Perkins Eastman

Lowell High School

Lowell, Massachusetts

Traffic Impact Analysis

May 2017

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TABLE OF CONTENTS

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Section Page

Section Page

Section Page

1.0 Introduction

1.1 Purpose of Study

This traffic study was prepared at the request of Perkins Eastman in connection with its study to renovate or replace the Lowell High School in Lowell, Massachusetts. During the preliminary evaluation of alternatives phase of the project, Perkins Eastman has developed alternatives on various parcels of land in the Downtown area (existing site) and other various sites in the City. For the benefit of the boards and the citizens of Lowell, the traffic impacts of both the Downtown area site and the Cawley Stadium site have been evaluated. The study analyzes traffic use attributable to the proposed high school renovation/replacement at each site and discusses transportation impacts in the vicinity of each site.

1.2 Description of Project

The existing high school campus is located in the heart of Downtown in the City of Lowell. The proposed project includes evaluating options of full renovation, addition/renovation, new buildings, etc. to the existing Lowell High School downtown campus to accommodate the future needs of the community. The proposed project also includes evaluating the option of the high school being relocated to the Cawley Stadium site.

The existing Lowell High School currently has approximately 3,255 high school students and 440 daytime employees. The projected student population for all design alternatives is 3,520 high school students and 500± (estimated) daytime employees.

1.2.1 Downtown Site

There are three alternatives being evaluated for the Downtown site based on the Preliminary Design Program (PDP) feasibility study that was submitted to the Massachusetts School Building Authority in February 2017. The three alternatives are the Full Renovation of the existing campus, the Addition/Renovation Option 2, and the Addition/Renovation Option 3 (see Figure Nos. 1 through 3, respectively). It is anticipated that the Full Renovation and the Addition/Renovation Option 3 would be fully constructed by 2024 and the Addition/Renovation Option 2 would be fully constructed by 2023.

Similar to current operations, all three proposed alternatives will not provide on-site parking and will continue to rely on the neighboring George Ayotte parking garage, public transit, etc. for students and staff to utilize when traveling to and from the high school. The City is considering the possibility of providing a school busing program for the high school, since the City does not currently have a busing program for the general high school student population.

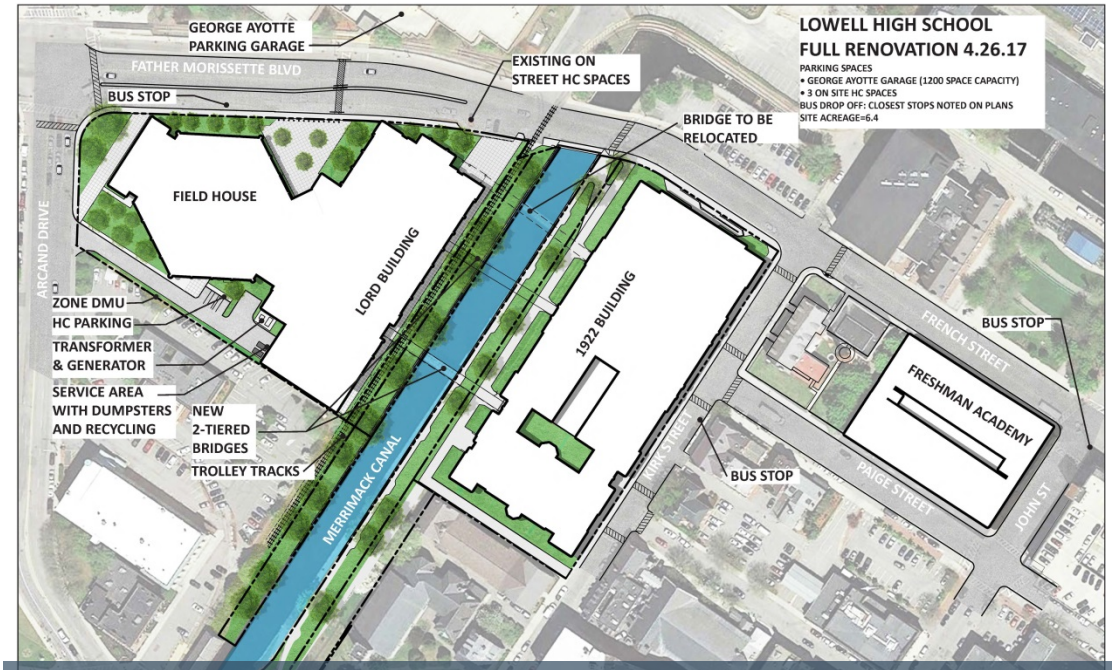


Figure No. 1 Full Renovation Option updated April 2017

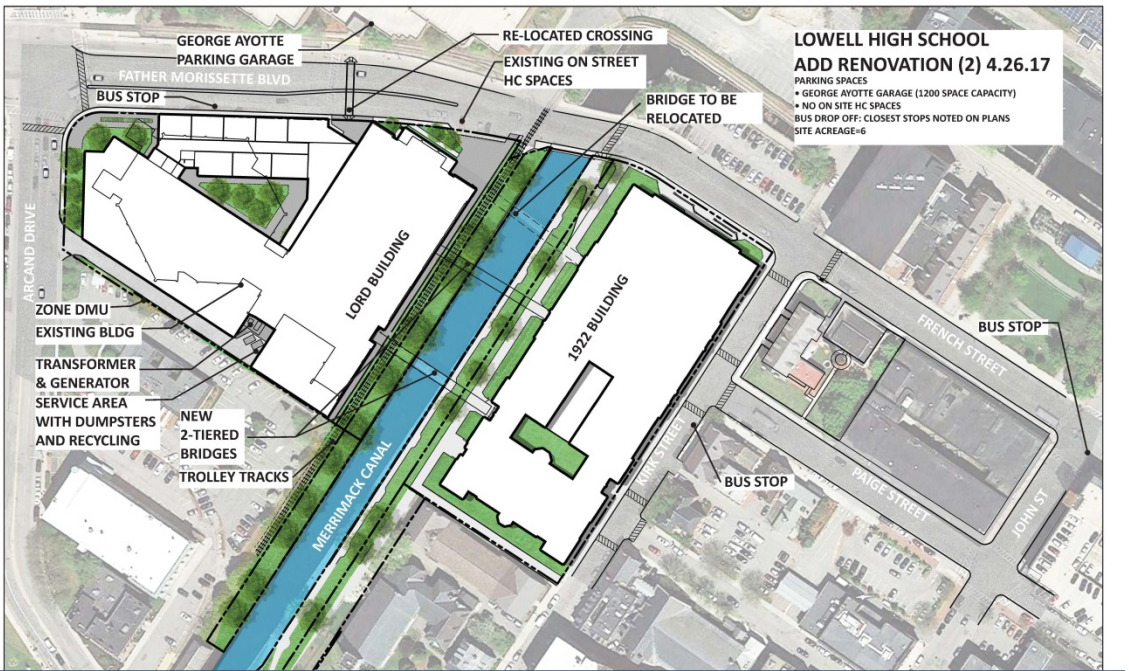


Figure No. 2 Addition/Renovation Option 2 updated April 2017

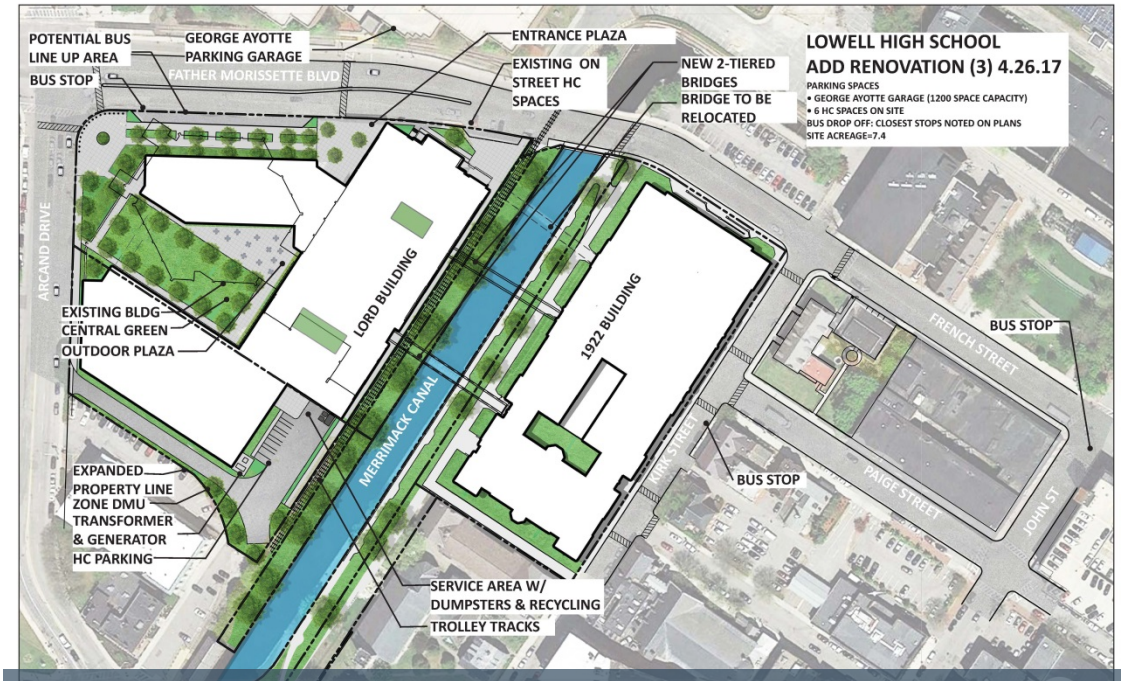


Figure No. 3 Addition/Renovation Option 3 updated April 2017

1.2.2 Cawley Site

The other alternative being considered for the proposed Lowell High School development is the construction of a new facility on the existing Cawley Stadium site, which is located in the Belvidere neighborhood of the city near the Tewksbury town line. A portion of the site would be located in the Town of Tewksbury. It is anticipated that the Cawley site alternative would be fully constructed by 2022.

For the purpose of this study, the schematic plans developed on May 10, 2017 for the 4-story and 5-story options for this alternative were analyzed. This schematic provides three driveways on Douglas Road, three driveways on Village Street, and one driveway on Clark Road (as shown in Figure Nos. 4 and 5). The schematic plans provide on-site parking for approximately 850 vehicles as well as an on-site bus drop-off and pick-up area. The Cawley site would require the City to develop and implement a city school busing program for the high school students. If the Cawley site is chosen, the City intends to direct the school buses along Route 38 and require the buses to turn left onto Village Street to access the proposed site.

Figure No. 4 New 4-Story School at Cawley site updated May 2017

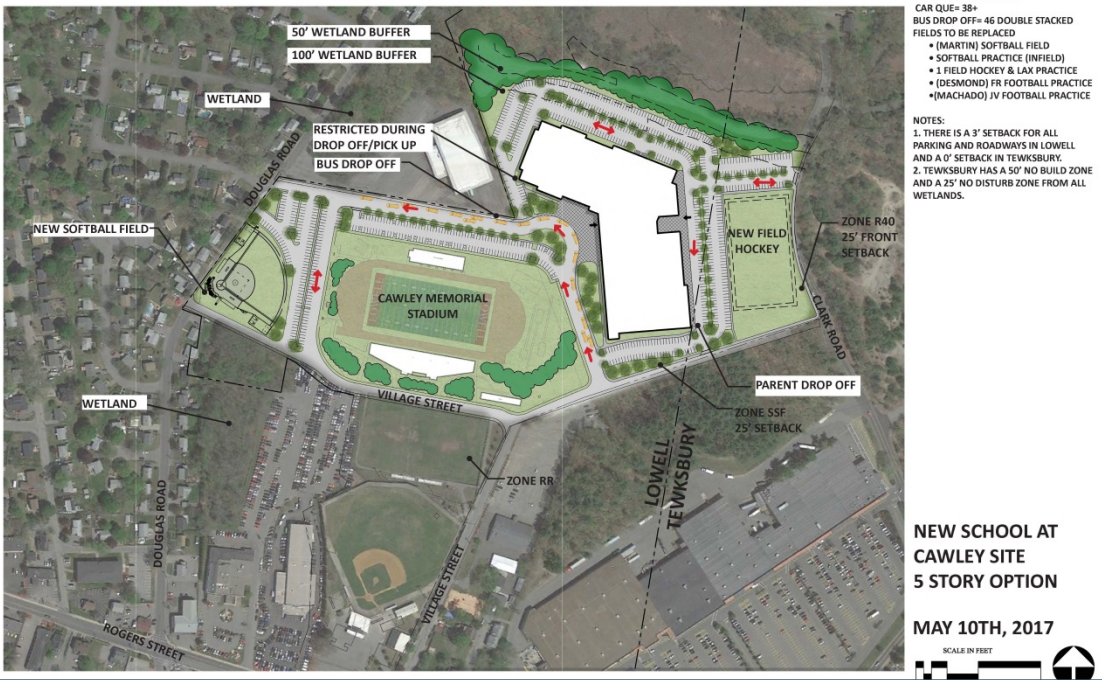


Figure No. 5 New 5-Story School at Cawley site updated May 2017

2.0 Existing Conditions

2.1 Downtown Site Study Area

2.1.1 Surrounding Roadways

The existing high school campus is nestled in the heart of the City's downtown. Traffic volumes are heavy on Bridge Street, which is classified as an urban principal arterial, as presented in the online MassDOT Road Inventory Interactive Map, which is based on the Year-End 2011 Road Inventory File maintained by the Massachusetts Office of Transportation Planning. By definition, an arterial highway emphasizes a high level of mobility for through traffic while providing access to local roadways. Father Morissette Boulevard, French Street, Arcand Street, and Merrimack Street are classified as urban minor arterials. Traffic volumes on Kirk Street and Paige Street, which are classified as urban collectors on the online MassDOT Road Inventory Interactive Map, are low. Land use in the area is mixed institutional, commercial, and residential.

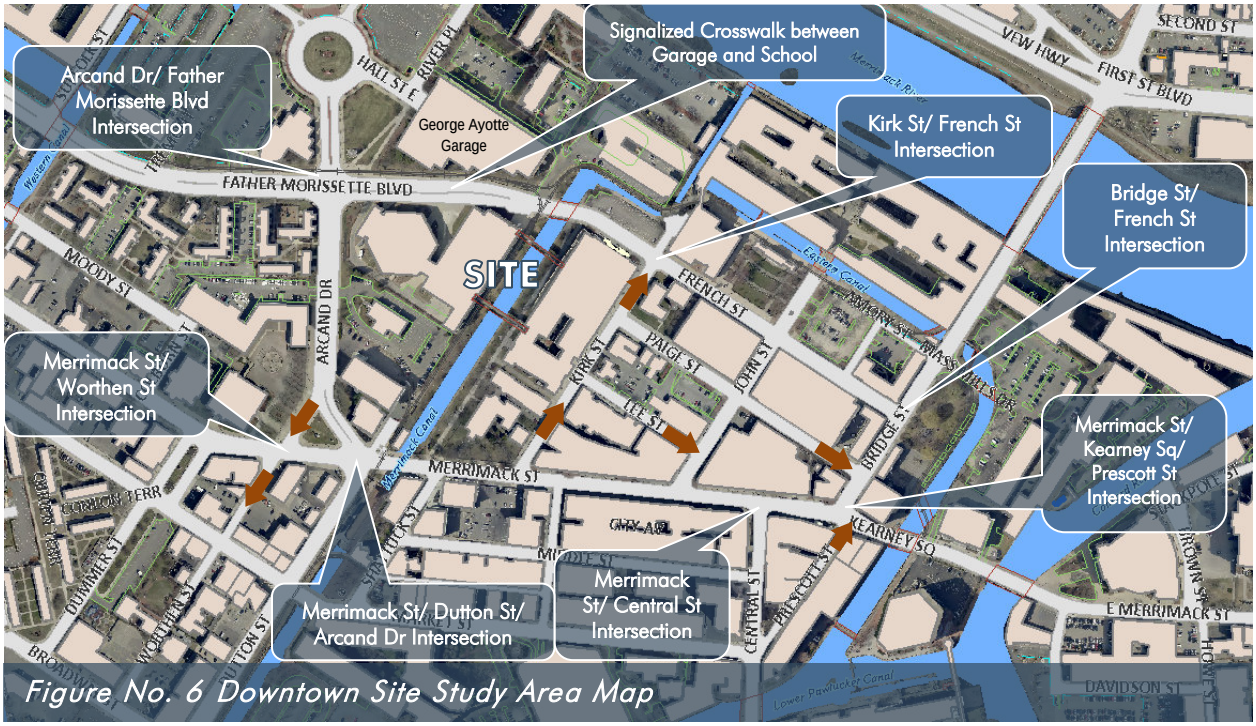


Figure No. 6 Downtown Site Study Area Map

Father Morissette Boulevard in the vicinity of the existing school is a multi-lane, divided two-way roadway in front of the existing Field House and Lord Building. At the Merrimack Canal, Father Morissette Boulevard narrows and east of the canal Father Morissette Boulevard becomes French Street. French Street in the vicinity of the 1922 Building and Freshmen Academy, is a two-lane, undivided two-way, roadway with shoulders that can accommodate on-street parking, although the majority is signed as a tow zone. Kirk Street between Merrimack Street and French Street is a one-lane, one-way (in the northbound direction) roadway with shoulders on either side that can

accommodate on-street parking. Paige Street between Kirk Street and John Street is a two-lane, two-way roadway with shoulders that can accommodate on-street parking, although parking is prohibited on the northern side of the roadway.

The signalized, four-way intersection of Father Morissette Boulevard and Arcand Drive is located to the west of the existing school campus. To the west of the intersection, Father Morissette Boulevard is a five-lane, divided two-way bituminous roadway, with two westbound travel lanes, a concrete median island, three eastbound travel lanes (a left turn lane, a through lane, and a right turn lane), and narrow shoulders. To the east of the intersection, Father Morissette Boulevard is a four-lane, divided two-way bituminous roadway, with three westbound travel lanes (two left turn lanes and a shared through/right turn lane), a concrete median island, one wide eastbound travel lane, and narrow shoulders. To the north of the intersection, Arcand Drive is a four-lane, divided two-way bituminous roadway, with two southbound travel lanes and two northbound travel lanes. There is a sign posted for the southbound approach prohibiting left turns from 2PM to 3PM on Mondays through Fridays from September to June. To the south of the intersection, Arcand Drive is a five-lane, undivided two-way bituminous roadway, with two southbound travel lanes, three northbound travel lanes (a left turn lane, a through lane, and a right turn lane), an on-street parking shoulder on the west side, and a narrow shoulder on the east side. There are concrete sidewalks on both sides of Father Morissette Boulevard and Arcand Drive. This traffic signal operates with an exclusive pedestrian phase when activated by a pedestrian pushbutton. There are curb ramps, pedestrian signal heads, and pedestrian pushbuttons associated with the marked crosswalks across all four approaches of this intersection.

