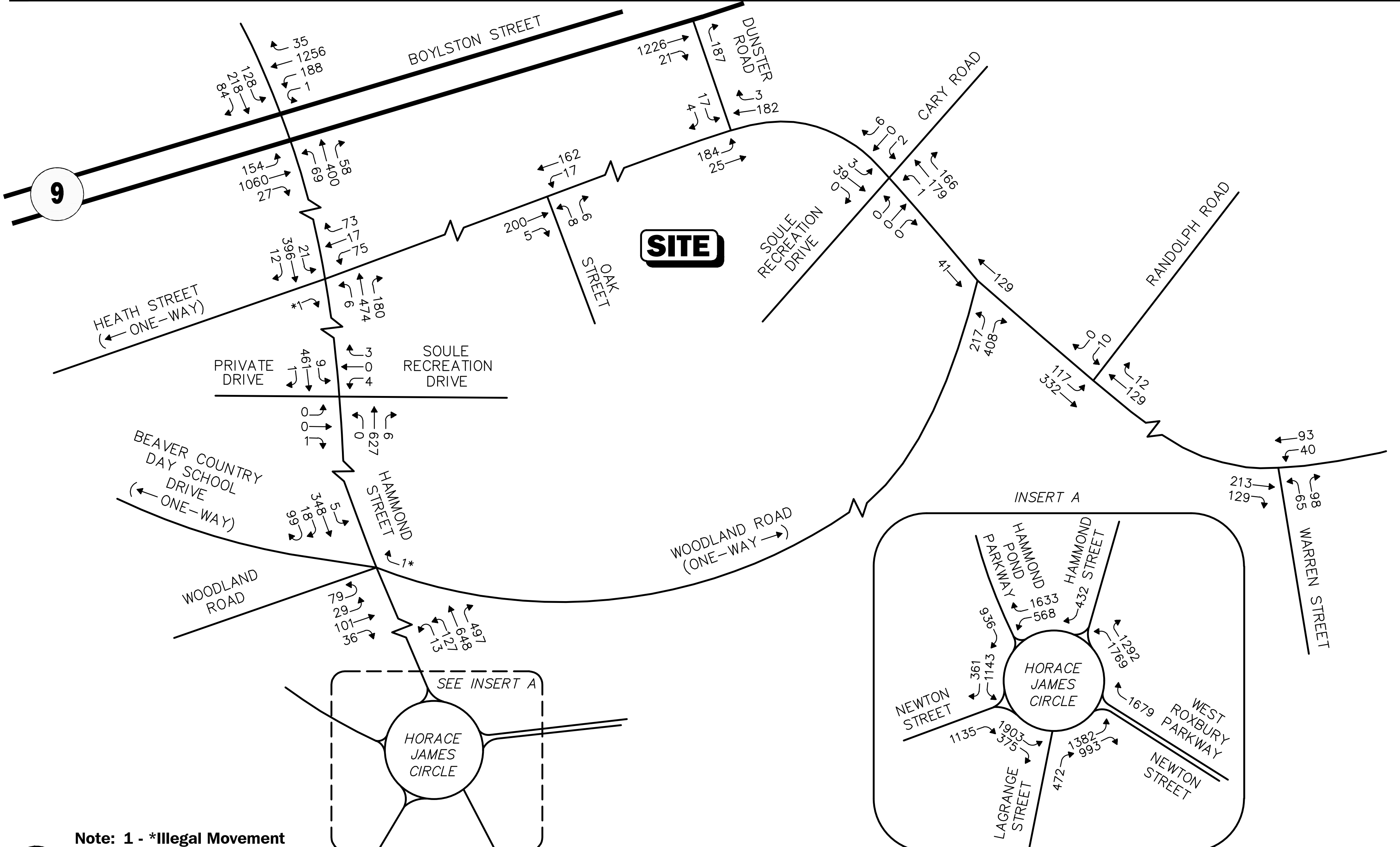
- ***Woodland Road Traffic Calming Study.*** The Town is currently assessing traffic calming measures for Woodland Road.

In addition, the Town is considering a potential "Road Diet" along Hammond Street allowing for left-turn lanes at intersections and bicycle lanes.

No-Build Traffic Volumes

The 2025 No-Build school peak-hour traffic-volume networks for weekday morning and weekday afternoon were developed by applying the 1.0 percent per year compounded annual background traffic growth rate to the Existing school peak-hour traffic volumes plus the identified background development. The resulting 2025 No-Build weekday morning and weekday afternoon school peak-hour traffic volume networks are shown on Figures 13 and 14.

[3] 1180 Boylston Street, VAI March 2016.



Note: 1 - *Illegal Movement

2 - Imbalances exist due to numerous curb cuts and side streets that are not shown.

Not To Scale

Figure 13

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Transportation Engineers & Planners

2025 No-Build
Weekday Morning
School Peak Hour Traffic Volume
(7:00 - 8:00 AM)

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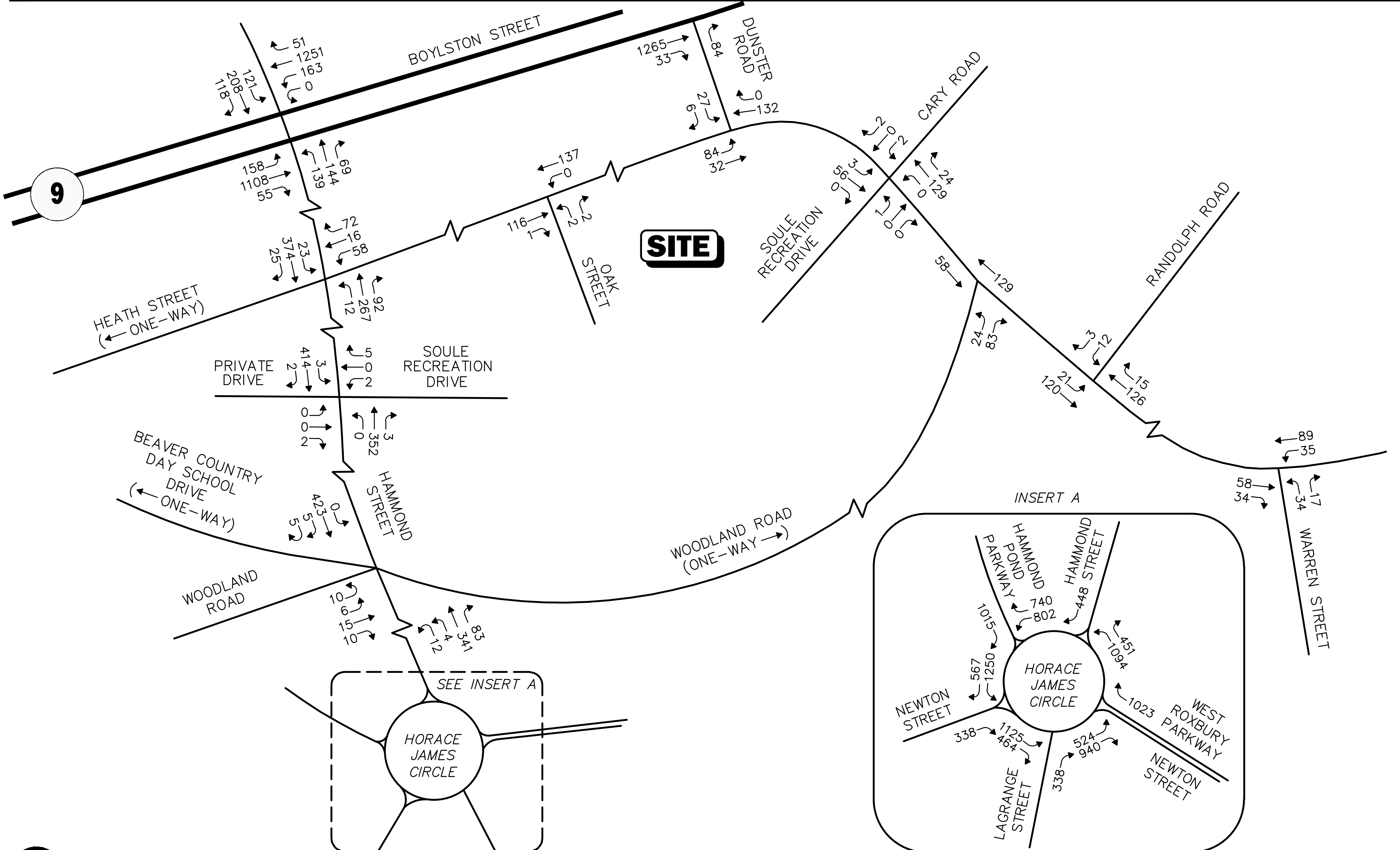

Note: Imbalances exist due to numerous curb cuts and side streets that are not shown.

Not To Scale

Figure 14

2025 No-Build Weekday Afternoon School Peak Hour Traffic Volume (1:30 - 2:30 PM)

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Transportation Engineers & Planners

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PROJECT-GENERATED TRAFFIC

Design year (2025 Build) traffic volumes for the study area roadways were determined by estimating Project-generated traffic volumes and assigning these volumes on the study roadways. The following describes the methodology used to establish the traffic characteristics of the Project. As proposed, the Project will entail the construction of a 453-student elementary school. Teacher and staff levels are estimated at 86.

In order to develop the traffic characteristics of the School, trip-generation statistics published by the ITE[4] for similar land uses as those proposed were used. ITE Land Use Code (LUC) 520, *Elementary School,* with the independent variable of "Number of Students" equal to 453. It should be noted that the trip-generation statistics published by the ITE for the aforementioned land uses reflect the common modes of transportation for schools and include buses, vans/carpools, as well as students that may walk or bicycle to school. Table 5 summarizes the anticipated characteristics of the Project based upon Industry Standards.

Table 5
BALDWIN ELEMENTARY SCHOOL
TRIP GENERATION SUMMARYa

Time Period/Direction	Vehicle Trips[a] Elementary School (453 Students)[a]
Average Weekday Daily:	
Entering	428
Exiting	428
Total	856
Weekday Morning Peak Hour:	
Entering	167
Exiting	137
Total	304
Weekday Afternoon Peak Hour:	
Entering	69
Exiting	85
Total	154

[a]Based on ITE LUC 520, *Elementary School.*

Overall, the above ITE estimates are reasonable, but may not reflective of actual Brookline conditions. As such, an alternative approach was developed based upon the following assumption provided for the proposed school.

- 453 Students
- 86 Staff (74 Arrive in Peak Hour and 1.0 Staff Per Car)
- 4% Daily Absenteeism
- 25 METCO Students Arriving by Bus

[4]Ibid 2.

- 30 Rise Students (9 Vans)
- 45 Brookline Early Education Program Students (Arrive After 8:00 AM)
- 120 Students Bus (2 Buses)
- 50 Students Walk[5]
- Student Car Occupancy Of 1.45 Student/Car

Afternoon traffic volumes were estimated based upon the reduced traffic percentage from the ITE data. A summary of expected vehicle trip generation is summarized in Table 6 based upon the above assumptions.

Table 6
TRIP GENERATION SUMMARY

Time Period	Staff	Vans	Buses	Car Drop-off/ Pick-up	Total Trips
Weekday Morning Peak Hour:					
Entering	74	9	3	121	207
Exiting	0	9	3	121	133
Total	74	18	6	242	340
Weekday Afternoon Peak Hour:					
Entering	0	9	3	70	82
Exiting	10	9	3	70	92
Total	10	18	6	140	174

As can be seen in Table 6, the school is expected to generate approximately 340 vehicle trips (207 vehicles entering and 133 exiting) during the weekday morning peak school hour. During the weekday afternoon peak school hour, the Project is expected to generate approximately 174 vehicle trips (82 vehicles entering and 92 exiting). The above estimates were utilized for analysis purposes in assessing the overall impacts and are slightly above the industry standard projections.

