UPDATED TRAFFIC IMPACT AND ACCESS STUDY

PROPOSED APARTMENTS
LITTLETON, MA

PREPARED FOR:

15 GREAT ROAD, LLC
CONCORD, MASSACHUSETTS

JULY 9, 2012

PREPARED BY:

BAYSIDE ENGINEERING

600 UNICORN PARK DRIVE
WOBURN, MA 01801

UPDATED TRAFFIC IMPACT AND ACCESS STUDY

PROPOSED RESIDENTIAL DEVELOPMENT

15 Great Road
LITTLETON, MASSACHUSETTS

Prepared for:

Fifteen Great Road, LLC
c/o Omni Properties

July 9, 2012

Prepared by:

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SECTION 1: INTRODUCTION

Bayside Engineering has prepared this updated study to assess the traffic impact and to evaluate the access requirements of the proposed residential development to be located on Great Road in Littleton, Massachusetts. The original Traffic Impact and Access Study (TIAS) was prepared by LandStrategies, dated October 19, 2011.

PROJECT DESCRIPTION

The development is to be located on approximately 23 acres of land on the north side of Great Road, east of Grist Mill Road. Currently, the site is a vacant, wooded parcel of land. As currently proposed, the project will consist of 142 residential townhouse units and 48 residential apartment units. This study has been specifically prepared to address the impacts of the residential apartments. Parking for 411 vehicles will be provided.

Access to the project will be provided by way of a full-movement driveway to Great Road and an emergency access only driveway to Grist Mill Road. Figure 1 shows the site location in relation to the surrounding area.

CHANGES FROM ORIGINAL OCTOBER 2011 TRAFFIC STUDY

Traffic Generation

As a result of project related changes since the date of the original TIAS, the size of the project has changed. The original study consisted of 200 apartment units and the project now consists of 142 residential townhouse units and 48 residential apartment units. This change results in 50 fewer daily vehicle trips generated by the project (1,286 daily vehicle trips vs. 1,336 daily vehicle trips). Correspondingly, the peak hour traffic generation is slightly lower with the current build proposal (95 trips vs. 102 trips) during the weekday morning peak hour and (124 trips vs. 128 trips) during the weekday evening peak hour. When the new trips were assigned to the roadway network and analyzed, the resulting levels of service remain unchanged for the future Build conditions.

Mitigation

It was also previously recommended that Great Road be widened to provide an exclusive left-turn lane into the site. This recommendation remains the same. However, the Massachusetts Department of Transportation (MassDOT) requested the proponent explore options to improve sight distances at the site driveway to/from the east. Based on subsequent review, the proposed profile of Great Road in the vicinity of the site will be improved to further extend the available lines of sight. As part of the proposed widening to provide the exclusive left-turn lane into the site, the grade of Great Road will be raised and the profile designed to meet MassDOT requirements. With this change, the stopping sight distance (SSD) approaching from the east will increase to 428 feet (over the existing 326 feet), which exceeds the American Association of State Highway and Transportation Officials (AASHTO) requirements for 50 mph, the posted speed limit. In excess of 500 feet will continue to be provided for SSD approaching from the west. The intersection sight distance (ISD) will also improve with the change in grade, from 402 feet to in excess of 500 feet.

STUDY METHODOLOGY

This study has been prepared in three stages. The first stage involved an assessment of existing conditions within the study area and included an inventory of roadway geometrics, pedestrian and bicycle facilities and public transportation services. Existing traffic counts were performed at the study area intersections.

In the second stage of the study, future traffic conditions were projected and analyzed. Specific travel demand forecasts for the project were assessed along with future traffic demands due to expected traffic growth independent of the proposed project. In accordance with Massachusetts Department of Transportation (MassDOT) and Executive Office of Environmental Affairs (EEA) guidelines, the year 2016 was selected as the basis for modeling future transportation impacts of the proposed development to reflect a five-year planning horizon.

The third stage of the study presents and evaluates measures to address traffic issues, if any, and necessary improvements to accommodate the development.

SUMMARY

Review of the proposed project and access plan shows that in relation to roadway capacity, traffic safety, and traffic impacts upon the surrounding roadway network, the proposed project will have minimal impact on the surrounding roadways and intersections. The existing roadway system has sufficient capacity for the proposed project.

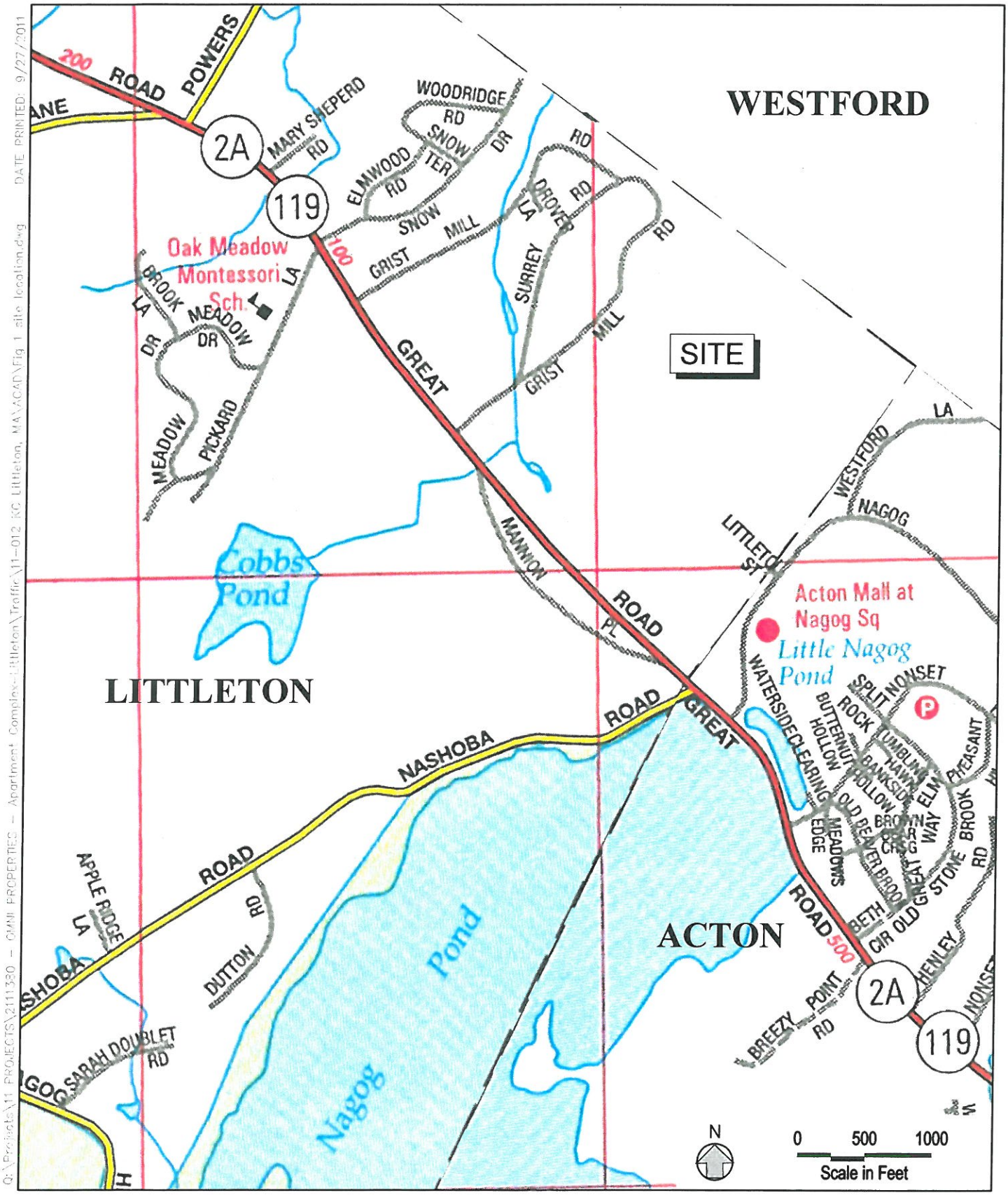

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Figure 1

Site Location Map

SECTION 2: EXISTING TRAFFIC CONDITIONS

STUDY AREA

Roadway geometry and traffic control information was collected for the following locations:

- Great Road and Nashoba Road
- Great Road and Mannion Place
- Great Road and Grist Mill Road (east)
- Great Road and Grist Mill Road (west)

FIELD SURVEY

A comprehensive field inventory of the proposed site was conducted in May and June 2011. The inventory included collection of existing roadway geometrics, traffic volumes, and safety data for the existing study area intersections and site access driveway locations. Traffic volumes were measured by means of automatic traffic recorder (ATR) counts and substantiated by manual turning movement counts (TMCs) conducted at the study area intersections.

