2

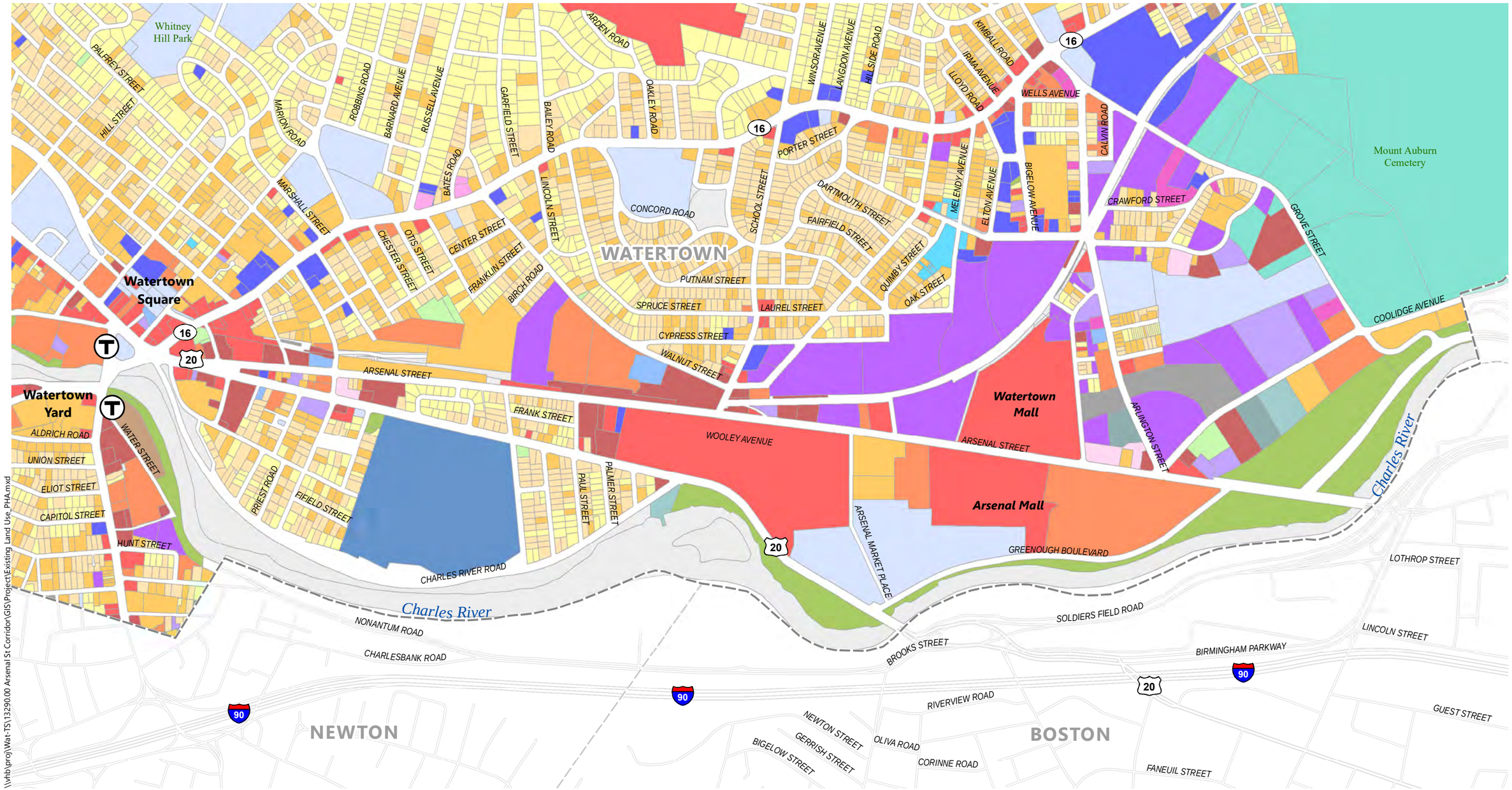
Existing Conditions

This chapter provides an assessment of Existing Conditions within the study area. Sections of this chapter present demographics, environmental resources, land use and economic development, a multimodal transportation assessment, and a summary of the transportation infrastructure deficiencies and needs as of winter 2016.

Land Use

The Local Study Area contains nearly 1,820 separate parcels comprising approximately 442 acres of land. There is nearly 9.2 million square feet of development in this Corridor, containing a mix of residential, commercial, retail and other uses, as shown in Figure 2-1. The assessed value (2015) of these properties equates to approximately $1.6 billion. A detailed land use evaluation (including expanded information on the data above) is included in the Appendix and key takeaways from the analysis include:

- Retail developments comprise approximately 1.13 million square feet of the parcels fronting Arsenal Street. The retail uses in the frontage parcels account for approximately 88 percent of all retail development in the Local Study Area, likely reflecting favorable traffic and location characteristics of Arsenal Street. The average assessed value (per square foot) of retail properties is similar between the Frontage Parcels and the Local Study Area.
- Industrial parcels with Arsenal Street frontage comprise 251,200 square feet and are primarily warehouse space. By comparison, there is more than 1.35 million square feet of industrial space throughout the Local Study Area, perhaps reflecting a lesser desirability for these uses (or a stronger desirability for other industrial uses) on Arsenal Street or a lack of suitable land (sites) for development. The warehouse space that exists could represent the historic



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Arsenal Street Corridor Study | Watertown, Massachusetts

Existing Land Use

- Single Family
- Two Family
- Other Residential
- Retail Trade
- Automotive Sales and Services
- Office
- Indoor Recreation
- Outdoor Recreation
- Manufacturing and Processing
- Storage and Distribution Facilities
- Utility
- Public Service Properties
- Child Care Facilities
- Hotels and Nursing Homes
- Private Schools
- Non-profit and Religious
- Cemeteries
- Vacant Land - Developable
- Vacant Land - Undevelopable
- State - DCR
- State - Other
- Housing Authority
- Town-owned
- Other

Existing Land Use

Source: MassGIS, Town of Watertown

- nature and uses of development associated with the Arsenal, which zoning has not adjusted since its departure.
- Residential uses among the frontage parcels represent about five percent of the residential uses in the Local Study Area, both in terms of acreage and in terms of square feet of development. However, the average assessed value of single family residential and condominiums among frontage parcels, are both above those values for the Local Study Area residential uses, at 119 percent and 124 percent, respectively (albeit from a limited count of such uses on Arsenal Street).
- About one-half of the Local Study Area commercial development, at 520,500 square feet, is among the Frontage parcels. The average assessed value of these parcels, at $390 per square foot, is 53 percent greater than for the Local Study Area as a whole.

Socio-Economics

This section provides an overview of the relevant transportation-related socio-economic indicators and demographics for the study area. Key indicators such as population, households, and employment are directly relevant to transportation demands and are the primary parameters used in travel demand forecasting models.

Estimated population, housing, and employment levels for the Arsenal Street Corridor for the years 2010 and 2015 are summarized in Table 2-1.

Table 2-1 Local Study Area Socio-Economic Indicators

Indicator	2010 Census[1]	2015 Estimate[2]	Percent Growth
Population	5,504	5,708	3.7%
Household Units	2,740	2,471	-0.1%
Employees	n/a	6,630	n/a

1 2010 U.S. Census
2 Based on US Census, Alteryx, Dun and Bradstreet, and RKG Associates, Inc.

A complete market analysis of both the Local Study Area (the Arsenal Street Corridor) and the Regional Study Area is presented in the Appendix. Key findings of this analysis are summarized below.

Demographic Indicators

Analysis of population trends from 2010 to 2015 indicate:

- The estimated population of the Local Study Area was 5,700 persons in 2015, representing an increase of 200 people since 2010. Total population in the

Regional Study Area has grown by slightly more than four percent over the 2010 to 2015 time (similar to the Local Study Area).

- In 2015, three-fourths of the population in both the Local and Regional Study Areas identifies as white, with five percent or less of the population identifies as black. More than 15 percent of the population of each identified themselves as "Other." Persons of Hispanic/Latino heritage identified themselves as 7.6 percent of the Local Study Area population and 8.5 percent of the Regional Study Area population.
- The Local and Regional Study Area populations aged 65 and older increased by 6.2 percent and 5.4 percent between 2010 and 2015, respectively.
- Conversely, the population aged 15 to 24 years has declined in the Local Study Area by 3.1 percent between 2010 and 2015. Similarly, the Region has lost 0.4 percent of population aged 15 to 24 years over the same timeframe.

Housing Indicators

Analysis of housing trends from 2010 to 2015 indicate:

- Between 2010 and 2015, the total number of housing units in the Local Study Area remained constant. Unlike the Local Study Area, there was a 1.4 percent growth in total housing units in the Region between 2010 and 2015.
- Current housing in the Local Study Area reflects a mix of 60 percent renter occupancy and 40 percent owner occupancy. Tenure characteristics for the Region indicate 55 percent renter occupancy and 45 percent owner occupancy.
- The Local Study Area's mean household income (2015) is nearly $100,000 and the median household income is approximately $75,700. The Region's mean and median household incomes are slightly higher at nearly $111,400 and $78,800, respectively.
- In 2015, slightly more than 73 percent of the Corridor households were comprised of one or two persons, with an average household size of 2.08 persons and an average of 1.64 vehicles per household. Most of the 2015 households in the Region are either single person households (37 percent) or two person households (34 percent) with an average household size of 2.13 persons (slightly larger than in the Corridor). In 2015, approximately 16 percent of the Region households had no vehicle available.

Employment Indicators

Employment and labor force analysis indicates:

- The Watertown labor force averaged 20,817 persons (aged 16 and over) during the October 2014 through October 2015 period. Employment during this period averaged 20,119 persons, indicating average monthly unemployment of nearly 700 persons; an average unemployment rate of 3.4 percent.
- Since October 2014, the unemployment rate for Watertown has consistently been lower than that for the Metro North Workforce Investment Area (WIA), Massachusetts and the United States.
- In 2015, the approximate 6,630 employees in the Local Study Area represented 13 percent of the 50,800 employees in the Region. The greatest concentration of employment in the Local Study Area is among industry sectors with an institutional use, including health and education services (35 percent).
- Employment in the health sector in the Local Study Area represents slightly more than 21 percent of the health sector employment in the Region. Retail employment in the Local Study Area is also very strong, accounting for 29 percent of Regional retail employment.
- Employment in the finance/insurance industry in the Local Study Area accounts for less than one percent of that sector's employment in the Region.
- The 2015 daytime population in the Local Study Area (aged 16+ years) is nearly 8,120 persons, of which nearly 6,500 persons are at their workplace. The estimated resident population is 5,700 persons. Therefore, the Local Study Area is a net employment importer.
- Major employers along the Arsenal Street Corridor include athenahealth, tenants of the Arsenal Mall, Lexus of Watertown, Enanta Pharmaceuticals, Harvard Vanguard Medical (Atrius Health) and VHB.

Journey-to-Work and Mode Share

This section provides an overview of journey-to-work and mode share data for the study area. The data provides an insight to commuting patterns and mode choice that are useful in forecasting and future planning purposes.

Journey-to-Work

Journey-to-work data from the 2006-2010 U.S. Census is used to show the key origin and destination trip patterns. The journey-to-work data provide a wealth of information on commuting patterns and trends and is useful in travel demand modeling and forecasting.

Table 2-2 summarizes the daily work trips that occur for residents in Watertown, work trips within Watertown and work trips to the top communities (where percent of total trips is greater than one percent).

Table 2-2 Daily Work Trip Generation FROM Watertown, MA (Home-Based)

City/Town	Number of Trips	Percent of Trips
Boston	4,986	27%
Watertown	3,405	18.4%
Cambridge	2,002	10.8%
Waltham	1,171	6.3%
Newton	1,006	5.4%
Belmont	667	3.6%
Lexington	299	1.6%
Somerville	285	1.5%
Wellesley	278	1.5%
Needham	265	1.4%
Framingham	231	1.2%
Brookline	224	1.2%
Burlington	202	1.1%
Others (less than 1%)	3,462	19%
Total Trips	18,483	100%

Source: U.S. Census Bureau, 2006-2010 American Community Survey

The key home-based commuting trends are as follows:

- Based on the U.S. Census data, a total of 18,483 daily work trips originate from the Town of Watertown. Of these, 3,405 work trips, or 18.4 percent, are within Watertown.
- The city of Boston has the highest work trip generation (4,986 trips).
- Thirteen communities (including Watertown) have work trips that are higher than one percent of total work trips.

Table 2-3 summarizes the daily work trips that enter Watertown, showing the total work trips, work trips within Watertown, and work trips that originate from top communities (percent of trips greater than one percent of total trips).

Table 2-3 Daily Work Trip Generation TO Watertown, MA (Work-Based)

City/Town	Number of Trips	Percent of Trips
Watertown	3,405	17.4%
Boston	3,118	15.9%
Waltham	1,468	7.5%
Newton	822	4.2%
Cambridge	813	4.2%
Belmont	485	2.5%
Everett	407	2.1%
Arlington	381	1.9%
Framingham	344	1.8%
Medford	342	1.7%
Brookline	325	1.7%
Somerville	304	1.6%
Natick	298	1.5%
Malden	260	1.3%
Woburn	212	1.1%
Others	6,591	33.7%
Total	19,575	100%

Source: U.S. Census Bureau, 2006-2010 American Community Survey

From Table 2-3, key work-based commuting trends to Watertown are as follows:

- A total of 19,575 daily work trips are destined for Watertown. Of these, 3,405 work trips are internal (within Watertown).
- Fifteen communities (including Watertown) have work trips that are higher than one percent of all work trips.

These journey-to-work trip characteristics are important fundamental considerations for modeling existing and forecasted conditions.

Mode Share

Understanding how people get to and from work in the study area is an important initial step of the transportation system deficiencies and needs. An evaluation of mode choice using the US Census data helps measure auto-dependency.

Table 2-4 and Figure 2-2 summarize the mode share for people who live in Watertown from the 2010 Census. As shown, the majority of Watertown residents (over 70 percent) either drive alone or carpool to work. Transit is the second most prevalent mode, with 15 percent of residents relying on transit for their commute to and from work. The percentage of residents that bike or walk to work is at three percent, while telecommuters, or residents who regularly work from home, account for four percent of total trips.

Table 2-4 Mode Choice for Watertown Residents (Home-Based)

Mode	Number of Residents	Percent of Residents
Single- Occupant Automobile	12,495	68%
Multiple - Occupant Automobile	1,705	9%
Transit	2,730	15%
Bicycle/Walk	625	3%
Work at Home	820	4%
Other	120	1%
Total	18,495	100%

Source: U.S. Census Bureau, American Community Survey 2006-2010 Five-year estimates. Special Tabulation: Census Transportation Planning

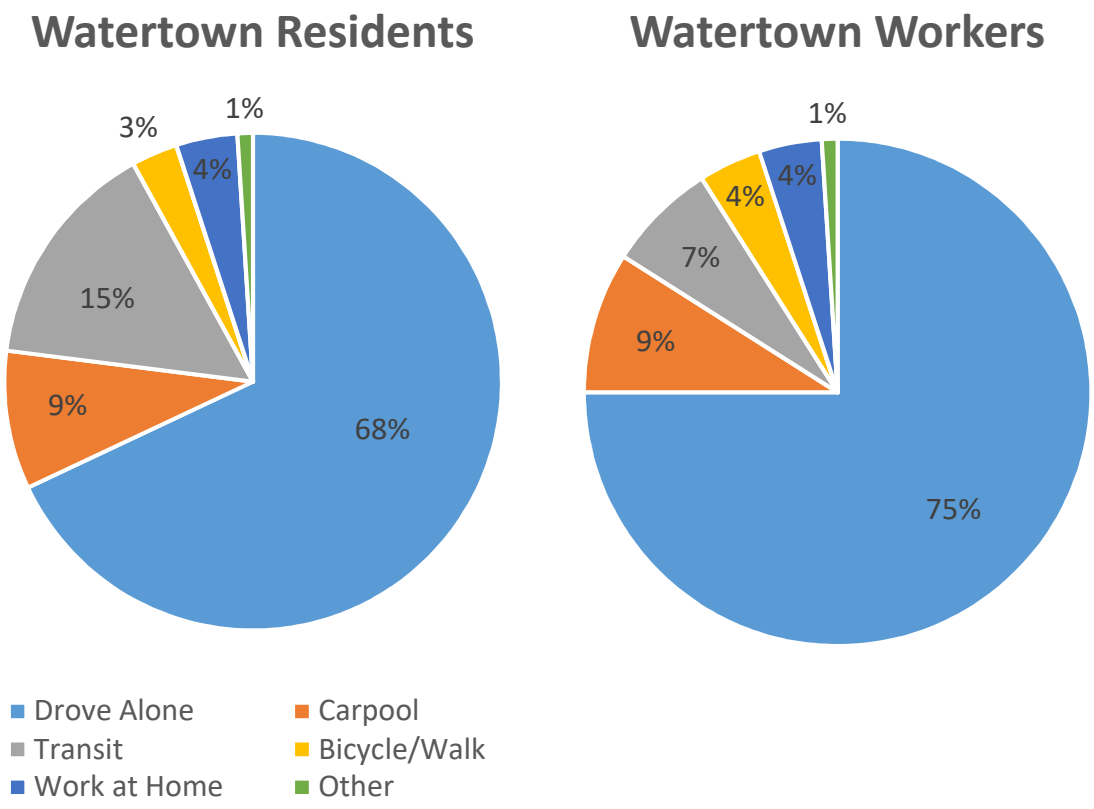
Table 2-5 and Figure 2-2 summarize the mode share for workers that are employed in Watertown based on the 2010 Census. Much like other communities and throughout the US, there is a strong reliance on the automobile and lower on transit use.

Table 2-5 Mode Choice for Watertown Workers (Work-Based)

Mode	Number of Residents	Percent of Residents
Single- Occupant Automobile	14,665	75%
Multiple - Occupant Automobile	1,730	9%
Transit	1,440	7%
Bicycle/Walk	750	4%
Work at Home	820	4%
Other	175	1%
Total	18,495	100%

Source: U.S. Census Bureau, American Community Survey 2006-2010 Five-year estimates. Special Tabulation: Census Transportation Planning

As shown, over 80 percent of workers either drive alone or carpool to work. The number of workers that travel to Watertown via transit accounts for seven percent of total workers. The percentage of workers that bike or walk to work is at four percent, while telecommuters and employees who regularly work from home accounts for four percent of total workers.



Source: U.S. Census Bureau, American Community Survey 2006-2010.