It is important to note that as reduced student alternatives have been reviewed, the amount of area traffic has also been reduced. Table 7 depicts the reduction in morning traffic drop-off when comparing the original 800-student population, to 600 students to the current 453 student population.

[5]This is a conservative estimate. 195 K-8 children live within 0.5 miles of the site, so the number of children who walk to school when it opens will be higher.

Table 7
DROP-OFF TRIP GENERATION COMPARISON

Time Period	Drop-Off (800 Students)	Drop-Off (600 Students)	Drop-Off (453 Students)
Weekday Morning Peak Hour:			
Entering	330	232	121
Exiting	330	232	121
Total	660	464	242

As shown, the drop-offs have been reduced dramatically from 330 to 121 vehicles.

TRIP DISTRIBUTION AND ASSIGNMENT

Separate trip distributions were developed for staff and students. The directional distribution of the site-generated trips to the proposed development by the staff was determined based on a review of origin to workplace data for Brookline. The directional distribution for the drop-offs and pick-ups was based on existing travel patterns at the study area intersections, directional data provided by the architect and it was further assumed that 30 percent of parents dropping-off students would be traveling on to work. The weekday morning trip distribution for staff is depicted on Figure 15 and the drop-off (morning) and pick-up (afternoon) patterns are depicted in Figures 16 and 17. The weekday morning and weekday afternoon peak-hour traffic volumes expected to be generated by the school are shown on Figures 18 and 19.

FUTURE TRAFFIC VOLUMES – BUILD CONDITION

The 2025 Build condition networks consist of the 2025 No-Build traffic volumes with the anticipated site-generated traffic added to them. The 2025 Build weekday morning and weekday afternoon traffic-volume networks are graphically depicted on Figures 20 and 21.

A summary of peak-hour projected traffic-volume increases external to the study area that is the subject of this assessment is shown in Table 8. These volumes are based on the expected increases from the project.

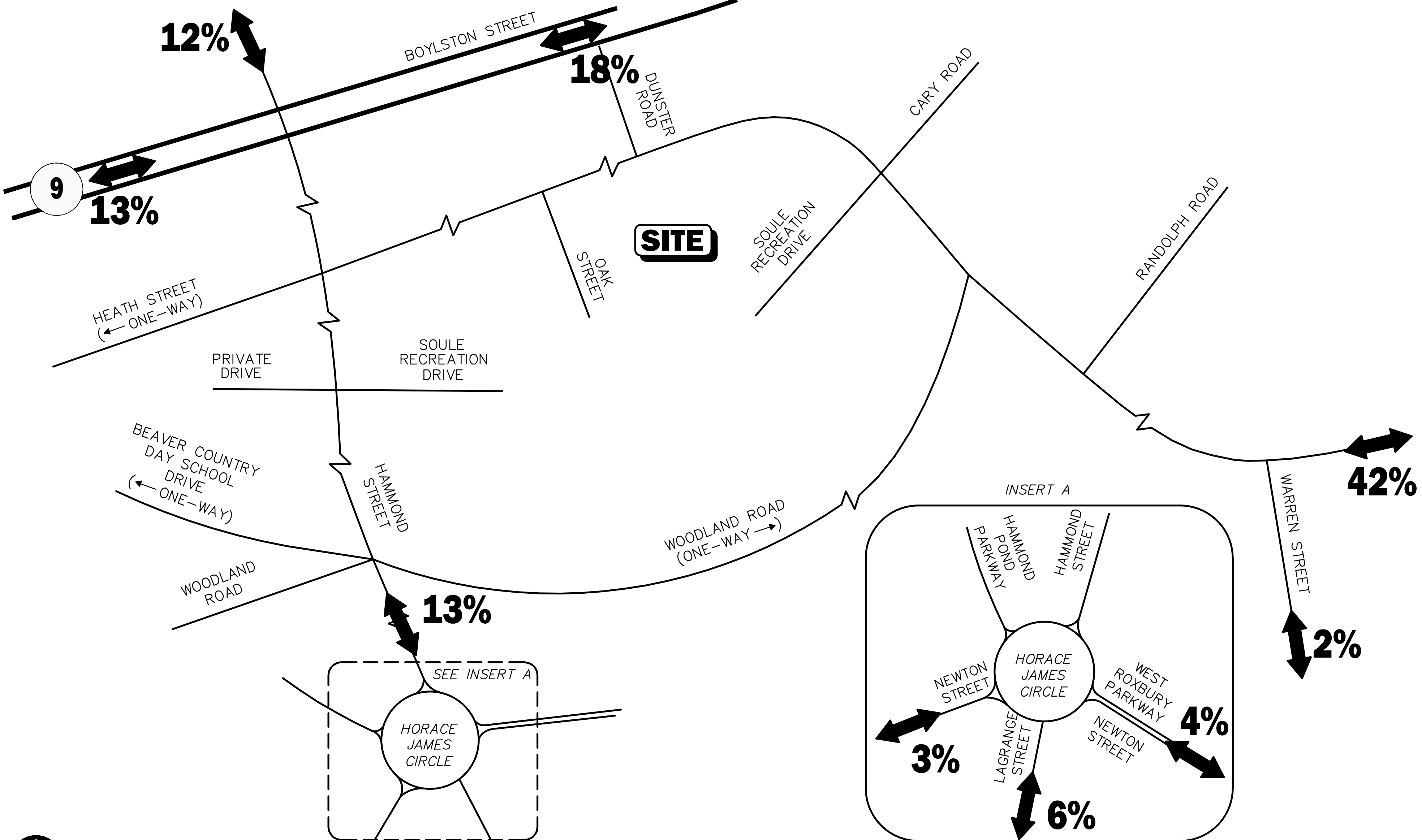

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Figure 15

Trip Distribution - Staff

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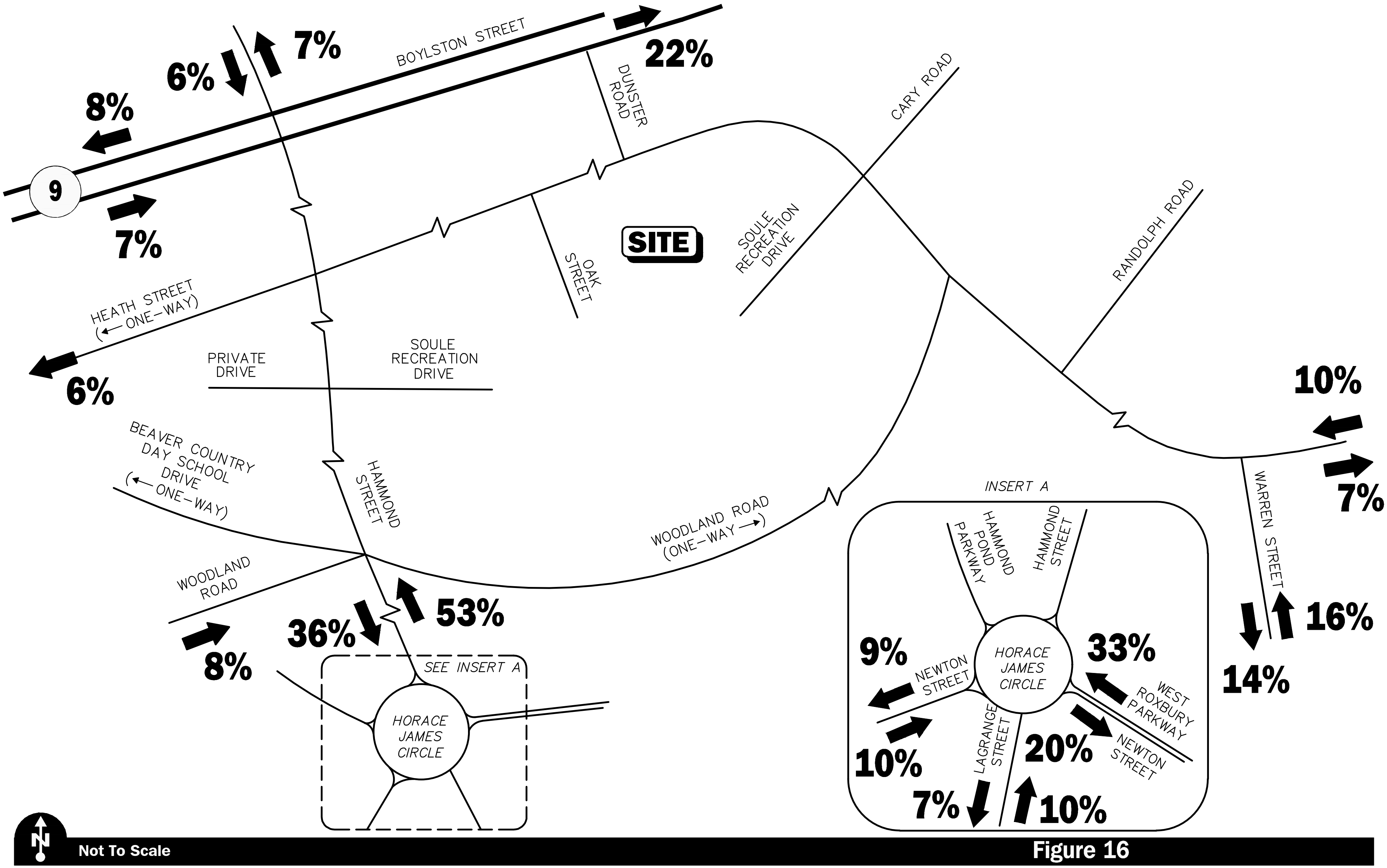