GEOMETRICS

Primary study area roadways are described below.

Roadways

Great Road (Route 2A/119)

Great Road (Route 2A/119) is a two-lane, Urban Principal Arterial under the jurisdiction of the Massachusetts Department of Transportation (MassDOT). Great Road traverses the study area in a general east/west direction. Additional turn lanes are provided at major intersections. Travel lanes are generally separated by a double yellow centerline. Marked shoulders are also provided. The posted speed limit on Great Road in the vicinity of the site is 50 miles per hour (mph). Land

use along Great Road in the study area consists of primarily residential uses.

Intersections

Great Road and Nashoba Road

Nashoba Road intersects Great Road from the south to form this three-legged, unsignalized intersection. The Great Road approaches consist of single lanes permitting left- or right-turn movements. The Nashoba Road approach consists of a single lane which widens at Great Road to provide separate left-and right-turn movements separated by a triangular shaped grassed island. The Nashoba Road approach is under STOP sign control. Land use in the area consists of residential homes, retail uses to the north and Nagog Pond to the east.

Great Road and Mannion Place

Mannion Place intersects Great Road from the south to form this three-legged, unsignalized intersection. The Great Road eastbound and westbound approaches each consist of a single lane permitting left- or right-turns. The Mannion Place approach consists of a wide, single lane approach, permitting left- or right-turn movements. Mannion Place operates under STOP like control. Land use in the area consists of residential homes.

Great Road and Grist Mill Road (East)

Grist Mill Road (east) intersects Great Road from the north to form this three-legged, unsignalized intersection. The Great Road eastbound and westbound approaches each consist of a single lane permitting left- or right-turns. The Grist Mill Road (east) approach consists of a wide lane which was observed to allow vehicles turning right to by-pass vehicles making left-turns. Grist Mill Road (east) is under STOP sign control. Land use in the area consists of residential homes.

Great Road and Grist Mill Road (West)

Grist Mill Road (west) intersects Great Road from the north to form this three-legged, unsignalized intersection. The Great Road eastbound and westbound approaches each consist of a single lane permitting left- or right-turns. The Grist Mill Road (west) approach consists of a single lane which permits both left- and right-turns. Grist Mill Road (west) is under STOP sign control. Land use in the area consists of residential homes and the Oak Meadow Montessori School to the south.

TRAFFIC VOLUMES

Existing Traffic Volumes

To establish base traffic conditions within the study area, manual turning movement and vehicle classification counts were obtained in May 2011. Peak-period turning movement counts were conducted during the weekday morning peak period (7:00 to 9:00 AM) and weekday evening period (4:30 to 6:30 PM). Daily traffic counts were conducted on Great Road and Grist Mill Road for a two day period using automatic traffic recorders (ATR).

Analysis of the peak-period traffic counts indicated that the weekday morning commuter peak hour occurs between 8:00 and 9:00 AM and the weekday evening commuter peak hour occurs between 5:00 and 6:00 PM. It should be noted, however, that the individual intersection peak hours were used in the analysis to present a "worst case" condition. The traffic count worksheets are provided in the Appendix.

Seasonal Adjustment

The traffic-volume data gathered as part of this study was collected during the month of May 2011. Data from the MassDOT was reviewed to determine the monthly variations of the traffic volumes. The traffic data showed May volumes to be slightly higher than average month conditions. Therefore, the May traffic volumes were not adjusted in order to provide for a conservative analysis scenario. The 2011 existing daily and peak-hour traffic volumes for average-month conditions are summarized below in Table 1. The 2011 Existing peak hour traffic flow networks are shown graphically on Figures 2 and 3. The traffic count worksheets are provided in the Appendix.

TABLE 1
EXISTING TRAFFIC-VOLUME SUMMARY[a]

Location	Weekday Traffic Volume[b]	Weekday Morning Peak Hour			Weekday Evening Peak Hour		
		Traffic Volume[c]	K Factor[d]	Directional Distribution[e]	Traffic Volume	K Factor	Directional Distribution
Great Road, east of Grist Mill Road (East)	16,850	1,396	8.3	62.3% EB	1,550	9.2	61.3% WB
Great Road, between Mannion Place and Nashoba Road	17,100	1,401	8.2	62.5% EB	1,562	9.1	61.1% WB
Grist Mill Road (East) approximately 2,400 ft north of Great Road	115	9	7.8	55.6% SB	10	8.7	50.0% NB

[a]Two-way traffic volume
[b]Daily traffic expressed in vehicles per day.
[c]Expressed in vehicles per hour.
[d]Percent of daily traffic volumes which occurs during the peak hour.
[e]Percent of peak-hour volume in the predominant direction of travel.
NB = northbound; SB = southbound; EB = eastbound; WB = westbound.

Great Road was recorded to carry approximately 17,000 vehicles per day (vpd) during average month conditions in front of the site. During the weekday morning peak hour, approximately 1,400 vehicles per hour (vph) were recorded, and during the weekday evening peak hour, approximately 1,560 vph were recorded.