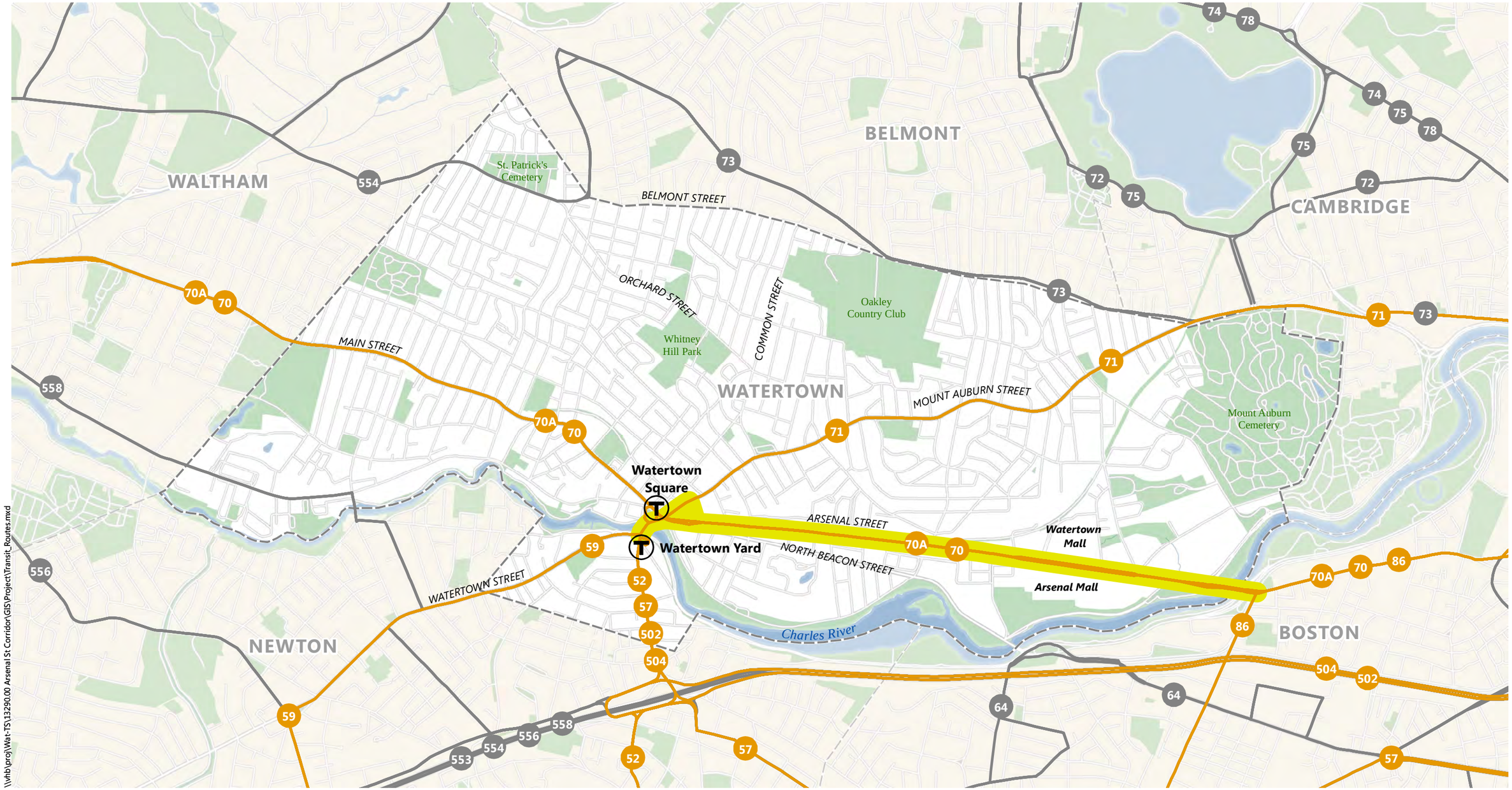
Figure 2-2 Mode Share for Watertown Residences and Workers

Transit Services

Existing transit service along and connecting to the Arsenal Street Corridor is provided by the Massachusetts Bay Transportation Authority (MBTA), the Boston Metropolitan Region's public transit operator. The MBTA operates seven local bus routes and two express bus routes within the Regional Study Area. Two local bus routes, 70 and 70A, run the length of the Arsenal Street Corridor. The seven remaining routes connect with the corridor either on the west end, at Watertown Square or the adjacent Watertown Yard, or on the east end at Western Avenue.

Figure 2-3 illustrates the Arsenal Street Corridor and the transit services operating within the Study Area. Additional detail on the specific routes serving the Study Area are provided below and in the following sections:

Apr 03, 2017 | **FIGURE 2-3**



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- Study Area MBTA Bus Routes
- Other MBTA Bus/Trackless Trolley Routes
- Arsenal Street Corridor

Arsenal Street Corridor Study | Watertown, Massachusetts

Existing MBTA Transit Routes

Source: MassGIS

- **Route 52** operates on weekdays only from Dedham Mall or Charles River Loop to Watertown Yard via VFW Parkway, Baker Street, Parker Street, and Centre Street. The route provides service in Dedham, Boston, Newton, and Watertown, and provides a connection to MBTA Green Line D Branch rapid transit service at Newton Centre. Route 52 has two separate route variations in Newton along Winchester Street and Wheeler Road.
- **Route 57** operates daily from Watertown Yard to Kenmore Station via Tremont Street, Washington Street, and Commonwealth Avenue. The route provides service in Watertown, Newton, and Boston, and provides connections to the MBTA Green Line B Branch rapid transit service between Packards Corner and Kenmore. Route 57 has a short turn service that does not serve the Study Area, referred to as the 57A, which runs from Oak Square to Kenmore Station.
- **Route 59** operates daily from Needham Junction to Watertown Square via Chestnut Street, Highland Avenue, Walnut Street, and Watertown Street. The route provides service in Needham, Newton, and Watertown. Connections to MBTA Needham Line commuter rail service are provided at Needham Junction, Needham Center, and Needham Heights, connections to MBTA Green Line D Branch rapid transit service are provided at Newton Highlands, and connections to MBTA Worcester Line commuter rail service are provided at Newtonville. Route 59 has one route variation in Newton that serves Needham Street.
- **Route 70** operates daily from Cedarwood or Central Square in Waltham to University Park in Cambridge via Main Street, Arsenal Street, and Western Avenue. The route provides service in Waltham, Watertown, Boston, and Cambridge. Connections to MBTA Fitchburg Line commuter rail service are provided at Waltham and connections to MBTA Red Line rapid transit service are provided at Central Square.
- **Route 70A** operates six days a week from North Waltham to University Park via Main Street, Arsenal Street, and Western Avenue. The route provides service in Waltham, Watertown, Boston, and Cambridge. In the North Waltham area, Route 70A operates with several route variants depending on direction and time of day. Connections to MBTA Fitchburg Line commuter rail service are provided at Waltham and connections to MBTA Red Line rapid transit service are provided at Central Square.
- **Route 71** operates daily from Watertown Square to Harvard Station via Mt. Auburn Street. The route provides service in Watertown and Cambridge, and provides connections to MBTA Red Line rapid transit service at Harvard Station. Route 71 operates using trolley buses every day except Sunday, when diesel buses replace the trolley buses.
- **Route 86** operates daily from Sullivan Square Station to Reservoir Station at Cleveland Circle via Washington Street, JFK Street, Western Avenue, and

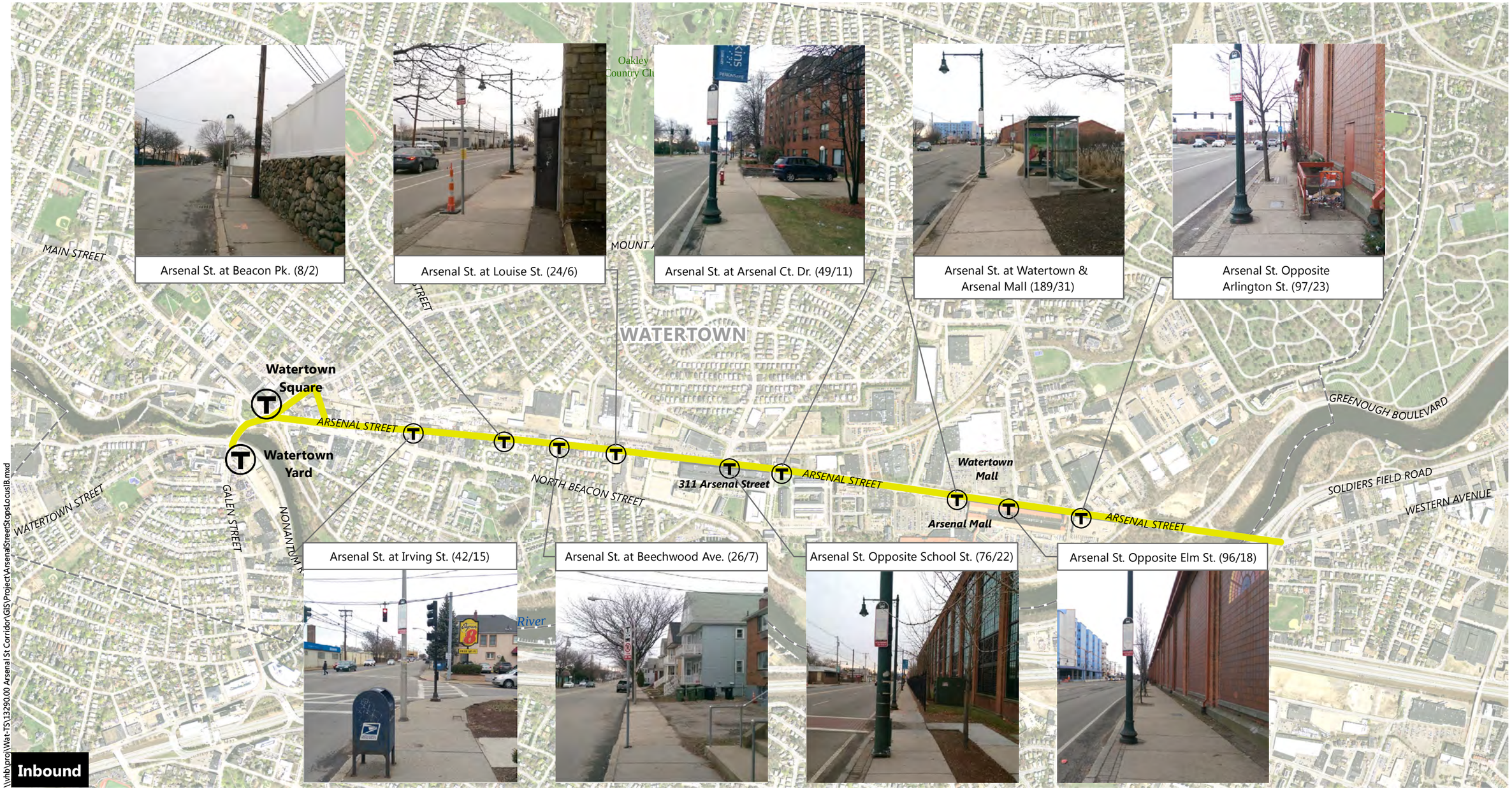
Market Street. The route provides service in Somerville, Cambridge, Boston, and Brookline. Connections to MBTA Orange Line rapid transit service are provided at Sullivan Square, connections to MBTA Red Line rapid transit service are provided at Harvard, and connections to MBTA Green Line rapid transit services are provided to the B Branch at Chestnut Hill Avenue, to the C Branch at Cleveland Circle, and to the D Brach at Reservoir.

- **Route 502** is an express service that operates weekdays from Watertown Yard to Copley Square via the Massachusetts Turnpike, providing bus service between the Study Area and the Back Bay in Boston. Route 502 operates in both directions during the peak periods only.
- **Route 504** is an express service that operates six days a week from Watertown Yard to Federal Street and Franklin Street in Downtown Boston via the Massachusetts Turnpike. Route 504 operates with increased service during the peak periods.

The MBTA operates three types of buses within the Study Area, including Compressed Natural Gas (CNG) and diesel buses, as well as electric trolley buses. Only diesel buses operate along the Arsenal Street Corridor. These buses are standard 40-foot long buses with a seated capacity of 39 passengers. All of the MBTA's buses are equipped with wheelchair lifts or ramps.

Study Area Bus Stops

Along the Arsenal Street Corridor, there are nine inbound bus stops located on the southern side of Arsenal Street and ten outbound stops located on the northern side, as illustrated in Figure 2-4 and Figure 2-5 respectively. Many of the bus stops located on Arsenal Street do not have formal shelters and consist of a posted sign along the existing sidewalk to designate the bus stop. In some locations, these bus stops are on narrow sidewalks which provide no additional space for waiting passengers outside the path of pedestrians. The inbound and outbound bus stops located at the Watertown and Arsenal Malls have single, standard covered bus shelters. The bus stops along the corridor and their associated facilities are outlined in Table 2-6.



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Bus Stop Name
(Route 70 Daily Boardings/ Route 70A Daily Boardings)

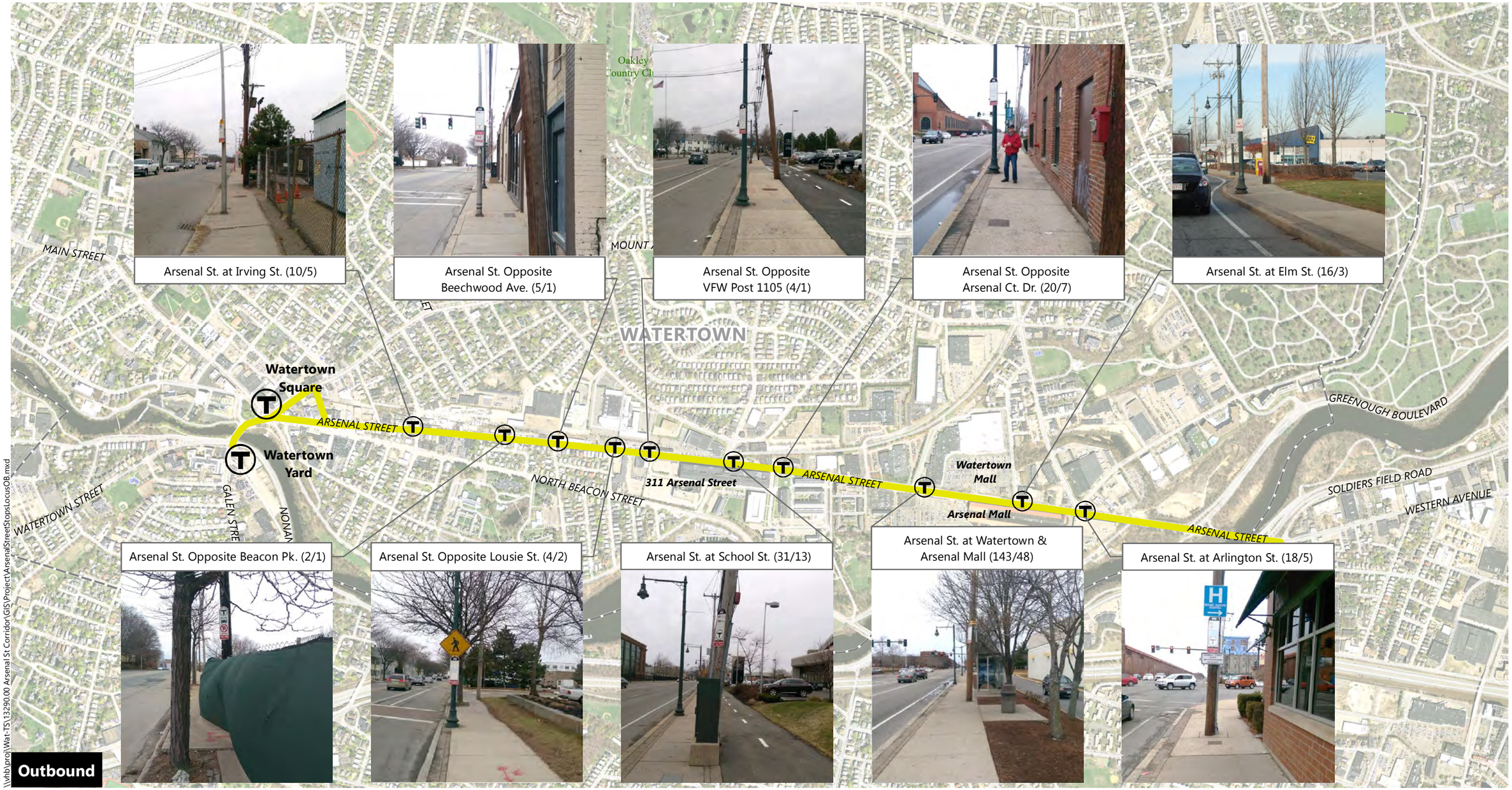
Bus Stop

Arsenal Street Corridor

Arsenal Street Corridor Study | Watertown, Massachusetts

MBTA Routes 70/70A
Arsenal Street Inbound
Bus Stop Locus Map

Source: MassGIS, MBTA



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Bus Stop Name
(Route 70 Daily Boardings/ Route 70A Daily Boardings)

Bus Stop

Arsenal Street Corridor

Arsenal Street Corridor Study | Watertown, Massachusetts

MBTA Routes 70/70A
Arsenal Street Outbound
Bus Stop Locus Map

Source: MassGIS, MBTA

Table 2-6 Arsenal Street Corridor Bus Stops

Bus Stop Name	Direction	Bus Stop Location	Stop Facilities
Arsenal St. @ Arlington St.	Outbound	Near-Side	Sign Post
Arsenal St. @ Elm St.	Outbound	Far-Side	Sign Post
Arsenal St. @ Watertown + Arsenal Mall	Outbound	Mid-Block	One Bus Shelter
Arsenal St. Opposite Arsenal Ct. Dr.	Outbound	Mid-Block	Sign Post
Arsenal St. @ School St.	Outbound	Far-Side	Sign Post
Arsenal St. Opposite VFW Post 1105	Outbound	Mid-Block	Sign Post
Arsenal Street Opposite Louise St.	Outbound	Mid-Block	Sign Post
Arsenal St. Opposite Beechwood Ave.	Outbound	Near-Side	Sign Post
Arsenal St. Opposite Beacon Park	Outbound	Mid-Block	Sign Post
Arsenal St. @ Irving St.	Outbound	Mid-Block	Sign Post
Arsenal St. @ Irving St.	Inbound	Near-Side	Sign Post
Arsenal St. @ Beacon Park	Inbound	Near-Side	Sign Post
Arsenal St. @ Beechwood St.	Inbound	Far-Side	Sign Post
Arsenal St. @ Louise St.	Inbound	Mid-Block	Sign Post
Arsenal St. Opposite School St.	Inbound	Mid-Block	Sign Post
Arsenal St. @ Arsenal Ct. Dr.	Inbound	Mid-Block	Sign Post
500 Arsenal St. @ Watertown + Arsenal Mall	Inbound	Far-Side	One Bus Shelter
Arsenal St. Opposite Elm St.	Inbound	Mid-Block	Sign Post
Arsenal St. Opposite Arlington St.	Inbound	Mid-Block	Sign Post

Source: Names from MassGIS MBTA Bus Stops Datalayer; All other information from field visits by VHB

Operations

The following sections describe the operational characteristics of the existing transit services within the project Study Area.

