TRANSPORTATION IMPACT AND ACCESS STUDY

The Northland Newton Development

Newton, Massachusetts

PREPARED FOR

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Introduction

VHB, on behalf of Northland Investment Corporation (Northland) has prepared a detailed Transportation Impact and Access Study for the proposed mixed-use project known as The Northland Newton Development (The Project). The approximately 22.6-acre site is located along Needham Street in Newton, MA. The Project will include approximately 1.9 million gross square feet (sf) of development (approximately 400 ksf of which consists of parking structures) and will retain the historic Saco Petee mill building that was previously converted to office space. The project includes 180,000 sf of leasable office space (in the historic Saco Petee mill building), 822 residential housing units, 237,000 sf of retail/restaurant/active use space, approximately 1,953 parking spaces, as well as substantial public amenities such as plazas and greens, enhanced pedestrian and bicycle connections and amenities, passive open space enhancements, and a series of robust traffic demand management initiatives. It should be noted that while Northland owns land on both sides of Needham Street, the Project outlined in this document only encompasses the parcel of land west of Needham Street, bounded by Needham Street, Oak Street, the Upper Falls Greenway, and neighboring businesses.

The Project is consistent with local and regional redevelopment goals for the area as outlined in the City of Newton Comprehensive Plan of 2007 as amended in 2011 and with the Needham Street Area Vision Plan in 2018. One particular goal involves the enhancement of previously developed areas to create smarter, more walkable, and connected neighborhoods while including historic preservation. Other goals include providing numerous public benefits, including affordable and market rate housing in an accessible, desirable location, creating a vibrant and safe environment with new open spaces; and improving transportation access and connectivity.

The Project is located along Needham Street where the City and MassDOT are currently in final design for improvements that will be implemented along the entire Needham Street corridor including the project frontage. The roadway project is anticipated to improve multimodal accommodations, safety, and traffic operations. New sidewalks and raised bike lanes / multiuse off-road paths will be constructed to improve accommodations for bicycles and pedestrians and to help further the goal of making Needham Street a desirable location for all roadway users. In addition, the roadway improvement project will add traffic signals at several locations along the corridor, including Winchester Street at the Route 9 Service Roads and at the Northland development at Needham Street and the re-aligned Charlemont Street.

Northland has actively engaged the City and MassDOT throughout the development of the Needham Street Improvement Project. Northland will be providing private land on the southwest corner of the Needham Street and Charlemont Street intersection to allow a realignment of the Charlemont Street approach to align with a site driveway and enable a significant operational improvement to the Needham Street corridor. Currently the two intersections are offset which creates an awkward and inefficient condition. Construction on the MassDOT roadway improvement project is expected to begin in late 2019/early 2020.

Considering the substantial improvements being proposed along the Needham Street corridor and to be consistent with the initiatives identified in the Needham Street Area Vision Plan, a major focus of the mitigation to accommodate expected project traffic is the provision of alternative modes of transportation. Northland has focused on creating significant multi-modal opportunities for residents, customers, employees at the site and for the public. The plan focuses specifically on pedestrian and bicycle facilities and the introduction of substantial connections to the local and regional transit opportunities through a robust shuttle bus system. Details of the plan are outlined in this document, but Northland's approach is innovative and un-matched by any project in the region.

Northland has engaged the Route 128 Business Council to assist the Project team with potential local and regional shuttle connections to key transit hubs. Northland is committed to providing strong connections to regional transit opportunities and thus will be considering the most efficient ways to make these connections and obtain high ridership by Project tenants, patrons, employees, and the general public. The potential for shared shuttle activity among the Site and other developments, businesses, and residences in the immediate vicinity will also be sought to promote efficiency and high ridership.

Northland will work with MBTA to encourage enhanced bus transit opportunities in the area. This will include exploring additional bus routing through the "Mobility Hub" on-Site and additional or enhanced bus stops with covered waiting areas.

The Project will strive to strike a balance between accommodating Project needs and discouraging single occupancy vehicle usage. The information outlined in the "Metro

Boston Perfect Fit Parking Initiative,"[1] prepared by the Metropolitan Area Planning Council, suggests that parking is often oversupplied for residential uses in the region. In light of the study findings, the desire to provide and promote strong mobility choices at the Site, and the inherent efficiencies in co-locating a mix of uses, Northland is considering committing to lower parking ratios than those required locally as a way to create a new mindset about driving to the Site. Given the sensitivities around parking supply, Northland will continue to monitor parking occupancy and attempt to limit the number of parking spaces to provide the minimum number necessary for efficient Site operations. Northland will encourage and promote the many mobility choices that will be available to access and navigate the Project Site.

Based on current zoning in the City of Newton, the Site is currently zoned to allow for up to 1.48 million sf of development consisting of all office space on Site. While the as-of-right development of all office space is allowed and could be developed, the proposed Project will have a much greater effect in achieving the goals outlined by the City for the Needham Street corridor. The proposed Project will diversify the land uses in the area and will help to develop a vibrant and desirable neighborhood in ways that the as-of-right development would not achieve.

Study Methodology

The following transportation analysis has been performed in general conformance with the Massachusetts Executive Office of Environmental Affairs (EEA)/Executive Office of Transportation (EOT) guidelines. Prior to completing this study, VHB completed a Traffic Scoping Letter (TSL) process with MassDOT to get buy-in on the many facets of the traffic study. This study has been prepared based on that process and agreement to the scope. VHB also consulted with City transportation staff on traffic study requirements.

VHB prepared the traffic assessment in three stages. The first stage involved an assessment of existing traffic conditions within the Project study area including an inventory of existing roadway geometry; observations of traffic flow, including daily and peak period traffic counts; a summary of existing public transit facilities in the area; and a review of vehicular crash data.

The second stage of the study established the framework for evaluating the transportation impacts of the proposed Project. Specific travel demand forecasts for the Project were assessed along with future traffic demands on the study area roadways due to projected background traffic growth and other proposed area developments that may occur independent of the Project. The year 2025, a seven-year time horizon, was selected as the design year for analysis for the preparation of this traffic impact and access assessment in accordance with the standard industry practices in Massachusetts.

[1] "Metro Boston Perfect Fit Parking Initiative - Phase 1 Report: New Metrics and Models for Parking Supply and Demand", Metropolitan Area Planning Council, February 2017.

The third and final stage of the study discusses possible measures to improve existing and future traffic operations in the area and offsetting the traffic-related impacts associated with the development of the proposed Project.

2

Existing Conditions

Evaluation of the transportation impacts associated with the Project requires an understanding of the existing transportation conditions in the study area including; an inventory of the traffic control, roadway, driveway, and intersection geometry in the study area, the collection of daily and peak hour traffic volumes, a summary of public transit options in the area, and a review of recent crash history. Each of these elements is described in detail below.

Study Area

Based on VHB's knowledge of the area transportation network and the operational characteristics of the Project as well as input from the City of Newton and MassDOT, a study area comprised of the following intersections in Newton and Needham and their approach roadways were selected for review:

Newton

- 1: Chestnut Street at Route 9 Westbound Service Road
- 2: Chestnut Street at Route 9 Eastbound Service Road
- 3: Chestnut Street at Elliot Street
- 4: Chestnut Street at Oak Street
- 5: Oak Street at Site Driveway
- 6: Needham Street at Oak Street / Christina Street

- 7: Needham Street at South Site Driveway
- 8: Needham Street at Middle Site Driveway / Old TJ Maxx Driveway
- 9: Needham Street at North Site Driveway / Charlemont Street
- 10: Needham Street at Tower Road / Industrial Place
- 11: Needham Street at Jaconnet Street
- 12: Needham Street at Rockland Street
- 13: Needham Street at Columbia Avenue / Avalon Driveway
- 14: Winchester Street at Needham Street / Dedham Street
- 15: Winchester Street at Route 9 Eastbound Service Road
- 16: Winchester Street at Route 9 Westbound Service Road
- 17: Centre Street at Walnut Street
- 18: Nahanton Street at Winchester Street
- 19: Nahanton Street at Wells Avenue / JCC Driveway

Needham

- 20: Highland Avenue at Riverside Street
- 21: Highland Avenue at Highland Terrace / Highland Circle
- 22: Highland Avenue at 2nd Avenue / Staples Driveway
- 23: Highland Avenue at Charles Street
- 24: Highland Avenue at Wexford Street
- 25: Highland Avenue at 1st Avenue / Riverside Community Health Driveway
- 26: Highland Avenue at I-95 Northbound Ramps
- 27: Highland Avenue at I-95 Southbound Ramps

The project location and study area intersections are shown in Figure 1 and the observed existing geometry and traffic control at each study area intersection are illustrated in Figure 2.

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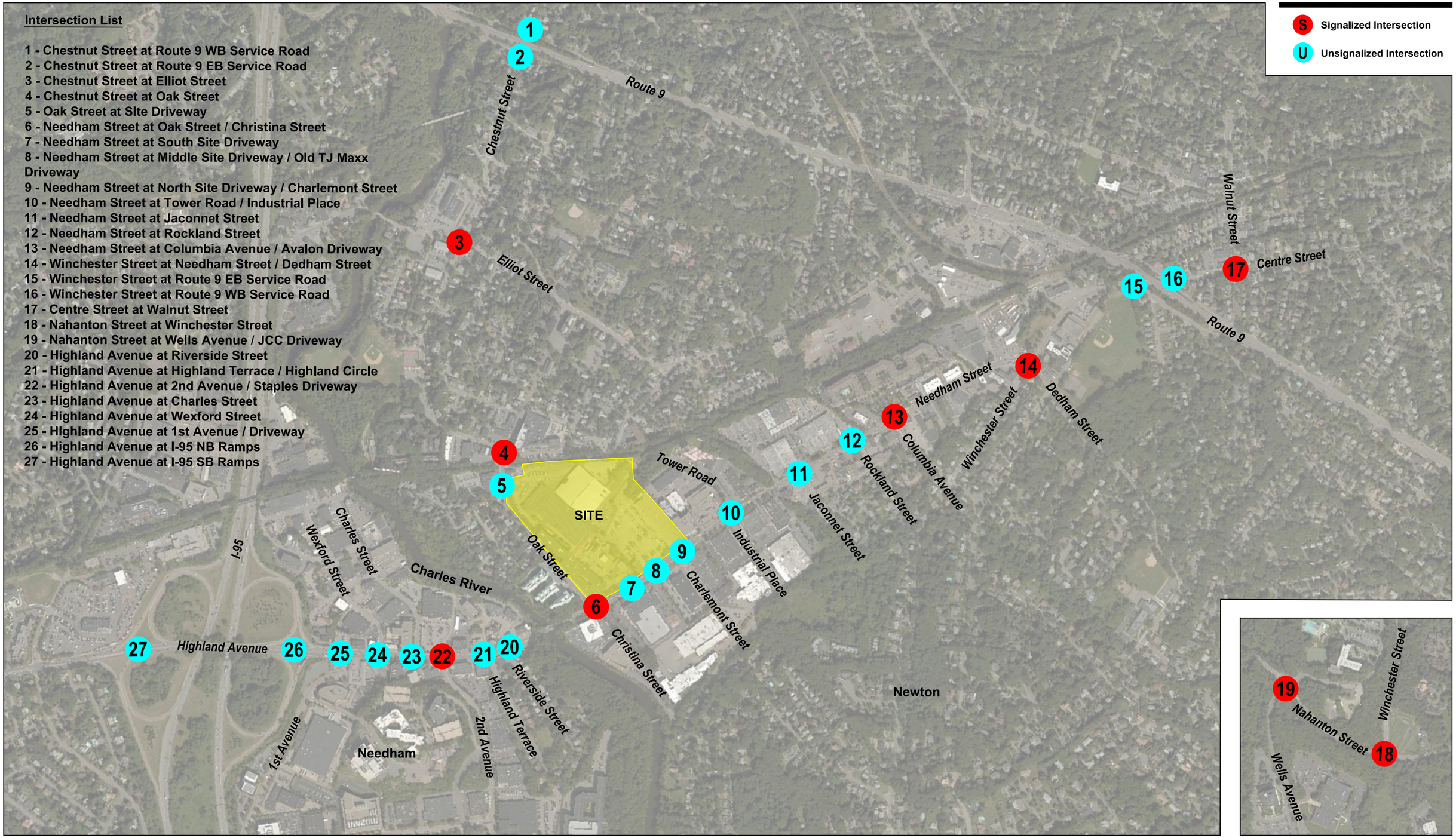

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Locus Map and
Study Area Intersections
The Northland Newton Development
Newton, Massachusetts

Figure 1

Signalized Intersection
Stop Controlled Approach
Yield Controlled Movement
Center Two-Way Left-Turn Lane

Inset 1 Highland Avenue - Needham

I-95 SB Ramps
I-95 NB Ramps
Riverside Community Care Driveway
Wexford Street
Highland Avenue
Charles Street
Staples Driveway
Highland Circle
Needham
Newton
Match Line
I-95 SB Ramps
I-95 NB Ramps
1st Avenue
2nd Avenue
Highland Terrace
Riverside Street
95
128

Inset 2 Nahanton Street

Match Line
JCC Driveway
Winchester Street
Nahanton Street
Wells Avenue

Route 9 WB Access Road
Route 9 EB Access Road
Elliot Street
Oak Street
Chestnut Street
Site
Site Driveway
Needham
Newton
See Inset 1
South Site Driveway
Middle Site Driveway
North Site Driveway
Tower Road
Needham Street
Avalon Driveway
Christina Street
Old TJ Maxx Driveway
Charlemont Street
Industrial Place
Jaconnet Street
Rockland Street
Columbia Avenue
Winchester Street
See Inset 2
Dedham Street
Route 9 EB Access Road
Route 9 WB Access Road
Walnut Street
Centre Street
9

Not to Scale

Study Area Intersections
Lane Geometry and Traffic Control
The Northland Newton Development
Newton, Massachusetts

Figure 2

Roadway Geometry

Descriptions of the study area roadways and intersections are provided below, including descriptions of the existing lane configurations, traffic control at the study intersections, and the roadway jurisdiction in this area.

Roadways

Needham Street

Needham Street runs from Winchester Street in the north and turns into Highland Avenue at the Needham Town Line to the south. It is classified as an urban minor arterial roadway and as it was the former layout of Route 128 it remains under Massachusetts Department of Transportation (MassDOT) jurisdiction. Needham Street runs in a generally north/south direction and consists of one travel lane in each direction. A center two-way left-turn lane is shared between both directions of travel along several portions of the corridor. There is no posted speed limit along Needham Street. Exclusive turn lanes are provided at the signalized intersections along the corridor. Sidewalks are provided along both sides of the road and crosswalks are provided at major intersections. One route of MBTA bus route 59 travels along Needham Street. Land use along Needham Street is primarily commercial.

It should be noted that the Needham Street / Winchester Street / Highland Avenue corridor is currently in the final planning stages of a reconstruction project by MassDOT[2]. The reconstruction project will enhance bicycle and pedestrian accommodations along the corridor and improve traffic flow. A functional design report (FDR) for the project was submitted in August 2017 and construction on the project is expected to start in late 2019/early 2020. The project is described in detail later in this report.

Winchester Street

Winchester Street begins at Nahanton Street in the south and turns into Centre Street in the north after it intersects with Route 9. The segment from Nahanton Street to Needham Street is classified as a major urban collector under City of Newton jurisdiction while the segment from Needham Street to Route 9 is classified as an urban minor arterial under MassDOT jurisdiction. Winchester Street runs in a generally north/south direction and consists of one lane of travel in each direction. The posted speed limit on the roadway is 30 mph. Sidewalks are provided on both sides of the road for most of the length of the roadway, and crosswalks are provided at major intersections. One route of MBTA bus route 52 travels along Winchester Street. Land use along Winchester Street is mostly residential but includes more

[2] Functional Design Report, Reconstruction of Highland Avenue, Needham Street, and Charles River Bridge; MassDOT Project No. 606635; Submitted by Stantec Consulting Services, Inc.; August 2017.

commercial usage toward the northern end of the corridor north of its intersection with Needham Street.

Highland Avenue

Highland Avenue begins at Great Plain Avenue in the south and turns into Needham Street at the Newton City Line to the north. Within the study area, Highland Avenue is under MassDOT jurisdiction. The roadway within the study area is classified as a minor urban arterial. Highland Avenue runs in a generally northeast/southwest direction within the study area. Highland Avenue consists of one travel lane in each direction northeast of 2nd Avenue, and consists of two lanes in each direction southwest of 2nd Avenue. There is no posted speed limit within the study area along Highland Avenue. Sidewalks are provided on both sides of the roadway and crosswalks are provided at major intersections. Land use around Highland Avenue is mainly commercial.

Oak Street

Oak Street runs between Needham Street in the southeast and Elliot Street in the northwest. It is classified as a major urban collector under City of Newton jurisdiction within the study area. Oak Street runs in a generally northwest/southeast direction and consists of one lane for each direction of travel. There is no posted speed limit on Oak Street. Sidewalks are provided on both sides of the roadway, and crosswalks are provided at the Chestnut Street and Needham Street intersections. One route of MBTA bus route 59 travels along Oak Street. Land use along Oak Street is a mixture of commercial and residential.

Intersections

1: Chestnut Street at Route 9 Westbound Service Road

Chestnut Street and the Route 9 Westbound Service Road form a four-way unsignalized intersection. Chestnut Street runs north/south, and the service road intersects from the east and west. The service road provides access to Route 9 westbound. Each approach to the intersection consists of a single general-purpose lane. The eastbound, westbound, and southbound approaches operate under STOP control while the northbound approach is free-flowing. Sidewalks are provided along the northern side of the intersection, and a crosswalk is provided across the southbound approach of Chestnut Street. Land use around the intersection is residential.

2: Chestnut Street at Route 9 Eastbound Service Road

Chestnut Street and the Route 9 Eastbound Service Road form a four-way unsignalized intersection. Chestnut Street runs north/south, and the service road intersects from the east and west. The service road provides access to Route 9 eastbound. Each approach to the intersection consists of a single general-purpose

lane. The eastbound, westbound, and southbound approaches operate under STOP control while the northbound approach is free-flowing. Sidewalks are provided along the southern side of the intersection, and a crosswalk is provided across the northbound approach of Chestnut Street. Land use around the intersection is residential.

3: Chestnut Street at Elliot Street

Chestnut Street and Eliot Street form a four-way signalized intersection. Chestnut Street runs north/south, and Eliot Street intersects from the east and west. Each approach to the intersection consists of a single general-purpose lane under signalized control. Sidewalks and crosswalks are available on all sides of the intersection. MBTA bus route 59 has stops just south of the intersection on both sides of Chestnut Street. Land use around the intersection is a mixture of commercial and residential.

4: Chestnut Street at Oak Street

Chestnut Street and Oak Street form a four-way signalized intersection. Oak Street runs north/south, and Chestnut Street intersects from the east and west. Each approach to the intersection consists of a single general-purpose lane under signalized control. Crosswalks and sidewalks are available on all sides of the intersection. MBTA bus route 59 has stops on Oak Street on the northwest and southwest corners of the intersection. Land use around the intersection is a mixture of commercial and residential.

5: Oak Street at Site Driveway

Oak Street and the existing site driveway form a three-way unsignalized intersection approximately 250 feet south of the intersection of Chestnut Street at Oak Street. Oak Street travels north/south, and the site driveway connects to a large parking lot and intersects with Oak Street from the east. Each approach to the intersection consists of a single general-purpose lane. Oak Street operates under free flow while the site driveway operates under STOP control. Sidewalks are provided along both sides of Oak Street and there are no crosswalks at the intersection. Land use around the intersection is a mixture of commercial and residential.

6: Needham Street at Oak Street / Christina Street

Needham Street, Oak Street, and Christina Street form a four-way signalized intersection. Needham Street travels north/south, Oak Street intersects from the west, and Christina Street intersects from the east. Oak Street and Christina Street intersect Needham Street offset from each other. While Oak Street runs in a north-south orientation through the previously described two intersections, prior to approaching Needham Street the roadway curves to approach Needham Street from the west. The northbound and southbound approaches from Needham Street consist of a left-turn lane and a shared through/right-turn lane. The eastbound

approach from Oak Street consists of a shared left-turn/through lane and a right-turn lane. The westbound approach from Christina Street consists of a single general-purpose lane. Sidewalks are provided along all sides of the intersection, and crosswalks are provided across each approach except for the northbound approach on Needham Street. Land use around the intersection is commercial. It should be noted that a reconstruction project to properly align the Oak Street and Christina Street approaches is in the final design stage and is expected to start construction in 2019. The project is described in detail later in this report.

7: Needham Street at South Site Driveway

Needham Street and a site driveway form a three-way unsignalized intersection. The site driveway currently accesses a small parking lot and loading area for the former mill building and is located approximately 250 feet north of the intersection of Needham Street at Oak Street / Christina Street. Needham Street runs north/south, and the site driveway intersects from the west. The northbound and southbound approaches from Needham Street both consist of a single general-purpose lane with a two-way left-turn lane in the center of the roadway. The eastbound approach from the site driveway consists of a single general-purpose lane operating under STOP control although no stop sign is present. Sidewalks are provided along both sides of Needham Street and there are no crosswalks provided at the intersection. Land use around the intersection is commercial.

8: Needham Street at Middle Site Driveway / Old TJ Maxx Driveway

Needham Street, and two driveways form a four-way unsignalized intersection. Needham Street runs north/south, and the driveways intersect from the east and west. The driveway from the west currently provides access to the southern portion of the Marshalls Plaza parking lot adjacent to AAA, and the driveway from the east is in-only (one-way away from the intersection) and provides access to the location of a former TJ Maxx (260 Needham Street). The northbound and southbound approaches from Needham Street both consist of a single general-purpose lane with a two-way left-turn lane in the center of the roadway. The eastbound driveway consists of a single general-purpose lane operating under STOP control although no stop sign is present. Sidewalks are provided along both sides of Needham Street and there are no crosswalks provided at the intersection. Land use around the intersection is commercial. It should be noted that the Middle Site Driveway is proposed to be eliminated with the current Site plan and therefore this intersection is proposed to become a three-way intersection under Build Conditions.

9: Needham Street at North Site Driveway / Charlemont Street

Needham Street, Charlemont Street and a site driveway form a four-way unsignalized intersection. Needham Street runs north/south, and Charlemont Street and the site driveway intersect from the east and west, respectively. Charlemont Street and the site driveway intersect Needham Street slightly offset from each other. The northbound and southbound approaches from Needham Street both

consist of a general-purpose lane with a two-way left-turn lane in the center of the roadway. The eastbound and westbound approaches, from the site driveway and Charlemont Street respectively, both consist of a single general-purpose lane operating under STOP control, although neither approach has a stop sign. MBTA bus route 59 has stops on Needham Street in both directions on the south side of the intersection. Sidewalks are provided along both sides of Needham Street and there are no crosswalks provided at the intersection. Land use around the intersection is commercial.

10: Needham Street at Tower Road / Industrial Place

Needham Street, Tower Road, and Industrial Place form a four-way unsignalized intersection. Needham Street runs north/south, and Tower Road and Industrial Place intersect from the west and east, respectively, but are offset from each other. All approaches to this intersection consist of single general-purpose lanes. Needham Street operates under free flow while Tower Road and Industrial Place operate under STOP control, although no stop signs are present. Sidewalks are present on all sides of the intersection, and crosswalks are present on all approaches except for the southbound approach from Needham Street. Land use around the intersection is commercial.

11: Needham Street at Jaconnet Street

Needham Street and Jaconnet Street form a three-way unsignalized intersection. Needham Street runs north/south, and Jaconnet Street intersects from the east. All approaches to this intersection consist of single general-purpose lanes. Needham Street operates under free flow while Jaconnet Street operates under STOP control, although no stop sign is present. MBTA bus route 59 has stops on either side of Needham Street just south of the intersection. Sidewalks are provided on both sides of Needham Street, and a crosswalk is provided across the westbound approach from Jaconnet Street. Land use around the intersection is commercial.

12: Needham Street at Rockland Street

Needham Street and Rockland Street form a three-way unsignalized intersection. Needham Street runs north/south, and Rockland Street intersects from the east. All approaches to this intersection consist of single general-purpose lanes while a two-way left-turn lane is provided in the center of Needham Street. Needham Street operates under free flow while Rockland Street operates under STOP control, although no stop sign is present. Sidewalks are provided on both sides of Needham Street, and a crosswalk is provided across the westbound approach from Rockland Street. Land use around the intersection is commercial.

13: Needham Street at Columbia Avenue / Avalon Driveway

Needham Street, Columbia Avenue, and a driveway form a four-way signalized intersection. Needham Street runs north/south, and Columbia Avenue and the

driveway intersection from the east and west, respectively. The driveway provides access to the Avalon at Newton Highlands residential development. The northbound and southbound approaches from Needham Street consist of a left-turn lane and a shared through/right-turn lane. The eastbound approach from Columbia Avenue consists of a shared left-turn/through lane and a right-turn lane. The westbound approach from the driveway consists of a single general-purpose lane. MBTA bus route 59 has stops on either side of Needham Street just south of the intersection. Sidewalks are provided on all sides of the intersection, and a crosswalk is provided across each side of the intersection except the northbound approach from Needham Street. Land use around the intersection is commercial.

14: Winchester Street at Needham Street / Dedham Street

Needham Street, Dedham Street, and Winchester Street intersect to form a four-way signalized intersection. Winchester Street runs north/south, Dedham Street intersects from the east, and Needham Street intersects from the west due to a bend on the approach to Winchester Street. The northbound approach from Winchester Street and westbound approach from Dedham Street consist of a single general-purpose lane. The southbound approach from Winchester Street consists of a shared left-turn/through lane and a channelized right-turn lane under YIELD control. The eastbound approach from Needham Street consists of an exclusive left-turn lane, a shared left-turn/through lane, and an exclusive right-turn lane (onto Winchester Street). MBTA bus route 52 has stops on either side of Winchester Street just south of the intersection. Sidewalks are provided on all sides of the intersection, and a crosswalk is provided across each approach to the intersection except the westbound approach from Needham Street. Land use around the intersection is a mixture of commercial and residential.

15: Winchester Street at Route 9 Eastbound Service Road

Winchester Street and the Route 9 Eastbound Service Road form a three-way unsignalized intersection. Winchester Street runs north/south, and the service road intersects from the east. All approaches to this intersection consist of single general-purpose lanes, although the roadways are very wide and sometimes vehicles waiting to turn create separate queueing lanes. Winchester Street operates under free flow while the service road operates under STOP control. Sidewalks are provided on both sides of Winchester Street and on the south side of the service road, and a crosswalk is provided across the westbound approach from the service road. Land use around the intersection is residential.

16: Winchester Street at Route 9 Westbound Service Road

Winchester Street and the Route 9 Westbound Service Road form a four-way unsignalized intersection. Winchester Street runs north/south, and the service road intersects from the east and west. The westbound service road is one-way approaching the intersection while the eastbound service road is two-way between Floral Street and Winchester Street only, allowing exiting vehicles from Floral Street

to access Winchester Street. The southbound Winchester Street and eastbound service road approaches to the intersection consist of single general-purpose lanes while the northbound Winchester Street approach consists of a left-turn lane and a through lane and the westbound service road approach consists of a shared left-through lane and an exclusive right-turn lane. Winchester Street operates under free flow while the service road operates under STOP control. Sidewalks are provided along both sides of Winchester Street and the north side of the service road west of the intersection. Crosswalks are provided across the eastbound and westbound approaches from the service road. Land use around the intersection is residential.

17: Centre Street at Walnut Street

Centre Street and Walnut street form a four-way signalized intersection. Centre Street runs northeast/southwest, and Walnut Street intersects from the northwest and southeast. The northeastbound approach from Centre Street and the southeastbound approach from Walnut Street consist of a left-turn lane and shared through/right-turn lane. The northwestbound approach from Walnut Street and the southwestbound approach from Centre Street consist of single general-purpose lanes. MBTA bus route 52 has stops on Centre Street on the northern and southern corners of the intersection. Sidewalks and crosswalks are provided on all sides of this intersection. Land use around the intersection is residential and commercial.

18: Nahanton Street at Winchester Street

Winchester Street and Nahanton Street form a three-way signalized intersection. Nahanton Street runs east/west, and Winchester intersects from the north. The eastbound approach from Nahanton Street consists of a left-turn lane and a through lane. The westbound approach from Nahanton Street consists of a single general-purpose lane. The southbound approach from Winchester Street consists of a left-turn lane and a right-turn lane. Sidewalks are provided along both sides of Winchester Street. A faded crosswalk is provided across the Winchester Street southbound approach. Land use at this intersection a mixture of agriculture and undeveloped land.

19: Nahanton Street at Wells Avenue / JCC Driveway

Nahanton Street, Wells Avenue, and a driveway form a four-way signalized intersection. Nahanton Street runs east/west, and Wells Avenue and the driveway intersect from the south and north, respectively. The driveway provides access to the Jewish Community Center complex and Wells Avenue provides access to the Wells Business Park. The eastbound approach from Nahanton Street consists of a left-turn lane, a through lane, and a right-turn lane. The westbound approach from Nahanton Street and southbound approach from the driveway consist of a left-turn lane and a shared through/right-turn lane. The northbound approach from Wells Avenue consists of a shared left-turn/through lane and a channelized right-turn lane under YIELD control. Sidewalks are provided along both sides of Wells Avenue, the east side of the driveway, and the south side of Nahanton Street west of the intersection.

No crosswalks are provided at this intersection. Land use at this intersection is mainly commercial and institutional.

20: Highland Avenue at Riverside Street

Highland Avenue and Riverside Street form a three-way unsignalized intersection. Highland Avenue runs northeast/southwest, and Riverside Street intersects from the southeast. Each approach to this intersection consists of a single general-purpose lane. Highland Avenue operates under free flow and Riverside Street operates under STOP control, although no stop sign is present. Sidewalks are provided on all sides of the intersection and no crosswalks are provided. Land use around the intersection is mainly commercial and residential.

21: Highland Avenue at Highland Terrace / Highland Circle

Highland Avenue, Highland Terrace, and Highland Circle form a four-way unsignalized intersection. Highland Avenue runs northeast/southwest, and Highland Terrace and Highland Circle intersect from the southeast and northwest, respectively. Each approach to this intersection consists of a single general-purpose lane. Highland Avenue operates under free flow and Highland Terrace and Highland Circle operate under STOP control, although no stop signs are present. Sidewalks are provided on both sides Highland Avenue and Highland Terrace and a crosswalk is provided across the northwestbound approach from Highland Terrace. Land use around the intersection is mainly commercial and residential.

22: Highland Avenue at 2nd Avenue / Staples Driveway

Highland Avenue, 2nd Avenue, and a driveway form a signalized four-way intersection. Highland Avenue runs east/west, and 2nd Avenue and the driveway intersection from the south and north, respectively. The driveway provides access to Staples and Petco. The eastbound and westbound approaches from Highland Avenue consist of a shared through/left-turn lane and a shared through/right-turn lane. The northbound approach from 2nd Avenue consists of a left-turn lane, a shared through/left-turn lane, and a right turn lane. The southbound approach from the driveway consists of a shared left-turn/through lane and a right-turn lane. Sidewalks are provided on both sides of Highland Avenue and the east side of 2nd Avenue, and crosswalks are provided on all approaches except the eastbound approach from Highland Avenue. Land use in the area is mainly commercial.

23: Highland Avenue at Charles Street

Highland Avenue and Charles Street form a three-way unsignalized intersection. Highland Avenue runs east/west, and Charles Street intersects from the north. The eastbound approach from Highland Avenue consists of a shared left-turn/through lane and a through lane. The westbound approach from Highland Avenue consists of a through lane and a shared through/right-turn lane. The southbound approach from Charles Street consists of a single general-purpose lane. Highland Avenue

operates under free flow and Charles Street operates under STOP control, although no stop sign is present. Sidewalks are provided on both sides of Highland Avenue and no crosswalks are provided. Land use around the intersection is commercial.

24: Highland Avenue at Wexford Street

Highland Avenue and Wexford Street form a three-way unsignalized intersection. intersection. Highland Avenue runs east/west, and Wexford Street intersects from the north. The eastbound approach from Highland Avenue consists of a shared left-turn/through lane and a through lane. The westbound approach from Highland Avenue consists of a through lane and a shared through/right-turn lane. The southbound approach from Wexford Street consists of a single general-purpose lane. Highland Avenue operates under free flow and Wexford Street operates under STOP control, although no stop sign is present. Sidewalks are provided on all sides of the intersection and no crosswalks are present. Land use around the intersection is commercial.