The signalized, mid-block crosswalk across Father Morissette Boulevard is located between the George Ayotte parking garage and the existing Lord Building. At the crosswalk, Father Morissette Boulevard is a four-lane, divided two-way bituminous roadway, with one wide westbound travel lane transitioning into three westbound travel lanes (two left turn lanes and a shared through/right turn lane), a concrete median island with a narrow at grade opening, one wide eastbound travel lane, a narrow shoulder on the south side of the road, and no marked shoulder on the north side of the road. There are concrete sidewalks on either side of Father Morissette Boulevard. There are curb ramps on both sides of Father Morissette Boulevard for the signalized crosswalk. The curb ramp on the north side of Father Morissette has an adjacent wooden landing at the railroad crossing. Both sides of the crosswalk have pedestrian pushbuttons and pedestrian signal heads. The concrete median on Father Morissette Boulevard has a ramp opening to allow pedestrians to navigate through the median and across the street.

The unsignalized, four-way intersection of French Street and Kirk Street is located adjacent to the existing school campus. French Street at its intersection with Kirk Street is a two-lane, two-way bituminous roadway with one eastbound travel lane, one westbound travel lane, and wide unmarked shoulders on both sides of the roadway. Kirk Street at its intersection with French Street is a northbound one-way, one-lane bituminous roadway with wide unmarked shoulders. There is parking on the east side of the roadway. Kirk Street is the stop controlled approach at this intersection. There is a two-lane, two-way unmarked bituminous driveway at the northern side of the intersection. There

are concrete sidewalks on both sides of Kirk Street and French Street, except for the northern side of French Street to the west of the driveway where it is a bituminous sidewalk. There are curb ramps associated with the marked crosswalk across Kirk Street and the one marked crosswalk across French Street, on the east side of Kirk Street. The curb ramps on Kirk Street are located behind the stop sign, which currently does not have a stop bar associated with it. There are non-ADA compliant curb ramps across the driveway opening on the north side of the intersection. There also is curb ramp on the southwest corner of the intersection, which is not associated with a marked crosswalk.

The signalized, three-way intersection of Bridge Street and French Street is located to the east of the existing school campus. Bridge Street at its intersection with French Street is a four-lane, two-way bituminous roadway with two southbound travel lanes and two northbound travel lanes. French Street at its intersection with Bridge Street is a three-lane, two-way bituminous roadway with one westbound travel lane, and two eastbound turning lanes, which consists of one left turn lane and one right turn lane. There is parking on the north side of the roadway. There are concrete sidewalks on both sides of Bridge Street and French Street. There are curb ramps associated with the marked crosswalks across Bridge Street on both the northern and southern side of French Street, as well as curb ramps associated with the marked crosswalk across the French Street approach at this intersection. There are pedestrian signal heads only for the southern marked crosswalk across Bridge Street. The existing pushbutton on the southwest corner is operational for the southern crosswalk across Bridge Street, but the existing pedestrian pushbutton on the southeast corner is not functioning. There are no pedestrian signal heads or pushbuttons associated with the northern Bridge Street crosswalk or the French Street crosswalk. The City currently has a proposed project in the design phase to upgrade the traffic signal, which includes upgrading the pedestrian accommodations at this intersection.

The signalized four-way intersection of Merrimack Street and Worthen Street, which is currently set to flashing, is located to the southwest of the existing school campus. Merrimack Street at its intersection with Worthen Street is a two-lane, two-way bituminous roadway with one eastbound travel lane and one westbound travel lane for each approach and parking lanes on both sides. To the north of the intersection, Worthen Street is a two-lane, one-way bituminous roadway, with one southbound right turn lane, one southbound through lane and a parking lane on the west side of the roadway. Currently, there are no traffic signs or pavement markings that would prohibit southbound vehicles from turning left and heading eastbound on Merrimack Street. Worthen Street to the south of the intersection is a one-lane, one-way bituminous roadway for vehicles to travel southbound away from the intersection. The Merrimack Street approaches have a flashing yellow signal indication and the Worthen Street approach has a flashing red signal indication. All of the pedestrian signal heads and pushbuttons at this intersection are currently covered. There are concrete sidewalks on both sides of Merrimack Street and Worthen Street. There are curb ramps associated with both of the marked crosswalks across Worthen Street. There are curb ramps associated with the one marked crosswalk across Merrimack Street, which is located to the west of Worthen Street.

The signalized, five-way intersection of Merrimack Street, Dutton Street, and Arcand Drive is located to the southwest of the existing school campus. Merrimack Street at its intersection with Arcand Drive

and Dutton Street, is a three-lane, two-way bituminous roadway. To west of the intersection, Merrimack Street has an eastbound through lane, an eastbound right turn lane, and a westbound travel lane. Left turns from the eastbound approach are prohibited. There is parking on the north side of this approach. To east of the intersection, Merrimack Street has a westbound left turn lane, a westbound shared through/right lane, an eastbound travel lane, a narrow northern shoulder, and a southern parking shoulder. There is a trolley rail crossing Merrimack Street on the west side of the intersection. Arcand Drive at its intersection with Merrimack Street and Dutton Street is a four-lane, two-way bituminous roadway with two northbound travel lanes and two southbound travel lanes. To the north of the intersection, Dutton Street is a narrow two-lane, two-way bituminous roadway that provides access for perpendicular street parking. To the south of the intersection, Dutton Street is a four-lane, two-way bituminous roadway with two southbound travel lanes and two northbound travel lanes. There are concrete sidewalks on both sides of Merrimack Street, both sides of Arcand Drive, and the west side of Dutton Street. There are curb ramps or sidewalk cut-outs associated with the marked crosswalks across each leg of the intersection. There are pedestrian signal heads and pushbuttons at every crosswalk except for the crosswalk across the Dutton Street southbound approach. The northwest curb ramp at the corner of Merrimack Street and Arcand Drive is not aligned with the Arcand Drive approach crosswalk and is located at a low point in the roadway, which causes water to pond at the bottom of the ramp.

The signalized, three-way intersection of Merrimack Street and Central Street is located to the southeast of the existing school campus. Merrimack Street to the east of its intersection with Central Street is a three-lane, two-way bituminous roadway with a westbound left turn lane, a westbound through lane, and one eastbound travel lane with a narrow shoulder on the north side of the roadway. There is parking on the south side of the roadway beyond a sidewalk bump-out. Merrimack Street to the west of its intersection with Central Street is a two-lane, two-way bituminous roadway with one eastbound travel lane and one westbound travel lane. There is parking on the south side of the roadway. Central Street at its intersection with Merrimack Street a two-lane, two-way bituminous roadway with a shared northbound left and right turn lane and a southbound travel lane. Central Street has cobble stone gutter on both sides of the roadway. There is concrete sidewalk on both sides of Merrimack Street and Central Street, however, there is granite and concrete sidewalk on the north side of Merrimack Street and a bituminous sidewalk on the southeast corner of the intersection. The crosswalks and the center of the intersection consist of cobblestones and pavers. There are curb ramps and crosswalks at each leg of the intersection. The curb ramps associated with the crosswalks across Merrimack Street are not located directly across from each other. The width of the curb ramps at the southeast corner on the intersection is too narrow. There are pedestrian signal heads and pushbuttons at each leg of the intersection, however, the pushbutton at the northwest corner of the intersection was observed to not function properly. Some of the pedestrian pushbutton location and mounting heights at this intersection are not within the recommended limits per guidelines from ADA and the *Manual on Uniform Traffic Control Devices* (MUTCD).

The signalized, four-way intersection of Merrimack Street, Bridge Street, Kearney Square, and Prescott Street is located to the southeast of the existing school campus. Merrimack Street at its intersection with Bridge Street, Kearney Square, and Prescott Street is a three-lane, two-way bituminous roadway with one eastbound through lane and two westbound travel lanes, one of which is a left turn lane at its intersection with Central Street. Left turns from Merrimack Street eastbound onto Bridge Street are prohibited. Bridge Street at its intersection with Merrimack Street, Kearney Square, and Prescott Street is four-lane, two-way bituminous roadway with one southbound left turn lane, one southbound right turn lane, and two northbound travel lanes. Kearney Square at its intersection with Merrimack Street, Bridge Street, and Prescott Street is a three-lane, two-way bituminous roadway with one westbound right turn lane, one westbound through lane, and one eastbound travel lane. There is parking on the south side of the roadway. Prescott Street at its intersection with Merrimack Street, Bridge Street, and Kearney Square is a two-lane, one-way bituminous roadway with two northbound travel lanes. There is concrete sidewalk on both sides of Bridge Street, Kearney Square, and Prescott Street. There is concrete sidewalk on the south side of Merrimack Street and a brick and concrete sidewalk on the north side. There are marked crosswalks across all four approaches at the intersection and most are accessible by curb ramps. There is no curb ramp, however, within the marked crosswalk across Prescott Street on the southwest corner of the intersection. There is flush curb north of the Prescott Street crosswalk on the southwest corner of the intersection, which is non-ADA compliant and is inaccessible due to obstructions. The width of the curb ramp on the northwest corner of the intersection is too narrow. There are pedestrian signal heads and pushbuttons at each leg of the intersection, however, the pushbutton at the southwest corner of the intersection is inaccessible for the Prescott Street crossing.

2.1.2 Mode of Transportation

The Lowell High School administration conducted multiple student mode of transportation surveys and a staff mode of transportation survey. The survey information can be found in Appendix G. Based on the survey information, Figure Nos. 7 and 8 were developed to show the approximate mode of transportation for students and staff, respectively.

Figure No. 7
Estimated Student Mode of Transportation for the Downtown Site
Based on January and April 2017 Survey Results

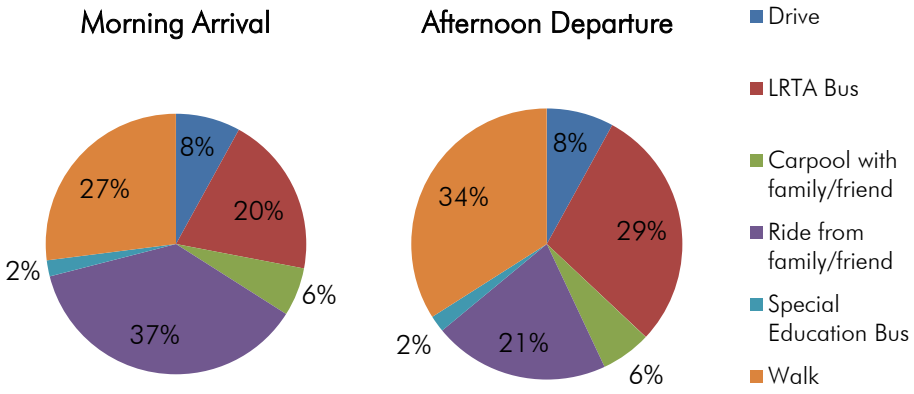
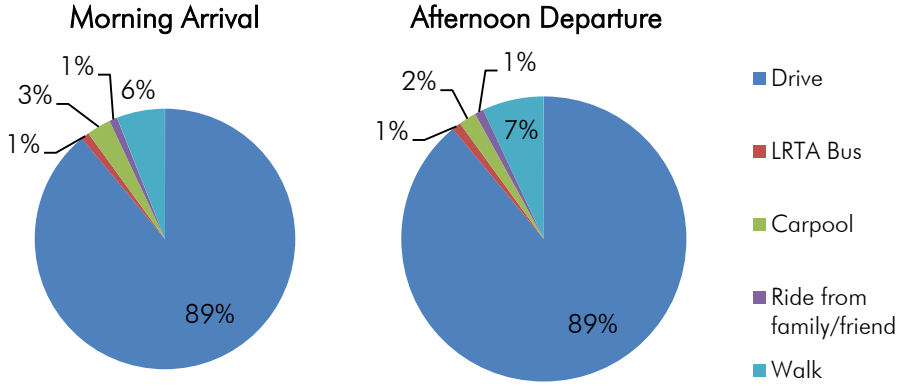


Figure No. 8
Estimated Staff Mode of Transportation for the Downtown Site
Based on April 2017 Survey Results



The April 2017 staff survey also gathered additional information about when staff arrived and departed from the school. The survey indicated that approximately 75% of the staff arrived within the school A.M. peak hour of 7:15 to 8:15. The survey also indicated that approximately 70% of the staff departed during the school P.M. peak hour of 2:30 to 3:30.

2.1.3 Parking

The existing high school does not have its own on-site parking facility. There is limited staff parking available behind the Riddick Field House that is accessible from a narrow driveway on Father Morissette Boulevard located directly east of Arcand Drive. There are six (6) perpendicular handicap designated parking spaces located on Father Morissette Boulevard located in front of the Lord Building, directly west of the canal.

The student and staff surveys indicate that the majority of those who drive will park their vehicles in the George Ayotte Parking Garage. In accordance with the City Ordinances Article IX, Chapter 266, a discounted rate is offered to all students within the City of Lowell public school system at the George Ayotte Parking Garage as well as five (5) other facilities throughout the city (Davidson Street Lot, Joseph Downes Parking Garage, Leo A. Roy Parking Garage, Lower Locks Parking Facility, and Edward J. Early, Jr. Parking Garage).

Based on the April 2017 student and staff surveys, it is estimated that there are approximately 725 vehicles currently parking near the existing high school on a daily basis.

2.1.4 Busing

Unlike the lower grades, the City does not currently provide a school busing program for the general high school student population. There are special education students that are transported to and from the high school by approximately 10 vehicles (i.e. wheelchair vans, yellow buses, and other smaller vehicles). Many of these vehicles wait on Kirk Street adjacent to the 1922 Building during afternoon dismissal.

The City does provide transportation for afterschool athletics programs from the existing high school to the Cawley Stadium, the boat house, and other locations. There are approximately 7 buses that will bring students to activities, but the students must provide transport from the program locations back to their homes at the end of the program. On game days, there can be up to four additional buses that transport students to games.

Many students utilize the discounted student bus pass for the Lowell Regional Transit Authority (LRTA) buses. Approximately 7 LRTA buses arrive prior to dismissal and park along the north side of Paige Street between Kirk Street and John Street. An additional 4± LRTA buses also park along the south side of French Street in front of the existing school campus prior to dismissal. A map of the existing Lowell High School Bus Locations for afternoon dismissal from the LRTA website is shown in Figure No. 9.

Just before the afternoon dismissal, city police officers block vehicular traffic on Paige Street west of John Street and Kirk Street north of Merrimack Street. After the LRTA buses have loaded the students, police officers allow only the LRTA buses to travel south (countraflow) on Kirk Street and temporary block traffic on Merrimack Street to allow LRTA to continue their bus routes on Merrimack Street.

Additional city police officers patrol Father Morissette Boulevard/French Street during afternoon dismissal to help facilitate pedestrian and vehicular movements during dismissal.

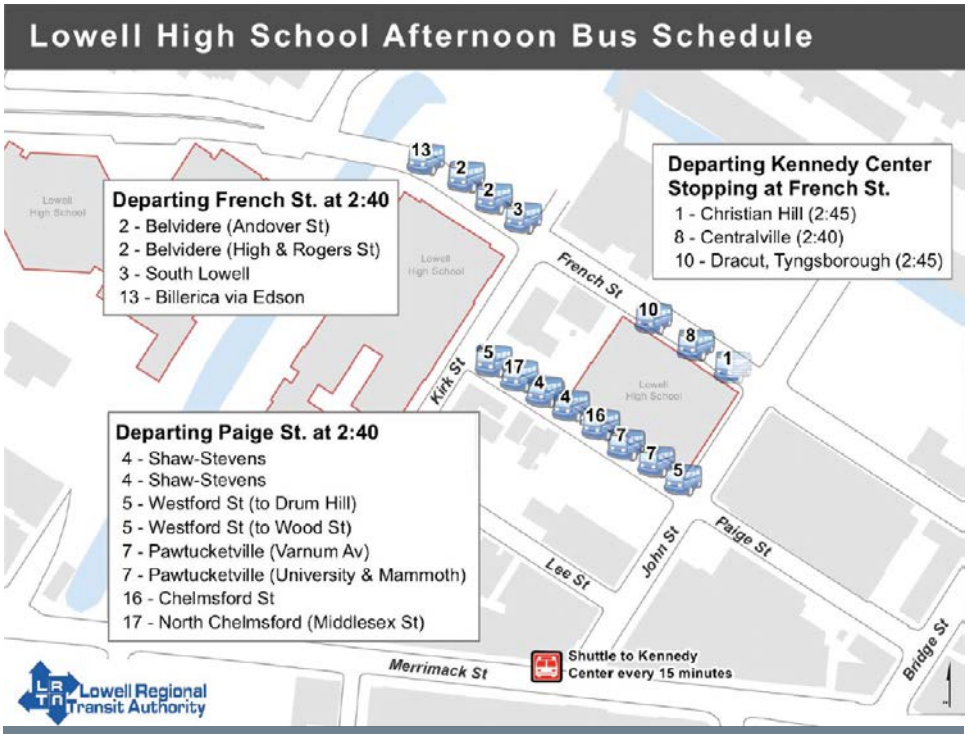


Figure No. 9 Lowell High School Bus Locations (Source: LRTA.com)

2.1.5 Drop-off and Pick-up Area

The existing high school does not have any signed or official drop-off and pick-up areas for family or friends transporting students to and from the school. During dismissal, vehicles waiting for students were observed standing along Father Morissette Boulevard/French Street, Kirk Street, Paige Street, and John Street. Based on the April 2017 Student Survey is appears that the locations of where the students are being dropped-off and picked-up varies dependent on the time of day, as shown in Figure Nos. 10 and 11. Many more vehicles opt for locations further away from the school to pick-up students during dismissal period.

