# Proposed Mixed-Use Development
# 500 Main Street

**Groton, MA**


**December 9, 2022**

Prepared by:

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Prepared for:
**Groton ZBA**

Applicant:
**500 MG LLC**

# TRAFFIC IMPACT AND ACCESS STUDY

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# SECTION 1: EXECUTIVE SUMMARY

Bayside Engineering has prepared this study to assess the traffic impact and to evaluate the access requirements of a proposed mixed-use development to be located at 500 Main Street in Groton, Massachusetts. This traffic study has been prepared to address the traffic impacts associated with a Comprehensive 40B permit to the Town of Groton.

This report identifies existing traffic operating parameters on key roadways and intersections within the study area, evaluates the anticipated traffic volume increases as a result of the proposed project, analyzes the project's traffic-related impacts, determines the projects access/egress requirements and identifies appropriate mitigating measures designed to minimize the traffic-related impacts created by the project. The following provides a summary of the study findings.

## PROJECT DESCRIPTION

The site is located on the north side of Main Street, west of Mill Street. The site is abutted by Main Street to the south, commercially zoned land to the west, residential properties to the east and wooded land to the north. Currently, the site consists of a vacant office building and a single-family home. Two curb cuts provide access to the buildings on the site. Access to the existing office building by way of a single unsignalized driveway approximately 250 west of Mill Street. The driveway to the single-family home is located approximately 50 feet east of Mill Street.

As currently proposed, the Project will consist of the demolition of the existing office building and single-family home and the construction of:

- Three (3) residential apartment buildings with associated amenities (clubhouse with pool) with 168 dwelling units
- Thirty-two (32) townhouse units,

Parking will be provided for 405 vehicles. Access to the site is proposed by way of the existing main driveway to Main Street with a secondary, right turn in/out only driveway for the commercial property. Emergency access would be provided by way of a connection

to the end of Taylor Street. The project has approximately 1,000 feet of frontage along Main Street. Figure 1 shows the site location in relation to the surrounding area.


**Figure 1**
**Site Location Map**

## 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) guidelines, the year 2029 was selected as the basis for modeling future transportation impacts of the proposed mixed-use development to reflect the opening year conditions and a seven-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 mixed-use development.

## STUDY AREA

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

- Main Street (Route 111), Fitchs Bridge Road and Nod Road
- Main Street, Anytime Fitness Driveway and Groton Residential Gardens Driveway
- Main Street and Groton Residential Gardens/Country Kids Child Development Center Driveway
- Main Street and Mill Street
- Main Street and Taylor Street
- Main Street and Arlington Street
- Main Street and Champney Street

## EXISTING CONDITIONS

Evaluation of existing conditions within the study area includes a description of roadway geometrics, traffic constraints, land uses at the intersections, and quantification of traffic volumes.

### Existing Traffic Volumes

To establish base traffic conditions within the study area, manual turning movement and vehicle classification counts were obtained in February 2022. The manual turning movement counts were conducted on Wednesday February 2, 2022 during the weekday

morning (7:00 to 9:00 AM) and weekday evening (4:00 to 6:30 PM) peak periods. Data from the MassDOT was reviewed to determine the monthly variations of the traffic volumes. Based upon available data, February volumes were found to be slightly lower than average month conditions. To be conservative, the February volumes were adjusted upward by a factor of 1.03 to reflect average month conditions.

Due to the Covid-19 pandemic, traffic volumes are currently lower than normal. To account for this, data from the Massachusetts Department of Transportation's (MassDOT) Mobility Dashboard website was used. This data showed that February 2022 traffic volumes for the Groton area are approximately sixteen (16) percent lower than normal. The 2022 traffic counts performed for this study were increased by a factor of 1.158 to represent pre-COVID conditions.

Main Street, west of the site was recorded to carry approximately 16,550 vehicles per day (vpd) on a weekday. During the weekday morning peak hour, approximately 1,382 vehicles per hour (vph) were recorded and during the weekday evening peak hour, 1,551 vph were recorded.

Mill Street, west of the site was recorded to carry approximately 2,200 vpd on a weekday. During the weekday morning peak hour, approximately 208 vph were recorded and during the weekday evening peak hour, 229 vph were recorded.

## Vehicle Speeds

Existing speed data for Main Street was also collected. The average speed of vehicles travelling eastbound and westbound on Main Street, west of Mill Street site was found to be 38.9 miles per hour (mph to 38.7 mph, respectively. The posted speed limit on Main Street is 40 mph. The 85$^{th}$ percentile speed was found to be 43 mph for both eastbound and westbound vehicles. The 85$^{th}$ percentile speed is the speed at which sight distances are evaluated.

## Motor Vehicle Crash Data

Motor vehicle crash data for the study area intersections were obtained from the MassDOT Crash Portal for 2015 through the end of 2021. The motor vehicle crash data was reviewed to determine crash trends in the study area. Thirty-two (32) crashes were reported at the study area intersections. Of the thirty-two (32) crashes, five (5) crashes were reported at the intersection of Main Street and Fitchs Bridge Road and Nod Road, two (2) crashes were reported near the intersection of Main Street and the Anytime Fitness and Groton Residential Gardens driveways, zero (0) crashes were reported at the intersection of Main Street and the Country Kids Development Center and Groton Residential Gardens driveway, ten (10) crashes were reported at the intersection of Main Street and Mill Street, five (5) crashes were reported at the intersection of Main Street and Taylor Street, two (2) crashes were reported at the intersection of Main Street and Arlington Street, and eight (8) crashes were reported at the intersection of Main Street and Champney Street. No fatalities were reported. None of the study area intersections are on the MassDOT Highway Safety

Improvement Program (HSIP) list.

## PROBABLE IMPACTS OF THE PROJECT

### No-Build Traffic Volumes

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 2029. 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 2029. A one-half (0.5) percent compounded growth rate was used to develop future No-Build conditions based on communications with representatives from the Central Transportation Planning Staff (CTPS).

Conversations with the Town of Groton indicated that there are three (3) projects identified in the area that would generate traffic beyond the general background growth rate. Traffic from each of these projects were included in the background projections.

### Build Traffic Volumes

Site generated traffic was based on trip-generation data published by the ITE *Trip Generation* manual[1]. The proposed Comprehensive 40B application is expected to consist of the construction of 200 residential dwelling units. Trip generation data for LUC 215 – Single-Family Attached Housing and ITE LUC 221 – Multifamily Housing (Mid-Rise was reviewed.

On a typical weekday, the proposed development is expected to generate 948 daily vehicle trips (474 vehicles entering and 474 vehicles exiting). During the weekday morning peak hour, 73 vehicle trips (17 vehicles entering and 56 vehicles exiting) are expected. During the weekday evening peak hour, 81 vehicle trips (49 vehicles entering and 32 vehicles exiting) are expected.

Compared to the existing office building, the proposed project would have less impact during the weekday morning and weekday evening peak hours. The Project is expected to result in 494 *fewer* daily vehicle trips on an average weekday, with 135 *fewer* vehicle trips expected during the weekday morning peak-hour and 123 *fewer* vehicle trips during the weekday evening peak-hour.

### Trip Distribution

The trip distribution is expected to be regionally oriented. A gravity model was developed based on Groton Journey-to-Work data from the U.S. Census to determine the expected trip distribution.

[1] *Trip Generation,* Eleventh Edition; Institute of Transportation Engineers; Washington, DC; 2021.

## TRAFFIC OPERATIONS ANALYSIS

To assess the impacts of the proposed project on the roadway network, traffic operations analyses were performed at the study area intersections under 2022 Existing, 2029 No-Build and 2029 Build conditions. These analyses indicate that the proposed project will generally not result in an impact on traffic operations at the study area intersections over No-Build conditions.

Level-of-service analyses were conducted for 2022 Existing, 2029 No-Build, and 2029 Build conditions for the intersections within the study area. All of the intersections in this study area are unsignalized intersections. Except for three intersections, the critical movements at the remaining intersections are modeled to operate at LOS D to LOS F during the respective weekday morning peak hours. The corresponding volume to capacity (v/c) ratios are 0.25 or less with projected 95$^{th}$ percentile queues of one (1) vehicle or less, indicating that there is capacity for the critical movements.

Further, as shown in Table 2 of this study, for the unsignalized intersection of Main Street and Mill Street, utilizing the existing, unadjusted count data, the observed delays are significantly less than the capacity analysis model predicts. As shown in Table 2, the observed average delay for left and right-turning vehicles during the morning peak hour was 21 seconds. The corresponding capacity analysis indicates the calculated delay would be 43.1 seconds (twice as high as the observed). Similarly, the observed average delay for left and right-turning vehicles during the evening peak hour was 23 seconds. The corresponding capacity analysis indicates the calculated delay would be 162.9 seconds (seven times as high as the observed). This indicates that the calculated delays represent a conservative analysis result.

## RECOMMENDATIONS

A comprehensive transportation mitigation program has been developed that is designed to reduce automobile trips associated with the Project and accommodate the additional traffic expected to be generated by the Project in a safe and efficient manner. The elements of the transportation mitigation program have been separated into the following categories: Project Access, Level-of Service/Congestion Mitigation; and Transportation Demand Management and are described in the following sections.

### Project Access

Access to the Project site will be provided by way of the existing site driveway to Main Street. The following recommendations are offered with respect to the design and operation of the Project site driveway:

- The Project primary site driveway will be a minimum of 36 feet in width and designed to accommodate the turning and maneuvering requirements of the largest anticipated responding emergency vehicle. The driveway will consist of one (1) entering lane and two (2) exiting lanes (an exclusive left-turn lane and an exclusive right-turn lane).

- Vehicles exiting the Project site will be placed under STOP-sign control with a marked STOP line provided.

- The Project site driveway and internal circulating aisles will be designed to accommodate the turning and maneuvering requirements of service and delivery trucks and emergency vehicles.

- All signs and pavement markings to be installed within the Project site will conform to the applicable standards of the *Manual on Uniform Traffic Control Devices*[2] (MUTCD).

- A sidewalk will be provided within the Project site to link the proposed buildings to the sidewalk infrastructure along Main Street, with Americans with Disabilities Act (ADA)-compliant wheelchair ramps provided at all pedestrian crossings internal to the Project site and for crossing the Project site driveway at Main Street.

- A sidewalk will be provided along the property frontage easterly from the Primary site driveway to the eastern property line. A crosswalk across Main Street with a Rectangular Rapid Flashing Beacon (RRFB) will be installed with a connection to the existing sidewalk along the south side of Main Street. The location and design of the crossing will be subject to MassDOT review and approval.

- Signs and landscaping to be installed as a part of the Project within the intersection sight triangle areas of the Project site driveway will be designed and maintained so as not to restrict lines of sight.

- Snow windrows within sight triangle areas of the Project site driveway will be promptly removed where such accumulations would impede sight lines.

- Bicycle racks will be installed at convenient locations within the Project site proximate to the building entrances and at the clubhouse.

- Accommodations will be provided for electric vehicle charging by residents of the Project.

[2] *Manual on Uniform Traffic Control Devices;* Federal Highway Administration; Washington D.C.; 2009.

## Level-of-Service/Congestion Mitigation

***Main Street and Mill Street -*** Under 2029 No-Build conditions, the critical movements at this unsignalized intersection were shown to operate at an overall LOS F during both the weekday morning and evening peak hours. Under 2029 Build peak-month conditions, the critical movements were shown to continue to operate at an overall LOS F during the weekday morning peak hour (no change over No-Build conditions). A review of the existing traffic volume data indicates that the intersection currently would not meet the warrants for signalization as identified in the MUTCD. Further, as noted in the Capacity Analysis section, the overall delays projected by the capacity analysis methodology exceed the observed delays. It is recommended that upon completion and occupancy of the Project, the intersection be monitored. If at that time, the traffic volumes meet the MUTCD traffic signal warrant criteria, the project proponent will design a traffic signal system for the intersection.