25: Highland Avenue at 1st Avenue / Riverside Community Care Driveway

Highland Avenue, 1st Avenue, and a driveway form a four-way unsignalized intersection. Highland Avenue runs east/west, and 1st Avenue and the driveway intersect from the south and north respectively. The driveway provides access to a small parking lot for Riverside Community Care. The eastbound and westbound approaches from Highland Avenue consist of a through lane and shared through/right-turn lane. The northbound and southbound approaches, from 1st Avenue and the driveway respectively, consist of a single general-purpose lane. The northbound and southbound approaches are right-in/right-out and movements across Highland Avenue are restricted. Highland Avenue operates under free flow while the driveway and 1st Avenue operate under STOP control, although no stop sign is present at the driveway. Sidewalks are provided on both sides of Highland Avenue and 1st Avenue, and a crosswalk is provided across the westbound approach on Highland Avenue. Land use in the area is mainly commercial.

It should be noted that the intersection of Highland Avenue at 1st Avenue / Riverside Community Care Driveway was recently reconstructed as a signalized intersection to allow left-turns out of 1st Avenue. However, the existing traffic counts were conducted in 2017 before construction was completed.

26: Highland Avenue at I-95 Northbound Ramps

The interchange ramps for I-95 Northbound intersect with Highland Avenue, forming a four-way unsignalized intersection. Highland Avenue runs east/west, and the I-95 Northbound on/off ramps intersect from the north and south. The northbound and southbound approaches are right-in/right-out and movements across Highland Avenue are restricted. The eastbound approach from Highland Avenue consists of two through lanes and a right-turn lane operating under free flow. The westbound approach from Highland Avenue consists of a through lane and a shared through/right-turn lane operating under free flow. The northbound

and southbound approaches from I-95 both consist of right turn lanes operating under YIELD control. Sidewalks are provided along both sides of Highland Avenue and crosswalks are provided across the northbound and southbound approaches. Land use around the interchange is commercial.

It should be noted that a reconstruction of the interchange was recently completed, as of January 2018. The project included reconstruction of the ramps and of the Highland Avenue bridge over I-95 as well as a new interchange at Kendrick Street approximately three-fourths of a mile south of Highland Avenue as part of the I-95 add-a-lane project.

27: Highland Avenue at I-95 Southbound Ramps
The interchange ramps for Route I-95 Southbound intersect with Highland Avenue, forming a four-way unsignalized intersection. Highland Avenue runs east/west, and the I-95 Southbound on/off ramps intersect from the north and south. The northbound and southbound approaches are right-in/right-out and movements across Highland Avenue are restricted. The westbound approach from Highland Avenue consists of two through lanes and a right-turn lane operating under free flow. The eastbound approach from Highland Avenue consists of a through lane and a shared through/right-turn lane operating under free flow. The northbound and southbound approaches from I-95 both consist of right turn lanes operating under YIELD control. Sidewalks are provided along both sides of Highland Avenue and crosswalks are provided across the northbound and southbound approaches. Land use around the interchange is commercial.

It should be noted that a reconstruction of the interchange was recently completed, as of January 2018. The project included reconstruction of the ramps and of the Highland Avenue bridge over I-95 as well as a new interchange at Kendrick Street approximately three-fourths of a mile south of Highland Avenue as part of the I-95 add-a-lane project.

Traffic Volumes

Traffic volumes for a portion of the study area roadways and intersections were collected by Stantec in April-May 2017 for the Functional Design Report (FDR) of the reconstruction of Highland Avenue and Needham Street. These counts were used by VHB to provide consistency in the existing conditions analysis between the Needham Street FDR and this traffic study. Traffic volumes at additional intersections not included in Needham Street FDR were collected by VHB in October 2017. This time of year was specifically chosen to capture conditions in Newton when schools were in operation and typical commuter traffic was present on the study area roadways as well as after the Elliot Street bridge over the Charles River was reopened to traffic. In addition, traffic volumes at the I-95 on/off ramps at Highland Avenue were conducted in January-February 2018, after reconstruction was mostly completed of the I-95 ramps and the Highland Avenue bridge over I-95.

Peak-period turning movement and classification (TMC) counts were collected at the study area intersections on a typical weekday from 7:00 PM to 9:00 AM and 4:00 PM to 6:00 PM, and on a typical Saturday from 11:00 AM to 2:00 PM. These time periods were selected so that the combined peak periods for the roadway and Project Site activity would be evaluated. Based on the TMCs, the weekday morning peak period generally occurs from 8:00 AM to 9:00 AM, the weekday evening peak period generally occurs from 4:30 PM to 5:30 PM, and the Saturday midday peak period occurs from 12:15 PM to 1:15 PM.

In addition, automatic traffic (ATR) counts were conducted for a continuous 48-hour period over two typical weekdays. These counts were conducted on Highland Avenue, Needham Street, and Winchester Street in April-May 2017 for the Needham Street FDR, and on Oak Street in October 2017. In addition, a continuous 24-hour ATR was conducted on Needham Street on a typical Saturday in October 2017. The observed traffic volumes are summarized in Table 1 and adjusted to reflect 2018 conditions. All traffic count data is included in Appendix A.

Table 1 Observed Traffic Volumes

Location	Weekday Daily [a] Vol.	Weekday Morning Peak Hour Vol. [b]	K Factor [c]	Dir. Dist. [d]	Weekday Evening Peak Hour Vol.	K Factor	Dir. Dist.	Saturday Daily Vol.	Saturday Midday Peak Hour Vol.	K Factor	Dir. Dist.
Needham Street -				NB			NB				NB
North of Oak Street	20,500	1,365	6.7%	54%	1,425	7.0%	55%	19,600	1,690	8.6%	51%
Winchester Street -				NB			NB				
North of Needham Street	25,700	2,065	8.0%	56%	1,955	7.6%	53%		*n/a*		
Highland Avenue -				EB			WB				
West of 2nd Avenue	28,000	1,855	6.6%	50%	2,075	7.4%	75%		*n/a*		
Oak Street -				WB			EB				
West of Needham Street	9,600	780	8.1%	54%	800	8.3%	54%		*n/a*		

Source: VHB/Stantec; Based on automatic traffic recorder (ATR) counts conducted in April-May 2017 and October 2017.

a Average Daily Traffic (ADT) volume, expressed in vehicles per day

b Peak period traffic volumes expressed in vehicles per hour

c Represents the percent daily traffic which occurs during the peak hour

d Directional distribution of peak hour traffic

Note: Peak hours do not necessarily coincide with the peak hours of turning movement counts.

As shown in Table 1, Needham Street north of Oak Street carries approximately 20,500 vehicles on a typical weekday with the peak hours accounting for 6.7 percent (morning peak hour) and 7.0 percent (evening peak hour) of the weekday daily traffic flow. On a typical Saturday, Needham Street north of Oak Street carries approximately 19,600 vehicles with the midday peak hour accounting for 8.6 percent of the Saturday daily traffic flow. Traffic flow along Needham Street is heavier in the northbound direction during all peak periods.

Winchester Street north of Needham Street carries approximately 25,700 vehicles on a typical weekday with the peak hours accounting for 8.0 percent (morning peak hour) and 7.6 percent (evening peak hour) of the weekday daily traffic flow. Traffic flow along Winchester Street is heavier in the northbound direction during both peak periods.

Highland Avenue west of 2nd Avenue carries approximately 28,000 vehicles on a typical weekday with the peak hours accounting for 6.6 percent (morning peak hour) and 7.4 percent (evening peak hour) of the weekday daily traffic flow. Traffic flow along Highland Avenue is evenly distributed between the eastbound and westbound directions during the weekday morning peak hour and is heavier in the westbound direction during the weekday evening peak hour.

Oak Street west of Needham Street carries approximately 9,600 vehicles on a typical weekday with the peak hours accounting for 8.1 percent (morning peak hour) and 8.3 percent (evening peak hour) of the weekday daily traffic flow. Traffic flow along Oak Street is heavier in the westbound direction during the weekday morning peak hour and heavier in the eastbound direction during the weekday evening peak hour. It should be noted that the ATR along Oak Street was collected closer to Needham Street than Chestnut Street, on the portion of the roadway that runs in an east-west orientation.

Seasonal Adjustment

The traffic data collected for the study area was obtained during the months of January, February, April, May, and October. To quantify the seasonal variation of traffic volumes in the area, historic traffic data available from MassDOT were reviewed. Specifically, 2017 monthly traffic volumes were reviewed at MassDOT permanent counting stations along I-90 and I-95 in Newton, Needham, and Wellesley. Multiple count stations on I-90 and I-95 were reviewed in order to get an accurate representation of seasonal traffic volumes in the region. Based on the review, traffic volumes in April, May, and October are slightly higher than average month conditions while traffic volumes in January and February are slightly lower than average months conditions by approximately six-percent and nine-percent, respectively. To present a conservative analysis, the April, May, and October observed traffic volumes were not adjusted while the January and February observed traffic volumes were adjusted by six-percent and nine-percent, respectively. The seasonal adjustment factors are included in Appendix A.

The 2017 counts were also adjusted to represent 2018 Existing conditions based on a historical growth rate described in detail later in this report. The resulting 2018 Existing Conditions weekday morning, weekday evening, and Saturday midday peak hour traffic volumes are shown in Figures 3, 4 and 5, respectively.

Ⓢ Signalized Intersection

neg = Negligible

Inset 1 Highland Avenue - Needham

Inset 2 Nahanton Street

Site

Not to Scale

2018 Existing Conditions
Weekday Morning Peak Hour Traffic Volumes
The Northland Newton Development
Newton, Massachusetts

Figure 3

Ⓢ Signalized Intersection

neg = Negligible

Inset 1 Highland Avenue - Needham

Inset 2 Nahanton Street

Site

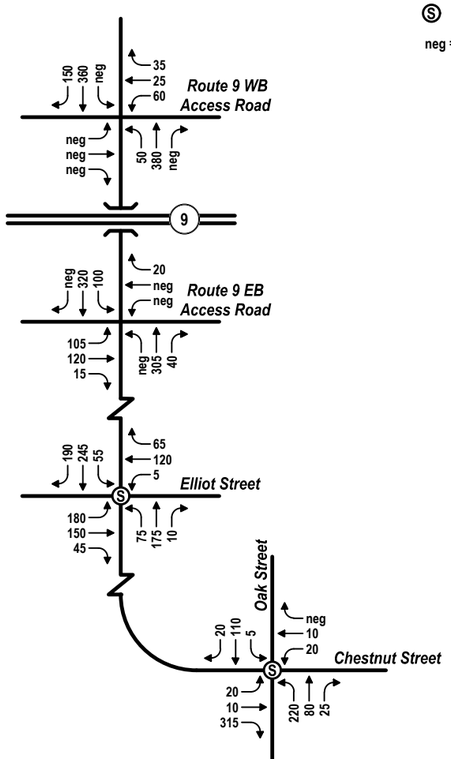
Not to Scale

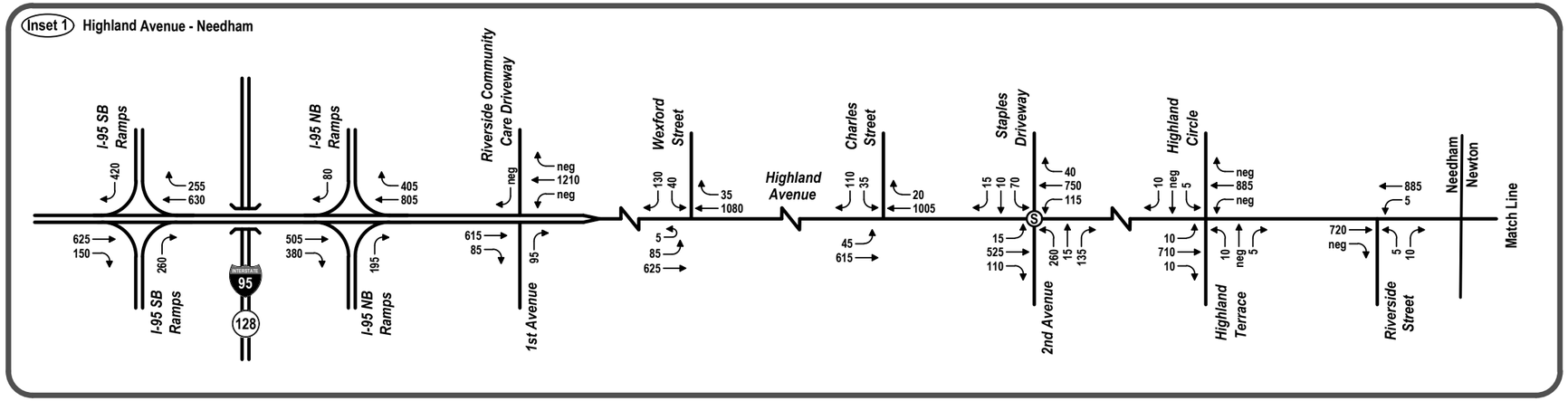
2018 Existing Conditions
Weekday Evening Peak Hour Traffic Volumes
The Northland Newton Development
Newton, Massachusetts

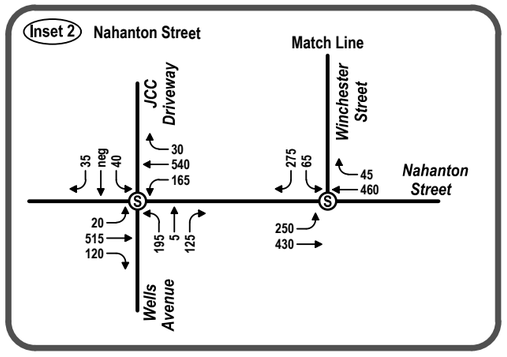
Figure 4

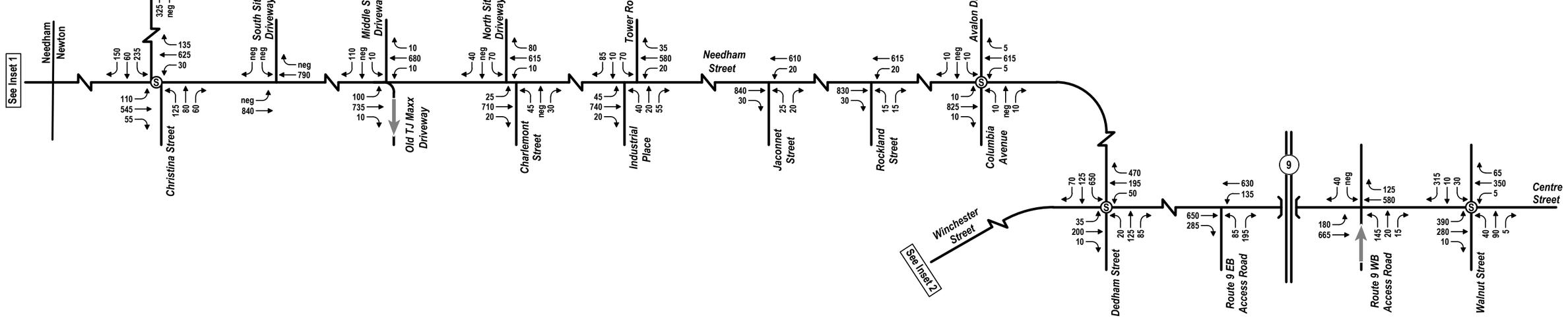
Ⓢ Signalized Intersection

neg = Negligible









Not to Scale

vhb

2018 Existing Conditions
Saturday Midday Peak Hour Traffic Volumes
The Northland Newton Development
Newton, Massachusetts

Figure 5

Pedestrian and Bicycle Facilities

Varying level of pedestrian and bicycle facilities are provided in the study area. Sidewalks are provided on both sides of all major roadways in the study area, except in the Nahanton Street area. Crosswalks are provided at all signalized intersections, except the intersection of Nahanton Street at Wells Avenue, and mid-block crossings are provided on Needham Street north of Charlemont Street and south of Industrial Place. No on-road bicycle facilities are currently provided in the study area.

Adjacent to the Site is the Upper Falls Greenway, an off-road, multi-use path. The Upper Falls Greenway parallels Needham Street and runs for approximately one-mile, from Easy Street in the northeast to the Charles River in the southwest with a spur connecting to Needham Street south of the Newton Nexus development. The Upper Falls Greenway is on the site of a former railroad bed and opened to the public in 2016. An additional multi-use path is located in Needham on land owned and operated by the Department of Conservation and Recreation (DCR). The path parallels the Charles River and runs from Highland Avenue to 4th Avenue.

In Summer 2018, the City of Newton entered into a bike-sharing agreement with Limebike, a California based bike sharing system. Limebike uses a dock-less system where bikes can be picked up and dropped off at any location in the City or in neighboring municipalities that also have contracts with Limebike. Customers use smartphones to unlock the bikes, and unlike the BlueBike bike-sharing system in neighboring Brookline and Boston, customers do not need to pick up or return bikes at designated bike-docking locations. To start off the bike-sharing program, over 250 dock-less bikes were places around the City of Newton.

As mentioned previously, The Highland Avenue / Needham Street / Winchester Street corridor redesign and construction is expected to start in late 2019/early 2020. The reconstruction of the corridor will include both pedestrian and bicycle enhancements. Some of the pedestrian accommodations will include reconstructed sidewalks, additional mid-block crossings with rectangular rapid flashing beacons (RRFBs), and leading pedestrian intervals at the signalized intersections, while the bicycle improvements will result in a continuous combination of on-road and off-road bicycle accommodations throughout the length of the entire corridor in both directions. In addition, two new cantilevered sidewalks for shared pedestrian and bicycle use will be built onto each side of the Needham Street / Highland Avenue bridge over the Charles River, providing separated spaces for pedestrian and bicycles away from vehicles on the bridge.

All proposed pedestrian and bicycle facilities by the Project will tie into the existing and proposed network to enhance multi-modal mobility in the local area. Proposed pedestrian and bicycle enhancements connected with the Project are described in detail later in this report. A link to the MassDOT project page is provided below and the MassDOT roadway design plans are included in Appendix A:

https://hwy.massdot.state.ma.us/ProjectInfo/Main.asp?ACTION=ViewProject&PROJECT_NO=606635#

Public Transportation

Public transportation in Newton and Needham is provided by the Massachusetts Bay Transportation Authority (MBTA). The proposed development is directly served by one MBTA bus route; Bus Route #59. Additional service within close proximity of the Site include the MBTA's Bus Route #52, the D Branch of the Green Line, and the Needham Line of the commuter rail. Figure 6 displays the existing public transportation services provided in the study area. Descriptions of each transit service is provided below and detailed maps and schedules can be found in Appendix A.

- Bus Route 59 travels between Watertown Square in Watertown and Needham Junction in Needham via Newton. Stops are provided directly in front of the Site on Needham Street and on Oak Street. Approximately half of the scheduled trips on Bus Route 59 travel down Needham Street serving the Site directly. The remaining scheduled trips travel down Elliot Street and Chestnut Street, with the closest stop to the Site at the intersection of Oak Street and Chestnut Street, approximately 250 feet from the Site. Bus Route 59 runs seven days a week and during peak periods has a frequency of approximately 30-40 minutes. Bus Route 59 provides connections to the D Branch of the Green Line at Newton Highlands, to the Needham Line of the commuter rail at Needham Highlands, Needham Center, and Needham Junction, and to the Worcester Line of the commuter rail at Newtonville.
- Bus Route 52 travels between Watertown Yard in Watertown and the Dedham Mall in Dedham via Newton. The nearest stop to the Site is on Winchester Street, approximately 0.5 miles east of the Site. Similar to Bus Route 59, not all of the scheduled trips travel via Winchester Street. Approximately 5-6 scheduled trips a day travel via Winchester Street and the remainder travel via Dedham Street and Parker Street, approximately one mile east of the Site. Bus Route 59 runs five days a week, Monday through Friday, and during peak periods has a frequency of approximately 30-45 minutes.
- The D branch of the Green Line connects Newton with Brookline and Boston and travels from Riverside in Newton to Government Center in Downtown Boston. The nearest stops to the Site on the D branch of the Green Line are Newton Highlands, approximately one-mile northeast of the Site on Walnut Street, and Elliot, approximately one-mile north of the Site on Route 9. Service is provided seven days a week and runs approximately every six-to-eight minutes during peak hours.
- The Needham Line of the MBTA Commuter Rail travels between Needham Heights and Back Bay Station and South Station in Boston. The nearest stop to the Site is Needham Heights, approximately 1.5-miles south of the Site on Highland Avenue. Service is provided six days a week, Monday through Saturday, and during peak periods service is provided every 30-50 minutes in peak directions.

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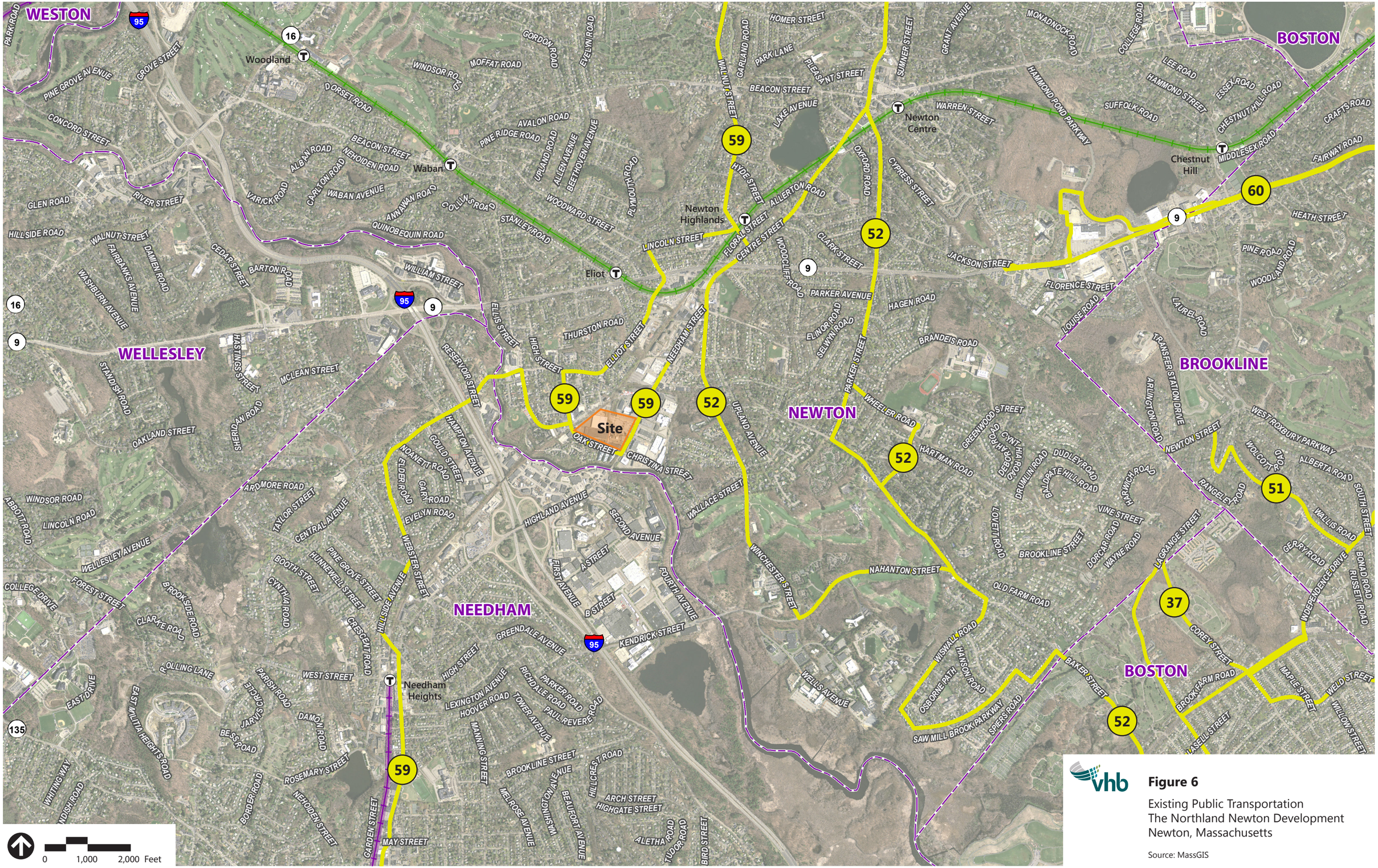

Figure 6

Existing Public Transportation
The Northland Newton Development
Newton, Massachusetts

Source: MassGIS

Private Shuttle Service

In addition to the MBTA, a private shuttle service is provided in the area by the 128 Business Council. The 128 Business Council operates the Needham Shuttle between the Newton Highlands T Station on the Green Line and different companies in and around the Needham Crossing area that are members of the 128 Business Council. The Needham Shuttle runs Monday through Friday and makes seven departures in the morning from Newton Highlands to Needham Crossing and six departures in the evening from Needham Crossing to Newton Highlands. Service is provided approximately every 25-40 minutes between 6:25 AM and 9:20 AM and approximately every 30-60 minutes between 3:40 PM and 6:40 PM. Fares are free for employees who work at member companies and are $4 per ride for non-members. The Needham Shuttle travels down Needham Street in front of the Site and the closest stop currently is at 320 Needham Street.

Crash History

A detailed crash analysis was conducted to identify potential vehicle accident trends and/or roadway deficiencies in the traffic study area. The most current vehicle accident data for the traffic study area intersections were obtained from MassDOT for the years 2011 to 2015. The MassDOT database is comprised of crash data from the Massachusetts Registry of Motor Vehicles (RMV) Division primarily for use in traffic studies and safety evaluations. Data files are provided for an entire city or town for an entire year, though it is possible that some crash records may be omitted either due to individual crashes not being reported, or the city crash records not being provided in a compatible format for RMV use. A summary of the study intersections vehicle accident history based on the available RMV data is presented in Table 2 and the detailed crash data is provided in Appendix A.

Crash rates are calculated based on the number of accidents at an intersection and the volume of traffic traveling through that intersection on a daily basis. Rates that exceed MassDOT's average for accidents at intersections in the MassDOT district in which the town or city is located could indicate safety or geometric issues for a particular intersection. For our study area, the calculated crash rates were compared to MassDOT's District 6 average, as Newton and Needham are located in District 6. In District 6, the average crash rate is 0.70 for signalized intersections and 0.53 for unsignalized intersections. These rates imply that, on average, 0.70 accidents occurred per million vehicles entering signalized intersections throughout District 6 and 0.53 accidents occurred per million vehicles entering unsignalized intersections in District 6. It should be noted that the location for some accidents cannot be precisely determined from the database. These locations typically involve interchange intersections. Additionally, some accidents may have occurred but were either not reported or not included in the database, and therefore not considered.

Table 2 Vehicular Crash Summary (2011-2015)

	1: Chestnut Street at Route 9 WB Service Road	2: Chestnut Street at Route 9 EB Service Road	3: Chestnut Street at Elliot Street	4: Chestnut Street at Oak Street	5: Oak Street at Site Driveway	6: Needham Street at Oak Street / Christina Street	7: Needham Street at South Site Driveway	8: Needham Street at TJ Maxx Driveway / Middle Site Driveway	9: Needham Street at Charlemont Street / North Site Driveway
Signalized?	No	No	Yes	Yes	No	Yes	No	No	No
MassDOT Average Crash Rate	0.52	0.52	0.71	0.71	0.52	0.71	0.52	0.52	0.52
Calculated Crash Rate	0.16	0.11	0.70	0.86	0.06	0.79	0.19	0.51	1.15
Exceeds Average?	No	No	No	Yes	No	Yes	No	No	Yes
Year									
2011	0	0	6	2	0	10	0	0	9
2012	0	0	4	4	0	5	1	6	5
2013	2	2	7	1	0	8	1	4	8
2014	1	1	4	4	0	6	2	3	6
2015	2	0	2	4	1	7	2	2	7
Total	**5**	**3**	**23**	**15**	**1**	**36**	**6**	**15**	**35**
Collision Type									
Angle	2	1	13	1	0	9	2	5	17
Head-on	0	0	1	0	0	1	1	0	1
Rear-end	0	1	2	0	0	12	1	1	8
Rear-to-rear	0	0	0	1	0	0	1	2	1
Sideswipe, opposite direction	0	0	1	1	0	2	0	1	0
Sideswipe, same direction	0	0	3	3	0	7	0	4	1
Single Vehicle Crash	3	1	1	4	0	5	0	1	5
Not reported	0	0	2	5	1	0	1	1	2
Severity									
Fatal Injury	0	0	0	0	0	0	0	0	0
Non-Fatal Injury	0	1	10	1	0	11	2	1	8
Property Damage Only	4	2	10	6	1	24	2	12	23
Not Reported	1	0	3	8	0	1	2	2	4
Time of day									
Weekday ,7:00 AM - 9:00 AM	0	0	0	2	0	3	0	0	0
Weekday, 4:00 – 6:00 PM	1	0	2	3	0	7	2	3	5
Saturday 11:00 AM – 2:00 PM	1	0	1	0	0	0	0	1	1
Weekday, other time	1	3	16	9	1	20	4	7	24
Weekend, other time	2	0	4	1	0	6	0	4	5
Pavement Conditions									
Dry	1	3	16	8	0	27	6	14	28
Wet	1	0	3	3	1	9	0	1	7
Snow	0	0	3	1	0	0	0	0	0
Ice	3	0	0	0	0	0	0	0	0
Slush	0	0	0	1	0	0	0	0	0
Not reported	0	0	1	2	0	0	0	0	0
Non-Motorist (Bike, Pedestrian)	0	1	1	0	0	5	0	0	4

Source: Crash data was obtained from MassDOT Crash Portal, accessed in November 2017.

Table 2 Vehicular Crash Summary (2011-2015) (Continued)

	10: Needham Street at Tower Road / Industrial Place	11: Needham Street at Jaconnet Street	12: Needham Street at Rockland Street	13: Needham Street at Columbia Avenue	14: Winchester Street at Dedham Street / Needham Street	15: Winchester Street at Route 9 EB Ramps	16: Winchester Street at Route 9 WB Ramps	17: Centre Street at Walnut Street	18: Nahanton Street at Wells Avenue / Winchester Street
Signalized?	No	No	No	Yes	Yes	No	No	Yes	Yes
MassDOT Average Crash Rate	0.52	0.52	0.52	0.71	0.71	0.52	0.52	0.71	0.71
Calculated Crash Rate	0.70	0.32	0.65	1.18	0.97	0.41	0.19	1.04	0.43
Exceeds Average?	Yes	No	Yes	Yes	Yes	No	No	Yes	No
Year									
2011	9	3	3	6	7	3	1	6	4
2012	4	0	2	4	5	1	1	3	2
2013	3	2	3	7	7	5	3	11	6
2014	2	3	5	12	12	7	0	7	4
2015	5	1	5	4	8	3	3	13	4
Total	**23**	**9**	**18**	**33**	**39**	**19**	**8**	**40**	**20**
Collision Type									
Angle	8	1	8	8	11	11	4	8	9
Head-on	1	0	3	0	0	0	0	1	2
Rear-end	7	3	5	11	12	3	3	10	7
Rear-to-rear	1	0	0	2	2	0	0	0	0
Sideswipe, opposite direction	0	0	0	1	1	1	0	2	0
Sideswipe, same direction	2	1	1	4	5	1	0	10	0
Single Vehicle Crash	2	4	0	6	6	1	1	8	0
Not reported	2	0	1	1	2	2	0	1	2
Severity									
Fatal Injury	0	0	0	0	0	0	0	0	0
Non-Fatal Injury	3	3	8	13	9	6	3	9	9
Property Damage Only	18	5	8	16	26	12	5	25	9
Not Reported	2	1	2	4	4	1	0	6	2
Time of day									
Weekday ,7:00 AM - 9:00 AM	0	1	1	3	1	5	2	2	5
Weekday, 4:00 – 6:00 PM	2	0	3	6	6	3	1	6	3
Saturday 11:00 AM – 2:00 PM	1	0	0	1	1	0	1	2	0
Weekday, other time	16	8	12	21	24	11	3	21	10
Weekend, other time	4	1	2	2	7	0	1	9	2
Pavement Conditions									
Dry	16	7	15	22	31	15	6	31	12
Wet	5	2	2	9	3	1	2	5	6
Snow	0	0	0	1	2	0	0	1	0
Ice	0	0	0	0	2	0	0	0	0
Slush	0	0	0	0	0	0	0	0	0
Not reported	2	0	1	1	1	3	0	3	2
Non-Motorist (Bike, Pedestrian)	1	1	1	4	3	3	1	2	2

Source: Crash data was obtained from MassDOT Crash Portal, accessed in October 2017.