Figure No. 10
Student Drop-off Locations during A.M. Arrival
Based on April 2017 Survey Results

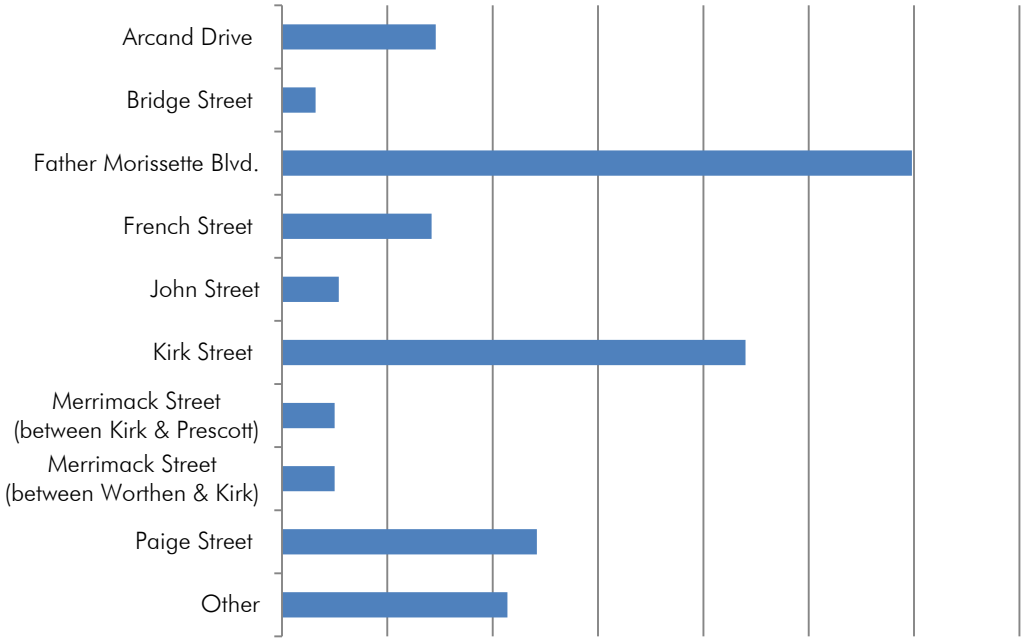
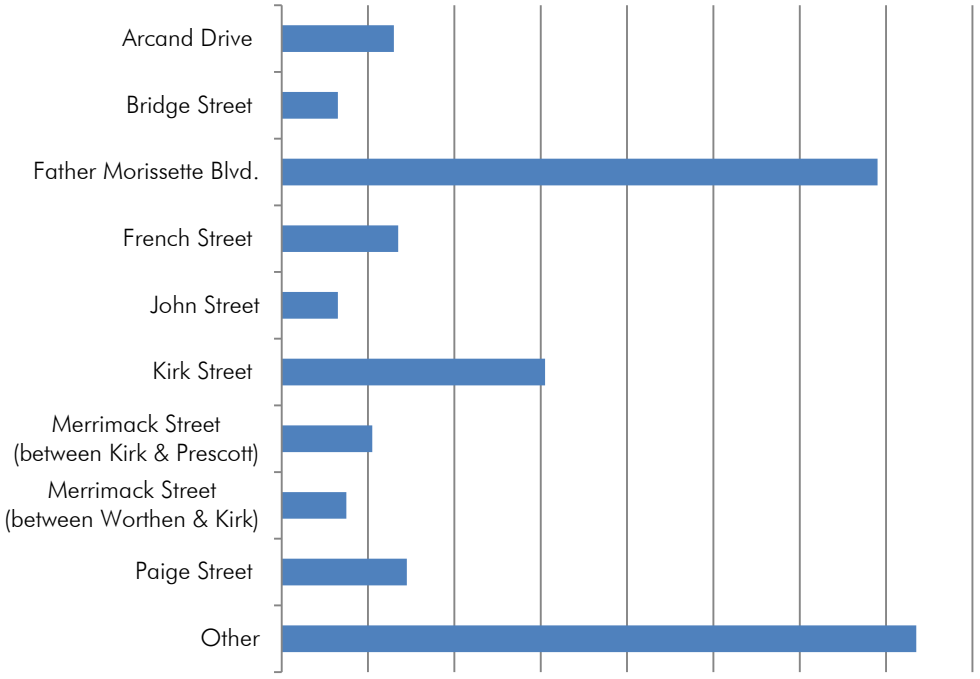


Figure No. 11
Student Pick-up Locations during P.M. Dismissal
Based on April 2017 Survey Results



2.1.6 Walking

Based on the student surveys, it is estimated that approximately ¼ of the high school students currently walk to school in the morning and approximately $^{1}/_{3}$ of the high school students walk home in the afternoon.

2.2 Cawley Site Study Area

2.2.1 Surrounding Roadways

The new high school site is proposed to be located at the existing high school athletic complex, Cawley Memorial Stadium. The Cawley site is located in the Belvidere neighborhood of the City, although a portion of the site is located in Tewksbury. Traffic volumes are heavy on Andover Street and Rogers Street, which are classified as urban principal arterials, as presented in the online MassDOT Road Inventory Interactive Map. Douglas Road and Clark Road are classified as urban collectors. Village Street is defined as a local road on the online MassDOT Road Inventory Interactive Map. Land use in the area is mainly residential although there are pockets of institutional and commercial uses, especially along Rogers Street and the southern end of Clark Road.

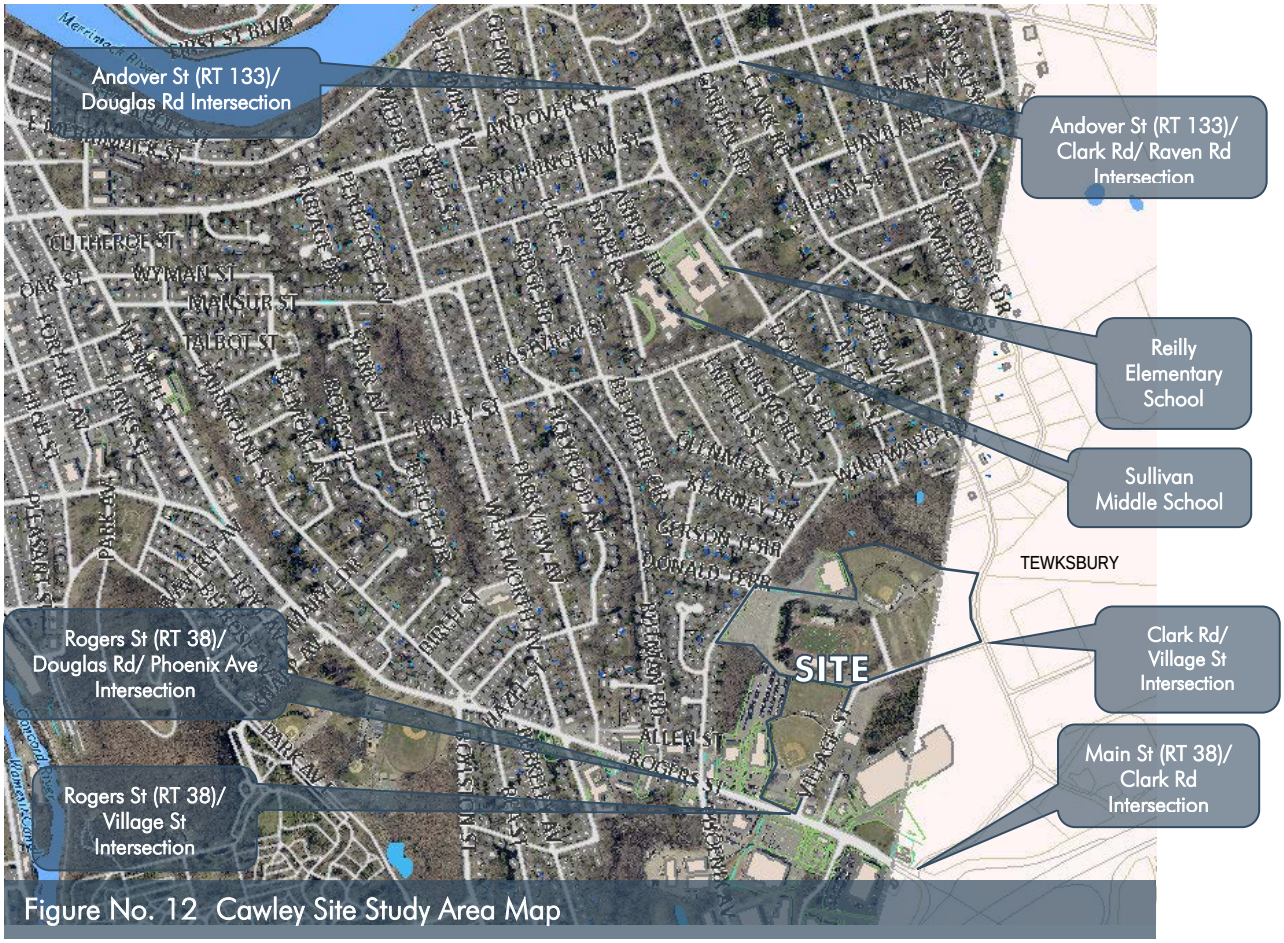


Figure No. 12 Cawley Site Study Area Map

Douglas Road in the vicinity of the proposed site is a two-way roadway with no pavement markings or sidewalks. Clark Road in the vicinity of the proposed site, which is located in Tewksbury, is a two-way, striped two-lane roadway with narrow shoulders and no sidewalks. Village Street in the vicinity of the proposed site is a two-way roadway with segmented sidewalks and no pavement markings. Additional information about the existing sidewalk and pedestrian facilities surrounding the Cawley site can be found in Section 2.2.2.

The unsignalized, three-way intersection of Andover Street and Douglas Road is located to the northwest of the proposed school site. Andover Street at its intersection with Douglas Road is a three-lane, two-way bituminous roadway with one eastbound travel lane, a two-way left turn lane in the middle for both directions of travel, a westbound travel lane, and wide shoulders on either side of the roadway. Douglas Road at its intersection with Andover Street is a two-lane, two-way bituminous roadway with no pavement markings. The northbound approach of Douglas Road is stop controlled.

The unsignalized, four-way intersection of Andover Street, Clark Road, and Raven Road is located to the north of the proposed school site. Andover Street at its intersection with Douglas Road is a three-lane, two-way bituminous roadway with one eastbound travel lane, a two-way left turn lane in the middle for both directions of travel, a westbound travel lane, and wide shoulders on either side of the roadway. Clark Road at its intersection with Andover Street and Raven Road is a two-lane, two-way bituminous roadway with no pavement markings. The northbound approach of Clark Road is stop controlled. Raven Road at its intersection with Andover Street and Clark Road is a two-lane, two-way bituminous roadway with one northbound travel lane, a landscaped median island, and one southbound travel lane. The southbound approach of Raven Road is stop controlled.

The unsignalized, three-way intersection of Clark Road and Village Street is located to the southeast of the proposed school site in the Town of Tewksbury. Clark Road at its intersection with Village Street is a two-lane, two-way bituminous roadway with one northbound travel lane, one southbound travel lane and marked shoulders on either side of the roadway. Village Street at its intersection with Clark Road is a two-lane, two-way bituminous roadway with no pavement markings. There is an eroded gravel area on the north side of the roadway that is used for perpendicular street parking for the nearby recreation fields. The eastbound approach of Village Street is stop controlled.

The signalized, four-way intersection of Rogers Street, Douglas Road, and Phoenix Avenue is located to the southwest of the proposed school site. Rogers Street at its intersection with Douglas Road and Phoenix Avenue is a four-lane, two-way bituminous roadway with two westbound travel lanes, two eastbound travel lanes, and narrow shoulders on either side of the roadway. Douglas Road at its intersection with Rogers Street is a two-lane, two-way bituminous roadway with one northbound travel lane, one southbound travel lane, and no marked shoulders. To the north of the intersection, Douglas Road has no pavement markings. Within the functional area of the southbound approach, vehicles are backing onto Douglas Road from the Milan Pizza restaurant due to their on-site parking configuration. Phoenix Avenue at its intersection with Rogers Street is a three-lane, two-way bituminous roadway with a shared northbound left turn/through lane, a northbound right turn lane,

and one southbound travel lane. MassDOT currently has a project in the design phase to upgrade this intersection and its associated traffic signal equipment.

The unsignalized, three-way intersection of Rogers Street and Village Street is located to the south of the proposed school site. Rogers Street at its intersection with Village Street is a four-lane, two-way bituminous roadway with two westbound travel lanes, two eastbound travel lanes, and narrow shoulders on either side of the roadway. Village Street at its intersection with Rogers Street is a two-lane, two-way bituminous roadway with no pavement markings. Currently, the northeast corner of the intersection is under construction due to construction of a NTB Tire and Service Center.

The signalized, three-way intersection of Main Street (Route 38) and Clark Road is located to the southeast of the proposed school site in the Town of Tewksbury. Main Street at its intersection with Clark Road is a five-lane, two-way bituminous roadway. To the west of the intersection, Main Street has one eastbound left turn lane, two eastbound through lanes, two westbound travel lanes, and narrow shoulders on both sides of the roadway. There are driveway curb cuts along the south side of the roadway near the intersection. To the east of the intersection, Main Street has two westbound through lanes, a westbound right turn lane onto Clark Road, a striped median, two eastbound travel lanes, and narrow shoulders on both sides of the roadway. The southern eastbound travel lane splits into an Interstate 495 southbound on-ramp. Clark Road at its intersection with Main Street is a three-lane, two-way bituminous roadway with one southbound right turn lane, one southbound left turn lane, one northbound travel lane, and narrow shoulders on both sides of the roadway. The intersection is located directly west of the intersection of Main Street and the Interstate 495 southbound ramps.

2.2.2 Existing Pedestrian and Sidewalk Facilities

The City requested a field review of the existing conditions to determine the sidewalk/pedestrian improvements required to accommodate walkers in the immediate vicinity of the Cawley site, see Figure No. 13.

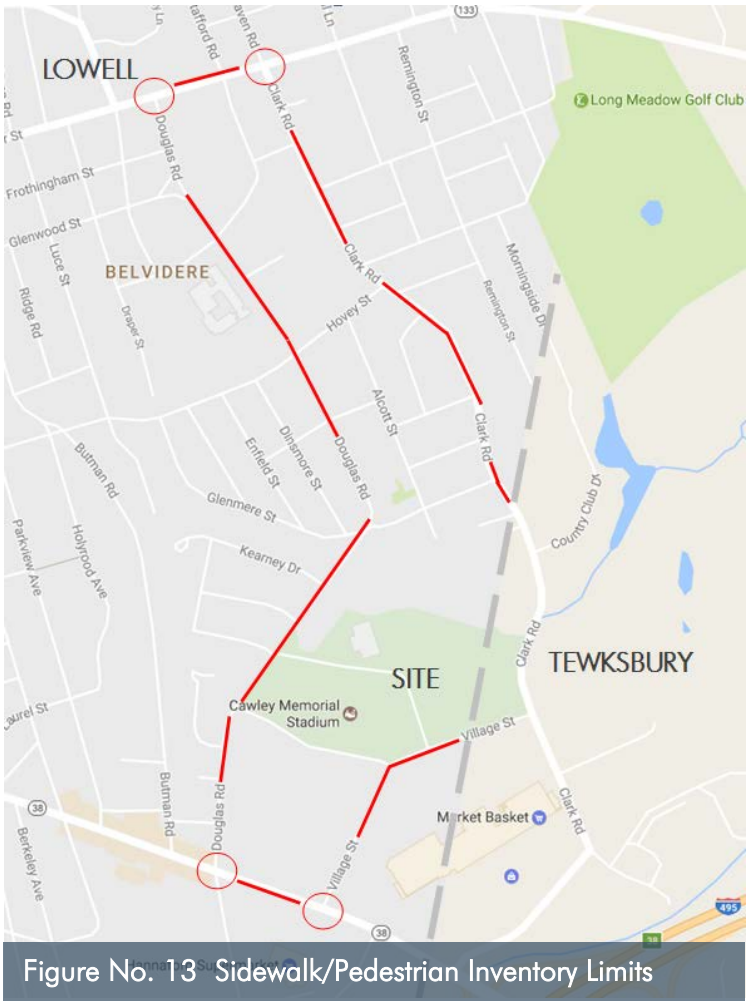


Figure No. 13 Sidewalk/Pedestrian Inventory Limits

This review has identified the areas that have no sidewalks, the areas of existing sidewalks where improvements are needed, the presence of curb ramps, and an inventory of the available pedestrian accommodations at existing traffic signals and/or crossings on Andover Street (Route 133) and Rogers Street (Route 38).

All possible improvements discussed in this section should be further investigated by the City for feasibility (e.g. available right-of-way, grades, utilities, vegetation, etc.). The information presented in this section should only be referred to as a high level planning tool.

2.2.2.1 Andover Street

Figure No. 14 Andover Street (Route 133) from Douglas Road to Clark Road

Andover Street from Douglas Road to Clark Road has existing bituminous sidewalks that are setback by a grass strip on either side of the roadway. There is no south sidewalk for 135 feet± immediately east of Clark Road. The utility poles are located on the south side of the roadway. West of Douglas Road, there is an existing marked crosswalk across Andover Street that is used by the students of the nearby elementary and middle schools. The City has investigated ways to increase safety for pedestrians at this crossing, including the installation of rectangular rapid flashing beacon (RRFD) assemblies, the construction of bump outs on both sides of the road, and the construction of a center median island (see Appendix I). Twelve (minimum) curb ramps with ADA detectable warning panels are recommended to be constructed (or reconstructed) where the sidewalk terminates at the side streets and at the existing Andover Street/Douglas Road crosswalk. A summary of the field evaluation can be found in Table No. 1, including the length of possible sidewalk and driveway improvements, the minimum number of possible curb ramps with ADA detectable warning panels to be reconstructed or constructed, and the presence of existing utility poles.