Figure 16

Trip Distribution
Student Drop-off
Weekday Morning

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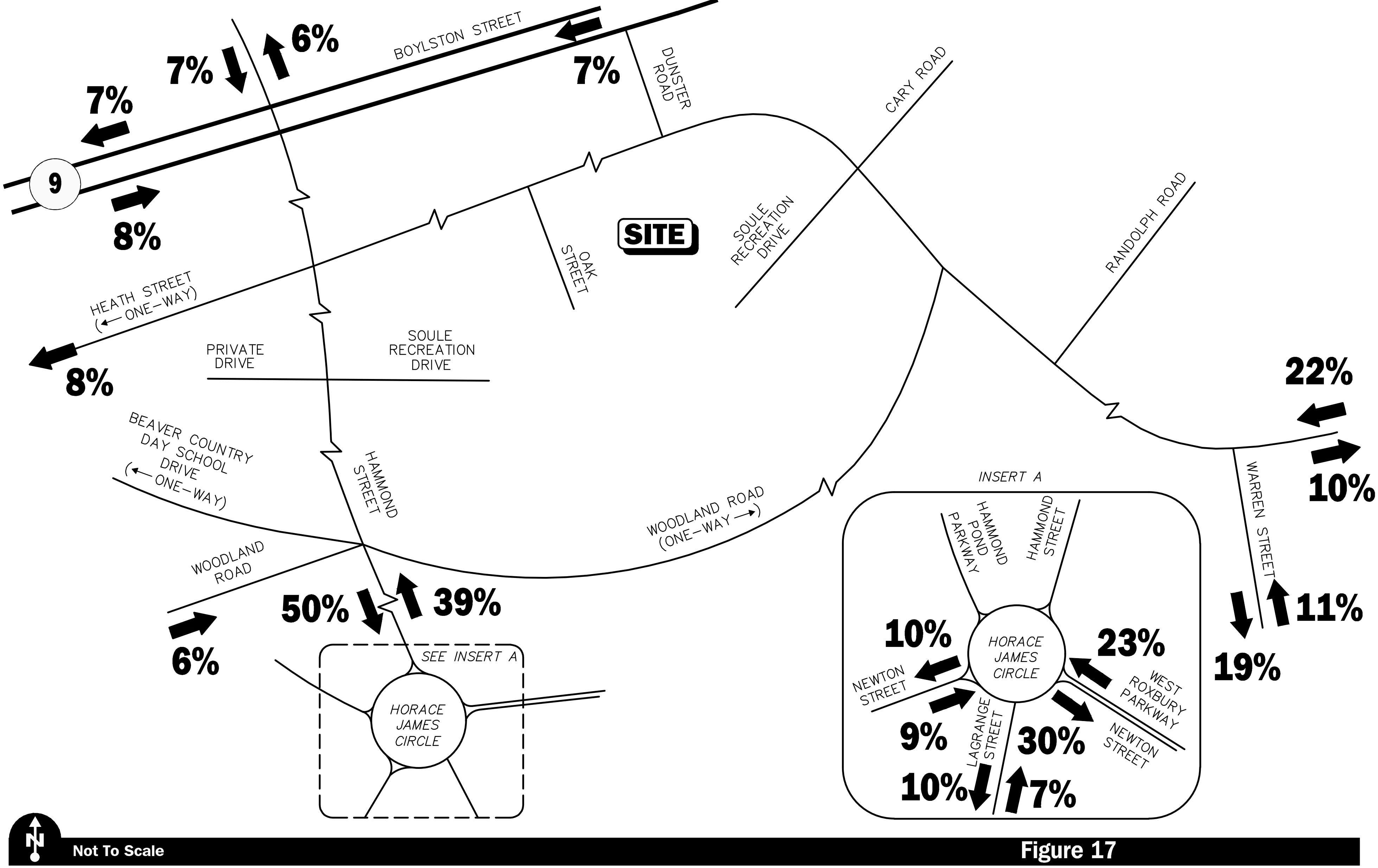

Figure 17

Trip Distribution
Student Pick Up
Weekday Afternoon

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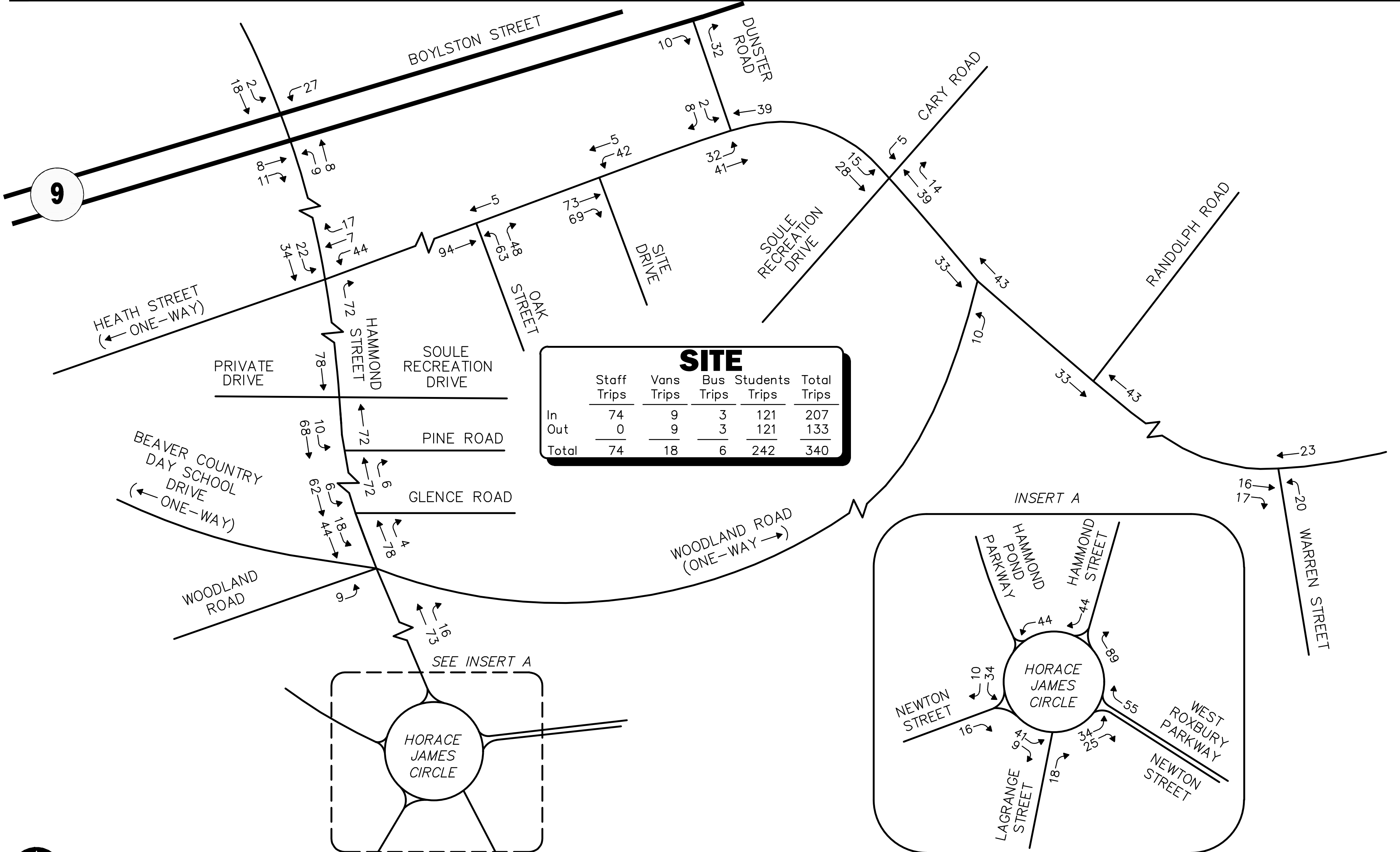

	Staff Trips	Vans Trips	Bus Trips	Students Trips	Total Trips
In	74	9	3	121	207
Out	0	9	3	121	133
Total	74	18	6	242	340

Not To Scale

Figure 18

Trip Generation
Weekday Morning
School Peak Hour Traffic Volume

VAi Vanasse & Associates, Inc.
Transportation Engineers & Planners

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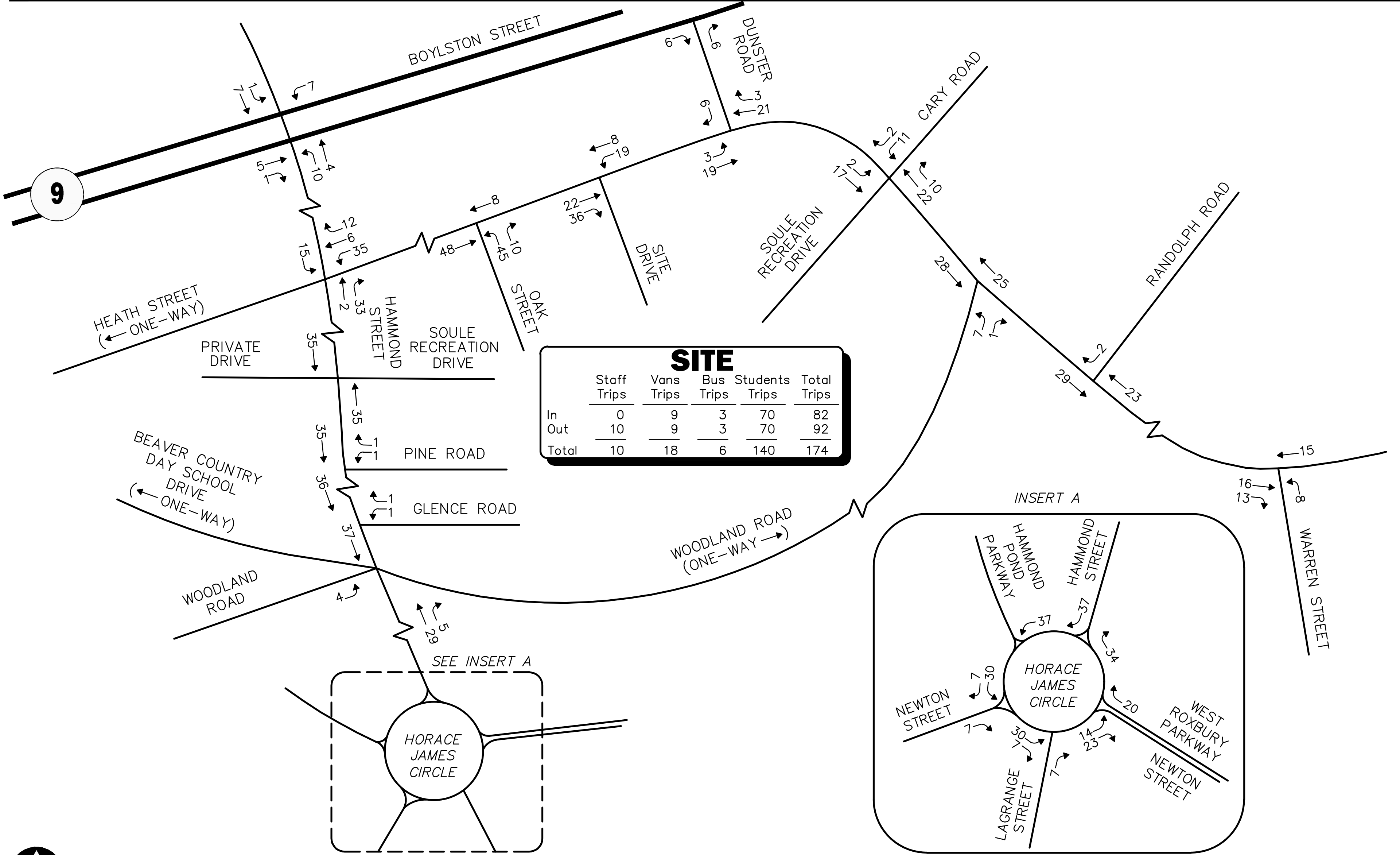

SITE

	Staff Trips	Vans Trips	Bus Trips	Students Trips	Total Trips
In	0	9	3	70	82
Out	10	9	3	70	92
Total	10	18	6	140	174