Span of Service and Frequency

MBTA bus routes serve the Study Area seven days a week, however, not all bus routes offer off-peak, late night, or weekend service. A span of service summary showing operating times for buses within the Study Area (operating along or connecting to the Arsenal Street Corridor) is shown in Table 2-7. These times are based on currently published schedules, valid from September 5, 2015 to December 25, 2015.

Table 2-7 Study Area Bus Span of Service

Route	Weekday	Saturday	Sunday
52	6:15 a.m. - 7:57 p.m.	Does not Operate	Does not Operate
57	4:33 a.m. - 2:35 a.m.	4:33 a.m. - 2:38 a.m.	6:00 a.m. - 1:32 a.m.
59	6:05 a.m. - 8:21 p.m.	7:05 a.m. - 7:35 p.m.	7:50 a.m. - 6:51 p.m.
70	4:50 a.m. - 1:19 a.m.	5:00 a.m. - 1:27 a.m.	6:00 a.m. - 1:22 a.m.
70A	5:30 a.m. - 8:22 p.m.	7:05 a.m. - 8:43 p.m.	Does not Operate
71	4:51 a.m. - 1:40 a.m.	4:57 a.m. - 1:36 a.m.	6:30 a.m. - 1:22 a.m.
86	5:00 a.m. - 1:07 a.m.	5:00 a.m. - 1:02 a.m.	7:30 a.m. - 10:05 a.m.
502	6:45 a.m. - 7:22 p.m.	Does not Operate	Does not Operate
504	6:20 a.m. - 8:09 p.m.	7:30 a.m. - 8:04 p.m.	Does not Operate

Source: MBTA Bus Timetables (valid from 9/5/15 to 12/25/15), accessed from www.mbta.com on 12/1/15.

Approximate service frequencies for each time period and day of the week are shown for each route operating in the Study Area in Table 2-8. These frequencies are based on the currently published schedules, valid from September 5, 2015 to December 25, 2015.

Table 2-8 Study Area Bus Frequency (Minutes)

	Weekday					Weekend	
	Early AM & AM Peak	Midday Base & Midday School	PM Peak	Evening	Late Evening & Night/Sunrise	Saturday Peak	Sunday Peak
Route	6:00 a.m. – 8:59 a.m.	9:00 a.m. – 3:59 p.m.	4:00 p.m. – 6:29 p.m.	6:30 p.m.- 9:59 p.m.	10:00 p.m. – 5:59 a.m.	Varies	Varies
52	30	60	35	35	n/a	n/a	n/a
57	6	10	6	10	20	10	15
59	35	45	35	35	n/a	90	90
70	15	25	15	25	35	20	25
70A	30	65	30	30	n/a	40	n/a
71	10	15	10	15	20	15	20
86	15	20	15	30	45	30	35
502	6	n/a	12	n/a	n/a	n/a	n/a
504	10	30	10	25	n/a	35	n/a

Source: MBTA Bus Timetables (valid from 9/5/15 to 12/25/15), accessed from www.mbta.com on 12/1/15.

Ridership

Existing transit ridership within the Study Area was analyzed using Fall 2014 data provided by the MBTA, the most current data available at the time of the existing conditions analysis. Average daily ridership totals for each line operating through the

Study Area are provided in Table 2-9 and represent the average daily boardings along the entire line, including boardings outside of the Arsenal Street Corridor. The inbound and outbound directions indicated in Table 2-9 are as defined in the current MBTA schedules. For routes serving Boston, inbound routes travel towards Boston. For Route 59, inbound is defined as traveling from Needham to Watertown, while Route 52, inbound is defined as traveling from Dedham Mall to Watertown. For Route 86, inbound is defined as traveling from Sullivan Square to Reservoir Station.

Table 2-9 Average Weekday Boardings for Routes Serving the Study Area

	Weekday			Saturday			Sunday		
Route	Inbound	Outbound	Total	Inbound	Outbound	Total	Inbound	Outbound	Total
52	340	368	708	n/a	n/a	n/a	n/a	n/a	n/a
57	5,007	5,360	10,367	3,909	3,643	7,552	2,598	2,379	4,977
59	731	731	1,462	208	237	445	143	182	325
70	2,733	2,818	5,551	1,913	2,091	4,004	1,842	1,870	3,712
70A[a]	810	1,192	2,002	745	829	1,574	n/a	n/a	n/a
71[b]	2,690	2,858	5,548	1,618	1,504	3,122	1,079	873	1,952
86	2,582	3,045	5,627	1,376	1,659	3,035	928	1,091	2,019
502	568	437	1,005	n/a	n/a	n/a	n/a	n/a	n/a
504	821	661	1,482	243	217	460	n/a	n/a	n/a

Source: Fall 2014 Bus Ridership Data (provided by MBTA)
Note: [a] The discrepancy in ridership between the inbound and outbound 70A is due to the loop in Waltham and riders being counted as they ride around the loop.
[b] Ridership data for the 71 is from two different time periods; Weekday and Saturday ridership figures are from Spring 2013, Sunday ridership is from Fall 2014; all 71 ridership data is non-APC data.

Average combined daily boardings and alightings for each stop along the Arsenal Street Corridor, for both Routes 70 and 70A, are summarized in Table 2-10. The Arsenal Mall area sees over 1,300 combined boardings and alightings at its six bus stops each weekday, comprising over two thirds of all weekday boardings and alightings along the corridor.

Table 2-10 Arsenal Street Corridor Weekday Boardings and Alightings by Stop

Bus Stop Location	Direction of travel	Boardings	Alightings
Arsenal St at Watertown + Arsenal Mall	Outbound	190	217
500 Arsenal St - Watertown + Arsenal Mall	Inbound	220	153
Arsenal St opposite Elm St	Inbound	114	29
Arsenal St opposite Arlington St	Inbound	120	22
Arsenal St at Arlington St	Outbound	23	117
Arsenal St opposite School St	Inbound	98	39
Arsenal St at School St	Outbound	43	88
Arsenal St at Elm St	Outbound	19	109
Arsenal St opposite Arsenal Ct Dr	Outbound	27	72
Arsenal St at Arsenal Ct	Inbound	60	27
Arsenal St at Irving St	Inbound	57	19
Arsenal St at Irving St	Outbound	15	44
Arsenal St at Beachwood Ave	Inbound	33	5
Arsenal St at Louise St	Inbound	30	5
Arsenal St opposite Beachwood Ave	Outbound	6	29
Arsenal St opposite Louise St	Outbound	6	19
Arsenal St opposite VFW Post 1105	Outbound	6	12
Arsenal St at Beacon Pk	Inbound	9	3
Arsenal St opposite Beacon Pk	Outbound	2	7

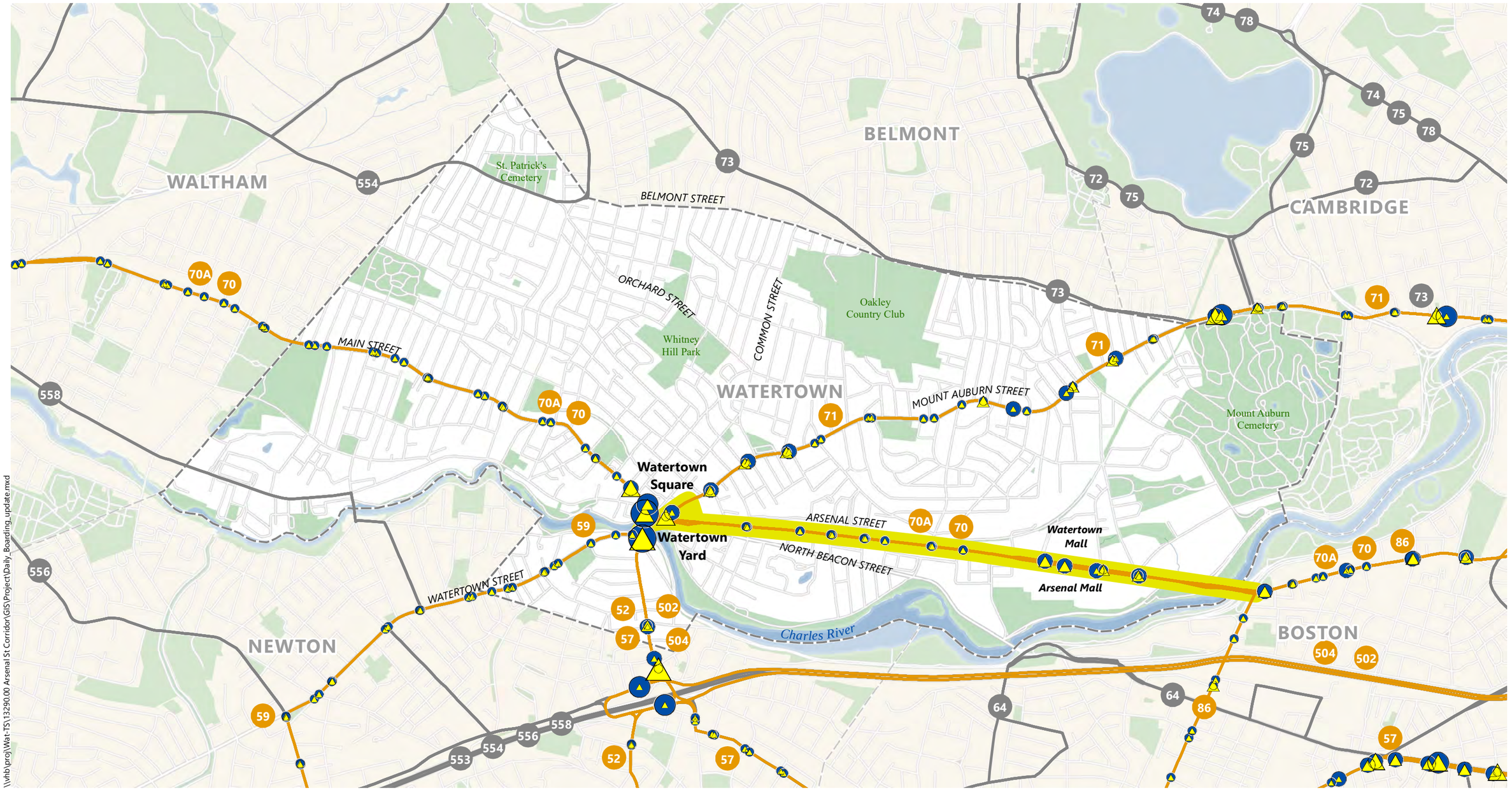
Source: Fall 2014 Bus ridership data (Provided by MBTA). Results rounded to nearest whole number.
Note: Bus stops sorted by total combined boardings and alightings in descending order

Average weekday boardings and alightings by stop for bus routes travelling within or connecting to the Arsenal Street Corridor are illustrated in Figure 2-6. Located off of but proximate to the corridor, the Watertown Yard and Watertown Square stops are the two busiest stops in the Study Area vicinity with over 3,100 and 1,600 daily combined boardings and alightings, respectively.

Vehicle Loading

The MBTA's *Service Delivery Policy*[2] defines the levels of crowding that are acceptable by time period and mode of transportation. For MBTA bus service, the acceptable ratio of passengers to seats during Early AM, AM Peak, Midday School, and PM Peak periods is 140 percent. For all other periods, the acceptable ratio is 100 percent. For buses along the Arsenal Street Corridor which have a seated capacity of 39 passengers, the maximum acceptable load equals 54 passengers during the peak periods. According to the *Service Delivery Policy*, "For bus, on weekdays the loads

[2] MBTA. *Service Delivery Policy*. June 2, 2010.



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0 425 850 1700 Feet

Alightings
- 0 to 100
- 101 to 250
- 251 to 750
- Over 750

Boardings
- 0 to 100
- 101 to 250
- 251 to 750
- Over 750

- Study Area MBTA Bus Routes
- Other MBTA Bus/Trackless Trolley Routes
- Arsenal Street Corridor

Arsenal Street Corridor Study | Watertown, Massachusetts

Daily Transit Ridership Map

Source: MassGIS, MBTA

cannot exceed the standard when averaged over any 30-minute segment of an Early AM, AM Peak, Midday School or PM Peak period, or any 60-minute segment of a Midday Base, Evening, Late Evening, or Night/Sunrise period."[3]

For the vehicle loading analysis, only transit routes serving the length of the Arsenal Street Corridor were analyzed. The two routes that serve the length of the corridor are the 70 and the 70A, which each serve the 19 stops along the corridor. For this analysis, the ratio of passengers to seats was calculated based on existing weekday ridership data supplied by the MBTA from the Spring 2013 and Fall 2014 seasons, the most current data available at the time of the existing conditions analysis. The analysis consisted of averaging the peak loads during 30 or 60-minute segments (as appropriate). Subsequently, the maximum 30 or 60-minute segment loading for each period of the day was identified, as summarized in Table 2-11. These values represent maximum average loading values that occur on the entire line, not just over the Arsenal Street Corridor. High loads during the Night/Sunrise period are due to high ridership at the beginning of the morning commute, which is included as part of the nighttime ridership period as defined by MBTA convention.

Table 2-11 Route 70/70A Weekday Maximum Average Passenger Loads by Time Period

		Route 70		Route 70A	
Period		**Inbound**	**Outbound**	**Inbound**	**Outbound**
Early AM	6:00 a.m. – 6:59 a.m.	**55**	28	**58**	30
AM Peak	7:00 a.m. – 8:59 a.m.	47	52	45	45
Midday Base	9:00 a.m. – 1:29 p.m.	33	36	33	34
Midday School	1:30 p.m. – 3:59 p.m.	**57**	42	39	43
PM Peak	4:00 p.m. – 6:29 p.m.	42	50	50	44
Evening	6:30 p.m. – 9:59 p.m.	**40**	**48**	29	n/a
Late Evening	10:00 p.m. – 11:59 p.m.	28	33	n/a	n/a
Night/Sunrise	12:00 a.m. – 5:59 a.m.	**43**	21	n/a	23

Source: MBTA Provided Ridership Data, from SP13 and FA14

Note: Results rounded to the nearest whole number. Bold text indicates passenger loads exceed acceptable levels for the given time period, based on levels defined in the MBTA's *Service Delivery Policy*. For Early AM, AM Peak, Midday School, and PM Peak, the loads above represent the maximum 30 minute load, where the acceptable load is 54 passengers or less. For all other periods the loads above represent the maximum 60 minute load, where the acceptable load is 39 passengers or less.

Findings of the existing load conditions analysis for Routes 70 and 70A show that despite meeting acceptable service standards during most service periods, the existing passenger loads slightly exceed the MBTA's *Service Delivery Policy* standards during the early morning peak in the inbound direction, in the evening peak on the Route 70 in both directions, and in the midday and late night inbound runs on the Route 70.

[3] MBTA Service Delivery Policy - 2010 Update, Pg. 13

A similar analysis was performed for the Arsenal Street Corridor segment, based on the combined loads on the Routes 70 and 70A. Average loading for the peak 30-minutes along the Arsenal Street Corridor is shown in Figure 2-7 and Figure 2-8 for the morning and evening peaks, respectively. During the AM Peak, the highest inbound loads within the corridor average approximately 46 passengers as buses depart the stop opposite Arlington Street. The highest outbound loads on the corridor occur approaching Arlington Street, at an average of approximately 49 passengers. During the PM peak, the highest inbound loads on the corridor occur as buses depart the stop opposite Arlington Street, at an average of approximately 40 passengers. The highest outbound loads on the corridor occur between VFW Post 1105 and Louise Street, at an average of approximately 40 passengers. While the 70 and 70A do see heavy loading in each direction during peak periods, loading within the Arsenal Street Corridor itself is within acceptable levels as defined by the MBTA's *Service Delivery Policy*.

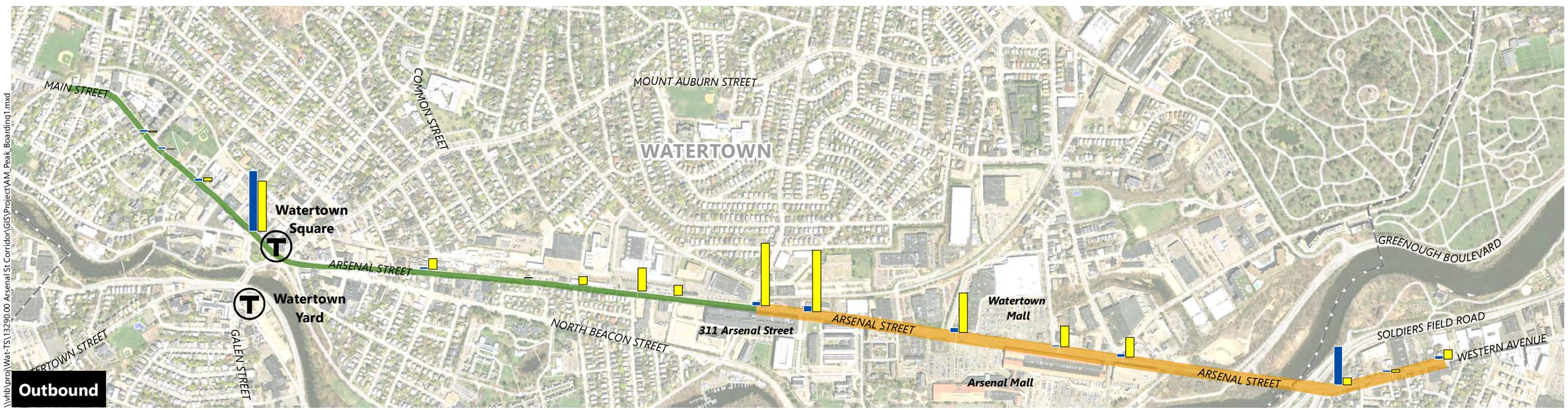
Service Reliability

On-time performance of existing transit services operating along the Arsenal Street Corridor was assessed using Running Time Report data from October 2015, provided by the MBTA. Average on-time performance percentages on the trip level, which consider departure lateness (and penalties for early departure) from the first stop of each trip, were calculated by time period using trip on-time performance data on Routes 70 and 70A. Findings of the trip level reliability analysis are summarized in Table 2-12. When averaged over the full day, on-time performance for bus trips on the corridor ranges from 47.3 percent to 77.8 percent.