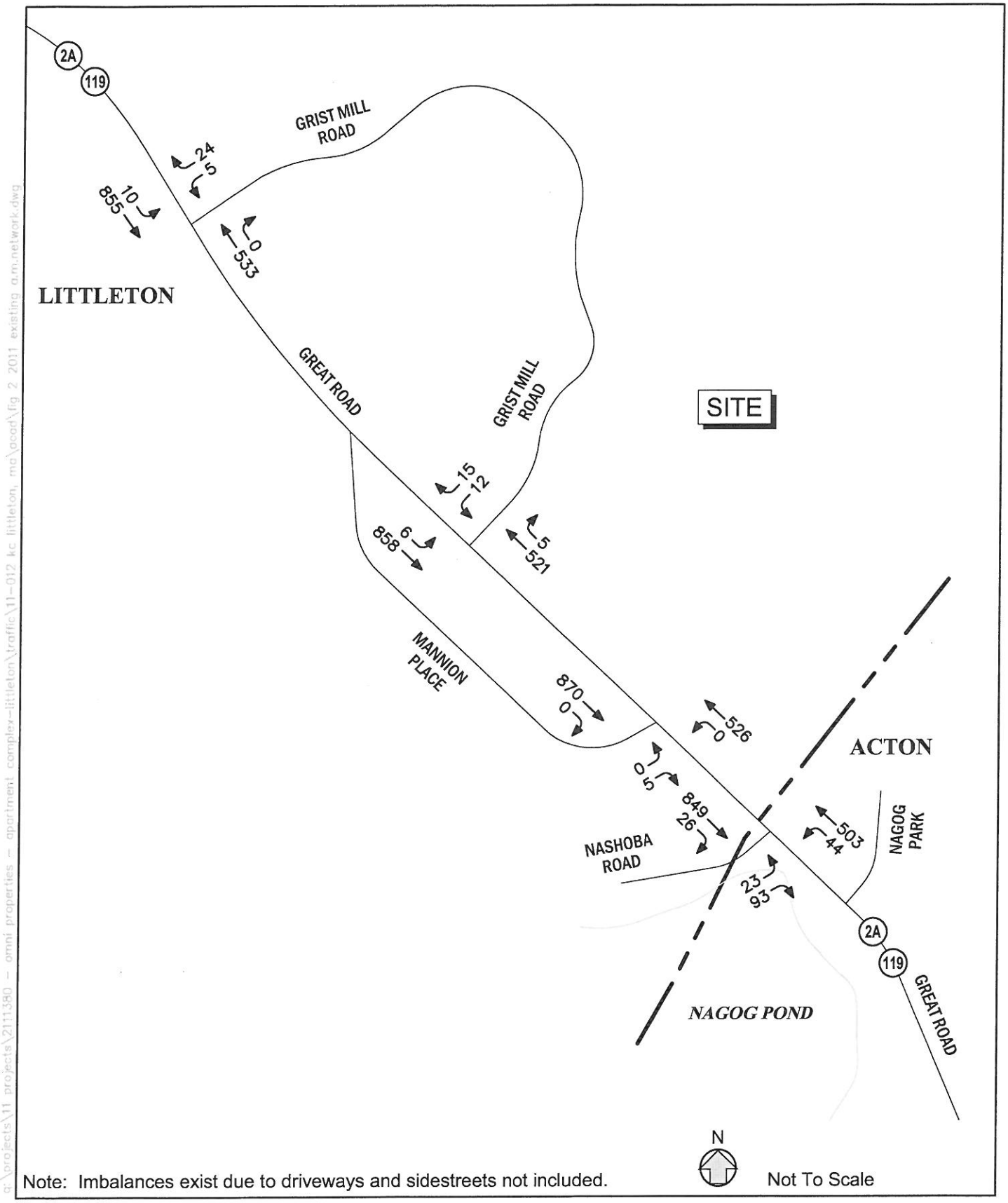

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Figure 2

2011 Existing
Weekday Morning Peak Hour
(8:00 - 9:00 A.M.)
Traffic Volumes

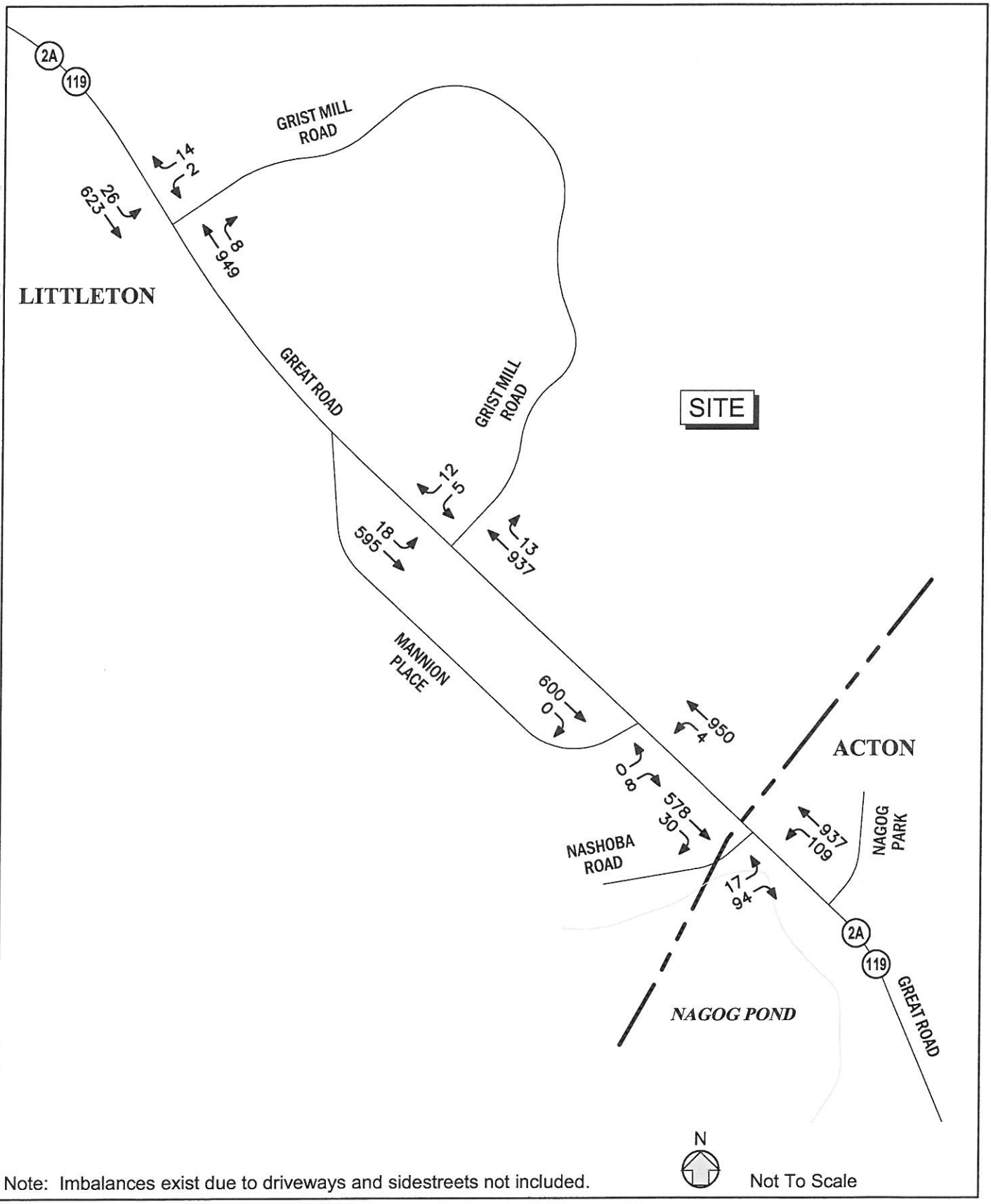

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Figure 3

2011 Existing
Weekday Evening Peak Hour
(5:00 - 6:00 P.M.)
Traffic Volumes

MOTOR VEHICLE CRASH DATA

Motor vehicle crash data for the study area intersections and roadways were obtained from the MassDOT database for 2007 through 2009, the most recent three-year period for which data is available. The motor vehicle crash data was reviewed to determine crash trends in the study area. A summary of the data is provided in Table 2 and the crash data is included in the Appendix.

TABLE 2
MOTOR VEHICLE CRASH DATA SUMMARY[a]

Scenario	Location: Great Road and Nashoba Road	Great Road Mannion Place	Great Road and Grist Mill Road (East)	Great Road and Grist Mill Road (West)
Year:				
2007	0	1	0	0
2008	1	0	0	0
2009	1	0	0	0
Total	2	1	0	0
Average[b]	0.67	0.33	0.00	0.00
Crash Rate[c]	0.09	0.05	0.00	0.00
Significant[d]	No	No	No	No
Type:				
Angle	0	0	0	0
Rear-End	1	0	0	0
Head-On	0	0	0	0
Sideswipe	0	0	0	0
Run off Road/Hit Fixed Object	0	0	0	0
Single Vehicle Crash	1	0	0	0
Unknown	0	1	0	0
Total	2	0	0	0
Time of Day:				
Weekday (7:00 to 9:00 AM)	0	0	0	0
Weekday (4:00 to 6:00 PM)	0	0	0	0
Remainder of Day	2	1	0	0
Total	2	1	0	0
Pavement Conditions:				
Dry	1	0	0	0
Wet	1	0	0	0
Snow	0	0	0	0
Icy	0	1	0	1
Other	0	0	0	0
Unknown	0	0	0	0
Total	0	1	0	0
Day of Week:				
Monday through Friday	0	1	0	0
Saturday and Sunday	2	0	0	0
Total	2	1	0	0
Severity:				
Property Damage Only	2	1	0	0
Personal Injury	0	0	0	0
Fatal Accident	0	0	0	0
Hit and Run	0	0	0	0
Unknown	0	0	0	0
Total	2	1	0	0

[a]Source: MassDOT Safety Management/Traffic Operations Unit records, 2007 through 2009.
[b]Average crashes over three-year period.
[c]Crash rate per million entering vehicles (mev).
[d]Signalized intersections are significant if rate >0.75 crashes per million vehicles, and unsignalized intersections are significant if rate >0.58 crashes per million vehicles.

Vehicle Speeds

Existing speed data for Great Road were also collected using the ATRs. The posted speed limit on Great Road in the site vicinity is 50 mph. The speed data is summarized in Table 3.

TABLE 3
GREAT ROAD VEHICLE SPEEDS

Direction	Posted Speed Limit (mph)	Average Observed Speed[a] (mph)	85th Percentile Speed (mph)
Great Road Eastbound	50	43	48
Great Road Westbound	50	37	43

[a]Based on speed data compiled on May 24-26, 2011.

As shown in Table 3, the average speed of vehicles travelling eastbound or westbound was found to be 43 and 37 mph, respectively. The 85th percentile speed was found to be 48 mph for eastbound vehicles and 43 mph for westbound vehicles. The 85th percentile speed is the speed at which sight distances are typically evaluated.

PLANNED ROADWAY IMPROVEMENTS

Officials for MassDOT and the Town of Littleton were contacted regarding roadway improvements planned for the study area intersections. No improvement projects were identified that would increase capacity at the study area intersections.