***Main Street and Champney Street -*** Under 2029 No-Build conditions, the critical movements at this unsignalized intersection were shown to operate at an overall LOS F during both the weekday morning and evening peak hours. Under 2029 Build peak-month conditions, the critical movements were shown to continue to operate at an overall LOS F during the weekday morning peak hour (no change over No-Build conditions). A review of the existing traffic volume data indicates that the intersection currently would not meet the warrants for signalization as identified in the MUTCD. It is recommended that upon completion and occupancy of the Project, the intersection be monitored. If at that time, the traffic volumes meet the MUTCD traffic signal warrant criteria, the project proponent will design a traffic signal system for the intersection.

## Transportation Demand Management

The following Transportation Demand Management (TDM) measures will be implemented as a part of the Project to encourage the use of alternative modes of transportation to single-occupant vehicles:

- A Transportation Coordinator will be designated for the Project to coordinate the elements of the TDM program,

- Information regarding public transportation services, maps, schedules and fare information will be posted in a central location and/or otherwise made available to residents,
- A “welcome packet” will be provided to residents detailing available public transportation services, bicycle and walking alternatives, and commuter options,

- Work-at-home workspaces will be provided to support telecommuting by residents of the Project,

- Pedestrian accommodations will be incorporated into the Project and consist of sidewalks and ADA-compliant wheelchair ramps at all pedestrian crossings internal to the Project site that will link building entrances to the sidewalk infrastructure along Main Street,

- A mail drop will be provided in a central location; and

- Secure bicycle parking will be provided within the Project site consisting of both exterior and interior (covered) bicycle parking.

## CONCLUSION

Based on this assessment, the following can be concluded with respect to the Project:

- None of the study area intersections are on the MassDOT Highway Safety Improvement Program (HSIP) list.

- Using trip-generation statistics published by the Institute of Transportation Engineers (ITE), the Project is expected to generate 948 daily vehicle trips (474 vehicles entering and 474 vehicles exiting). During the weekday morning peak hour, 73 vehicle trips (17 vehicles entering and 56 vehicles exiting) are expected. During the weekday evening peak hour, 81 vehicle trips (49 vehicles entering and 32 vehicles exiting) are expected.

- In comparison to the office use that could be re-occupied within the Project site, the Project is expected to result in 494 *fewer* daily vehicle trips on an average weekday, with 135 *fewer* vehicle trips expected during the weekday morning peak-hour and 123 *fewer* vehicle trips during the weekday evening peak-hour compared to the former office use.

- The Project will not have a significant impact (increase) on motorist delays or vehicle queuing over Existing or anticipated future conditions without the Project (No-Build conditions), with the majority of the critical movements at the study intersections shown to operate at LOS D or better under all analysis conditions where a level-of-service of "D" or better is defined as "acceptable" operating conditions.

- Independent of the Project, operating conditions for the critical movements at the intersections of Main Street and Mill Street and at Main Street and Champney Street were identified to be operating at or over capacity (i.e., LOS "E" or "F"), with Project-related impacts, the predicted increase in vehicle queuing is three (3) vehicles.

- Lines of sight at the Project site driveway intersection with Main Street were found to exceed the recommended minimum distances for safe and efficient operation based on the appropriate approach speed.

- A review of the Site Plan for the Project indicates that human-made objects, landscaping, and signs have been appropriately designed and located so as not to inhibit sight lines to and from the Project site driveway or along Main Street.

# SECTION 2: EXISTING TRAFFIC CONDITIONS

## STUDY AREA

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

- Main Street (Route 111), Fitchs Bridge Road and Nod Road
- Main Street, Anytime Fitness Driveway and Groton Residential Gardens Driveway
- Main Street and Groton Residential Gardens/Country Kids Child Development Center Driveway
- Main Street and Mill Street
- Main Street and Taylor Street
- Main Street and Arlington Street
- Main Street and Champney Street

## FIELD SURVEY

A comprehensive field inventory of the proposed site was conducted in February 2022. 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

#### Main Street (Route 111/Route 119)

Main Street (Route 111/Route 119) is under the jurisdiction of the Massachusetts Department of Transportation (MassDOT) in the vicinity of the site. Main Street is functionally classified as a Rural Minor Arterial. Main Street provides one travel lane per direction that runs through Groton from the Pepperell Town line easterly to Ayer Road where the name changes to Boston Road and continues into Littleton to the east. Travel lanes are separated by a dashed yellow centerline, with marked shoulders (approximately 2 to 3 feet wide) provided. The posted speed limit in the vicinity of the site is 40 miles per hour (mph). Illumination is provided by luminaries mounted on poles. The pavement is in fair condition. There is a bituminous concrete sidewalk along the south side of Main Street in the site vicinity. Land use along Main Street consists primarily of commercial uses.

#### Mill Street

Mill Street is under the jurisdiction of the Town of Groton and is functionally classified as a local road. Mill Street runs in a general north/south direction from Main Street southerly to Farmers Row, which continues southerly into the Town of Ayer. Trucks are prohibited on Mill Street. Near the site, Mill Street provides one travel lane per direction. Travel lanes are separated by a double yellow centerline, with marked shoulders provided. The posted speed limit is 30 mph. Illumination is provided by luminaries mounted on poles. The roadway pavement is generally in good condition. There are no sidewalks or bicycle facilities on Mill Street. Land use along Mill Street consists of commercial properties (near Main Street) and residential uses further to the south.

### Intersections

#### Main Street, Fitchs Bridge Road and Nod Road

Fitchs Bridge Road intersects Main Street from the south and Nod Road intersects from the north to form this four-legged unsignalized intersection. The Main Street eastbound and westbound approaches consist of one general purpose lane in each direction, approximately 11 to 12 feet wide, separated by a double yellow centerline. The Fitchs Bridge Road approach consists of an 11.5-foot lane permitting left, through and right-turn movements. The Nod Road southbound approach consists of a 16-foot lane permitting left, through and right-turn movements. Both the Fitchs Bridge Road and Nod Road approaches operate under STOP control. A sidewalk exists along the north side of Main Street, west of Nod Road. Land use at the intersection consists of open space and a nursery.

#### Main Street, Anytime Fitness Driveway and Groton Residential Gardens Driveway

The Groton Residential Gardens driveway intersects Main Street from the south and the Anytime Fitness driveway intersects from the north to form this four-legged unsignalized

intersection. The Main Street eastbound and westbound approaches consist of one general purpose lane in each direction, approximately 12 feet wide, separated by a dashed-yellow centerline. The Groton Residential Gardens driveway approach consists of a 12-foot lane permitting left, through and right-turn movements. The Anytime Fitness driveway southbound approach consists of a 10.5-foot lane permitting left, through and right-turn movements. Both the Groton Residential Gardens and Anytime Fitness driveway approaches operate under STOP control. A sidewalk exists along the south side of Main Street. Land use at the intersection consists of the Groton Residential Gardens residential development and the Anytime Fitness facility.

**Main Street, Country Kids Child Development Center Driveway**

The Country Kids Child Development Center driveway intersects Main Street from the south to form this three-legged unsignalized intersection. The Main Street eastbound and westbound approaches consist of one general purpose lane in each direction, approximately 12-feet wide, separated by a dashed-yellow centerline. The Country Kids Child Development Center driveway approach consists of an 11-foot lane permitting left and right-turn movements. The Country Kids Child Development Center driveway approach operates under STOP control. A sidewalk exists along the south side of Main Street. Land use at the intersection consists of the Groton Residential Gardens residential development, the Country Kids Child Development Center facility and the Project site.

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**Main Street and Existing Site Driveway**

The existing site driveway intersects Main Street from the north to form this three-way, unsignalized intersection. The Main Street eastbound and westbound approaches consist of one general purpose lane in each direction, approximately 12-feet wide, separated by a dashed-yellow centerline. The existing site driveway approach consists of a 12-foot-wide exclusive left-turn lane and a 12-foot-wide exclusive right-turn lane. Sidewalks are provided along the south side of Main Street. The driveway approach operates under STOP control. Land uses in the vicinity of the intersection consists of the Mill Run Plaza, the Country Kids Child Development Center facility and the Project site.

**Main Street and Mill Street**

Mill Street intersects Main Street from the south to form this three-way, unsignalized intersection. The Main Street eastbound and westbound approaches consist of one general purpose lane in each direction, approximately 12-feet wide, separated by a dashed-yellow centerline. The Mill Street northbound approach consists of a 14-foot-wide lane permitting left and right-turn movements. The Mill Street approach operates under STOP control. Sidewalks are provided along the south side of Main Street. Land uses in the vicinity of the intersection consists of the Mill Run Plaza, the Country Kids Child Development Center facility and the Project site.

**Main Street and #500 Main Street Driveway**

The driveway to the single-family home on the site intersects Main Street from the north to form this three-way, unsignalized intersection. This driveway is approximately fifty

(50) feet east of Mill Street. The Main Street eastbound and westbound approaches consist of one general purpose lane in each direction, approximately 12 feet wide, separated by a double yellow centerline. The driveway approach consists of a single lane permitting left and right-turn movements. The driveway approach operates under STOP control. Sidewalks are provided along the south side of Main Street. Land uses in the vicinity of the intersection consists of the site, the existing residential property and the Mill Run Plaza.

**Main Street and Taylor Street**

Taylor Street intersects Main Street from the north to form this three-way, unsignalized intersection. The Main Street eastbound and westbound approaches consist of one general purpose lane in each direction, approximately 12-feet wide, separated by a double yellow centerline. The Taylor Street approach consists of an approximate 18-foot-wide lane permitting left and right-turn movements. The Taylor Street approach operates under STOP control. Sidewalks are provided along the south side of Main Street. Land uses in the vicinity of the intersection consists of residential properties and an autobody shop.

**Main Street and Arlington Street**

Arlington Street intersects Main Street from the south to form this three-way, unsignalized intersection. The Main Street eastbound and westbound approaches consist of one general purpose lane in each direction, approximately 12-feet wide, separated by a double yellow centerline. The Arlington Street approach consists of a 10-foot-wide lane permitting left and right-turn movements. The Arlington Street approach operates under STOP control. Sidewalks are provided along the south side of Main Street. Land uses in the vicinity of the intersection consists of residential properties and an autobody shop.

**Main Street and Champney Street**

Champney Street intersects Main Street from the north to form this three-way, unsignalized intersection. The Main Street eastbound and westbound approaches consist of one general purpose lane in each direction, approximately 11 to 12-feet wide, separated by a double yellow centerline. The Champney Street approach consists of a 10-foot-wide lane permitting left and right-turn movements. The Champney Street approach operates under STOP control. Sidewalks are provided along the north side of Main Street. A crosswalk exists across the Champney Street approach. Land uses in the vicinity of the intersection consists of a gas station and residential properties.