Figure 19

Trip Generation
Weekday Afternoon
School Peak Hour Traffic Volume

Vanasse & Associates, Inc.
Transportation Engineers & Planners

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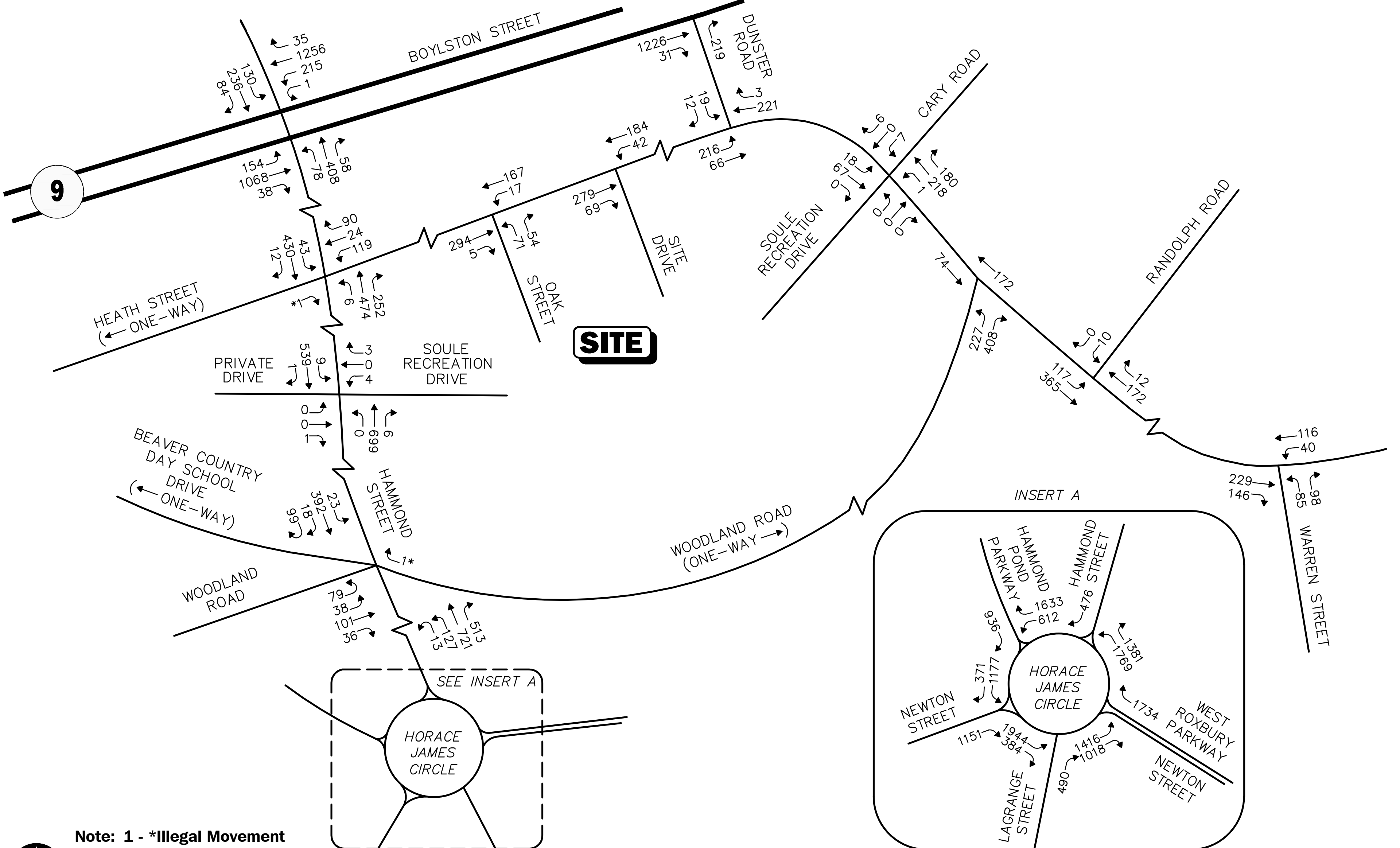

Note: 1 - *Illegal Movement

2 - Imbalances exist due to numerous curb cuts and side streets that are not shown.

Not To Scale

Figure 20

Vanasse & Associates, Inc.
Transportation Engineers & Planners

2025 Build
Weekday Morning
School Peak Hour Traffic Volume
(7:00 - 8:00 AM)

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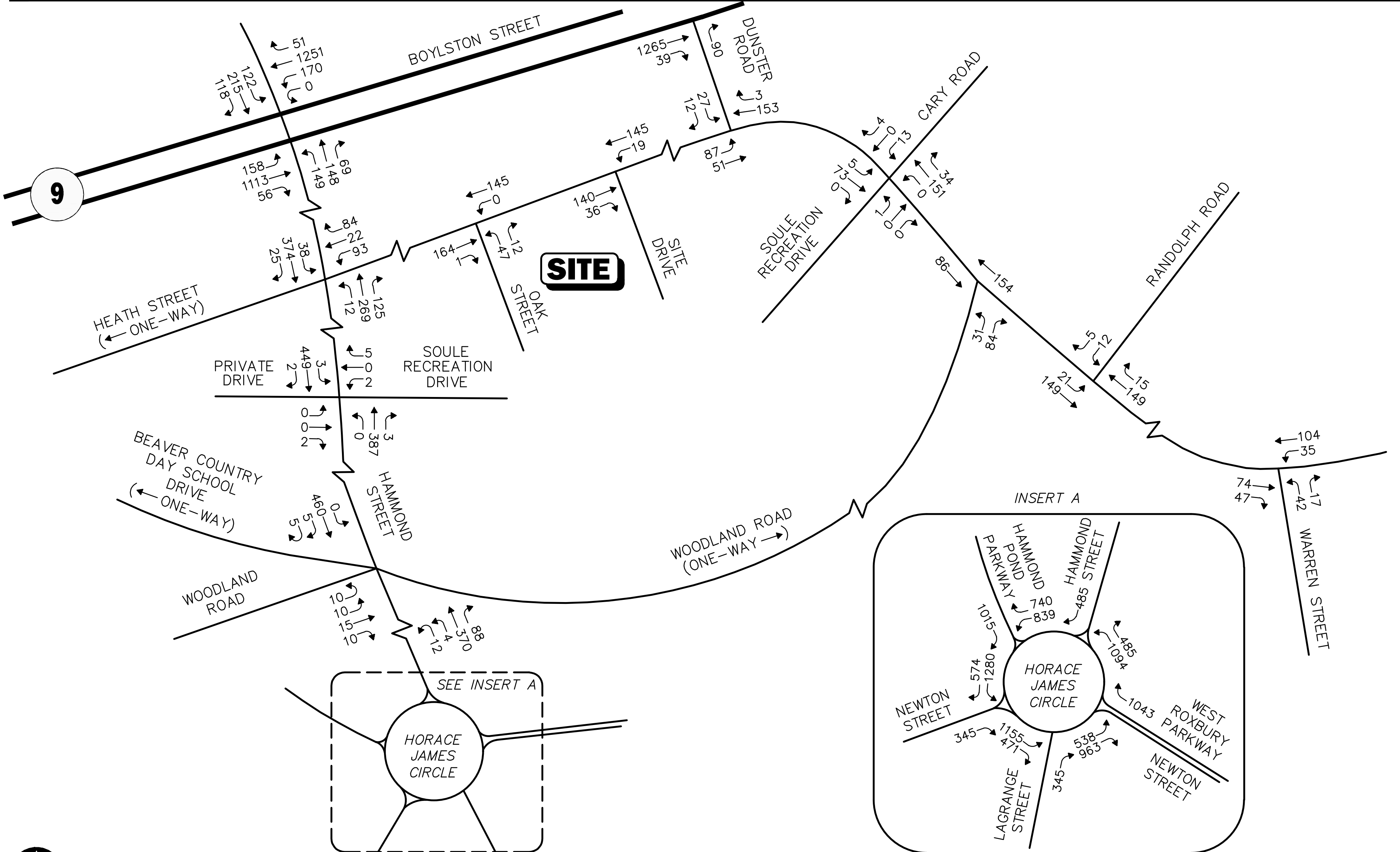

Note: Imbalances exist due to numerous curb cuts and side streets that are not shown.

Not To Scale

Figure 21

2025 Build
Weekday Afternoon
School Peak Hour Traffic Volume
(1:30 - 2:30 PM)

Vanasse & Associates, Inc.
Transportation Engineers & Planners

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Table 8
PEAK-HOUR TRAFFIC-VOLUME INCREASES

Location/Peak Hour	2025 No-Build	2025 Build	Traffic Volume Increase Over No-Build	Percent Increase Over No-Build
Heath Street, east of Warren Street:				
Weekday Morning	444	483	39	8.7
Weekday Afternoon	199	230	31	15.5
Boylston Street, west of Hammond Street:				
Weekday Morning	2,650	2,678	28	1.0
Weekday Afternoon	2,829	2,845	16	0.6
Heath Street, east of Hammond Street:				
Weekday Morning	366	528	162	44.2
Weekday Afternoon	261	362	101	38.7
Woodland Road, east of Hammond Street:				
Weekday Morning	604	638	34	5.6
Weekday Afternoon	98	103	5	5.1

As shown in Table 8, project-related traffic-volume increases external to the study area relative to 2025 No-Build conditions are anticipated to range from 1.0 to 44.2 percent during the peak periods.

TRAFFIC OPERATIONS ANALYSIS

Measuring existing and future traffic volumes quantifies traffic flow within the study area. To assess quality of flow, roadway capacity and vehicle queue analyses were conducted under Existing, No-Build, and Build traffic-volume conditions. Capacity analyses provide an indication of how well the roadway facilities serve the traffic demands placed upon them, with vehicle queue analyses providing a secondary measure of the operational characteristics of an intersection or section of roadway under study.

METHODOLOGY

Levels of Service

A primary result of capacity analyses is the assignment of level of service to traffic facilities under various traffic-flow conditions.[6] The concept of level of service is defined as a qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or passengers. A level-of-service definition provides an index to quality of traffic flow in terms of such factors as speed, travel time, freedom to maneuver, traffic interruptions, comfort, convenience, and safety.

Six levels of service are defined for each type of facility. They are given letter designations from A to F, with level-of-service (LOS) A representing the best operating conditions and LOS F representing congested or constrained operating conditions.

Since the level of service of a traffic facility is a function of the traffic flows placed upon it, such a facility may operate at a wide range of levels of service, depending on the time of day, day of week, or period of year.

[6] The capacity analysis methodology is based on the concepts and procedures presented in the *Highway Capacity Manual;* Transportation Research Board; Washington, DC; 2010.

Unsignalized Intersections

The six levels of service for unsignalized intersections may be described as follows:

- *LOS A* represents a condition with little or no control delay to minor street traffic.
- *LOS B* represents a condition with short control delays to minor street traffic.
- *LOS C* represents a condition with average control delays to minor street traffic.
- *LOS D* represents a condition with long control delays to minor street traffic.
- *LOS E* represents operating conditions at or near capacity level, with very long control delays to minor street traffic.
- *LOS F* represents a condition where minor street demand volume exceeds capacity of an approach lane, with extreme control delays resulting.

The levels of service of unsignalized intersections are determined by application of a procedure described in the 2010 *Highway Capacity Manual.*[7] Level of service is measured in terms of average control delay. Mathematically, control delay is a function of the capacity and degree of saturation of the lane group and/or approach under study and is a quantification of motorist delay associated with traffic control devices such as traffic signals and STOP signs. Control delay includes the effects of initial deceleration delay approaching a STOP sign, stopped delay, queue move-up time, and final acceleration delay from a stopped condition. Definitions for level of service at unsignalized intersections are also given in the *2010 Highway Capacity Manual*. Table 9 summarizes the relationship between level of service and average control delay for two way stop controlled and all-way stop controlled intersections.

Table 9
LEVEL-OF-SERVICE CRITERIA FOR UNSIGNALIZED INTERSECTIONS[a]

Level-Of-Service by Volume-to-Capacity Ratio		Average Control Delay (Seconds Per Vehicle)
v/c ≤ 1.0	v/c > 1.0	
A	F	≤10.0
B	F	10.1 to 15.0
C	F	15.1 to 25.0
D	F	25.1 to 35.0
E	F	35.1 to 50.0
F	F	>50.0

[a]Source: *Highway Capacity Manual*; Transportation Research Board; Washington, DC; 2010; page 19-2.

[7]*Highway Capacity Manual*; Transportation Research Board; Washington, DC; 2010.