Table 2-12 Route 70/70A Trip On-Time Performance Summary

	Route 70		Route 70A	
Period	**Inbound**	**Outbound**	**Inbound**	**Outbound**
Early AM	96.4%	87.5%	48.0%	81.9%
AM Peak	75.4%	77.0%	61.6%	60.5%
Midday Base	75.5%	79.2%	43.9%	88.1%
Midday School	68.9%	72.9%	63.2%	83.3%
PM Peak	54.5%	78.8%	36.8%	61.2%
Evening	55.2%	59.5%	25.1%	n/a
Late Evening	89.5%	94.5%	n/a	n/a
Night/Sunrise	85.5%	89.3%	n/a	76.5
Service Day Average	70.2%	77.8%	47.3%	73.6%

Source: MBTA Running Time Reports (Trip Level) for October 2015 (provided by MBTA)



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0 250 500 1000 Feet

BY SEGMENT

Average Vehicle Load (Passengers)

- 0 to 39 (Seats Available)
- 40 to 54 (Some Standees)
- Over 54 Passengers

BY STOP

Average Number of Boardings/Alightings

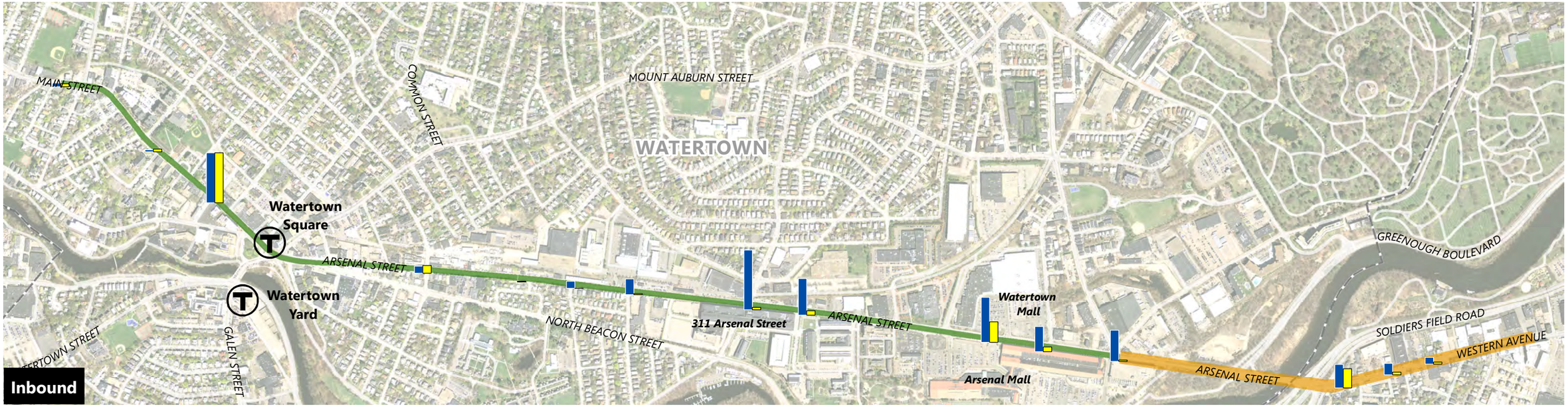
4
2
1

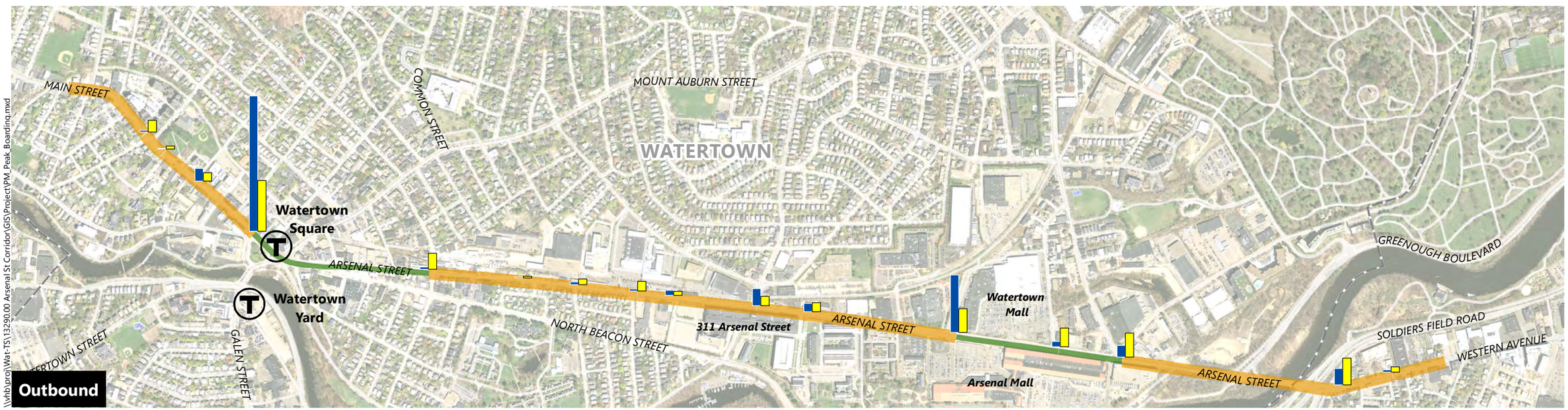
Boardings
Alightings

Arsenal Street Corridor Study | Watertown, Massachusetts

MBTA Routes 70/70A
AM Peak 30-Minute Vehicle Loads

Source: MassGIS, MBTA





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0 250 500 1000 Feet

BY SEGMENT

Average Vehicle Load (Passengers)

- 0 to 39 (Seats Available)
- 40 to 54 (Some Standees)
- Over 54 Passengers

BY STOP

Average Number of Boardings/Alightings

4
2
1

Boardings
Alightings

Arsenal Street Corridor Study | Watertown, Massachusetts

MBTA Routes 70/70A
PM Peak 30-Minute Vehicle Loads

Source: MassGIS, MBTA

According to the MBTA's *Service Delivery Policy*[4], for any bus route to be in compliance with the Schedule Adherence Standard, 75 percent of all time points along a route over the entire service day must be on time. Average on time performance percentages on the timepoint level, which consider departure lateness (and penalties for early departure) for all trip timepoints, were calculated by time period using timepoint on-time performance data on Route 70 and 70A. Findings for the timepoint reliability analysis are summarized in Table 2-13. When averaged over the full day, neither the Route 70 or Route 70A meet the Schedule Adherence Standard of 75 percent.

Table 2-13 Route 70/70A Timepoint On-Time Performance Summary

	Route 70		Route 70A	
Period	**Inbound**	**Outbound**	**Inbound**	**Outbound**
Early AM	80.5%	69.7%	61.8%	72.7%
AM Peak	58.2%	56.1%	31.3%	59.6%
Midday Base	66.6%	68.4%	46.1%	79.6%
Midday School	49.1%	63.4%	57.1%	63.5%
PM Peak	42.1%	53.0%	25.0%	38.3%
Evening	57.4%	59.5%	25.4%	n/a
Late Evening	81.0%	89.8%	n/a	n/a
Night/Sunrise	80.1%	90.8%	n/a	73.8%
Service Day Average	60.6%	66.2%	39.4%	61.7%

Source: MBTA Timepoint On-Time Reports for October 2015 (provided by MBTA)

Vehicular Traffic Evaluation

The following section provides a description and assessment of the existing transportation conditions of the study area. This includes traffic volumes, operations, safety, pedestrian and bicycle concerns.

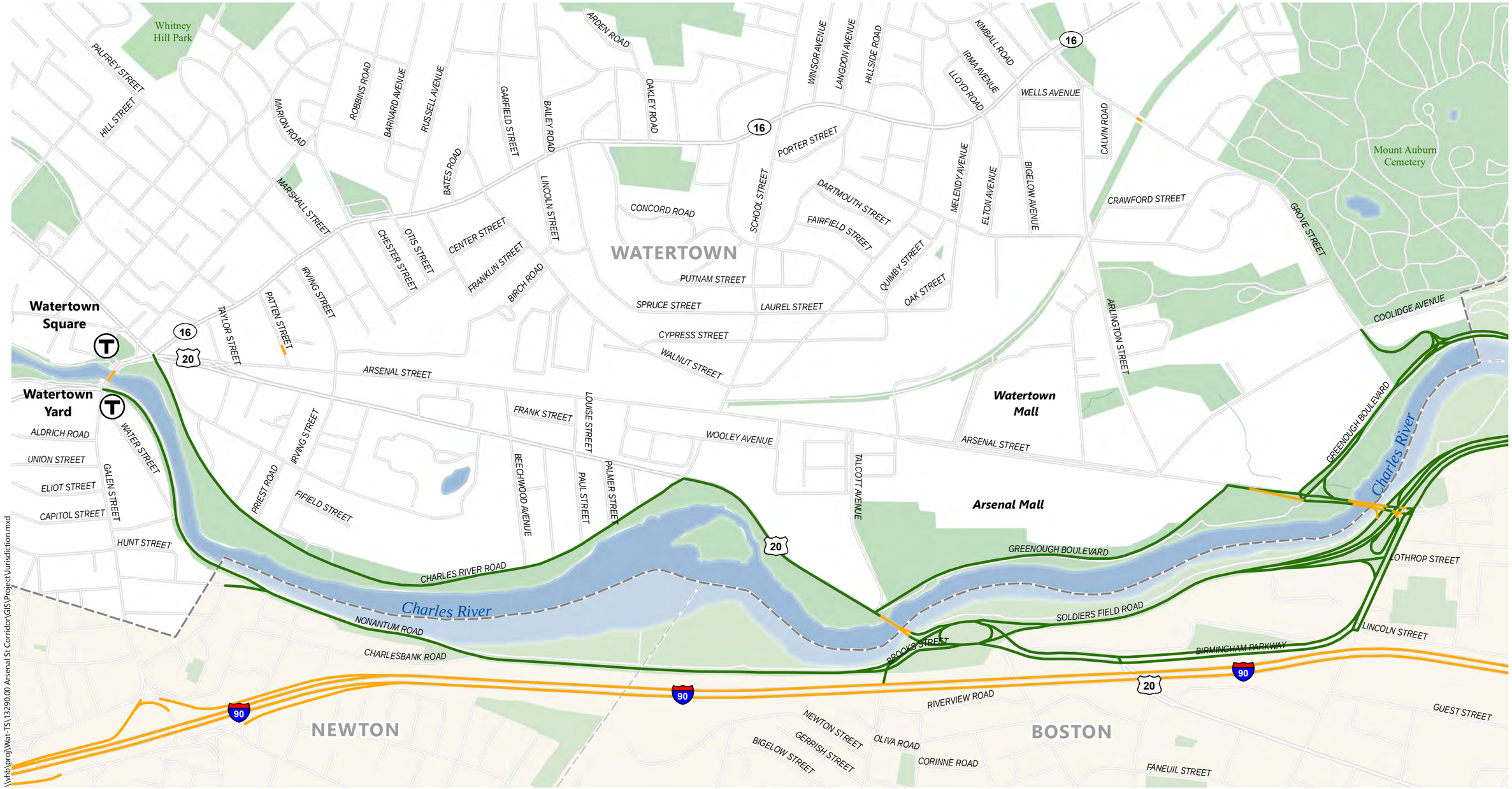
Existing Infrastructure Review

Arsenal Street, the major route of travel in this corridor study, is an urban minor arterial roadway that provides an east-west connection between Soldiers Field Road/ Birmingham Parkway to the east and Main Street/Galen Street/ Mount Auburn Street/North Beacon Street (Watertown Square) to the west. West of Watertown Square, Arsenal Street continues as Main Street, and extends to the Watertown/

[4] MBTA Service Delivery Policy - 2010 Update, Pg. 10

Waltham town line. Arsenal Street, west of Louise Street, generally consists of one lane in each direction. East of Louise Street, two lanes are provided in each direction throughout the remainder of the corridor.

Within the study area, Arsenal Street is under local jurisdiction between Watertown Square and Greenough Boulevard (south). East of Greenough Boulevard (south), Arsenal Street is under the jurisdiction of the Massachusetts Department of Conservation and Recreation (DCR), with the exception of the bridge over the Charles River, which is owned by MassDOT. An illustration of the roadway jurisdiction within the study area is shown in Figure 2-9.



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Signalized Study Intersection

Unsignalized Study Intersection

Roadway Jurisdiction

MassDOT

DCR

City or Town Road

Arsenal Street Corridor Study | Watertown, Massachusetts

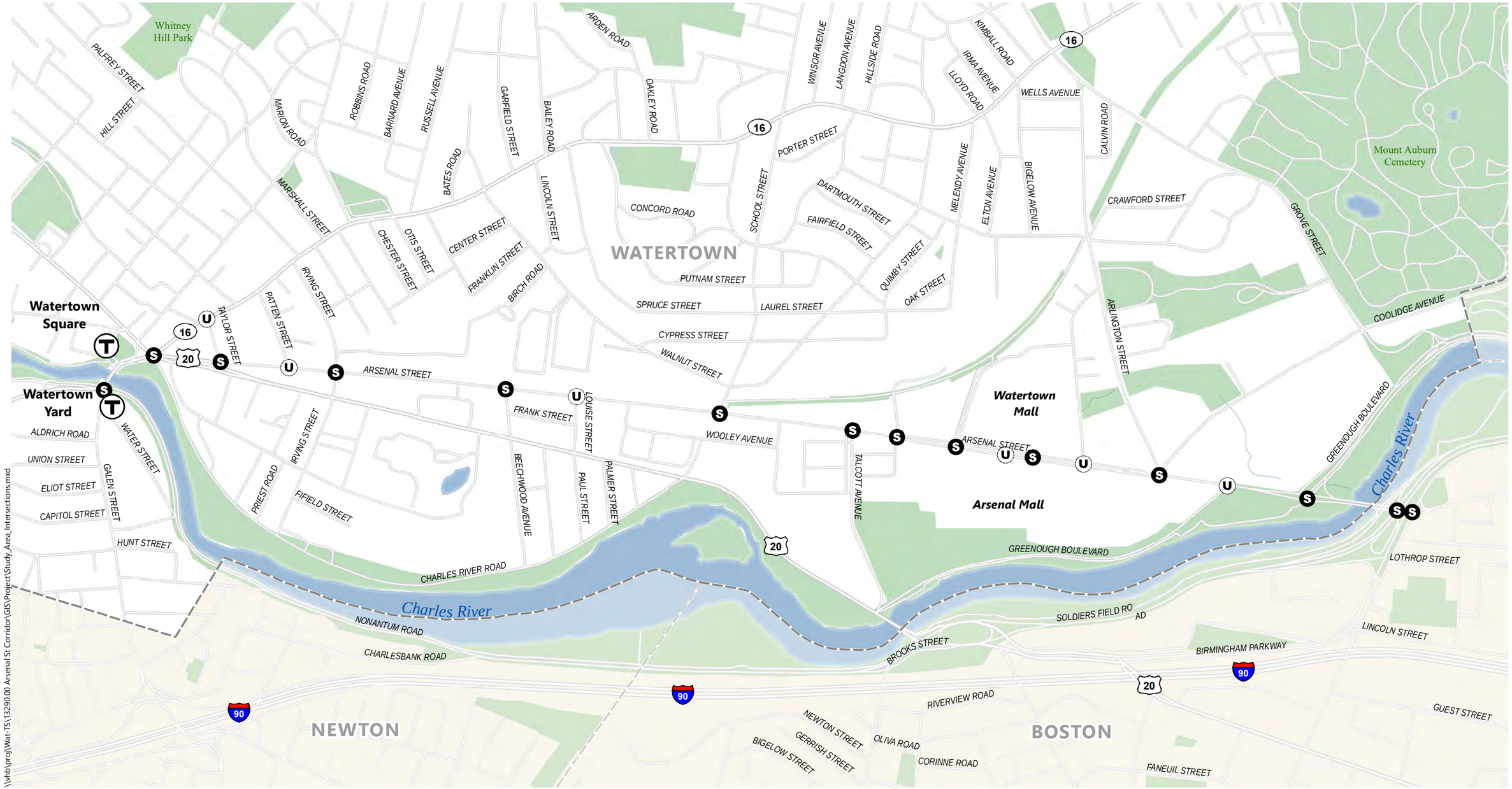
Roadway Jurisdiction Map

Source: MassGIS

Study Area Intersections

The focus of the study primarily spans along Arsenal Street/Western Avenue, between Birmingham Parkway in the east and Watertown Square in the west. Depicted in Figure 2-10, the study area intersections include the following:

- Watertown Street/Nonantum Road at Galen Street (signalized)
- Mt Auburn Street at Main Street, Arsenal Street, and Charles River Road (signalized)
- North Beacon Street/Arsenal Street/Taylor Street (signalized)
- Mt Auburn Street at Taylor Street (unsignalized)
- Arsenal Street at Patten Street (unsignalized)
- Arsenal Street at Irving Street (signalized)
- Arsenal Street at Beechwood Avenue (signalized)
- Arsenal Street at Louise Street (unsignalized)
- Arsenal Street at School Street (signalized)
- Arsenal Street at Talcott Avenue/Roma Tile driveway (signalized)
- Arsenal Street at Birch Street/Arsenal Court (signalized)
- Arsenal Street at Arsenal Mall/ Watertown Mall Rear Entrance (signalized)
- Arsenal Street at Arsenal Mall (unsignalized)
- Arsenal Street at Watertown Mall (signalized)
- Arsenal Street at Elm Street (unsignalized)
- Arsenal Street at Arlington Street/Coolidge Avenue/Home Depot Driveway (signalized)
- Arsenal Street at Greenough Boulevard (south) (unsignalized)
- Arsenal Street at Greenough Boulevard (north) (signalized)
- Arsenal Street at Soldiers Field Road (signalized)
- Arsenal Street at Birmingham Parkway (signalized)



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S Signalized Study Intersection

U Unsignalized Study Intersection

Arsenal Street Corridor Study | Watertown, Massachusetts

Study Area Intersections Map

Source: MassGIS

Signal Inventory

The traffic signal and controller equipment at the 14 signalized intersections within the study area were reviewed. Issues were noted at all locations and include:

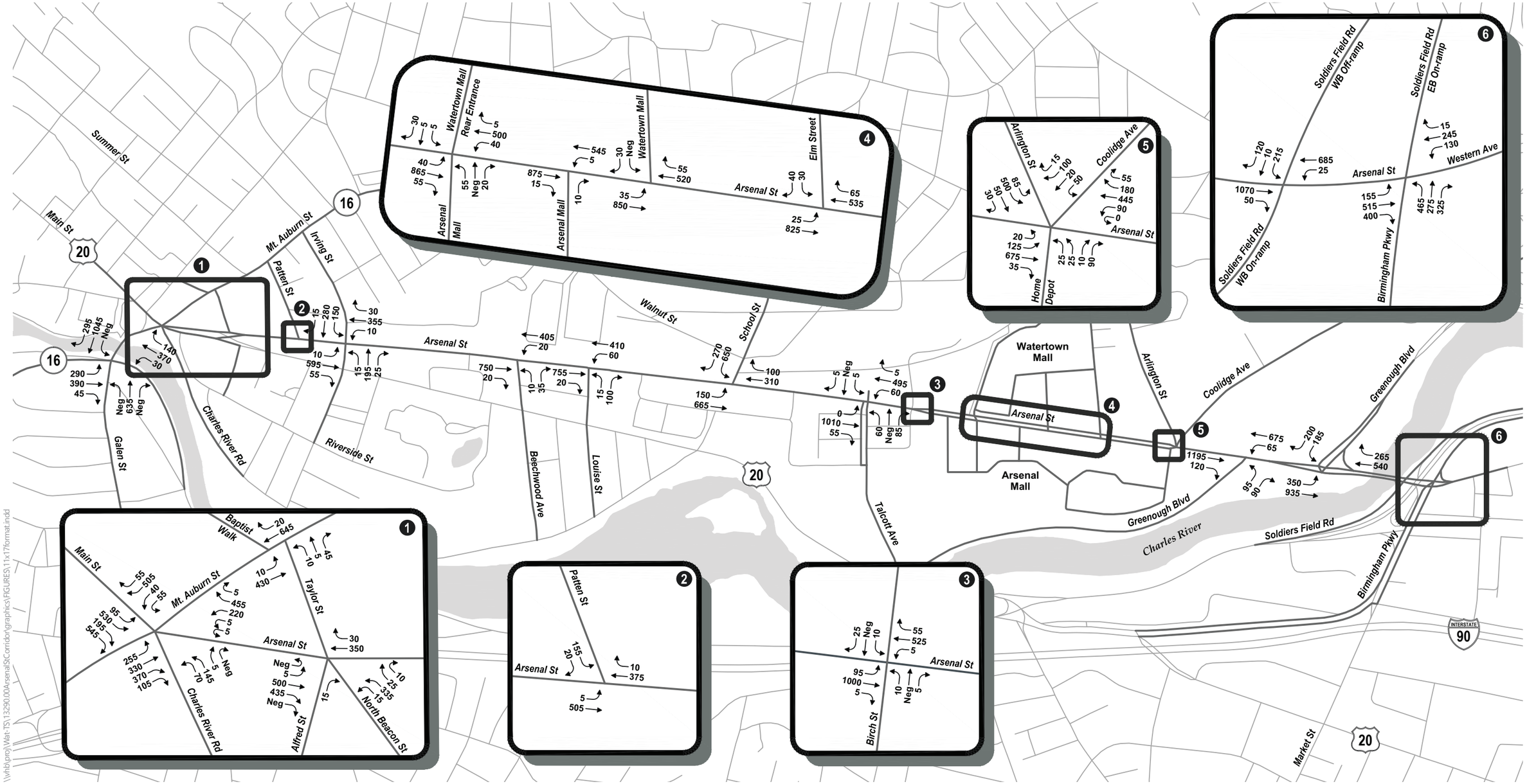
- **Manual on Uniform Traffic Control Devices (MUTCD) Compliance** – Non-conforming pedestrian signal head type, push button placement, pedestrian signal operations, etc.
- **Americans with Disabilities Act (ADA) Compliance** – Push button type, lack of pedestrian accommodations, etc.
- **Operational/Maintenance Issues** – Vehicle recall, detection, controller clock off (time of day, daylight savings), coordination issues, etc.
- **Safety Deficiencies** – Pedestrian signal phasing, pedestrian-vehicle and vehicle-vehicle conflicts.

A complete signal inventory summary by location is included in the Appendix. Deficiencies noted during the inventories were reviewed and short- and long-term solutions (as applicable) were identified as part of the Alternatives Development process (Chapter 4).

Traffic Demands

To identify current flow characteristics along the Arsenal Street corridor, automatic traffic recorder (ATR) data were obtained for a typical weekday to quantify hourly fluctuations. Table 2-14 summarizes the traffic volumes at various locations along Arsenal Street. In addition, turning movement counts (TMCs) were collected at key intersections to quantify peak hour vehicular, pedestrian, and bicycle demands. Weekday morning and evening peak hour turning movement are illustrated in Figures 2-11 and Figure 2-12 respectively. Traffic volume data are included in the Appendix.

Arsenal Street carries between 14,500 and 23,500 vehicles per day (vpd). West of School Street, traffic patterns reflect a typical commuting pattern, with the majority of traffic traveling eastbound during the morning and westbound during the evening. Traffic increases towards the eastern section of Arsenal Street, which could be attributed to the major employers located along the corridor and the use of Soldier's Field Road, Greenough Boulevard, and Western Avenue to regionally access these employment centers.

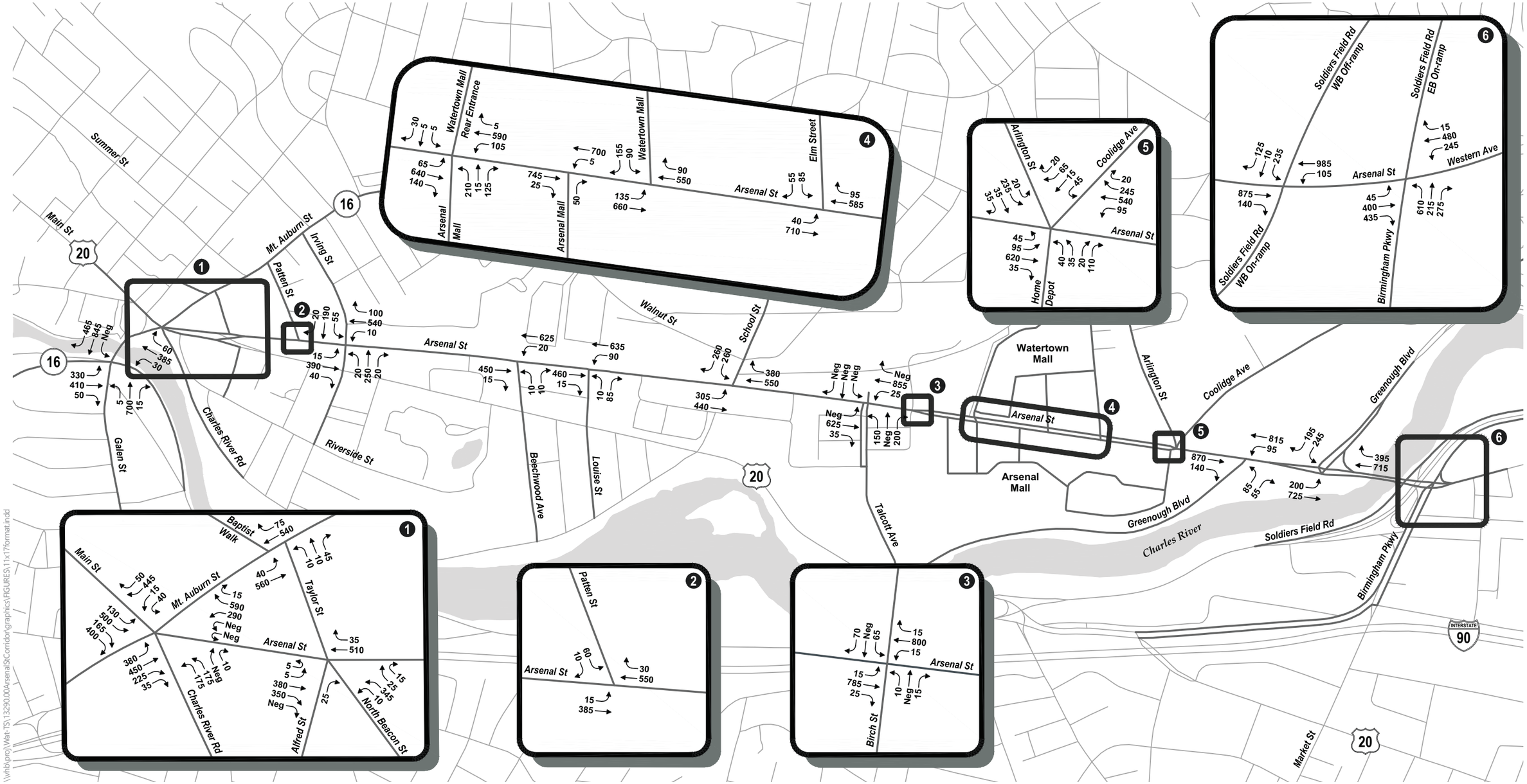


Not to scale

Arsenal Street Corridor Study | Watertown, Massachusetts

2015 Existing Condition
Weekday Morning Peak Hour
Traffic Volume

Source: MassGIS



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Arsenal Street Corridor Study | Watertown, Massachusetts

2015 Existing Condition
Weekday Evening Peak Hour
Traffic Volume

Source: MassGIS

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Table 2-14 ATR Summary

Location	Daily [a]	Weekday Morning Peak Hour				Weekday Evening Peak Hour			
	Weekday	Volume [b]	K Factor [c]	Dir. Dist. [d]		Volume	K Factor	Dir. Dist.	
Arsenal Street, Between Patten Street and Taylor Street	14,515	885	6.1%	57%	EB	1,035	7.1%	57%	WB
Arsenal Street, Between Wooley Ave and School Street	19,685	1,345	6.8%	56%	EB	1,535	7.8%	53%	WB
Arsenal Street, Between Arsenal Mall Driveways	17,430	1,260	7.2%	56%	EB	1,395	8.0%	50%	EB
Arsenal Street, Between Greenough Boulevard (north) and Greenough Boulevard (south)	23,500	2,035	8.7%	64%	EB	1,820	7.7%	53%	EB

Source: MassDOT. Based on automatic traffic recorder (ATR) counts conducted in September 2015.
a - Average daily traffic (ADT) volume expressed in vehicles per day
b - Peak period traffic volumes expressed in vehicles per hour
c - Percent of daily traffic that occurs during the peak hour
d - Directional distribution of peak period traffic

Traffic Operations

To understand the existing traffic operations and assess the quality of flow at the study area intersections, traffic analysis was conducted using VISSIM software.

VISSIM is a transportation planning and operations software package that is designed to provide a sophisticated visual and analytical representation of traffic operations on a full range of functionally classified roadways. A microscopic simulation software, where each vehicle is simulated individually, VISSIM can simulate complicated driving behavior on roadway facilities as well as interaction between all modes. Users can also program realistic lane geometries, various vehicle types, public transit, and designate different vehicle routes within the model.

Simulation Methodology

The VISSIM model development primarily consists of three stages: data compilation/ network coding, model calibration/ validation, and model application. The following describes each stage as applied to the VISSIM model for this Project.

Data Compilation/ Network Coding

The initial step in creating a VISSIM network involves compiling all essential background data for the model, which typically includes lane geometries and widths of study area roadways, pedestrian crosswalk locations, signal timing plans, and roadway speeds. Based on these collected data, a base roadway network of the study area was then created. As VISSIM allows for extreme precise route assignments for vehicles within the simulation area, that capability was applied in the Project's model by inputting volumes to individual approaches and basing routing decisions on peak hour traffic volumes collected in the study area, defining the percentage of traffic entering and exiting each roadway link.

Model Calibration/ Validation

Separate simulation models for the morning and evening peak hours were created at the end of the data compilation and network coding stage. These two models were then calibrated to ensure accurate model operations. In this stage, the models were calibrated based on characteristics such as turning movement counts and queues at the intersections.

Multiple runs of each of the VISSIM models were conducted to introduce variation to vehicle loadings and the nature of vehicle arrivals in the simulation. Calibration of the VISSIM model for each of the peak hour was conducted to accurately and realistically model operations as they were observed in the field. Traffic volume data was collected from each model and compared to the existing peak hour traffic volumes.

All model runs were conducted using a 30-minute seeding period, followed by a 60-minute simulation period and a 30-minute "cool-down" period. Evaluation of the results included in this report are based on operations of the roadway facilities within the 60-minute simulation period only.

Model Application

Future condition scenarios will be based on the calibrated existing models, and will include proposed roadway improvements and future traffic volume projections.

Simulation Results

The evaluation criteria used to analyze the roadway segments in this simulation evaluation were based on the measures of effectiveness (MOEs) provided by the VISSIM model. The VISSIM output includes a variety of MOEs, which are used to evaluate the operational qualities of a roadway segment or an entire network. For this project, three critical measures of effectiveness (MOE) from the VISSIM data output include: average vehicle delay, average queue lengths, and maximum queue lengths.

The term 'level of service' (LOS) is used to denote the different operating conditions that occur on a given roadway segment under various traffic volume loads, and provides an index to the operational qualities of a roadway segment or an intersection. According to the Highway Capacity Manual (HCM)[5], LOS designations for intersections are based on vehicle delays. Ranging from A to F, LOS A represents the least congested operating conditions and LOS F represents the most congested conditions. Typically, LOS D (as defined in the HCM) is considered to be the acceptable limit and LOS E or LOS F conditions are typically considered unacceptable. LOS criteria are defined differently for signalized and unsignalized intersections. As VISSIM only provides the average vehicle delays and does not specifically report levels-of-service, HCM level-of-service designations were applied to VISSIM delay results.

Signalized Intersections

Morning and evening peak hour VISSIM results for the signalized intersections in the study area are presented in Table 2-15 and Table 2-16 respectively and illustrated in Figure 2-13. The tables summarize the delay, level of service, average queues and maximum queues for each lane group, as well as the intersection as a whole.

The following intersections operate at LOS E or LOS F during the morning and/or evening peak hours:

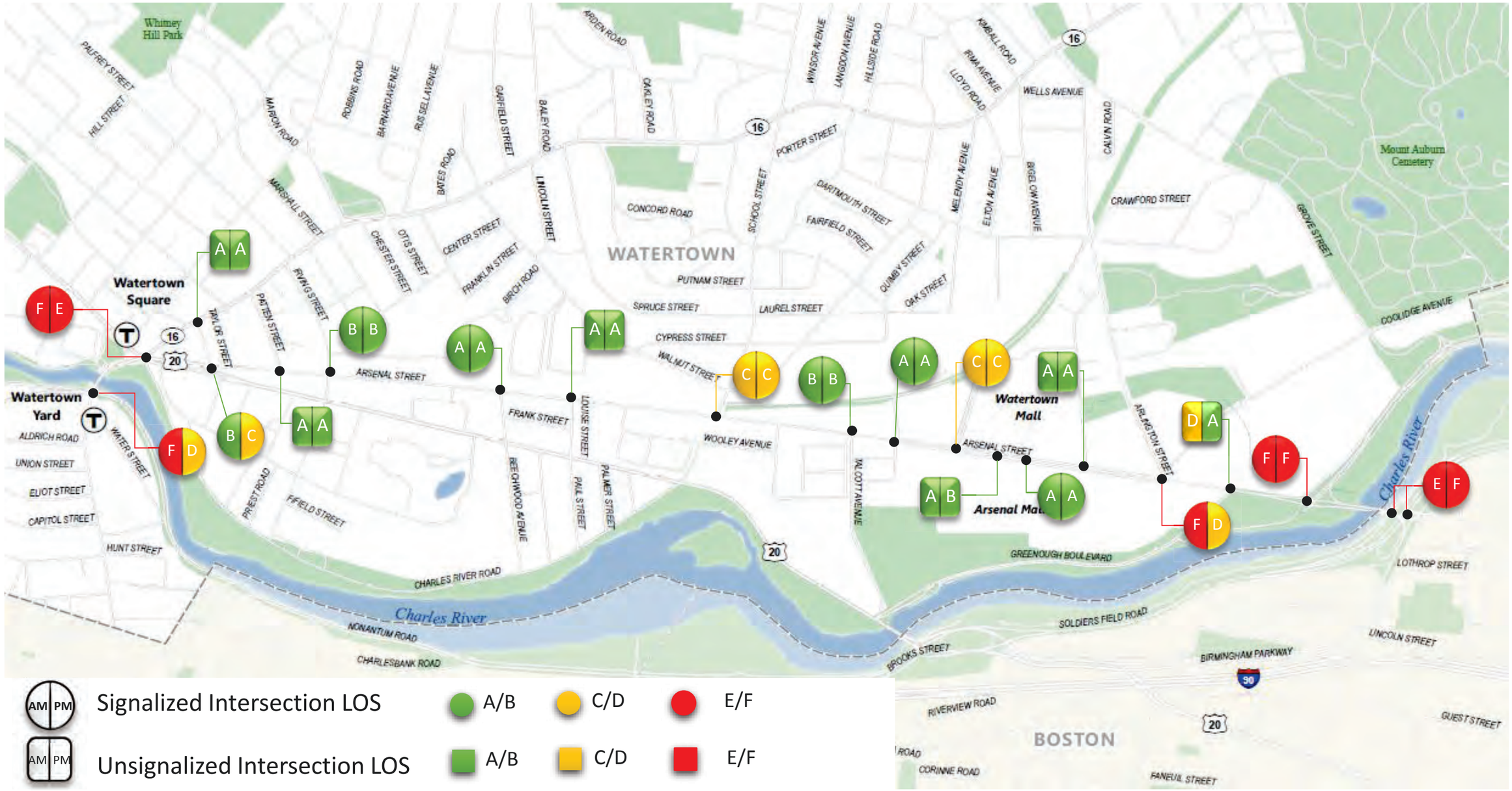
- Galen Street at Watertown Street/ Nonantum Road (Weekday morning)
    - Eastbound left-turns on Watertown Street operate at LOS E while westbound Nonantum Road and northbound Galen Street operates at LOS F. The deficiencies for these approaches are mostly likely related to the northbound Galen Street queue that extends from the downstream intersection (Arsenal Street/ Main Street at Galen Street/ North Beacon Street/Charles River Road/Mount Auburn Street).
- Arsenal Street/ Main Street at Galen Street/ North Beacon Street/Charles River Road/Mount Auburn Street (Weekday morning and evening)
    - During the morning peak hour, eastbound Main Street operates at LOS F, and average queues for this approach extends past the Watertown Fire Department.
    - Westbound Arsenal Street left-turns operate at LOS E during both morning and evening peak hours.
    - Northbound through/right-turn lanes along Galen Street operate at LOS F and LOS E during the morning and evening peak hour respectively. The average queues for this lane group extends past the next intersection (Galen Street at Nonantum Road/ Watertown Street).