Table 2 Vehicular Crash Summary (2011-2015)

	19: Nahanton Street at Winchester Street	20: Highland Avenue at Riverside Street	21: Highland Avenue at Highland Terrace / Highland Circle	22: Highland Avenue at 2nd Avenue	23: Highland Avenue at Charles Street	24: Highland Avenue at Wexford Street	25: Highland Street at 1st Avenue	26: Highland Avenue at I-95 NB Ramps [a]	27: Highland Avenue at I-95 SB Ramps [a]
Signalized?	Yes	No	No	Yes	No	No	No	No	No
MassDOT Average Crash Rate	0.71	0.52	0.52	0.71	0.52	0.52	0.52	0.52	0.52
Calculated Crash Rate	0.49	0.58	0.45	0.51	0.24	0.74	0.64	0.53	0.13
Exceeds Average?	No	Yes	No	No	No	Yes	Yes	Yes	No
Year									
2011	2	6	2	5	0	8	7	6	1
2012	4	2	0	7	3	8	4	8	2
2013	5	4	2	8	2	6	8	5	3
2014	5	4	5	1	2	6	11	3	2
2015	1	3	6	5	4	9	4	10	0
Total	**17**	**19**	**15**	**26**	**11**	**37**	**34**	**32**	**8**
Collision Type									
Angle	6	5	8	5	5	17	10	1	0
Head-on	2	0	1	1	0	1	2	0	0
Rear-end	1	10	5	7	3	12	12	28	7
Rear-to-rear	0	0	0	0	1	0	0	0	0
Sideswipe, opposite direction	1	2	1	1	0	0	0	0	0
Sideswipe, same direction	1	0	0	10	0	6	8	0	1
Single Vehicle Crash	6	2	0	1	2	1	2	1	0
Not reported	0	0	0	1	0	0	0	2	0
Severity									
Fatal Injury	0	0	0	0	0	0	0	0	0
Non-Fatal Injury	8	2	3	3	3	5	9	10	4
Property Damage Only	7	17	11	21	7	32	28	21	4
Not Reported	2	0	1	2	1	0	0	1	0
Time of day									
Weekday ,7:00 AM - 9:00 AM	5	1	0	3	1	2	4	9	0
Weekday, 4:00 – 6:00 PM	1	2	2	1	1	9	5	4	0
Saturday 11:00 AM – 2:00 PM	1	2	0	0	0	1	0	2	0
Weekday, other time	8	12	12	18	8	23	24	12	6
Weekend, other time	2	2	1	4	1	2	1	5	2
Pavement Conditions									
Dry	9	13	10	18	11	32	27	28	7
Wet	5	5	3	6	0	4	6	3	1
Snow	1	1	1	1	0	0	1	0	0
Ice	0	0	1	0	0	0	0	0	0
Slush	2	0	0	0	0	0	0	0	0
Not reported	0	0	0	1	0	1	0	1	0
Non-Motorist (Bike, Pedestrian)	1	0	1	1	0	0	1	0	0

Source: Crash data was obtained from MassDOT Crash Portal, accessed in November 2017.
a Intersection reconstructed in 2017. All crash data for intersection prior to reconstruction.

As shown in Table 2, review of the accident data indicates that twelve of the study area intersections are above the district crash rate averages. Three of the intersections had crash rates greater than 1.00: Needham Street at Charlemont Street / North Site Driveway, Needham Street at Columbia Avenue, and Centre Street at Walnut Street. The majority of crashes throughout the study area were angle crashes and rear-end crashes occurring on dry pavement resulting in property damage only. Based on the MassDOT records, there were no fatal accidents that occurred within the study area during the five-year period studied. The intersections that saw the highest number of crashes involving pedestrians or bicycles were Needham Street at Oak Street / Christina Street, which saw five crashes involving pedestrians or bicyclists over the five-year period, and Needham Street at Charlemont Street / North Site Driveway and Needham Street at Columbia Avenue, both of which saw four crashes involving pedestrians or bicyclists over the five-year period.

Several of the study area intersections have been reconstructed in recent years or are expected to be reconstructed in future years, which will address some of the existing safety concerns listed above. The intersections of Highland Avenue at the I-95 Ramps finished construction in 2017 while other study area intersections on Highland Avenue, Needham Street, Winchester Street, and Nahanton Street are expected to be reconstructed within the next few years. However, all of the data presented above is from 2011-2015 and does not reflect these recent or future improvements.

Highway Safety Improvement Program

In addition to calculating the crash rate, study area intersections should also be reviewed in the MassDOT's Highway Safety Improvement Program (HSIP) database. An HSIP-eligible cluster is one in which the total number of "equivalent property damage only"[3] crashes in the area is within the top 5% of all clusters in that region. Being HSIP-eligible makes the location eligible for FHWA and MassDOT funds to address the identified safety issues at these locations.

As part of this effort, VHB reviewed this database and found that the following intersections are listed under the following HSIP-eligible clusters:

2013-2015 HSIP Cluster:

- Needham Street at Oak Street / Christina Street
- Centre Street at Walnut Street
- Highland Avenue at Wexford Street

[3] Equivalent property damage only" is a method of combining the number of crashes with the severity of the crashes based on a weighted scale. Crashes involving property damage only are reported at a minimal level of importance, while collisions involving personal injury (or fatalities) are weighted more heavily.

- Highland Avenue at 1st Avenue
- Highland Avenue at I-95 Northbound Ramps
- Highland Avenue at I-95 Southbound Ramps

It should be noted that all of these HSIP-eligible locations, except for the intersection of Centre Street at Walnut Street, have either recently been reconstructed or will be reconstructed in the near future. The reconstruction projects at these intersections are intended to improve safety for drivers, pedestrians, and bicyclists. The HSIP-eligible ranking is based on the most recent three years of crash data (2013-2015) and therefore do not include any of the intersection improvements. Each of the construction projects are described in detail later in this report.

A road safety audit (RSA) was conducted in March 2014 at the intersections of Highland Avenue at 1st Avenue and Wexford Street and Needham Street at Oak Street / Christina Street. The RSA highlighted current safety deficiencies and identified potential safety improvements at the intersections. As noted above, the intersections included in the RSA have either recently been constructed or will be reconstructed in the near future. The improvements proposed along the corridor will help to address the safety deficiencies identified in the RSA.

Northland is committed to funding an RSA at the intersection of Centre Street and Walnut Street, which is the only HSIP-eligible location that is not expected to be reconstructed in the next few years. The results of the RSA would provide the City of Newton with a list of potential recommendations to improve safety conditions at the intersection. It is expected that the RSA would be conducted prior to Project completing state review.

3

Future Conditions

Traffic volumes in the study area were projected to a seven-year traffic-planning horizon. Independent of the Project, volumes on the roadway network under the future No-Build conditions were assumed to include existing traffic and new traffic resulting from background traffic growth. Under the Build condition, Project generated traffic volumes were added to the No-Build volumes to reflect the Build conditions within the Project study area.

Background Traffic Growth

Traffic growth on area roadways is a function of the expected land development, economic activity, and changes in demographics. Several methods can be used to estimate this growth. A procedure frequently employed is to estimate an annual percentage increase and apply that increase to study area traffic volumes. An alternative procedure is to identify estimated traffic generated by planned new major developments that would be expected to impact the project study area roadways. For the purpose of this assessment, both methods were considered.

Historic Traffic Growth

Historic traffic data and previously submitted traffic studies in the vicinity of the Project Site were reviewed to determine an appropriate growth rate. Based on this research, a growth rate of 0.5-percent was determined to be appropriate for this

study. This growth rate is consistent with the Needham Street FDR, which was submitted in August 2017 and overlaps with a majority of the study area.

Site-Specific Growth

In addition to accounting for background growth, the traffic associated with other planned and/or approved developments near the Site was also considered. Based on research by VHB and discussions with the City of Newton and the Town of Needham, it was determined that there are several planned development projects within the vicinity of the study area that would need to be considered as part of the future traffic conditions, independent of the Project. The planned/approved projects are described below in detail and the traffic volumes associated with them have been included in the No-Build and Build conditions. The associated traffic volumes are included in Appendix A.

- **Newton Nexus**: The project, located at 131-181 Needham Street in Newton, involves the redevelopment of the Newton Technology Park into a mixed-use development known as Newton Nexus. The site previously contained 163,820 sf of office space and the new site will consist of 55,060 sf of office space, 66,960 sf of retail, and a 20,000 sf market. Existing and announced tenants in the new development include TJ Maxx (relocated from 260 Needham Street) Sierra Trading Post, Boston Ski and Tennis, and a Stop and Shop Neighborhood Market. The first new tenants moved into the development in Fall 2017. To present a conservative analysis, it was assumed that none of the site was occupied when the existing traffic counts were conducted in the area in May and October 2017. Therefore, all traffic expected to be generated from the project was incorporated into the future analysis. Projected traffic volumes expected to be generated by this project were obtained from the published traffic study submitted as part of the permitting process for the project.
- **49 Winchester Street:** The project involves the tenanting of a 90-student day care center at an existing office building at 49 Winchester Street in Newton. The space is currently vacant. Projected traffic volumes expected to be generated by this project were estimated based on ITE projections and added to the study area roadways based on existing travel patterns.
- **180 Wells Avenue:** The project involves the renovation and expansion of an existing office building in the Wells Avenue Office Park. The expansion will add approximately 60,565 sf to the existing office building, increasing the overall square footage from 55,775 sf to 116,340 sf. Phase I of the project involves renovating the existing space and Phase II involves the proposed expansion. As of June 2018, Phase I of the project has been completed but not yet tenanted and Phase II has yet to start construction. Projected traffic volumes expected to be generated by this project were obtained from the published traffic study submitted as part of the permitting process for the project.

- **2 Wells Avenue:** The project also involves the renovation and expansion of an existing office building in the Wells Avenue Office Park. The expansion will add approximately 66,510 sf to the existing office building, increasing the overall square footage from 68,740 sf to 135,598 sf. The project was recently completed but has not yet been occupied, as of June 2018. Projected traffic volumes expected to be generated by this project were obtained from the published traffic study submitted as part of the permitting process for the project.
- **The Kendrick:** The development, located at 275 2nd Avenue in Needham, involves the construction of 390 residential units on a former parking lot. The development is currently under construction and is expected to open in late 2018. Projected traffic volumes expected to be generated by this project were estimated based on ITE projections and added to the study area roadways based on existing travel patterns.
- **156 B Street:** The development involves the construction of a 128-room hotel within the Needham Crossing Business Park. The development will replace a vacant office building and is currently in the planning stages. Projected traffic volumes were estimated based on ITE projections and added to the study area roadways based on existing travel patterns.
- **NBC Universal Regional Headquarters:** The development, located at 189 B Street in Needham, involves the redevelopment of 171,00 sf of vacant office space. The development will become the regional headquarters for NBC Universal and will consolidate other operations in the region to this location. Projected traffic volumes expected to be generated by this project were estimated based on ITE projections and added to the study area roadways based on existing travel patterns.
- **160 Charlemont Street:** The location contains a 91,000 sf light industrial building that is currently vacant. The location is owned by an affiliate of Northland. Projected traffic volumes based on the reoccupation of the site was estimated based on ITE projections and added to the study area roadways based on existing travel patterns.
- **Former TJ Maxx Location:** Located at 260 Needham Street in Newton, this location contains a 35,100 sf retail building that formerly housed a TJ Maxx. The location is owned by an affiliate of Northland. The TJ Maxx relocated to the Newton Nexus development in Fall 2017 and the building is currently vacant. However, traffic counts in the area were conducted prior to the relocation of the TJ Maxx. Since the Existing conditions already consider the traffic associated with this site, no additional traffic was added to the No-Build condition.

Project Site Full Occupancy

In addition to external background growth, VHB considered the effect of re-tenanting the Site in its current configuration. As stated previously, the Site currently contains approximately 180,000 sf of office space in the former mill building, 62,600

sf of retail, and 257,100 sf of former manufacturing space. At the time of the traffic counts, it was estimated that the retail space was fully occupied while the office and manufacturing spaces were fully vacant. Based on discussions with the Client, it is understood that the office space could be tenanted without the Project while it is unlikely that the manufacturing space would be tenanted in the future. To be conservative, the No Build condition includes the traffic that would be generated by the tenanting of the 180,00 sf of office space inside the former mill building. Projected traffic volumes were estimated based on ITE projections and added to the study area roadways based on the anticipated Site distribution, which is discussed later in this report.

Roadway Improvements

In assessing future traffic conditions, proposed and recently completed roadway improvements within the study area were considered. Based on research by VHB and discussions with the City of Newton, there are several projects may affect traffic volumes within the seven-year horizon and were incorporated into the No-Build and Build condition traffic analyses. The proposed and recently completed roadway improvement projects are illustrated in Figure 7 and are described in detail below:

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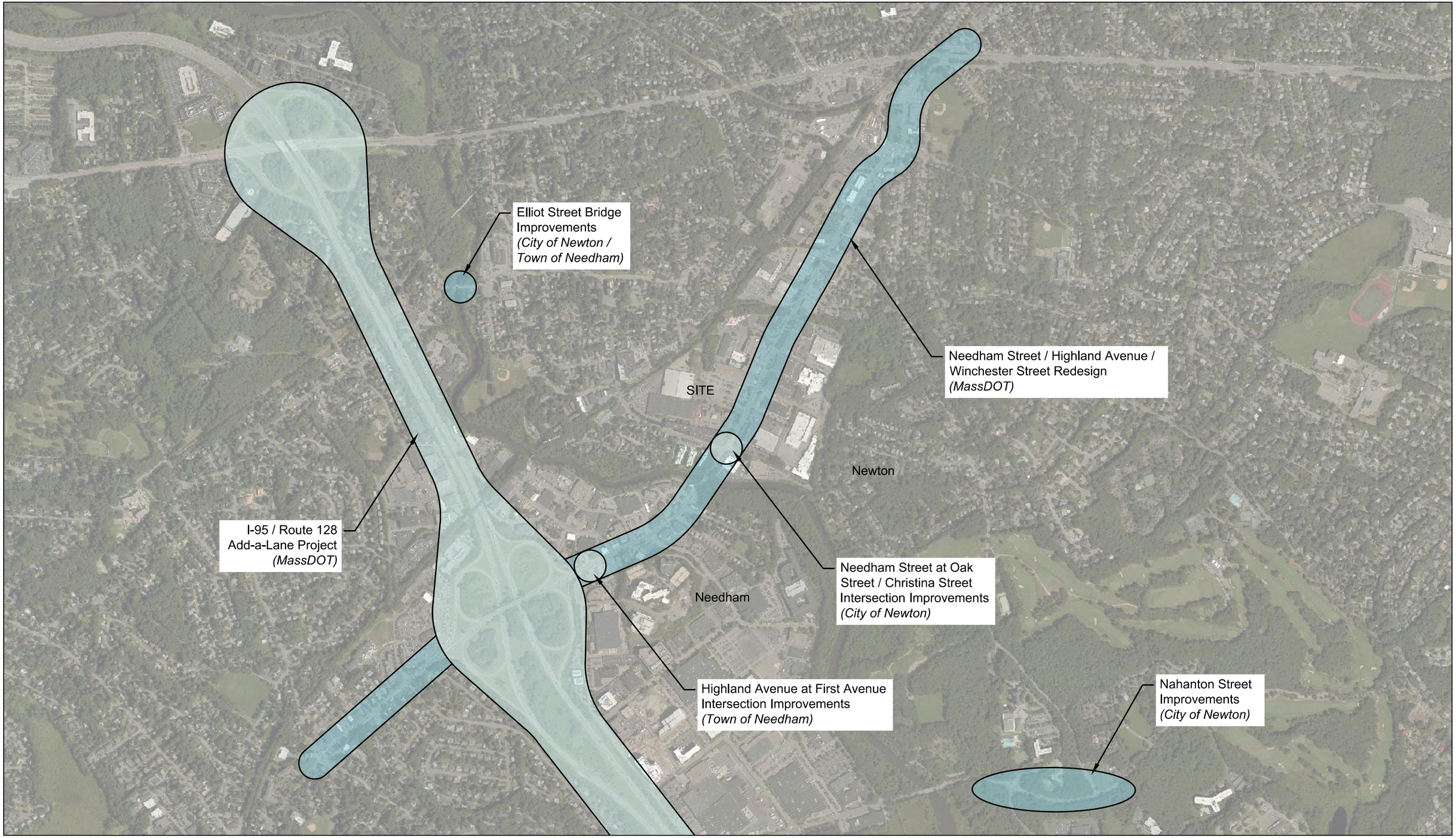

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Figure 7

Roadway Improvement Projects
The Northland Newton Development
Newton, Massachusetts

- **Needham Street / Highland Avenue / Winchester Street Redesign:** The redesign of Needham Street, Highland Avenue, and Winchester Street (MassDOT Project No. 606635) involves reconstruction of portions of these three roadways to improve traffic operations, safety, and multimodal accommodations. The project includes three different segments; Highland Avenue from Webster Street to the I-95 Southbound ramps, Highland Avenue from Wexford Street to Needham Street just west of Oak Street (including the bridge over the Charles River), and Needham Street from just east of Oak Street to Winchester Street at the Route 9 Eastbound ramps. The project will involve the following improvements:
    - New traffic signals at the intersections of Needham Street at Charlemont Street, Winchester Street at Route 9 EB Service Road, and Winchester Street at Route 9 WB Service Road
    - Realignment of Charlemont to align with site driveway. This improvement is being made possible by Northland's donation of land.
    - Updated signal timings throughout the corridor to include leading pedestrian intervals
    - Raised bike lanes / multiuse off-road paths throughout the corridor
    - Reconstructed sidewalks
    - Seven additional crosswalks; four at signalized intersections and three unsignalized with Rectangular Rapid Flashing Beacons
    - Additional left-turn lanes along Highland Avenue at unsignalized intersections
    - Construction of cantilevered shared use paths on both sides of the bridge over the Charles River to allow for two northbound travel lanes and one southbound travel lane on the bridge

  Construction is anticipated to start on the corridor in 2019 and be completed in 2022. It is anticipated that the corridor reconstruction project will be completed and fully operational prior to the completion of our Project. The proposed design plans for the roadway improvements are included in Appendix A.
- **Needham Street at Oak Street / Christina Street Improvements:** The Needham Street at Oak Street / Christina Street project (MassDOT Project No. 608137) involves shifting Christina Street south so that it more directly aligns with Oak Street. Currently Oak Street and Christina Street are offset and do not intersect Needham Street across from each other. The intersection will be reconfigured so that the through lanes better line up with each other. The proposed improvements involve replacing the traffic signal, geometric improvements including roadway widening for a 5-foot bike lane in each direction, roadway paving, signing, and striping.

  The project was initially part of the Needham Street / Highland Avenue / Winchester Street redesign described previously, but was spun off as a

separate project when the City of Newton received a Mass Works grant. The City of Newton is doing the construction for this project through the Mass Works grant and construction is expected to start in Spring 2019.

- **Highland Avenue at 1st Avenue Improvements:** The Highland Avenue at First Avenue project (MassDOT Project No. 607889) improvements include constructing additional approach turn lanes at the intersection to alleviate congestion, new pavement markings and signage, and removing the median on Highland Avenue to allow left-turns from 1st Avenue onto Highland Avenue. This will alleviate congestion at the 2nd Avenue approach to Highland Avenue by allowing a second exit point from the Needham Crossing Business Park to Highland Avenue westbound and I-95. A new traffic signal will be installed at the intersection and sidewalks and crosswalks will be reconstructed to ADA standards.

  The project was initially part of the Needham Street / Highland Avenue / Winchester Street redesign described previously but was spun off as a separate project when the Town of Needham received a Mass Works grant. Construction for this project was completed by the Town of Needham, and the project has been substantially completed and final condition operations are in effect as of September 2018.

- **I-95 / Route 128 Add-a-Lane:** The I-95 Add-a-Lane project (MassDOT Project No. 603711) is an ongoing project to provide an additional travel lane and shoulder on I-95 / Route 128 from Route 24 in Randolph to Route 9 in Wellesley. The project is currently in its sixth and final stage; reconstructing a 3.8-mile segment of I-95 from the Needham Branch railroad bridge in Needham to about 5,000 feet north of Route 9 in Wellesley. Work under this stage includes adding an additional travel lane in both directions, a new interchange at Kendrick Street and two new collector-distributor roads connecting Kendrick Street and Highland Avenue, seven new noise barriers, upgrades to the interchanges at Highland Avenue and Route 9 to improve safety and mobility to reduce traffic diversion to local roads, and several new bridges, including Highland Avenue over I-95. The project in its entirety is expected to be completed in 2019.

  Directly related to the study area, the new Highland Avenue bridge over I-95 opened in late 2017 and included reconstructed ramps, sidewalks, and bike lanes on Highland Avenue. The Kendrick Avenue interchange opened in 2016 and provided an additional point of access to I-95 in the Needham / Newton area alleviating reliance on the existing Highland Avenue interchange.

- **Nahanton Street Improvements:** The City of Newton is currently reviewing concept level proposals for improvements to the Nahanton Street corridor, including the intersections of Nahanton Street at Wells Avenue and Nahanton Street at Winchester Street. The intersection of Nahanton Street at Wells Avenue is expected to see upgraded traffic signal equipment, enhanced pedestrian and accessibility accommodations, and roadway geometry improvements, and the intersection of Nahanton Street at

Winchester Street is expected to have at a minimum signal timing and coordination changes. However, at this time all improvements are still in the planning stages and no final design has been proposed or determined. Therefore, this project has been included for reference purposes only and no enhancements were included in the No-Build or Build conditions.

- **Elliot Street Bridge Improvements:** The Elliot Street / Central Avenue bridge was recently reconstructed over the Charles River. The reconstruction occurred between early 2016 and June 2017 and the bridge was closed to traffic for approximately six months in 2016. While some traffic counts were conducted in the study area along Needham Street and Highland Avenue in April 2017, the bridge was opened to traffic at that point and it is not expected to have had an impact on traffic conditions at the time of the counts.

Needham Street Area Vision Plan

The Needham Street Area Vision Plan[4] has recently been adopted by the City Council as an Amendment to the Comprehensive plan to act as a guideline for future development along the Needham Street corridor. The Vision Plan is being created by a board of community engagement members that includes local residents, City Councilors, representatives of local organizations, and a representative for Northland. The document provides a specific vision for the future of the Needham Street corridor, which is as stated:

The Needham Street area will be a prosperous mixed-use district that emulates many of the positive aspects of Newton's villages. The area will be designed for all ages and connected to transportation options. The Needham Street area will continue to reflect its industrial history and current commercial strength while adding diverse residential options and modern innovation industries. It will also be supported by a mix of cultural and recreational opportunities. Future growth will incorporate environmentally sustainable technologies and design.

To reach that overall vision, the plan sets out a variety of guidelines to help shape development along the corridor. Some of the guidelines for future development and improvements include; additional open space, greater connectivity to trails in the area, improved safety, expand and enhance transit connections, manage transportation demand in new developments, support a variety of land uses including residential and small businesses, encourage human-scale building design and high-quality architecture, and several other specific visions. The vision plan has been adopted as an amendment to the City of Newton Comprehensive Plan and will be a basis for future decision making by the City of Newton.

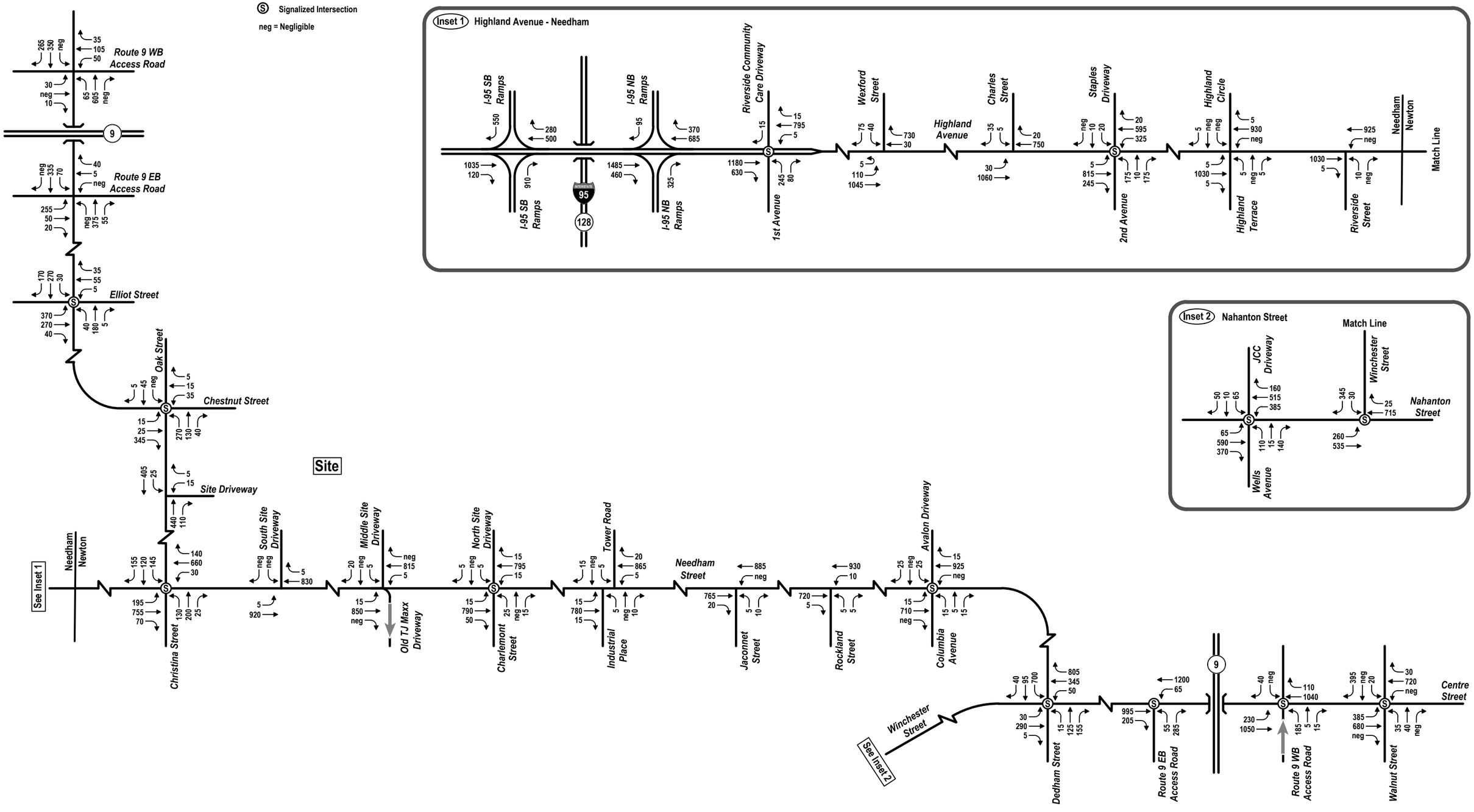
[4] Needham Street Area Vision Plan 2018, Adopted 8.13.2018.

No-Build Traffic Volumes

The 2025 No-Build traffic volumes were developed using a growth rate of 0.5-percent per year and adding in the background projects and roadway improvement projects described above. The resulting 2025 No-Build weekday morning, weekday evening, and Saturday midday peak hour traffic volume networks are shown in Figures 8-10, respectively.

Ⓢ Signalized Intersection

neg = Negligible



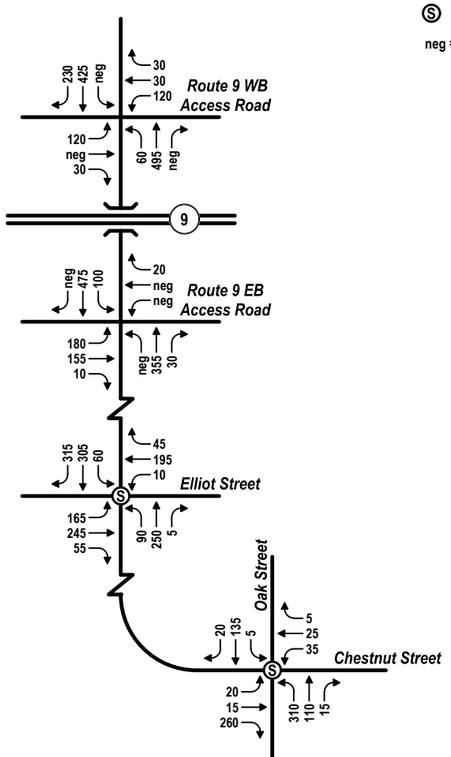
Not to Scale

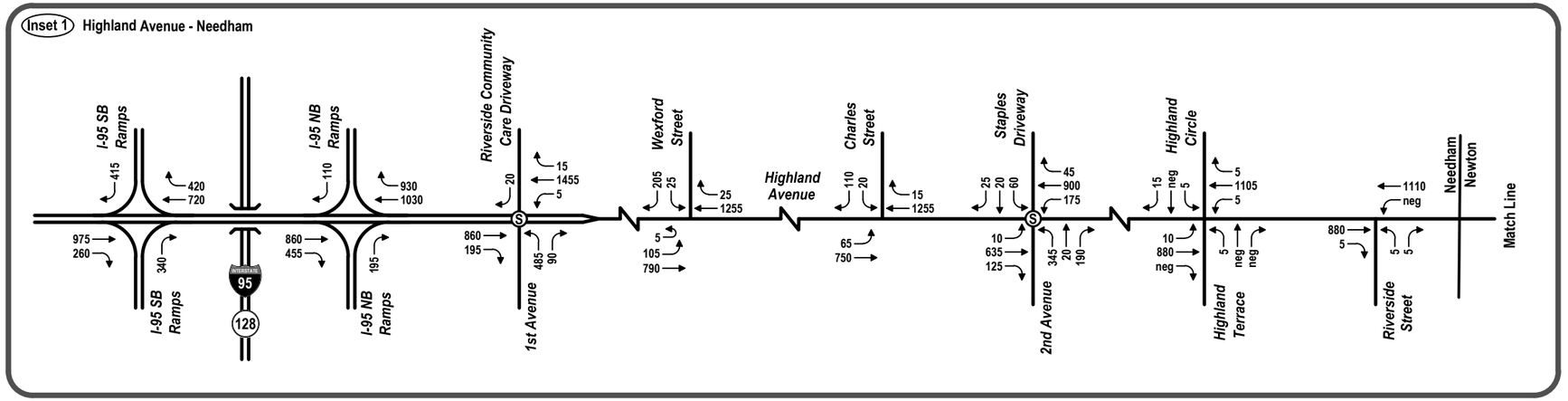
2025 No Build Conditions
Weekday Morning Peak Hour Traffic Volumes
The Northland Newton Development
Newton, Massachusetts

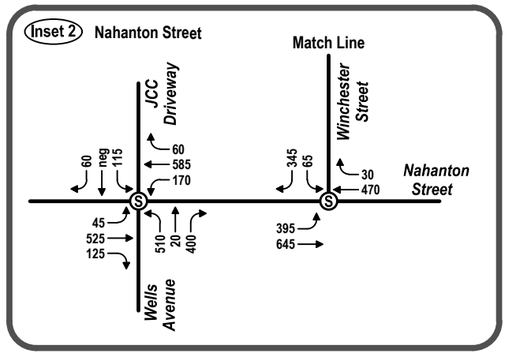
Figure 8

Ⓢ Signalized Intersection

neg = Negligible







Not to Scale

2025 No Build Conditions
Weekday Evening Peak Hour Traffic Volumes
The Northland Newton Development
Newton, Massachusetts

Figure 9

Signalized Intersection

neg = Negligible

Inset 1 Highland Avenue - Needham

Inset 2 Nahanton Street

Not to Scale

2025 No Build Conditions
Saturday Midday Peak Hour Traffic Volumes
The Northland Newton Development
Newton, Massachusetts

Figure 10

Trip Generation

The rate at which any development generates traffic is dependent upon the size, location, and concentration of surrounding developments. As mentioned previously, the Project is comprised of office, residential, and retail use, as described in Chapter 1. The ITE *Trip Generation Manual*[5] categorizes these land uses and provides weekday daily, weekday morning, weekday evening, Saturday daily, and Saturday midday peak hour unadjusted vehicle trip generation estimates for each use. The trip generation estimates for the proposed uses were projected using Land Use Code (LUC) 221 (Mid-Rise Residential), LUC 710 (General Office Building), and LUC 820 (Shopping Center). The trip generation analyses are presented below.