Signalized Intersections

The six levels of service for signalized intersections may be described as follows:

- *LOS A* describes operations with very low control delay; most vehicles do not stop at all.
- *LOS B* describes operations with relatively low control delay. However, more vehicles stop than LOS A.
- *LOS C* describes operations with higher control delays. Individual cycle failures may begin to appear. The number of vehicles stopping is significant at this level, although many still pass through the intersection without stopping.
- *LOS D* describes operations with control delay in the range where the influence of congestion becomes more noticeable. Many vehicles stop and individual cycle failures are noticeable.
- *LOS E* describes operations with high control delay values. Individual cycle failures are frequent occurrences.
- *LOS F* describes operations with high control delay values that often occur with over-saturation. Poor progression and long cycle lengths may also be major contributing causes to such delay levels.

Levels of service for signalized intersections are calculated using the operational analysis methodology of the 2010 *Highway Capacity Manual*. This method assesses the effects of signal type, timing, phasing, and progression; vehicle mix; and geometrics on delay. Level-of-service designations are based on the criterion of control or signal delay per vehicle. Control or signal delay is a measure of driver discomfort, frustration, and fuel consumption, and includes initial deceleration delay approaching the traffic signal, queue move-up time, stopped delay and final acceleration delay. Table 10 summarizes the relationship between level of service and control delay. The tabulated control delay criterion may be applied in assigning level-of-service designations to individual lane groups, to individual intersection approaches, or to entire intersections.

Table 10
LEVEL-OF-SERVICE CRITERIA
FOR SIGNALIZED INTERSECTIONS[a]

Level-Of-Service by Volume-to-Capacity Ratio		Average Control Delay
v/c ≤ 1.0	v/c > 1.0	(Seconds Per Vehicle)
A	F	≤10.0
B	F	10.1 to 20.0
C	F	20.1 to 35.0
D	F	35.1 to 55.0
E	F	55.1 to 80.0
F	F	>80.0

[a]Source: *Highway Capacity Manual*; Transportation Research Board; Washington, DC; 2010; page 18-6.

Roundabouts

The roundabout capacity analysis is based on the procedures described in the *Traffic Signalized* and *Unsignalized Intersection Design and Research Aid* (*SIDRA*) *Intersection*.[8] The main features of the *SIDRA Intersection* method for roundabout capacity estimation are the dependence of gap acceptance parameters on rotary geometry, circulating flows and entry lane flows, and the designation of approach lanes as controlling and otherwise that have different capacity characteristics. Provision of two-lane approaches tend to substantially increase roundabout capacity. As a general rule, individual approach volumes exceeding 85 percent of the calculated capacity of that approach are considered over-saturated and indicate areas of concern.

The SIDRA analytical model calculates several components of delay. One of these, the average total delay component, produces level-of-service results based on the concepts described in the HCM. The delay ranges that define levels of service for roundabouts are shown in Table 11.

Table 11
LEVEL-OF-SERVICE CRITERIA FOR ROUNDABOUTS[a]

Level-Of-Service by Volume-to-Capacity Ratio		Control Delay Per Vehicle (Seconds)
v/c ≤ 1.0	v/c > 1.0	
A	F	≤10.0
B	F	10.1 to 15.0
C	F	15.1 to 25.0
D	F	25.1 to 35.0
E	F	35.1 to 50.0
F	F	>50.0

[a]Source: *SIDRA Intersection User Guide;* Akcelik & Associates Pty Ltd; Greythorn, Victoria 3104, Australia; November 2012.

ANALYSIS RESULTS

Level-of-service analyses were conducted for Baseline, 2025 No-Build, and 2025 Build conditions for the study area intersections. The results of the intersection capacity analysis within the study area are described below, with a tabular summary provided in Tables 12 and 13. The results of the SIDRA Rotary Capacity Analysis are summarized in Table 14.

Unsignalized Intersection Analysis Results

Hammond Street at Soule Recreation Drive

Under the all conditions, the Soule Recreation Drive operates at LOS C during the weekday morning peak hour and LOS B during the weekday afternoon peak hour. Impacts in delays at this location are in the order of 2 seconds or less.

[8]Traffic Signalized and Unsignalized Intersection Design and Research Aid, SIDRA Intersection User Guide; Akcelik & Associates Pty Ltd; Greythorn, Victoria 3104, Australia; November 2012.

Hammond Street at Woodland Road

Under Existing conditions, Woodland Road operates at LOS C during the weekday morning peak hour (under police officer control) and LOS B during the weekday afternoon peak hour. This intersection is expected to be signalized under future conditions.

Heath Street at Oak Street (School Drive)

Under Existing and No-Build conditions, Oak Street operates at LOS B or higher during both the weekday morning and weekday afternoon peak hours. Under Future Build conditions, the intersection drops to LOS C during the morning period without police officer control.

Boylston Street at Dunster Road

Under Existing and No-Build conditions, this intersection operates at LOS D or higher during both the weekday morning peak school hours and LOS C during weekday afternoon peak school hours. Under Future Build conditions, the intersection will operate under LOS E during the morning period and LOS C during weekday afternoon peak school hours.

Heath Street at Dunster Road

Under Existing conditions, Dunster Road operates at LOS B during the weekday morning and weekday afternoon peak hours. Under No-Build and Build conditions, Dunster Road operates at LOS C during the weekday morning peak hour and LOS B during the weekday afternoon peak hour. Impacts to delays at this location are in the order of 2 seconds or less.

Heath Street at Cary Road and Soule Recreation Drive

Under Existing, No-Build and Build conditions, Cary Road operates at LOS B or better during the weekday morning and weekday afternoon peak hours. Impacts to delays at this location are in the order of 2 seconds or less.

Heath Street at Woodland Road

Under Existing, No-Build and Build conditions, the intersection operates at LOS B or better. Impacts to delays at this location are minimal.

Heath Street at Randolph Road

Under all conditions, this intersection operates at LOS C during the weekday morning peak hour and at LOS B during the weekday afternoon peak hour. Impacts to delays at this location are in the order of 2 seconds or less.

Heath Street at Warren Street

During the weekday morning peak hour, Warren Street operates at LOS B under Existing conditions and at LOS C under No-Build and Build conditions. During the weekday afternoon peak hour, Warren Street operates at LOS B under all conditions. Impacts to delays at this location are 3 seconds or less.

Heath Street at Site Entrance Drive

Under Build conditions, the left-turn entering traffic is expected to operate at LOS A.

<u>Signalized Intersection Analysis Result</u>

Boylston Street at Hammond Street

Under Existing conditions, this intersection operates at an overall LOS E during the weekday morning period and LOS D during the weekday afternoon period. Under No-Build and Build conditions, this intersection operates at an overall LOS F during the weekday morning period and LOS D during the weekday afternoon period. Overall impacts at this location will be in the order of 5 seconds.

Hammond Street at Heath Street

Under Existing and No-Build conditions, this intersection operates at an overall LOS C during both the weekday morning and weekday afternoon periods. Under Build conditions without mitigation, this intersection operates at an overall LOS D during the weekday morning period and LOS C during weekday afternoon period.

Hammond Street at Woodland Road

The Town has created a concept plan for the signalization of Hammond Street at Woodland Road. Under all Future conditions, this signalized intersection operates at LOS B or better, during both the weekday morning and weekday afternoon peak hours.

James Horace Circle

Under Existing condition, James Horace Circle operates at LOS F, during weekday morning school periods and at LOS E during weekday afternoon school periods. Under Future conditions, James Horace Circle operates at LOS F, during both the weekday morning and weekday afternoon school periods. Delays increase of up to an overall of 8 seconds can be expected during the critical morning period.

Table 12
UNSIGNALIZED INTERSECTION CAPACITY ANALYSIS SUMMARY

	2018 Existing				2025 No-Build				2025 Build			
Unsignalized Intersection Movements	Demand[a]	Delay[b]	LOS[c]	Queue[d]	Demand	Delay	LOS	Queue	Demand	Delay	LOS	Queue
Hammond Street at Soule Recreation Drive and Private Drive												
Weekday Morning :												
Private Drive EB LT/TH/RT	1	10	B	0.0	1	10.2	B	0.0	1	10.6	B	0.0
Soule Rec Drive WB LT/TH/RT	7	17	C	0.1	7	18.3	C	0.0	7	20.4	C	0.1
Hammond Street SB LT	8	8.8	A	0.0	9	9.0	A	0.0	9	9.1	A	0.0
Weekday Afternoon:												
Private Drive EB LT/TH/RT	2	10.6	C	0.0	2	10.8	B	0.0	2	11	B	0.0
Soule Rec Drive WB LT/TH/RT	7	10.8	B	0.0	7	11.0	B	0.0	7	11.4	B	0.0
Hammond Street SB LT	3	8.0	A	0.0	3	8.0	A	0.0	3	8.1	A	0.0
Hammond Street at Woodland Road												
Weekday Morning :												
Woodland Road EB LT/TH	--	--	--	--	--	--	--	--	--	--	--	--
Woodland Road EB RT	--	--	--	--	--	--	--	--	--	--	--	--
Hammond Street SB LT	--	--	--	--	--	--	--	--	--	--	--	--
Weekday Afternoon:												
Woodland Road EB LT/TH	23	11.7	B	0.2	--	--	--	--	--	--	--	--
Hammond Street NB LT	15	8.2	A	0.0	--	--	--	--	--	--	--	--
Heath Street at Oak Street (School Drive)												
Weekday Morning :												
Heath Street WB LT	16	7.7	A	0.0	17	7.7	A	0.1	17	8.3	A	0.0
Oak Street NB LT/RT	13	10.7	B	0.1	14	11.1	B	0.1	125	19.9	C	0.0
Weekday Afternoon:												
Heath Street WB LT	0	0.0	A	0.0	0	9.6	A	0	0	0.0	A	0.0
Oak Street NB LT/RT	4	9.5	A	0.0	4	0.0	A	0	59	12.3	B	0.6

See notes at end of table.

Table 12 (Continued)
UNSIGNALIZED INTERSECTION CAPACITY ANALYSIS SUMMARY

	2018 Existing				2025 No-Build				2025 Build			
Unsignalized Intersection Movements	Demand[a]	Delay[b]	LOS[c]	Queue[d]	Demand	Delay	LOS	Queue	Demand	Delay	LOS	Queue
Boylston Street at Dunster Road												
Weekday Morning :												
Dunster Street NB RT	175	29.6	D	4.1	187	32.3	D	$\boxed{4.7}$	219	44.2	E	$\boxed{6.8}$
Weekday Afternoon:												
Dunster Street NB RT	78	16.3	C	0.9	84	18.0	C	1.1	90	18.6	C	1.3
Heath Street at Dunster Road												
Weekday Morning :												
Heath Street EB LT	172	8.1	A	0.5	184	8.2	A	0.6	216	8.5	A	0.7
Dunster Road SB LT/RT	20	14.2	B	0.2	21	15.1	C	0.2	31	16.8	C	0.4
Weekday Afternoon:												
Heath Street EB LT	78	7.6	A	0.2	84	7.7	A	0.2	87	7.8	A	0.2
Dunster Road SB LT/RT	31	10.9	B	0.2	33	11.1	B	0.2	39	11.4	B	0.3
Heath Street at Cary Road and Soule Recreation Drive												
Weekday Morning :												
Heath Street EB LT	3	8.2	A	0.0	3	8.2	A	0.0	18	8.5	A	0.1
Heath Street WB LT	1	7.3	A	0.0	1	7.3	A	0.0	1	7.5	A	0.0
Cary Road SB LT/TH/RT	8	10.4	B	0.0	8	10.6	B	0.1	13	12.2	B	0.1
Weekday Afternoon:												
Heath Street EB LT	3	7.5	A	0.0	3	7.6	A	0.0	5	7.7	A	0.0
Soule Recreation NB LT/TH/RT	1	9.9	A	0.0	1	10.0	B	0.0	0	10.5	B	0.0
Cary Road SB LT/TH/RT	4	9.5	A	0.0	4	9.6	A	0.0	15	10.5	B	0.1

See notes at end of table.