Table No. 1
Andover Street Summary*

FROM	TO	North Side			South Side		
		SWK/ DWY Improv./ Construction (feet)	Min. Number of Curb Ramp Construction	Utility Poles	SWK/ DWY Improv./ Construction (feet)	Min. Number of Curb Ramp Construction	Utility Poles
Douglas Rd	Clark Rd	N/A	5		N/A	7	✓
Immediately East of Clark Rd		N/A	N/A		135±	N/A	✓

* The City's improvements proposed for the existing Andover Street crosswalk is not included in this table.

Note: further investigation is needed to evaluate feasibility (e.g. available right-of-way, grades, utilities, vegetation, etc.) of these improvements.

2.2.2.2 Clark Road

In general, Clark Road (ranging from 25 to 30 feet in width) is a curvy residential roadway in Lowell and Tewksbury. This urban collector provides a connection between the commercial area of Rogers Street/Main Street (Route 38) and Andover Street. Although there are some existing sidewalks on the northern end near Andover Street, the majority of the roadway does not have any existing sidewalks on either side of the roadway. Aside from a few isolated areas on the roadway, there is no indication of many vehicles routinely parking on the side of road. Numerous curb ramps with ADA detectable warning panels along Clark Road are recommended to be constructed (or reconstructed) where the existing sidewalk (or the proposed sidewalk) terminates at the side streets or at any proposed marked crosswalks. A summary of the field evaluation can be found in Table No. 2, including the length of possible sidewalk and driveway improvements, the minimum number of possible curb ramps with ADA detectable warning panels to be constructed or reconstructed, and the presence of existing utility poles.

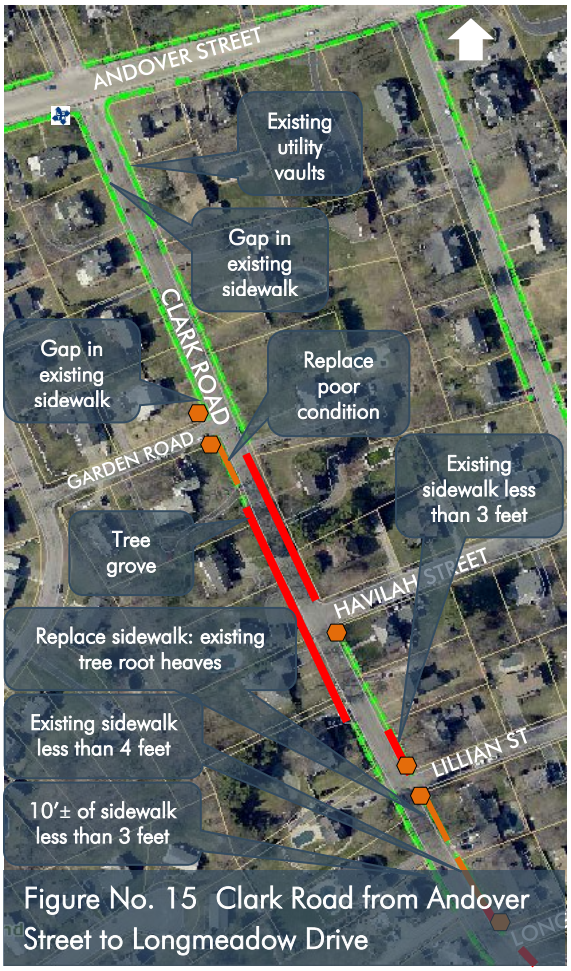


Figure No. 15 Clark Road from Andover Street to Longmeadow Drive

The majority of the existing sidewalks on Clark Road, which are found between Andover Street and Longmeadow Drive, are bituminous sidewalks that are setback by a grass strip. There are areas in this section of Clark Road where there are no existing sidewalks or existing sidewalks that are less than three feet wide. The utility poles are located on the west side of the road until south of Garden Road, where the utility poles switch to the east side of the road. Figure No. 15 shows the noted observations along Clark Road from Andover Street to Longmeadow Drive.

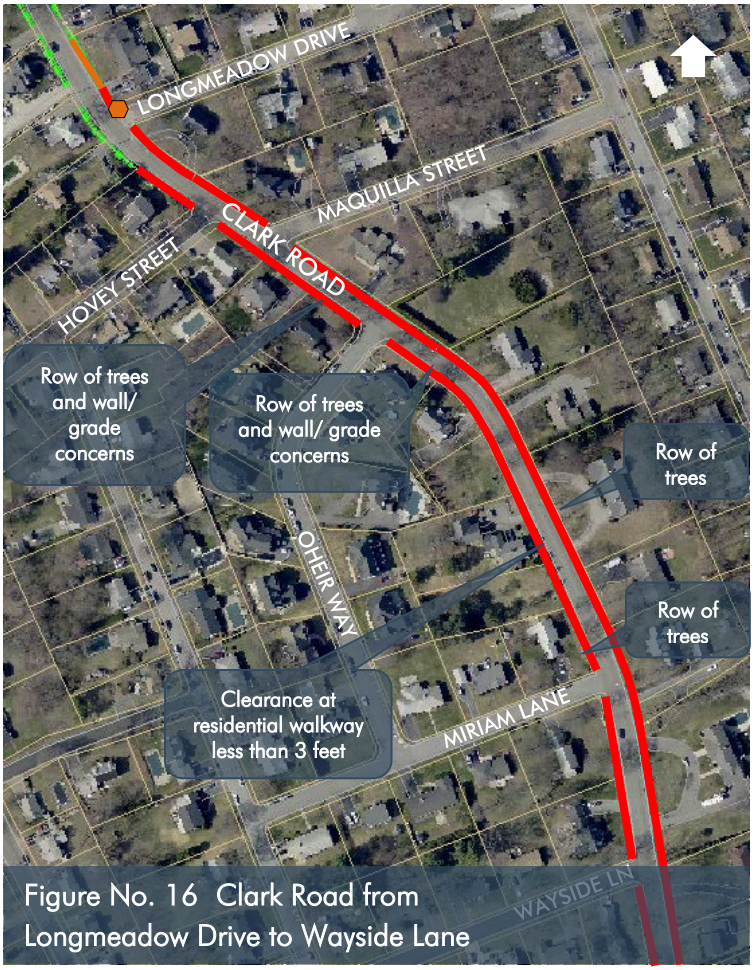


Figure No. 16 Clark Road from Longmeadow Drive to Wayside Lane

There are no existing sidewalks on Clark Road between Longmeadow Drive and Wayside Lane, except for a small section of sidewalk on the west side of the road near Longmeadow Drive. In this section, the utility poles are located on the east side of Clark Road. Areas where there are a row of trees adjacent to the roadway and other field observations have been indicated in Figure No. 16.

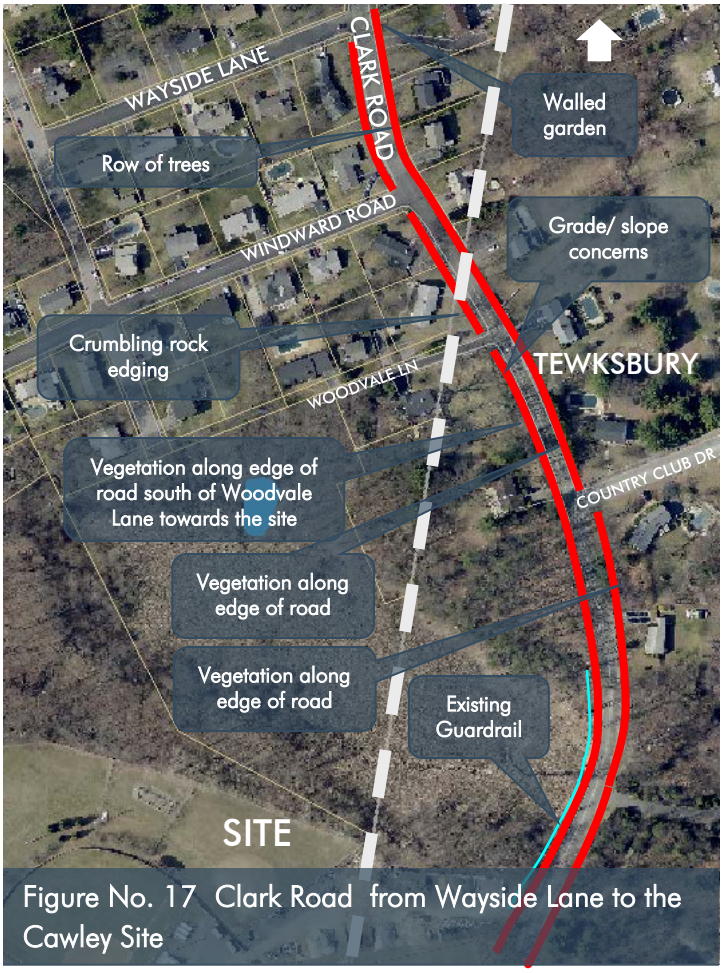


Figure No. 17 Clark Road from Wayside Lane to the Cawley Site

There are no existing sidewalks on Clark Road between Wayside Lane and Village Street. The utility poles are located on the east side of the road between Garden Road and Windward Road as well as between Woodvale Lane and the Cawley site. The utility poles switch to the west side of Clark Road between Windward Road and Woodvale Lane. Figure No. 17 shows the noted observations along Clark Road from Wayside Lane to the Cawley Site.

Table No. 2
Clark Road Summary

FROM	TO	West Side			East Side		
		SWK/ DWY Improv./ Construction (feet)	Min. Number of Curb Ramp Construction	Utility Poles	SWK/ DWY Improv./ Construction (feet)	Min. Number of Curb Ramp Construction	Utility Poles
Andover St	Garden Rd	20±	1	✓	N/A	0	
Garden Rd	Hovey St	550±	2		750±	6	✓
Hovey St	Woodvale Ln	1,680±	10	✓	1,720±	2	✓
Woodvale Ln	Village St	1,400±	2	✓	1,330±	2	✓

Note: further investigation is needed to evaluate feasibility (e.g. available right-of-way, grades, utilities, vegetation, etc.) of these improvements.

2.2.2.3 Douglas Road

In general, Douglas Road (typically ranging from 28 to 32 feet in width) is a residential roadway that also provides access to the Reilly Elementary School and the Sullivan Middle School. Similar to Clark Road, this urban collector also provides a connection between the commercial area of Rogers Street (Route 38) and Andover Street. The majority of the roadway does not have sidewalks on either side of the roadway, except near Andover Street and the adjacent elementary school. For many sections of Douglas Road, it is evident that vehicles routinely park on the side of the road, however, there are existing signs prohibiting parking in certain areas of Douglas Road. Numerous curb ramps with ADA detectable warning panels along Douglas Road are recommended to be constructed (or reconstructed) where the existing sidewalk (or the proposed sidewalk) terminates at the side streets or at any existing (or proposed) marked crosswalks. A summary of the field evaluation can be found in Table No. 3, including the length of possible sidewalk and driveway improvements, the minimum number of possible curb ramps with ADA detectable warning panels to be constructed (or reconstructed), and the presence of existing utility poles.

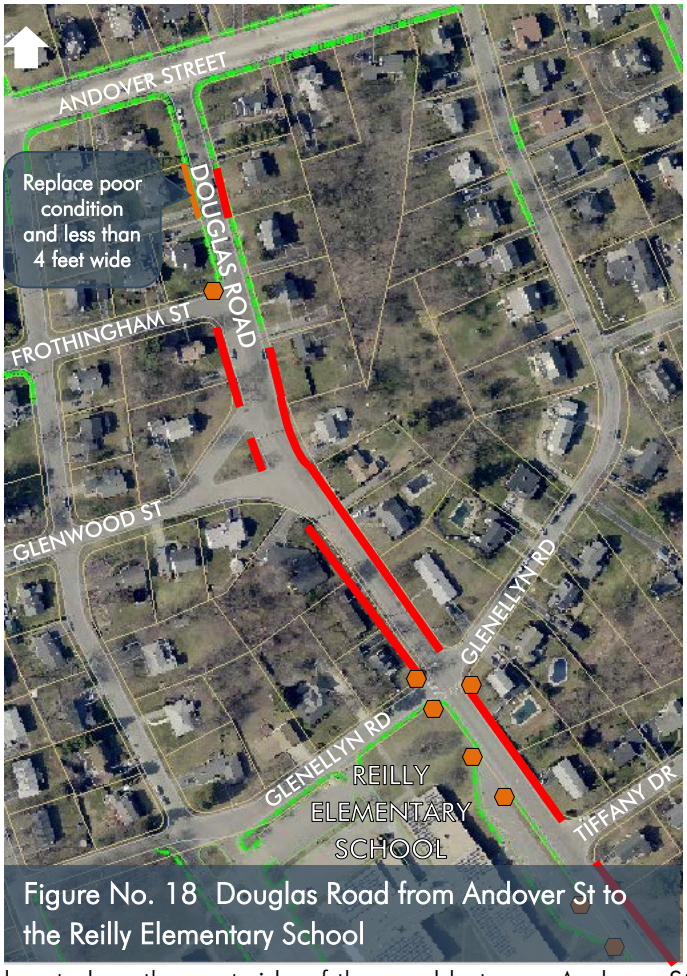


Figure No. 18 Douglas Road from Andover St to the Reilly Elementary School

The majority of the existing sidewalks on Douglas Road, which are found between Andover Street and Frothingham Street, are bituminous sidewalks that are setback by a grass strip. The existing bituminous sidewalks that are found adjacent to the elementary school are not setback from Douglas Road. The existing elementary school sidewalks do not have curb ramps where they terminate at the side streets or the school driveways. Generally, there are no sidewalks on either side of the road between Frothingham Street and Glenellyn Road. There are no sidewalks on the east side of Douglas Road between Glenellyn Road and Hovey Street.

Douglas Road is at its widest (approximately 50 feet) between Frothingham Street and Glenwood Street. There are existing signs prohibiting parking on both sides of Douglas Road between Glenellyn Road and Hovey Street (in front of the elementary school) during school hours. The utility poles are located on the east side of the road between Andover Street and Glenwood Street, as well as between Glenellyn Road and Hovey Street. The utility poles switch to the west side of Douglas Road between

Glenwood Street and Glenellyn Road. Figure No. 18 shows the noted observations along Douglas Road from Andover Street to the elementary school.

Figure No. 19 Douglas Road from the Reilly Elementary School to Glenmere Street

There are no existing sidewalks on Douglas Road between Hovey Street and Glenmere Street. Along with no sidewalks noted in this section of Douglas Road, indications of vehicles routinely park (sporadically) along the either side of the roadway were noted.

In this section, the utility poles are located on the west side of Douglas Road (between Hovey Street and Windward Road). Figure No. 19 shows the noted observations along Douglas Road from the elementary school to Glenmere Street.

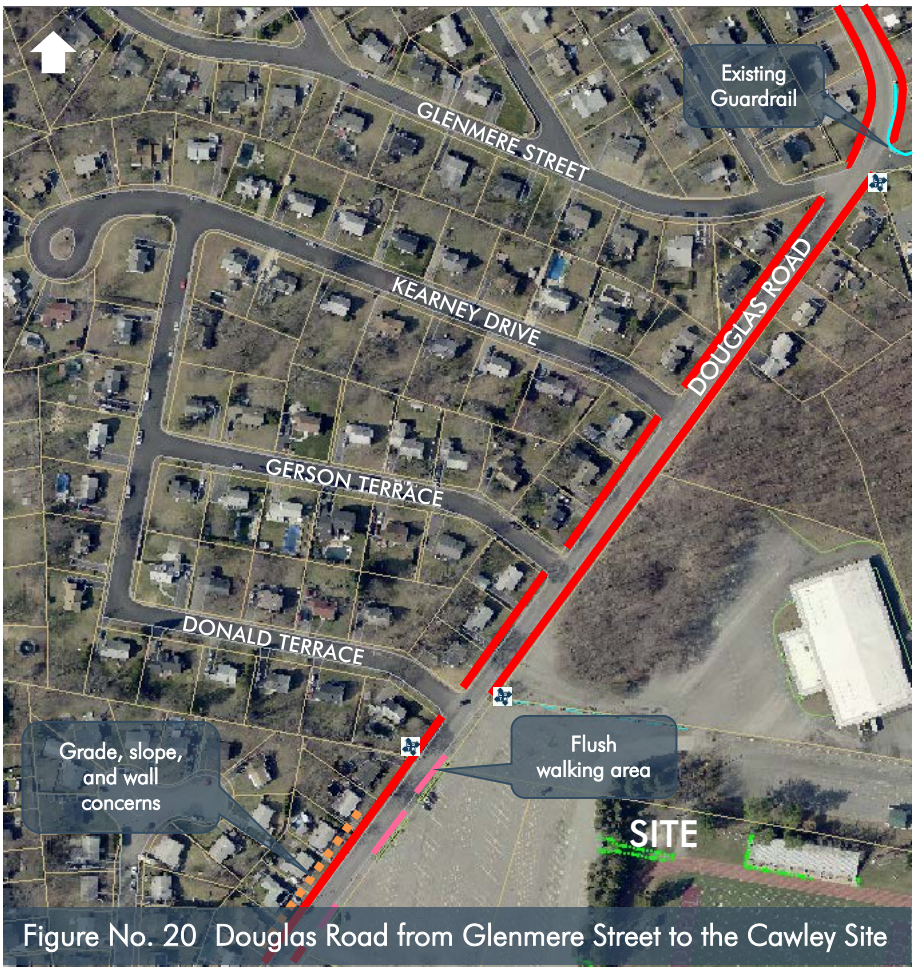


Figure No. 20 Douglas Road from Glenmere Street to the Cawley Site

There are no existing sidewalks on Douglas Road between Glenmere Street and Wedgemere Drive. On the east side of the road, the landscape islands in the existing Cawley stadium parking lot are setback from the road. This setback allows for a flush walking area with the adjacent roadway.

There are grade, slope, and wall concerns on the west side of Douglas Road between Donald Terrace and the southern boundary of the Cawley site.

There are existing 'no parking at any time' signs posted at various locations along the west side of Douglas Road: one south of Kearney Drive, one between Gerson Terrace and Donald Terrace, one south of Wiltshire Circle and one south of Allen Street. There is also a 'tow area, no parking' sign on the east side of Douglas Road at Kearney Drive.