## TRAFFIC VOLUMES

### Existing Traffic Volumes

To establish base traffic conditions within the study area, manual turning movement and vehicle classification counts were obtained in February 2022. Peak-period turning

movement counts were conducted on Wednesday, February 2, 2022 during the weekday morning and evening peak periods (7:00 to 9:00 AM and 4:00 to 6:30 PM). Counts were performed at the following intersections:

- Main Street (Route 111), Fitchs Bridge Road and Nod Road
- Main Street, Anytime Fitness Driveway and Groton Residential Gardens Driveway
- Main Street and Groton Residential Gardens/Country Kids Child Development Center Driveway
- Main Street and Mill Street
- Main Street and Taylor Street
- Main Street and Arlington Street
- Main Street and Champney Street

Daily traffic counts were conducted on Main Street for a two-day period using automatic traffic recorders (ATR) on Wednesday February 2, 2022 to Thursday February 3, 2022.

Analysis of the peak-period traffic counts indicated that the weekday morning commuter peak hour generally occurs between 7:00 and 8:00 AM and the weekday evening commuter peak hour generally occurs between 4:00 and 5:00 PM. The traffic count worksheets are provided in the Appendix.

**Seasonal Adjustment**

To establish base traffic conditions within the study area, manual turning movement and vehicle classification counts were obtained in February 2022. Data from the MassDOT was reviewed to determine the monthly variations of the traffic volumes. Based upon available data, February volumes were found to be slightly lower than average month conditions. To be conservative, the February volumes were adjusted upward by a factor of 1.03 to reflect average month conditions.

Due to the Covid-19 pandemic, traffic volumes are currently lower than normal. To account for this, data from the Massachusetts Department of Transportation's (MassDOT) Mobility Dashboard website was used. This data showed that February 2022 traffic volumes for the Groton area are approximately sixteen (16) percent lower than normal. The 2022 traffic counts performed for this study were increased by a factor of 1.158 to represent pre-COVID conditions.

The 2022 existing weekday daily and peak-hour traffic volumes for average-month conditions are summarized below in Table 1. The 2022 Existing weekday morning and weekday evening peak hour traffic flow networks are shown graphically on Figures 2 and 3, respectively. The seasonal worksheets are provided in the Appendix.

Main Street, west of the site was recorded to carry approximately 16,550 vehicles per day (vpd) on a weekday. During the weekday morning peak hour, approximately 1,382 vehicles per hour (vph) were recorded and during the weekday evening peak hour, 1,551

vph were recorded.

Mill Street, west of the site was recorded to carry approximately 2,200 vpd on a weekday. During the weekday morning peak hour, approximately 208 vph were recorded and during the weekday evening peak hour, 229 vph were recorded.

**TABLE 1**
**EXISTING WEEKDAY TRAFFIC-VOLUME SUMMARY[a]**

| Location | Daily 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 |
| Main Street, west of Mill Street | 16,550 | 1,382 | 8.4 | 81.6% EB | 1,551 | 9.4 | 71.8% WB |
| Mill Street, south of Main Street | 2,200 | 208 | 9.5 | 65.4% SB | 229 | 10.4 | 69.4% 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.

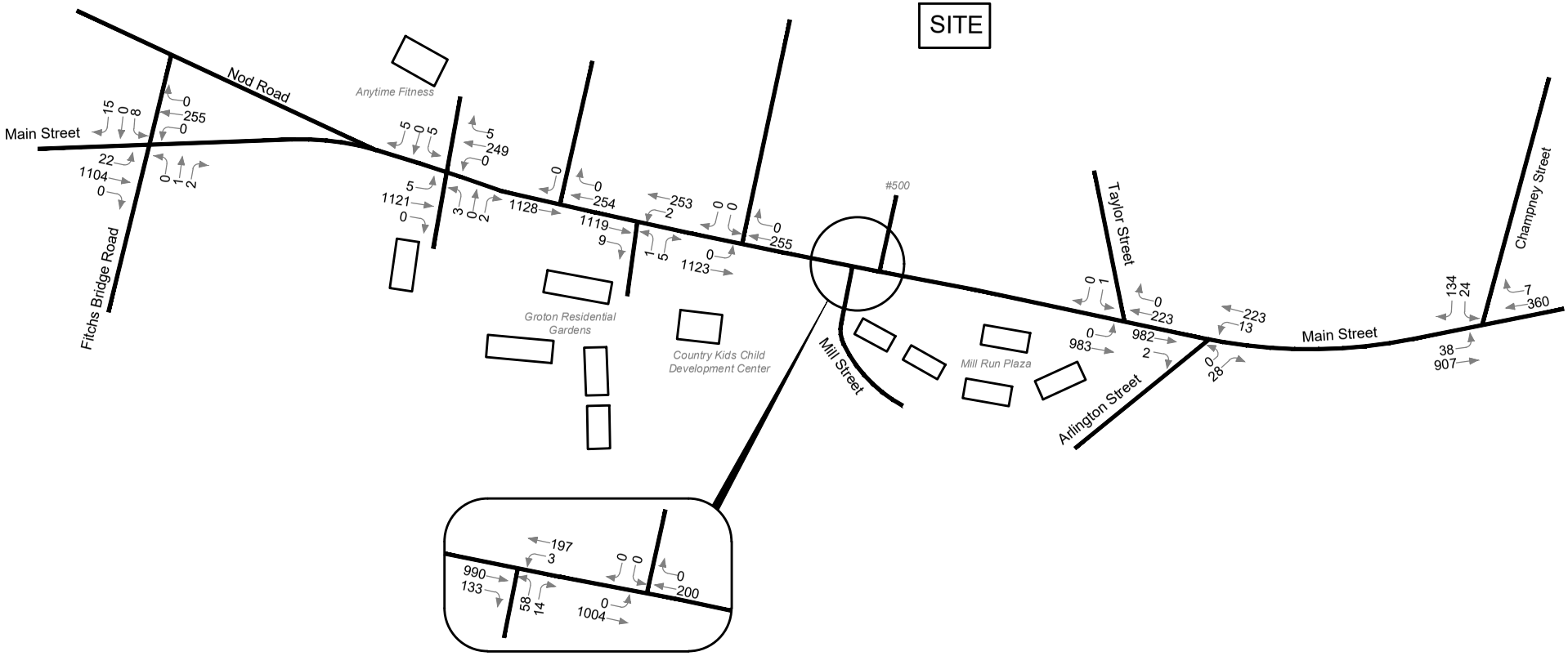
## Observed Vehicle Delays

At the intersection of Main Street and Mill Street, vehicle queues and delays for the critical movements (shared left and right-turn movements from Mill Street). The queues and delays were video recorded for Mill Street northbound vehicles. These observations were performed on the same days as the manual turning movement counts, Wednesday February 2, 2022. The vehicle queues and delays are summarized in Table 2 for the observed approach. These delays were recorded to calibrate the capacity analysis model used in the Capacity Analysis section of this study. The traffic delay worksheets are provided in the Appendix.

**TABLE 2**
**MILL STREET NORTHBOUND TO MAIN STREET OBSERVED DELAYS AND QUEUES**

| Time Period | Average Peak Hour Delay per Vehicle[a] (sec) | Minimum Peak Hour Delay Observed (sec) | Maximum Peak Hour Delay per Vehicle Observed (sec) | Average Vehicle Queue Observed (Veh) | Maximum Queue Observed (Veh) |
|---|---|---|---|---|---|
| Weekday Morning Peak Hour[b] | 21 | 0 | 132 | 1.4 | 5 |
| Weekday Evening Peak Hour[c] | 23 | 1 | 81 | 2.2 | 6 |

[a]Based on count data compiled on February 2, 2022.
[b]Morning Peak Hour from 7:00 – 8:00 AM.
[c]Evening Peak Hour from 4:30 – 5:30 PM.




Note: Imbalances exist due to side streets and driveways not shown.

N

Not To Scale

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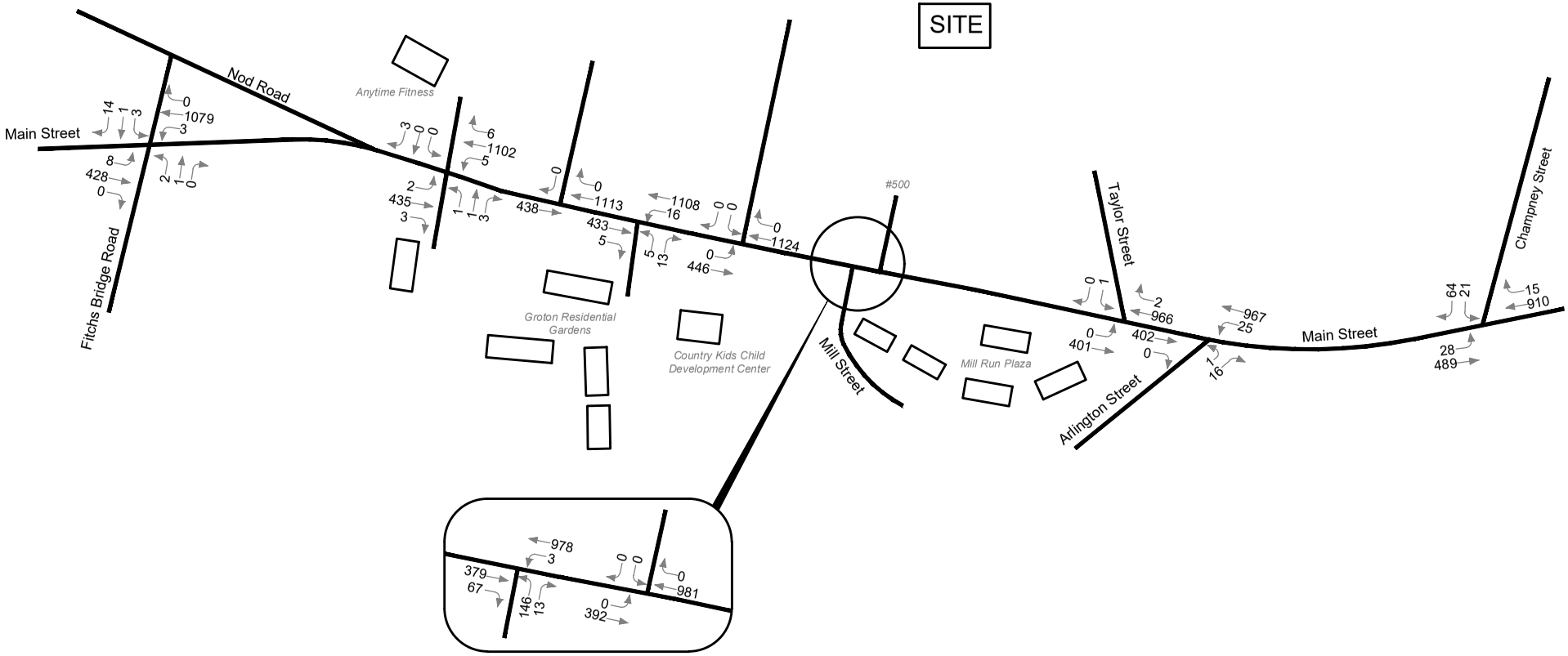
Proposed Residential Development
Groton, MA

Figure 2

2022 Existing
Weekday Morning
Peak Hour Traffic Volumes




Note: Imbalances exist due to side streets and driveways not shown.

N Not To Scale

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Figure 3

2022 Existing
Weekday Evening
Peak Hour Traffic Volumes

## VEHICLE SPEEDS

Existing speed data for Main Street was also collected using the ATR. The speed data is summarized in Table 3.

**TABLE 3**
**OBSERVED VEHICLE SPEEDS**

| Location | Posted Speed Limit (mph) | Direction | Average Observed Speed[a] (mph) | 85th Percentile Speed (mph) |
|---|---|---|---|---|
| Main Street, west of Mill Street | 40 | EB | 38.9 | 43 |
| | 40 | WB | 38.7 | 43 |

[a]Based on speed data compiled on February 2 and 3, 2022.