▼

[5] Highway Capacity Manual; Transportation Research Board; 2010.

- Southbound Mount Auburn Street left-turns operate at LOS E during the morning peak hour, while through/right-turn lanes operate at LOS F and LOS E during the respective morning and evening peak hours.
- The deficiencies at Watertown Square intersection can be attributed to high vehicle demands on all approaches to the intersection, the proximity of major signalized intersections on each end of the bridge over the Charles River, and complex traffic signal phasing.

- Arsenal Street at Arlington Street/Coolidge Avenue/Home Depot Driveway (Weekday morning)
  - With the exception of westbound Arsenal Street and the northbound left-turn/through lanes, all lane groups operate at either LOS E or LOS F. The five-legged geometry and difficulty making some conflicting turning movements at this location contribute to the poor levels of service.
- Arsenal Street at Greenough Boulevard (north) (Weekday morning and evening)
  - Eastbound left-turn lane operates at LOS E during the morning peak hour, while through lanes operate at LOS F during both morning and evening peak hours. Similarly, southbound left-turn lanes also operate at LOS E during both morning and evening peak hours. These deficiencies are mostly likely related to the eastbound Arsenal Street queue that extends from the next intersection (Arsenal Street/Western Avenue at Soldiers Field Road On-Off Ramps/ Birmingham Parkway).
- Arsenal Street/Western Avenue at Soldiers Field Road On-Off Ramps/ Birmingham Parkway (Weekday morning and evening)
  - With the exception of northbound Birmingham Parkway, all of the approaches operate at either LOS E or LOS F during both morning and evening peak hours. The average queue along eastbound Arsenal Street extends to the next intersection (Arsenal Street at Greenough Boulevard (north)) during both peak hours. As noted above, these deficiencies are most likely related to the proximity of the adjacent traffic signal, as well as the inability to modify geometry on the bridge deck.



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Arsenal Street Corridor Study | Watertown, Massachusetts

Existing Traffic Operation Results

Source: MassGIS

Table 2-15 Signalized Intersection Capacity Analysis Summary (Morning Peak Hour)

Movement		Veh. Delay[1]	LOS[2]	Avg. Q[3]	Max. Q[4]
Galen Street at Watertown Street/Nonantum Road					
Watertown Street	EB LT	58	E	75	267
Watertown Street	EB TH/RT	31	C	75	267
Nonantum Road	WB LT-TH/TH-RT	106	F	152	367
Galen Street	NB LT/TH-TH/RT	211	F	347	864
Galen Street	SB LT/TH-TH	41	D	146	405
Galen Street	SB RT	16	B	18	210
	Overall	**82**	**F**		
Arsenal Street/Main Street at Galen Street/North Beacon Street/Charles River Road/ Mount Auburn Street					
Main Street	EB LT	126	F	29	149
Main Street	EB TH-TH/RT	137	F	895	1,486
Main Street	EB RT	127	F	919	1,507
Arsenal Street	WB LT	66	E	85	503
Arsenal Street	WB TH/RT	44	D	62	217
Charles River Road	NWB LT/TH/RT	54	D	61	293
Galen Street	NB LT-LT	40	D	33	236
Galen Street	NB TH-TH/RT	102	F	426	542
Mount Auburn Street	SB LT	63	E	29	149
Mount Auburn Street	SB TH-TH/RT	93	F	203	398
	Overall	**95**	**F**		
Arsenal Street at North Beacon Street					
Arsenal Street	EB LT/TH-TH	8	A	15	171
Arsenal Street	WB TH-TH/RT	10	A	8	112
North Beacon Street	NWB LT/TH-TH	21	C	17	105
North Beacon Street	NWB RT	8	A	0	27
	Overall	**13**	**B**		
Arsenal Street at Irving Street					
Arsenal Street	EB LT/TH/RT	9	A	13	114
Arsenal Street	WB LT/TH/RT	8	A	8	83
Irving Street	NB LT/TH/RT	18	B	19	172
Irving Street	SB LT/TH/RT	29	C	87	543
	Overall	**16**	**B**		
Arsenal Street at Beechwood Avenue					
Arsenal Street	EB TH/RT	2	A	2	84
Arsenal Street	WB LT/TH	4	A	3	110
Beechwood Avenue	NB LT/RT	20	B	3	66
	Overall	**3**	**A**		

Table 2-15 Signalized Intersection Capacity Analysis Summary (Morning Peak Hour) cont.

Movement		Veh. Delay[1]	LOS[2]	Avg. Q[3]	Max. Q[4]
Arsenal Street at School Street					
Arsenal Street	EB LT	18	B	22	234
Arsenal Street	EB TH	13	B	22	234
Arsenal Street	WB TH-TH/RT	23	C	26	146
School Street	SB LT	25	C	80	363
School Street	SB LT/RT	28	C	80	363
	Overall	**21**	**C**		
Arsenal Street at Talcott Street/ Roma Tile Driveway					
Arsenal Street	EB LT/TH-TH/RT	17	B	34	198
Talcott Street	NB LT/TH	14	B	3	65
Arsenal Street	WB LT/TH-TH/RT	11	B	16	178
Talcott Street	NB RT	12	B	4	84
Roma Tile Driveway	SB LT/TH/RT	0	A	0	0
	Overall	**15**	**B**		
Arsenal Street at Birch Street/ Arsenal Court					
Arsenal Street	EB LT/TH-TH/RT	3	A	5	152
Arsenal Street	WB LT/TH-TH/RT	6	A	6	137
Arsenal Court	NB LT/TH/RT	49	D	3	21
Birch Street	SB LT	38	D	2	42
Birch Street	SB TH/RT	34	C	3	41
	Overall	**5**	**A**		
Arsenal Street at Arsenal Mall/ Watertown Mall (rear) Entrance					
Arsenal Street	EB LT	30	C	5	64
Arsenal Street	EB TH-TH	13	B	25	178
Arsenal Street	EB RT	12	B	3	61
Arsenal Street	WB LT	36	D	7	92
Arsenal Street	WB TH-TH/RT	29	C	101	273
Arsenal Mall Driveway	NB LT/TH	31	C	9	88
Arsenal Mall Driveway	NB RT	19	B	1	68
Watertown Mall (Rear Entrance)	SB LT/TH/RT	21	C	3	88
	Overall	**20**	**C**		
Arsenal Street at Arsenal Mall/ Watertown Mall					
Arsenal Street	EB LT	8	A	0	0
Arsenal Street	EB TH-TH	1	A	1	131
Arsenal Street	WB TH-TH	6	A	5	111
Arsenal Street	WB RT	4	A	1	45
Watertown Mall Driveway	SB LT	0	A	1	42
Watertown Mall Driveway	SB RT	17	B	1	42
	Overall	**3**	**A**		

Table 2-15 Signalized Intersection Capacity Analysis Summary (Morning Peak Hour) cont.

Movement		Veh. Delay[1]	LOS[2]	Avg. Q[3]	Max. Q[4]
Arsenal Street at Arlington Street/ Coolidge Ave/ Home Depot Driveway					
Arsenal Street	EB LT	63	E	51	327
Arsenal Street	EB TH-TH/RT	91	F	83	329
Arsenal Street	WB LT	54	D	25	135
Arsenal Street	WB TH-TH/RT	39	D	72	281
Home Depot Driveway	NB LT/TH	27	C	21	127
Home Depot Driveway	NB RT	86	F	21	127
Coolidge Avenue	SWB LT/TH-TH/RT	56	E	31	157
Arlington Street	SEB LT/TH-TH/RT	155	F	842	1,658
	Overall	**86**	**F**		
Arsenal Street at Greenough Boulevard (North)					
Arsenal Street	EB LT	98	F	686	810
Arsenal Street	EB TH-TH	312	F	749	814
Arsenal Street	WB TH-TH	33	C	36	191
Arsenal Street	WB RT	1	A	0	0
Greenough Boulevard	SB LT-LT/RT	133	F	23	120
Greenough Boulevard	SB RT	39	D	31	256
	Overall	**>120**	**F**		
Arsenal Street/Western Avenue at Soldiers Field Road/ Birmingham Parkway					
Arsenal Street	EB LT/TH-TH/RT	62	E	587	744
Western Avenue	WB LT/TH-TH/RT	80	F	142	462
Birmingham Parkway	NB LT-LT	46	D	68	295
Birmingham Parkway	NB TH	51	D	84	341
Birmingham Parkway	NB RT	56	E	111	379
Soldiers Field Road WB Off-Ramp	SB LT/TH	70	E	51	280
Soldiers Field Road WB Off-Ramp	SB TH/RT	58	E	24	216
	Overall	**61**	**E**		

Source: VHB, Inc. using VISSIM Software
1 – Average Delay, in seconds per vehicle
2 – Level of Service
3 – Average queue length estimate, in feet
4 – Maximum queue length estimate, in feet
EB = Eastbound, WB = Westbound; NB = Northbound; SB = Southbound; NWB= Northwestbound; SEB = Southeastbound; SWB = Southwestbound
LT = Left-turn; TH = Through; RT = Right-turn

Table 2-16 Signalized Intersection Capacity Analysis Summary (Evening Peak Hour)

Movement		Veh. Delay[1]	LOS[2]	Avg. Q[3]	Max. Q[4]
Galen Street at Watertown Street/ Nonantum Road					
Watertown Street	EB LT	47	D	84	322
Watertown Street	EB TH/RT	36	D	84	322
Nonantum Road	WB LT-TH/TH-RT	65	E	72	254
Galen Street	NB LT/TH-TH/RT	27	C	55	349
Galen Street	SB LT/TH-TH	34	C	98	424
Galen Street	SB RT	17	B	41	400
	Overall	**36**	**D**		
Arsenal Street/Main Street at North Beacon Street/Charles River Road/ Mount Auburn Street					
Main Street	EB LT	51	D	33	215
Main Street	EB TH-TH/RT	53	D	90	408
Main Street	EB RT	28	C	58	429
Arsenal Street	WB LT	68	E	140	532
Arsenal Street	WB TH/RT	44	D	80	304
Galen Street	NB LT-LT	55	D	67	390
Galen Street	NB TH-TH/RT	55	E	148	492
Charles River Road	NWB LT/TH/RT	131	F	380	482
Mount Auburn Street	SB LT	46	D	12	84
Mount Auburn Street	SB TH-TH/RT	66	E	134	344
	Overall	**59**	**E**		
Arsenal Street at North Beacon Street					
Arsenal Street	EB LT/TH-TH	12	B	20	433
Arsenal Street	WB TH-TH/RT	12	B	14	142
North Beacon Street	NWB LT/TH-TH	43	D	69	848
North Beacon Street	NWB RT	9	A	0	28
	Overall	**22**	**C**		
Arsenal Street at Irving Street					
Arsenal Street	EB LT/TH/RT	10	B	12	137
Arsenal Street	WB LT/TH/RT	10	B	17	245
Irving Street	NB LT/TH/RT	16	B	22	170
Irving Street	SB LT/TH/RT	19	B	22	190
	Overall	**13**	**B**		
Arsenal Street at Beechwood Avenue					
Arsenal Street	EB TH/RT	1	A	0	36
Arsenal Street	WB LT/TH	2	A	3	131
Beechwood Avenue	NB LT/RT	18	B	1	22
	Overall	**2**	**A**		

Table 2-16 Signalized Intersection Capacity Analysis Summary (Evening Peak Hour) cont.

Movement		Veh. Delay[1]	LOS[2]	Avg. Q[3]	Max. Q[4]
Arsenal Street at School Street					
Arsenal Street	EB LT	19	B	25	175
Arsenal Street	EB TH	14	B	25	175
Arsenal Street	WB TH-TH/RT	25	C	54	246
School Street	SB LT	20	C	39	192
School Street	SB LT/RT	23	C	39	192
	Overall	**21**	**C**		
Arsenal Street at Talcott Street/ Roma Tile Driveway					
Arsenal Street	EB LT/TH-TH/RT	17	B	24	152
Arsenal Street	WB LT/TH-TH/RT	11	B	22	227
Talcott Street	NB LT/TH	13	B	8	83
Talcott Street	NB RT	13	B	9	105
Roma Tile Driveway	SB LT/TH/RT	0	A	0	0
	Overall	**13**	**B**		
Arsenal Street at Birch Street/ Arsenal Court					
Arsenal Street	EB LT/TH-TH/RT	3	A	5	164
Arsenal Street	WB LT/TH-TH/RT	7	A	12	229
Arsenal Court	NB LT/TH/RT	39	D	5	44
Birch Street	SB LT	41	D	11	67
Birch Street	SB TH/RT	41	D	13	84
	Overall	**8**	**A**		
Arsenal Street at Arsenal Mall/ Watertown Mall (rear) Entrance					
Arsenal Street	EB LT	36	D	9	85
Arsenal Street	EB TH-TH	15	B	22	196
Arsenal Street	EB RT	15	B	9	199
Arsenal Street	WB LT	40	D	21	159
Arsenal Street	WB TH-TH/RT	32	C	111	291
Arsenal Mall Driveway	NB LT/TH	33	C	40	236
Arsenal Mall Driveway	NB RT	27	C	14	124
Watertown Mall (Rear Entrance)	SB LT/TH/RT	30	C	5	60
	Overall	**25**	**C**		
Arsenal Street at Arsenal Mall/ Watertown Mall					
Arsenal Street	EB LT	17	B	0	43
Arsenal Street	EB TH-TH	5	A	7	196
Arsenal Street	WB TH-TH	10	A	9	130
Arsenal Street	WB RT	6	A	2	84
Watertown Mall Driveway	SB LT	16	B	14	156
Watertown Mall Driveway	SB RT	20	B	14	156
	Overall	**10**	**A**		

Table 2-16 Signalized Intersection Capacity Analysis Summary (Evening Peak Hour) cont.

Movement		Veh. Delay[1]	LOS[2]	Avg. Q[3]	Max. Q[4]
Arsenal Street at Arlington Street/ Coolidge Ave/ Home Depot Driveway					
Arsenal Street	EB LT	55	D	40	215
Arsenal Street	EB TH-TH/RT	48	D	75	297
Arsenal Street	WB LT	59	E	33	263
Arsenal Street	WB TH-TH/RT	44	D	85	346
Home Depot Driveway	NB LT/TH	36	D	28	152
Home Depot Driveway	NB RT	40	D	28	152
Coolidge Avenue	SWB LT/TH-TH/RT	38	D	17	111
Arlington Street	SEB LT/TH-TH/RT	35	C	39	181
	Overall	**44**	**D**		
Arsenal Street at Greenough Boulevard (North)					
Arsenal Street	EB LT	53	D	14	205
Arsenal Street	EB TH-TH	256	F	277	708
Arsenal Street	WB TH-TH	45	D	57	326
Arsenal Street	WB RT	3	A	0	0
Greenough Boulevard	SB LT-LT/RT	210	F	53	201
Greenough Boulevard	SB RT	33	C	42	211
	Overall	**>120**	**F**		
Arsenal Street/Western Avenue at Soldiers Field Road/ Birmingham Parkway					
Arsenal Street	EB LT/TH-TH/RT	70	E	684	728
Western Avenue	WB LT/TH-TH/RT	236	F	534	1,172
Birmingham Parkway	NB LT-LT	51	D	90	340
Birmingham Parkway	NB TH	47	D	57	319
Birmingham Parkway	NB RT	54	D	84	359
Soldiers Field Road WB Off-Ramp	SB LT/TH	73	E	57	341
Soldiers Field Road WB Off-Ramp	SB TH/RT	59	E	26	341
	Overall	**111**	**F**		

Source: VHB, Inc. using VISSIM Software
1 – Average Delay, in seconds per vehicle
2 – Level of Service
3 – Average queue length estimate, in feet
4 – Maximum queue length estimate, in feet
EB = Eastbound, WB = Westbound; NB = Northbound; SB = Southbound; NWB= Northwestbound; SEB = Southeastbound; SWB = Southwestbound
LT = Left-turn; TH = Through; RT = Right-turn

Unsignalized Intersections Results

The morning and evening peak hour VISSIM results for the seven unsignalized intersections in the study area are presented in Table 2-17 and Table 2-18 respectively. The tables summarize the delay, level of service, average queues and maximum queues for each lane group, as well as the intersection as a whole.

As shown, all of the unsignalized intersections are currently operating at acceptable levels of service under existing conditions.

Table 2-17 Unsignalized Intersection Capacity Analysis Summary (Morning Peak Hour)

Movement		Veh. Delay[1]	LOS[2]	Avg. Q[3]	Max. Q[4]
North Beacon Street at Alfred Street					
North Beacon Street	EB TH/RT	0	A	0	0
North Beacon Street	WB LT/TH	2	A	0	20
Alfred Street	NB LT/ RT	6	A	1	57
	Overall	**5**	**A**		
Mount Auburn Street at Taylor Street					
Mount Auburn Street	EB LT/TH-TH	1	A	0	48
Mount Auburn Street	WB TH-TH/RT	6	A	11	184
Taylor Street	NB LT/TH/RT	11	B	1	48
	Overall	**4**	**A**		
Arsenal Street at Patten Street					
Arsenal Street	EB LT/TH	1	A	0	47
Arsenal Street	WB TH/RT	0	A	0	0
Patten Street	SB LT/RT	14	B	9	97
	Overall	**3**	**A**		
Arsenal Street at Louise Street					
Arsenal Street	EB TH/RT	1	A	1	101
Arsenal Street	WB LT/TH	9	A	40	202
Louise Street	NB LT/RT	25	C	4	76
	Overall	**6**	**A**		
Arsenal Street at Arsenal Mall/ Watertown Mall					
Arsenal Street	EB RT	0	A	0	0
Arsenal Mall Driveway	NB RT	9	A	0	24
	Overall	**-**	**-**		

Table 2-17 Unsignalized Intersection Capacity Analysis Summary (Morning Peak Hour) cont.