There is guardrail located near the edge of pavement on the east side of the roadway, north of Windward Road. The utility poles are located on the east side of the road between Windward Road and Donald Terrace. The utility poles then switch to the west side of Douglas Road between Donald Terrace and Wedgemere Drive. Figure No. 20 shows the noted observations along Douglas Road from Glenmere Street to the Cawley site.

Figure No. 21 Douglas Road from the Cawley Site to Rogers Street

There are no existing sidewalks on Douglas Road between Wedgemere Drive and Rogers Street. The roadway width of Douglas Road between Wedgemere Drive and Rogers Street is approximately 30 feet. The utility poles are located on the east side of the road between Wedgemere Drive and Rogers Street. There are multiple obstructions (e.g. fences, walls, post, vegetation, etc.) at various locations within 4 feet (or less) of the edge of pavement on both sides of Douglas Road from the Cawley site to Rogers Street.

As previously discussed, there are existing 'no parking at any time' signs posted at various locations along the west side of Douglas Road, including one south of Wiltshire Circle and one south of Allen Street. Although there are no indications of parking immediately near the existing no parking signs, there are indications of vehicles parking along the west side of Douglas Road between the Cawley site and Rogers Street. Figure No. 21 shows the noted observations along Douglas Road from the Cawley site to Rogers Street.

Table No. 3
Douglas Road Summary

FROM	TO	West Side			East Side		
		SWK/ DWY Improv./ Construction (feet)	Min. Number of Curb Ramp Construction	Utility Poles	SWK/ DWY Improv./ Construction (feet)	Min. Number of Curb Ramp Construction	Utility Poles
Andover St	Glenellyn Rd	670±	7	✓	650±	1	
Glenellyn Rd	Hovey St	N/A	5		820±	3	✓
Hovey St	Glenmere St	1,260	4	✓	1,250±	4	✓
Glenmere St	Wedgemere Dr	1,580±	8	✓	1,270±*	1	✓
Wedgemere Dr	Rogers St	710±	5		790±	0	✓

* The area adjacent to the Cawley site is not included in this length.

Note: further investigation is needed to evaluate feasibility (e.g. available right-of-way, grades, utilities, vegetation, etc.) of these improvements.

2.2.2.4 Rogers Street

Rogers Street from Douglas Road to Village Street has existing concrete sidewalks on either side of the roadway. There is no northern sidewalk between the Market Basket shopping plaza driveway and Clark Road in Tewksbury. The existing southern sidewalk terminates approximately 100 feet west of the Douglas Road intersection (i.e. there is a gap in the southern sidewalk along Rogers Street from Parkview Avenue to this terminus). The utility poles are located on the south side of the roadway.

A summary of the field evaluation can be found in Table No. 4, including the length of possible sidewalk and driveway improvements, the minimum number of possible curb ramps with ADA detectable warning panels to be constructed or reconstructed, and the presence of existing utility poles. As will be discussed further in this section, all the of traffic signals on Rogers Street/Main Street in this area would benefit from pedestrian signal equipment upgrades.

Figure No. 22 Rogers Street from Douglas Road to Village Street

At the signalized intersection of Rogers Street, Douglas Road and Phoenix Avenue, there are curb ramps associated with the marked crosswalks across all four approaches. The eastern marked crosswalk across Rogers Street is the only crosswalk at this signalized intersection that provides pedestrian signal heads (without countdown timers), and pedestrian pushbuttons. MassDOT currently has a project in the design phase to upgrade this intersection and its associated traffic signal equipment (see Appendix I).

There are curb ramps associated with a marked crosswalk across the Village Street approach at the unsignalized intersection of Rogers Street and Village Street. Although the existing curb ramps have detectable warning panels, it is suggested that these curb ramps be reconstructed and repositioned to direct pedestrians towards the crossing of Village Street rather than the narrow shoulder of Rogers Street, as well as providing the required 5-foot square landing area within the marked crosswalk.

There are curb ramps associated with a marked crosswalk across the Groton Street approach at the unsignalized intersection of Rogers Street and Groton Street.

At the signalized intersection of Rogers Street, Research Center Drive, and the Market Basket shopping plaza driveway, there are curb ramps associated with two marked crosswalks. There is one marked crosswalk across Rogers Street on the west side of intersection. The other marked crosswalk crosses the Research Center Drive approach to the south of the intersection. There are no pedestrian signal heads provided for these crosswalks. There is a pedestrian pushbutton on the northwest corner of the intersection. There is a pedestrian pushbutton housing located on the southwest corner, but the actual button is missing. The southeast corner is not equipped with a pedestrian pushbutton. Overall, the pedestrian accommodations can be upgraded at this traffic signal due to the lack of pedestrian signal heads and condition of the pedestrian pushbuttons.

At the signalized intersection of Main Street and Clark Road, there are curb ramps associated with one marked crosswalk across Clark Road on the north side of intersection. There are no pedestrian signal heads or pushbuttons provided for the Clark Road crosswalk. The curb ramp on the northwest corner stands alone since there are no sidewalks on this side of Main Street or Clark Road. If sidewalks were installed on the north side of Main Street in front of the Mobil gas station, there are existing bollards and utilities that could be obstacles. There are no marked crosswalks across Main Street.

Table No. 4
Rogers Street/ Main Street Summary

FROM	TO	North Side			South Side		
		SWK/ DWY Improv./ Construction (feet)	Min. Number of Curb Ramp Construction	Utility Poles	SWK/ DWY Improv./ Construction (feet)	Min. Number of Curb Ramp Construction	Utility Poles
Douglas Road	Research Center Dr	N/A	2		N/A	0	✓
Research Center Dr	Clark Rd	500±	0		N/A	0	✓

Notes: (1) Further investigation is needed to evaluate feasibility (e.g. available right-of-way, grades, utilities, vegetation, etc.) of these improvements.
(2) There are pedestrian traffic signal upgrades suggested at the Douglas Road/ Phoenix Avenue intersection, at the Research Center Drive intersection, and at the Clark Road intersection.

2.2.2.5 Village Street

Village Street (ranging from 24 to 35 feet in width) is a roadway with access to the newly constructed NTB service center, the existing Cawley stadium site, a residential home, and the Holy Ghost Society in Lowell and Tewksbury. This local road provides a connection between the commercial area of Rogers Street and Clark Road. During events at the Cawley site, vehicles likely parallel park on both sides of Village Street, although there are existing signs prohibiting parking on the west and north side of the roadway. However, it appears that vehicles park perpendicular to Village Street (on gravel area located at the Cawley site) on the north side of the roadway between the existing eastern Cawley site driveway and Clark Road.

There are some existing sidewalks on the west side of Village Street near Rogers Street, however, the majority of the roadway does not have sidewalks on either side of the roadway. The existing bituminous sidewalk on the west side of the roadway does have existing utility poles located in the middle of it.

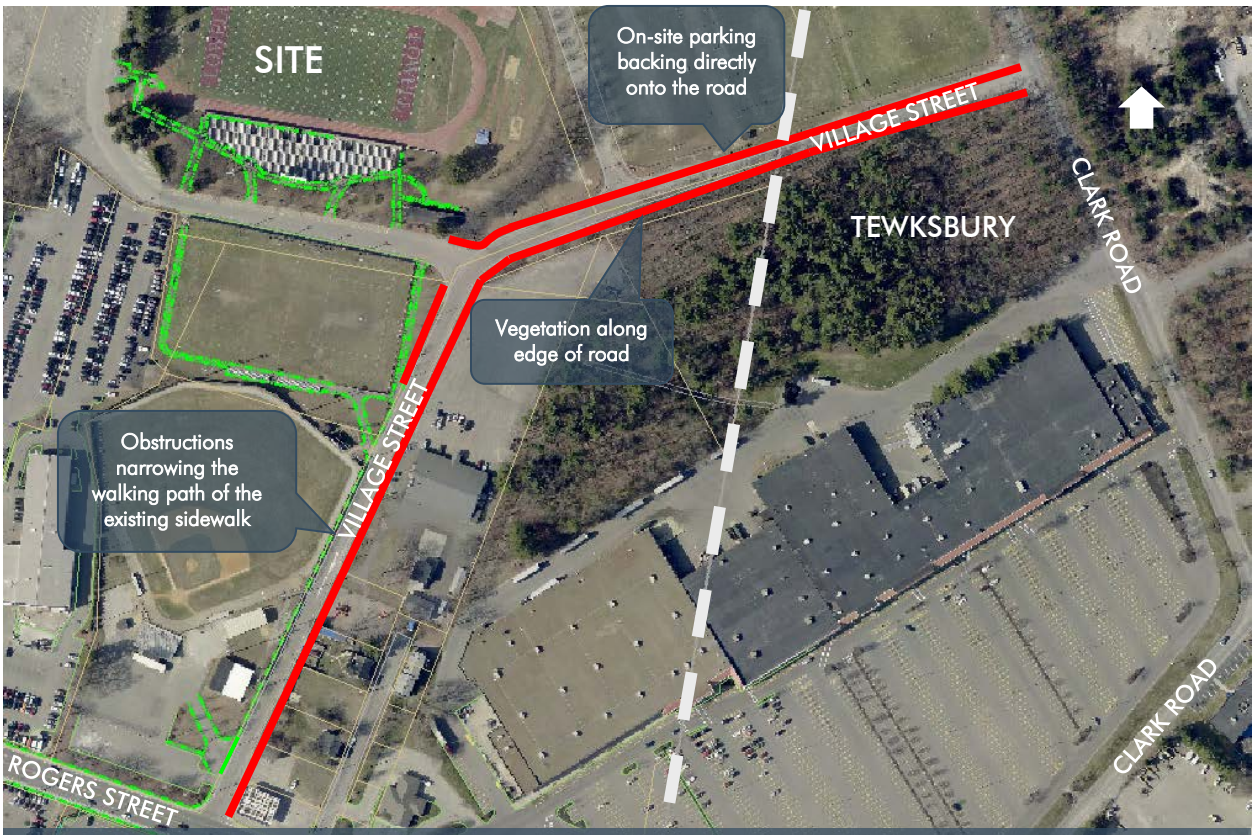


Figure No. 23 Village Street from Rogers Street to Clark Road

A summary of the field evaluation can be found in Table No. 5, including the length of possible sidewalk and driveway improvements, the minimum number of possible curb ramps with ADA

detectable warning panels to be constructed or reconstructed, and the presence of existing utility poles.

Table No. 5
Village Street Summary

FROM	TO	West Side			East Side		
		SWK/ DWY Improv./ Construction (feet)	Min. Number of Curb Ramp Construction	Utility Poles	SWK/ DWY Improv./ Construction (feet)	Min. Number of Curb Ramp Construction	Utility Poles
Rogers St	Existing Western Site Driveway	175±	1	✓	1,050±	N/A	
		North Side			South Side		
Existing Western Site Driveway	Clark Rd	1,020±	2	✓	950±	1	

Note: further investigation is needed to evaluate feasibility (e.g. available right-of-way, grades, utilities, vegetation, etc.) of these improvements.

2.3 Data Collection

Traffic turning movement counts were conducted at both study areas between the hours of 6:00 and 10:00 A.M. and 2:00 and 6:00 P.M. on Wednesday, March 29, 2017. Extended traffic turning movement counts were conducted at the Rogers Street and Village Street intersection and the Andover Street and Douglas Road intersection to obtain counts at these intersections from 6:00 A.M. to 8:00 P.M. on Wednesday, March 29, 2017. The traffic count data is shown in Appendix A.

The calculated school A.M. peak hour for the existing Lowell High School is 7:15 – 8:15 and the school P.M. peak hour is 2:30 – 3:30. These peak hours were utilized for the analysis of all the study intersections since the school renovation is the focus of this report.

Pertinent field observations including existing stopping sight distance, location of existing utilities, posted speed limits, traffic control devices, etc. were made on April 12, April 27, and May 9, 2017. Crash data (Appendix D) for the period from January 2014 through March 2017, was obtained from the Lowell and Tewksbury Police Departments. Continuous traffic speed data was obtained within both study areas using road tubes or radar on Wednesday, March 29, 2017 and is shown in Appendix E.

3.0 Traffic Forecasts

3.1 Observed Traffic Volumes

Existing traffic volumes for the study areas were developed from traffic data obtained by Precision Data Industries, LLC (PDI) on Wednesday, March 29, 2017.

3.1.1 Downtown Site Study Area

The school hours for the existing Lowell High School are from 7:50 A.M. to 2:30 P.M. The school A.M. and school P.M. peak hours used for purposes of the analysis of this study, as indicated in Section 2.3, will be between 7:15 and 8:15 and 2:30 and 3:30, respectively.

Table No. 6 summarizes the two-way (or one-way, as applicable) existing traffic volumes for the studied roadways in the Downtown site area during the school A.M. and school P.M. peak hours.

Table No. 6
March 2017 Existing Traffic Volumes
Downtown Site Area

Intersection/ Roadway/	2-Way or 1-Way Volume	Peak Hour	
		School A.M. Volume (vehicles per hour)	School P.M. Volume (vehicles per hour)
Father Morissette Boulevard/ Arcand Drive			
Father Morissette Blvd	2	919	710
Arcand Dr	2	1,035	697
French Street/ Kirk Street/ Driveway			
French St	2	917	488
Kirk St	1	257	99
Driveway	2	32	9
French Street/ Bridge Street			
French St	2	728	474
Bridge St	2	1,075	1,307
Merrimack Street/ Worthen Street			
Merrimack St	2	728	657
Worthen St	1	125	107
Merrimack Street/ Dutton Street/ Arcand Drive			
Merrimack St	2	849	674
Dutton St	2	1,169	870
Arcand Dr	2	910	607
Merrimack Street/ Central Street			
Merrimack St	2	922	838
Central St	2	873	726
Merrimack Street/ Bridge Street/ Kearney Square/ Prescott Street			
Merrimack St	2	874	839
Bridge St	2	1,067	1,181
Kearney Sq	2	1,025	850
Prescott St	1	446	635

The total 24-hour two-way traffic volume (from the road tube counts) on Father Morissette Boulevard in the vicinity of the existing high school near the existing signalized mid-block crosswalk is approximately 8,000 vehicles per day. The total 24-hour two-way traffic volume on Arcand Drive in the vicinity of the existing high school is approximately 9,000 vehicles per day.

3.1.2 Cawley Site Study Area

The school A.M. and school P.M. peak hours used for purposes of the analysis of this study will be between 7:15 and 8:15 and 2:30 and 3:30, respectively.

Table No. 7 summarizes the two-way (or one-way, as applicable) existing traffic volumes for the studied roadways in the Cawley site area during the school A.M. and school P.M. peak hours.

Table No. 7
March 2017 Existing Traffic Volumes
Cawley Site Area

Intersection/ Roadway/	2-Way or 1-Way Volume	Peak Hour	
		School A.M. Volume (vehicles per hour)	School P.M. Volume (vehicles per hour)
Andover Street/ Douglas Road			
Andover St	2	1,777	1,507
Douglas Rd	2	103	111
Andover Street/ Clark Road/ Raven Road			
Andover St	2	1,817	1,513
Clark Rd	2	282	294
Raven Rd	2	61	64
Rogers Street/ Douglas Road/ Phoenix Avenue			
Rogers St	2	1,388	1,759
Douglas Road	2	231	303
Phoenix Ave	2	194	278
Rogers Street/ Village Street			
Rogers St	2	1,311	1,675
Village St	2	22	56
Main Street/ Clark Road/ 495 Southbound On Ramp			
Main St	2	1,339	1,879
Clark Rd	2	504	758
495 SB On Ramp	1	396	374

The total 24-hour two-way traffic volume (from the road tube counts) on Clark Road in the vicinity of the proposed high school is approximately 5,800 vehicles per day. The total 24-hour two-way traffic volume on Village Street in the vicinity of the proposed high school is approximately 500 vehicles per day.

3.2 Area Traffic Growth Rate

The Northern Middlesex Council of Governments (NMCOG) is the regional planning agency for the Greater Lowell region. NMCOG indicates an annual traffic growth rate of 0.16% for the City of Lowell based on data collected between 2008 and 2016. NMCOG recommends the study use a conservative annual traffic growth rate 0.5% for the City of Lowell. Although parts of the Cawley study area are in the Town of Tewksbury, the analysis presented in this report will utilize and apply the City of Lowell's annual 0.5% traffic growth rate to all the existing traffic volumes.

3.3 Forecasted Traffic Volumes

3.3.1 Vehicle Trip Generation

The traffic anticipated to be generated by the high school development was added to the turning movement count volumes adjusted by the traffic growth rate for use in determining levels of service (LOS) in the capacity analysis calculations.

To evaluate the traffic impacts of the proposed development, it is necessary to determine the amount of traffic expected to be generated by the proposed development. Typically, the trip generation calculations are based on data compiled in *Trip Generation* (9th edition), an informational report published by the Institute of Transportation Engineers (ITE). *Trip Generation* is a tool for planners, transportation professionals, zoning boards, and others who are interested in estimating the number of vehicle trips generated by a proposed development or land use. This document is based on more than 5,500 trip generation studies submitted to the Institute by public agencies, developers, consulting firms, and associations.

However, more specific information from the traffic turning movement counts and mode of transportation surveys conducted for the existing Lowell High School have been used for the trip generation and distribution for both the Downtown and Cawley sites. The mode of transportation surveys identified three basic vehicular modes that a student uses to travel to and from the high school: (1) driving and parking, (2) riding with family and friends, or (3) riding the bus.

The largest generator of vehicle trips of these three modes is a student that is transported by rides from family and friends. This is because a student that is transported by rides from family and friends will generate two trips per student (a vehicle going to and from the site) during both morning arrival and afternoon dismissal. A student that drives and parks on-site will generate one trip to arrive in the morning and one trip in the afternoon for dismissal. Although school buses also generate two trips during both morning arrival and afternoon dismissal, the capacity of a bus versus a standard vehicle is much greater, which results in a net decrease in generated vehicle trips to and from the site. An example of this principle is shown in Figure No. 24.