As shown in Table 3, the average speed of vehicles travelling eastbound and westbound on Main Street, west of Mill Street site was found to be 38.9 mph to 38.7 mph, respectively. The 85th percentile speed was found to be 43 mph for both eastbound and westbound vehicles. The 85th percentile speed is the speed at which sight distances are evaluated.

## MOTOR VEHICLE CRASH DATA

Motor vehicle crash data for the study area intersections were obtained from the MassDOT Crash Portal for 2015 through the end of 2021. The motor vehicle crash data was reviewed to determine crash trends in the study area. Thirty-two (32) crashes were reported at the study area intersections. Of the thirty-two (32) crashes, five (5) crashes were reported at the intersection of Main Street and Fitchs Bridge Road and Nod Road, two (2) crashes were reported near the intersection of Main Street and the Anytime Fitness and Groton Residential Gardens driveways, zero (0) crashes were reported at the intersection of Main Street and the Country Kids Development Center and Groton Residential Gardens driveway, ten (10) crashes were reported at the intersection of Main Street and Mill Street, five (5) crashes were reported at the intersection of Main Street and Taylor Street, two (2) crashes were reported at the intersection of Main Street and Arlington Street, and eight (8) crashes were reported at the intersection of Main Street and Champney Street. No fatalities were reported. None of the study area intersections are on the MassDOT Highway Safety Improvement Program (HSIP) list. The crash data is summarized in Table 4 and included in the Appendix.

**TABLE 4**
**MOTOR VEHICLE CRASH DATA SUMMARY[a]**

| Scenario | Main Street and Champney Street | Main Street and Arlington Street | Main Street and Taylor Street | Main Street and Mill Street |
|---|---|---|---|---|
| *Year:* | | | | |
| 2015 | 3 | 1 | 2 | 2 |
| 2016 | 1 | 1 | 0 | 0 |
| 2017 | 2 | 0 | 1 | 2 |
| 2018 | 1 | 0 | 1 | 3 |
| 2019 | 1 | 0 | 1 | 3 |
| Total | 8 | 2 | 5 | 10 |
| Average[b]: | 1.6 | 0.4 | 1.0 | 2.0 |
| Crash Rate[c]: | 0.32 | 0.40 | 0.22 | 0.39 |
| Significance[d]: | No | No | No | No |
| *Type:* | | | | |
| Angle | 3 | 1 | 0 | 4 |
| Rear-End | 3 | 0 | 5 | 3 |
| Head-On | 0 | 0 | 0 | 0 |
| Sideswipe | 0 | 0 | 0 | 1 |
| Single Vehicle Crash | 2 | 1 | 0 | 2 |
| Unknown | 0 | 0 | 0 | 0 |
| Total | 8 | 2 | 5 | 10 |
| *Time of Day:* | | | | |
| Weekday (7:00 to 9:00 AM) | 3 | 1 | 0 | 2 |
| Weekday (4:00 to 6:00 PM) | 1 | 0 | 1 | 4 |
| Remainder of Day | 4 | 1 | 4 | 4 |
| Total | 8 | 2 | 5 | 10 |
| *Pavement Conditions:* | | | | |
| Dry | 7 | 2 | 4 | 6 |
| Wet | 0 | 0 | 1 | 2 |
| Snow/Ice | 1 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 |
| Unknown | 0 | 0 | 0 | 2 |
| Total | 8 | 2 | 5 | 10 |
| *Severity:* | | | | |
| Property Damage Only | 7 | 2 | 4 | 8 |
| Personal Injury | 0 | 0 | 1 | 2 |
| Fatal Accident | 0 | 0 | 0 | 0 |
| Unknown | 1 | 0 | 0 | 0 |
| Total | 8 | 2 | 5 | 10 |

[a]Source: MassDOT Crash Portal, 2015 to 2019.
[b]Average crashes over analysis period.
[c]Crash rate per million entering vehicles (mev).
[d]Signalized intersections are significant if rate >0.73 crashes per million vehicles, and unsignalized intersections if rate >0.57 crashes per million vehicles.

**TABLE 4**
**MOTOR VEHICLE CRASH DATA SUMMARY[a]**

| Scenario | Main Street and Country Kids Center Driveway | Main Street and Anytime Fitness Driveway | Main Street, Fitchs Bridge Road and Nod Road |
|---|---|---|---|
| *Year:* | | | |
| 2015 | 0 | 0 | 1 |
| 2016 | 0 | 1 | 0 |
| 2017 | 0 | 0 | 0 |
| 2018 | 0 | 1 | 1 |
| 2019 | 0 | 0 | 3 |
| Total | 0 | 2 | 5 |
| Average[b]: | 0 | 0.4 | 1.0 |
| Crash Rate[c]: | 0 | 0.08 | 0.20 |
| Significance[d]: | No | No | No |
| *Type:* | | | |
| Angle | 0 | 1 | 1 |
| Rear-End | 0 | 1 | 1 |
| Head-On | 0 | 0 | 1 |
| Sideswipe | 0 | 0 | 0 |
| Single Vehicle Crash | 0 | 0 | 2 |
| Unknown | 0 | 0 | 0 |
| Total | 0 | 2 | 5 |
| *Time of Day:* | | | |
| Weekday (7:00 to 9:00 AM) | 0 | 0 | 0 |
| Weekday (4:00 to 6:00 PM) | 0 | 0 | 0 |
| Remainder of Day | 0 | 2 | 5 |
| Total | 0 | 2 | 5 |
| *Pavement Conditions:* | | | |
| Dry | 0 | 1 | 2 |
| Wet | 0 | 1 | 1 |
| Snow/Ice | 0 | 0 | 1 |
| Other | 0 | 0 | 0 |
| Unknown | 0 | 0 | 1 |
| Total | 0 | 2 | 5 |
| *Severity:* | | | |
| Property Damage Only | 1 | 2 | 4 |
| Personal Injury | 0 | 0 | 1 |
| Fatal Accident | 0 | 0 | 0 |
| Unknown | 0 | 0 | 0 |
| Total | 0 | 2 | 5 |

[a]Source: MassDOT Crash Portal, 2015 to 2019.
[b]Average crashes over analysis period.
[c]Crash rate per million entering vehicles (mev).
[d]Signalized intersections are significant if rate >0.73 crashes per million vehicles, and unsignalized intersections if rate >0.57 crashes per million vehicles.

## PUBLIC TRANSPORTATION

The Ayer Station on the MBTA's Fitchburg Branch is the closest public transportation to Groton. The Fitchburg commuter rail train departs from North Station and terminates in Fitchburg at the Wachusett Station.

## PLANNED ROADWAY IMRPOVEMENTS

The Town of Groton and MassDOT were contacted to determine if there were any projects in the study area that would affect future conditions. No projects were identified.

# SECTION 3:
# FUTURE 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 2029. 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 2029. Consideration of these factors resulted in the development of 2029 No-Build traffic volumes. Anticipated site-generated traffic volumes were then superimposed upon these No-Build traffic flow networks to develop the 2029 Build conditions.

## FUTURE 2029 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 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

To determine the impact of site-generated traffic volumes generated by the project on the

roadway network, under future conditions, baseline traffic volumes in the study area were projected to the year 2029. Traffic volumes on the roadway network at that time, in 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 2029. Based on the Central Transportation Planning Staff (CTPS) data, the growth rate for this section of Groton is 0.02 percent. Therefore, a one-half (0.5) percent compounded growth rate was used to develop future baseline No-Build conditions.

**Specific Development by Others**

Traffic volumes generated by the specific local developments by others were included in the 2029 No-Build condition. Conversations with the Town of Groton indicated that there are three projects identified in the area that could generate traffic beyond the general background growth rate. These include:

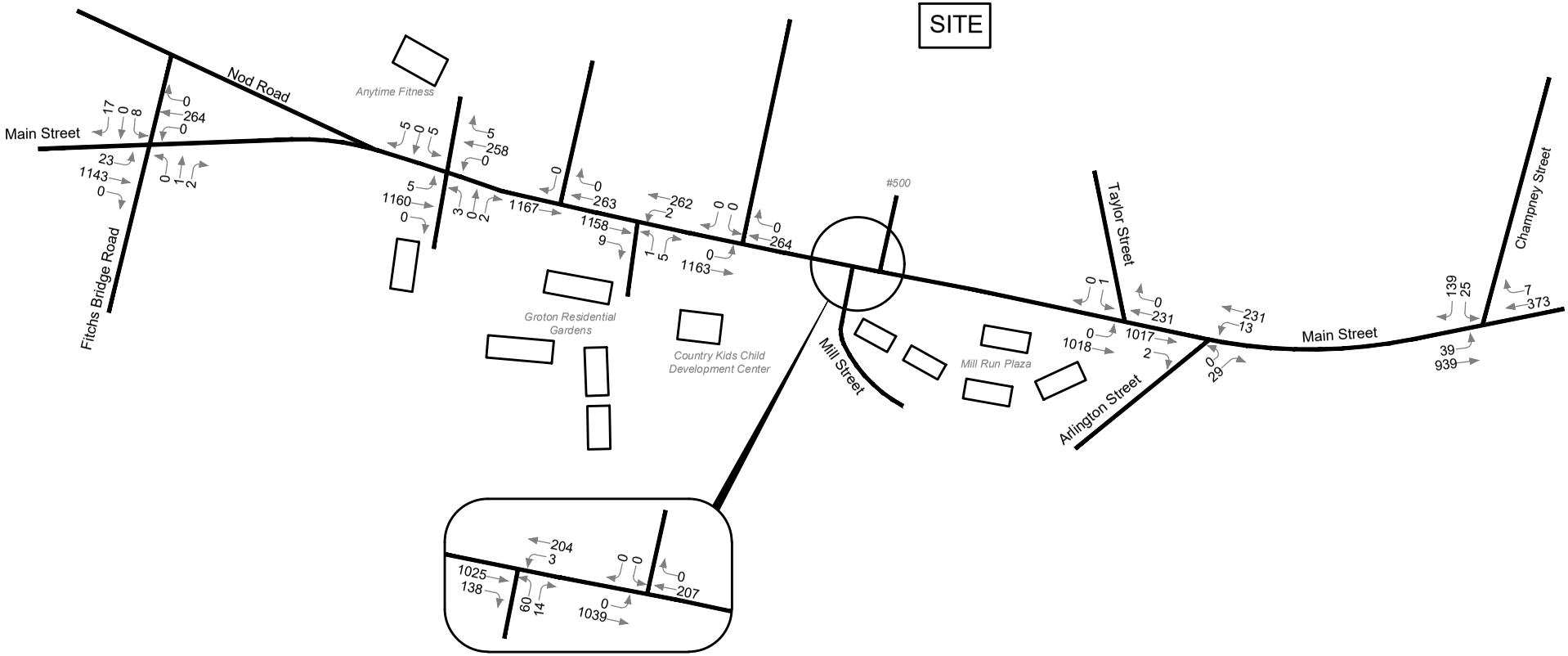
- Village at Shepley Hill (26 residential dwelling units)
- Music Center
- Hayes Woods (7 to 9 residential lots)

Traffic projections for each of these projects was obtained from the relevant traffic studies performed or from the ITE *Trip Generation* manual[3]. The worksheets are included in the Appendix.

**No-Build Condition Traffic Volumes**

The 2029 No-Build weekday morning and weekday evening peak-hour traffic volumes were developed by applying a compounded one-half (0.5) percent annual growth rate to the 2022 Existing peak-hour traffic volumes and adding traffic from the identified background projects. Figures 4 and 5 show the projected 2029 No-Build peak hour traffic volumes for the respective weekday morning and weekday evening peak-hours.