SECTION 3:
2016 NO-BUILD AND BUILD TRAFFIC CONDITIONS

To determine the impact of site-generated traffic volumes on the roadway network under future conditions, baseline traffic volumes in the study area were projected to the year 2016. Traffic volumes on the roadway network at that time, in the absence of the proposed project, would include existing traffic, new traffic due to general background traffic growth, and traffic related to specific developments by others expected to be completed by 2016. Consideration of these factors resulted in the development of 2016 No-Build traffic volumes. Anticipated site-generated traffic volumes were then superimposed upon these No-Build traffic flow networks to develop 2016 Build conditions.

2016 NO-BUILD TRAFFIC VOLUMES

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 can be 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.

Background Traffic Growth

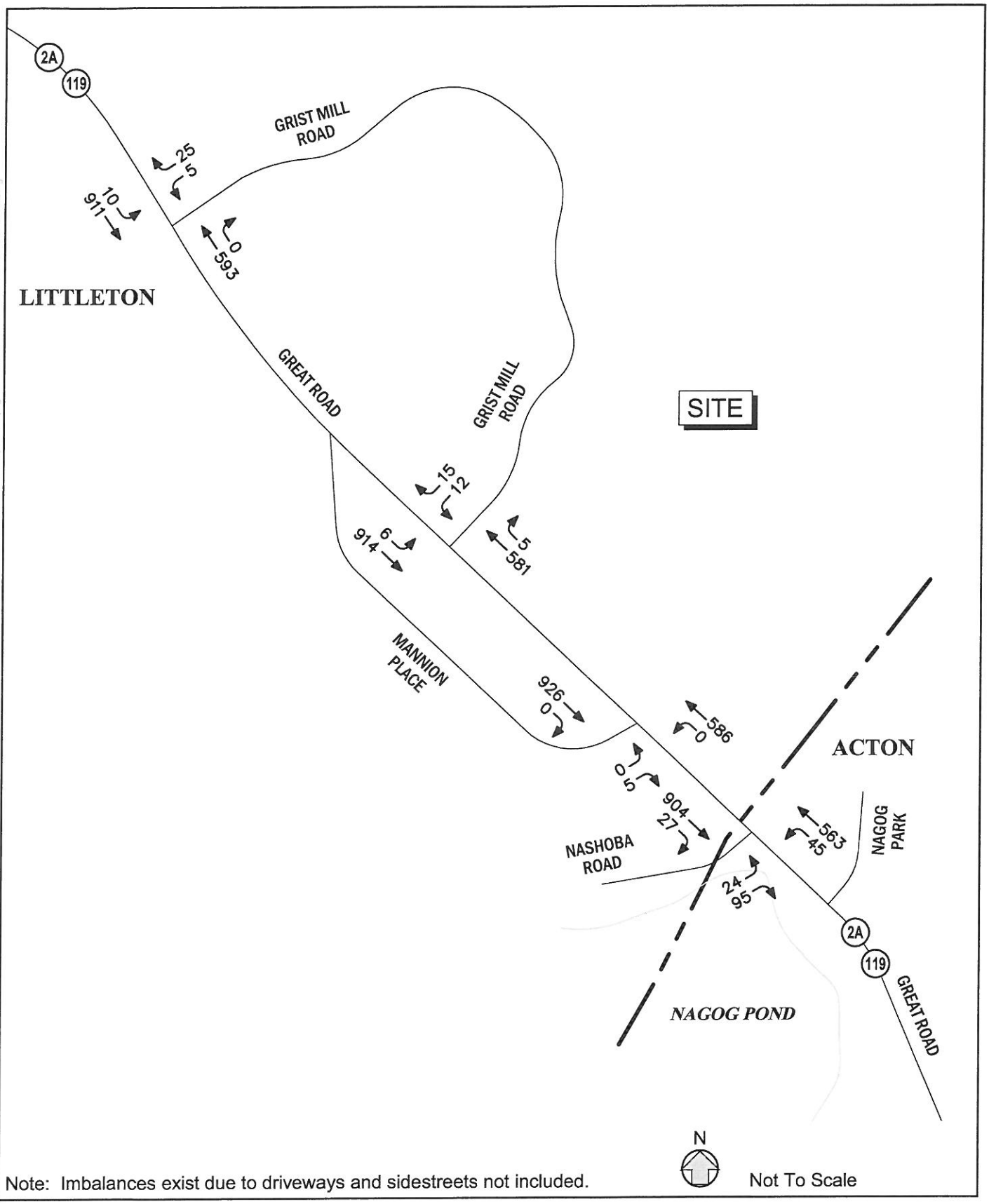
Traffic-volume data compiled by MassDOT from permanent count stations and historic traffic counts in the area were reviewed in order to determine traffic growth trends. Based on a review of this data, it was determined that traffic volumes within the study area have generally decreased by one to two percent per year over the past several years. This decline in traffic volume is not expected to continue. Therefore, to provide a conservative case, a 0.5 percent per year compounded annual background traffic growth rate was used to account for potential future traffic growth external to the study area and presently unforeseen development.

Specific Development by Others

Traffic volumes generated by the specific local developments by others were included in the 2016 No-Build condition. The Towns of Littleton and Acton were contacted to identify specific planned developments. Based on these discussions, there are three potential projects that are currently planned or have been approved in the immediate area that could impact future traffic volumes beyond the general background traffic growth rate. These include an approved 108 unit apartment project, the re-development of the former Cisco site at I-495 (mixed-use retail/commercial), and an approved, but not constructed senior community (153 homes) at the Quail Ridge Country Club in Acton. Site generated traffic volumes were calculated and assigned according to Institute of Transportation Engineers (ITE) recommended procedures.

No-Build Condition Traffic Volumes

The 2016 No-Build weekday morning peak-hour traffic volumes were developed by applying a compounded 0.5 percent annual growth rate to the 2011 Existing peak-hour movement traffic volumes and adding traffic from the identified background projects. Figures 4 and 5 show the projected 2016 No-Build peak hour traffic volumes for the weekday morning and weekday evening peak-hour conditions.



Note: Imbalances exist due to driveways and sidestreets not included.