Figure No. 24
Number of Vehicle Trips Generated During a School Peak Hour
Based on Vehicle Mode

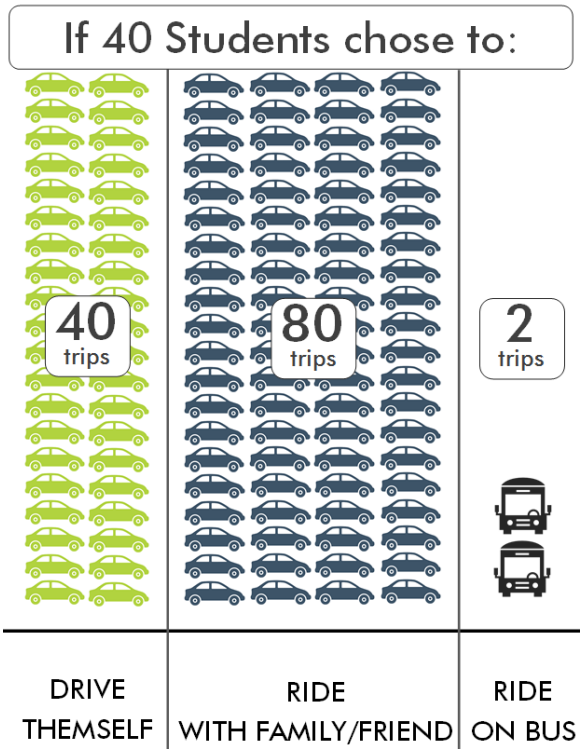


Figure No. 24 shows when 40 students travel to or from school, 40 vehicle trips are anticipated if each student drives themself, 80 vehicle trips are anticipated if each student rides with a family or friend, and 2 vehicle trips are anticipated if each student rides the bus during each school peak hour.

As stated in Section 1.2, the existing Lowell High School currently has approximately 3,255 high school students and 440 daytime employees. All of the proposed alternatives for Lowell High School will be designed to accommodate 3,520 high school students and estimated to have 500± daytime employees. A ratio has been developed for the additional new trips from the existing and proposed student and staff populations for the Downtown site. The additional new trips for the Downtown site were developed and distributed based on the anticipated future transportation modes of the students and staff (see Section 3.3.2). The proposed high school at the Cawley site will need to accommodate generated trips for all 3,520 high school students and the estimated 500 daytime employees. An anticipated allocation of future transportation modes used by the students and staff was developed for the Cawley site based on the April 2017 surveys, but modified to reflect the site specific characteristics of the site (see Section 3.3.3). The trip generation calculations and the distribution of the traffic anticipated by the school at each site are shown in Appendix B.

3.3.2 Downtown Site

The City is considering the possibility of providing a city busing program for the Downtown site. The City is anticipating the future busing program for the Downtown site would be comprised of 30 buses, which would carry approximately 1,300 students. With the implementation of a city school busing program, it is anticipated that the students that currently use the LRTA buses would switch to using the city school buses. It is also anticipated that there may be a decrease in walkers and students that ride with family/friends to and from school with the city school busing program implementation.

Although there is a possibility of a city school busing program for the Downtown site, for this study, the build analysis was based on current observed traffic patterns and the modes of travel that students and staff indicated in the April 2017 surveys and previously discussed in Section 2.1. Therefore, the analysis is based on students traveling on LTRA buses, not school buses.

The vehicle volumes anticipated to be generated by the proposed high school development at the Downtown site during the school A.M. and school P.M. peak hours, can be found in Table No. 8.

Table No. 8
Anticipated Generated New Vehicle Trips Summary
Downtown Site

Time Period	Direction	New Vehicle Trips
School A.M. Peak Hour	Enter	159
	Exit	91
School P.M. Peak Hour	Enter	35
	Exit	100

The distribution of the anticipated new vehicle trips by direction were based upon the existing trip patterns observed in the traffic count data and the expected usage of the roadways for the school. These trips were added to the no-build volumes for analysis of the build conditions. The trip generation calculations and the distribution of the traffic anticipated by the school are shown in Appendix B.

3.3.3 Cawley Site

For the purpose of this study, the schematic plans developed on May 10, 2017 for the 4-story and 5-story options for this alternative were analyzed. Assumptions were made about how the site can be used for drop-off and pick-up area, school bus loading area, the parking areas, and the internal circulation (see Figure Nos. 4 and 5). It was assumed that the Clark Road driveway and the eastern Village Street driveway would be used for accessing the drop-off and pick-up area. It was assumed the middle driveway on Village Street and the northern Douglas Road driveway would be used to access the school bus loading area. The southern Douglas Road driveway was assumed to operate as a right turn entrance only driveway.

3.3.3.1 Parking

The site layout plans in Figure Nos. 4 and 5 provide approximately 850 on-site parking spaces.

The parking requirement for a new high school per the City's Zoning Book (adopted 12/7/2004, with amendments through 10/22/2013) indicates 6 spaces per instructional room are required. Depending on the City's interruption of an 'instructional' room, the minimum number of on-site parking spaces is 840 parking spaces. The Cawley site layout is still evolving, where the ultimate goal is to balance of all the needs of the site (i.e. building, fields, parking, etc.), the final Cawley site design may require an on-site parking variance.

The anticipated parking demand for the Cawley site can be estimated based on the number of estimated vehicles that currently park around the existing Downtown high school site by students and staff. Based on the projected 500 staff and 3,520 students at the Cawley site, it is assumed that 500 spaces will be required for staff/visitors. If there is a similar demand (see Figure No. 6) of 10% of the student population who will want to park at the Cawley site, then 350 spaces would be needed to satisfy the anticipated student parking demand for the proposed site. Therefore, 850 on-site parking spaces would be needed at the Cawley site to meet this anticipated parking demand from students, staff, and visitors.

3.3.3.2 Busing

The City must develop a city school busing program for the Cawley site. Legally, the LRTA is prohibited from competing with school busing businesses. The City estimates that the proposed high school would need a fleet of 46 buses, which will carry approximately 2,000 students.

As was done for the Downtown site, it is assumed that 11 special education vehicles will be used by the proposed student population.

The City has indicated that they will be implementing a preferred bus route for the school buses and special education vehicles, which would require buses to use Route 38 and Village Street to access the Cawley site.

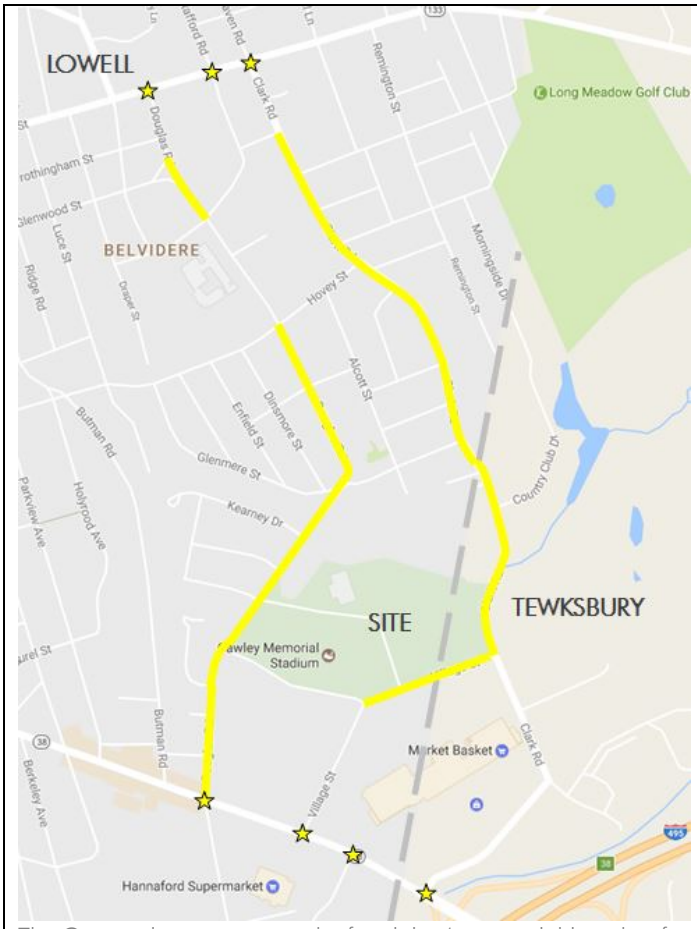
3.3.3.3 Drop-off and Pick-up

The more students that take advantage of the available busing, on-site parking, and walking will reduce the number of vehicles generating trips to drop-off and pick-up students (see Figure No. 24). Where the student drop-off and pick-up areas are located within the Cawley will influence the routes that these vehicles will use to access the site.

3.3.3.4 Walking

It is anticipated that there will be fewer students walking to and from the Cawley site than what the Downtown site currently experiences due to location of the Cawley site within the City. The Downtown site is centrally located in the City, while the Cawley site is on the east side of the City directly adjacent to Tewksbury, thus, fewer students would be able to walk to the school. Another factor that influences the number of walkers to the school is access to sidewalks and other pedestrian facilities on the walking route between their homes and the school.

Figure No. 25
Summary of Recommendations for
Pedestrian and Sidewalk Facilities near the Cawley Site



The City needs to investigate the feasibility (e.g. available right-of-way, grades, utilities, vegetation, etc.) of implementing these improvements.

Existing Sidewalk Areas: The following is a general summary of the recommendations for the existing sidewalks on the inventoried roadways:

- Installation/reconstruction of curb ramps at all side streets and other marked crosswalks;
- Spot reconstruction of existing sidewalks due to poor condition or inadequate sidewalk width;
- Installation of pedestrian improvements to the existing Andover Street/Douglas Road crosswalk previously investigated by the City; and
- Upgrade existing/ install additional pedestrian signal heads and pushbuttons at signalized intersections on Rogers Street/Main Street (Route 38).

Existing No Sidewalk Areas: In general, Douglas Road and Clark Road do not provide a connection for pedestrians between Andover Street (Route 133) and Rogers Street (Route 33) and the proposed school site. Sidewalks are not necessarily needed or recommended on both sides of the inventoried roadways. At a sidewalk terminus, a crosswalk with curb ramps will need to be marked and signed to allow pedestrians to cross and continue on the sidewalk on the other side of the road.

The Cawley site requires the City to investigate and invest in upgrading the sidewalk and pedestrian facilities in and around the site to accommodate students and staff that desire to walk. As discussed in Section 2.2.2, the inventory of the existing pedestrian and sidewalk facilities indicates areas that would

benefit from the construction or reconstruction of sidewalks and other pedestrian facilities. The discussions in Section 2.2.2 can be used by the City as a high level planning tool. The City needs to investigate the feasibility (e.g. available right-of-way, grades, utilities, vegetation, etc.) of implementing these improvements. For example, the City can propose to install a sidewalk on only one side of a road, rather than both sides, due to physical and/or budget constraints. However, if the City decides to install sidewalk on the west side, for instance, then a crosswalk with curb ramps will need to be marked and signed to allow pedestrians to cross and continue on the sidewalk on the east side of the road.

3.3.3.5 Mode of Transportation

It is assumed that the first priority of the available on-site parking will be for staff/visitors and the remaining spaces will be used by students. As with the Downtown site, the majority of the staff is anticipated to be driving and parking on site. It is assumed that 97% of staff will either self-drive or carpool during both school peak hours. It was assumed that the same percentages of 75% of staff arriving during the school A.M. peak hour and 70% of staff departing during the school P.M. peak hour would be the same for the Cawley site, as indicated in the April 2017 staff survey.

The percentages of the modes anticipated for the student population were adjusted to reflect the Cawley site's particular features and limitations (e.g. the location within the City, the number of available on-site student parking, the school busing program, etc.) as shown in Figure No. 26. The build conditions have been based on the Cawley site providing 350 on-site student parking spaces.

Figure No. 26
Anticipated Student Mode of Transportation for the Cawley Site

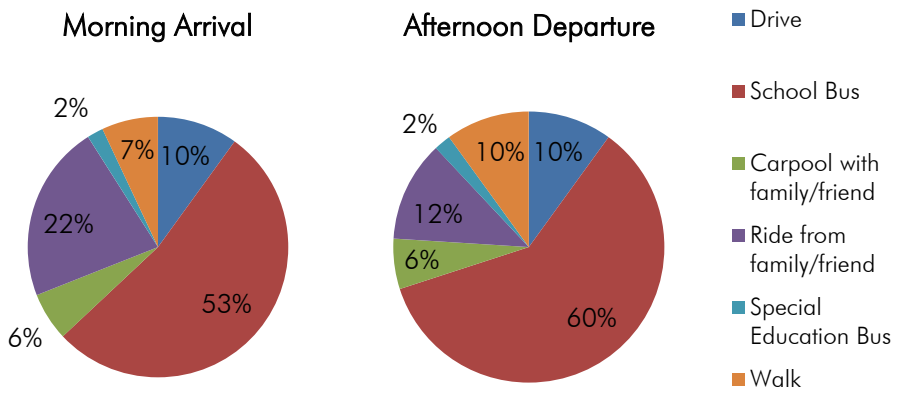


Table No. 9
Anticipated Number of Students Using Each Mode under Build Conditions
Cawley Site

Mode	Morning Arrival	Afternoon Departure
Drive	352	352
School Bus	1,866	2,112
Ride - Carpool	211	211
Ride - Drop-off/Pick-up	775	423
Special Education Bus	70	70
Walk	246	352
TOTAL	3,520	3,520

The largest generator of vehicle trips for these modes are the students that are transported by rides from family and friends. The students that are transported by rides from family and friends generate two trips per student (a vehicle going to and from the site) during both morning arrival and afternoon dismissal. A student that drives and parks on-site generates one trip to arrive in the morning and one trip in the afternoon for dismissal. Although school buses also generate two trips during both morning arrival and afternoon dismissal, the capacity of a bus versus a standard vehicle is much greater, which results in a net decrease in generated trips to and from the site.

Therefore, a few ways to decrease overall generated vehicle trips to the proposed high school is to reduce students that get rides to and from school by increasing the number of students using school buses, encouraging more students to walk or bike to school, and providing adequate on-site student parking.

3.3.3.6 Anticipated Generated Trips

The vehicle volumes anticipated to be generated by the proposed high school development at the Cawley site during the school A.M. and school P.M. peak hours, can be found in Table Nos. 10 and 11, respectively.

Table No. 10
Anticipated Vehicle Trips Generated under Build Conditions
During School A.M. Peak
Cawley Site

Mode	School A.M. Peak				
	Students	Staff	Total	Entering	Exiting
Drive	352	357	709	709	0
LRTA Bus	N/A	8	0	0	0
School Bus	46	N/A	92	46	46
Ride - Carpool	N/A	8	8	8	0
Ride - Drop-off	775	N/A	1,550	775	775
Special Education Bus	11	N/A	22	11	11
		TOTAL	2,381	1,549	832

Table No. 11
Anticipated Vehicle Trips Generated under Build Conditions
During School P.M. Peak
Cawley Site

Mode	School P.M. Peak				
	Students	Staff	Total	Entering	Exiting
Drive	352	333	685	0	685
LRTA Bus	N/A	7	0	0	0
School Bus	46	N/A	92	46	46
Ride - Carpool	N/A	7	7	0	7
Ride - Pick-up	423	N/A	846	423	423
Special Education Bus	11	N/A	22	11	11
		TOTAL	1,652	480	1,172

The distribution of the anticipated new vehicle trips by direction were based upon the existing trip patterns observed in the traffic count data and the expected usage of the roadways for the school. These trips were added to the no-build volumes for analysis of the build conditions. The trip generation calculations and the distribution of the traffic anticipated by the school are shown in Appendix B.

4.0 Capacity Analysis

4.1 General

Capacity analyses in this report focus on the peak hours of traffic volume for the high school because they represent the most critical periods for operations and have the highest capacity requirements. If traffic operates at acceptable levels of service during the peak hours, then it will operate at acceptable levels during the remaining hours of the day.

The intersection capacity analysis was prepared using the *Highway Capacity Manual* (HCM), 2010 edition, published by the Transportation Research Board. The analysis utilizes the concept of Level of Service. The term "level of service" is defined as a qualitative measure describing operational conditions within a traffic stream based on service measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience. There are six levels of service utilized for the analysis. They are given letter designations from A to F, with Level of Service A representing the most favorable operating conditions and Level of Service F the least. Level of Service F is assigned to the movement if the volume-to-capacity ratio for the movement exceeds 1.0, regardless of the control delay. The level of service criteria for both unsignalized and signalized intersections is shown in Table No. 12.

The computer software, Synchro 8, was utilized to perform the capacity analysis for the study area.

Table No. 12
Level of Service Criteria for Unsignalized and Signalized Intersections
Source: Highway Capacity Manual, 2010

Level Of Service	Average Total Delay (Second/Vehicle)	
	Unsignalized Intersection	Signalized Intersection
A	≤10	≤10
B	>10 and ≤15	>10 and ≤20
C	>15 and ≤25	>20 and ≤35
D	>25 and ≤35	>35 and ≤55
E	>35 and ≤50	>55 and ≤80
F	>50	>80

The existing traffic counts were adjusted with an annual growth rate discussed in Section 3.2. Based on the Preliminary Design Program (PDP) feasibility study, the analysis for the Downtown site will be conservative and use a build year of 2024. The Cawley site will use a build year of 2022.

4.2 Downtown Intersections

4.2.1 Unsignalized Intersections

Since the intersection of Merrimack Street and Worthen Street is operating under flashing red and yellow setting, this intersection was modeled as an unsignalized intersection with Worthen Street acting as the stop controlled approach. Unsignalized intersection capacity analysis for the intersections of French Street and Kirk Street and Merrimack Street and Worthen Street was undertaken using the school A.M. and school P.M. peak hour traffic volumes under no-build and build conditions. The capacity analysis computations are included in Appendix C. A summary of the level of service for these intersections is shown in Table Nos. 13 and 14 for the school A.M. and school P.M. peak hour, respectively.