[3] *Trip Generation,* Eleventh Edition; Institute of Transportation Engineers; Washington, DC; 2021.




Note: Imbalances exist due to side streets and driveways not shown.

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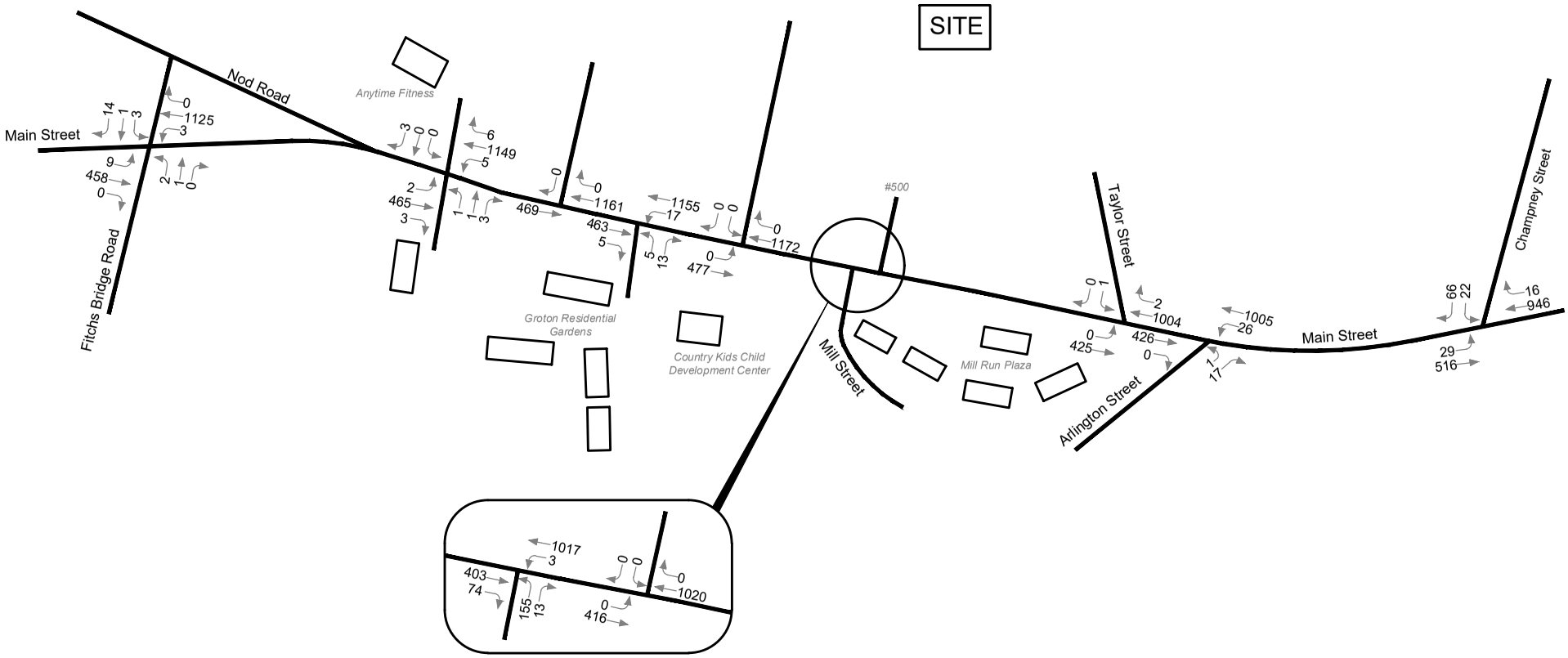
Groton, MA

Figure 4

2029 No-Build
Weekday Morning
Peak Hour Traffic Volumes




Note: Imbalances exist due to side streets and driveways not shown.

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Figure 5

2029 No-Build
Weekday Evening
Peak Hour Traffic Volumes

## FUTURE 2029 BUILD CONDITIONS

### Project Description

The project will consist of the demolition of the existing office building and single-family home and the construction of:

- Three (3) residential apartment buildings with associated amenities (clubhouse with pool) with 168 dwelling units
- Thirty-two (32) townhouse units,

Parking for a total of 405 vehicles is proposed.

### Existing Site Traffic Generation

Site generated traffic was based on trip-generation data published by the ITE *Trip Generation* manual[4] for the existing vacant office building, assuming it were to be re-occupied. Trip generation data for Land Use Code (LUC) 710 – General Office Building was reviewed. The existing building comprises approximately 128,400 sf of space. The trip generation for the existing building is summarized in Table 5. The trip generation worksheets are included in the Appendix.

**TABLE 5**
**EXISTING TRIP GENERATION SUMMARY**

| | Existing Office Building Trips[a] |
|---|---|
| Average Weekday Daily Traffic | 1,442 |
| *Weekday Morning Peak Hour:* | |
| Entering | 183 |
| Exiting | 25 |
| Total | 208 |
| *Weekday Evening Peak Hour:* | |
| Entering | 35 |
| Exiting | 169 |
| Total | 204 |

[a]Based on ITE LUC 710 – General Office Building; 128.4 ksf.

On a typical weekday, the existing office would be expected to generate 1,442 daily vehicle trips (721 vehicles entering and 721 vehicles exiting). During the weekday morning peak

[4]Ibid.

hour, 208 vehicle trips (183 vehicles entering and 25 vehicles exiting) would be expected. During the weekday evening peak hour, 204 vehicle trips (35 vehicles entering and 169 vehicles exiting) would be expected.

**Proposed Site Traffic Generation**

Site generated traffic was based on trip-generation data published by the ITE *Trip Generation* manual[5]. Trip generation data for LUC 215 – Single-Family Attached Housing and ITE LUC 221 – Multifamily Housing (Mid-Rise) was reviewed. The trip generation for the project is summarized in Table 6. The trip generation worksheets are included in the Appendix.

**TABLE 6**
**PROPOSED TRIP GENERATION SUMMARY**

| | Townhouse Trips[a] | Apartment Trips[b] | Total Trips |
|---|---|---|---|
| Average Weekday Daily Traffic | 194 | 754 | 948 |
| *Weekday Morning Peak Hour:* | | | |
| Entering | 3 | 14 | 17 |
| Exiting | 8 | 48 | 56 |
| Total | 11 | 62 | 73 |
| *Weekday Evening Peak Hour:* | | | |
| Entering | 9 | 40 | 49 |
| Exiting | 6 | 26 | 32 |
| Total | 15 | 66 | 81 |

[a]Based on ITE LUC 215 – Single-Family Attached Housing; 32 dwelling units.
[b]Based on ITE LUC 221 – Multifamily Housing (Mid-Rise); 168 dwelling units.

On a typical weekday, the proposed development is expected to generate 948 daily vehicle trips (474 vehicles entering and 474 vehicles exiting). During the weekday morning peak hour, 73 vehicle trips (17 vehicles entering and 56 vehicles exiting) are expected. During the weekday evening peak hour, 81 vehicle trips (49 vehicles entering and 32 vehicles exiting) are expected.

Compared to the existing office building, the proposed project would have less of an impact during the weekday morning and weekday evening peak hours.

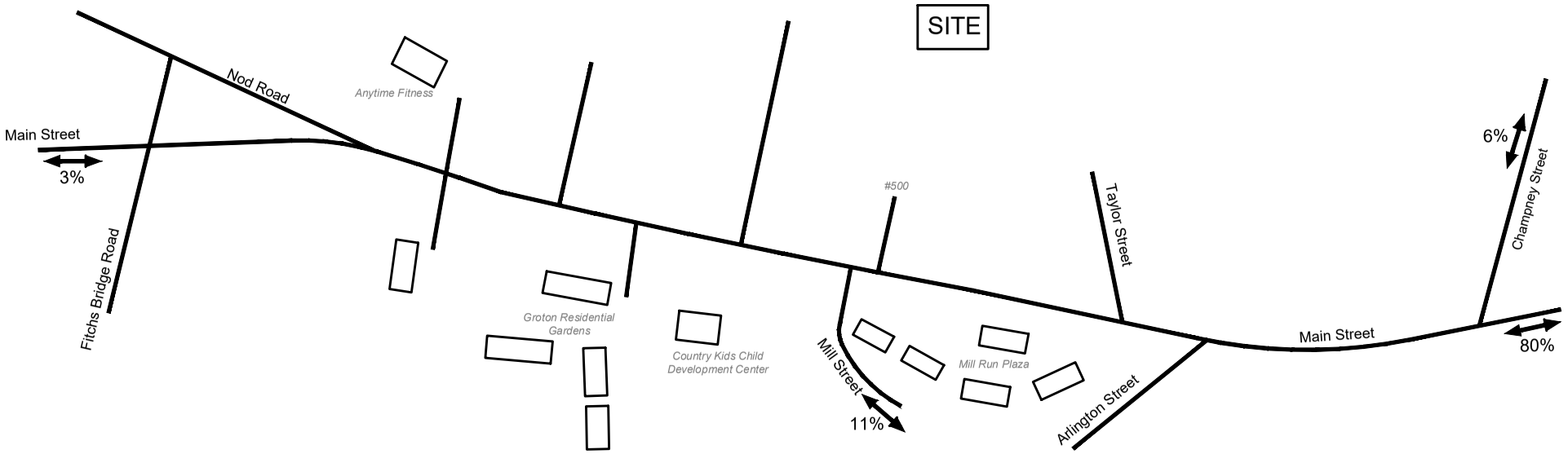
[5]Ibid.

## Trip Distribution

The directional distribution of the vehicular traffic approaching and departing the site is typically a function of population densities, the location of employment, existing travel patterns, similar uses, and the efficiency of the existing roadway system. A gravity model was developed based on Groton Journey-to-Work data from the U.S. Census to determine the expected trip distribution. Table 7 summarizes the expected trip distribution. The trip distribution is shown graphically on Figure 6 and the gravity model is in the Appendix.

**TABLE 7**
**PROPOSED TRIP DISTRIBUTION**

| Route | Direction | Percent of Trips |
|---|---|---|
| Main Street | West | 3 |
| Main Street | East | 80 |
| Mill Street | South | 11 |
| Champney Street | North | 6 |
| TOTALS | | 100 |




Note: Imbalances exist due to side streets and driveways not shown.

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Figure 6

Trip Distribution

## Future Traffic Volumes - Build Condition

The site-generated traffic was distributed within the study area according to the percentages summarized in Table 6. The site generated trips are shown on Figures 7 and 8. The site generated volumes were then superimposed onto the 2029 No-Build traffic volumes to represent the 2029 Build traffic-volume conditions and the existing site trips were removed. The anticipated 2029 Build weekday morning and weekday evening peak-hour traffic volumes are graphically presented in Figures 9 and 10. These volumes were used as the basis for all analysis as well as to identify potential mitigation measures to ameliorate the project's impacts.