As discussed previously, the Project is expected to develop a transportation management plan including a robust shuttle service program that includes direct shuttle bus service to nearby transit stations and to key regional hubs in Cambridge and Boston. The inclusion of the shuttle bus service will alter the mode split for the Project, as it is expected that many residents, patrons, employees and some local residents in proximity to the site will take advantage of the shuttle system instead of driving. The level of use of the shuttle system will take time to materialize, but the expectation is that it will become a valuable and well used service in the area. As the actual use is unknown at this stage, trip generation analyses were conducted under two different scenarios in order to provide a thorough understanding of the trip generation potential; one scenario with a more robust shuttle service and potential usage and one scenario with a less robust shuttle service and less usage. The results of both scenarios are presented below.

Project-Generated Trips

Estimating future conditions volumes for the Site involved a review of the existing development on those parcels, along with the additional trip generation expected from the Project development.

Existing Site-Generated Traffic

The planned development parcels currently are occupied by a shopping center containing approximately 62,600 sf of general retail space, the former mill building that contains approximately 180,000 sf of office space, and a vacant 257,000 sf manufacturing building. At the time of the traffic counts, it was estimated that the retail space was fully occupied while the office and manufacturing spaces were fully vacant. Based on discussions with Northland, it is understood that the office space could be tenanted without the Project while it is unlikely that the manufacturing space would be tenanted in the future. Based on that information, the potential site trip generation under the existing conditions was estimated using the ITE methodology. Table 3 summarizes the Project-related trips for the existing uses within the Project Site and trip generation worksheets are included in Appendix A.

[5] Trip Generation Manual, 10th Edition, Institute of Transportation Engineers, Washington, D.C., 2017.

Table 3 Existing Site Trip Generation

	Retail [a]	Office [b]	Total Unadjusted Trips	Total Net Vehicle Trips [c]	Total Pass-By
Weekday Daily					
Enter	2,186	938	3,124	**2,154**	475
Exit	2,186	938	3,124	**2,154**	475
Total	4,372	1,877	6,249	**4,297**	950
Weekday Morning					
Enter	114	168	282	**221**	20
Exit	70	27	97	**56**	20
Total	183	196	379	**277**	40
Weekday Evening					
Enter	184	32	216	**120**	56
Exit	200	167	367	**248**	56
Total	384	199	583	**368**	112
Saturday Daily					
Enter	3,333	199	3,552	**2,380**	745
Exit	3,333	199	3,552	**2,376**	745
Total	6,666	398	7,064	**4,756**	1,490
Saturday Midday					
Enter	222	52	274	**186**	49
Exit	205	44	249	**163**	49
Total	428	95	523	**349**	98

a Based on ITE LUC 820 (Shopping Center) for 62,600 sf
a Based on ITE LUC 710 (General Office Building) for 180,000 sf
c Net vehicle trips includes credit for internal capture, mode shares, and pass-by trips.

As shown in Table 3, the existing trip generation for the Site is able to take credit for shared trips, mode shares beyond vehicular travel, and pass-by trips. This is due to the availability of public transportation, shared trips within the multiple uses on Site, and the benefits of being located within an area with bicycle and pedestrian accommodations. In addition, a portion of the retail trips visiting the Site under existing conditions are assumed to be pass-by trips drawn from the traffic volume roadways adjacent to the Site, as noted in Table 3. The details of these assumed trip credits are discussed in greater detail later in this section.

Unadjusted Project-Generated Traffic

The proposed development will consist of a mixture of residential, office, and supporting retail uses. Specifically, the Site is proposed to include 822 residential units, 180,000 sf of office space to be located in the former mill building, and 237,000 sf of supporting restaurant/retail/active uses. An additional 4,000 sf of community center space is proposed to be provided on Site, but it is assumed that

this space will be community oriented for the Site and the adjacent neighborhood and any vehicular traffic generated during the peak hours will be negligible.

As noted above, traffic associated with the residential units was estimated using ITE LUC 221 (Mid-Rise Residential), traffic associated with the office space was estimated using ITE LUC 710 (General Office Building), and traffic associated with the retail uses was estimated with ITE LUC 820 (Shopping Center). The retail uses are expected to be smaller, Main Street style businesses catering to the residential units on-Site and the adjacent neighborhoods as opposed to large big-box style retail stores. Potential uses will include small eating establishments, coffee shops, pharmacies, or gallery uses. While these do not fit the exact description of a traditional ITE "Shopping Center", retail traffic was estimated using this land use code, which results in an overly conservative analysis. The unadjusted vehicle trip estimates for are presented in Table 4 and trip generation worksheets are included in Appendix A.

Table 4 Project Trip Generation – ITE Unadjusted Vehicle Trips

	Residential [a]	Office [b]	Retail [c]	Total Unadjusted Vehicle Trips
Weekday Daily				
Enter	2,245	938	5,405	**8,588**
Exit	2,245	938	5,405	**8,588**
Total	4,489	1,877	10,811	**17,176**
Weekday Morning				
Enter	70	168	168	**406**
Exit	200	27	103	**330**
Total	270	196	270	**736**
Weekday Evening				
Enter	205	32	494	**730**
Exit	131	167	535	**833**
Total	335	199	1,029	**1,564**
Saturday Daily				
Enter	1,461	199	7,609	**9,269**
Exit	1,461	199	7,609	**9,269**
Total	2,922	398	15,317	**18,537**
Saturday Midday				
Enter	173	52	636	**861**
Exit	180	44	587	**811**
Total	353	95	1,224	**1,672**

a Based on ITE LUC 221 (Mid-Rise Residential) for previously proposed Site plan of 824 residential units. Since the analysis for this study was conducted, the actual building program has been reduced to 822 residential units.

b Based on ITE LUC 710 (General Office Building) for 180,000 sf

c Based on ITE LUC 820 (Shopping Center) for 237,000 sf

Person Trips

The unadjusted vehicle trips are converted into person trips by applying the average vehicle occupancy (AVO) of 1.13 for residential and office trips and of 1.78 for retail trips, as outlined by the U.S. Department of Transportation[6]. The unadjusted vehicle trips were converted into person trips in order to apply internal capture credits and applicable mode share credits, as described below. Applying these credits to person trips allows for estimates to be made for the total number of Site-generated transit users, walkers, and bicyclists in addition to the total number of Site-generated vehicles.

Internal Capture Trips

Since the proposed development is a mixed-use project, the trip generation characteristics of the Site will be different from a single-use project. Some of the traffic to be generated by the proposed development will be contained on site as "internal" or "shared vehicle" trips. For example, workers at the office space on Site may patron the retail shops after work, or residents who live in the development may also work in the office on Site. While these shared trips represent new traffic to the individual uses, they would not show up as new vehicle trips on the surrounding roadway network.

As described in the ITE Trip Generation Handbook[7] "because of the complementary nature of these land uses, some trips are made among the on-site uses. This capture of trips internal to the site has the net effect of reducing vehicle trip generation between the overall development site and the external street system (compared to the total number of trips generated by comparable land uses developed individually on stand-alone sites) an internal capture rate can generally be defined as the percentage of total person trips generated by a site that are made entirely within the site. The trip origin, destination, and travel path are all within the site."

Based on the methodology outlined in the ITE Trip Generation Handbook, internal capture rates were applied to the gross person trips. The resulting peak-hour person trip estimates for the Project and are presented in Table 5 and worksheets are included in Appendix A.

6 Summary of Travel Trends: 2009 National Household Survey, US Department of Transportation, Federal Highway Administration, Washington D.C., 2009

7 Trip Generation Handbook, 3rd Edition, Institute of Transportation Engineers, Washington, D.C., 2017.

Table 5 Project Peak-Hour Person Trips

	Residential [a]	Office [a]	Retail [a]	Total Person Trips
Weekday Morning				
Enter	77	177	287	**541**
Exit	219	22	173	**414**
Total	296	199	460	**955**
Weekday Evening				
Enter	121	19	779	**919**
Exit	80	147	835	**1,062**
Total	201	166	1,614	**1,981**
Saturday Midday				
Enter	104	32	1,038	**1,174**
Exit	110	39	938	**1,087**
Total	214	71	1,976	**2,261**

a Person trip generation estimate with internal capture credits applied.

Mode Share

It is expected that residents, visitor, and commuters to the Site will use a variety of transportation options to reach the Site, including private vehicles, walking, bicycling, and public transportation. To determine the number of vehicle trips, walk/bike trips, and transit trips, mode shares have been applied to the Person trips presented in Table 5.

As mentioned previously and described in detail later in the report, the Project will include a robust shuttle service program that includes direct shuttle bus service to nearby transit stations and to regional mobility hubs in Cambridge and Boston. The inclusion of the shuttle bus service will affect the mode split for the Project, as it is expected that many residents, employees, patrons, and the general public will use the shuttle bus service for trips to and from the Site. The level of use of the shuttles by the residents and workers will take time to materialize and the overall usage is not known at this time. As the exact usage will vary and is not known at this time, analysis for two levels of potential mode share has been conducted. To provide a complete understanding of the trip generation potential, two different mode splits were applied to the person trips to develop two different Build scenarios.

The first Build scenario, referred to as "Build Condition with Robust Shuttle Service" assumes a robust shuttle service that includes frequent peak and off-peak connections between the Site, nearby transit stations, and downtown Boston with strong usage expected. Mode shares were estimated with an assumption that there will be strong demand for residents and workers to use the shuttle service.

The second Build scenario, referred to as "Build Condition with Existing Mode Share" assumes that existing mode shares are realized. Mode shares for the Project under this scenario were based on the existing mode shares in the City of Newton according to Journey to Work data from the 2010 US Census, as in this scenario it is

assumed that the shuttle service would be used with a similar frequency to transit options that currently exist within the City of Newton. While it is expected that the shuttle service in-place will be robust and will provide frequent peak and off-peak connections, this scenario presents a conservative "worst-case" trip-generation estimate.

The peak hour/peak direction mode share estimates, by use, are presented in Table 6 and all mode share data is included in Appendix A. It should be noted that the level of robustness for the shuttle service was assumed to directly affect the residential and office mode shares, but not the retail mode shares. It is estimated that patrons to the retail uses on Site will not significantly change their pattern of travel based on the availability and service levels of the shuttle service. Under both conditions it is assumed that the shuttle service will account for approximately 5% of all retail trips, which includes both patrons to the retail uses and employees of the retail uses. It should also be noted that the walk/bike mode share is expected to be higher with the shuttle service in place as well, as residents and workers will be less likely to have a vehicle on Site with the shuttle service, so for shorter trips in the immediate area they will be more likely to walk or bike than to drive or take transit.

Table 6 Project Mode Share

Use	Vehicle	Transit	Walk/Bike
Build Condition with Robust Shuttle Service [a]			
Residential	60%	30%	10%
Office	60%	30%	10%
Retail	90%	5%	5%
Build Condition with Existing Mode Share [b]			
Residential	82%	13%	5%
Office	88%	7%	5%
Retail	90%	5%	5%

a Peak hour/peak direction mode share estimates developed with the assumption that there will be a strong usage (expected) of the shuttle system

b Peak hour/peak direction mode share estimates based on Journey to Work data from the 2010 US Census data for the City of Newton

The mode shares discussed above were applied to the net-new person trips to generate the adjusted Project trips by mode for the Build Condition with Robust Shuttle Service and the Build Condition with Existing Mode Share, respectively. The local average vehicle occupancy, based US Census data for each primary use was then applied to the vehicle mode to reflect the number of vehicle trips generated by the Site.

Pass-By Trips

While the ITE rates provide estimates for all the traffic associated with each land use, not all of the traffic generated by the Project will be new to the area roadways. A portion of the vehicle-trips generated by the retail land use will likely be drawn from

the traffic volume roadways adjacent to the Project Site. For example, someone traveling on Needham Street may choose to deviate from their original travel path to visit the site retail, before heading back to continue to their final destination. For this evaluation, ITE pass-by rates for LUC 820 (Shopping Center) were utilized for the retail trip generation and applied to existing trips on Needham Street and Oak Street. Specifically, 34-percent and 26-percent of the Site trip generation was assumed to be drawn from the surrounding roadway network during the weekday evening and Saturday midday peak hours, respectively, as outlined in the ITE Trip Generation Handbook. For all other time periods studied, a 25-percent pass-by rate was assumed.

Project-Generated Trips – Build Condition with Robust Shuttle Service

The mode share and local average vehicle occupancy rates were applied to convert the person trips into net new transit trips, walk/bike trips, and vehicle trips for the Build Condition with Robust Shuttle Service. A pass-by reduction was applied to the vehicle trips generated by the retail portion of the Site. Tables 7 and 8 summarize the net new trips by mode and net new vehicle trips by use, respectively.

Table 7 Project-Generated Peak-Hour Trips by Mode – Build Condition with Robust Shuttle Service

	Vehicle Trips [a]	Transit Trips	Walk/Bike Trips
Weekday Morning			
Enter	252	90	40
Exit	186	82	33
Total	438	172	73
Weekday Evening			
Enter	329	81	53
Exit	404	110	65
Total	733	191	118
Saturday Midday			
Enter	467	93	65
Exit	423	92	62
Total	890	185	127

a Net vehicle trips not including pass-by trips associated with the retail portion.

As shown in Table 7, with a robust shuttle service in place the Project is expected to generate between 172 and 191 transit trips, between 73 and 127 walk/bike trips, and between 438 and 890 vehicle trips during the peak hours studied (including trip generated by the existing Project Site uses). The breakdown of the vehicle trips by use are summarized below in Table 8.

Table 8 Project-Generated Peak-Hour Vehicle Trips by Use – Build Condition with Robust Shuttle Service

	Residential [a]	Office [b]	Retail [c]	Pass-By [d]	Total Net Vehicle Trips [e]	Existing Vehicle Trips [f]	Total Net New Vehicle Trips
Weekday Morning							
Enter	41	95	116	29	252	221	**31**
Exit	116	12	58	29	186	56	**130**
Total	157	107	174	58	438	277	**161**
Weekday Evening							
Enter	64	10	255	139	329	120	**209**
Exit	42	79	283	139	404	248	**156**
Total	106	89	538	278	733	368	**365**
Saturday Midday							
Enter	55	17	395	130	467	186	**281**
Exit	58	21	344	130	423	163	**260**
Total	113	38	739	260	890	349	**541**

a New vehicle trips with internal capture credits applied.
b New vehicle trips with internal capture credits applied.
c New vehicle trips with internal capture and pass-by credits applied.
d Pass-by Credits of 25%, 34%, and 26% applied to weekday morning, weekday evening, and Saturday midday peak hour retail trip generation, respectively.
e Sum of columns a through c.
f Net vehicle trips that can be generated by the Site under existing conditions (from Table 3).

As shown in Table 8, the Project is expected to generate a total 438, 733, and 890 new vehicle trips during the respective weekday morning, weekday evening, and Saturday midday peak hours with a robust shuttle service in place. However, these totals include traffic already being generated by the Project Site under existing conditions (as shown in Table 3). After considering this existing traffic generation, the Project will result in an additional 161, 365, and 541 vehicle trips compared to existing conductions during the weekday morning, weekday evening, and Saturday midday peak hours, respectively.

Project-Generated Trips – Build Condition with Existing Mode Share

Similar to the Build Condition with Robust Shuttle Service, the mode share and local average vehicle occupancy rates were applied to the person trips to estimate the net new trips by mode for the Build Condition with Existing Mode Share, and then a pass-by reduction was applied to the vehicle trips generated by the retail portion of the Site. Tables 9 and 10 summarize the net new trips by mode and net new vehicle trips by use, respectively.

Table 9 Project-Generated Peak-Hour Trips by Mode – Build Condition with Existing Mode Share

	Vehicle Trips [a]	Transit Trips	Walk/Bike Trips
Weekday Morning			
Enter	311	36	27
Exit	234	39	21
Total	545	75	48
Weekday Evening			
Enter	358	56	46
Exit	457	62	53
Total	815	118	99
Saturday Midday			
Enter	495	68	59
Exit	455	64	55
Total	950	132	114

a Net vehicle trips not including pass-by trips associated with the retail portion.

As shown in Table 9, without a robust shuttle service in place the Project is expected to generate between 75 and 132 transit trips, between 48 and 114 walk/bike trips, and between 545 and 950 vehicle trips during the peak hours studied (including trip generated by the existing Project Site uses). The breakdown of the vehicle trips by use are summarized below in Table 10.

Table 10 Project-Generated Peak-Hour Vehicle Trips by Use – Build Condition with Existing Mode Share

	Residential [a]	Office [b]	Retail [c]	Pass-By [d]	Total Net Vehicle Trips [e]	Existing Vehicle Trips [f]	Total Net New Vehicle Trips
Weekday Morning							
Enter	56	139	116	29	311	221	**90**
Exit	159	17	58	29	234	56	**178**
Total	215	156	174	58	545	277	**268**
Weekday Evening							
Enter	88	15	255	139	358	120	**238**
Exit	58	116	283	139	457	248	**209**
Total	146	131	538	278	815	368	**447**
Saturday Midday							
Enter	75	25	395	130	495	186	**309**
Exit	80	31	344	130	455	163	**292**
Total	155	56	739	260	950	349	**601**

a New vehicle trips with internal capture credits applied.
b New vehicle trips with internal capture credits applied.
c New vehicle trips with internal capture and pass-by credits applied.
d Pass-by Credits of 25%, 34%, and 26% applied to weekday morning, weekday evening, and Saturday midday peak hour retail trip generation, respectively.
e Sum of columns a through c.
f Net vehicle trips that can be generated by the Site under existing conditions (from Table 3).

As shown in Table 10, the Project without a robust shuttle service in place is expected to generate a total 545, 815, and 950 vehicle trips during the respective weekday morning, weekday evening, and Saturday midday peak hours. However, these totals include traffic already being generated by the Project Site under existing conditions (as shown in Table 3). After considering this existing traffic generation, the Project without a robust shuttle service in place will result in an additional 268, 447, and 601 vehicle trips compared to existing conductions during the weekday morning, weekday evening, and Saturday midday peak hours, respectively.

As of Right Project Comparison

For the purpose of comparison, a potential redevelopment of the proposed project has been considered under an "as of right" type of use. This type of development could be accomplished on site within the existing uses and allowable 1.5 floor area ratio (FAR) and would result in density and traffic projections in the same range as those proposed by the mixed-use project. The Site is currently zoned as Mixed-Use 1 under City of Newton zoning, which allows for industrial, office, and health club uses by-right . If the Site was to be redeveloped as a 100-percent office development, the zoning allows for up to 1.48 million sf of office space to be constructed by-right under the existing zoning. Table 11 below has been prepared to demonstrate gross traffic projections of an as of right use of the property versus that which is being

proposed by the mixed-use project with existing mode share. The as-of-right trip generation worksheets are included in Appendix A to this report.

Table 11 As-Of-Right Trip Generation Summary

	As-of-Right Gross Trips [a]	As-of-Right Net Trips [b]	Proposed Project Gross Trips [c]	Proposed Project Net Trips [d]	Difference in Net Trips
Weekday Morning					
Enter	1,219	1,083	406	311	+ 772
Exit	198	176	330	234	- 58
Total	1,418	1,259	736	545	+ 714
Weekday Evening					
Enter	236	209	730	358	- 149
Exit	1,237	1,098	833	457	+ 641
Total	1,473	1,307	1,564	815	+ 492
Saturday Midday					
Enter	424	376	861	495	- 119
Exit	361	321	811	455	- 134
Total	784	697	1,672	950	- 253

a As-of-Right unadjusted gross vehicle trips, based on ITE LUC 710 (General Office Building) for 1.48 million square feet.
b As-of-Right net trips, including mode share credits (using existing mode shares).
c Proposed Project unadjusted gross vehicle trips, as displayed in Table 4.
d Proposed Project net trips, including internal capture, mode share, and pass-by credits for building program (using existing mode shares), as displayed in Table 9.

As shown in Table 11, the as-of-right development over the proposed Project would generate approximately 714 additional trips (+772 entering/-58 exiting) during the weekday morning peak hour, 492 additional trips (-149 entering/+641 exiting) during the weekday evening peak hour, and 253 fewer trips (-119 entering/-134 exiting) during the Saturday midday peak hour. During the weekday morning and weekday evening peak hours, the as-of-right development would have a significantly greater impact on the local roadway network than the proposed Project. Since the as-of-right development would be all office use as opposed to mixed-use, the trips would be far less distributed between the entering and exiting directions during the peak hours. This would cause a major impact on the roadway network, as the effects of the Site-generated trips would be concentrated on the direction approaching the Site in the morning and the direction departing the Site in the evening. The proposed Project more evenly distributes the Site-generated traffic onto the local roadway network on roadways approaching and departing the Site.

It should be noted that the as-of-right trip generated has been presented for comparison purpose only to demonstrate the potential magnitude of vehicle trips the Site could generate based on existing zoning. No operational analyses have been conducted using the as-of-right trip generation volumes.

Trip Distribution

The directional distribution of the traffic approaching and departing the Site is a function of population densities, the location of employment opportunities, existing travel patterns, and the efficiency of the roadway system. Due to the varying trip characteristics of the Project uses – residential, office, and retail – each use is expected to experience a different distribution pattern. Thus, regional trip distribution percentages were calculated separately for each of the Project's uses.

Trips made from and to the proposed office and residential spaces during the peak hours are expected to be predominantly home-to-work and work-to-home trips in the morning and evening peak hours. Accordingly, the trip distribution for the office and residential portions of the proposed development has been derived based on Journey-to-Work data for the City of Newton with the 2010 U.S. Census data. The trip distribution for the retail portion of the proposed development has been derived based on the existing traffic patterns entering/exiting the Site and in the study area under existing conditions. As the retail spaces under the proposed development are expected to be more Main Street style businesses catering to neighborhood residents than large-scale retail stores catering to regional customers, it is expected that the majority of trips will start and end in the local area. The retail trip distribution reflects the more localized nature of the proposed retail uses.

Table 12 and Figure 11 illustrate the trip distribution. Detailed trip distribution calculations are provided in Appendix A to this document.

Table 12 Trip Distribution Summary

Travel Route	Direction	Residential Trips	Office Trips	Retail Trips
Centre Street	North	15%	15%	16%
Walnut Street	North	7%	7%	10%
Chestnut Street	North	9%	9%	13%
I-95 / Route 128	North	44%	35%	8%
	South	3%	11%	5%
Highland Avenue	South	2%	4%	17%
Dedham Street	East	1%	1%	6%
Nahanton Street [a]	East	6%	5%	10%
	West	0%	0%	3%
Route 9	East	10%	8%	8%
	West	3%	5%	4%
Total		100%	100%	100%

a Assumes approximately 50% of Nahanton Street traffic will arrive/depart Site via Christina Street and 50% will arrive/depart the Site via Winchester Street.

Build Traffic Volumes

The project-related traffic volumes for both the Build Condition with Robust Shuttle Service and the Build Condition with Existing Mode Share are assigned to the study area roadway network based on the trip distribution patterns shown in Table 12. The assigned volumes are then added to the 2025 No-Build peak hour traffic volume networks to develop the 2025 Build with Robust Shuttle Service and 2025 Build with Existing Mode Share weekday morning, weekday evening, and Saturday midday peak hour traffic volume networks, respectively. The site-generated trip traffic volume networks for both Build Conditions are provided in Appendix A.

The 2025 Build with Robust Shuttle Service traffic volumes are shown in Figures 12-14 for the weekday morning, weekday evening, and Saturday midday peak hours, respectively. The 2025 Build with Existing Mode Share traffic volumes are shown in Figures 15-17 for the weekday morning, weekday evening, and Saturday midday peak hours, respectively.

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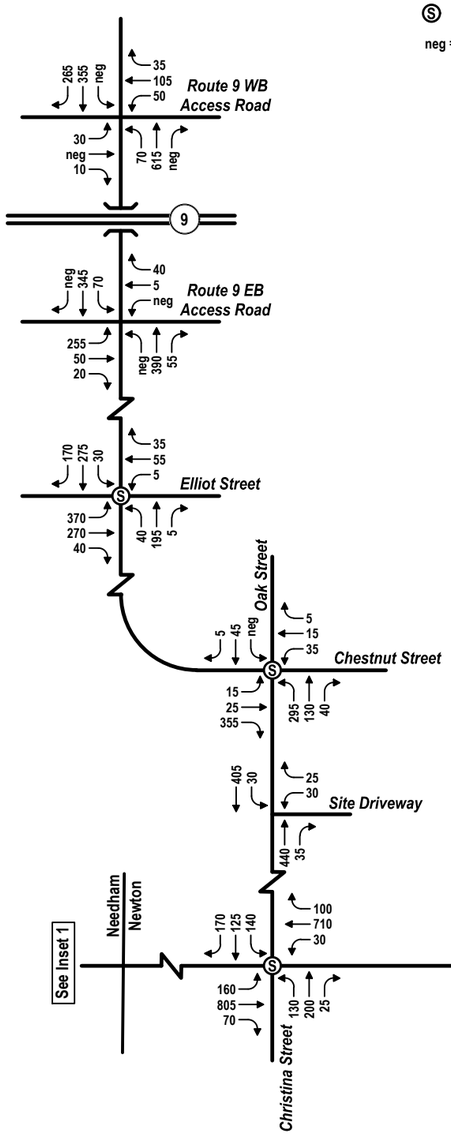
0 350 700 Feet

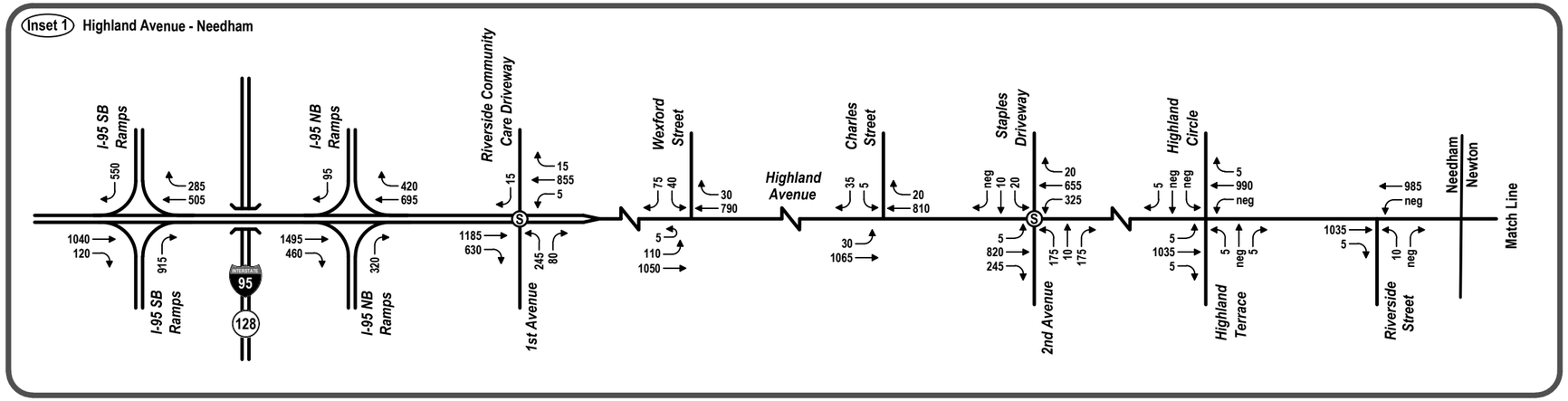
Figure 11

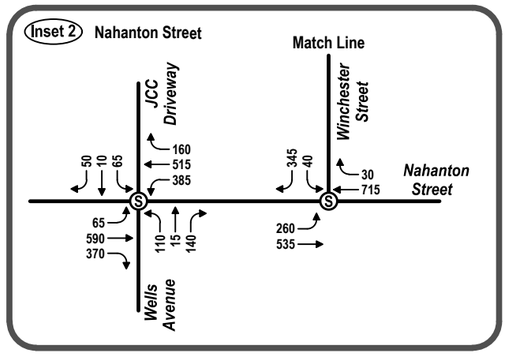
Trip Distribution
The Northland Newton Development
Newton, Massachusetts

Signalized Intersection

neg = Negligible







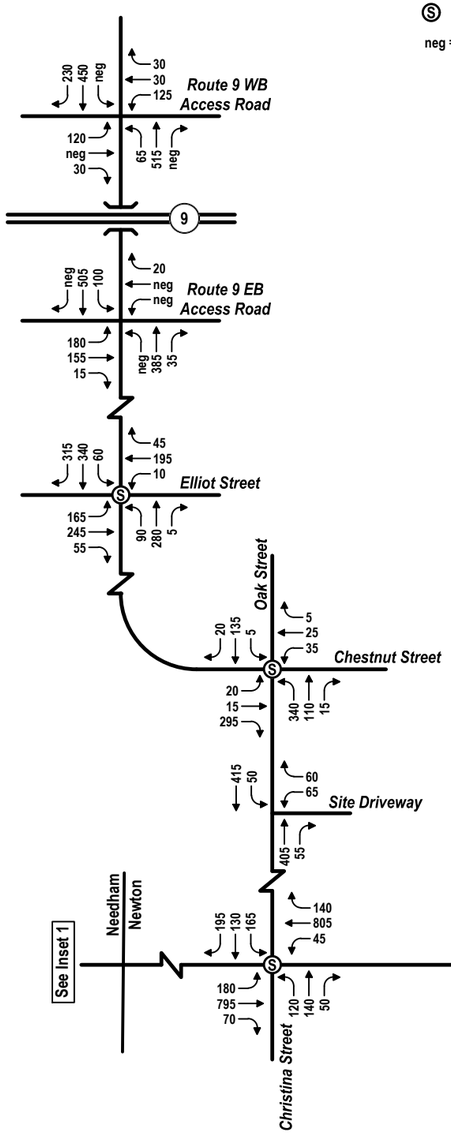
Not to Scale

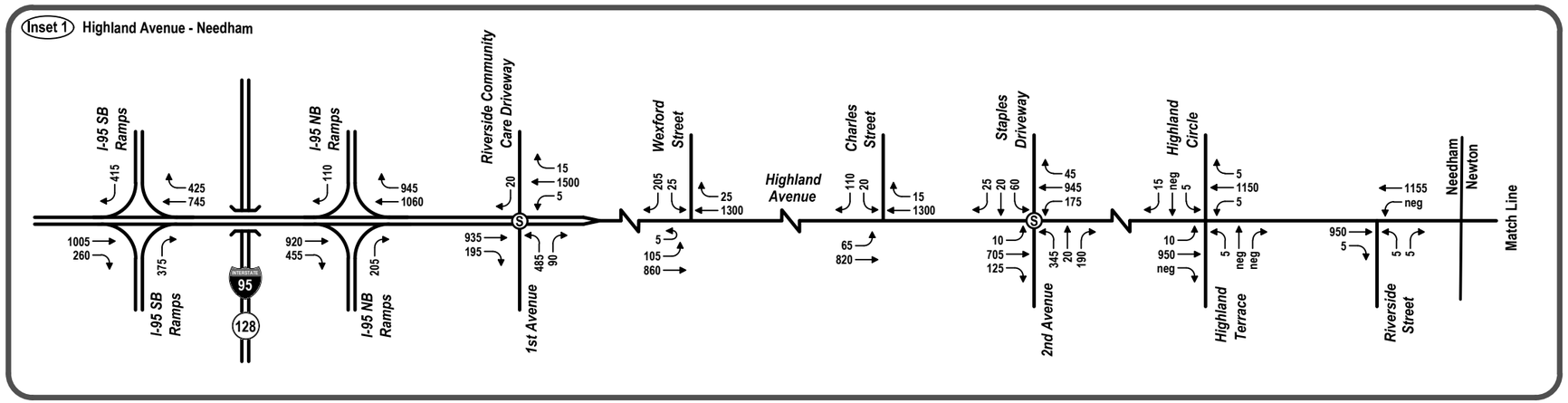
2025 Build Conditions
With Robust Shuttle Service
Weekday Morning Peak Hour Traffic Volumes
The Northland Newton Development