Table No. 13
School A.M. Peak Hour - Level of Service Summary
Downtown Unsignalized Intersection

Intersection/ Critical Movement	Level of Service (Delay-Second/Vehicle)	
	2024 No-Build	2024 Build
French Street/ Kirk Street/ Driveway		
Eastbound Approach	A (0.8)	A (0.8)
Northbound Approach	F (210.3)	F (*)
Southbound Approach	C (15.4)	C (16.6)
Merrimack Street/ Worthen Street		
Westbound Approach	A (0.5)	A (0.5)
Southbound Approach	B (11.3)	B (11.4)

(* Delay exceeds 300 seconds)

Table No. 14
School P.M. Peak Hour - Level of Service Summary
Downtown Unsignalized Intersection

Intersection/ Critical Movement	Level of Service (Delay-Second/Vehicle)	
	2024 No-Build	2024 Build
French Street/ Kirk Street		
Eastbound Approach	A (0.1)	A (0.1)
Northbound Approach	B (14.4)	C (15.3)
Southbound Approach	A (9.7)	A (9.8)
Merrimack Street/ Worthen Street		
Westbound Approach	A (0.3)	A (0.3)
Southbound Approach	B (11.3)	B (11.4)

Under both no-build and build conditions, the unsignalized capacity analysis shows that Kirk Street will operate at LOS F during the school A.M. peak hour. Under build conditions, the unsignalized capacity analysis shows that Kirk Street will have an increase of about 1 second per vehicle during the school P.M. peak hour.

Under both no-build and build conditions, the unsignalized capacity analysis shows that the intersection of Merrimack Street and Worthen Street will continue to operate at excellent levels of service during the school A.M. and school P.M. peak hours.

4.2.2 Signalized Intersections

Signalized intersection capacity analysis for the intersections of Father Morissette Boulevard and Arcand Drive; French Street and Bridge Street; Merrimack Street, Dutton Street, and Arcand Drive; Merrimack Street and Central Street; and Merrimack Street, Kearney Square, and Prescott Street was undertaken using the school A.M. and school P.M. peak hour traffic volumes under no-build and build conditions. The capacity analysis computations are included in Appendix C. A summary of the level of service for these intersections is shown in Table Nos. 15 and 16 for the school A.M. and school P.M. peak hour, respectively.

Table No. 15
School A.M. Peak Hour - Level of Service Summary
Downtown Signalized Intersections

Intersection/ Critical Movement	Level of Service (Delay-Second/Vehicle)	
	2024 No-Build	2024 Build
Father Morissette Boulevard/ Arcand Drive		
Overall Intersection	D (36.6)	D (40.9)
Eastbound Approach	C (33.2)	D (36.6)
Westbound Approach	C (31.1)	C (33.1)
Northbound Approach	D (42.9)	D (49.8)
Southbound Approach	D (39.8)	D (43.4)
French Street/ Bridge Street		
Overall Intersection	C (20.0)	C (20.1)
Eastbound Approach	A (7.7)	A (8.0)
Northbound Approach	D (37.6)	D (38.9)
Southbound Approach	B (13.0)	B (13.0)
Merrimack Street/ Dutton Street/ Arcand Drive		
Overall Intersection	C (34.6)	D (35.6)
Eastbound Approach	C (25.2)	C (26.8)
Westbound Approach	C (31.2)	C (34.0)
Northbound Approach	D (39.2)	D (39.2)
Southbound Approach (Arcand)	D (40.7)	D (40.2)
Southbound Approach (Dutton)	D (46.0)	D (47.0)
Merrimack Street/ Central Street		
Overall Intersection	D (40.1)	D (40.3)
Eastbound Approach	C (25.9)	C (26.0)
Westbound Approach	D (53.1)	D (52.4)
Northbound Approach	C (27.0)	C (28.7)
Merrimack Street/ Kearney Square/ Prescott Street		
Overall Intersection	C (24.6)	C (25.7)
Eastbound Approach	B (12.8)	B (12.2)
Westbound Approach	C (31.9)	C (32.6)
Northbound Approach	B (18.6)	B (19.6)
Southbound Left Turn Lane	D (46.9)	D (46.2)
Southbound Right Turn Lane	B (13.0)	B (16.5)

Table No. 16
School P.M. Peak Hour - Level of Service Summary
Downtown Signalized Intersections

Intersection/ Critical Movement	Level of Service (Delay-Second/Vehicle)	
	2024 No-Build	2024 Build
Father Morissette Boulevard/ Arcand Drive		
Overall Intersection	C (22.3)	C (24.0)
Eastbound Approach	B (12.8)	B (13.2)
Westbound Approach	B (19.5)	B (19.5)
Northbound Approach	C (32.6)	D (37.0)
Southbound Approach	C (22.7)	C (23.3)
French Street/ Bridge Street		
Overall Intersection	B (19.0)	B (19.3)
Eastbound Approach	A (9.0)	A (9.2)
Northbound Approach	C (27.0)	C (28.0)
Southbound Approach	B (14.8)	B (14.8)
Merrimack Street/ Dutton Street/ Arcand Drive		
Overall Intersection	C (29.9)	C (30.5)
Eastbound Approach	B (15.2)	B (15.9)
Westbound Approach	C (22.7)	C (23.6)
Northbound Approach	D (40.5)	D (40.6)
Southbound Approach (Arcand)	D (35.3)	D (35.6)
Southbound Approach (Dutton)	D (40.0)	D (41.0)
Merrimack Street/ Central Street		
Overall Intersection	C (23.6)	C (23.8)
Eastbound Approach	C (29.6)	C (29.8)
Westbound Approach	B (17.5)	B (17.8)
Northbound Approach	C (32.7)	C (32.8)
Merrimack Street/ Kearney Square/ Prescott Street		
Overall Intersection	C (21.9)	C (22.0)
Eastbound Approach	B (16.1)	B (16.0)
Westbound Approach	C (31.4)	C (31.7)
Northbound Approach	B (19.4)	B (19.6)
Southbound Left Turn Lane	D (40.0)	D (40.0)
Southbound Right Turn Lane	A (9.7)	A (9.8)

Under build conditions, the signalized capacity analysis shows that the study intersections will continue to operate at equivalent levels of services with similar delays as experienced under no-build conditions during both the school A.M. and school P.M. peak hours.

4.3 Cawley Intersections

4.3.1 Unsignalized Intersections

Unsignalized intersection capacity analysis for the intersections of Andover Street and Douglas Road; Andover Street, Clark Road, and Raven Road; Clark Road and Village Street; and Rogers Street and Village Street was undertaken using the school A.M. and school P.M. peak hour traffic volumes under no-build and build conditions. Unsignalized intersection capacity analysis for the proposed driveways

on Douglas Road, Village Street, and Clark Road were undertaken using the school A.M. and school P.M. peak hour traffic volumes under build conditions. The capacity analysis computations are included in Appendix C. A summary of the level of service for these intersections is shown in Table Nos. 17 and 18 for the school A.M. and school P.M. peak hour, respectively.

Table No. 17
School A.M. Peak Hour - Level of Service Summary
Cawley Unsignalized Intersections

Intersection/ Critical Movement	Level of Service (Delay-Second/Vehicle)	
	2022 No-Build	2022 Build
Andover Street/ Douglas Road		
Westbound Approach	A (0.6)	A (2.7)
Northbound Approach	F (97.4)	F (*)
Andover Street/ Clark Road/ Raven Road		
Eastbound Approach	A (0.2)	A (0.1)
Westbound Approach	A (1.7)	A (6.0)
Northbound Approach	F (*)	F (*)
Southbound Approach	F (*)	F (*)
Clark Road/ Proposed Clark Road Driveway		
Eastbound Approach	N/A	A (0.0)
Northbound Approach	N/A	F (85.9)
Clark Road/ Village Street		
Eastbound Approach	B (10.4)	F (*)
Northbound Approach	A (0.2)	A (0.3)
Village Street/ Proposed Village Street Eastern Driveway		
Southbound Approach	N/A	F (224.3)
Village Street/ Proposed Village Street Middle Driveway		
Eastbound Approach	N/A	A (2.6)
Village Street/ Proposed Village Street Western Driveway		
Eastbound Approach	N/A	E (39.4)
Rogers Street/ Village Street		
Eastbound Approach	A (0.2)	A (4.9)
Southbound Approach	C (15.0)	F (*)
Douglas Road/ Proposed Douglas Road Southern Driveway **		
Douglas Road/ Proposed Douglas Road Middle Driveway		
Southbound Approach	N/A	A (4.7)
Douglas Road/ Proposed Douglas Road Northern Driveway		
Westbound Approach	N/A	B (13.5)

* Delay exceeds 300 seconds
** No delay associated with this intersection

Table No. 18
School P.M. Peak Hour - Level of Service Summary
Cawley Unsignalized Intersections

Intersection/ Critical Movement	Level of Service (Delay-Second/Vehicle)	
	2022 No-Build	2022 Build
Andover Street/ Douglas Road		
Westbound Approach	A (0.3)	A (0.4)
Northbound Approach	E (46.8)	F (*)
Andover Street/ Clark Road/ Raven Road		
Eastbound Approach	A (0.4)	A (0.4)
Westbound Approach	A (0.9)	A (2.0)
Northbound Approach	F (*)	F (*)
Southbound Approach	F (52.1)	F (*)
Clark Road/ Proposed Clark Road Driveway		
Eastbound Approach	N/A	F (254.5)
Northbound Approach	N/A	A (4.3)
Clark Road/ Village Street		
Eastbound Approach	B (11.2)	F (191.6)
Northbound Approach	A (0.4)	A (0.2)
Village Street/ Proposed Village Street Eastern Driveway		
Southbound Approach	N/A	E (37.5)
Village Street/ Proposed Village Street Middle Driveway		
Eastbound Approach	N/A	A (2.5)
Village Street/ Proposed Village Street Western Driveway		
Eastbound Approach	N/A	B (14.2)
Rogers Street/ Village Street		
Eastbound Approach	A (0.4)	A (3.0)
Southbound Approach	D (26.5)	F (*)
Douglas Road/ Proposed Douglas Road Southern Driveway **		
Douglas Road/ Proposed Douglas Road Middle Driveway		
Southbound Approach	N/A	A (0.6)
Douglas Road/ Proposed Douglas Road Northern Driveway		
Westbound Approach	N/A	C (18.5)

***** Delay exceeds 300 seconds
****** No delay associated with this intersection

The unsignalized intersection capacity analysis of the Andover Street, Clark Road, and Raven Road and Andover Street and Douglas Road intersections under no-build conditions shows poor level of service with long delays and long queue lengths on the stopped controlled approaches, which suggests that additional analysis at these intersections would help to determine if the installation of a traffic signal is warranted or if reconfiguring the stop controlled approaches to provide an additional approach lane could improve the overall operations of this intersection.

Under build conditions, the unsignalized intersection capacity analysis shows the existing side streets will continue to operate at poor levels of service with increased delays as compared to no-build conditions during the school A.M. and school P.M. peak hours.

Under build conditions, the unsignalized intersection capacity analysis of the proposed school driveways shows that some of the driveways will operate at poor levels of service during the school A.M. and school P.M. peak hours. If the Cawley site is chosen, the site layout can be investigated for the feasibility of installing turn lanes to improve the delays.

4.3.2 Signalized Intersections

Signalized intersection capacity analysis for the intersections of Rogers Street, Douglas Road, and Phoenix Avenue and Main Street and Clark Road was undertaken using the school A.M. and school P.M. peak hour traffic volumes under no-build and build conditions. The capacity analysis computations are included in Appendix C. A summary of the level of service for these intersections is shown in Table Nos. 19 and 20 for the school A.M. and school P.M. peak hour, respectively.

Table No. 19
School A.M. Peak Hour - Level of Service Summary
Cawley Signalized Intersections

Intersection/ Critical Movement	Level of Service (Delay-Second/Vehicle)	
	2022 No-Build	2022 Build
Rogers Street/ Douglas Road/ Phoenix Avenue		
Overall Intersection	B (12.8)	E (61.3)
Eastbound Approach	A (8.2)	F (90.1)
Westbound Approach	A (7.1)	A (9.6)
Northbound Approach	B (16.7)	B (15.7)
Southbound Approach	D (45.1)	D (44.5)
Main Street/ Clark Road		
Overall Intersection	C (20.7)	D (42.0)
Eastbound Approach	A (8.2)	E (60.9)
Westbound Approach	C (26.8)	C (24.4)
Southbound Approach	D (38.1)	C (33.5)

Table No. 20
School P.M. Peak Hour - Level of Service Summary
Cawley Signalized Intersections

Intersection/ Critical Movement	Level of Service (Delay-Second/Vehicle)	
	2022 No-Build	2022 Build
Rogers Street/ Douglas Road/ Phoenix Avenue		
Overall Intersection	B (15.6)	E (68.0)
Eastbound Approach	B (10.2)	F (89.9)
Westbound Approach	B (10.4)	E (60.0)
Northbound Approach	D (44.3)	D (37.0)
Southbound Approach	C (34.7)	E (58.0)
Main Street/ Clark Road		
Overall Intersection	C (21.1)	C (34.5)
Eastbound Approach	A (9.7)	B (11.6)
Westbound Approach	C (22.9)	C (21.3)
Southbound Approach	D (39.4)	F (95.1)

Under build conditions, the signalized intersection capacity analysis shows that the Rogers Street, Douglas Road, and Phoenix Avenue intersection will operate at poor levels of service during the school A.M. and school P.M. peak hours. This intersection could benefit from adjusting signal timings/phasing to increase dedicated time for left turning vehicles for the eastbound and southbound approaches during the school peak hours. The City and MassDOT could investigate the possibility of installing turn lanes for the approaches to help improve the overall operations at this intersection under build conditions.

The signalized intersection capacity analysis shows that the Main Street and Clark Road intersection will operate at acceptable levels of services under build conditions, with the exception of the eastbound approach during the A.M. peak hour and the southbound approach during the P.M. peak hour. This intersection could benefit from adjusting signal timings during the school peak hours.

4.3.3 Traffic Signal Warrant Analysis

The City requested that a traffic signal warrant analysis be performed for two existing unsignalized intersections within the Cawley study area: the Andover Street and Douglas Road intersection and the Rogers Street and Village Street intersection.

The *Manual on Uniform Traffic Control Devices* (MUTCD) contains nine traffic signal warrants that are used to aid in the decision whether a traffic signal should be considered at an intersection. Traffic volumes were counted at the intersection of Andover Street and Douglas Road and the intersection of Rogers Street and Village Street between 6:00 A.M. and 8:00 P.M. on Wednesday, March 29, 2017.

The traffic volumes counted at these intersections indicate that the intersections would not meet Warrant 1, Eight Hour Vehicular Volume, Warrant 2, Four-Hour Vehicular Volume, Warrant 4, Pedestrian Volume, or Warrant 7, Crash Experience under the future no build and future build conditions. See appendix H for the warrant analysis worksheets.

Four other warrants, Warrant 3 Peak Hour, Warrant 6, Coordinated Signal System, Warrant 8 Roadway Network, and Warrant 9, Intersection Near a Grade Crossing, are not applicable for these intersections.

If the Cawley site is selected for the high school, Warrant 5, School Crossing could be investigated after the school is opened. This warrant requires an established school crossing and also requires consideration of other remedial measures, such as warning signs and flashers, school zones, school crossing guards, etc. before a decision is made to install a signal.

Although a traffic signal warrant analysis was not requested for the intersection of Andover Street and Clark Road, preliminary findings suggest that this intersection may meet warrants for signalization. Additional traffic data (that was not collected) is required for a complete analysis.

Since Roger Street (Route 38) is a State highway, any traffic signal installation or improvements would need to be reviewed and approved by MassDOT. It appears that Andover Street (Route 133) is under the City's jurisdiction.

5.0 Safety Analysis

5.1 Geometrics

The geometric configurations of the intersections affected by traffic generated by the proposed improvements were examined with regard to safe stopping sight distance using principles presented in *A Policy on Geometric Design of Highways and Streets*, 2011, of the American Association of State Highway and Transportation Officials (AASHTO). AASHTO provides recommendations for necessary sight distance at intersections. For this analysis, the minimum safe stopping distance for the roadways based on the determined design speed is found in AASHTO, Table 3-1, Stopping Sight Distance on Level Roadways, P. 3-4.

5.1.1 Downtown Site

A design speed of 30 mph was utilized for Arcand Drive in the vicinity of the existing Field House based on the observed 85th percentile speed of 31 mph for northbound traffic and 30 mph for southbound traffic. The minimum safe stopping distance for roadways with a design speed of 30 mph is 200 feet, as required by AASHTO. The existing sight distance at the proposed Arcand Drive driveway for the Full Renovation and the Addition/Renovation Option 2 alternatives is in excess of the minimum sight distance required. The existing sight distance to the south at the proposed Arcand Drive driveway for the Addition/Renovation Option 3 alternatives is approximately125 feet. The sight distance to the south at the proposed Addition/Renovation Option 3 driveway can be improved with the trimming or elimination of the shrubs on the adjacent property and/or the reconfiguration of the on-street parking to the south of the proposed driveway.

5.1.2 Cawley Site

A design speed of 35 mph was utilized for Douglas Road in the vicinity of the Cawley site based on the observed 85th percentile speed of 33 mph for northbound traffic and 36 mph for southbound traffic. The minimum safe stopping distance for roadways with a design speed of 35 mph is 250 feet, as required by AASHTO. A design speed of 40 mph was utilized for Clark Road in the vicinity of the Cawley site based on the observed 85th percentile speed of 37 mph for both northbound and southbound traffic. The minimum safe stopping distance for roadways with a design speed of 40 mph is 305 feet. A design speed of 30 mph was utilized for Village Street in the vicinity of the Cawley site based on the observed 85th percentile speed of 28 mph for eastbound traffic and 29 mph for westbound traffic. The minimum safe stopping distance for roadways with a design speed of 30 mph is 200 feet. A conservative design speed of 45 mph was utilized for Andover Street and Rogers Street, which is 10 mph above the posted or assumed posted speed limits of 35 mph. The minimum safe stopping distance for roadways with a design speed of 45 mph is 360 feet.

The existing sight distance at both Douglas Road and Clark Road at Andover Street is in excess of the minimum sight distance required. The existing sight distance at Village Street with both Rogers Street and Clark Road is in excess of the minimum sight distance required. All three of the proposed Village Street driveways have existing sight distances that are in excess of the minimum required. The existing sight distance at the proposed Clark Road driveway and the proposed northern and middle Douglas Road driveway is in excess of the minimum sight distance required.

Although the sight distance at the Clark Road driveway is in excess of the minimum stopping sight distance, the final location of this driveway should be re-evaluated due to the existing vertical and horizontal alignment of Clark Road. The final location may need to shift slightly to obtain the optimum sight distance at this proposed driveway.