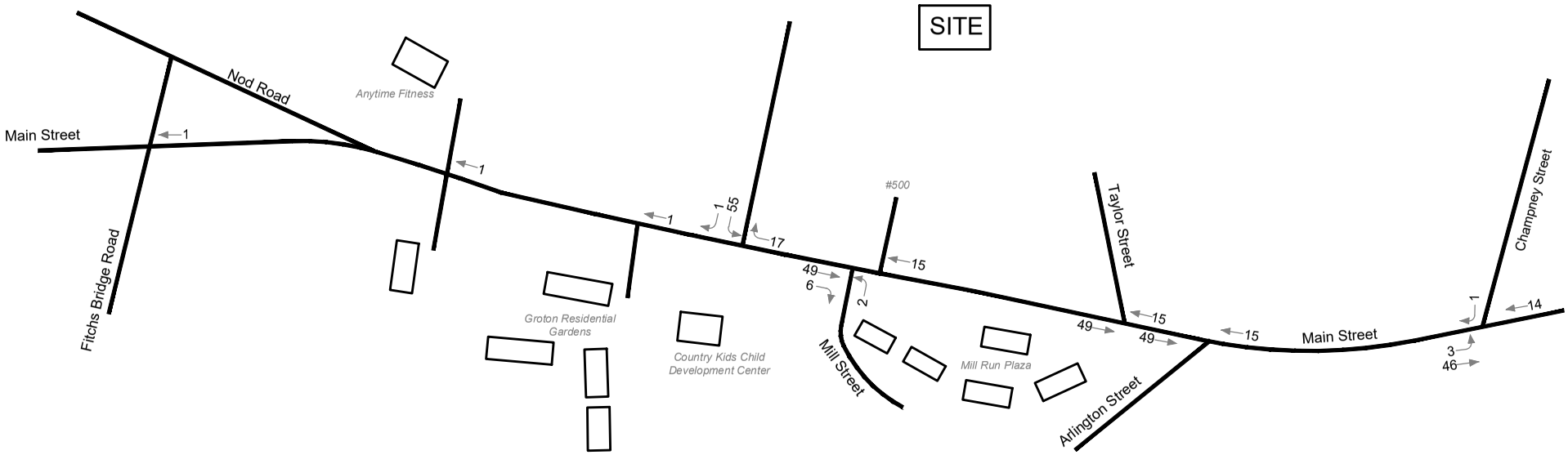
A summary of 2029 peak-hour projected traffic-volume changes in the site vicinity are shown in Table 8. These volumes are based on the expected increases from the site traffic generation.

**TABLE 8**
**TRAFFIC-VOLUME INCREASES[a]**

| Location/Peak Hour | 2029 No-Build | 2029 Build | Volume Increase over No-Build |
|---|---|---|---|
| ***Main Street, west of Fitchs Bridge Road*** | | | |
| Weekday Morning | 1,447 | 1,448 | 1 |
| Weekday Evening | 1,608 | 1,610 | 2 |
| ***Main Street, east of Champney Street*** | | | |
| Weekday Morning | 1,344 | 1,404 | 60 |
| Weekday Evening | 1,500 | 1,565 | 65 |
| ***Mill Street south of Main Street*** | | | |
| Weekday Morning | 215 | 223 | 8 |
| Weekday Evening | 245 | 254 | 9 |
| ***Champney Street, north of Main Street*** | | | |
| Weekday Morning | 210 | 214 | 4 |
| Weekday Evening | 133 | 138 | 5 |

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

As shown in Table 8, project-related increases are in the range of 1 to 65 bi-directional vehicles during the peak hours entering or exiting the study area. This is equivalent to approximately one additional vehicle every minute or less per direction on average during the peak hours.




Site Generated Trips:

In = 17

Out = 56

Total = 73

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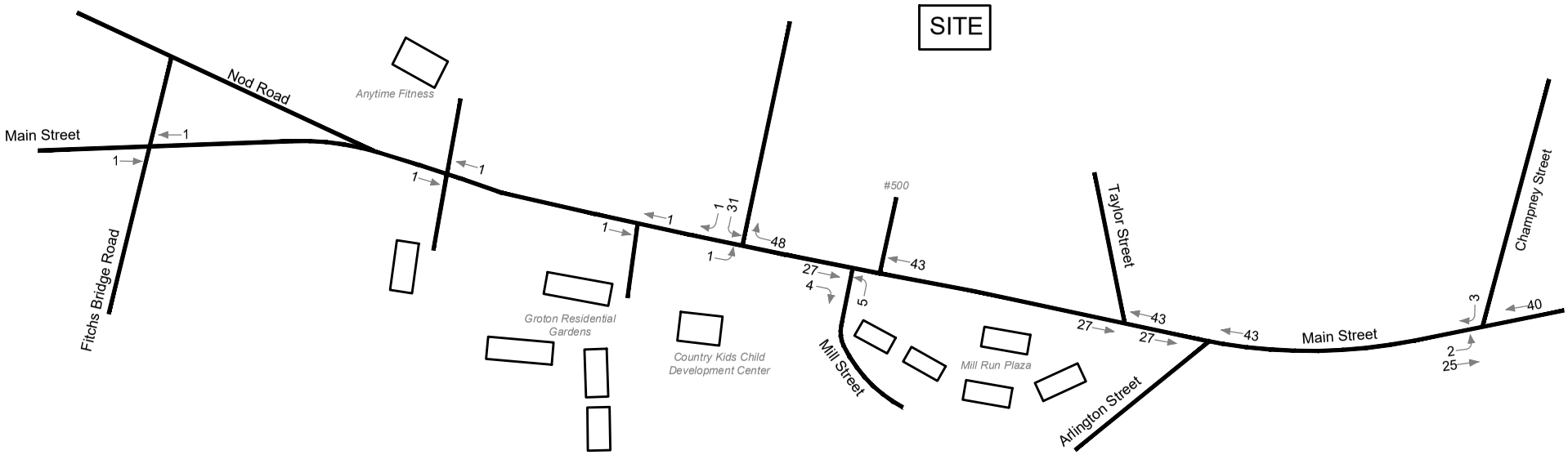
Figure 7

Site Generated
Weekday Morning




Site Generated Trips:
In = 49
Out = 32
Total = 81

N
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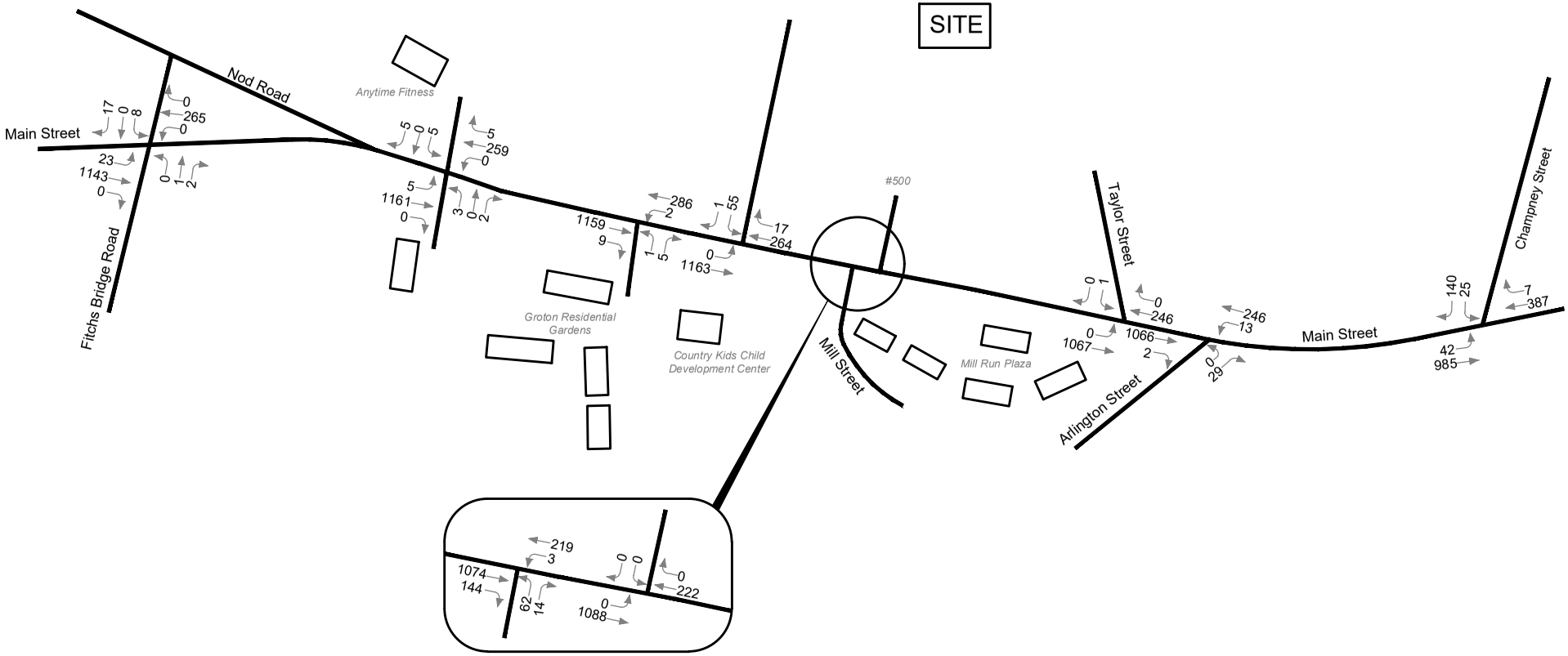
Figure 8

Site Generated
Weekday Evening




Note: Imbalances exist due to side streets and driveways not shown.

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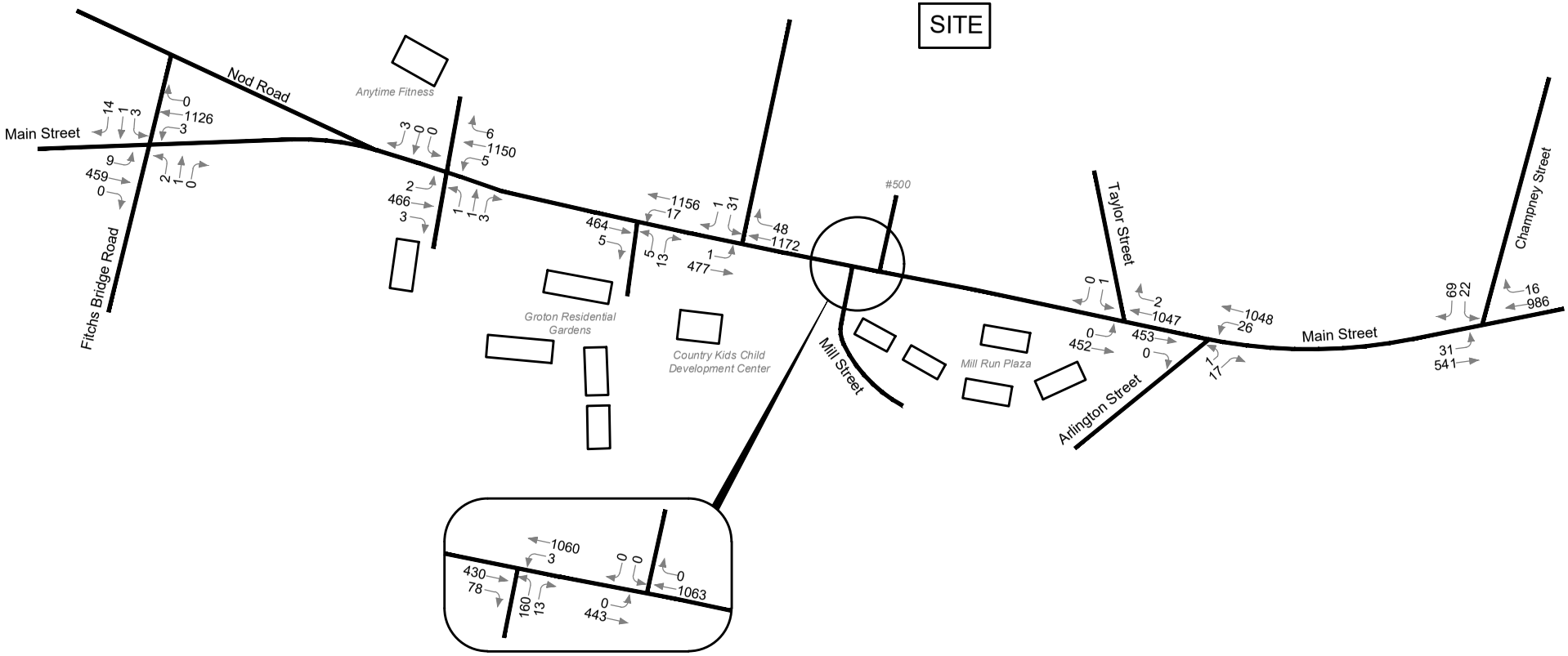
Figure 9

2029 Build
Weekday Morning
Peak Hour Traffic Volumes




Note: Imbalances exist due to side streets and driveways not shown.