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Figure 4

2016 No-Build
Weekday Morning Peak Hour
(8:00 - 9:00 A.M.)
Traffic Volumes

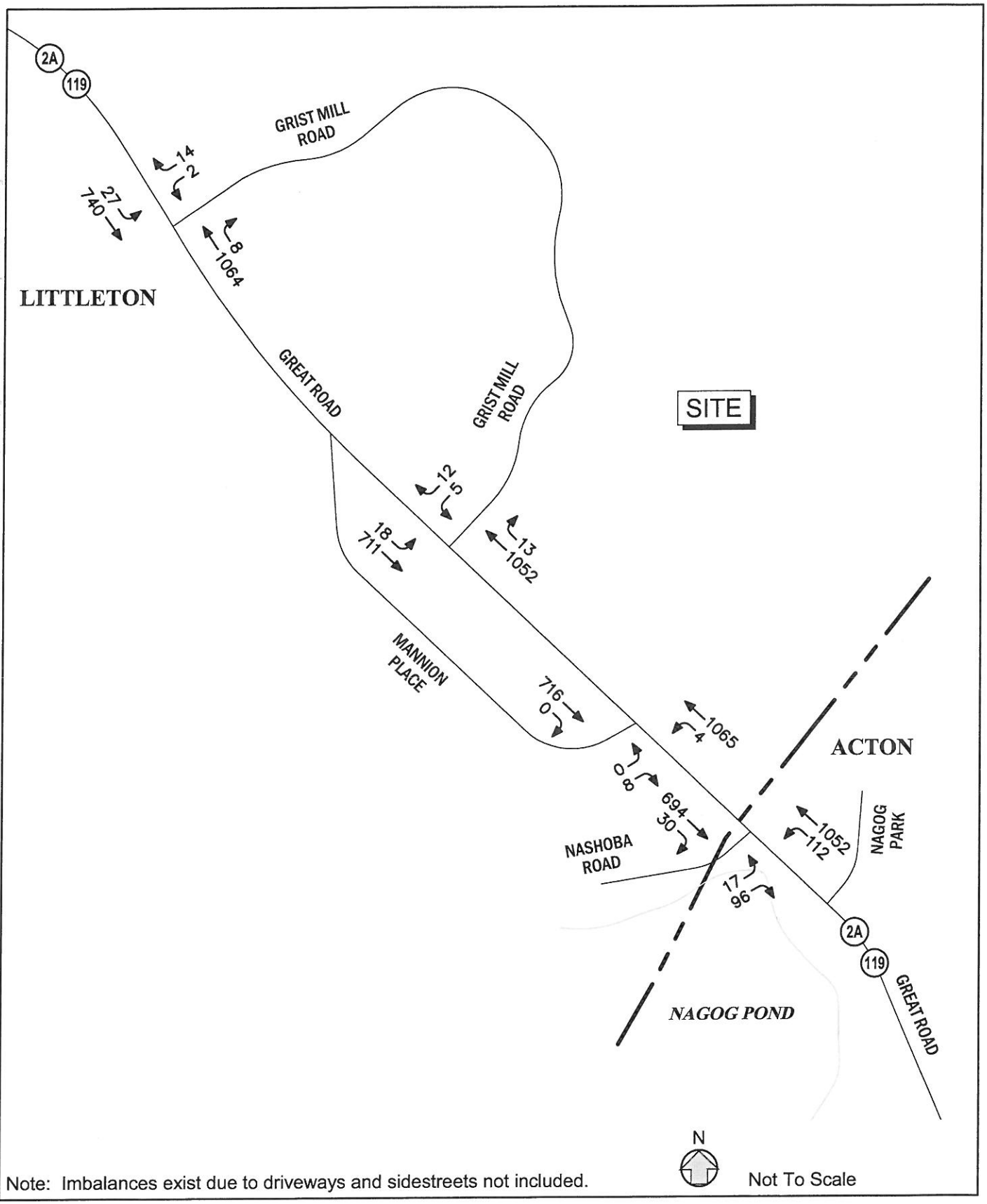

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Figure 5

2016 No-Build
Weekday Evening Peak Hour
(5:00 - 6:00 P.M.)
Traffic Volumes

FUTURE 2016 BUILD CONDITIONS

Project Description

As currently proposed, the project will consist of 142 residential townhouse units and 48 residential apartment units. This study has been prepared specifically to address the traffic impacts of the residential units. Parking for 411 vehicles will be provided. Access to the project will be provided by way of a full-movement driveway to Great Road and an emergency access only driveway to Grist Mill Road. All site generated traffic was assigned to the Great Road site driveway.

Traffic Generation

Trip-generation data published by the ITE *Trip Generation* manual[1] was reviewed. Trip generation data for Land Use Code (LUC) 220 – Apartments and LUC 230 – Residential Condominium/Townhouse was used to determine the expected trip generation for the proposed project. The expected trip generation for the proposed development is summarized in Table 4 and the trip generation worksheets are included in the Appendix.

TABLE 4
TRIP-GENERATION SUMMARY

	Proposed Apartments Trips[a]	Proposed Townhouse Trips[b]	Total Trips
Average Weekday Daily Traffic	414	872	1,286
Weekday Morning Peak Hour:			
Entering	5	12	17
Exiting	22	56	78
Total	27	68	95
Weekday Evening Peak Hour:			
Entering	29	54	83
Exiting	15	26	41
Total	44	80	124

[a]Based on ITE LUC 220, Apartments; 48 dwelling units.
[a]Based on ITE LUC 230, Residential Condominium/Townhouse; 142 dwelling units.

On a typical weekday, the proposed development is expected to generate 1,286 vehicle trips (643 vehicles entering and 643 vehicles exiting). During the weekday morning peak hour, 95 vehicle trips (17 vehicles entering and 78 vehicles exiting) are expected. During the weekday evening peak hour, 124 vehicle trips (83 vehicles entering and 41 vehicles exiting) are expected.

[1]*Trip Generation*, Eighth Edition; Institute of Transportation Engineers; Washington, DC; 2009.

Trip Distribution

The directional distribution of the vehicular traffic approaching and departing the site is a function of population densities, the location of employment, existing travel patterns, similar uses, and the efficiency of the existing roadway system.

The trip distribution for the project was developed based on a review of Journey to work data for the town of Littleton. Table 6 summarizes the expected trip distribution, which is also shown on Figure 5. The trip distribution worksheets are included in the Appendix.

TABLE 5
PROPOSED TRIP DISTRIBUTION

Route	Direction	Percent of Trips
Great Road	East	44
Great Road	West	55
Nashoba Road	South	1
TOTAL		100

As shown in Table 5, approximately 55 percent of the site traffic is anticipated to arrive and depart the site by way of Great Road to the west and 44 percent by way of Great Road to the east. The remaining one percent is expected to use Nashoba Road.

Future Traffic Volumes - Build Condition

The site-generated traffic presented in Table 4 was distributed within the study area according to the percentages summarized in Table 5. The site generated volumes were superimposed onto the 2016 No-Build traffic volumes to represent the 2016 Build traffic-volume conditions. The anticipated 2016 Build weekday morning and weekday evening traffic volumes are graphically presented in Figures 7 and 8. These volumes were used as the basis for all analysis as well as to identify potential mitigation measures to ameliorate the project's impacts.

A summary of peak-hour projected traffic-volume changes in the site vicinity are shown in Table 6. These volumes are based on the expected increases from the site traffic generation.