Table 12 (Continued)
UNSIGNALIZED INTERSECTION CAPACITY ANALYSIS SUMMARY

	2018 Existing				2025 No-Build				2025 Build			
Unsignalized Intersection Movements	Demand[a]	Delay[b]	LOS[c]	Queue[d]	Demand	Delay	LOS	Queue	Demand	Delay	LOS	Queue
Heath Street at Woodland Road												
Weekday Morning :												
Woodland Road NB LT/RT	584	9.6	A	2.9	625	10	B	3.3	635	10.5	B	3.8
Weekday Afternoon:												
Woodland Road NB LT/RT	99	8.1	A	0.3	107	8.1	A	0.3	115	8.0	A	0.4
Heath Street at Randolph Road												
Weekday Morning :												
Heath Street EB LT	109	7.9	A	0.3	117	7.9	A	0.4	117	8.1	A	0.4
Randolph Road SB LT/RT	9	18.4	C	0.1	10	20.1	C	0.2	10	22.7	C	0.2
Weekday Afternoon:												
Heath Street EB LT	20	7.9	A	0.1	21	7.6	A	0.1	21	7.7	A	0.1
Randolph Road SB LT/RT	14	11.4	B	0.1	15	10.6	B	0.1	17	10.9	B	0.1
Heath Street at Warren Street												
Weekday Morning :												
Heath Street WB LT	37	8.3	A	0.1	40	8.4	A	0.1	40	8.5	A	0.2
Warren Street NB LT/RT	152	14.2	B	1.5	163	15.2	C	1.8	183	18.1	C	2.5
Weekday Afternoon:												
Heath Street WB LT/TH	33	7.4	A	0.1	35	7.5	A	0.1	35	7.5	A	0.1
Warren Street NB LT	48	10	B	0.2	52	10.1	B	0.2	59	10.5	B	0.3
Heath Street at Site Drive												
Weekday Morning :												
Heath Street EB LT	--	--	--	--	--	--	--	--	42	2.2	A	0.2
Weekday Afternoon:												
Heath Street EB LT	--	--	--	--	--	--	--	--	19	1.1	A	0.0

[a]Demand in vehicles per hour.
[b]Delay in seconds per vehicle.
[c]Level of service.
[d]Queue Length in Vehicles.
*Geometry only existing under Build conditions with construction of Site Driveway. NB = northbound; WB = westbound; LT = left-turning movements; RT = right-turning movements

Table 13
SIGNALIZED INTERSECTION CAPACITY ANALYSIS SUMMARY

Signalized Intersection Movements	2018 Existing				2025 No-Build				2025 Build			
	V/C[a]	Delay[b]	LOS[c]	Queue	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Boylston Street at Hammond Street												
Weekday Morning:												
Boylston Street EB LT	0.78	79.2	E	136/249	0.83	>80.0	F	148/270	0.94	>80.0	F	149/270
Boylston Street EB TH/RT	1.06	>80.0	F	615/713	1.05	>80.0	F	603/700	1.07	>80.0	F	625/722
Boylston Street WB LT	0.95	>80.0	F	170/322	1.05	>80.0	F	214/352	1.22	>80.0	F	280/414
Boylston Street WB TH	1.12	>80.0	F	708/754	1.23	>80.0	F	825/864	1.23	65.6	F	825/864
Boylston Street WB RT	0.04	0.30	A	0/0	0.05	0.40	A	0/1	0.05	0.4	A	0/1
Hammond Street NB LT/TH/RT	0.73	20.0	C	99/103	0.77	2.80	C	83/110	0.79	25.2	C	98/121
Hammond Street SB LT/TH	0.66	53.2	D	178/188	0.70	54.6	D	192/202	0.73	55.8	E	202/213
Hammond Street SB RT	0.17	6.70	A	3/25	0.18	7.70	A	7/30	0.18	8.6	A	10/34
Overall	**1.12**	**77.7**	**E**	--	**1.23**	**>80.0**	**F**	**--**	**1.23**	**>80.0**	**F**	--
Weekday Afternoon:												
Boylston Street EB LT	0.66	66.2	E	128/194	0.70	68.0	E	138/211	0.70	68.4	E	138/212
Boylston Street EB TH/RT	0.80	41.2	D	440/726	0.92	50.6	D	531/827	0.95	55.0	D	545/835
Boylston Street WB LT	0.65	64.3	E	130/200	0.68	35.8	E	138/215	0.70	66.7	E	145/225
Boylston Street WB TH	0.84	42.4	D	476/795	0.96	55.6	E	577/901	0.97	58.9	E	584/901
Boylston Street WB RT	0.05	0.9.	A	0/6	0.06	1.00	A	0/6	0.06	1.00	A	0/6
Hammond Street NB LT/TH/RT	0.68	76.5	E	183/210	0.69	30.0	C	180/210	0.71	27.6	C	148/170
Hammond Street SB LT/TH	0.63	56.5	E	136/178	0.65	56.3	E	145/188	0.65	56.1	E	148/192
Hammond Street SB RT	0.20	5.10	A	0/37	0.20	4.90	A	0/38	0.20	4.90	A	0/38
Overall	**0.84**	**47.4**	**D**	--	**0.96**	**49.8**	**D**	--	**0.97**	**52.0**	**D**	--
Hammond Street at Heath Street												
Weekday Morning:												
Heath Street WB LT/TH.RT	0.69	56.2	E	143/171	0.72	57.4	E	155/183	0.86	69.9	E	236/273
Hammond Street NB LT/TH/RT	0.69	44.0	D	247/341	0.76	47.2	D	275/398	0.93	65.0	E	322/455
Hammond Street SB LT/TH/RT	0.20	0.09	A	7/10	0.23	1.00	A	8/10	0.28	1.40	A	14/13
Overall	**0.69**	**29.5**	**C**	--	**0.76**	**31.2**	**C**	--	**0.93**	**42.5**	**D**	--
Weekday Afternoon:												
Heath Street WB LT/TH.RT	0.65	52.3	D	107/152	0.66	52.8	D	117/161	0.73	56.0	E	176/218
Hammond Street NB LT/TH/RT	0.34	29.9	C	114/169	0.37	31.3	C	126/185	0.46	35.0	**C**	144/212
Hammond Street SB LT/TH/RT	0.18	2.60	A	9/24	0.19	2.50	A	16/52	0.22	3.40	**A**	20/66
Overall	**0.65**	**21.0**	**C**	--	**0.66**	**21.5**	**C**	--	**0.73**	**25.6**	**C**	--

See notes at end of table.

Table 13 (Continued)
SIGNALIZED INTERSECTION CAPACITY ANALYSIS SUMMARY

	2018 Existing				2025 No-Build**				2025 Build**			
Signalized Intersection Movements	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Hammond Street at Woodland Road*												
Weekday Morning:												
Woodland Road EB LT/TH/RT	0.54	24.1	C	57/82	0.56	24.3	C	61/88	0.58	24.7	C	65/94
Hammond Street NB LT/TH/	0.71	6.90	C	76/157	0.78	9.40	C	98205	0.86	13.6	B	137/358
Hammond Street SB LT/TH/RT	0.25	3.40	A	23/38	0.27	3.60	A	27/44	0.34	4.50	A	36/57
Overall	**0.71**	**7.50**	**A**	--	**0.78**	**9.30**	**A**	--	**0.86**	**12.1**	**B**	--
Weekday Afternoon:												
Woodland Road EB LT/TH/RT	--	--	--	--	0.10	6.8	A	1/14	0.10	6.9	A	1/15
Hammond Street NB LT/TH/	--	--	--	--	0.16	1.3	A	0/30	0.17	1.3	A	0/33
Hammond Street SB LT/TH/RT	--	--	--	--	0.14	1.4	A	33/809	0.14	1.4	A	0/33
Overall					**0.16**	**1.6**	**A**		**0.17**	**1.6**	**A**	--

[a]Volume to Capacity
[b]Delay in seconds per vehicle.
[c]Level of service.
[d]Queue Length in Feet (50th/95th percentile)
NB = northbound; SB = southbound; EB = eastbound; WB = westbound; LT = left-turning movements; TH = through movements; RT = right-turning movements.
*Police Detail During Weekday Morning School Peak Hour.

Table 14
SIDRA ROUNDABOUT CAPACITY ANALYSIS SUMMARY

	2018 Existing				2025 No-Build				2025 Build			
Critical Movement/Peak Hour	Demand[a]	Delay[b]	LOS[c]	Queue[d]	Demand	Delay	LOS	Queue	Demand	Delay	LOS	Queue
James Horace Circle												
Weekday Morning:												
Hammond Street SWB	403	28.3	D	75.4	432	34	D	90.4	476	40.6	E	101.9
Hammond Pond Parkway SEB	872	96.8	F	1274.1	936	139.3	F	1899.5	936	159	F	2101.6
Newton Street EB	1,059	168.5	F	3343.8	1,135	192	E	3880.7	1,151	181.1	F	3826.2
LaGrange Street NB	440	646.7	F	2376.8	472	732	F	2681.4	490	775.6	F	2845.4
Newton Street NB	1,563	190.2	F	2137.7	1,679	231.8	F	2595.3	1,734	251.7	F	2782.1
Overall	**--**	**188.7**	**F**	--		**223.9**	**F**	--	**--**	**232**	**F**	--
Weekday Afternoon:												
Hammond Street SWB	418	17	C	45.3	448	20.2	C	54.4	485	22.2	C	66.2
Hammond Pond Parkway SEB	941	70	F	842.65	1,015	107.8	F	1457.1	1,015	118.6	F	1581
Newton Street EB	316	12.1	B	91.0	338	18.8	B	108.1	345	13.4	B	108.6
LaGrange Street NB	316	106.7	F	448.3	338	137.5	F	657.4	345	155.2	F	762.5
Newton Street NB	949	17.2	C	42.5	1,023	13.5	C	48.0	1,043	19.5	C	48.7
Overall	**--**	**42.2**	**E**	--	**--**	**58.8**	**F**	--	**--**	**63.8**	**F**	--

[a]Demand in Vehicles per Hour.
[b]Delay in seconds per vehicle.
[c]Level of service.
[d]Queue Length in Feet.
NB = northbound; SB = southbound; EB = eastbound; WB = westbound; LT = left-turning movements; TH = through movements; RT = right-turning movements.
*Assume Concept Plan has Northbound Right Turn Lane on Hammond Street

In order to facilitate improved traffic operations and safety conditions, crossing guard control is proposed at both the school exit drive at Oak Street and at Hammond Street at Heath Street. The signal timing and phasing will be modified to provide an exclusive pedestrian phase and more green time to Heath Street. This analysis is presented in Table 15.