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Figure 10

2029 Build
Weekday Evening
Peak Hour Traffic Volumes

# SECTION 4: 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[6] 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.

### Signalized Intersections

Levels of service for signalized intersections are calculated using the methodology and procedures described in the 2010 *Highway Capacity Manual*[7] *(HCM)*. 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 9 summarizes the relationship between level of service and delay. The calculated delay values result in level-of-service designations which

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

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

are applied to individual lane groups, to individual intersection approaches, and to the entire intersection. In the 2010 HCM methodology, the critical lane group volume to capacity ratio is reported.

**TABLE 9**
**LEVEL-OF-SERVICE CRITERIA FOR SIGNALIZED INTERSECTIONS[a]**

| Delay per Vehicle (Seconds) | Defined Level of Service v/c[b] < 1.0 | Defined Level of Service v/c[b] > 1.0 |
|---|---|---|
| ≤10.0 | A | F |
| 10.1 to 20.0 | B | F |
| 20.1 to 35.0 | C | F |
| 35.1 to 55.0 | D | F |
| 55.1 to 80.0 | E | F |
| >80.0 | F | F |

[a]*Highway Capacity Manual*; Transportation Research Board; Broad, DC; 2010; page 18-6.
[b]Volume to capacity ratio.

## Unsignalized Intersections

The level of service for an unsignalized intersection is determined by the methodology and procedures described in the 2010 HCM. 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 effects 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 unsignalized intersections are also provided in the 2010 *Highway Capacity Manual*. Table 10 summarizes the relationship between level of service and average control delay for the critical movements at unsignalized intersections.

**TABLE 10**
**LEVEL-OF-SERVICE CRITERIA FOR UNSIGNALIZED INTERSECTIONS[a]**

| Average Delay (seconds per vehicle) | Defined Level of Service v/c[b] < 1.0 | Defined Level of Service v/c > 1.0 |
|---|---|---|
| ≤ 10.0 | A | F |
| 10.1 to 15.0 | B | F |
| 15.1 to 25.0 | C | F |
| 25.1 to 35.0 | D | F |
| 35.1 to 50.0 | E | F |
| >50.0 | F | F |

[a]*Highway Capacity Manual*; Transportation Research Board; Broad, DC; 2010; page 19-2
[b]Volume to capacity ratio.

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 at the study area intersections 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 from the HCM model 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.

## CAPACITY ANALYSIS RESULTS

Level-of-service analyses were conducted for 2022 Existing, 2029 No-Build, and 2029 Build conditions for the intersections within the study area. All of the intersections in this study area are unsignalized intersections. Except for three intersections, the critical movements at the remaining intersections are modeled to operate at LOS D to LOS F during the respective weekday morning peak hours. The corresponding volume to capacity (v/c) ratios are 0.25 or less with projected 95$^{th}$ percentile queues of one (1) vehicle or less, indicating that there is capacity for the critical movements.

Further, as shown in Table 2, for the unsignalized intersection of Main Street and Mill Street, utilizing the existing, unadjusted count data, the observed delays are significantly less than the capacity analysis model predicts. As shown in Table 2, the observed average delay for left and right-turning vehicles during the morning peak hour was 21 seconds. The corresponding capacity analysis indicates the calculated delay would be 43.1 seconds (twice as high as the observed). Similarly, the observed average delay for left and right-turning vehicles during the evening peak hour was 23 seconds. The corresponding capacity

analysis indicates the calculated delay would be 162.9 seconds (seven times as high as the observed). This indicates that the calculated delays represent a conservative analysis result.

The results of the 2029 unsignalized analyses are summarized in Table 11. Detailed analysis sheets are presented in the Appendix.

**Main Street, Fitchs Bridge Road and Nod Road**

Under 2022 Existing conditions, the critical movements at this unsignalized intersection (all movements from Fitchs Bridge Road) are modeled to operate at LOS D during the weekday morning peak hour and at LOS F during the weekday evening peak hour. Under future 2029 No-Build conditions, the critical movements are projected to operate at LOS E during the weekday morning peak hour and at LOS F during the weekday evening peak hour. Under 2029 Build conditions, with the project, the critical movements are projected to continue to operate at LOS E during the weekday morning peak hour and at LOS F during the weekday evening peak hour.

**Main Street, Groton Residential Gardens Driveway and Anytime Fitness Driveway**

Under 2022 Existing conditions, the critical movements at this unsignalized intersection (all movements from the Groton Residential Gardens driveway) are modeled to operate at LOS E during the weekday morning peak hour and at LOS D during the weekday evening peak hour. Under future 2029 No-Build conditions, the critical movements are projected to operate at LOS E during the weekday morning peak hour and at LOS E during the weekday evening peak hour. Under 2029 Build conditions, with the project, the critical movements are projected to continue to operate at LOS E during the weekday morning peak hour and at LOS E during the weekday evening peak hour.

**Main Street and Country Kids Child Development Center Driveway**

Under 2022 Existing conditions, the critical movements at this unsignalized intersection (all movements from the driveway) are modeled to operate at LOS D during the weekday morning and weekday evening peak hours. Under future 2029 No-Build conditions, the critical movements are projected to operate at LOS D during the weekday morning and weekday evening peak hours. Under 2029 Build conditions, with the project, the critical movements are projected to continue to operate at LOS D during the weekday morning and weekday evening peak hours.

**TABLE 11**
**UNSIGNALIZED LEVEL-OF-SERVICE ANALYSIS SUMMARY**

| Critical Movement/ Peak Hour | 2022 Existing | | | | | 2029 No-Build | | | | | 2029 Build | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Demand[a] | V/C[b] | Delay[c] | LOS[d] | Queue[e] | Demand | V/C | Delay | LOS | Queue | Demand | V/C | Delay | LOS | Queue |
| ***Main Street and Fitchs Bridge Road*** | | | | | | | | | | | | | | | |
| *All movements from Fitchs Bridge Road (NEB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 3 | 0.06 | 32.7 | D | 5 | 3 | 0.06 | 35.0 | E | 5 | 3 | 0.06 | 35.0 | E | 5 |
| Weekday Evening | 3 | 0.07 | 69.2 | F | 5 | 3 | 0.08 | 81.5 | F | 5 | 3 | 0.08 | 81.5 | F | 5 |
| *All movements from Fitchs Bridge Road (SWB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 23 | 0.19 | 31.1 | D | 17.5 | 25 | 0.22 | 32.9 | D | 20 | 25 | 0.22 | 32.9 | D | 20 |
| Weekday Evening | 18 | 0.20 | 38.5 | E | 17.5 | 18 | 0.22 | 43.4 | E | 20 | 18 | 0.22 | 43.4 | E | 20 |
| ***Main Street, Groton Residential Gardens, and Anytime Fitness Driveway*** | | | | | | | | | | | | | | | |
| *All movements from Groton Residential Gardens (NB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 5 | 0.06 | 35.0 | E | 5 | 5 | 0.07 | 37.7 | E | 5 | 5 | 0.07 | 37.7 | E | 5 |
| Weekday Evening | 5 | 0.08 | 31.4 | D | 7.5 | 5 | 0.09 | 35.2 | E | 7.5 | 5 | 0.09 | 35.5 | E | 7.5 |
| *All movements from Anytime Fitness Driveway (SB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 10 | 0.12 | 28.5 | D | 10 | 10 | 0.13 | 30.7 | D | 10 | 10 | 0.13 | 30.7 | D | 10 |
| Weekday Evening | 3 | 0.02 | 22.7 | C | 2.5 | 3 | 0.02 | 24.1 | C | 2.5 | 3 | 0.02 | 24.1 | C | 2.5 |
| ***Main Street and Country Kids Development Center Driveway*** | | | | | | | | | | | | | | | |
| *All movements from Country Kids Development Center Driveway (NB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 6 | 0.05 | 25.3 | D | 5 | 6 | 0.05 | 26.6 | D | 5 | 6 | 0.06 | 26.9 | D | 5 |
| Weekday Evening | 18 | 0.19 | 25.2 | D | 17.5 | 18 | 0.22 | 28.1 | D | 20 | 18 | 0.22 | 28.1 | D | 20 |
| ***Main Street and Primary Site Driveway*** | | | | | | | | | | | | | | | |
| *Left-turn movements from Site Driveway (SB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 0 | 0.00 | 0.0 | A | 0 | 0 | 0.00 | 0.0 | A | 0 | 55 | 0.51 | 64.2 | F | 60 |
| Weekday Evening | 0 | 0.00 | 0.0 | A | 0 | 0 | 0.00 | 0.0 | A | 0 | 31 | 0.44 | 84 | F | 45 |
| *Right-turn movements from Site Driveway (SB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 0 | 0.00 | 0.0 | A | 0 | 0 | 0.00 | 0.0 | A | 0 | 1 | 0.00 | 10.3 | B | 0 |
| Weekday Evening | 0 | 0.00 | 0.0 | A | 0 | 0 | 0.00 | 0.0 | A | 0 | 1 | 0.01 | 24.8 | C | 0 |
| ***Main Street and Mill Street*** | | | | | | | | | | | | | | | |
| *All movements from Mill Street (NB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 72 | 0.66 | 60.1 | F | 95 | 74 | 0.73 | 73.0 | F | 110 | 76 | 0.87 | 97.9 | F | 135 |
| Weekday Evening | 159 | 1.42 | 293.4 | F | 305 | 168 | 1.68 | 404.8 | F | 362.5 | 173 | 1.95 | 530.3 | F | 410 |

[a]Demand of critical movements in vehicles per hour.
[b]Volume-to-capacity ratio.
[c]Delay in seconds per vehicle.
[d]Level of service.
[e]95th percentile queue in feet.