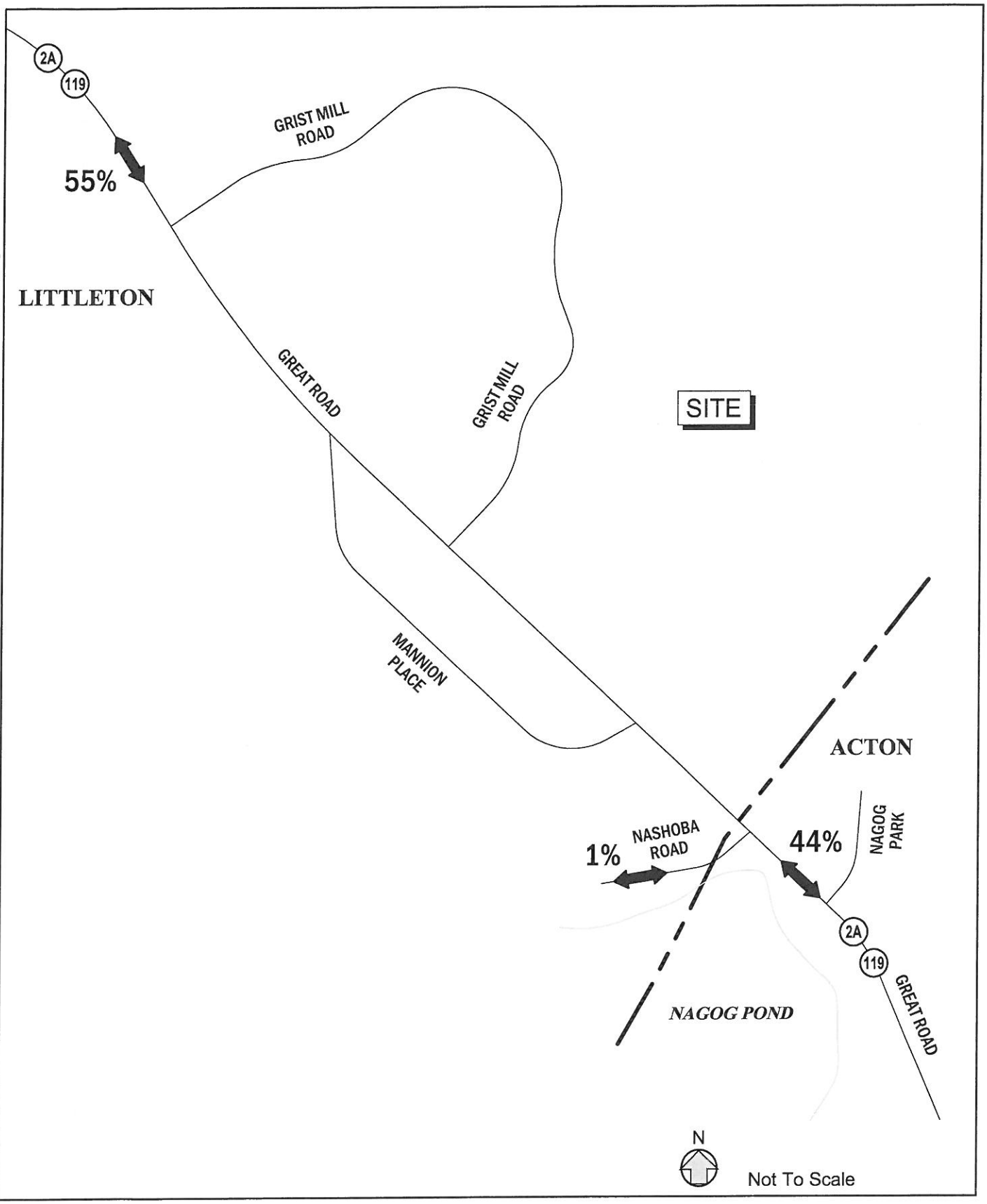

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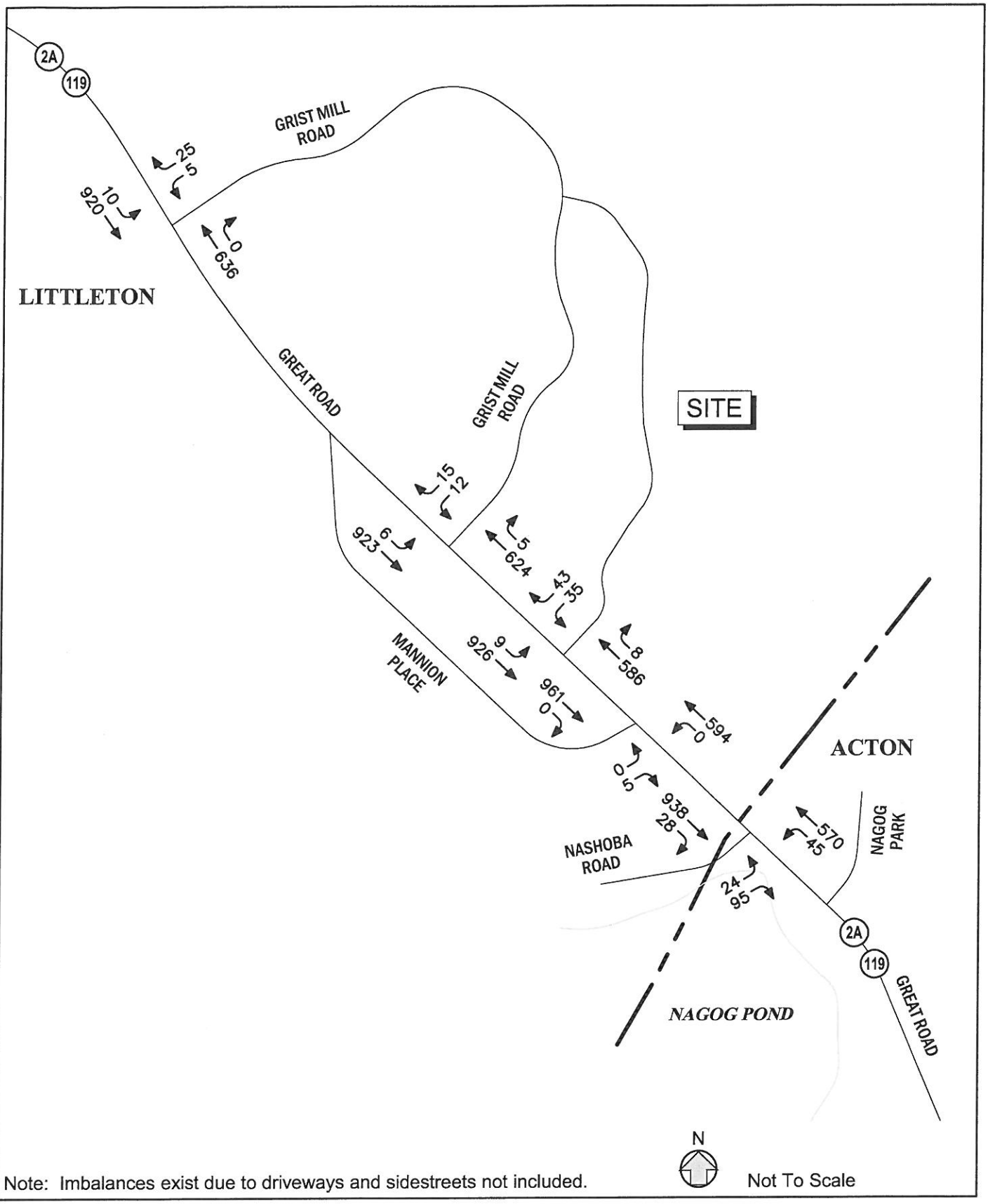
Figure 6

Trip Distribution Map



Note: Imbalances exist due to driveways and sidestreets not included.

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Figure 7

2016 Build
Weekday Morning Peak Hour
(8:00 - 9:00 A.M.)
Traffic Volumes

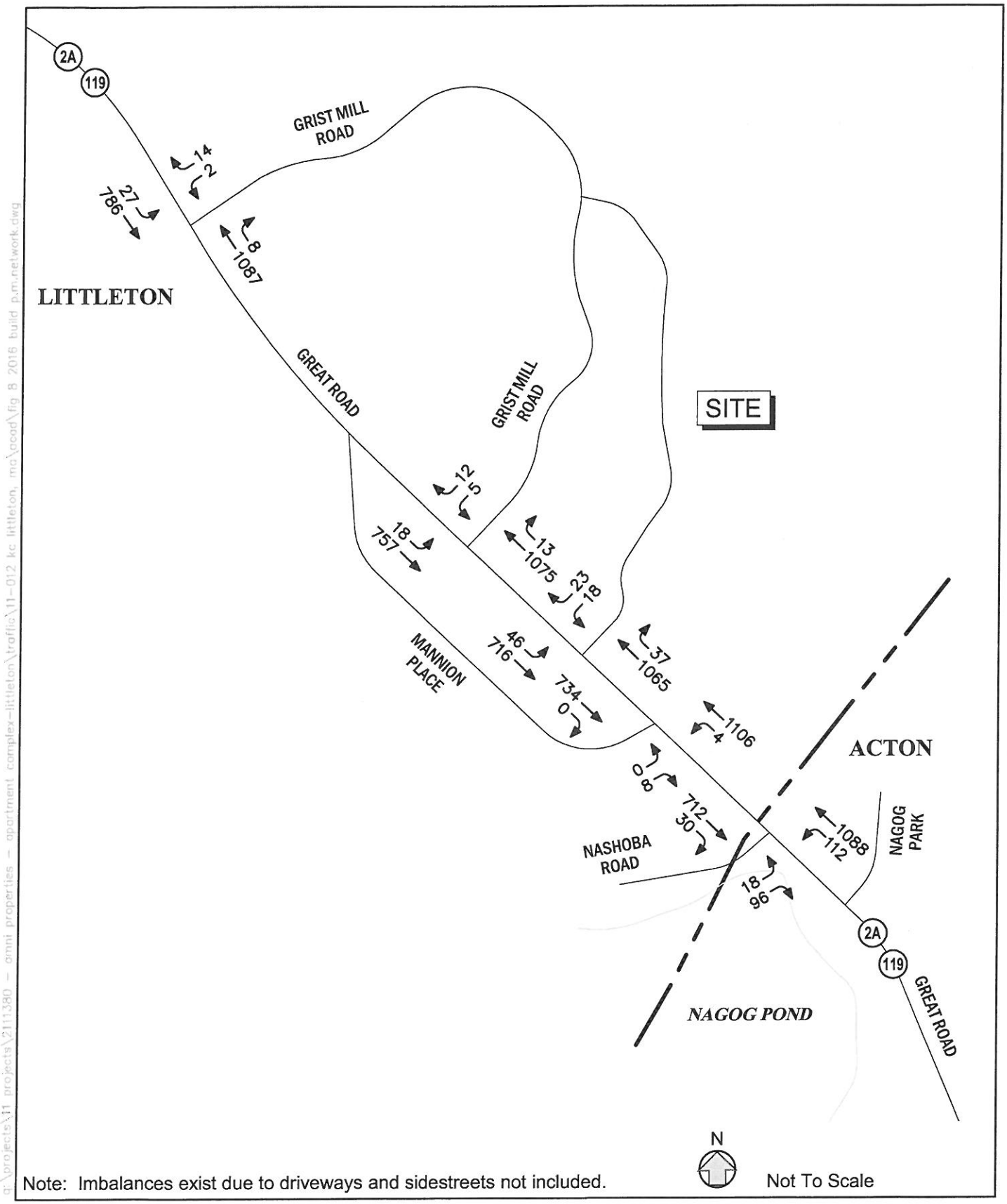

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Figure 8

2016 Build
Weekday Evening Peak Hour
(5:00 - 6:00 P.M.)
Traffic Volumes

TABLE 6
TRAFFIC-VOLUME INCREASES[a]

Location/Peak Hour	2016 No-Build	2016 Build	Volume Increase over No-Build	Percent Increase over No-Build
Great Road, west of Grist Mill Road (West)				
Weekday Morning	1,539	1,591	52	3.4
Weekday Evening	1,845	1,914	69	3.7
Great Road, east of Nashoba Road				
Weekday Morning	1,607	1,648	41	2.6
Weekday Evening	1,954	2,008	54	2.8

[a]All volumes are vehicles per hour, total of both directions.