Table 15
BUILD MITIGATED/ CROSSING GUARD/ NEW TIMINGS

	2025 Build - Mitigated			
Signalized Intersection Movements	V/C	Delay	LOS	Queue
Hammond Street at Heath Street				
Weekday Morning:				
Heath Street WB LT/TH.RT	0.62	44.2	D	213/246
Hammond Street NB LT/TH/RT	0.92	67.5	E	316/436
Hammond Street SB LT/TH/RT	0.59	14.2	B	27/144
Overall	**0.92**	**43.7**	**D**	**--**
Weekday Afternoon:				
Heath Street WB LT/TH.RT	0.57	44.8	D	164/221
Hammond Street NB LT/TH/RT	0.67	47.8	D	167/211
Hammond Street SB LT/TH/RT	0.37	13.5	B	38/178
Overall	**0.67**	**32.5**	**C**	**--**
Heath Street at Oak Street				
Weekday Afternoon:				
Heath Street EB TH	0.59	11.1	B	43/83
Heath Street WB LT/TH	0.41	8.8	A	26/50
Oak Street NB LT /RT	0.50	8.7	A	21/16
Overall	**0.59**	**9.8**	**A**	
Weekday Morning:				
Heath Street EB TH	0.37	7.6	A	16/31
Heath Street WB LT/TH	0.36	7.5	A	27/295
Oak Street NB LT /RT	0.15	6.1	A	12/201
Overall	**0.37**	**7.3**	**A**	

[a]Volume to Capacity
[b]Delay in seconds per vehicle.
[c]Level of service.
[d]Queue Length in Feet ($50^{th}/95^{th}$ percentile)
NB = northbound; SB = southbound; EB = eastbound; WB = westbound; LT = left-turning movements; TH = through movements; RT = right-turning movements.

As shown, with crossing guard control the intersection of Hammond Street at Heath Street will operate at LOS D during the weekday morning peak school periods and at LOS C during the weekday evening peak school periods. The school exit driveway will operate at LOS A. While Heath Street queues will increase to 221-246 feet, they will be less than the 310 feet distance available.

PARKING

As previously stated, a minimum of 10 parking spaces will be available on site for visitor and handicap parking. As depicted in Figure 22, parent on-street parking will be available on Heath Street, Cary Road, and Randolph Road. Staff parking is under consideration by the Transportation Board and potential locations for staff parking are depicted in Figure 23 and will be subject to further review.

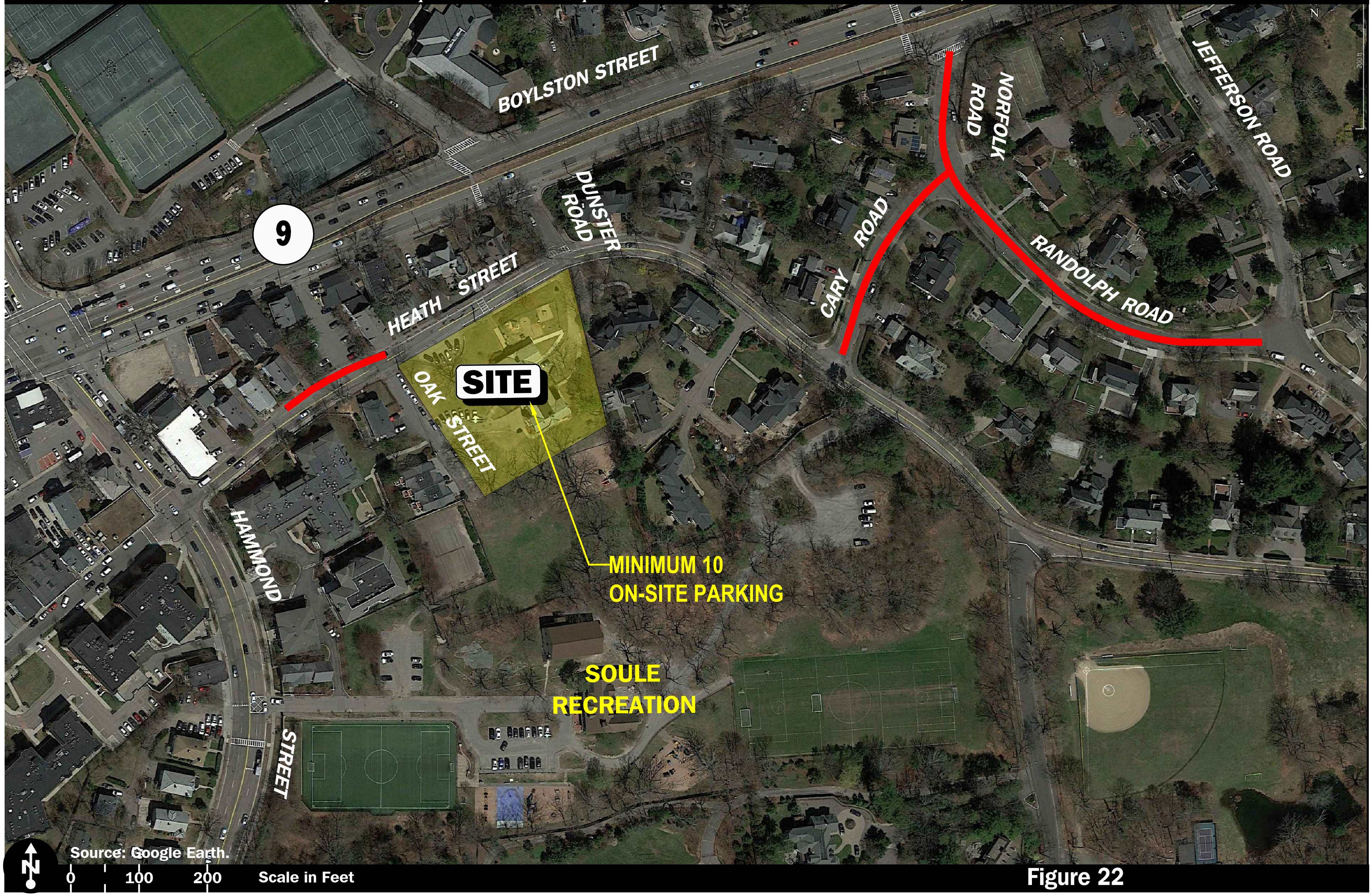

Figure 22

Parent On-Street Parking

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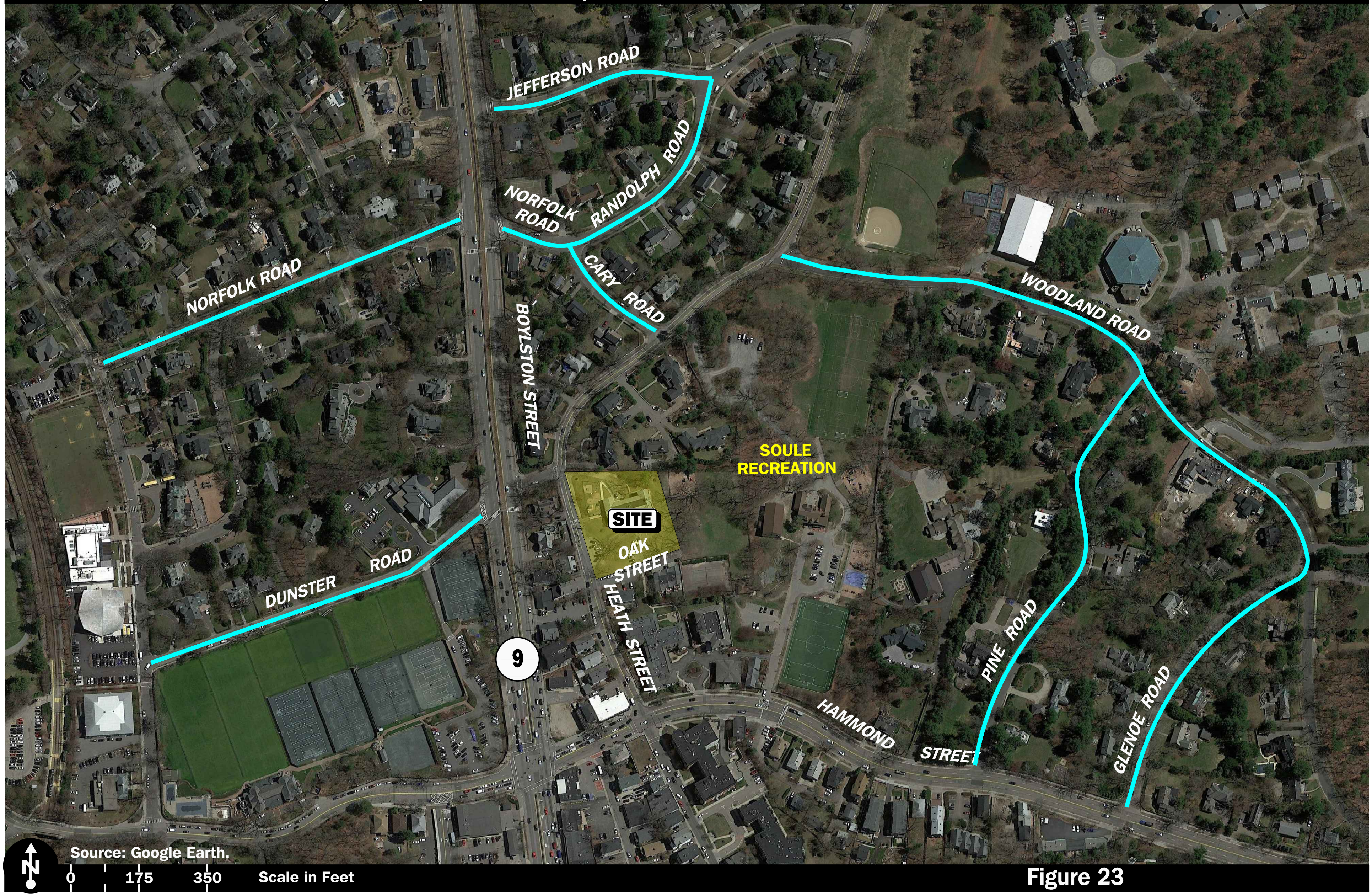

Figure 23

On-Street Parking Option (Currently Under Review on the Transportation Board)

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SCHOOL COMPARISONS

VAI has conducted observations and surveys at comparable schools in Brookline. Where schools are located, there is a reality that during a 15-20 minute period during the drop-off and pick-up times, there will be increased congestion in the area and on neighboring streets. Observations were conducted at three (3) schools including the Runkle School, Lincoln School, and the Driscoll School for comparison purposes. A summary of the data collected is contained in Table 16.

Table 16
SCHOOL COMPARISON ANALYSIS

	Proposed Baldwin School	Runkle School	Lincoln School	Driscoll School
Students	453	581	581	632
Buses (Students in Buses)	2(120)	4(15)	4(18)	2(20)
Estimated Walkers	50	132	140	425
Teachers	86	132	113	99
Neighborhood Street Teacher Parking	86	120	33	53
Traffic Generation[a]				
Weekday Morning period	340	355	272	305
Weekday Afternoon period	174	142	193	165
Queueing Area	on-site	Druce Street	Kennard Road	Washington St./ Westbourne Terrace
Delays	2-3 minutes[b]	2-5 minutes	3-5 minutes	3-5 minutes

[a]Total vehicles in and out of the school area.
[b]Currently one minute.