**TABLE 11 (Cont.)**
**UNSIGNALIZED LEVEL-OF-SERVICE ANALYSIS SUMMARY**

| Critical Movement/ Peak Hour | 2022 Existing | | | | | 2029 No-Build | | | | | 2029 Build | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Demand[a] | V/C[b] | Delay[c] | LOS[d] | Queue[e] | Demand | V/C | Delay | LOS | Queue | Demand | V/C | Delay | LOS | Queue |
| ***Main Street and Taylor Street*** | | | | | | | | | | | | | | | |
| *All movements from Taylor Street (SB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 1 | 0.02 | 27.5 | D | 2.5 | 1 | 0.03 | 29.2 | D | 2.5 | 1 | 0.03 | 31.9 | D | 2.5 |
| Weekday Evening | 1 | 0.03 | 34.3 | D | 2.5 | 1 | 0.03 | 37.1 | E | 2.5 | 1 | 0.04 | 41.4 | E | 2.5 |
| ***Main Street and Arlington Street*** | | | | | | | | | | | | | | | |
| *All movements from Arlington Street (EB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 28 | 0.21 | 23 | C | 20 | 29 | 0.23 | 24.5 | C | 22.5 | 29 | 0.25 | 26.4 | D | 25 |
| Weekday Evening | 17 | 0.06 | 12.9 | B | 5 | 18 | 0.06 | 13.3 | B | 5 | 18 | 0.07 | 13.8 | B | 5 |
| ***Main Street and Champney Street*** | | | | | | | | | | | | | | | |
| *All movements from Champney Street (WB):* | | | | | | | | | | | | | | | |
| Weekday Morning | 158 | 0.72 | 42 | E | 130 | 164 | 0.80 | 52.5 | F | 157.5 | 165 | 0.88 | 69.2 | F | 187.5 |
| Weekday Evening | 85 | 0.64 | 55.1 | F | 92.5 | 88 | 0.73 | 70.4 | F | 112.5 | 91 | 0.82 | 90.1 | F | 132.5 |

[a]Demand of critical movements in vehicles per hour.
[b]Volume-to-capacity ratio.
[c]Delay in seconds per vehicle.
[d]Level of service.
[e]95th percentile queue in feet.

**Main Street and Proposed Primary Site Driveway**

Under 2029 Build conditions, the critical movements at this unsignalized intersection (left-turn movements from the driveway) are modeled to operate at LOS F during the weekday morning peak hour and at LOS F during the weekday evening peak hour.

**Main Street and Mill Street**

Under 2022 Existing conditions, the critical movements at this unsignalized intersection (all movements from Mill Street) are modeled to operate at LOS F during the weekday morning and weekday evening peak hours. Under future 2029 No-Build conditions, the critical movements are projected to operate at LOS F during the weekday morning and weekday evening peak hours. Under 2029 Build conditions, with the project, the critical movements are projected to continue to operate at LOS F during the weekday morning and weekday evening peak hours.

**Main Street and Taylor Street**

Under 2022 Existing conditions, the critical movements at this unsignalized intersection (all movements from Taylor Street) are modeled to operate at LOS D during the weekday morning peak hour and at LOS D during the weekday evening peak hour. Under future 2029 No-Build conditions, the critical 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 2029 Build conditions, with the project, the critical movements are projected to continue to operate at LOS D during the weekday morning peak hour and at LOS E during the weekday evening peak hour.

**Main Street and Arlington Street**

Under 2022 Existing conditions, the critical movements at this unsignalized intersection (all movements from Arlington Street) are modeled to operate at LOS C during the weekday morning peak hour and at LOS B during the weekday evening peak hour. Under future 2029 No-Build conditions, the critical movements are projected to operate at LOS C during the weekday morning peak hour and at LOS B during the weekday evening peak hour. Under 2029 Build conditions, with the project, the critical movements are projected to operate at LOS D during the weekday morning peak hour and at LOS B during the weekday evening peak hour.

**Main Street and Champney Street**

Under 2022 Existing conditions, the critical movements at this unsignalized intersection (all movements from Champney Street) are modeled to operate at LOS E during the weekday morning peak hour and at LOS F during the weekday evening peak hour. Under future 2029 No-Build conditions, the critical movements are projected to operate at LOS F during the weekday morning and weekday evening peak hours. Under 2029 Build conditions, with the project, the critical movements are projected to continue to operate at

LOS F during the weekday morning and weekday evening peak hours.

## SIGHT DISTANCE

Sight distance measurements were performed at the proposed site driveway intersection with Main Street in accordance with Massachusetts Department of Transportation (MassDOT) and American Association of State Highway and Transportation Officials (AASHTO) standards. Stopping sight distance (SSD) 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. Table 12 presents the measured SSD at the site access intersection. The sight distance calculations are included in the Appendix.

**TABLE 12**
**SIGHT DISTANCE SUMMARY**

| | Required Minimum (Feet)[a] | Measured (Feet) |
|---|---|---|
| ***Main Street and Proposed Primary Site Driveway*** | | |
| *Stopping Sight Distance:* | | |
| Main Street approaching from the east | 335 | 500+ |
| Main Street approaching from the west | 335 | 500+ |
| *Intersection Sight Distance:* | | |
| Site Driveway looking to the east | 411[b]/474[c] | 500+ |
| Site Driveway looking to the west | 411[b]/474[c] | 500+ |

[a]Recommended minimum values obtained from *A Policy on Geometric Design of Highways and Streets*; American Association of State Highway and Transportation Officials (AASHTO); 2018 and based on observed 85th percentile speed.
[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 12, the SSD measurements performed at Main Street and the proposed site driveway intersection indicate that the intersection exceeds the recommended minimum requirements based on the 85th percentile speeds. In accordance with the 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. It is recommended that any landscaping or site signage be set-back from Main Street to not impede sight lines.

# SECTION 5: CONCLUSION AND RECOMMENDATIONS

## CONCLUSION

A detailed assessment of the potential impacts on the transportation infrastructure associated with the proposed construction of the mixed-use development was performed. 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 capacity analyses performed for 2022 Existing and 2029 future No-Build and Build conditions indicate that the proposed project will not result in a significant impact on traffic operations at the study area intersections.

Based on this assessment, the following can be concluded with respect to the Project:

- None of the study area intersections are on the MassDOT Highway Safety Improvement Program (HSIP) list.

- Using trip-generation statistics published by the Institute of Transportation Engineers (ITE), the Project is expected to generate approximately 948 vehicle trips on an average weekday (two-way, 24-hour volume), with 73 vehicle trips expected during the weekday morning peak hour and 81 vehicle trips expected during the weekday evening peak hour.

- In comparison to the office use that could be re-occupied within the Project site, the Project is expected to result in 494 fewer daily vehicle trips on an average weekday, with 135 *fewer* vehicle trips expected during the weekday morning peak-hour and 123 *fewer* vehicle trips during the weekday evening peak-hour compared to the former office use.

- The Project will not have a significant impact (increase) on motorist delays or vehicle queuing over Existing or anticipated future conditions without the Project (No-Build conditions), with the majority of the critical movements at the study intersections shown to operate at LOS D or better under all analysis

conditions where a level-of-service of "D" or better is defined as "acceptable" operating conditions.

- Independent of the Project, operating conditions for the critical movements at the intersections of Main Street and Mill Street and at Main Street and Champney Street were identified to be operating at or over capacity (i.e., LOS "E" or "F"), with Project-related impacts, the predicted increase in vehicle queuing is three (3) vehicles.

- Lines of sight at the Project site driveway intersection with Main Street were found to exceed the recommended minimum distances for safe and efficient operation based on the appropriate approach speed.

- A review of the Site Plan for the Project indicates that human-made objects, landscaping, and signs have been appropriately designed and located so as not to inhibit sight lines to and from the Project site driveway or along Main Street.

## RECOMMENDATIONS

A comprehensive transportation mitigation program has been developed that is designed to reduce automobile trips associated with the Project and accommodate the additional traffic expected to be generated by the Project in a safe and efficient manner. The elements of the transportation mitigation program have been separated into the following categories: Project Access, Level-of Service/Congestion Mitigation; and Transportation Demand Management and are described in the following sections.

### Project Access

Access to the Project site will be provided by way of the existing site driveway to Main Street. The following recommendations are offered with respect to the design and operation of the Project site driveway:

- The Project primary site driveway will be a minimum of 36 feet in width and designed to accommodate the turning and maneuvering requirements of the largest anticipated responding emergency vehicle. The driveway will consist of one (1) entering lane and two (2) exiting lanes (an exclusive left-turn lane and an exclusive right-turn lane).

- Vehicles exiting the Project site driveway will be placed under STOP-sign control with a marked STOP line provided.

- The Project site driveway and internal circulating aisles will be designed to accommodate the turning and maneuvering requirements of service and delivery trucks and emergency vehicles.

- All signs and pavement markings to be installed within the Project site will conform to the applicable standards of the *Manual on Uniform Traffic Control Devices* (MUTCD).

- A sidewalk will be provided within the Project site to link the proposed buildings to the sidewalk infrastructure along Main Street, with Americans with Disabilities Act (ADA)-compliant wheelchair ramps provided at all pedestrian crossings internal to the Project site and for crossing the Project site driveway at Main Street.

- A sidewalk will be provided along the property frontage easterly from the Primary site driveway to the eastern property line. A crosswalk across Main Street with a Rectangular Rapid Flashing Beacon (RRFB) will be installed with a connection to the existing sidewalk along the south side of Main Street. The location and design of the crossing will be subject to MassDOT review and approval.

- Signs and landscaping to be installed as a part of the Project within the intersection sight triangle areas of the Project site driveway will be designed and maintained so as not to restrict lines of sight.

- Snow windrows within sight triangle areas of the Project site driveway will be promptly removed where such accumulations would impede sight lines.

- Bicycle racks will be installed at convenient locations within the Project site proximate to the building entrances and at the clubhouse.

- Accommodations will be provided for electric vehicle charging by residents of the Project.

**Level-of-Service/Congestion Mitigation**

***Main Street and Mill Street -*** Under 2029 No-Build conditions, the critical movements at this unsignalized intersection were shown to operate at an overall LOS F during both the weekday morning and evening peak hours. Under 2029 Build peak-month conditions, the critical movements were shown to continue to operate at an overall LOS F during the weekday morning peak hour (no change over No-Build conditions). A review of the existing traffic volume data indicates that the intersection currently would not meet the warrants for signalization as identified in the MUTCD. Further, as noted in the Capacity Analysis section, the overall delays projected by the capacity analysis methodology exceed the observed delays. It is recommended that upon completion and occupancy of the Project, the intersection be monitored. If at that time, the traffic volumes meet the MUTCD traffic signal warrant criteria, the project proponent will design a traffic signal system for the intersection.

***Main Street and Champney Street -*** Under 2029 No-Build conditions, the critical movements at this unsignalized intersection were shown to operate at an overall LOS F during both the weekday morning and evening peak hours. Under 2029 Build peak-month conditions, the critical movements were shown to continue to operate at an overall LOS F during the weekday morning peak hour (no change over No-Build conditions). A review of the existing traffic volume data indicates that the intersection currently would not meet the warrants for signalization as identified in the MUTCD. It is recommended that upon completion and occupancy of the Project, the intersection be monitored. If at that time, the traffic volumes meet the MUTCD traffic signal warrant criteria, the project proponent will design a traffic signal system for the intersection.

**Transportation Demand Management**

The following Transportation Demand Management (TDM) measures will be implemented as a part of the Project to encourage the use of alternative modes of transportation to single-occupant vehicles:

- A Transportation Coordinator will be designated for the Project to coordinate the elements of the TDM program,

- Information regarding public transportation services, maps, schedules and fare information will be posted in a central location and/or otherwise made available to residents,

- A "welcome packet" will be provided to residents detailing available public transportation services, bicycle and walking alternatives, and commuter options,

- Work-at-home workspaces will be provided to support telecommuting by residents of the Project,

- Pedestrian accommodations will be incorporated into the Project and consist of sidewalks and ADA-compliant wheelchair ramps at all pedestrian crossings internal to the Project site that will link building entrances to the sidewalk infrastructure along Main Street,

- A mail drop will be provided in a central location; and

- Secure bicycle parking will be provided within the Project site consisting of both exterior and interior (covered) bicycle parking.

With implementation of the above recommendations, safe and efficient vehicular, pedestrian and bicycle access will be provided to the Project site and the Project can be accommodated within the confines of the existing transportation system.