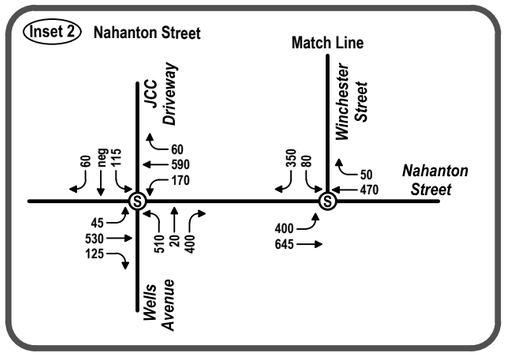
Figure 12

Signalized Intersection

neg = Negligible







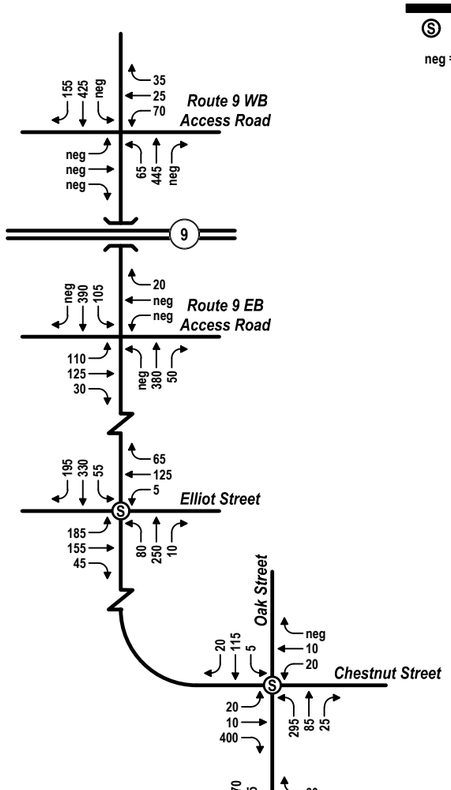
Not to Scale

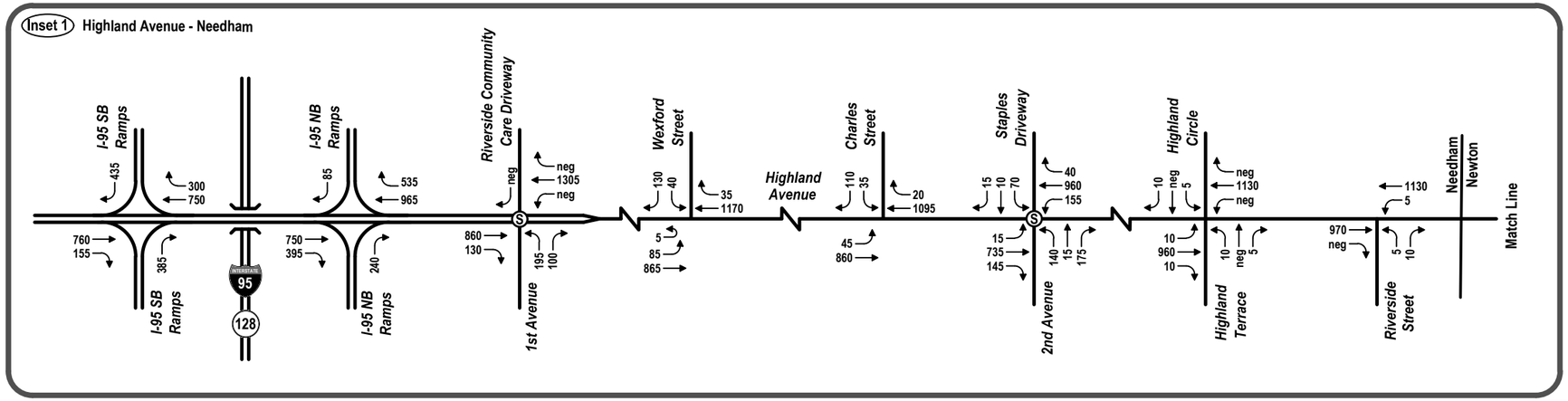
2025 Build Conditions
With Robust Shuttle Service
Weekday Evening Peak Hour Traffic Volumes
The Northland Newton Development

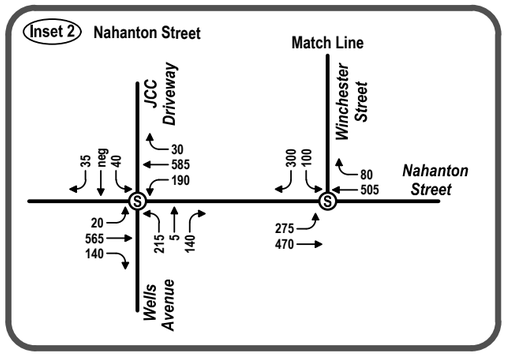
Figure 13

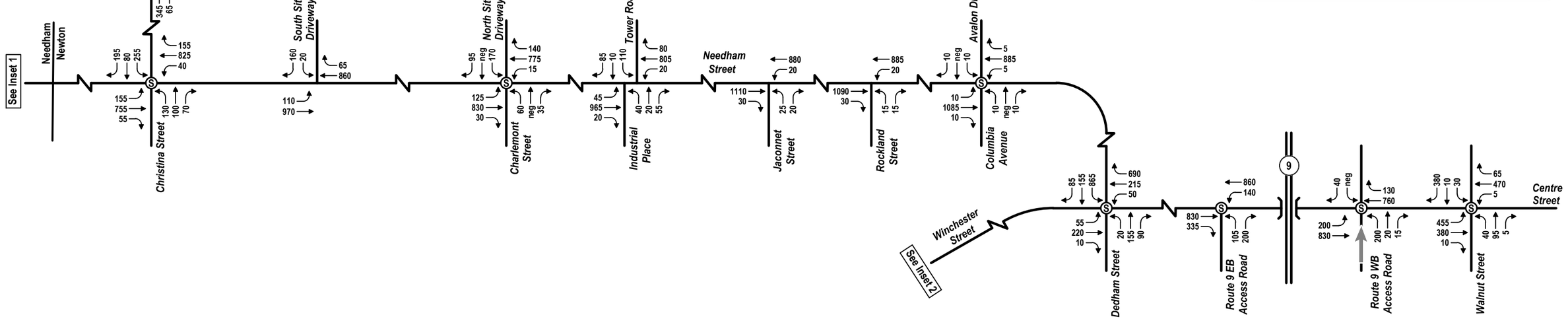
Ⓢ Signalized Intersection

neg = Negligible









Not to Scale

2025 Build Conditions
With Robust Shuttle Service
Saturday Midday Peak Hour Traffic Volumes
The Northland Newton Development

Figure 14

Signalized Intersection

neg = Negligible

Inset 1 Highland Avenue - Needham

Inset 2 Nahanton Street

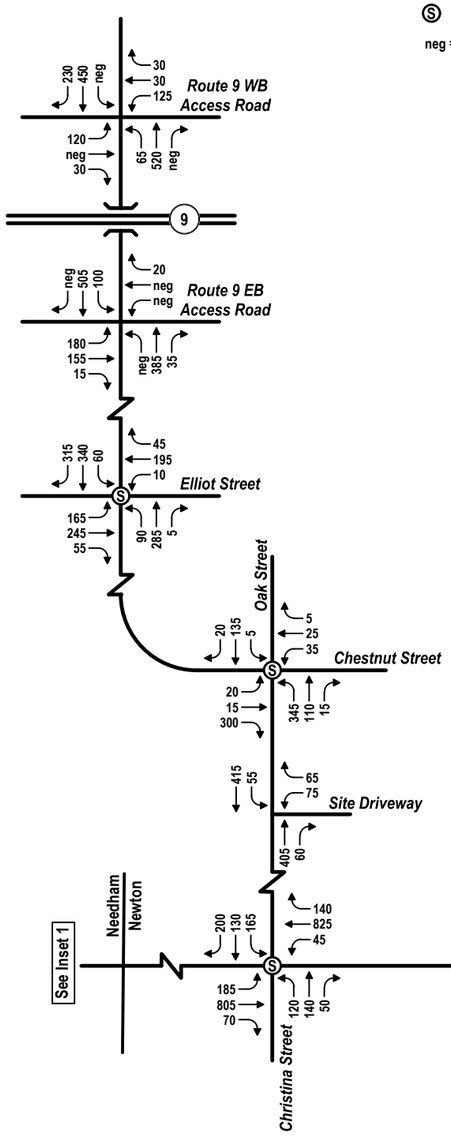
Not to Scale

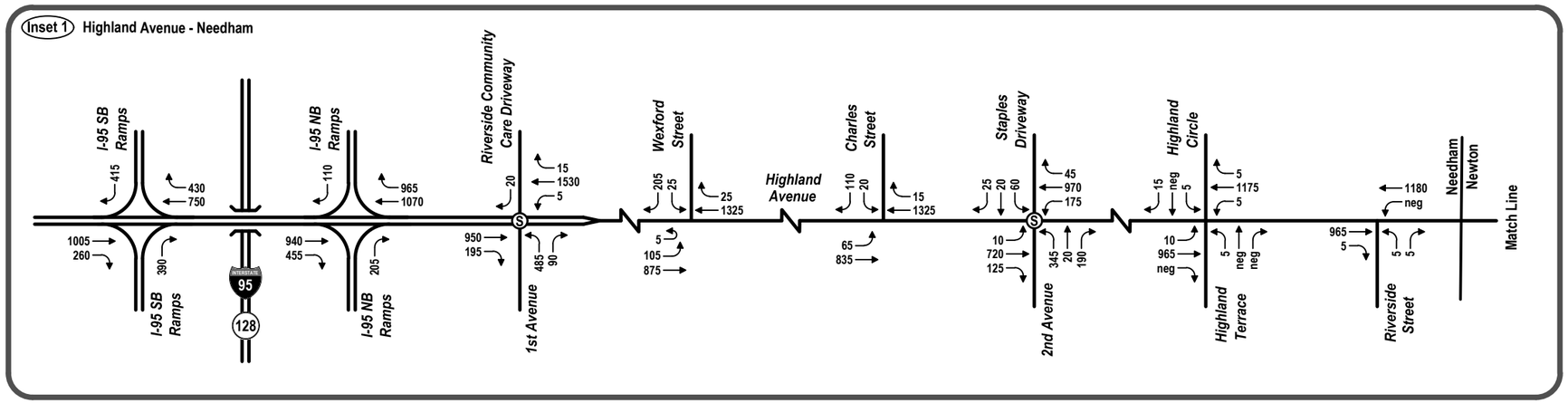
2025 Build Conditions
With Existing Mode Share
Weekday Morning Peak Hour Traffic Volumes
The Northland Newton Development

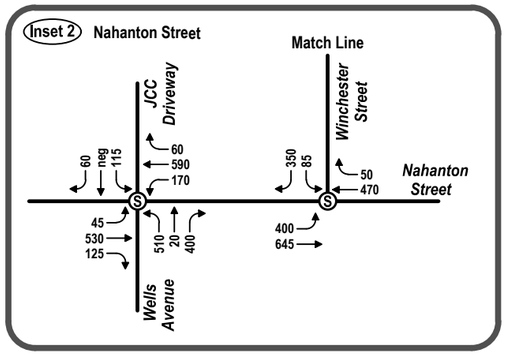
Figure 15

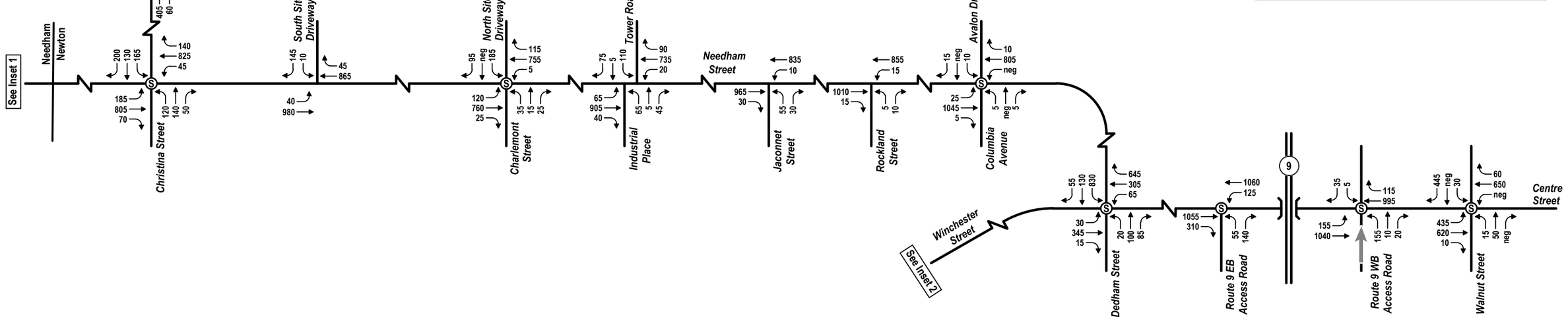
Ⓢ Signalized Intersection

neg = Negligible









Not to Scale

2025 Build Conditions
With Existing Mode Share
Weekday Evening Peak Hour Traffic Volumes
The Northland Newton Development

Figure 16

Ⓢ Signalized Intersection

neg = Negligible

Inset 1 Highland Avenue - Needham

Inset 2 Nahanton Street

Site

Not to Scale

2025 Build Conditions
Without Robust Shuttle Service
Saturday Midday Peak Hour Traffic Volumes
The Northland Newton Development

Figure 17

Proposed Site Access Plan

In addition to the off-Site traffic operations analysis, a detailed review of the proposed Site access plan also was conducted as part of this evaluation as described in the following sections.

Existing Site Access

As noted previously, the Site is approximately 22.6 acres and is bounded by Oak Street to the south, Needham Street to the east, the Upper Falls Greenway to the west, and an office building/parking garage to the north. The Site is currently occupied by a former mill building in the southeast corner of the Site that contains 180,000 sf of leasable office space, a shopping center with 62,600 sf of retail space in the northeast corner of the Site, and a vacant building of 257,000 sf that formerly housed manufacturing space on the western portion of the Site.

Access to the Site is currently provided by five full-access driveways that connect to four individual parking lots on the Site. None of the four parking lots are connected internally within the Site. A driveway on the southwest corner of the Site on Oak Street provides access to the main parking lot for the mill building. Three driveways are located along Needham Street, with the southern driveway providing access to a small parking lot and the loading docks for the former mill building and the middle and northern driveways providing access to the shopping center parking lot. A fifth point of egress is via Tower Road in the north, which connects to a parking lot in the center of the Site that was for the former manufacturing building.

Two additional driveways for service vehicles only are provided on Needham Street approximately 150 feet north of the northern Site driveway and on Oak Street approximately 300 feet west of Needham Street. The Needham Street curb cut provides access to the service/loading areas behind the existing retail building containing the Marshalls and CVS and the Oak Street curb cut provides access to the service/loading areas for the historic mill building. Only service vehicles are allowed to use these driveways, as they only provide access to service/loading areas and do not connect to any parking lots.

Proposed Project Site Access

As noted previously, the proposed Project will include residential, retail, office, and community space within 13 buildings; one of which is existing (the former mill building) while the other 12 will be newly constructed. A new network of streets will connect the Site internally and will provide a through connection from Oak Street to Needham Street. Internal roadways will include, from north to south, Tower Road Extension, Pettee Lane, Charlemont Street Extension, Unnamed Road, Main Street, and the Village Green Perimeter Roadway. Figure 18 illustrates the site plan for the Project showing the street layout and the location of each building.

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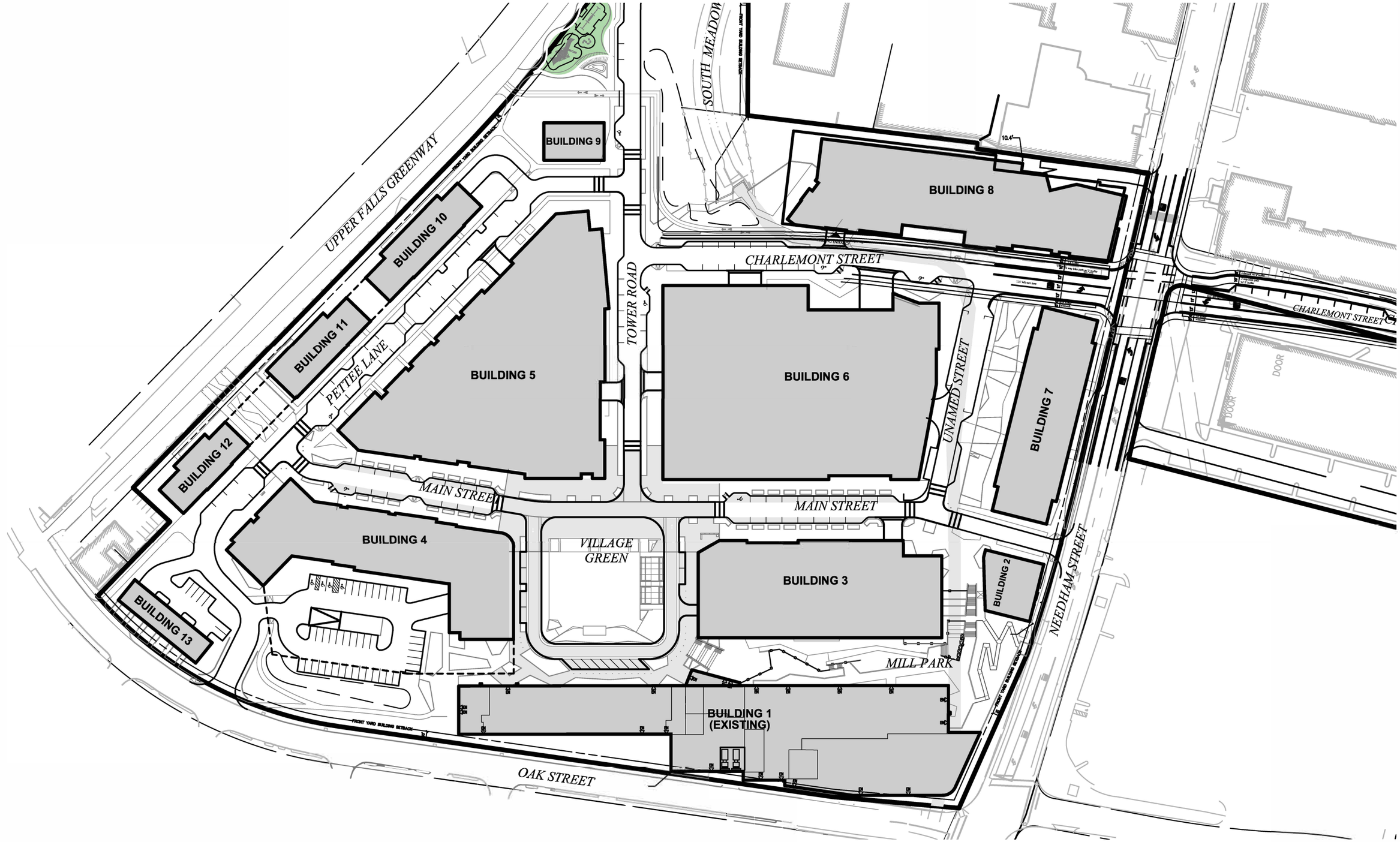

0 60 120 Feet

Proposed Site Plan
The Northland Newton Development
Newton, Massachusetts

Figure 18

External access to the Site will be provided via four full-access curb cuts. A curb cut on Oak Street for the proposed Pettee Lane on Site will be located approximately 200 feet east of the existing curb cut. This relocation is proposed to move the driveway further away from the signalized intersection of Oak Street and Chestnut Street, and to align the driveway directly with Saco Street creating a four-way, unsignalized intersection. Two curb cuts will provide full access to Needham Street; the southern access point will connect to the Site's Main Street and will be located approximately 100 feet north of the existing southern driveway while the northern access point will connect to the Site's Charlemont Street Extension and will be located where the existing northern driveway is currently located. The northern Needham Street driveway will align directly with Charlemont Street east of the intersection since Northland will provide the state land to allow Charlemont Street to be shifted to the south at the intersection. A final access point from the north will extend Tower Road into the Site and provide another access point to Needham Street north of the northern Site driveway. Charlemont Street Extension will connect to Needham Street at a signalized intersection while the other three approaches will connect to the external roadway network at unsignalized intersections. Internally, parking locations for each of the buildings will connect to Pettee Lane, Main Street, Charlemont Street Extension, or Tower Road Extension to then access the local roadway network.

The curb cuts for the existing service/loading areas north of the northern site driveway on Needham Street and for the historic mill building on Oak Street will be maintained and will provide access to the service/loading area for Buildings 1 and 8, respectively.

Pedestrian Access

As part of the Proposed Project, new sidewalks will be provided along each of the proposed internal streets. The internal sidewalks will connect to the Oak Street sidewalk and the new Needham Street sidewalks, which is being redesigned in accordance with the state plan. Raised crosswalks will be provided at key internal intersections within the Site to allow safe pedestrian connections in high activity areas. Internal pedestrian accommodations will connect at each of the external egress points to Oak Street, Needham Street, and Tower Road.

Adjacent to the Site is the Upper Falls Greenway. Currently, pedestrian access to the Upper Falls Greenway from Needham Street and the east is provided at three locations; via Oak Street, Easy Street, and an extension of the path that connects to Needham Street south of the Newton Nexus site. Three additional easterly connections to the Upper Falls Greenway will be developed through the Site. The connections to the Upper Falls Greenway will create new pedestrian connections through the Site from the Greenway to the Needham Street corridor via both Charlemont Street Extension and Main Street.

A focal point of the proposed Project will be the Village Green. The Village Green will to be a pedestrian-friendly park south of the Site's Main Street and will act as the focal point for the development. The Village Green will serve as a location for

neighborhood activities and events, and pedestrian activity will be encouraged. In addition, adjacent to the north side of the mill building will be a second park, Mill Park. Both parks will provide green space for the development and will encourage pedestrian activities among the Site's workers and residents. Refer to Figure 19, referenced later in the report, for details of all the pedestrian amenities that are to be included on site.

Bicycle Accommodations

As part of the Project, a bicycle connection will be provided between the Upper Falls Greenway, the Needham Street corridor, residential areas to south, and the Needham trail network via the Charles River pedestrian bridge. As described above, there are limited connection opportunities from the east and the Upper Falls Greenway. The Project will include an off-road bicycle connection along the northern portion of the Site from the Upper Falls Greenway, along Charlemont Street Extension, to Needham Street. This off-road bicycle facility will serve as two-way separated bike lanes along Charlemont Street Extension and will connect to the bicycle facilities along Needham Street that will be constructed in the near future by MassDOT. The multi-use path will be constructed along Charlemont Street to the south of the site as well.

In addition, Northland recently acquired the buildings at 55 Christina Street (former Stark Industries). With this in mind, Northland can now extend the multi-use path from Charlemont Street, south through the former Stark property, to Christina Street, which would ultimately get a pedestrian or bicyclist to the Charles River pedestrian bridge. This will link the Upper Falls Greenway with the residential neighborhoods to the south as well as the extensive trail network in Needham.

Additionally, the internal street network will consist of low-speed, shared streets that will allow for shared bicycle and vehicular traffic. Raised intersections will be located in key areas of the internal street network, discouraging vehicles from travelling at high speeds and ensuring that the streets will be safe for both vehicles and bicycles.

The potential bicycle parking needs for the proposed Project will be accommodated through the provision of secured bicycle parking within the various Project buildings and by bicycle racks through the development. A minimum of at least one secured bicycle parking space per residential unit will be provided by Northland.

Bike-Sharing System

In addition, the Project will be a supporter of a City-wide bike-sharing initiative. In Summer 2018, the City of Newton entered into a bike-sharing agreement with Limebike, a California based bike sharing system. Limebike uses a dock-less system where bikes can be picked up and dropped off at any location in the City or in neighboring municipalities that also have contracts with Limebike. Customers use smartphones to unlock the bikes, and unlike the BlueBike bike-sharing system in neighboring Brookline and Boston, customers do not need to pick up or return bikes at designated bike-docking locations. The Project will support bike sharing on Site, with specific locations available for dock-less or docked bikes to be located,

depending on the model that the City of Newton is using at the time the Project opens.

Curbside Activity

Curbside activity will be regulated throughout and adjacent to the Site. Under existing conditions, no on-street parking is allowed along Needham Street adjacent to the Site and two-hour on-street parking is provided along both sides of Oak Street adjacent to the Site. Curbside regulations are proposed to be the same as existing conditions in the future with the Project in place along Needham Street and Oak Street.

Internally to the Site, on-street parking will be provided in the following locations:

- Tower Road: 13 on-street spaces
- Pettee Lane: 32 on-street spaces
- Charlemont Street Extension: 16 on-street spaces (12 of which will be time restricted spaces for Building 6 Loading Dock)
- Main Street: 34 on-street spaces
- Village Green Perimeter Road: 14 on-street spaces (8 of which are angled space as opposed to parallel spaces)

Unnamed Road will serve as a transportation hub for all bus service and pick-up/drop-off operations on-Site, including ride-sharing activity. Designated curbside space will be provided on both sides of Unnamed Road for shuttle bus stops and for pick-up/drop-off operations. The intended use of Unnamed Road will be to centralize all transit and pick-up/drop-off operations on Site to one designated location. In addition, a "Mobility Hub" will be located in Building 7 next to Unnamed Road, providing a central location for residents and employees looking to take public transit, shuttle service, or ride-shares. The "Mobility Hub" will be described in detail later in this report. Unnamed Road parallels Needham Street and provides easy access to and from the Site externally via Charlemont Street and Main Street.

Service and Loading

Service and loading locations will be provided for several buildings that contain office space and retail/restaurant establishments, either through loading docks or through designated on-street parking locations for service and loading vehicles. Specific service and loading locations will be provided for the following buildings:

- Building 1: The existing loading dock and driveway on Oak Street will be maintained.
- Building 2: On-street loading spaces will be provided along Unnamed Road for vehicles to park while loading and unloading.
- Building 3: A loading dock will be accessed via a driveway along the Village Green Perimeter Roadway.

- Building 4: A loading dock will be accessed via the surface parking lot for the residents of Building 4 off Pettee Lane.
- Building 5: A loading dock will be located inside the Building 5 parking garage. Loading vehicles will use one of the two garage entrances to access the loading dock.
- Building 6: A loading dock will be accessed via a curb-cut along Charlemont Street Extension. On-street parking will be restricted along Charlemont Street Extension during service and loading hours to provide room for the trucks to maneuver.
- Building 7: On-street loading spaces will be provided along Unnamed Road for vehicles to park while loading and unloading.
- Building 8: The location of the existing loading dock for the shopping center will be retained for the Building 8 loading dock. Access will be via a separate curb-cut along Needham Street that will only serve the loading dock. The driveway is located north of the Charlemont Street intersection and the existing curb-cut will be retained.

While designated service and loading locations will not be provided for the other buildings on-Site, these buildings will not contain office or retail spaces and therefore are not expected to receive as many deliveries. It is expected that service and loading vehicles for Buildings 9-13 will be able to use the on-street parking spaces along Pettee Lane.

The exact number and timing of deliveries will vary depending on the nature of the various retail establishments, in addition to standard office and residential delivery activity. Most retail activity typically occurs during morning hours so as not to interfere with the operation of the business. Due to the smaller sizes of the retail uses, most deliveries likely will be made by smaller, single-unit trucks. These are the same types of vehicles, typically seen on a daily basis in the Upper Falls and Needham Street area making deliveries to other existing retail businesses and restaurants. Smaller single-unit trucks can easily be accommodated and should typically only be on Site for a short time.

Project Site Parking Plan

One of the project design goals is to reduce reliance on personal automobile use. Parking management is an effective tool in influencing travel behavior. Right-sizing the parking supply balances the parking needs of the project while minimizing not only the physical footprint of parking, but also the number of motor vehicle trips that excess parking can incentivize.

As shown in Table 13, the Site will be supported by 1,953 parking spaces. The largest amount of parking in one location, 1,125 parking spaces, will be provided in the Building 6 parking garage. It is expected that retail/restaurant customers to the Site will be directed to park in this garage.

The proposed parking supply is less than the approximately 3,400 required by the Newton zoning ordinance without a special permit that considers shared parking and incentives to reduce commuting by private automobile. One of the reasons this project requires less parking is the desire to limit the residential parking supply to an average of one parking space per dwelling unit rather than the generic standard of two spaces per unit. Another is that a mixed-use project can share the parking supply among users who have peak parking demand at different times of day and days of week. An analysis of the shared parking demand for the overall project is provided in Appendix B.

Table 13 Proposed Parking Supply

	Number of Parking Spaces
Garage Parking	
Building 3	113
Building 4	159
Building 5	220
Building 6	1,125
Building 8	118
Buildings 10-12 [a]	52
Building 13	6
Total Garage	**1,793**
Surface Parking	
Building 4	44
Building 13	7
On-Street	109
Total Surface	**160**
All Parking Total	**1,953**

a Basement parking connects Buildings 10, 11, and 12.

Sight Distance

VHB conducted a sight distance analysis, conforming to guidelines of the American Association of State Highway and Transportation Officials (AASHTO)[8], at the proposed Site driveways. Sight distance considerations are generally divided into two categories: Stopping Sight Distance (SSD) and Intersection Sight Distance (ISD). SSD is the distance required for a vehicle approaching an intersection to perceive, react, and come to a complete stop before colliding with an object in the road, in

8 A Policy on the Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials, 2011.

this case an existing vehicle. In this respect, SSD can be considered as the minimum visibility criterion for the safe operation of an unsignalized intersection.

ISD is based on the time required for perception, reaction, and completion of the desired critical exiting maneuver once the driver on a minor street approach decided to execute the maneuver. Calculation for the critical ISD includes the time to (1) turn left, and to clear the half of the intersection without conflicting with the vehicles approaching from the left; and (2) accelerate to the operating speed of the roadway without causing approaching vehicles to unduly reduce their speed. In this context, ISD can be considered as a desirable visibility criterion for the safe operation of an unsignalized intersection. Essentially, while SSD is the minimum distance needed to avoid collisions, ISD is the minimum distance needed so that mainline motorists will not have to substantially reduce their speed due to turning vehicles. To maintain the safe operation of an unsignalized intersection, ISD only needs to be equal to the stopping sight distance, though it is desirable to meet ISD requirements by themselves.

Sight distance measurements were conducted at the proposed Site driveway on Oak Street, the proposed south Site driveway on Needham Street, and the Tower Road approach to Needham Street. The northern Site driveway on Needham Street is proposed to be under signalized control and therefore sight distance conflicts will be restricted. It should be noted that the Site driveway on Oak Street and the southern Site driveway on Needham Street are proposed to be relocated from their existing locations under future conditions, while the Tower Road approach will maintain its existing location.

To calculate the required SSD and ISD at the unsignalized Site driveway, the 85th percentile speeds along Oak Street and Needham Street measured by the ATR count was utilized. The 85th percentile speed along Oak Street was observed to be 34 mph in the northbound direction and 30 mph in the southbound direction and the 85th percentile speed along Needham Street was observed to be 30 mph in both the northbound and southbound directions.

Table 14 summarizes the sight distance analysis for the proposed unsignalized Site access points. The sight distance worksheets are included in Appendix A.

Table 14 Sight Distance Analysis

		Stopping Sight Distance [a]		Intersection Sight Distance [a]		
Location	**Traveling**	**Required (ft)**	**Measured (ft)**	**Looking**	**Desired (ft)**	**Measured (ft)**
Site Driveway at Oak Street [b]	Northbound	240	435	Left	375	420
	Southbound	200	400	Right	325	330
South Site Driveway at Needham Street	Northbound	200	>500	Left	335	>500
	Southbound	200	>500	Right	290	350
Tower Road at Needham Street	Northbound	200	>500	Left	335	>500
	Southbound	200	>500	Right	290	>500

Source: Based on guidelines established in A Policy on the Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials [AASHTO], 2011.

a Speeds are based the 85th percentile speed of 30-34 mph.

b Oak Street is described as running in a north-south orientation at the Site driveway.

As shown in Table 14, the required stopping sight distance and the desirable intersections sight distances are available on all approaches at all three of the proposed unsignalized Site access points. It should be noted that the sight distances along Needham Street in both directions at the south Site driveway are visible to/from the existing signalized intersection at Oak Street/Christina Street to the south and the proposed signalized intersection at Charlemont Street to the north.

While all sight measurements are met, the desired intersection sight distance is barely met looking right from the Site driveway on Oak Street (330 feet versus 325 feet). However, the intersection sight distance is met from just south of the signalized intersection of Oak Street at Chestnut Street, and it is expected that vehicles will be travelling slower and will be more alert just after departing the signalized intersection before they reach full travel speed. In addition, while the desired intersection is just met, the minimum required intersection sight distance (200 feet) is fully met at this location.