The existing sight distance at the proposed southern Douglas Road driveway is in excess of the minimum sight distance to the north of the intersection, however the sight distance to the south of the intersection of 200'± does not meet minimum requirements due to the existing horizontal curve in Douglas Road. There is an existing driveway for the existing Cawley Stadium parking lot where this proposed driveway is located. The sight distance could be improved if the proposed southern Douglas Road driveway is eliminated, relocated further north, or restricted to a right turn entrance only driveway.

5.2 Crash History

5.2.1 Downtown Site

Crash data for the downtown study area was obtained from the Lowell Police Department for the period from January 1, 2014 through March 30, 2017. A summary of the data received is contained in Appendix D. There were 126 crashes within the study area of the site, as shown in Table No. 21.

There was one crash on Merrimack Street between Cardinal O' Connell Parkway and Worthen Street. It was a rear-end crash that occurred in snow, which did not result in injuries.

There were five crashes at the intersection of Merrimack Street and Worthen Street. These crashes include four sideswipe crashes and one crash involved hitting an object. Two of these crashes occurred in the rain. None of these crashes resulted in injuries.

There were eleven crashes at the intersection of Merrimack Street, Arcand Drive, and Dutton Street. These crashes include four angle crashes, three rear-end crashes, three sideswipe crashes, and one crash involved hitting a bicyclist, which resulted in an injury. Two of these crashed occurred in the rain.

There were two crashes on Merrimack Street between Arcand Drive and Shattuck Street. These crashes include two sideswipe crashes, one of that occurred in snow and one that occurred in rain. Neither of these crashes resulted in injuries.

There were three crashes at the intersection of Merrimack Street and Kirk Street. These crashes include a sideswipe crash, a rear-end crash, and an angle crash. None of these crashes resulted in injuries.

There were two crashes on Merrimack Street between Kirk Street and Palmer Street. These crashes include an angle crash and a rear-end crash. Neither of these crashes resulted in injuries.

There were five crashes at the intersection of Merrimack Street and Palmer Street. These crashes include three rear-end crashes and two sideswipe crashes. None of these crashes resulted in injuries.

There were nine crashes on Merrimack Street between Palmer Street and John Street. These crashes include four rear-end crashes, two unknown crashes, an angle crash, a sideswipe crash, and one crashed involved hitting a pedestrian. One of these crashes occurred in rain. Two of these crashes resulted in injuries.

There was one crash at the intersection of Merrimack Street and John Street. It was a rear-end crash, which did not result in injuries.

Table No. 21
Summary of Downtown Crashes
Source: Lowell Police Department

Crash Location	Jan. 1, 2014 - March 30, 2017
Merrimack Street between Cardinal O' Connell Parkway and Worthen Street	1
Intersection of Merrimack Street and Worthen Street	5
Intersection of Merrimack Street, Arcand Drive, and Dutton Street	11
Merrimack Street between Arcand Drive and Shattuck Street	2
Intersection of Merrimack Street and Kirk Street	3
Merrimack Street between Kirk Street and Palmer Street	2
Intersection of Merrimack Street and Palmer Street	5
Merrimack Street between Palmer Street and John Street	9
Intersection of Merrimack Street and John Street	1
Merrimack Street between John Street and Central Street	2
Intersection of Merrimack Street and Central Street	5
Merrimack Street between Central Street and Bridge Street	1
Intersection of Merrimack Street, Bridge Street, Kearney Square, and Prescott Street	4
Intersection of Paige Street and Bridge Street	3
Paige Street between John Street and Bridge Street	2
Paige Street between Kirk Street and John Street	1
Intersection of French Street and Kirk Street	3
French Street between Kirk Street and John Street	2
French Street between John Street and Brookings Street	1
Intersection of French Street and Brookings Street	1
Intersection of French Street and John Street	14
Intersection of French Street and Bridge Street	6
John Street at 75 John Street Parking Garage Entrance	4
Intersection of John Street and Paige Street	2
Intersection of John Street and Lee Street	1
Kirk Street between Merrimack Street and Lee Street	2
Intersection of Kirk Street and Lee Street	1
Intersection of Father Morissette Blvd. and Arcand Drive	10
Father Morissette Blvd. between Arcand Drive and Post Office Square	2
Intersection of Father Morissette Blvd. and Post Office Square	3
Arcand Drive between Father Morissette Blvd. and Merrimack Street	9
Within Ayotte Parking Garage Structure	8
TOTAL	126

There were two crashes on Merrimack Street between John Street and Central Street. These crashes include one sideswipe crash and one crash involved hitting an object, which resulted in an injury.

There were five crashes at the intersection of Merrimack Street and Central Street. These crashes include three sideswipe crashes, a rear-end crash, and a crash involved hitting a pedestrian. One of these crashes occurred in the rain and two of these crashes resulted in injuries.

There was one crash on Merrimack Street between Central Street and Bridge Street. It was an angle crash, which did not result in injuries.

There were four crashes at the intersection of Merrimack Street, Bridge Street, Kearney Square, and Prescott Street. These crashes include two sideswipe crashes and two angle crashes. None of these crashes resulted in injuries.

There were three crashes at the intersection of Paige Street and Bridge Street. These crashes include two angle crashes and one head-on crash. None of these crashes resulted in injuries.

There were two crashes on Paige Street between John Street and Bridge Street. These crashes include two rear-end crashes and neither resulted in injuries.

There was one crash on Paige Street between Kirk Street and John Street. It was an angle crash and did not result in injuries.

There were three crashes at the intersection of French Street and Kirk Street. There were two rear-end crashes and one sideswipe crash. None of these crashes resulted in injuries.

There were two crashes on French Street between Kirk Street and John Street. These crashes include one sideswipe crash and one crash involved hitting a pedestrian, which resulted in injuries.

There was one crash on French Street between John Street and Brookings Street, which involved hitting a pedestrian and resulted in injuries.

There was one crash at the intersection of French Street and Brookings Street. It was a rear-end crash that occurred in the rain and resulted in injuries.

There were fourteen crashes at the intersection of French Street and John Street. These crashes include five angle crashes, five rear-end crashes, three sideswipe crashes, and one unknown crash. Two of these crashes occurred in snow and one crash resulted in injuries.

There were six crashes at the intersection of French Street and Bridge Street. These crashes include two angle crashes, two head-on crashes, one crash involved hitting a bike, and one crash involved hitting a pedestrian, which resulted in injuries.

There were four crashes at the 75 John Street Parking Garage Entrance. These crashes include three angle crashes and one crash involved hitting a pedestrian. One of these crashes occurred in the rain and none of these crashes resulted in injuries.

There were two crashes at the intersection of John Street and Paige Street. These crashes include a rear-end crash and a crash involved hitting a pedestrian, which resulted in injuries.

There was one crash at the intersection of John Street and Lee Street. It was an angle crash and did not result in injuries.

There were two crashes on Kirk Street between Merrimack Street and Lee Street. These crashes were sideswipe crashes, neither of which resulted in injuries.

There was one crash at the intersection of Kirk Street and Lee Street. It was a sideswipe crash that occurred in the snow, and did not result in injuries.

There were ten crashes at the intersection of Father Morissette Boulevard and Arcand Drive. These crashes include three sideswipe crashes, two angle crashes, two rear-end crashes, a crash involved hitting an object, a crash involved hitting a bicyclist, and a crash involved hitting a pedestrian, which resulted in injuries. Two of these crashes occurred in the rain and one of these crashes occurred in the snow.

There were two crashes on Father Morissette Boulevard between Arcand Drive and Post Office Square. These crashes include two rear-end crashes, neither of which resulted in injuries.

There were three crashes at the intersection of Father Morissette Boulevard and Post Office Square. These crashes include two sideswipe crashes and an angle crash. One of these crashes occurred in the rain and none of these crashes resulted in injuries.

There were nine crashes on Arcand Drive between Father Morissette Boulevard and Merrimack Street. These crashes include four sideswipe crashes, two angle crashes, one rear-to-rear crash, one head-on crash, and one crash involved hitting an object. One of these crashes occurred in the snow and none of these crashes resulted in injuries.

There were eight crashes in the Ayotte Parking Garage Structure. These crashes include three angle crashes, two sideswipe crashes, two unknown crashes, and a rear-end crash. None of these crashes resulted in injuries.

Based on the extended study limits, the number of signalized intersections, and volume of traffic, the number and type of crashes that occurred over this nearly three and a half year period does not indicate the presence of unusual conditions that might be worsened by the addition of the proposed school.

5.2.2 Cawley Site

Table No. 22
Summary of Cawley Stadium Crashes
Source: Lowell and Tewksbury Police Departments

Crash Location	Jan. 1, 2014 through March 30, 2017
Intersection of Rogers Street, Douglas Road, and Phoenix Avenue	8
Rogers Street 300 Feet East of Douglas Road	4
Intersection of Rogers Street and Village Street	1
Rogers Street between Village Street and Groton Street	4
Intersection of Rogers Street and Groton Street	1
Intersection of Rogers Street and Research Center Drive	10
Rogers Street between Research Center Drive and Clark Road	5
Intersection of Main Street and Clark Road	9
546 Douglas Road	1
Intersection of Douglas Road and Donald Terrace	1
Intersection of Douglas Road and Windward Road	2
276 Douglas Road	1
65 Village Street	1
Intersection of Clark Road and Market Basket Plaza Driveway	1
Clark Road between Main Street and Market Basket Plaza Driveway	1
Intersection of Clark Road and 600 Clark Road	2
150 Feet South of Intersection of Clark Road and Country Club Drive	3
Intersection of Clark Road and Country Club Drive	2
Intersection of Clark Road and Woodvale Lane	1
Clark Road between Windward Road and Woodvale Lane	3
Intersection of Clark Road and Windward Road	1
Clark Road between Miriam Lane and Oheir Way	1
Intersection of Clark Road and Oheir Way	1
Intersection of Clark Road and Hovey Street	1
Intersection of Clark Road and Havilan Street	2
Intersection of Clark Road and Andover Street	3
Andover Street between Clark Road and Garden Road	1
Intersection of Andover Street and Garden Road	1
TOTAL	72

Crash data for the Cawley Stadium study area was obtained from the Lowell Police Department and the Tewksbury Police Department for the period from January 1, 2014 through March 30, 2017. A summary of the data received is contained in Appendix D. There were 72 crashes within the study area of the site, as shown in Table No. 22.

There were eight crashes at the intersection of Rogers Street, Douglas Road, and Phoenix Avenue. These crashes include four rear-end crashes, two angle crashes, one sideswipe crash, and one crash involved hitting an object. Two of these crashes occurred in the rain and none of these crashes resulted in injuries.

There were four crashes on Rogers Street 300 feet east of Douglas Road. These crashes include three angle crashes and one rear-end crash. One of these crashes resulted in injuries.

There was one crash at the intersection of Rogers Street and Village Street. It was an angle crash, which did not result in injuries.

There were four crashes on Rogers Street between Village Street and Groton Street. These crashes include three rear-end crashes and one angle crash. One of these crashes resulted in injuries.

There was one crash at the intersection of Rogers Street and Groton Street. It was a sideswipe crash that did not result in injuries.

There were ten crashes at the intersection of Rogers Street and Research Center Drive. These crashes include six rear-end crashes, one angle crash, one sideswipe crash, one crash involved hitting an object, and one crash involved hitting a bicyclist. Three of these crashes resulted in injuries.

There were five crashes on Rogers Street between Research Center Drive and Clark Road. These crashes include four angle crashes and one rear-end crash. One of these crashes resulted in injuries.

There were nine crashes at the intersection of Main Street and Clark Road. These crashes include five rear-end crashes, two angle crashes, one sideswipe crash, and one crash involved hitting an object. Two of these crashes occurred on wet pavement and four of these crashes resulted in injuries.

There was one crash at 546 Douglas Road. It was a sideswipe crash that did not result in injuries.

There was one crash at the intersection of Douglas Road and Donald Terrace. It was an angle crash and did not result in injuries.

There were two crashes at the intersection of Douglas Road and Windward Road. These crashes include one angle crash and one rear-end crash. Neither of these crashes resulted in injuries.

There was one crash at 276 Douglas Road. It was a sideswipe crash that occurred in sleet. It did not result in injuries.

There was one crash at 65 Village Street. It was an unknown crash that did not result in injuries.

There was one crash at the intersection of Clark Road and the Market Basket Plaza driveway. It was a crash that involved hitting an object and resulted in injuries.

There was one crash on Clark Road between Main Street and the Market Basket Plaza driveway. It was an angle crash and did not result in injuries.

There were two crashes at the intersection of Clark Road and 600 Clark Road. These crashes include one angle crash and one crash involved hitting an object. Neither of these crashes resulted in injuries.

There were three crashes 150 feet south of the intersection of Clark Road and Country Club Drive. All three crashes involved hitting an object. One of these crashes occurred in the rain on slushy pavement and one of these crashes occurred in the snow. Two of these crashes resulted in injuries.

There were two crashes at the intersection of Clark Road and Country Club Drive. Both crashes involved hitting an object and occurred in the snow. One of these crashes resulted in injuries.

There was one crash at the intersection of Clark Road and Woodvale Lane. It was a head-on crash that resulted in injuries and a fatality. A vehicle traveling southbound on Clark Road crossed over the center line and hit another vehicle head-on. The elderly driver of the vehicle who crossed over the center line was critically injured and later passed away.

There were three crashes on Clark Road between Windward Road and Woodvale Lane. These crashes include a crash involved hitting a deer, a crash involved hitting an object, and a crash involved hitting a bicyclist, which resulted in injuries. One of these crashes occurred in the rain and one of these crashes occurred in the snow.

There was one crash at the intersection of Clark Road and Windward Road. It was a crash involved hitting an object, which did not result in injuries. This crash occurred in the snow.

There was one crash on Clark Road between Miriam Lane and Oheir Way. It was a crash involved hitting an object, which did not result in injuries.

There was one crash at the intersection of Clark Road and Oheir Way. It was a crash involved hitting an object, which did not result in injuries.

There was one crash at the intersection of Clark Road and Hovey Street. It was an angle crash, which did not result in injuries.

There were two crashes at the intersection of Clark Road and Havilan Street. These crashes include one angle crash and one rear-end crash, which resulted in injuries.

There were three crashes at the intersection of Clark Road and Andover Street. The three crashes were angle crashes, two of which resulted in injuries.

There was one crash on Andover Street between Clark Road and Garden Road. It was a rear-end crash that occurred on wet pavement and resulted in injuries.

There was one crash at the intersection of Andover Street and Garden Road. It was a crash involved hitting an object, which did not result in injuries.

Based on the extended study limits, the number of signalized intersections, and volume of traffic, the number and type of crashes that occurred over this nearly three and a half year period does not indicate the presence of unusual conditions that might be worsened by the addition of the proposed school.

5.3 Site Circulation

Once a finalized site plan for the chosen site has been developed, it will be reviewed with regard to layout and vehicular/pedestrian circulation. The proposed site will be designed to accommodate the safe movement of emergency vehicles to and from the development.

6.0 Conclusions and Recommendations

This traffic impact analysis was conducted to evaluate the impacts on surrounding roadways and intersections due to either the renovations to the Lowell High School building in the Downtown area or the construction of a new high school at the existing Cawley Stadium site in Lowell, Massachusetts.

Regardless of the type or the location of a development, traffic impacts are expected on the surrounding roadway network when the majority of the 4,000 people estimated to use the facility will arrive and depart within a short time frame.

6.1 Downtown Site

Lowell High School is currently 'functioning' with a large existing student and staff population. The proposed increase in the student and staff population is relatively small in comparison to the existing populations.

The unsignalized and signalized intersection capacity analysis shows that the proposed Lowell High School under build conditions will continue to operate at equivalent levels of services and similar delays as experienced under no-build conditions during both the school A.M. and school P.M. peak hours.

The sight distance at the proposed school driveway on Arcand Drive should be addressed once an alternative is chosen to ensure the minimum sight distance required is achieved. There are no existing unsafe conditions in the vicinity of the development that might be worsened by the design alternatives proposed for the existing school campus.

Based upon the analyses, traffic operations on the surrounding roadways and intersections in the Downtown area will experience minimal change with the proposed school renovation alternatives at the Downtown site. No reduction in safety will occur due to the renovated school alternatives as proposed.

6.2 Cawley Site

Similar to the Downtown site, the proposed high school at the Cawley site should anticipate a school peak of traffic twice a day, every school day for the duration of the school year. During the afternoon dismissal, it is anticipated that there will be a higher concentration of exiting vehicles for approximately 15 to 30 minute period of time.

The Cawley site requires the City to develop a city school busing program for the general high school population. The City has indicated that they would implement a preferred school bus route, which would require buses to use Route 38 and Village Street to access the Cawley site.

The number of vehicle trips generated by this site is largely dependent on how students travel to and from the school (i.e. the number that utilize the new busing program, the number that drive and park on-site, and the number that receive rides from family/friends).

The Cawley site requires the City to consider investing in intersection improvements as well as sidewalk and other pedestrian improvements to the surrounding roadways. The signalized intersection capacity analysis shows that the Rogers Street, Douglas Road, and Phoenix Avenue and Main Street and Clark Road intersections require improvements, such as the retiming or adjustment of the signal timings. The addition of turn lanes at the Rogers Street, Douglas Road, and Phoenix Avenue intersection could be investigated to help improve the overall operations at this intersection under build conditions.

The intersections of Andover Street and Douglas Road and Roger Street and Village Street do not meet traffic signal warrants. Although a traffic signal warrant analysis was not requested for the intersection of Andover Street and Clark Road, preliminary findings suggest that this intersection may meet warrants for signalization. Additional traffic data is required for a complete analysis. Since Roger Street (Route 38) is a State highway, any traffic signal installation or improvements would need to be reviewed and approved by MassDOT. It appears that Andover Street (Route 133) is under the City's jurisdiction.

The existing sight distance at the existing unsignalized intersections and proposed school driveways is in excess of the minimum sight distance required, except the southern Douglas Road driveway. If this alternative is chosen, the site design will account for the sight distance limitations at this driveway. There are no other existing unsafe conditions in the vicinity of the development that might be worsened by the construction of the school at the Cawley site.

Based upon the analyses, traffic operations on the surrounding roadways and intersections in the vicinity of the Cawley site will experience significant change with the proposed school during the A.M. arrival and the P.M. dismissal. No reduction in safety will occur due to the proposed school.