As shown, the proposed Baldwin 2 section PK-8 School is expected to have similar traffic volumes to the Driscoll School and Runkle School. All schools have same level of queues and delays with delays less than 5 minutes.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

VAI has completed a detailed assessment of the potential impacts on the transportation infrastructure associated with the proposed Baldwin 2 Section PK-8 School to be located off Heath Street in Brookline, Massachusetts. The proposed School will accommodate up to 453 students with 86 staff. The school size has been reduced from 800 students to the current 453 students which will significantly reduce the overall impact to the area. This assessment has been completed in accordance with State and Town standards and those of the Traffic Engineering and Transportation Planning professions for the preparation of such reports. The following specific areas have been evaluated as they relate to the Project: i) access requirements; ii) potential off-site improvements; and iii) safety considerations; under existing and future conditions, both with and without the Project. Based on this assessment, we have concluded the following with respect to the Project:

- Based upon a safety assessment of the area, the school can be safely accommodated with the design as planned.
- The impact of the proposed school will be very similar to conditions experienced at other schools in Brookline. Impacts are limited to a short 15-20-minute period during parents' drop-off and pick-up times.
- The school is expected to generate approximately 340 vehicle trips (207 entering/ 133 exiting) during the weekday morning peak-hour and 174 vehicle trips (82 entering/ 92 exiting) during the weekday afternoon peak-hour.
- During the peak period in the morning, only 71 vehicles turn left from the school driveway onto Heath Street over a one-hour period.
- The proposed driveway off Oak Street has adequate sight distances for safe and efficient operations.
- Safe conditions can be achieved with sidewalks, crosswalks and crossing guards at appropriate locations for students walking to school. The town will implement safety improvements to the area sidewalks.

- The Project will increase traffic in the morning and afternoon periods with increased delays and queues at locations within the study area. These delays and queues will be confined to limited and distinct periods during the morning drop-off and afternoon pick-up periods (15-20 minutes at peaks) and these periods are non-coincident with the peak periods of the adjacent roadways.

In summary, the proposed site is a good location for a new school and a safe environment can be maintained with traffic conditions at manageable levels. While the school can be safely accommodated, there will be delays and queues during limited period of the day, and improvements will be necessary to minimize the impacts and enhance safety conditions.

RECOMMENDATIONS

A detailed transportation improvement program has been developed that is designed to maintain safe and efficient access to the school and address any deficiencies identified at off-site locations evaluated in conjunction with this study. The following improvements, as depicted in Figure 24, have been recommended as a part of this evaluation and will be completed in coordination with the Town.

School Start Time

Based upon observations of area traffic it is recommended that the school start time begin prior to 8:00 AM in advance of peak traffic volumes. Even a 15-minute adjustment to a 7:45 AM start will significantly improve conditions.

Project Access and Circulation

The school driveways were planned such that traffic impacts to the area are minimized and safe and efficient access and egress is provided. As currently planned, an entrance driveway will be located along Heath Street at Dunster Street with an exit driveway at Oak Street. The on-site circulation includes a 650-foot drop-off area for queuing.

The following recommendations are offered with respect to the design and operation of the school site driveways:

- The main entrance driveway should have a minimum 24-foot entrance and will be illuminated. The driveway will provide two lanes with a drop-off/pick-up lane and a separate by-pass lane.

- The Oak Street driveway will be a minimum of 24-feet wide accommodating two-way traffic and will be under stop control and illuminated. During peak drop-off and pick-up periods this location will be placed under crossing guard control.

- A bus pull-off area is recommended off Heath Street and shall be designed such that buses pull-off from Heath Street to safely drop-off and pick-up students.

- School Zone signs, pavement markings and traffic control devices (i.e., flashing school speed limit signs) should be provided along Heath Street.

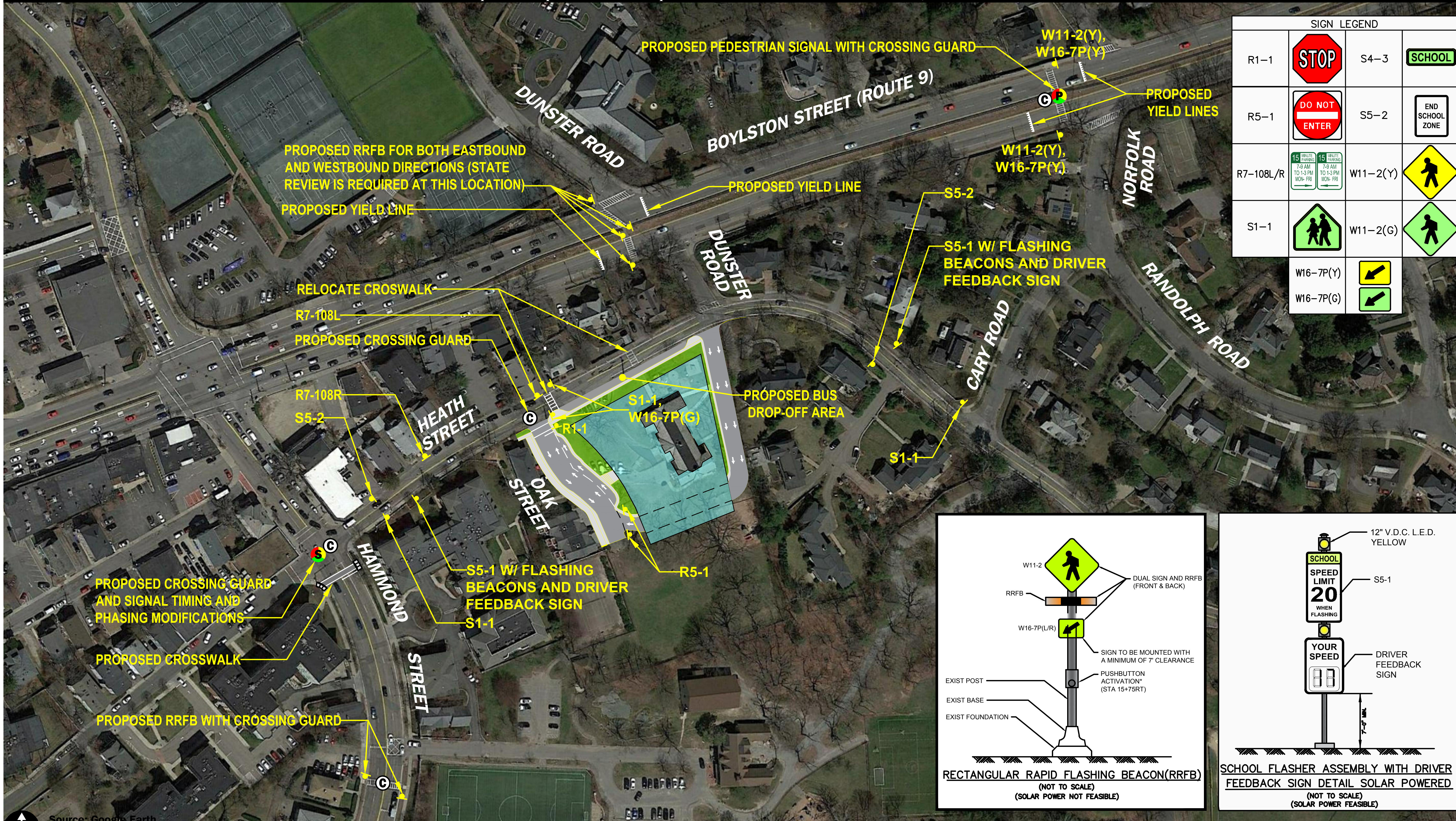

Figure 24

Conceptual Improvement Plan
Pedestrian Access and School Signage Plan

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Transportation Engineers & Planners

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- All signs and other pavement markings to be installed within the Project site shall conform to the applicable standards of the current Manual on Uniform Traffic Devices (MUTCD).[9]

- Signs and landscaping adjacent to the Project site driveway intersections should be designed and maintained so as not to restrict lines of sight.

Pedestrian Improvements

New crosswalks are proposed along Heath Street and Hammond Street. The new Heath Street crosswalk is located near Oak Street where the sight lines are better. Sidewalks entering the site will be provided along the bus pull-off area and entering the site. In addition, all of the identified existing pedestrian deficiencies should be addressed by the Town including all pedestrian routes which are anticipated to accommodate teacher parking. ADA-complaint sidewalks should be provided in the area. The desirable sidewalk minimum width is five (5) feet and a 3-foot clearance at point objects. Further review of the pedestrian improvements will be required.

Proposed Rectangular Rapid Flashing Beacon (RRFB) signs are proposed along Route 9 at Dunster Road in the both directions and Hammond Street to alert drivers of the crossings and enhance safety for the school children. A pedestrian traffic signal is also proposed at Route 9 and Norfolk Road.

Off-Site

Hammond Street at Route 9 and Hammond Street at Heath Street

The Heath Street and Hammond Street signalized intersections will be retimed to include an exclusive pedestrian phase and reallocated green time to Heath Street approach to better facilitate peak traffic movements associated with the school. The new phasing and timing can better serve the peak school demand in comparison to the current signal timing and phasing. The Heath Street approach to Hammond Street will operate at LOS D, an acceptable peak condition. Hammond Street at Boylston Street (Route 9) will remain unchanged.

Traffic Enforcement

Increased traffic enforcement along Heath Street is recommended to enforce the school speed zone.

Parking

Designated teacher parking on local street must be approved by the Transportation Board. In addition, existing Heath Street on-street parking should be considered for 15-minute parking during parent drop-off and pick-up times. A minimum of 10 parking spaces should be provided on-site for visitors and handicap parking. An EV installation should be considered. Similar to other schools in Brookline, off-site parent parking can be found on local residential streets a short walking distance from the school.

[9]*Manual on Uniform Traffic Control Devices (MUTCD); Federal Highway Administration; Washington, D.C.; 2009*

Bicycle Considerations

The following should be incorporated into the site plan.

- Bicycle racks should be provided proximate to the building entrance in a visible location.
- Interior bicycle storage and shower facilities should be provided.
- Bicycle enhancements by the Town should be reviewed for both Heath Street and Woodland Road.

Transit Usage

While public transit usage will be limited to staff, the school should actively promote staff usage of public transportation to the school. This should be incorporated into a school Travel Demand Management Plan.

School Drop-Off and Pick-Up Traffic Management Plan

A central feature of the Project is the implementation of a traffic and parking management plan for school drop-off and pick-up activities. The Project site and the site access and off-site improvements detailed herein have been developed to facilitate access to the school campus for pedestrians, bicyclists, school buses and parents/caregivers in a safe and efficient manner. The traffic and parking management plan has been designed to build-upon this created infrastructure and will consist of the following major elements, all of which are overseen by school staff:

- A crossing guard should be located at the Oak Street school driveway in order to manage the flow of vehicles exiting the school and pedestrian crossings.
- School staff should be stationed at the drop-off areas to manage traffic within the site and along the driveway, as well as to facilitate the safety of pedestrians and bicyclists.
- A designated drop-off/pick-up area should be designed to facilitate these movements.
- A lane along the entryway should remain unobstructed during student drop-off and pick-up times.
- Parents and caregivers should be given information on school drop-off and pick-up times and procedures at the beginning of the school year, with periodic updates and reminders provided as may be necessary.

The elements of the traffic and parking management plan for school drop-off and pick-up activities should be reviewed and updated as may be necessary in order to ensure the safety of students.

Regional Traffic in the Area

Regional traffic was observed to utilize Heath Street to access Route 9 and contribute to area delays. While not required for this project, neighborhood conditions can be improved with the following considerations:

- Implement peak hour on-way flow on Heath Street in the westbound direction.
- Closure of Dunster Road

These measures can be considered by the Town to reduce regional impacts to the immediate area.

Construction Management Plan

A detailed Construction Management Plan should be prepared and reviewed by the Town.

Traffic Monitoring

Within three months after school opening, a traffic monitoring study should be completed to review traffic counts at the school driveways and evaluate the traffic condition within the area.

Annually, the school should assess conditions and evaluate pedestrian safety, crossing guards, and evaluate the level of student busing and make adjustments, as necessary.

CONCLUSION

Overall, a safe environment to the school can be maintained and the increased traffic conditions with respect to delays and queues will be limited to short periods in the morning and afternoon.