Movement		Veh. Delay[1]	LOS[2]	Avg. Q[3]	Max. Q[4]
Arsenal Street at Elm Street					
Arsenal Street	EB LT	0	A	0	0
Arsenal Street	EB TH-TH	1	A	0	0
Arsenal Street	WB TH-TH/RT	0	A	0	0
Elm Street	SB LT/RT	10	A	2	48
	Overall	**1**	**A**		
Arsenal Street at Greenough Boulevard (South)					
Arsenal Street	EB TH-TH/RT	84	F	353	660
Arsenal Street	WB LT/TH-TH	5	A	11	165
Greenough Boulevard	NB LT/RT	34	D	26	186
	Overall	**53**	**D**		

Source: VHB, Inc. using VISSIM Software
1 – Average Delay, in seconds per vehicle
2 – Level of Service
3 – Average queue length estimate, in feet
4 – Maximum queue length estimate, in feet
EB = Eastbound, WB = Westbound; NB = Northbound; SB = Southbound;
LT = Left-turn; TH = Through; RT = Right-turn

Table 2-18 Unsignalized Intersection Capacity Analysis Summary (Evening Peak Hour)

Movement		Veh. Delay[1]	LOS[2]	Avg. Q[3]	Max. Q[4]
North Beacon Street at Alfred Street					
North Beacon Street	EB TH/RT	0	A	0	0
North Beacon Street	WB LT/TH	8	A	44	764
Alfred Street	NB LT /RT	10	A	1	54
	Overall	**9**	**A**		
Mount Auburn Street at Taylor Street					
Mount Auburn Street	EB LT/TH-TH	1	A	0	76
Mount Auburn Street	WB TH-TH/RT	1	A	0	73
Taylor Street	NB LT/TH/RT	11	B	1	50
	Overall	**1**	**A**		
Arsenal Street at Patten Street					
Arsenal Street	EB LT/TH	1	A	5	71
Arsenal Street	WB TH/RT	0	A	0	0
Patten Street	SB LT/RT	11	B	3	65
	Overall	**1**	**A**		
Arsenal Street at Louise Street					
Arsenal Street	EB TH/RT	1	A	0	64
Arsenal Street	WB LT/TH	6	A	18	126
Louise Street	NB LT/RT	10	A	3	54
	Overall	**4**	**A**		

Table 2-18 Unsignalized Intersection Capacity Analysis Summary (Evening Peak Hour) cont.

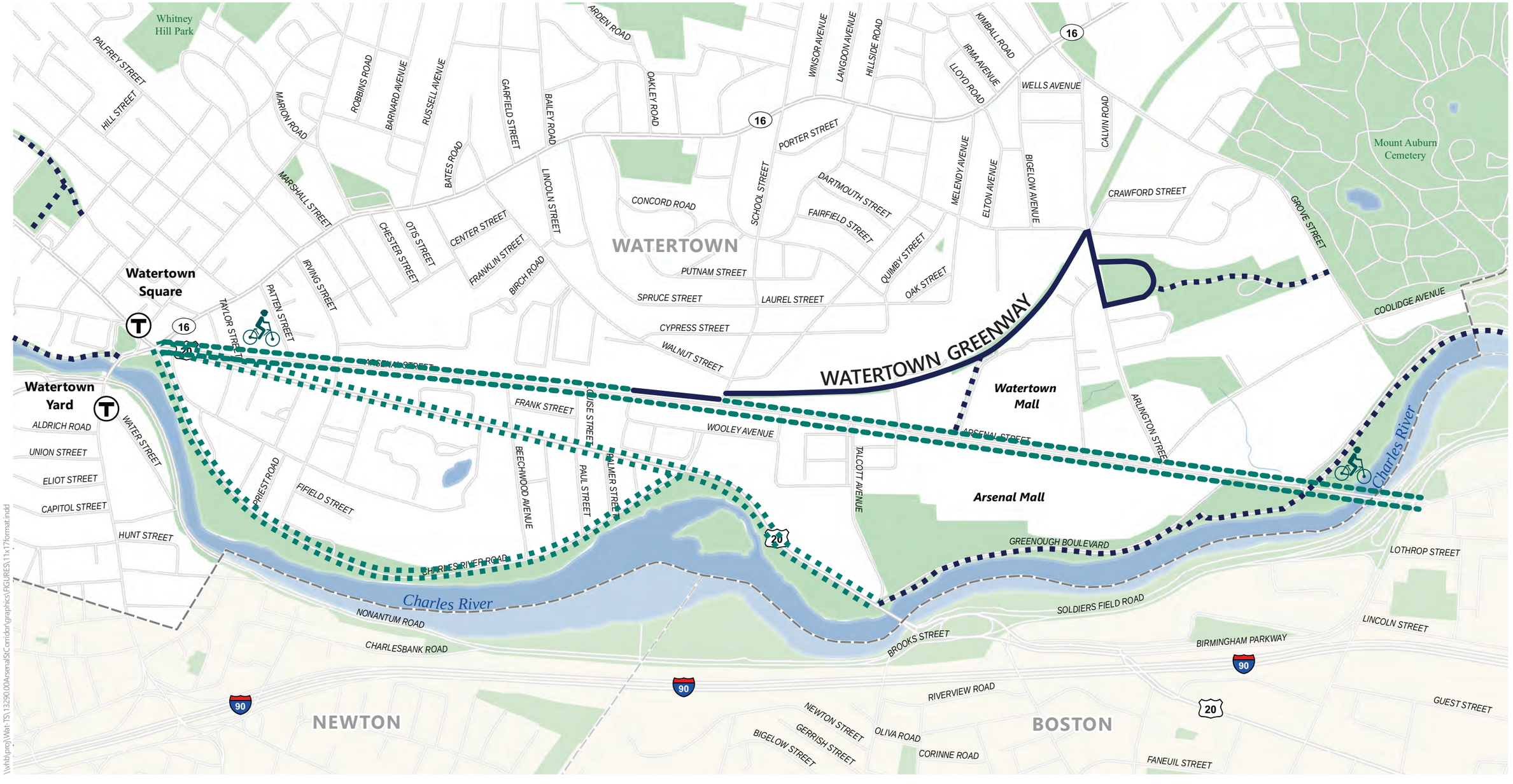
Movement		Veh. Delay[1]	LOS[2]	Avg. Q[3]	Max. Q[4]
Arsenal Street at Arsenal Mall/ Watertown Mall					
Arsenal Street	EB RT	0	A	0	0
Arsenal Mall Driveway	NB RT	15	B	1	47
	Overall	**-**	**-**		
Arsenal Street at Elm Street					
Arsenal Street	EB LT	3	A	0	47
Arsenal Street	EB TH-TH	0	A	0	0
Arsenal Street	WB TH-TH/RT	1	A	0	91
Elm Street	SB LT/RT	11	B	5	99
	Overall	**2**	**A**		
Arsenal Street at Greenough Boulevard (South)					
Arsenal Street	EB TH-TH/RT	4	A	0	72
Arsenal Street	WB LT/TH-TH	5	A	3	236
Greenough Boulevard	NB LT/RT	15	B	8	119
	Overall	**5**	**A**		

Source: VHB, Inc. using VISSIM Software
1 – Average Delay, in seconds per vehicle
2 – Level of Service
3 – Average queue length estimate, in feet
4 – Maximum queue length estimate, in feet
EB = Eastbound, WB = Westbound; NB = Northbound; SB = Southbound;
LT = Left-turn; TH = Through; RT = Right-turn

Bicycle and Pedestrian Assessment

Bicycle Accommodations

Bicycle accommodations connecting to and along Arsenal Street include shared lanes, on-road bicycle lanes and off-road bicycle (or multi-use) accommodations and are graphically presented in Figure 2-14. Along the westbound side of Arsenal Street, off-road bicycle accommodations connecting to the Watertown Greenway are provided in front of Lexus of Watertown. The off-road bicycle accommodation terminates east of Wooley Avenue and continues as on-road bicycle lane to just west of Louise Street. Along eastbound side of Arsenal Street, an on-road bicycle lane is provided just west of Louise Street to Wooley Avenue. Shared lane bicycle accommodations are provided along the remaining portions of the Arsenal Street corridor.



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0 200 400 800 Feet

Off-road Bike Lane
On-road Bike Lane
Shared Lane Bike Accommodation

Arsenal Street Corridor Study | Watertown, Massachusetts

Bicycle Accommodations

Source: MassGIS

Pedestrian Accommodations

Pedestrian accommodations were evaluated along the Arsenal Street corridor and are illustrated in Figure 2-15. Sidewalks are provided along both sides of Arsenal Street, and crosswalks are available at all study area intersections, except for the eastern project limits at Birmingham Parkway. In general, sidewalks along the corridor are in good to fair condition. However, uneven sidewalk surfaces have been observed in several locations. Trees and telephone poles are located in the center of the sidewalk in some locations and can inconvenience all sidewalk users. Examples of locations with these impediments can be found in the Appendix.

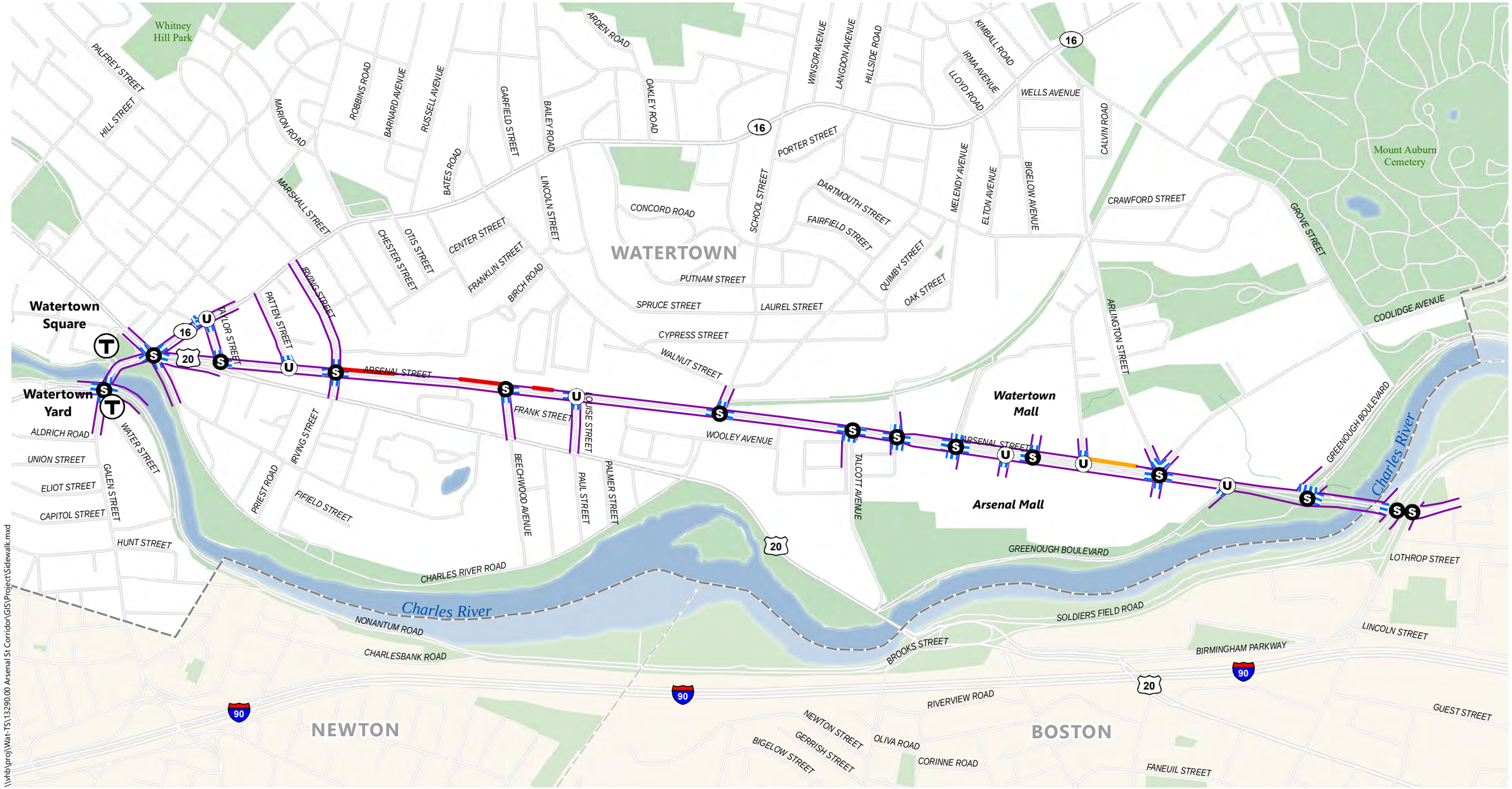
Crosswalks are provided along most stop and traffic signal controlled intersection approaches. Crosswalk treatments/striping vary throughout the corridor and could benefit from a cohesive pattern or aesthetic improvements.

Curb Ramp Audit

VHB inventoried curb ramps within the study area in November 2015. In total, 91 ramps were rated for overall condition (good, fair, or poor) and four key attributes were reviewed for compliance with current Americans with Disabilities Act Accessibility Guidelines (ADAAG) and Massachusetts Architectural Access Board (AAB) regulations:

- Tactile Warning Strip
- Slope
- Clear Path
- Level Landing

The results of the curb ramp audit are presented graphically in Figure 2-16 and are included in the Appendix. As shown, approximately 18 percent of the ramps are in good condition, 72 percent are in fair condition, and 10 percent are in poor condition. Based on the inventory, 17 of the 91 ramps (19 percent) are fully compliant. Of the non-compliant ramps, 37 locations are only lacking a tactile warning strip with the other features meeting current regulations. Addition of a tactile warning strip at these locations would make the ramp fully compliant.



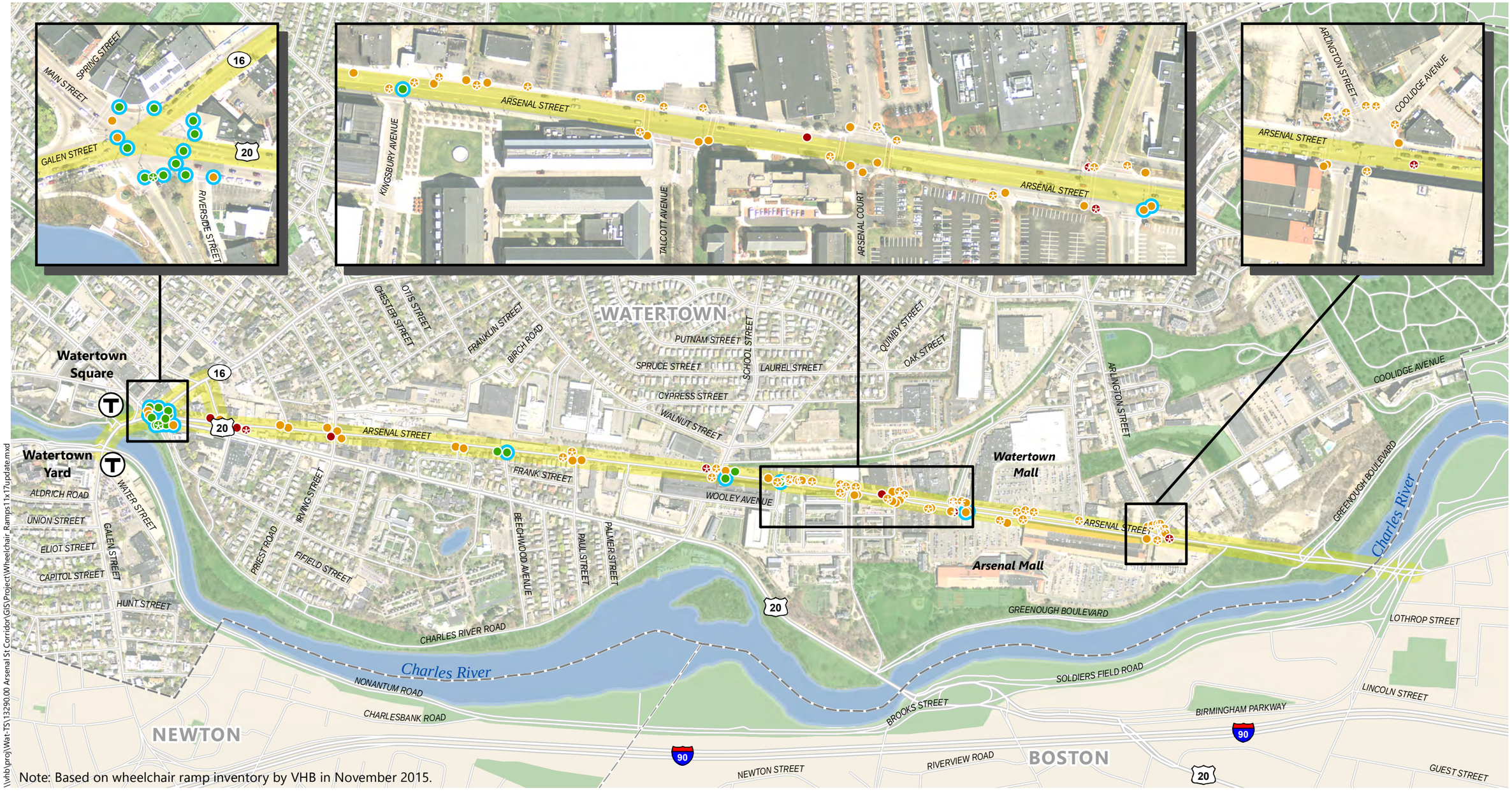
0 200 400 800 Feet

- Signalized Study Intersection
- Unsignalized Study Intersection
- Crosswalk
- Sidewalk
- Sidewalk with Deficiencies
- Under Construction

Arsenal Street Corridor Study | Watertown, Massachusetts

Sidewalk and Crosswalk Inventory

Source: MassGIS



Note: Based on wheelchair ramp inventory by VHB in November 2015.