As shown in Table 6, project-related increases are in the range of 2.6 to 3.7 percent during the weekday morning peak hour. This is approximately equivalent to one additional vehicle per minute during the respective peak hours.

SECTION 4: CAPACITY ANALYSIS

To assess intersection operations, capacity analyses were conducted for Existing, No-Build, and Build traffic-volume conditions. Capacity analyses provide an indication of how well the study area intersections serve existing and projected traffic volumes. Vehicle queue analyses provide a secondary measure of the operational characteristics of an intersection or section of roadway under study in terms of lane use and demand.

METHODOLOGY

Levels of Service

Level of service (LOS) is a quantitative measure used to describe the operation of an intersection or roadway segment. The level of service definition is described by the quality of traffic flow and is primarily defined in terms of traffic delays. The primary result of capacity analyses[2] is the assignment of a level of service to traffic intersections or roadway segments under various traffic-flow conditions. Six levels of service are defined for traffic intersections and roadway segments. Levels of service range from LOS A to LOS F. LOS A represents very good operating conditions and LOS F represents very poor operating conditions.

Unsignalized Intersections

The level of service for an unsignalized intersection is determined by the methodology and procedures described in the 2000 *Highway Capacity Manual.*[3] The level of service for unsignalized intersections is measured in terms of average delay for the critical movements (typically side street turning movements or mainline turning movements). The delay for the critical movements is a function of the available capacity for the movement and the degree of saturation of the lane group containing the critical movement. The delay calculation includes the affects of initial deceleration delay approaching a STOP sign, stopped delay, queue move-up time, and final acceleration delay from a stopped condition. The definitions for level of service at

[2]The capacity analysis methodology is based on procedures presented in the *Highway Capacity Manual;* Transportation Research Board; Washington, DC; 2000.

[3]*Highway Capacity Manual*; Transportation Research Board; Washington, DC; 2000.

unsignalized intersections are also provided in the 2000 *Highway Capacity Manual*. Table 7 summarizes the relationship between level of service and average control delay for the critical movements at unsignalized intersections.

TABLE 7
LEVEL-OF-SERVICE CRITERIA FOR UNSIGNALIZED INTERSECTIONS[a]

Average Delay (seconds per vehicle)	Resulting Level of Service
≤ 10.0	A
10.1 to 15.0	B
15.1 to 25.0	C
25.1 to 35.0	D
35.1 to 50.0	E
>50.0	F

[a]*Highway Capacity Manual*; Transportation Research Board; Washington, DC; 2000; page 17-2.

The analytical methodologies used for the analysis of unsignalized intersections use conservative analysis parameters, such as high critical gaps. The critical gap is defined as the minimum time between successive main line vehicles for a side street vehicle to execute the appropriate turning maneuver. Actual field observations indicate that drivers on minor streets accept smaller gaps in traffic than those used in the analysis procedures and therefore experience less delay than calculated by the HCM methodology. **The analysis results overstate the actual delays experienced in the field.** It should be noted that the unsignalized intersections along heavily trafficked roadways operate at constrained levels and the resulting calculated results of the unsignalized intersection analyses should be considered highly conservative.

Signalized Intersections

Levels of service for signalized intersections are calculated using the methodology and procedures described in the 2000 *Highway Capacity Manual*. The methodology assesses the intersection based on type of signal operation, signal timing and phasing, progression, vehicle mix, and intersection geometrics. Level-of-service designations are based on the delay per vehicle. Table 8 summarizes the relationship between level of service and delay. The calculated delay values result in level-of-service designations which are applied to individual lane groups, to individual intersection approaches, and to the entire intersection.

TABLE 8
LEVEL-OF-SERVICE CRITERIA FOR SIGNALIZED INTERSECTIONS[a]

Delay per Vehicle (Seconds)	Resulting Level of Service
≤10.0	A
10.1 to 20.0	B
20.1 to 35.0	C
35.1 to 55.0	D
55.1 to 80.0	E
>80.0	F

[a]*Highway Capacity Manual*; Transportation Research Board; Washington, DC; 2000; page 16-2.

ANALYSIS RESULTS

Level-of-service analyses were conducted for 2011 Existing, 2016 No-Build, 2016 Build As of Right and 2016 Build conditions for the intersections within the study area. The results of the capacity analyses are summarized in Table 9. Detailed analysis sheets are presented in the Appendix.

Great Road and Grist Mill Road (West)

Under 2011 Existing weekday morning conditions, the critical movements (all movements from Grist Mill Road) at this unsignalized intersection currently operate at level-of-service (LOS) C during the weekday morning peak hour and at LOS D during the weekday evening peak hour. Under future 2016 No-Build conditions, these movements are projected to operate at LOS D during the weekday morning peak hour and at LOS E during the weekday evening peak hour. Under 2016 Build conditions, with the project, the critical movements are modeled to continue to operate at LOS D during the weekday morning peak hour and at LOS E during the weekday evening peak hour.

Great Road and Grist Mill Road (East)

Under 2011 Existing weekday morning conditions, the critical movements (all movements from Grist Mill Road) at this unsignalized intersection currently operate at LOS D during the weekday morning peak hour and at LOS E during the weekday evening peak hour. Under future 2016 No-Build conditions, these movements are projected to operate at LOS D during the weekday morning peak hour and at LOS F during the weekday evening peak hour. Under 2016 Build conditions, with the project, the critical movements are modeled to continue to operate at LOS D during the weekday morning peak hour and at LOS F during the weekday evening peak hour.

TABLE 9
UNSIGNALIZED LEVEL-OF-SERVICE ANALYSIS SUMMARY

Critical Movement/ Peak Hour	2011 Baseline				2016 No-Build				2016 Build			
	Demand[a]	V/C[b]	Delay[c]	LOS[d]	Demand	V/C	Delay	LOS	Demand	V/C	Delay	LOS
Great Road and Grist Mill Road (West):												
All movements from Grist Mill Road:												
Weekday Morning	29	0.21	22.9	C	30	0.24	26.4	D	30	0.26	28.6	D
Weekday Evening	16	0.13	28.2	D	16	0.18	37.3	E	16	0.19	40.5	E
Great Road and Grist Mill Road (East):												
All movements from Grist Mill Road:												
Weekday Morning	27	0.17	25.2	D	27	0.20	29.6	D	27	0.21	32.0	D
Weekday Evening	17	0.24	39.6	E	17	0.33	59.6	F	17	0.36	68.2	F
Great Road and Site Driveway:												
All movements from Site Driveway:												
Weekday Morning	--	--	--	--	--	--	--	--	82	0.46	39.7	E
Weekday Evening	--	--	--	--	--	--	--	--	45	0.46	70.5	F
Great Road and Mannion Place:												
All movements from Mannion Place:												
Weekday Morning	5	0.03	17.6	C	5	0.03	18.7	C	5	0.03	19.5	C
Weekday Evening	8	0.05	14.1	B	8	0.06	16.2	C	8	0.06	16.5	C
Great Road and Nashoba Road:												
Left-turn movements from Nashoba Road:												
Weekday Morning	23	0.23	37.9	E	24	0.28	46.9	F	24	0.30	50.7	F
Weekday Evening	17	0.27	52.9	F	17	0.40	87.9	F	18	0.45	99.8	F
Right-turn movements from Nashoba Road:												
Weekday Morning	93	0.40	22.9	C	95	0.44	25.7	D	95	0.46	27.6	D
Weekday Evening	94	0.22	14.5	B	96	0.27	16.9	C	96	0.27	17.3	C

[a]Demand of critical movements in vehicles per hour.
[b]Volume-to-capacity ratio.
[c]Delay in seconds per vehicle.
[d]Level of service.