4

Traffic Operations Analysis

Measuring existing traffic volumes and projecting future traffic volumes quantifies traffic flow within the study area. To assess quality flow, roadway capacity analyses were conducted with respect to Existing and projected No-Build, Build with Robust Shuttle Service, and Build with Existing Mode Share traffic volume conditions. Capacity analyses provide an indication of how well the roadway facilities serve the traffic demands placed upon them. Roadway operating conditions are classified by calculated levels of service.

Level-of-Service Criteria

The evaluation criteria used to analyze area intersections in this traffic study are based on the 2010 Highway Capacity Manual (HCM)[9]. The term 'Level of Service' (LOS) is used to denote the different operating conditions that occur on a given roadway segment under various traffic volume loads. It is a qualitative measure that considers a number of factors including roadway geometry, speed, travel delay and freedom to maneuver. LOS provides an index to the operational qualities of a roadway segment or an intersection. LOS designations range from A to F, with LOS A representing the best operating conditions and LOS F representing the worst operating conditions.

In addition to LOS, two other measures of effectiveness are typically used to quantify the traffic operations at intersections; volume-to-capacity ratio (v/c) and delay (expressed in

[9] Transportation Research Board, *Highway Capacity Manual*, Washington, D.C., 2010.

seconds per vehicle). For example, an existing v/c ratio of 0.90 for an intersection indicates that the intersection is operating at 90 percent of its available capacity. A delay of 15 seconds for a particular vehicular movement or approach indicates that vehicles on the movement or approach will experience an average additional travel time of 15 seconds. For a given LOS letter designation there may be a wide range of values for both v/c ratios and delay. Comparison of intersection capacity results therefore requires that, in addition to the LOS, the other measures of effectiveness should also be considered.

The LOS designations, which are based on delay, are reported differently for signalized and unsignalized intersections. For signalized intersections, the analysis considers the operation of all traffic entering the intersection and the LOS designation is for overall conditions at the intersection. For unsignalized intersections, however, the analysis assumes that traffic on the mainline is not affected by traffic on the side streets. Thus, the LOS designation is for the critical movement exiting the side street, which is generally the left turn out of the side street or site driveway. Table 15 shows the LOS criteria for both signalized intersections and unsignalized intersections.

It should be noted that the analytical methodologies typically used for the analysis of unsignalized intersections use conservative analysis parameters, such as long critical gaps. Actual field observations indicate that drivers on minor streets generally accept shorter gaps in traffic than those used in the analysis procedures and therefore experience less delay than reported by the analysis software. The analysis methodologies also do not fully take into account the beneficial grouping effects caused by nearby signalized intersections. The net effect of these analysis procedures is the over-estimation of calculated delays at unsignalized intersections in the study area. Cautious judgment should therefore be exercised when interpreting the capacity analysis results at unsignalized intersections.

Table 15 Level of Service Criteria

Level of Service	Delay – Signalized Intersection	Delay – Unsignalized Intersection
A	0 to 10 seconds	0 to 10 seconds
B	10 to 20 seconds	10 to 15 seconds
C	20 to 35 seconds	15 to 25 seconds
D	35 to 55 seconds	25 to 35 seconds
E	55 to 80 seconds	35 to 50 seconds
F	Greater than 80 seconds	Greater than 50 seconds

Source: 2010 Highway Capacity Manual.

Intersection Capacity Analysis – With Existing Mode Share

While we believe that the proposed TDM plan, including a robust shuttle bus system, will significantly reduce single occupancy vehicle access to the site, for the purpose of presenting a highly conservative assessment of project impacts, the operations tables below provide future condition analysis results assuming Existing Mode Share conditions.

To demonstrate future operations with what is likely a more reasonable mode share with the Robust TDM plan, additional analyses are presented in Appendix A.

Signalized Intersection Capacity Analysis

Capacity analyses were conducted for the signalized study area intersections. Table 16 summarizes the results for the 2018 Existing, 2025 No-Build, and 2025 Build with Existing Mode Share Conditions. All capacity analysis worksheets are included in Appendix A. It should be noted that the MassDOT redesign project along Needham Street, Winchester Street, and Highland Avenue is assumed to be in place for the No-Build and Build conditions and some of the changes in operations at the study area intersections between the 2018 Existing and 2025 No-Build Conditions are directly due to that project.

Table 16 Signalized Intersection Capacity Analysis

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
3: Chestnut Street at Eliot Street															
Weekday Morning															
EB L/T/R	0.94	43	D	197	#734	1.10	89	F	~326	#805	1.13	100	F	~356	#805
WB L/T/R	0.12	10	B	12	63	0.13	11	B	13	61	0.13	11	B	15	61
NB L/T/R	0.51	23	C	61	162	0.47	21	C	68	177	0.48	21	C	77	197
SB L/T/R	0.80	31	C	120	298	0.82	32	C	157	#424	0.82	32	C	166	#447
Total		**34**	**C**				**56**	**E**				**59**	**E**		
Weekday Evening															
EB L/T/R	0.95	57	E	218	#657	1.13	114	F	~329	#686	>1.20	>120	F	~356	#696
WB L/T/R	0.35	22	C	76	223	0.43	27	C	110	241	0.46	29	C	115	241
NB L/T/R	0.56	21	C	94	233	0.61	22	C	128	313	0.62	22	C	145	353
SB L/T/R	0.87	33	C	239	#600	0.87	31	C	290	#717	0.86	31	C	322	#781
Total		**36**	**D**				**51**	**D**				**62**	**E**		
Saturday Midday															
EB L/T/R	0.75	32	C	117	#367	0.82	39	D	140	#402	0.83	40	D	140	#403
WB L/T/R	0.30	17	B	42	130	0.31	17	B	48	133	0.31	17	B	48	133
NB L/T/R	0.59	26	C	80	220	0.63	28	C	101	#288	0.73	33	C	125	#364
SB L/T/R	0.80	32	C	152	#432	0.83	35	C	193	#522	0.91	43	D	228	#604
Total		**28**	**C**				**32**	**C**				**37**	**D**		
4: Chestnut Street at Oak Street															
Weekday Morning															
EB L/T/R	0.61	10	A	10	86	0.66	10	A	11	92	0.67	10	A	11	94
WB L/T/R	0.46	31	C	15	56	0.43	30	C	14	57	0.42	29	C	14	57
NB L/T/R	0.59	16	B	68	#361	0.61	17	B	73	#407	0.65	19	B	80	#445
SB L/T/R	0.06	9	A	6	37	0.06	9	A	5	39	0.06	10	A	5	40
Total		**14**	**B**				**14**	**B**				**15**	**B**		
Weekday Evening															
EB L/T/R	061	10	B	11	59	0.61	10	B	9	81	0.63	10	B	9	85
WB L/T/R	0.42	28	C	18	64	0.43	29	C	17	64	0.46	31	C	18	65
NB L/T/R	0.57	16	B	61	#329	0.67	19	B	71	#407	0.73	22	C	88	#471
SB L/T/R	0.16	9	A	17	90	0.17	9	A	17	95	0.17	9	A	19	99
Total		**14**	**B**				**15**	**B**				**17**	**B**		
Saturday Midday															
EB L/T/R	0.58	8	A	6	81	0.64	9	A	7	86	0.70	10	A	8	92
WB L/T/R	0.19	20	B	8	33	0.17	20	C	7	36	0.20	22	C	8	36
NB L/T/R	0.59	17	B	49	#244	0.59	17	B	52	#318	0.62	18	B	64	#400
SB L/T/R	0.18	10	A	15	83	0.17	10	A	15	89	0.15	10	A	15	91
Total		**12**	**B**				**13**	**B**				**14**	**B**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

Table 16 Signalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
6: Needham Street at Oak Street / Christina Street [f]															
Weekday Morning															
EB L/T	0.65	31	C	81	#212	>1.20	>120	F	~289	#480	>1.20	>120	F	~295	#488
EB R	0.23	5	A	0	38	0.24	8	A	19	67	0.27	8	A	22	75
WB L	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.73	65	E	99	#224	0.73	66	E	99	#224
WB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.52	44	D	158	267	0.55	45	D	168	281
WB L/T/R	0.85	44	D	130	#327	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
NB L	0.63	27	C	32	#96	0.95	81	F	114	#294	0.83	58	D	90	#238
NB T/R	0.83	22	C	218	347	0.76	21	C	431	754	0.82	24	C	502	#895
SB L	0.19	11	B	6	20	0.18	21	C	13	41	0.24	25	C	14	45
SB T/R	0.78	19	B	194	309	0.96	59	E	608	#1025	0.99	67	E	645	#1070
Total		**25**	**C**				**60**	**E**				**62**	**E**		
Weekday Evening															
EB L/T	0.79	41	D	104	#287	>1.20	>120	F	~332	#545	1.19	>120	F	~293	#500
EB R	0.28	6	A	3	44	0.37	12	B	47	114	0.34	22	B	38	99
WB L	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	1.08	>120	F	~110	#249	0.92	102	F	97	#232
WB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.41	38	D	113	193	0.45	39	D	125	210
WB L/T/R	0.89	54	D	112	#330	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
NB L	0.84	52	D	44	#154	0.78	50	D	80	#204	0.89	67	E	103	#258
NB T/R	0.79	19	B	212	325	0.74	21	C	411	725	0.80	24	C	480	#876
SB L	0.21	11	B	7	22	0.23	22	C	18	48	0.35	28	C	22	63
SB T/R	0.81	21	C	222	343	1.04	86	F	~791	#1113	1.14	104	F	~931	#1263
Total		**28**	**C**				**68**	**E**				**70**	**E**		
Saturday Midday															
EB L/T	0.88	52	D	122	#285	>1.20	>120	F	~318	#490	>1.20	>120	F	~334	#510
EB R	0.26	5	A	0	39	0.26	8	A	23	67	0.29	8	A	28	75
WB L	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.95	103	F	92	#229	0.99	114	F	93	#232
WB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.35	29	C	71	139	0.40	31	C	86	160
WB L/T/R	0.87	50	D	106	#267	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
NB L	0.86	64	E	37	#137	0.64	31	C	42	#119	0.73	39	D	61	#173
NB T/R	0.69	16	B	177	279	0.69	18	B	304	563	0.77	21	C	376	#710
SB L	0.13	9	A	6	19	0.16	19	B	14	39	0.26	22	C	16	48
SB T/R	0.87	25	C	253	#410	1.14	102	F	~775	#1095	>1.20	>120	F	~881	#1209
Total		**30**	**C**				**76**	**E**				**93**	**F**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
f Intersection lane geometry proposed to change with the Needham Street at Oak Street / Christina Street MassDOT improvement project.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

Table 16 Signalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	2025 No-Build Condition v/c	Del	LOS	50 Q	95 Q	2025 Build Condition with Existing Mode Share v/c	Del	LOS	50 Q	95 Q
9: Needham Street at North Site Driveway/Charlemont Street															
Weekday Morning															
EB L						0.04	30	C	3	12	0.40	39	D	33	59
EB T/R						0.01	0	A	0	0	0.12	1	A	0	0
WB L						0.19	34	C	13	36	0.19	36	D	14	38
WB T/R						0.04	0	A	0	0	0.04	0	A	0	0
NB L						0.03	7	A	1	14	0.22	11	B	10	51
NB T/R						0.59	11	B	139	#733	0.63	13	B	164	#726
SB L						0.04	7	A	1	13	0.06	9	A	3	14
SB T/R						0.57	11	B	131	#692	0.71	19	B	281	#731
Total							**11**	**B**				**16**	**B**		
Weekday Evening															
EB L						0.50	43	D	35	92	0.81	61	E	112	#228
EB T/R						0.07	0	A	0	0	0.18	1	A	0	0
WB L						0.22	35	C	15	48	0.16	34	C	19	50
WB T/R	*Intersection is not signalized in Existing Condition*					0.18	20	B	6	37	0.13	18	B	8	37
NB L						0.06	7	A	1	18	0.58	35	D	24	92
NB T/R						0.66	13	B	194	712	0.69	16	B	268	#641
SB L						0.02	7	A	1	6	0.02	11	B	1	7
SB T/R						0.67	14	B	179	#668	0.95	41	D	501	#901
Total							**15**	**B**				**31**	**C**		
Saturday Midday															
EB L						0.49	44	D	31	82	0.78	59	E	105	#210
EB T/R						0.09	0	A	0	0	0.20	1	A	0	0
WB L						0.42	42	D	27	73	0.29	37	D	33	75
WB T/R						0.19	14	B	1	29	0.13	13	B	1	29
NB L						0.06	7	A	1	18	0.65	41	D	26	107
NB T/R						0.69	13	B	204	#766	0.77	20	C	303	#817
SB L						0.06	7	A	2	12	0.09	12	B	4	15
SB T/R						0.68	14	B	184	#705	1.00	51	D	~552	#980
Total							**15**	**B**				**36**	**D**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

Table 16 Signalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
13: Needham Street at Columbia Avenue/Avalon Driveway															
Weekday Morning															
EB L/T	0.10	21	C	8	29	0.09	30	C	7	40	0.10	31	C	8	40
EB R	0.11	9	A	0	11	0.08	1	A	0	0	0.09	1	A	0	0
WB L/T/R	0.15	16	B	6	30	0.14	22	C	6	40	0.15	23	C	6	40
NB L	0.05	5	A	1	10	0.07	6	A	1	12	0.07	6	A	1	12
NB T/R	0.47	7	A	83	273	0.52	7	A	110	377	0.57	8	A	128	442
SB L	0.00	5	A	0	2	0.00	5	A	0	2	0.00	5	A	0	2
SB T/R	0.58	9	A	118	391	0.69	11	B	186	664	0.71	11	B	204	#782
Total		**8**	**A**				**10**	**A**				**10**	**A**		
Weekday Evening															
EB L/T	0.04	23	C	2	17	0.03	28	C	1	22	0.04	31	C	2	22
EB R	0.06	5	A	0	2	0.05	0	A	0	0	0.05	0	A	0	0
WB L/T/R	0.04	18	B	1	16	0.04	23	C	1	19	0.05	25	C	1	19
NB L	0.05	4	A	0	14	0.05	4	A	0	16	0.06	4	A	0	16
NB T/R	0.55	7	A	0	371	0.64	8	A	0	688	0.69	10	A	0	#941
SB L	0.00	4	A	0	2	0.00	4	A	0	2	0.00	4	A	0	2
SB T/R	0.39	5	A	0	242	0.48	6	A	0	373	0.54	6	A	0	476
Total		**6**	**A**				**7**	**A**				**8**	**A**		
Saturday Midday															
EB L/T	0.04	21	C	1	16	0.04	28	C	2	21	0.05	33	C	4	21
EB R	0.04	2	A	0	0	0.03	0	A	0	0	0.04	0	A	0	0
WB L/T/R	0.07	16	B	1	23	0.08	23	C	3	30	0.12	26	C	4	31
NB L	0.02	4	A	0	7	0.02	4	A	0	8	0.03	4	A	0	9
NB T/R	0.54	6	A	0	378	0.65	9	A	0	#751	0.71	10	B	0	#1018
SB L	0.02	4	A	0	5	0.02	4	A	0	5	0.03	4	A	0	5
SB T/R	0.43	5	A	0	248	0.51	6	A	0	422	0.58	7	A	0	579
Total		**6**	**A**				**8**	**A**				**9**	**A**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
95th percentile volume exceeds capacity, queue may be longer.

Table 16 Signalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition [f]					2025 Build Condition with Existing Mode Share				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
14: Winchester Street at Needham Street/Dedham Street [g]															
Weekday Morning															
EB L	1.19	>120	F	~457	#676	0.75	36	D	206	305	0.79	38	D	227	334
EB L/T	1.18	>120	F	~458	#677	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
EB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.27	24	C	56	116	0.29	24	C	60	124
EB R	0.11	0.6	A	0	0	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
WB L/T/R	1.12	>120	F	~296	#646	1.02	93	F	~177	#390	1.05	100	F	~191	#399
NB L/T/R	1.07	117	F	~367	394	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
NB L	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.19	29	C	14	44	0.22	30	C	17	49
NB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.55	32	C	159	276	0.55	32	C	159	276
SB L/T	0.90	79	E	301	395	0.87	51	D	244	#452	0.88	53	D	245	#454
SB R	0.42	1	A	0	0	0.72	8	A	114	263	0.74	9	A	136	305
Total		**93**	**F**				**35**	**C**				**37**	**D**		
Weekday Evening															
EB L	0.95	85	F	298	#498	0.78	35	D	226	311	0.83	38	D	256	#351
EB L/T	0.96	86	F	307	#510	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
EB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.32	24	C	72	133	0.35	25	C	82	148
EB R	0.09	0	A	0	0	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
WB L/T/R	>1.20	>120	F	~176	#419	0.77	52	D	104	#207	0.80	55	E	113	#229
NB L/T/R	0.80	53	D	284	354	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
NB L	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.10	24	C	9	28	0.16	26	C	14	38
NB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.62	32	C	201	301	0.63	33	C	202	301
SB L/T	0.98	84	F	303	#475	1.03	86	F	~270	#471	1.09	105	F	~280	#479
SB R	0.34	1	A	0	0	0.48	2	A	9	45	0.54	3	A	30	84
Total		**67**	**E**				**35**	**D**				**38**	**D**		
Saturday Midday															
EB L	1.20	>120	F	~475	#696	0.76	33	C	204	#352	0.81	35	D	243	#443
EB L/T	1.20	>120	F	~488	#711	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
EB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.40	24	C	84	185	0.44	25	C	100	212
EB R	0.19	5	A	0	24	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
WB L/T/R	1.12	>120	F	~300	#517	0.82	55	D	134	#337	0.89	66	E	147	#365
NB L/T/R	1.10	>120	F	~284	#396	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
NB L	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.20	29	C	19	51	0.29	31	C	27	68
NB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.53	33	C	118	212	0.53	33	C	118	212
SB L/T	0.98	105	F	257	#350	0.78	46	D	147	265	0.78	47	D	147	266
SB R	0.33	1	A	0	0	0.56	5	A	50	137	0.65	7	A	91	230
Total		**106**	**F**				**29**	**C**				**31**	**C**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
f Operational improvements from Existing Conditions to No-Build conditions due to MassDOT reconstruction project.
g Intersection lane geometry proposed to change with the MassDOT reconstruction project.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

Table 16 Signalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	2025 No-Build Condition v/c	Del	LOS	50 Q	95 Q	2025 Build Cond. w/ Ex. Mode Share v/c	Del	LOS	50 Q	95 Q
15: Winchester Street at Route 9 Eastbound Service Road															
Weekday Morning															
EB L						0.18	56	E	53	99	0.18	56	E	53	99
EB R						0.50	33	C	159	257	0.51	34	C	165	263
NB T						1.10	97	F	~1258	#1523	1.14	111	F	~1350	#1615
NB R						0.27	9	A	53	84	0.29	9	A	58	90
SB L						0.30	33	C	38	m32	0.30	33	C	39	m31
SB T						0.94	59	E	288	m179	0.97	59	E	325	m180
Total							**65**	**E**				**71**	**E**		
Weekday Evening															
EB L						0.16	51	D	44	86	0.17	51	D	49	93
EB R						0.24	11	B	25	77	0.24	12	B	30	83
NB T	*Intersection is not signalized in Existing Condition*					1.14	112	F	~1227	#1491	>1.20	>120	F	~1357	#1623
NB R						0.40	11	B	81	123	0.42	11	B	87	132
SB L						0.53	51	D	93	m77	0.53	51	D	94	m69
SB T						0.79	57	E	150	m128	0.85	59	E	170	m135
Total							**70**	**E**				**83**	**F**		
Saturday Midday															
EB L						0.33	59	E	99	162	0.34	60	E	104	169
EB R						0.33	10	A	23	88	0.34	14	B	43	113
NB T						0.83	42	D	701	905	0.91	60	E	842	#1147
NB R						0.39	9	A	80	123	0.42	10	B	91	137
SB L						0.63	54	D	119	m132	0.63	51	D	118	m117
SB T						0.60	21	C	196	m210	0.68	50	D	220	m216
Total							**29**	**C**				**46**	**D**		
16: Winchester Street at Route 9 Westbound Service Road															
Weekday Morning															
EB L/T/R						0.09	1	A	0	0	0.09	1	A	0	0
WB L						1.16	>120	F	~244	#416	1.20	>120	F	~257	#431
WB T/R						0.06	0	A	0	0	0.06	0	A	0	0
NB L						1.05	103	F	~232	m#236	1.05	89	F	~232	m#221
NB T						0.83	35	D	193	m200	0.86	49	D	198	m198
SB L/T/R						>1.20	>120	F	~1640	#1908	>1.20	>120	F	~1700	#1968
Total							**110**	**F**				**120**	**F**		
Weekday Evening															
EB L/T/R						0.12	1	A	0	0	0.11	1	A	0	0
WB L						0.87	118	F	145	#267	0.93	>120	F	162	#305
WB T/R	*Intersection is not signalized in Existing Condition*					0.09	0	A	0	0	0.08	0	A	0	0
NB L						0.62	61	E	118	m110	0.65	64	E	124	m107
NB T						0.78	28	C	56	m70	0.83	54	D	120	m68
SB L/T/R						>1.20	>120	F	~1376	#1642	>1.20	>120	F	~1507	#1773
Total							**90**	**F**				**118**	**F**		
Saturday Midday															
EB L/T/R						0.12	1	A	0	0	0.12	1	A	0	0
WB L						0.99	>120	F	205	#377	1.10	>120	F	~253	#431
WB T/R						0.10	1	A	0	0	0.10	1	A	0	0
NB L						0.88	90	F	179	m#258	0.90	89	F	185	m#229
NB T						0.60	5	A	66	113	0.65	6	A	83	m122
SB L/T/R						0.92	97	F	829	#1135	1.01	102	F	~1019	#1322
Total							**64**	**E**				**66**	**E**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.
m Volume for 95th percentile queue is metered by upstream signal.

Table 16 Signalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
17: Centre Street at Walnut Street															
Weekday Morning															
SEB L/T	0.15	45	D	14	38	0.16	45	D	14	40	0.16	45	D	14	40
SEB R	0.67	36	D	189	285	0.84	47	D	256	#450	0.87	50	D	265	#468
NWB L/T/R	0.48	53	D	54	103	0.47	53	D	52	101	0.47	53	D	52	101
NEB L	0.65	16	B	107	209	0.81	33	C	170	#374	0.86	38	D	188	#409
NEB T/R	0.52	12	B	232	370	0.59	15	B	279	448	0.61	15	B	296	475
SWB L/T/R	0.82	38	D	396	#655	1.04	72	E	~627	#915	1.06	78	E	~649	#940
Total		**26**	**C**				**44**	**D**				**47**	**D**		
Weekday Evening															
SEB L/T	0.24	47	D	12	53	0.25	48	D	22	54	0.25	48	D	22	54
SEB R	0.80	44	D	233	#396	0.93	59	E	~294	#510	0.97	68	E	~335	#546
NWB L/T/R	0.40	50	D	45	89	0.40	50	D	45	89	0.40	50	D	45	89
NEB L	0.62	15	B	99	186	0.82	29	C	166	#371	0.88	38	D	198	#425
NEB T/R	0.38	9	A	145	230	0.51	12	B	219	343	0.53	13	B	240	374
SWB L/T/R	0.84	39	D	401	#662	0.93	49	D	~482	#770	0.99	61	E	~566	#836
Total		**29**	**C**				**37**	**D**				**44**	**D**		
Saturday Midday															
SEB L/T	0.31	47	D	21	63	0.33	47	D	22	64	0.33	47	D	22	64
SEB R	0.62	31	C	130	281	0.72	35	D	156	#352	0.78	39	D	173	#437
NWB L/T/R	0.70	60	E	76	#180	0.71	61	E	80	#192	0.71	61	E	80	#192
NEB L	0.68	15	B	68	210	0.72	17	B	73	#293	0.80	23	C	80	#381
NEB T/R	0.26	8	A	45	147	0.29	8	A	55	178	0.33	9	A	64	205
SWB L/T/R	0.63	27	C	195	374	0.67	29	C	215	459	0.74	32	C	247	#568
Total		**24**	**C**				**26**	**C**				**29**	**C**		
18: Nahanton Street at Winchester Street															
Weekday Morning															
EB L	0.50	8	A	52	51	0.63	12	B	57	90	0.63	13	B	57	94
EB T	0.37	6	A	127	116	0.40	5	A	143	115	0.40	5	A	142	115
WB T/R	0.59	18	B	295	450	0.72	22	C	395	586	0.73	22	C	399	594
SB L	0.07	42	D	13	41	0.12	46	D	21	55	0.16	47	D	27	67
SB R	0.60	39	D	183	262	0.73	44	D	247	352	0.74	44	D	248	352
Total		**17**	**B**				**20**	**C**				**21**	**C**		
Weekday Evening															
EB L/T/R	0.56	10	A	86	149	0.73	14	B	115	138	0.76	16	B	117	142
WB T/R	0.44	9	A	172	282	0.51	9	A	226	264	0.51	9	A	228	247
WB L	0.43	19	B	194	347	0.53	21	C	273	380	0.56	22	C	289	390
NB L/T/R	0.13	38	D	29	59	0.20	41	D	45	91	0.25	42	D	59	114
NB L/T	0.57	34	C	204	249	0.62	35	C	225	327	0.62	35	C	227	338
Total		**18**	**B**				**19**	**B**				**20**	**B**		
Saturday Midday															
EB L/T/R	0.48	8	A	43	77	0.59	10	B	52	79	0.63	12	B	54	79
WB T/R	0.33	6	A	83	137	0.38	7	A	103	149	0.38	7	A	106	145
WB L	0.55	17	B	190	316	0.62	19	B	228	346	0.66	20	C	251	367
NB L/T	0.21	30	C	35	67	0.23	31	C	38	78	0.31	32	C	51	100
SB R	0.56	26	C	141	192	0.55	26	C	137	216	0.55	26	C	137	222
Total		**15**	**B**				**16**	**B**				**17**	**B**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

Table 16 Signalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
19: Nahanton Street at Wells Avenue/JCC Driveway															
Weekday Morning															
EB L	0.15	4	A	6	19	0.16	4	A	8	19	0.16	4	A	8	19
EB T	0.58	14	B	145	287	0.64	17	B	215	349	0.64	17	B	215	349
EB R	0.29	3	A	4	39	0.40	4	A	17	61	0.40	4	A	17	61
WB L	0.49	7	A	28	63	0.79	19	B	57	#133	0.79	19	B	57	#133
WB T/R	0.71	17	B	183	371	0.75	19	B	259	428	0.75	19	B	259	428
NB L	0.52	42	D	40	101	0.63	50	D	64	121	0.63	50	D	64	121
NB T/R	0.44	13	B	6	60	0.47	13	B	8	63	0.47	13	B	8	63
SB L	0.43	40	D	29	78	0.48	46	D	37	80	0.48	46	D	37	80
SB T/R	0.23	14	B	4	40	0.23	15	B	5	40	0.23	15	B	5	40
Total		**14**	**B**				**17**	**B**				**17**	**B**		
Weekday Evening															
EB L	0.18	14	B	13	33	0.19	15	B	15	34	0.19	15	B	15	34
EB T	0.73	34	C	244	#430	0.93	55	D	330	#541	0.94	56	E	335	#548
EB R	0.18	10	B	13	52	0.24	12	B	23	67	0.24	12	B	23	67
WB L	0.44	17	B	44	85	0.70	32	C	61	#138	0.70	32	C	61	#138
WB T/R	0.92	50	D	336	#606	1.14	113	F	~501	#722	1.15	116	F	~507	#727
NB L	0.88	44	D	222	#396	0.97	59	E	313	#534	0.97	59	E	313	#534
NB T/R	0.44	4	A	7	60	0.51	7	A	39	115	0.51	7	A	39	116
SB L	0.41	24	C	44	93	0.47	27	C	52	109	0.47	27	C	52	109
SB T/R	0.10	5	A	1	24	0.09	5	A	1	24	0.09	5	A	1	24
Total		**32**	**C**				**56**	**E**				**57**	**E**		
Saturday Midday															
EB L	0.05	4	A	3	8	0.05	4	A	3	8	0.06	4	A	3	8
EB T	0.63	17	B	158	249	0.66	17	B	191	302	0.66	17	B	193	305
EB R	0.16	3	A	1	23	0.18	3	A	5	30	0.18	3	A	5	30
WB L	0.37	7	A	12	41	0.47	8	A	29	49	0.47	8	A	29	49
WB T/R	0.68	18	B	173	274	0.72	19	B	216	342	0.72	19	B	219	347
NB L	0.74	45	D	88	#246	0.80	55	D	102	#280	0.81	55	D	103	#280
NB T/R	0.32	8	A	2	44	0.34	9	A	2	54	0.34	9	A	2	54
SB L	0.14	28	C	13	49	0.17	31	C	16	52	0.17	31	C	16	52
SB T/R	0.10	12	B	1	27	0.11	12	B	1	28	0.11	12	B	1	28
Total		**18**	**B**				**19**	**B**				**20**	**B**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

Table 16 Signalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition [f]					2025 Build Condition with Existing Mode Share				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
22: Highland Avenue at 2nd Avenue/Staples Driveway [g]															
Weekday Morning															
EB L	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.02	13	B	1	10	0.02	14	B	1	10
EB L/T/R	0.54	14	B	171	155	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
EB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.58	14	B	158	442	0.59	15	B	167	464
WB L/T/R	1.18dl	27	C	222	231	>1.20dl	40	D	218	#635	>1.20dl	60	E	~276	#716
NB L	0.66	50	D	107	#280	0.39	40	D	47	128	0.40	41	D	51	128
NB L/T	0.67	50	D	108	#284	0.38	40	D	47	126	0.40	41	D	51	126
NB R	0.35	5	A	0	28	0.48	11	B	0	63	0.48	11	B	0	63
SB L/T	0.51	69	E	20	#72	0.18	39	D	15	49	0.18	39	D	16	49
SB R	0.00	0	A	0	0	0.00	0	A	0	0	0.00	0	A	0	0
Total		**25**	**C**				**27**	**C**				**35**	**C**		
Weekday Evening															
EB L	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.07	18	B	3	19	0.08	19	B	3	20
EB L/T/R	0.41	14	B	136	165	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
EB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.42	16	B	132	323	0.47	17	B	153	371
WB L/T/R	0.79	24	C	267	321	0.96	41	D	328	#798	1.06	67	E	~433	#882
NB L	>1.20	>120	F	~436	#602	0.67	49	D	112	231	0.67	49	D	112	231
NB L/T	>1.20	>120	F	~446	#612	0.66	48	D	112	230	0.66	48	D	112	230
NB R	0.40	9	A	0	46	0.46	9	A	0	63	0.46	9	A	0	63
SB L/T	>1.20	>120	F	~135	#193	0.45	49	D	48	112	0.45	49	D	48	112
SB R	0.11	1	A	0	0	0.08	0	A	0	0	0.08	0	A	0	0
Total		**118**	**F**				**32**	**C**				**43**	**D**		
Saturday Midday															
EB L	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.08	12	B	3	18	0.09	12	B	3	18
EB L/T/R	0.40	14	B	117	105	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
EB T/R	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	0.42	11	B	115	232	0.47	12	B	138	273
WB L/T/R	0.74	21	C	225	202	0.84	24	C	241	#540	0.96	37	D	310	#639
NB L	0.65	51	D	91	#212	0.37	40	D	44	95	0.37	40	D	44	95
NB L/T	0.64	50	D	90	#210	0.36	40	D	44	95	0.36	40	D	44	95
NB R	0.40	6	A	0	25	0.52	11	B	0	58	0.51	11	B	0	58
SB L/T	1.05	>120	F	~52	#169	0.49	49	D	44	103	0.49	49	D	44	103
SB R	0.04	0	A	0	0	0.05	0	A	0	0	0.05	0	A	0	0
Total		**27**	**C**				**20**	**C**				**26**	**C**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
f Operational improvements from Existing Conditions to No-Build conditions due to MassDOT reconstruction project.
g Intersection lane geometry proposed to change with the MassDOT reconstruction project.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.
dl Defacto Left Lane

Table 16 Signalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
25: Highland Avenue at 1st Avenue/Riverside Community Care Driveway															
Weekday Morning															
EB T						0.74	19	B	145	511	0.76	20	B	154	537
EB R						0.52	2	A	0	33	0.52	2	A	0	33
WB T/R						0.55	15	B	86	300	0.59	16	B	101	343
NB L						0.46	33	C	48	209	0.47	33	C	50	209
NB R						0.39	18	B	18	124	0.39	18	B	20	124
SB R						0.05	0	A	0	0	0.05	0	A	0	0
Total							**15**	**B**				**15**	**B**		
Weekday Evening															
EB T						0.49	16	B	127	348	0.53	17	B	145	395
EB R						0.17	1	A	0	22	0.17	1	A	0	22
WB T/R						0.87	26	C	303	#819	0.90	29	C	333	#881
NB L	*Intersection is not signalized in Existing Condition*					0.76	44	D	138	#383	0.76	45	D	138	#398
NB R						0.65	28	C	87	#250	0.65	28	C	87	#265
SB R						0.08	1	A	0	0	0.08	1	A	0	0
Total							**24**	**C**				**25**	**C**		
Saturday Midday															
EB T						0.44	8	A	64	137	0.47	8	A	77	160
EB R						0.12	0	A	0	3	0.11	0	A	0	3
WB T/R						0.68	10	B	122	225	0.69	10	B	142	253
NB L						0.43	22	C	42	112	0.46	25	C	48	122
NB R						0.35	11	B	13	64	0.38	13	B	15	68
SB R						0.00	0	A	0	0	0.00	0	A	0	0
Total							**10**	**A**				**10**	**A**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

As shown in Table 16, the following six signalized intersections are expected to see a degrade in overall LOS between the 2025 No-Build Conditions and the 2025 Build with Existing Mode Share Conditions:

- Chestnut Street at Elliot Street: From LOS D to LOS E during the weekday evening peak period and from LOS C to LOS D during the Saturday midday peak period.
- Needham Street at Oak Street / Christina Street: From LOS E to LOS F during the Saturday midday peak period.
- Needham Street at Charlemont Street / North Site Driveway: From LOS B to LOS C during the weekday evening peak period and from LOS B to LOS D during the Saturday midday peak period.
- Winchester Street at Needham Street / Dedham Street: From LOS C to LOS D during the weekday morning peak period.

- Winchester Street at Route 9 Eastbound Service Road: From LOS E to LOS F during the weekday evening peak period and from LOS C to LOS D during the Saturday midday peak period.
- Highland Avenue at 2nd Avenue / Staples Driveway: From LOS C to LOS D during the weekday evening peak period.

All other intersections and time periods are expected to see the overall LOS maintained from the 2025 No-Build Condition to the 2025 Build with Existing Mode Share Condition.

While queues and delays are expected to increase at some locations along Needham Street, Winchester Street, and Highland Avenue corridor, the No-Build and Build scenarios both include the design improvement project that is expected to start construction in 2019. The design MassDOT selected was analyzed to include future traffic growth and was approved with the understanding that the traffic issue will not be solved along this corridor. The design instead focuses on improving safety and accommodations for all users.

Off-Site mitigation in the form of signal timing adjustments are proposed at several study area intersections in order to improve traffic operations with the increase in Site-generated traffic. The off-Site mitigation measures are described in detail in the following chapter.

As noted previously, the Build with Existing Mode Share Condition assumes that the Site will not include a robust shuttle system and transit use on-Site will be comparable with existing transit use in the City of Newton. It is expected that the Site will include a robust shuttle bus system, and therefore the results presented above are very conservative. It is expected that the true operations will be better than the "worst-case" scenario presented above.

Unsignalized Intersection Capacity Analysis

Capacity analyses were conducted for the unsignalized study area intersections. Table 17 summarizes the results for the 2018 Existing, 2025 No-Build, and 2025 Build Existing Mode Share Conditions. All capacity analysis worksheets are included in Appendix A.

Table 17 Unsignalized Intersection Capacity Analysis

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	D [a]	v/c [b]	Del [c]	LOS [d]	95 Q [e]	D	v/c	Del	LOS	95 Q	D	v/c	Del	LOS	95 Q
1: Chestnut Street at Route 9 Westbound Service Road [f]															
Weekday Morning															
EB L/T/R	40	0.11	12	B	8	40	0.11	13	B	8	40	0.11	13	B	8
WB L/T/R	180	0.40	15	B	48	190	0.44	16	C	50	190	0.44	16	C	50
SB L/T/R	565	0.90	38	E	248	615	1.09	72	F	428	625	1.11	77	F	445
Weekday Evening															
EB L/T/R	145	0.39	16	C	43	150	0.41	17	C	43	150	0.42	18	C	43
WB L/T/R	175	0.42	17	C	48	180	0.47	18	C	53	185	0.50	19	C	55
SB L/T/R	615	1.09	95	F	495	655	>1.20	>120	F	665	680	>1.20	>120	F	733
Saturday Midday															
EB L/T/R	5	0.01	10	A	0	5	0.01	10	A	0	5	0.01	10	B	0
WB L/T/R	120	0.22	11	B	23	125	0.24	12	B	23	130	0.26	12	B	25
SB L/T/R	510	0.69	18	C	140	545	0.80	25	C	110	585	0.88	34	D	278
2: Chestnut Street at Route 9 Eastbound Service Road [f]															
Weekday Morning															
EB L/T/R	305	0.57	18	C	88	325	0.67	23	C	125	325	0.68	24	C	130
WB L/T/R	45	0.10	10	B	8	45	0.10	11	B	8	45	0.11	12	B	8
NB L/T/R	400	0.67	20	C	128	430	0.81	31	D	200	455	0.87	38	E	243
Weekday Evening															
EB L/T/R	330	0.62	20	C	108	345	0.74	26	D	143	350	0.77	28	D	150
WB L/T/R	20	0.06	11	B	5	20	0.06	12	B	5	20	0.06	12	B	5
NB L/T/R	320	0.57	17	C	88	385	0.77	26	D	160	420	0.86	33	D	203
Saturday Midday															
EB L/T/R	240	0.47	14	B	63	260	0.51	16	C	70	270	0.55	18	C	83
WB L/T/R	20	0.04	10	A	3	20	0.05	10	B	3	20	0.05	11	B	5
NB L/T/R	345	0.56	15	C	85	385	0.66	19	C	120	435	0.78	27	D	185
5: Oak Street at Site Driveway															
Weekday Morning															
WB L/R	neg	0.02	15	B	3	20	0.08	19	C	5	70	0.24	20	C	23
SB L	neg	-	8	A	0	25	0.03	9	A	3	40	0.04	9	A	3
Weekday Evening															
WB L/R	neg	0.01	14	B	0	120	0.41	24	C	48	140	0.47	26	D	60
SB L	neg	-	8	A	0	5	0.01	8	A	0	55	0.06	9	A	5
Saturday Midday															
WB L	neg	0.05	15	C	0	35	0.12	18	C	10	140	0.49	27	D	63
SB L	neg	-	8	A	0	5	0.01	8	A	0	70	0.07	9	A	5
7: Needham Street at South Site Driveway															
Weekday Morning															
EB L/R	neg	-	0	A	0	neg	0.02	35	E	3	65	0.34	31	D	35
NB L	neg	-	0	A	0	5	0.01	10	A	0	20	0.03	10	A	3
Weekday Evening															
EB L/R	neg	-	0	A	0	10	0.11	47	E	10	155	0.72	53	E	123
NB L	neg	-	0	A	0	neg	0.00	10	B	0	40	0.06	11	B	5
Saturday *Midday*															
EB L/R	neg	0.04	44	E	3	5	0.11	71	F	8	185	1.20	>120	F	275
NB L	neg	-	0	A	0	neg	0.00	10	B	0	110	0.17	11	B	15

a Demand
b Volume to capacity ratio.
c Average total delay, in seconds per vehicle.
d Level-of-service.
e 95th percentile queue, in feet.
f Analyzed as all-way STOP controlled.

Table 17 Unsignalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	D [a]	v/c [b]	Del [c]	LOS [d]	95 Q [e]	D	v/c	Del	LOS	95 Q	D	v/c	Del	LOS	95 Q
8: Needham Street at Middle Site Driveway/Former TJ Maxx Driveway [f]															
Weekday Morning															
EB L/T/R	25	0.10	19	C	8	25	0.13	26	D	13	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
NB L	15	0.02	9	A	3	15	0.02	10	A	3	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
SB L	5	0.01	9	A	0	5	0.01	10	A	0	5	0.01	10	B	0
Weekday Evening															
EB L/T/R	90	0.25	18	C	25	90	0.34	24	C	38	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
NB L	35	0.04	9	A	3	35	0.05	10	A	5	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
SB L	10	0.01	9	A	0	10	0.02	10	B	0	10	0.02	10	B	0
Saturday Midday															
EB L/T/R	120	0.43	25	D	50	120	0.61	45	E	88	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
NB L	100	0.12	10	A	10	100	0.15	11	B	13	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
SB L	10	0.01	9	A	0	10	0.02	10	B	0	10	0.02	11	B	3
9: Needham Street at North Site Driveway/Charlemont Street															
Weekday Morning															
EB L/T/R	10	0.29	29	D	8										
WB L/T/R	35	0.09	37	E	30										
NB L	15	0.02	9	A	3										
SB L	5	0.01	9	A	0										
Weekday Evening															
EB L/T/R	110	1.01	>120	F	165										
WB L/T/R	45	0.34	42	E	35	*Intersection to be Signalized under No-Build Conditions*					*Intersection to be Signalized under Build Conditions*				
NB L	25	0.03	9	A	3										
SB L	5	0.01	9	A	0										
Saturday Midday															
EB L/T/R	110	1.11	>120	F	188										
WB L/T/R	75	0.80	108	F	115										
NB L	25	0.03	9	A	3										
SB L	10	0.01	9	A	0										
10: Needham Street at Tower Road/Industrial Place															
Weekday Morning															
EB L/T/R	20	0.15	26	D	13	20	0.16	36	E	15	45	0.78	>120	F	88
WB L/T/R	15	0.14	30	D	13	15	0.15	43	E	13	15	0.16	47	E	13
NB L	15	0.02	10	A	3	15	0.02	10	B	3	15	0.02	10	B	3
SB L	5	0.01	9	A	0	5	0.01	10	A	0	5	0.01	10	A	0
Weekday Evening															
EB L/T/R	145	>1.20	>120	F	305	145	>1.20	>120	F	395	190	>1.20	>120	F	603
WB L/T/R	115	>1.20	>120	F	255	115	>1.20	>120	F	335	115	>1.20	>120	F	360
NB L	65	0.08	9	A	5	65	0.09	10	A	8	65	0.09	10	B	8
SB L	20	0.03	9	A	3	20	0.03	10	B	3	20	0.03	11	B	3
Saturday Midday															
EB L/T/R	165	>1.20	>120	F	418	165	>1.20	>120	F	500	210	>1.20	>120	F	728
WB L/T/R	115	>1.20	>120	F	215	115	>1.20	>120	F	318	115	>1.20	>120	F	365
NB L	45	0.05	9	A	5	45	0.06	10	A	5	45	0.07	11	B	5
SB L	20	0.03	10	A	3	20	0.03	10	B	3	20	0.03	11	B	3

a Demand
b Volume to capacity ratio.
c Average total delay, in seconds per vehicle.
d Level-of-service.
e 95th percentile queue, in feet.
f Middle Site Driveway to be Removed under Build Conditions

Table 17 Unsignalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	D [a]	v/c [b]	Del [c]	LOS [d]	95 Q [e]	D	v/c	Del	LOS	95 Q	D	v/c	Del	LOS	95 Q
11: Needham Street at Jaconnet Street															
Weekday Morning															
WB L/R	15	0.08	20	C	8	15	0.10	28	D	8	15	0.11	32	D	10
SB L	neg	-	9	A	0	neg	0.00	10	A	0	neg	0.00	10	A	0
Weekday Evening															
WB L/R	85	0.01	43	E	143	85	0.84	119	F	123	85	1.11	>120	F	163
SB L	10	0.52	9	A	0	10	0.02	10	B	0	10	0.02	11	B	3
Saturday Midday															
WB L/R	45	0.34	42	E	35	45	0.53	82	F	60	45	0.78	>120	F	88
SB L	20	0.03	10	B	3	20	0.04	11	B	3	20	0.04	12	B	3
12: Needham Street at Rockland Street															
Weekday Morning															
WB L/R	10	0.05	22	C	5	10	0.08	34	D	8	10	0.09	39	E	8
SB L	10	0.01	9	A	0	10	0.01	9	A	0	10	0.01	10	A	0
Weekday Evening															
WB L/R	15	0.07	20	C	5	15	0.11	32	D	10	15	0.14	40	E	13
SB L	15	0.02	9	A	3	15	0.02	11	B	3	15	0.03	11	B	3
Saturday Midday															
WB L/R	30	0.22	34	D	20	30	0.31	54	F	30	30	0.45	89	F	45
SB L	20	0.03	10	A	3	20	0.03	11	B	3	20	0.04	12	B	3
15: Winchester Street at Route 9 Eastbound Service Road															
Weekday Morning						*Intersection to be Signalized under No-Build Conditions*					*Intersection to be Signalized under Build Conditions*				
WB L/R	305	>1.20	>120	F	720										
SB L	65	0.12	13	B	10										
Weekday Evening															
WB L/R	170	>1.20	>120	F	443										
SB L	120	0.20	12	B	18										
Saturday Midday															
WB L/R	180	>1.20	>120	F	645										
SB L	135	0.22	12	B	23										
16: Winchester Street at Route 9 Westbound Service Road															
Weekday Morning						*Intersection to be Signalized under No-Build Conditions*					*Intersection to be Signalized under Build Conditions*				
EB L/T/R	40	0.20	19	C	18										
WB L/T	135	>1.20	>120	F	495										
WB R	15	0.06	20	C	5										
NB L	215	0.32	12	B	35										
Weekday Evening															
EB L/T/R	40	0.39	41	E	43										
WB L/T	120	>1.20	>120	F	445										
WB R	20	0.07	15	C	5										
NB L	125	0.16	10	B	15										
Saturday Midday															
EB L/T/R	40	0.14	17	C	13										
WB L/T	165	>120	>120	F	483										
WB R	15	0.04	14	B	3										
NB L	180	0.22	10	C	20										

a Demand
b Volume to capacity ratio.
c Average total delay, in seconds per vehicle.
d Level-of-service.
e 95th percentile queue, in feet.

Table 17 Unsignalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	D [a]	v/c [b]	Del [c]	LOS [d]	95 Q [e]	D	v/c	Del	LOS	95 Q	D	v/c	Del	LOS	95 Q
20: Highland Avenue at Riverside Street															
Weekday Morning															
NWB L/R	10	0.14	43	E	10	10	0.23	92	F	20	10	0.27	115	F	23
SWB L	neg	-	10	A	0	neg	0.00	11	B	0	neg	0.00	11	B	0
Weekday Evening															
NWB L/R	10	0.11	29	D	10	10	0.13	54	F	10	10	0.16	69	F	13
SWB L	neg	-	9	A	0	neg	0.00	10	A	0	neg	0.00	10	B	0
Saturday Midday															
NWB L/R	15	0.11	25	C	8	15	0.13	38	E	10	15	0.18	52	F	15
SWB L	5	0.01	9	A	0	5	0.01	10	B	0	5	0.01	11	B	0
21: Highland Avenue at Highland Terrace/Highland Circle															
Weekday Morning															
NEB L	5	0.01	10	A	0	5	0.01	10	B	0	5	0.01	11	B	0
SWB L	neg	-	10	A	0	neg	0.00	11	B	0	neg	0.00	11	B	0
NWB L/T/R	10	0.11	41	E	10	10	0.10	40	E	8	10	0.11	45	E	10
SEB L/T/R	5	0.07	23	C	5	5	0.03	20	C	3	5	0.03	22	C	3
Weekday Evening															
NEB L	10	0.01	10	B	0	10	0.02	11	B	3	10	0.02	12	B	3
SWB L	5	0.01	9	A	0	5	0.01	10	B	0	5	0.01	10	B	0
NWB L/T/R	5	0.17	59	F	15	5	0.09	49	E	8	5	0.11	63	F	10
SEB L/T/R	20	0.25	24	D	25	20	0.13	31	D	13	20	0.16	36	E	15
Saturday Midday															
NEB L	10	0.01	10	A	0	10	0.02	11	B	3	10	0.02	12	B	3
SWB L	neg	0.00	9	A	0	neg	0.00	10	A	0	neg	0.00	11	B	0
NWB L/T/R	15	0.20	53	F	18	15	0.16	46	E	13	15	0.21	63	F	18
SEB L/T/R	15	0.14	33	D	13	15	0.11	31	D	10	15	0.14	40	E	13
23: Highland Avenue at Charles Street															
Weekday Morning															
EB L	30	0.04	10	B	3	30	0.04	10	A	3	30	0.04	10	B	3
SB L/R	40	0.13	16	C	10	40	0.11	16	C	10	40	0.13	17	C	10
Weekday Evening															
EB L	65	0.15	14	B	13	65	0.14	14	B	13	65	0.15	14	B	13
SB L/R	130	0.78	74	F	128	130	0.73	63	F	118	130	0.84	88	F	145
Saturday Midday															
EB L	45	0.07	11	B	5	45	0.08	11	B	8	45	0.09	12	B	8
SB L/R	145	0.59	35	E	88	145	0.69	50	E	110	145	0.85	84	F	155

a Demand
b Volume to capacity ratio.
c Average total delay, in seconds per vehicle.
d Level-of-service.
e 95th percentile queue, in feet.

Table 17 Unsignalized Intersection Capacity Analysis (continued)

Location / Movement	2018 Existing Condition					2025 No-Build Condition					2025 Build Condition with Existing Mode Share				
	D [a]	v/c [b]	Del [c]	LOS [d]	95 Q [e]	D	v/c	Del	LOS	95 Q	D	v/c	Del	LOS	95 Q
24: Highland Avenue at Wexford Street															
Weekday Morning															
EB L	115	0.16	11	B	15	115	0.16	10	B	13	115	0.17	11	B	15
SB L/R	115	0.83	87	F	140	115	0.69	61	F	105	115	0.82	89	F	133
Weekday Evening															
EB L	110	0.25	16	C	25	110	0.24	15	B	23	110	0.26	15	C	25
SB L/R	230	>1.20	>120	F	385	230	>1.20	>120	F	353	230	>1.20	>120	F	405
Saturday Midday															
EB L	90	0.15	12	B	13	90	0.17	12	B	15	90	0.19	13	B	18
SB L/R	170	0.89	85	F	173	170	1.06	>120	F	225	170	>1.20	>120	F	288
25: Highland Avenue at 1st Avenue/Riverside Community Care Driveway															
Weekday Morning						*Intersection to be Signalized under No-Build Conditions*					*Intersection to be Signalized under Build Conditions*				
EB L/T	neg	-	0	A	0										
WB L/T	5	0.01	11	B	0										
NB L/T/R	75	0.20	15	B	18										
SB L/T/R	15	0.08	12	B	5										
Weekday Evening															
EB L/T	neg	-	0	A	0										
WB L/T	5	0.01	9	A	0										
NB L/T/R	85	0.21	13	C	20										
SB L/T/R	20	0.09	18	B	8										
Saturday Midday															
EB L/T	neg	-	0	A	0										
WB L/T	neg	-	0	A	0										
NB L/T/R	neg	0.16	11	B	15										
SB L/T/R	neg	-	0	A	0										
26: I-95 Northbound Ramps at Highland Avenue															
Weekday Morning															
NB R	270	0.69	31	D	125	320	1.10	117	F	343	330	1.15	>120	F	373
SB R	90	0.15	11	B	13	95	0.17	12	B	15	95	0.17	12	B	15
Weekday Evening															
NB R	165	0.29	13	B	30	195	0.39	16	C	45	205	0.44	18	C	55
SB R	105	0.23	14	B	23	110	0.26	15	C	25	110	0.27	16	C	28
Saturday Midday															
NB R	195	0.30	12	B	33	230	0.40	14	B	48	245	0.46	16	C	60
SB R	80	0.16	12	B	15	85	0.18	13	B	15	85	0.18	14	B	18
27: I-95 Southbound Ramps at Highland Avenue															
Weekday Morning															
NB R	750	>1.20	>120	F	>1000	910	>1.20	>120	F	>1000	935	>1.20	>120	F	>1000
SB R	530	0.71	20	C	148	550	0.82	29	D	225	550	0.83	29	D	225
Weekday *Evening*															
NB R	265	0.52	18	C	75	340	0.75	31	D	160	390	0.88	46	E	238
SB R	400	0.74	25	D	163	415	0.75	26	D	165	415	0.77	28	D	175
Saturday Midday															
NB R	260	0.42	14	B	53	350	0.63	20	C	110	400	0.74	27	D	163
SB R	420	0.68	21	C	133	435	0.77	27	D	175	435	0.79	30	D	190

a Demand
b Volume to capacity ratio.
c Average total delay, in seconds per vehicle.
d Level-of-service.
e 95th percentile queue, in feet.

As shown in Table 17, the critical movements at the majority of the unsignalized study area intersections currently operate at acceptable levels of service, with a few key exceptions. These conditions generally are expected to continue under the future 2025 conditions with and without the addition of Site-generated traffic. Examples of movements that see long delays and queues under existing and future conditions include the southbound approach of Chestnut Street at the Route 9 Westbound Service Road, the eastbound and westbound approaches of Tower Road and Industrial Place at Needham Street, the westbound approach of Jaconnet Street at Needham Street, the southbound approach of Charles Street at Highland Avenue, the southbound approach of Wexford Street at Highland Avenue, and the northbound approach of the I-95 southbound ramp at Highland Avenue. While extended queues and delays are expected under the 2018 Existing Conditions, 2025 No-Build Conditions, and 2025 Build Conditions with Existing Mode Share, the increase in traffic from Existing to No-Build to Build is expected to incrementally increase the delays and queues at each approach. However, as noted previously, operations in real life may be better than the results reported above due to drivers using less conservative analysis parameters, such as accepting shorter gaps in traffic when waiting to turn left.

At the unsignalized Site driveways, operations are expected to generally be acceptable. Each unsignalized driveway is proposed to consist of one general-purpose lane departing the Site and the results displayed at each driveway are for this shared lane. The Site driveway on Oak Street is expected to operate at LOS C and D, with delays ranging from 20 to 27 seconds and queues ranging from 23 to 63 feet. At the south Site driveway on Needham Street, the morning and evening operations are expected to operate at LOS D and E with delays ranging from 31 seconds to 53 seconds and queues ranging from 35 feet to 123 feet. During the Saturday midday peak period, the south Site driveway on Needham Street is expected to operate at LOS F, with delays greater than 120 seconds and queues reaching 275 feet. The amount of storage space at the south Site driveway between Needham Street and Unnamed Street is approximately 150 feet, so it is anticipated that the queue will not spill back past Unnamed Street during the weekday morning or evening peak hour but may spill back past Unnamed Street during the Saturday midday peak period. However, it is expected that if operations on Site reach this level with any frequency, residents, employees, and visitors to the Site will learn to adjust their travel habits and will shift which driveways they use to exit the Site until there is an equilibrium of delays and queues among the different exit points to the Site. For example, it is expected that if delays reach this level, all traffic heading north on Needham Street would instead use the signalized exit at Charlemont Street to exit the Site and some traffic heading south on Needham Street may use the signalized exit at Charlemont Street as well.

While queues and delays are expected to increase at some locations along Needham Street, Winchester Street, and Highland Avenue corridor, the No-Build and Build scenarios both include the design improvement project that is expected to start construction in 2019. The design MassDOT selected was analyzed to include future traffic growth and was approved with the understanding that the traffic issue will not be solved along this corridor. The design instead focuses on improving safety and accommodations for all users.

As noted previously, the Build with Existing Mode Share Condition assumes that the Site will not include a robust shuttle system and transit use on-Site will be comparable with existing transit use in the City of Newton. As proposed, the project will include a robust shuttle bus system, and therefore the results presented above are very conservative. The expectation with the proposed TDM plan and shuttle bus system is that modes of transportation for some residents, employees, patrons, and neighbors in the area will change and as a result traffic generation should decrease from the levels that are analyzed and presented in the tables above. To present a more realistic assessment of future conditions, with mode change expected with TDM plan and shuttle system, additional analyses have been conducted and are presented in Tables A-1 and A-2 in Appendix A.

Intersection Capacity Analysis – With Robust Shuttle Service

Capacity analyses were also conducted for all study area intersections for the 2025 Build with Robust Shuttle Service Conditions and compared against the 2018 Existing and 2025 No-Build Conditions. Tables summarizing the signalized and unsignalized capacity analysis results are included in Appendix A and a description of the analyses are described below.

As stated previously, it has not been decided what the schedule and service will be for the proposed shuttle service. It is expected that the actual operations at the study area intersections may be somewhere between the two conditions that are summarized.

Signalized Intersection Capacity Analysis

As expected, the effects of the Site-generated traffic on signalized intersection operations is less when a robust shuttle service is in place than when a robust shuttle service is not included. On average, the inclusion of the robust shuttle bus service will reduce overall delays at the study area intersections by up to 5 seconds. The intersection with the greatest improvement under the Build with Robust Shuttle Service Condition is the intersection of Needham Street at Oak Street / Christina Street. It should be noted that several intersections will operate with the same overall delay under the Build with Existing Mode Share Condition as under the Build with Robust Shuttle Service Condition.

Unsignalized Intersection Capacity Analysis

Similar to the signalized intersection capacity analysis, operations are better under the Build Condition with Robust Shuttle Service than under the Build Condition with Existing Mode Share. On average, the inclusion of the robust shuttle bus service will reduce delays on the minor street approaches by up to 12 seconds. At the Site driveway on Oak Street, the driveway approach delay is 2-3 seconds less and the queue is 8-12 feet shorter with a robust shuttle service and at the south Site driveway on Needham Street, the driveway approach delay is 1-6 seconds less and the queue is 5-18 feet shorter with a robust shuttle service.

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Recommendations

The preceding study has outlined the general impacts of the proposed Project on the study area roadways. In general, the Project will have a minor impact at the majority of study area intersections on the operations or safety of the roadway network. This is reflected in the operational analyses presented above. However, in order to limit the Project's impacts to the roadway system and to enhance the overall transportation network in the area, the following section discusses actions that will be implemented by the Project Proponent, including off-Site roadway mitigation, a centrally located "Mobility Hub" on-Site, and a robust transportation demand management system including a significant private shuttle bus system that will be available to all tenants, customers, and employees on site as well as the general public. We believe that the TDM program, in its entirety, will set the example for integrated TDM initiatives across the region.

Off-Site Roadway Mitigation

Several off-Site mitigation measures are proposed to help offset the impacts of the Project on the local area. Off-Site mitigation measures focus on improvements to all roadway users, including vehicles, pedestrians, and bicycles.

As mentioned previously, construction is going to start in 2019 on the reconstruction of the MassDOT Highland Avenue / Needham Street / Winchester Street corridor project. The roadway redesign project has been in the works for many years and has gone through several rounds of public comments to reach the current design plan. Therefore,

no off-Site mitigation measures were proposed that would alter the roadway design that MassDOT has selected for the corridor.

Signal Timing Adjustments

VHB has identified two intersection locations which would benefit from signal timing adjustments: the intersections of Chestnut Street at Elliot Street and Centre Street at Walnut Street. By adjusting the timings of these two signals, the overall delay at each intersection would decrease based on the Build Condition. While the overall delay is expected to decrease, there may be slight increases in delays and queues on some movements as the green time is shifted more equitably between the different approaches. The overall decrease in delay can be achieved without modifying the signal control equipment itself or the intersection geometry.

Intersection capacity analyses were conducted at these two locations based on the signal timing adjustments. Table 18 summarizes the capacity analyses for the 2025 Build Condition with Mitigation (with Existing Mode Share) in comparison to the 2025 No Build Condition and the 2025 Build Condition with Existing Mode Share. The 2025 Build Condition with Robust Shuttle Service with and without Mitigation is summarized and included in Appendix A. Capacity analyses worksheets are included in Appendix A as well.

Table 18 Signalized Intersection Capacity Analysis – With Mitigation

Location / Movement	2025 No-Build Conditions					2025 Build Conditions (With Existing Mode Share)					2025 Build Conditions w/ Mitigation (With Existing Mode Share)				
	v/c [a]	Del [b]	LOS [c]	50 Q [d]	95 Q [e]	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
3: Chestnut Street at Eliot Street															
Weekday Morning															
EB L/T/R	1.10	89	F	~326	#805	1.13	100	F	~356	#805	0.94	46	D	400	#876
WB L/T/R	0.13	11	B	13	61	0.13	11	B	15	61	0.11	10	A	20	63
NB L/T/R	0.47	21	C	68	177	0.48	21	C	77	197	0.56	35	C	137	278
SB L/T/R	0.82	32	C	157	#424	0.82	32	C	166	#447	0.87	49	D	296	#627
Total		**56**	**E**				**59**	**E**				**42**	**D**		
Weekday Evening															
EB L/T/R	1.13	114	F	~329	#686	>1.20	>120	F	~356	#696	1.02	78	E	313	#678
WB L/T/R	0.43	27	C	110	241	0.46	29	C	115	241	0.39	26	C	117	240
NB L/T/R	0.61	22	C	128	313	0.62	22	C	145	353	0.72	31	C	195	#463
SB L/T/R	0.87	31	C	290	#717	0.86	31	C	322	#781	0.94	45	D	422	#893
Total		**51**	**D**				**62**	**E**				**48**	**D**		
Saturday Midday															
EB L/T/R	0.82	39	D	140	#402	0.83	40	D	140	#403	0.86	47	D	151	#504
WB L/T/R	0.31	17	B	48	133	0.31	17	B	48	133	0.32	22	C	53	167
NB L/T/R	0.63	28	C	101	#288	0.73	33	C	125	#364	0.68	26	C	113	290
SB L/T/R	0.83	35	C	193	#522	0.91	43	D	228	#604	0.87	35	C	207	#547
Total		**32**	**C**				**37**	**D**				**34**	**C**		
17: Centre Street at Walnut Street															
Weekday Morning															
SEB L/T	0.16	45	D	14	40	0.16	45	D	14	40	0.20	50	D	15	42
SEB R	0.84	47	D	256	#450	0.87	50	D	265	#468	0.94	66	E	~293	#523
NWB L/T/R	0.47	53	D	52	101	0.47	53	D	52	101	0.54	61	E	56	#114
NEB L	0.81	33	C	170	#374	0.86	38	D	188	#409	0.83	31	C	172	#358
NEB T/R	0.59	15	B	279	448	0.61	15	B	296	475	0.59	14	B	300	423
SWB L/T/R	1.04	72	E	~627	#915	1.06	78	E	~649	#940	0.97	54	D	~645	#888
Total		**44**	**D**				**47**	**D**				**40**	**D**		
Weekday Evening															
SEB L/T	0.25	48	D	22	54	0.25	48	D	22	54	0.29	53	D	24	57
SEB R	0.93	59	E	~294	#510	0.97	68	E	~335	#546	0.98	71	E	~351	#574
NWB L/T/R	0.40	50	D	45	89	0.40	50	D	45	89	0.44	56	E	48	95
NEB L	0.82	29	C	166	#371	0.88	38	D	198	#425	0.83	31	C	193	#393
NEB T/R	0.51	12	B	219	343	0.53	13	B	240	374	0.52	12	B	239	346
SWB L/T/R	0.93	49	D	~482	#770	0.99	61	E	~566	#836	0.95	53	D	~579	#827
Total		**37**	**D**				**44**	**D**				**41**	**D**		
Saturday Midday															
SEB L/T	0.33	47	D	22	64	0.33	47	D	22	64	0.30	37	D	17	58
SEB R	0.72	35	D	156	#352	0.78	39	D	173	#437	0.73	29	C	130	#395
NWB L/T/R	0.71	61	E	80	#192	0.71	61	E	80	#192	0.68	50	D	63	#189
NEB L	0.72	17	B	73	#293	0.80	23	C	80	#381	0.81	24	C	81	#386
NEB T/R	0.29	8	A	55	178	0.33	9	A	64	205	0.33	7	A	54	191
SWB L/T/R	0.67	29	C	215	459	0.74	32	C	247	#568	0.81	32	C	214	#549
Total		**26**	**C**				**29**	**C**				**26**	**C**		

a Volume to capacity ratio.
b Average total delay, in seconds per vehicle.
c Level-of-service.
d 50th percentile queue, in feet.
e 95th percentile queue, in feet.
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.