Great Road and Site Driveway

Under 2016 Build conditions, the critical movements (left- and right-turn movements from the site driveway) are projected to operate at LOS E during the weekday morning peak hour and at LOS F during the weekday evening peak hour. All other critical movements (i.e. left- and right-turns from Great Road) are projected to operate at LOS A during the peak hours. The 95th percentile queue (the queue that can be expected five percent of the time during the peak hours) is expected to be 2 to 3 vehicles on the site driveway approach. The 95th percentile queue for eastbound left-turns is projected to be one vehicle.

Great Road and Mannion Place

Under 2011 Existing weekday morning conditions, the critical movements (all movements from Mannion Place) at this unsignalized intersection currently operate at LOS C during the weekday morning peak hour and at LOS B during the weekday evening peak hour. Under future 2016

No-Build conditions, these movements are projected to operate at LOS C during the weekday morning peak hour and at LOS C during the weekday evening peak hour. Under 2016 Build conditions, with the project, the critical movements are modeled to continue to C during the weekday morning peak hour and at LOS C during the weekday evening peak hour.

Great Road and Nashoba Road

Under 2011 Existing weekday morning conditions, the critical movements (left-turn movements from Nashoba) at this unsignalized intersection currently operate at LOS E during the weekday morning peak hour and at LOS F during the weekday evening peak hour. Under future 2016 No-Build conditions, these movements are projected to operate at LOS F during the weekday morning peak hour and at LOS F during the weekday evening peak hour. Under 2016 Build conditions, with the project, the critical movements are modeled to operate at LOS F during the weekday morning peak hour and at LOS F during the weekday evening peak hour.

Summary

As shown in Table 10, the project does not cause a significant change in the overall level of service at any of the study area intersections.

SIGHT DISTANCES

Sight distance measurements were performed at the intersection of Great Road at the potential site driveway in accordance with Massachusetts Department of Transportation (MassDOT) standards. Both stopping sight distance (SSD) and intersection sight distance (ISD) measurements were performed. In brief, 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. ISD or corner sight distance (CSD) is the sight distance required by a driver entering or crossing an intersecting roadway, to perceive an on-coming vehicle and safely complete a turning or crossing maneuver with on-coming traffic. In accordance with MassDOT standards, at a minimum, sufficient SSD must be provided to the intersection.

SSD is generally more important as it represents the minimum distance required for safe stopping while ISD is based only upon acceptable speed reductions to the approaching traffic stream. However, the ISD must be equal to or greater than the minimum required SSD in order to provide safe operations at the intersections. In accordance with the American Association of State Highway and Transportation Officials (AASHTO) manual, *"If the available sight distance for an entering or crossing vehicle is at least equal to the appropriate stopping sight distance for the major road, then drivers have sufficient sight distance to anticipate and avoid collisions. However, in some cases, this may require a major-road vehicle to stop or slow to accommodate the maneuver by a minor-road vehicle. To enhance traffic operations, intersection sight distances that exceed stopping sight distances are desirable along the major road."* Accordingly, the ISD should be at least equal to the SSD, which would allow a driver approaching the minor road to safely stop.

Both the SSD and ISD were measured in the field, as well as determined through a physical survey. The distances were measured in accordance with AASHTO requirements. Table 10 presents the measured SSD and ISD at the intersection of Great Road at the potential site access driveway. The sight distance worksheets are included in the Appendix.

TABLE 10
SIGHT DISTANCE SUMMARY

	Required Minimum (Feet)[a]	Measured (Feet)
Great Road and Proposed Site Driveway		
Stopping Sight Distance:		
Great Road approaching from the east	335	336
Great Road approaching from the west	397	547
Intersection Sight Distance:		
Looking to the east from the proposed site driveway	411[b]/474[c]	402
Looking to the west from the proposed site driveway	474[b]/529[c]	587

[a]Recommended minimum values obtained from *A Policy on Geometric Design of Highways and Streets*; American Association of State Highway and Transportation Officials (AASHTO); 2004, and based on a 43 mph speed westbound and 48 mph eastbound.
[b]Recommended minimum value for vehicles turning right exiting a roadway under STOP-sign control.
[c]Recommended minimum value for vehicles turning left exiting a roadway under STOP-sign control.

As can be seen in Table 4, the SSD measurements performed at the driveway intersection with Great Road indicate that the SSD currently meet or exceed the recommended minimum requirements based on the recorded 85th percentile speeds on Great Road. Additionally, the measured ISD also meets the SSD requirements. To maintain sight distances, it is recommended that a sight distance triangle be established along the site frontage, in both directions from a point 15 back at the site driveway and extending to each of the corners of the site along Great Road. Within this triangle, any existing vegetation should be cut-back and any plantings be designed to be low growth plantings so as to not impede sight distances. Additional measures are described in the next section, Recommendations and Conclusion.

SECTION 5: RECOMMENDATIONS AND CONCLUSION

The proposed project is expected to generate approximately 95 vehicle trips (17 vehicles entering and 78 vehicles exiting) during the weekday morning peak hour and 124 vehicle trips (83 vehicles entering and 41 vehicles exiting) during the weekday evening peak hour. An analysis of traffic operations at the study area intersections indicates that the proposed project does not result in a significant impact to existing operating conditions.

RECOMMENDATIONS

The final phase of the analysis process is to identify the mitigation measures necessary to minimize the impact of the project on the transportation system. The proponent has made a commitment to implement the mitigation measures listed below.

Great Road and Site Driveway

The capacity analyses performed indicate the critical movements at the site driveway are projected to operate at LOS E and LOS F during the respective weekday morning and evening peak hours. Additional analyses were performed assuming the intersection were to be signalized. These analyses indicate that the intersection would operate at LOS A during both the weekday morning and evening peak hours. This significant improvement in operating conditions indicates that the projected unsignalized analyses will not be as poor as the capacity analysis model indicates. Also, the volume of traffic generated by the proposed project is not large enough to warrant signalization. It is recommended that the site driveway be placed under STOP sign control and designed in accordance with MassDOT requirements.

Further, it is recommended that Great Road be widened to provide an exclusive left-turn lane into the site. Review of NCHRP criteria indicates that the projected left-turn volume into the site during the weekday evening peak hour is large enough to warrant an exclusive lane.

Based on discussions with MassDOT, the proposed profile of Great Road in the vicinity of the site will be improved to further extend the available lines of sight. As part of the proposed widening to provide the exclusive left-turn lane into the site, the grade of Great Road will be raised and the profile designed to meet MassDOT requirements. With this change, the SSD approaching from the east will increase to 428 feet, which exceeds the AASHTO requirements for 50 mph, the posted speed limit. In excess of 500 feet will continue to be provided for SSD

approaching from the west. The intersection sight distance (ISD) will also improve with the change in grade, from 402 feet to in excess of 500 feet.

Lastly, in order to maintain sight distances, it is recommended that a sight distance triangle be established along the site frontage, in both directions from a point 15 back at the site driveway and extending to each of the corners of the site along Great Road. Within this triangle, any existing vegetation should be cut-back and any plantings be designed to be low growth plantings so as to not impede sight distances.

CONCLUSION

Review of the proposed development and access plan shows that in relation to roadway capacity, traffic safety, and traffic impacts upon the surrounding roadway network, the proposed project will meet safety standards and have a minimal impact on existing traffic conditions. With the proposed access, in conjunction with the mitigation measures described above and maintaining sight distances from the driveway (clear sight lines along frontage), safe and efficient access can be provided to the clienteles of the proposed development and to the motoring public in the area. Any vehicle queuing expected at the site driveway will occur on the site driveway approach to Great Road.

APPENDIX

Traffic Count Data

Seasonal Adjustment Worksheets

Crash Data Worksheets

Traffic Growth Data

Trip Generation Worksheets

Trip Distribution Gravity Model

Capacity Analysis Worksheets

Sight Distance Worksheets