As shown in Table 18, the intersection of Chestnut Street at Elliot Street would see improvements in overall delays of 2-17 seconds and the intersection of Centre Street at Walnut Street would see improvements in overall delays of 3-7 seconds based on the proposed signal timing adjustments. The overall LOS at Chestnut Street at Elliot Street is proposed to decrease from LOS E to LOS D during the weekday morning and weekday evening peak hours, and from LOS D to LOS C during the Saturday midday peak hour with the signal timing adjustments.

Pedestrian Improvements

In addition to the signal timing adjustments, Northland is committed to improving the pedestrian network throughout the area, as described below.

Chestnut Street Corridor

While there are sidewalks located on both sides of Chestnut Street in the study area (from Route 9 to Oak Street), several of the crossings along the roadway are not ADA compliant. Northland is committed to making the following improvements:

- Chestnut Street at Route 9 WB Service Road: Upgrade all curb ramps to current ADA standards, including providing detectible warning strips. In addition, upgrade crosswalk pavement markings to more visible patterns, such as a continental style (as opposed to the existing transverse line style).
- Chestnut Street at Route 9 EB Service Road: Upgrade all curb ramps to current ADA standards, including providing detectible warning strips. In addition, upgrade crosswalk pavement markings to more visible patterns, such as a continental style (as opposed to the existing transverse line style).
- Chestnut Street at Elliot Street: Upgrade all curb ramps to current ADA standards, including providing detectible warning strips.

Charlemont Street to Charles River Connection

As part of the pedestrian and bicycle improvements being proposed, the proponent will create a multi-use path between Charlemont Street and Christina Street, which would provide pedestrian and bicycle access to the pedestrian bridge over the Charles River. Northland's recent acquisition of the Stark Building, located at 55 Christina Street, enables this connection to be made on private property. It is anticipated that this connection will be very valuable and will essentially connect the Project Site and other pedestrian and bicycle facilities with the extensive trail network in Needham, south of the Charles River.

Transportation Demand Management

The goal of a Transportation Demand Management (TDM) plan is to reduce the Project's overall traffic impact through the implementation of measures that are aimed at affecting the demand side of the transportation equation, rather than the supply side. By their nature, TDM programs are intended to change people's behavior, and to be successful,

they must rely on incentives or disincentives to make these shifts in behavior attractive to the commuter or retail customer.[10] TDM programs are designed to maximize the people-moving capability of the existing transportation infrastructure by increasing the number of persons in a vehicle, providing and/or encouraging the use of alternate modes of travel, or influencing the time of, or need to, travel.

TDM measures are most often directed at commuter travel and implemented at office sites. However, due to the mixed-use and transit-orientated nature of the Proposed Project, there also are opportunities to bring TDM programs to the Proposed Project's other land uses, including the retail shops and residential housing.

There is currently one active Transportation Management Association (TMA) in the study area that provides TDM services to area businesses and residences; the 128 Business Council. Northland is committed to joining the 128 Business Council to help develop and operate the proposed TDM measures.

As mentioned previously, a major component of the Project's TDM plan is the development of a private shuttle system. The following sections describe the proposed shuttle system in detail, the proposed "Mobility Hub" on-Site that will serve as a central location for all transportation-related needs, as well as additional TDM measures that Northland is committed to providing.

Mobility Hub

A Mobility Hub will be located on-Site in Building 7 and will serve as a coordinated, integrated transportation system facility that connects public transit, bicycling, walking, and automobiles in a center of activity. The Mobility Hub will be a central space for all forms of transportation and will provide information on alternative modes of transportation, bus and shuttle schedules, and other transportation alternatives including zip-car, car pool, bicycle and pedestrian connections. The space will likely include all of the following amenities at a minimum:

- A shuttle stop that will be built for the "connected" rider
- A custom branded bus shelter that will help protect riders from the elements
- Large scale waterproof maps of the entire MBTA bus and private shuttle bus system to be established (discussed below).
- An indoor digital TransitScreen information board displaying rider's transportation choices and real-time transit information.
- Sofa benches and seating which are likely to include solar powered phone charging stations that use sensors to measure activity in outdoor spaces.
- A Soofa sign which is a 42-inch electronic paper display built for the outdoors that can provide real-time transit information, as well as allowing communities to

[10] Implementing Effective Travel Demand Management Measures: Inventory of Measures and Synthesis of Experience, prepared by Comsis Corporation and the Institute of Transportation Engineers, for the U.S. Department of Transportation, DOT-T-94-02, September, 1993, p. I-1.

share events and local businesses in order to engage with customers (to be placed just outside the shelter).

- Nearby access to other modes of transportation including:
  - A development-specific fleet of zip cars with parking spaces provided at the discretion of the developer.
  - Dock-less bike share drop-off/pick-up location dedicated to a fleet of development specific bicycles (Limebike being an example)
  - Designated parking for car and vanpool in key areas on site.
  - Emergency ride home for all registered users of the carpool program.

The hub will also serve as an indoor shelter and waiting space for transit users waiting for the MBTA bus or the private shuttle. Information screens will provide data on wait times and route details for approaching buses.

Shuttle Bus System

Northland is committed to bring robust alternative transportation options to Needham Street as part of the Project. With that in mind, they are proposing implementation of a robust shuttle bus system that will make local and regional connections. The system is focused on providing strong and consistent connections to major transportation hubs and points of interest to give residents, patrons, and employees of the site good options for travel to and from the Project. In addition, the shuttle system as well as many of the other transportation initiatives that are being contemplated are being made available to the general public, and these initiatives are likely to be very attractive to residents who live or work off-Site but are in relative proximity of the Project. The goal of this unique and innovative system is to help move the needle and effect a change in mindset for consistent travel in single occupancy automobiles. As discussed in the previous chapter, intersection capacity analyses have been conducted with the shuttle bus system in place to quantify the potential effect of the shuttle bus system on the capacity of the regional roadway network and are included in Appendix A.

The 128 Business Council has been working closely with VHB and Northland to outline a robust shuttle system plan. As part of this work they have prepared a detailed Implementation Plan, which is included separately in the submittal package as the Transportation Implementation Plan from Route 128 Business Council (Final Report). Many of the details of the plan are summarized below for convenience. However, for more detail, please refer to the Transportation Implementation Plan.

It should be noted that the service outlined in the Implementation Plan is preliminary and no final decisions regarding scheduling or frequency of service has been made. The service plan is provided as a guide for what a robust shuttle service could look like serving the Project. Northland will work with the City of Newton and the 128 Business Council to determine what the specific service plan will be once the Project is operational, including the specific routes, number of buses, hours of operation, and headways. In addition, it is expected that the routes proposed would be phased into service in step

with the phasing of the development. The phasing will allow specific route stops, timing, and service hours to be adjusted to suit the needs of an evolving ridership.

As outlined in the Implementation Plan, Northland currently anticipates four (4) set shuttle bus routes as outlined below:

- Route 1 Newton Circulator (Newton Highlands, Newton Center, Newtonville)
- Route 2 Needham Commuter (Needham Heights)
- Route 3 Cambridge Express (Central Square, Kendall Square)
- Route 4 Boston Express (Seaport, World Trade Center, South Station)

Details of each route, including number of buses, weekly hours of operations, stops, and headways are provided in the Implementation Plan included in the submittal package. A brief summary of each route and potential schedule is provided below:

Route 1 Newton Circulator

This service provides a single out and back route in the City of Newton with stops in key areas. As currently envisioned, this route would depart from the on-Site transit hub and make stops at Newton Highlands, Newton Centre, and the Newtonville Commuter Rail Station. On the return from Newtonville, the shuttle would again stop at Newton Centre and Newton Highlands before returning to the transit hub. It is envisioned that the shuttle would operate between 5:15 AM and 12:53 AM. Frequency would be 30-45 minutes during rush hour service and 45 minutes the rest of the weekday and all weekend. Due to the more limited service at Newtonville on the commuter rail, only weekday rush hours shuttles would run all the way to and from Newtonville. Off-peak weekday shuttles and all weekend shuttles would only run between the on-Site transit hub, Newton Highlands, and Newton Centre. Travel times between stops would be approximately 10 minutes, although could vary a bit depending on the time of the day. On Saturday and Sunday, the schedule would likely be somewhat abbreviated starting at 6:15 AM and running until 12:53 AM with similar headways. It is expected that two buses would be required on this route to operate at the proposed level of service.

The proposed weekday schedule for the Newton Circulator route is displayed below in Table 19. The weekend schedule is included in the Implementation Plan provided which is part of the city submission for this project. In addition, several schedules with reduced service are also included in the Implementation Plan that include a lower frequency of service during peak and off-peak hours and the elimination of early morning and late-night service. For more specific details of the proposed plan, refer to the Transportation Implementation Plan from Route 128 Business Council (Final Report) included in the submittal package.

Route 2 Needham Commuter

This service provides access to the Needham Heights Commuter Rail Station and as such the scheduling would be consistent with commuter rails schedules. As currently envisioned, this route would depart from the on-Site transit hub and run directly to the

commuter rail station and back. This would be focused around commuter times starting at 5:50 AM in the morning on weekdays and extending to 8:27 PM. With lack of commuter rail activity during mid-afternoon, there would likely be a gap in service between 10:24 AM and 4:30 PM. Frequency would be 35–45 minutes but would be variable to best accommodate commuter schedules. Travel times between stops would be approximately 10 minutes, although will vary a bit depending on the time of the day. This shuttle is envisioned to operate exclusively Monday through Friday. It is expected that one bus would be required on this route to operate at the proposed level of service. The proposed weekday schedule for the Needham Commuter route is displayed below in Table 20. For more specific details of the proposed plan, refer to the Transportation Implementation Plan from Route 128 Business Council (Final Report) included in the submittal package.

Route 3 Cambridge Express

This service provides a single out and back route to Cambridge connecting with the Red Line and local bus systems. Stops would be at Central Square and at Kendall Square. The frequency would be every 60 minutes. It is envisioned that the shuttle would operate between 6:00 AM and 12:40 AM, seven days a week. Travel times between locations would be approximately 45 minutes, although could vary a bit depending on traffic and the time of the day. It is expected that two buses would be required on this route to operate at the proposed level of service. The proposed schedule for the Cambridge Express route is displayed below in Table 21. A reduced schedule is also included in the Implementation Report that would require only one bus during the off-peak period but would only provide service every two hours. For more specific details of the proposed plan, refer to the Transportation Implementation Plan from Route 128 Business Council (Final Report) included in the submittal package.

Route 4 Boston Express

This service provides a single out and back route with stops at Seaport/World Trade Center and South Station in Boston. Frequency of this route is 60 minutes. It is envisioned that the shuttle would operate between 6:00 AM and 12:43 AM, seven days a week. Travel times between locations would be approximately 45 minutes, although could vary a bit depending on traffic and the time of the day. It is expected that two buses would be required on this route to operate at the proposed level of service. The proposed schedule for the Boston Express route is displayed below in Table 22. For more specific details of the proposed plan, refer to the Transportation Implementation Plan from Route 128 Business Council (Final Report) included in the submittal package.

Table 19 Newton Circulator Proposed Weekday Schedule

Station	Morning										Afternoon							Evening									
On-Site Transit Hub	5:15	5:45	6:15	6:45	7:30	8:15	9:00	9:45	10:30	11:15	12:00	12:45	1:30	2:15	3:15	4:00	4:45	5:30	6:15	7:00	7:45	8:30	9:15	10:00	10:45	11:30	12:15
Newton Highlands	5:25	5:56	6:26	6:56	7:43	8:29	9:12	9:57	10:42	11:27	12:12	12:57	1:42	2:27	3:27	4:12	4:57	5:43	6:28	7:12	7:57	8:42	9:26	10:11	10:55	11:40	12:25
Newton Centre	5:34	6:05	6:36	7:07	7:55	8:41	9:24	-	-	-	-	-	-	-	3:37	4:23	5:08	5:54	6:40	7:22	-	-	-	-	-	-	-
Newtonville	5:45	6:17	6:49	7:25	8:15	9:01	9:44	-	-	-	-	-	-	-	3:54	4:40	5:25	6:11	6:57	7:36	-	-	-	-	-	-	-
Newton Centre	5:56	6:28	7:02	7:41	8:33	9:19	10:02	10:07	10:52	11:37	12:22	1:07	1:52	2:37	4:12	4:58	5:43	6:31	7:17	7:50	8:09	8:54	9:36	10:21	11:05	11:50	12:35
Newton Highlands	6:03	6:35	7:10	7:51	8:44	9:28	10:10	10:15	11:00	11:45	12:30	1:15	2:00	2:45	4:23	5:09	5:54	6:42	7:27	7:58	8:17	9:02	9:44	10:29	11:13	11:58	12:43
On-Site Transit Hub	6:12	6:45	7:20	8:03	8:56	9:40	10:22	10:27	11:12	11:57	12:42	1:27	2:12	2:57	4:37	5:24	6:10	6:56	7:39	8:10	8:29	9:13	9:54	10:39	11:23	12:08	12:53

Source: Needham Street Redevelopment Transportation Implementation Plan, 128 Business Council

Table 20 Needham Commuter Proposed Weekday Schedule

Station	Morning						Afternoon / Evening					
On-Site Transit Hub	5:50	6:30	7:10	7:45	8:30	9:45	4:30	5:10	5:55	6:30	7:05	7:40
Needham Heights *(arrive)*	5:56	6:38	7:18	7:54	8:39	9:54	4:42	5:22	6:05	6:40	7:13	7:47
Needham Heights *(depart)*	6:10	6:45	7:25	8:07	8:50	10:10	4:52	5:37	6:14	6:50	7:25	8:15
On-Site Transit Hub	6:20	6:57	7:39	8:23	9:06	10:24	5:08	5:53	6:28	7:02	7:37	8:27

Source: Needham Street Redevelopment Transportation Implementation Plan, 128 Business Council

Table 21 Cambridge Express Proposed Daily Schedule

Station	Morning							Afternoon					Evening						
On-Site Transit Hub	-	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
Central Square	5:45	6:45	7:45	8:45	9:45	10:45	11:45	12:45	1:45	2:45	3:45	4:45	5:45	6:45	7:45	8:45	9:45	10:45	11:45
Kendall Square	5:55	6:55	7:55	8:55	9:55	10:55	11:55	12:55	1:55	2:55	3:55	4:55	5:55	6:55	7:55	8:55	9:55	10:55	11:55
On-Site Transit Hub	6:40	7:40	8:40	9:40	10:40	11:40	12:40	1:40	2:40	3:40	4:40	5:40	6:40	7:40	8:40	9:40	10:40	11:40	12:40

Source: Needham Street Redevelopment Transportation Implementation Plan, 128 Business Council

Table 22 Boston Express Proposed Daily Schedule

Station	Morning							Afternoon					Evening						
On-Site Transit Hub	-	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
South Station	5:45	6:45	7:45	8:45	9:45	10:45	11:45	12:45	1:45	2:45	3:45	4:45	5:45	6:45	7:45	8:45	9:45	10:45	11:45
Seaport / World Trade Center	5:58	6:58	7:58	8:58	9:58	10:58	11:58	12:58	1:58	2:58	3:58	4:58	5:58	6:58	7:58	8:58	9:58	10:58	11:58
On-Site Transit Hub	6:43	7:43	8:43	9:43	10:43	11:43	12:43	1:43	2:43	3:43	4:43	5:43	6:43	7:43	8:43	9:43	10:43	11:43	12:43

Source: Needham Street Redevelopment Transportation Implementation Plan, 128 Business Council

As presented in the Service Implementation Plan, for each of the routes shown there is the potential for scaled-back service and/or a phased expansion of service, based on the ridership. Scaled back service plans for each line generally involve trimming back early morning and late-night service, as well as reducing the number of buses running on some routes from two to one. Expanded service on the lines generally involve running additional buses during the off-peak period to increase frequency, as well as expanding the number of stops on each route.

It should be noted that the routes and schedules that are being contemplated and presented in this document and in the 128 Business Council Report will be monitored and adjusted over time to provide an efficient and effective system representative of actual use. Discussions with the City regarding modifications to the system would be expected as necessary.

Additional TDM Measures

In addition to the proposed shuttle bus service described above, Northland is committed to providing a variety of additional TDM measures. The following sections discuss general TDM measures and the land use types for which TDM measures will be implemented. A description of the TDM elements is presented in this section along with information on how those elements aid employees, residents, visitors, residents, and retail patrons getting to and from the Project Site. The following plan first addresses general TDM measures that apply to the whole Project Site, then special programs for the residents, office uses, and retail shops and restaurants.

General Measures

Transportation Coordinator

In conjunction with the development, an overall on-site TDM coordinator will be designated to oversee all TDM programs for each building of the Proposed Project, and the Project Site in its entirety. The person(s) in this role will coordinate with organizations within the area to help promote a reduced reliance on single-occupant motor-vehicle travel to the Project Site. To that end, the TDM measures identified in the following sections will be implemented under the direction and supervision of this person.

The final job description for this role will be determined over time, but the duties of the on-site TDM coordinator may include, but not be limited to:

- Acting as a liaison with site employers and MassRIDES.
- Assisting site employees and residents with ride matching and transportation planning.
- Developing and implementing appropriate TDM measures.
- Disseminating information on alternate modes of transportation and developing transportation related marketing and education materials, including a website.
- Developing and maintaining information pertaining to pedestrian and cycling access to and from the Project Site.

- Hosting occasional transportation-related events to promote the use of commuting alternatives.
- Distributing transit maps and passes.
- Advocating with the state and local governments to improve transportation infrastructure and services.
- Monitoring the effectiveness of TDM measures through surveys and other tools and adjusting them as needed.
- Completing regulatory reports to state and city agencies, as required.
- Implementing a website providing travel-related information and promoting awareness of the items listed above.
- Provide Zip Car care share or similar.
- Provide Limebike bikeshare or similar.

Promote Transit Use

Access to public transportation and the proposed private shuttle system will reduce demand for vehicular travel and parking spaces. To serve visitors, employees, and residents, Northland will work with the MBTA to identify appropriate locations for new or relocated bus stops near the Project Site and other possible amenities, including bus shelters and real-time transit information.

The on-site TDM coordinator will provide a central commuter information center within the Project Site in a prominent location such as in a building foyer, or near garage elevators. This will provide employees, visitors, and residents with transit maps and schedules and route information for pedestrians and cyclists. One or two smaller centers also may be provided at central locations within the overall development, or possibly within each building. This also could include the residential lobbies or at the entrance of the planned office building among other possible locations that would be identified by the on-site TDM coordinator in consultation with the City of Newton planning staff.

Facilitate Bicycle and Pedestrian Travel

Travel to the Project Site by cycling or walking will be promoted by Northland through the provision of improved bicycle and pedestrian connections within the Project Site. Walking to and from, and throughout the Project Site will be encouraged by the provision of a pedestrian-friendly site layout, which features sidewalks and crosswalks at key points both within the Site and connecting to adjacent developments. Pedestrian shortcuts, such as connections between and around buildings, will be constructed and walking areas will be clean, attractive, and interesting to encourage walking. Street furniture, such as benches, trash cans, and street lights, will be provided throughout the area as well. Facility designs will accommodate special needs, including people using wheelchairs, walkers, strollers, and hand carts.

In addition to secured, covered bike storage within each building, bicycle racks also will be provided at locations near various buildings within the overall development. Northland will also work with the City of Newton with providing a bike-sharing service on Site, either through the dock-less Limebike system that the City is currently using or

through any new bike sharing system that the City is participating in when the Project comes online.

The design of the proposed roadway network within the Site will encourage walking and biking between uses on Site as opposed to driving and will address pedestrian safety concerns. Raised intersections will be located throughout, helping to encourage traffic calming and speed reductions. Shared parking uses will encourage visitors to park once on-Site and walk between different uses. Refer to Figure 19 for details of the proposed pedestrian, bicycle, shuttle, and general project amenities on site and that proposed in the immediate vicinity of the site.

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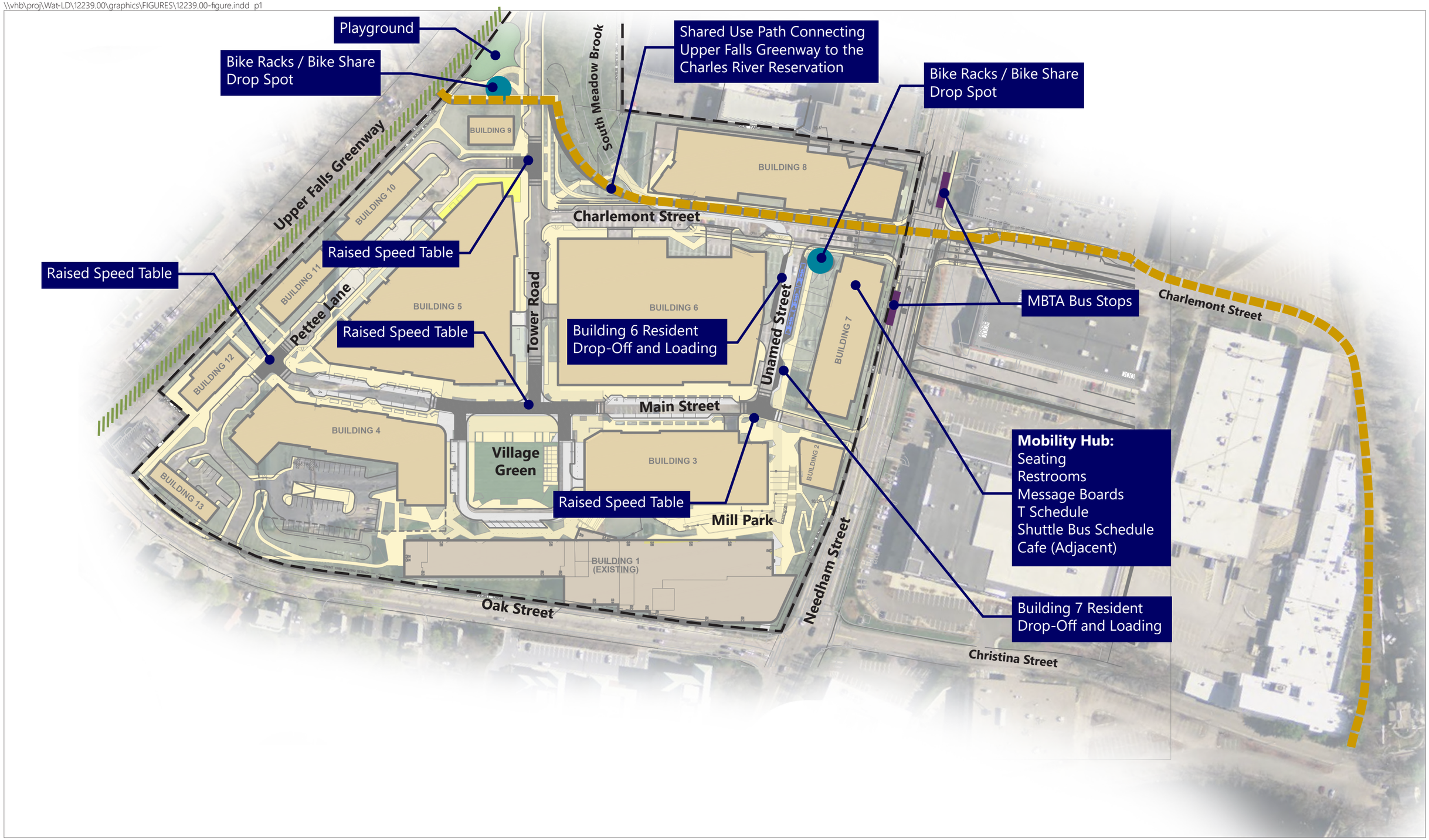

Figure 19

Pedestrian and Bicycle Infrastructure Improvements
The Northland Newton Development
Newton, Massachusetts

Office Uses

Office employers within the Project Site will be encouraged to implement appropriate TDM measures by the on-site TDM coordinator. As not every TDM program will be suitable for every type of employer, such as telecommuting or flexible work hours, the on-site TDM coordinator will offer technical assistance to employers to evaluate potential programs and implement them when appropriate. Employer-based TDM measures may include some or all of the following programs:

- Ride matching assistance managed by the on-site TDM coordinator or by MassRIDES so that employees find appropriate carpool and vanpool partners.
- Disseminating information on alternate modes of transportation and developing transportation.
- Sponsored vanpools and subsidized expenses.
- Employees can use pre-tax dollars for the purchase of MBTA passes. The pre-tax purchase is free from both federal and state income and payroll taxes.
- Provide telecommuting options or compressed work-week schedules for employees in appropriate jobs.
- Provide incentives for bicycle and pedestrian commutes, like covered bicycle storage, changing rooms, and shower facilities.
- Bike Share.
- Hold promotional events for transit-riders, cyclists, and pedestrians.
- Electric car charging stations.
- Offer direct deposit to employees.
- Preferential electric car/low emission car parking within the parking garage by designating and providing electric vehicle charging stations within the parking garage as a convenience to commuters and to promote environmentally-friendly transportation.
- Guaranteed ride home services that allow employees who don't bring a vehicle to work to get a free ride home (usually via taxi or ride-share) if they need to stay late or if they need to leave unexpectedly in the middle of the day.
- Shared services with other large employers in the area.
- Encourage retail uses on-Site to include services for employees during the day such as daycare, bank, dry cleaners, coffee shops, sandwich shops, etc.
- Paid parking charged directly to employers.
- Daily parking fees versus monthly permits to provide a daily incentive to use alternative modes of transportation.
- Parking "cash-out" programs (such as commuters who are offered subsidized parking are also offered the cash equivalent if they use alternative travel modes.

Retail/Restaurants

Northland will seek to attract a variety of retail shops, restaurants, and service tenants as ground-floor supporting uses. These shops will potentially include restaurants, apparel, furnishings, general merchandise, and service uses like banks and office supplies. As most of these businesses will be small shops, there will not be the same levels of TDM opportunities internal to each individual business as will be available with larger employers, but employees who work on the Project Site will be able to take advantage of the transportation guidance and programs coordinated by the transportation coordinator.

The suite of TDM measures to be implemented in association with the retail shops are fewer than for traditional offices, but will still have an impact in reducing single-occupant vehicle travel. The retail TDM program may include the following:

- Improved site amenities, like cycling paths and pedestrian crossings which enhance the ability of employees to walk or cycle to work.
- Ride matching services and transit information provided by the on-site TDM coordinator or MassRIDES.
- Hold promotional events for cyclists, pedestrians, and transit-riders.
- Offer direct deposit to employees.
- Bike share.
- Electric car charging stations.
- Preferential electric car/low emission car parking within the parking garage by designating spaces near building entrances within the parking garage as a convenience to commuters and customers and to promote environmentally-friendly transportation.
- Charge higher parking prices and shorter payment periods to reduce high turnover in congested portions of the Site, which helps reduce vehicle trips.
- Shared parking for all uses, encouraging customers to park once and walk between all destinations on-Site.

Residential

In addition to providing a pedestrian friendly, mixed-use transit-orientated environment, Northland will enact a variety of additional strategies to reduce the need for auto trips by residents. This will include working with a car-sharing service (such as Zipcar) to provide cars for periodic use by residents. Additional residential-based TDM measures may include the following programs:

- Disseminating information on alternate modes of transportation and developing transportation.
- Provide incentives for bicycle and pedestrian commutes, like covered bicycle storage to be available to all residents.
- Bike storage with fix-it station.

- Hold promotional events for transit-riders, cyclists, and pedestrians.
- Preferential electric car/low emission car parking within the parking garage by designating spaces and providing electric vehicle charging stations within the parking garage as a convenience to commuters and to promote environmentally-friendly transportation.
- "Unbundling" of parking costs from rent/leases so that residents with vehicles will pay more to allow access to the parking garage.
- Financial incentives for alternative transportation modes, such as discounted MBTA passes.
- Electric car charging stations.

Consistency with the Needham Street Area Vision Plan

As described earlier in the report, the city has recently adopted the Needham Street Area Vision Plan to help guide future development and public improvement along the corridor. The vision plan lays out a framework that all future development should follow, such as creating additional green space, expanding transit connections, supporting a variety of land uses, and creating human-scale street front developments.

The proposed Project has been designed to follow the vision plan very closely and become an exemplary project in the area that relies on more alternative means of transportation improvements than the traditional capacity-adding infrastructure improvements. Many of the specific elements of the vision plan are included in the Project, including but not limited to the following:

- Increased green space.
- Additional connections to local trails and paths.
- The development of a street network breaking up a large block into many smaller blocks.
- Helping to convert Needham Street from an isolated to a connected roadway.
- Supporting a variety of land uses, including residential and small retail to help create a vibrant destination with a distinct identity.
- Creating a better connection with the existing Upper Falls neighborhood.
- Designing human-scale buildings that promote an active pedestrian environment and help to create a sense of place.
- Expanded transit connections, including an increased shuttle bus service.
- Managing transportation demand in new development.

By including many elements of the Needham Street Area Vision Plan, the Project will help the Needham Street corridor evolve into the vibrant mixed-use neighborhood that the community members hope to achieve. As mentioned previously, the proposed Project is much more successful at meeting the goals outlined in the Needham Street Area Vision Plan than the as-of-right allowed development on Site of 1.48 million sf of all office space.

6

Conclusion

VHB has prepared a detailed Traffic Impact and Access Study for the proposed 28.7-acre mixed-use project known as The Northland Newton Development. The Project is located along Needham Street and Oak Street in Newton, MA. Currently the Site contains 62,600 sf of general retail space, a former mill building that contains approximately 180,000 sf of leasable office space, and a vacant 257,000 sf manufacturing building. Under proposed conditions, the retail and manufacturing buildings will be razed while the historic mill building will be preserved, and 12 new buildings will be constructed. The Site under proposed conditions will consist of 180,000 sf of leasable office space (in the historic mill building), 822 residential housing units, 237,000 sf of retail/restaurant/active use space, approximately 1,953 parking spaces, as well as substantial public amenities such as plaza's and greens, enhanced pedestrian and bicycle connections and amenities, passive open space enhancements, and a robust traffic demand management initiative.

The Proposed Project is consistent with the City of Newton's transportation-related goals for the Needham Street area as presented in the Needham Street Area Vision Plan. The Site has been designed to accommodate Project-generated vehicular traffic, as well as pedestrians, bicyclists, and transit riders. In summary, the Project will provide the following transportation-related benefits:

- The Project will be supported by a robust shuttle system that will provide local and regional connections for residents, employees, patrons, and the general public. The system will provide direct service to nearby transit stations in Newton and Needham as well as to employment centers in

Cambridge and Boston. The shuttle system will provide service all day long and will offer residents, commuters, and patrons an attractive alternative to accessing the Site via a private vehicle.

- A strong TDM program will be provided on-Site to further encourage alternative modes of transportation. Specific TDM measures will be applied for the residential, office, and retail portions of the Site.
- Strong bicycle and pedestrian accommodations will be provided on-Site, including a new connection between the Upper Falls Greenway and Needham Street via a mixed-use path and separated bike lanes along Charlemont Street Extension to the Charles River pedestrian bridge. This will link the Upper Falls Greenway with the extensive trail network in Needham. The Site layout will encourage pedestrian activities with raised intersections located at key intersections on-Site and the creation of the Village Green park.
- The Project will be a mixed-use, human-scale development consistent with the City's goals for this area. With the mixed-use environment, there should be considerable internal trip-sharing between the various uses proposed within the Site. For example, the retail space provided should be largely oriented to workers or residents already on-Site as opposed to traditional shopping center.
- The proposed on-Site parking supply will be kept to the minimum levels needed to satisfy tenant and resident needs, while being low enough to help promote travel by biking, walking, or using transit service, such as the MBTA or a private shuttle service. A total of 1,953 parking spaces will be provided on Site.
- Ample secured bicycle parking will be provided within the Project buildings, with outdoor bicycle racks provided at key points near the building entrances.
- The Project design will be consistent with the MassDOT roadway reconstruction project for the Needham Street corridor. All pedestrian and bicycle accommodations on-Site will connect with the proposed accommodations along Needham Street and Northland is donating land to allow for the realignment of Charlemont Street with the northern Site driveway.
- The transportation analysis for the Project was conducted based on two scenarios; a scenario assuming high usage of the robust shuttle service and a more conservative scenario based on the existing mode share. The second scenario with the conservatively high auto use was assumed so that the maximum potential vehicular traffic on the study area roadways would be evaluated. Even with these assumptions, the analysis indicates that the study area roadway will still functionally acceptably.

Overall, the additional new traffic generated by the Proposed Project can be accommodated on the surrounding roadway network and minimal impacts are expected from this proposed development.