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0 200 400 800 Feet

Arsenal Street Corridor

Ramp Condition

- Good
- Fair
- Poor

Ramp Compliance

- Fully Compliant
- Short-Term Eligible (only tactile warning strip needed)

Arsenal Street Corridor Study | Watertown, Massachusetts

Curb Ramp Inventory

Source: MassGIS, VHB

Bicycle and Pedestrian Demands

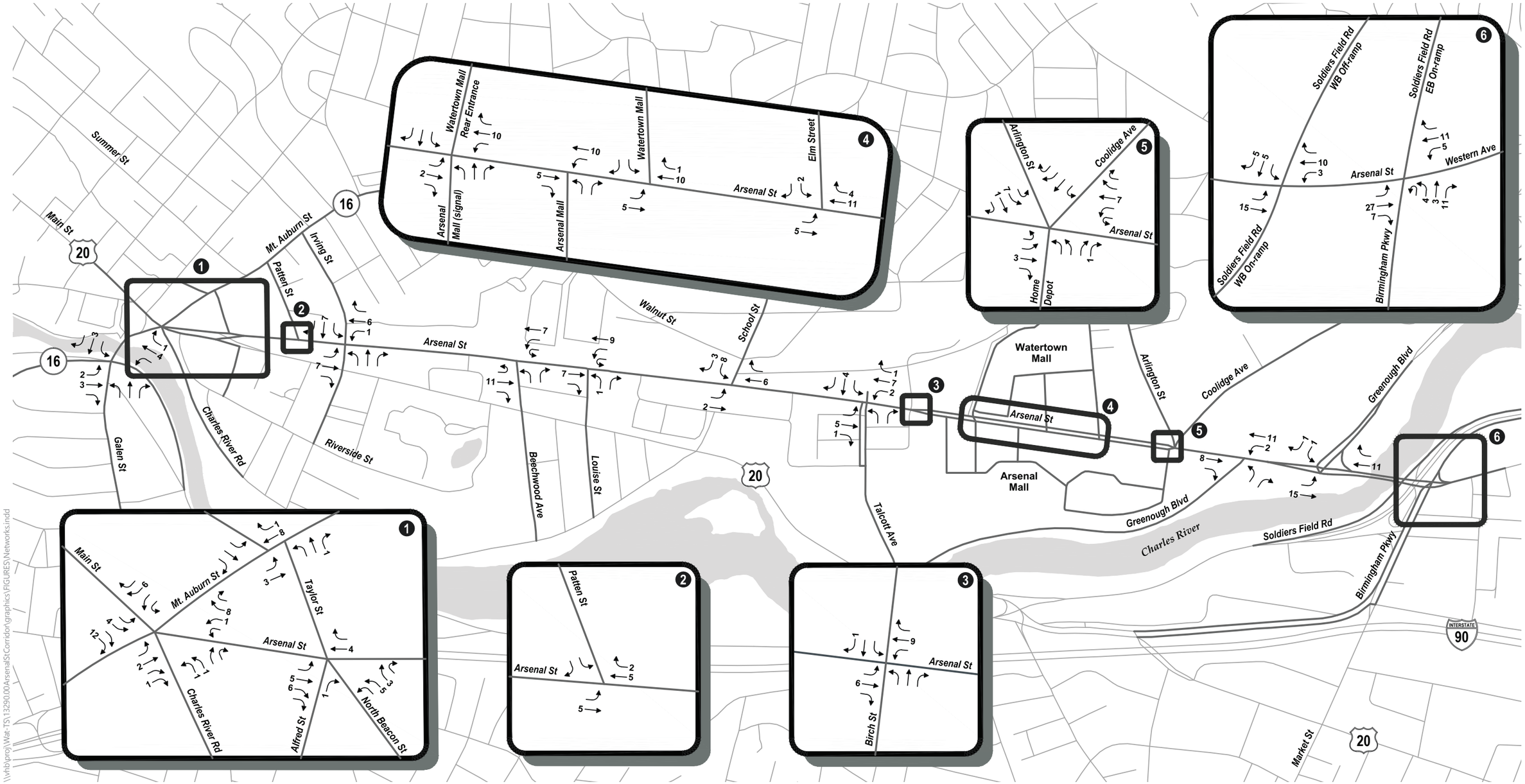
Bicycle and pedestrian volumes were collected at key intersections to quantify pedestrian and bicycle demands along the Corridor. Weekday morning and evening peak hour bicycle and pedestrian volumes are illustrated in Figures 2-17 through Figure 2-20. Bicycle and pedestrian volume data is included in the Appendix.

The highest number of pedestrian crossings is at the intersection of Galen Street at Watertown Street/Nonantum Road, adjacent to the Watertown Bus Yard, with over 400 pedestrians recorded during both morning and evening peak hours.

Safety

To identify potential vehicle crash trends and/or roadway deficiencies within the Local Study Area, a review of the Massachusetts Department of Transportation (MassDOT) Crash Database was conducted to document the number of vehicular collisions that have taken place over the most recent three years (2011-2013).
Using the weekday evening peak hour traffic volumes, combined with other observed traffic data, the number of crashes in the three-year total allows for the calculation of standardized crash rates for intersections. The calculation of intersection crash rate is an effective tool to measure and compare the relative safety of an intersection to other, similar intersections. The resulting crash rate is expressed in million entering vehicles (MEV), which is an industry standard to the traffic engineering profession. It relates to how many crashes occur at a particular intersection for every million vehicles that pass through it.

By way of comparison, the 2013 MassDOT average crash rates for signalized and unsignalized intersections for District 6 (the MassDOT district designation for Watertown) are 0.76 and 0.58, respectively. These rates imply that, on average, 0.76 crashes occurred per million vehicles entering signalized intersections throughout District 6, and 0.58 crashes occurred per million vehicles entering unsignalized intersections in the District. Any crash rate higher than these factors may indicate a higher than average crash tendency for a given facility or intersection. It should be noted that the location for some crashes cannot be precisely determined from the available information and that crashes that are not reported or involved only property damage in an amount less than $1,000 are not included in the database and therefore not considered. Table 2-19 presents the number of crashes, crash characteristics, as well as the crash rate for each of the study area intersections.



Not to scale

Arsenal Street Corridor Study | Watertown, Massachusetts

2015 Existing Condition
Weekday Morning Peak Hour
Bicycle Volume

Source: MassGIS

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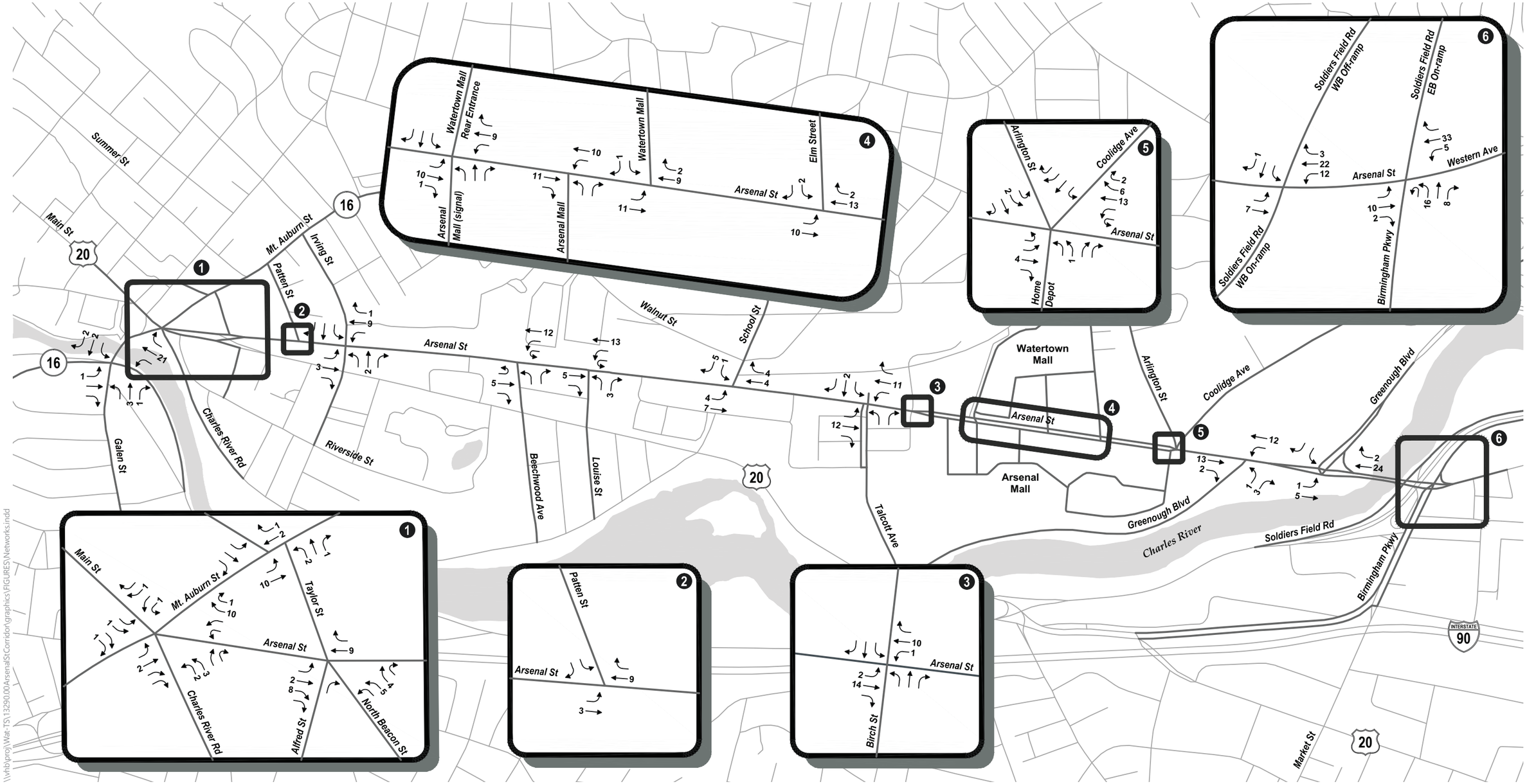
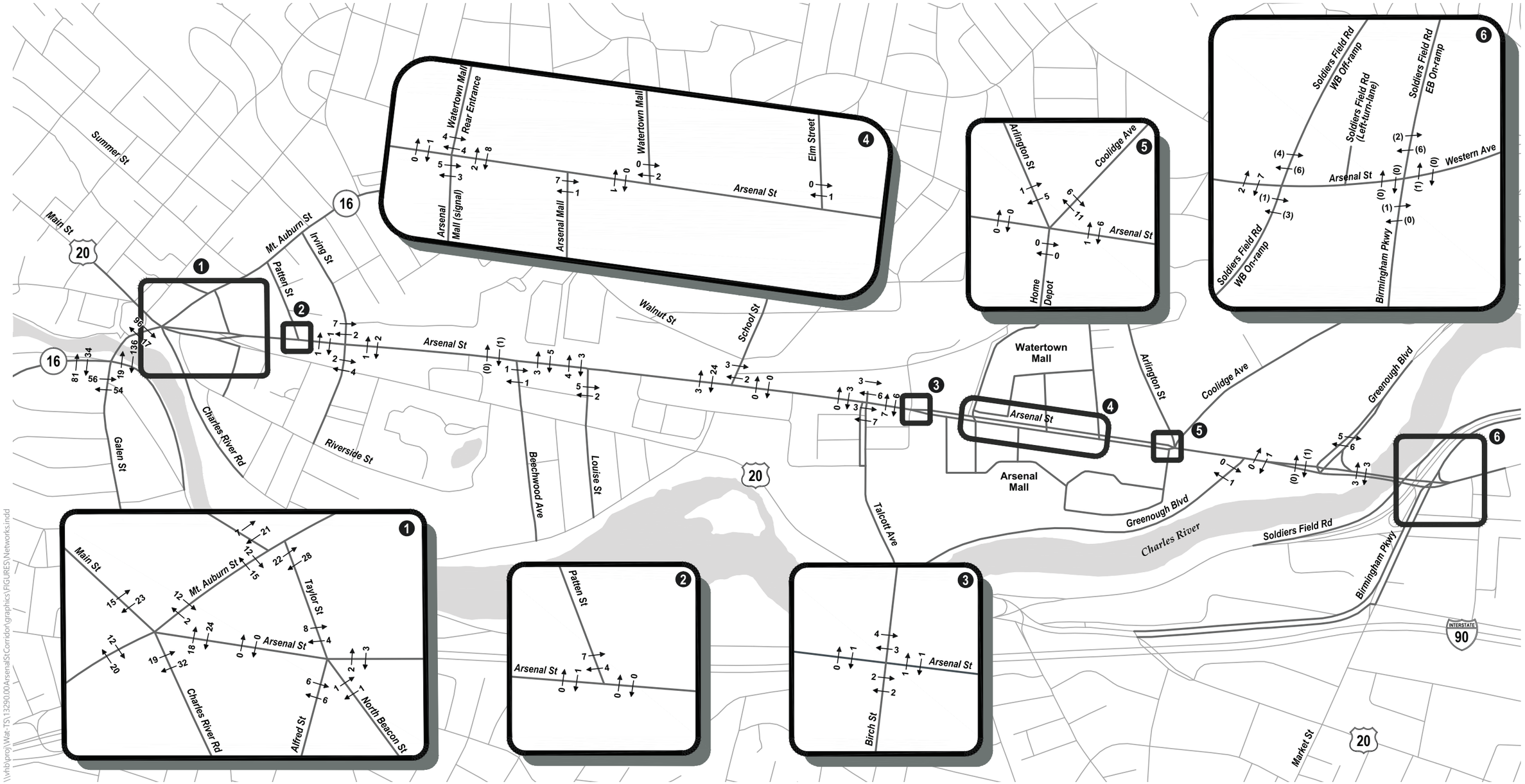


Not to scale

Arsenal Street Corridor Study | Watertown, Massachusetts

2015 Existing Condition
Weekday Evening Peak Hour
Bicycle Volume

Source: MassGIS



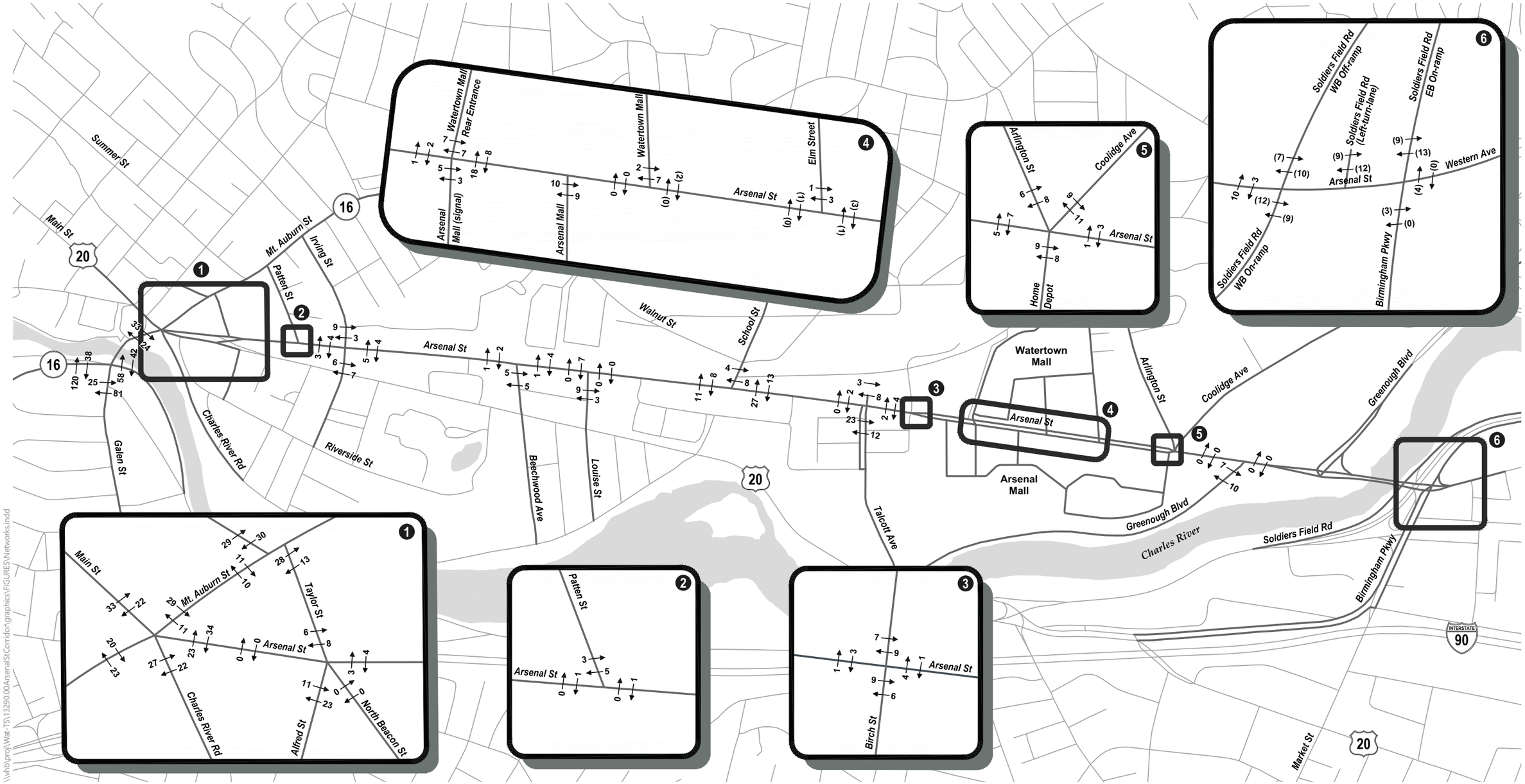
Not to scale

(XX) Number of Pedestrians not in Crosswalk
XX Number of Pedestrians

Arsenal Street Corridor Study | Watertown, Massachusetts

2015 Existing Condition
Weekday Morning Peak Hour
Pedestrian Volume

Source: MassGIS



Not to scale

(XX) Number of Pedestrians not in Crosswalk

XX Number of Pedestrians

Arsenal Street Corridor Study | Watertown, Massachusetts

2015 Existing Condition
Weekday Evening Peak Hour
Pedestrian Volume

Source: MassGIS

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Table 2-19 Vehicular Crash Summary 2011-2013

	Galen Street at Watertown Street/ Nonantum Road	Mount Auburn Street/ Main Street/ Arsenal Street/ Charles River Road	Arsenal Street at North Beacon Street/ Taylor Street	Mount Auburn Street at Taylor Street	Arsenal Street at															
					Patten Street	Irving Street	Beechwood Ave	Louise Street	School Street	Roma Tile Driveway/ Talcott Avenue	Birch Street/ Arsenal Court	Arsenal Mall Rear Entrance	Arsenal Mall unsignalized driveway	Watertown Mall	Elm Street	Arlington Street/ Coolidge Avenue	Greenough Boulevard (south)	Greenough Boulevard (north)	Soldiers Field Road	Western Ave at Birmingham Parkway
Currently Signalized	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes
Average Crash Rate	0.76	0.76	0.76	0.58	0.58	0.76	0.76	0.58	0.76	0.76	0.76	0.76	0.58	0.76	0.58	0.76	0.58	0.76	0.76	0.76
Calculated Crash Rate	0.92	0.77	0.26	0.12	0.14	0.44	0.13	0.23	0.47	0.35	0.20	0.00	1.11	0.35	0.62	0.38	0.92	0.24	0.23	0.49
Exceed?	**Yes**	**Yes**	No	No	No	No	No	No	No	No	No	No	**Yes**	No	**Yes**	No	**Yes**	No	No	No
Year																				
2011	13	12	5	1	1	5	1	0	4	4	0	0	10	0	6	6	7	3	2	6
2012	17	19	1	1	0	0	1	2	6	4	4	0	9	3	4	3	11	3	2	6
2013	11	12	0	0	1	5	0	2	4	1	1	0	4	5	3	3	8	2	3	8
Total	41	43	6	2	2	10	2	4	14	9	5	0	23	8	13	12	26	8	7	20
Collision Type																				
Angle	17	18	2	0	2	6	0	2	6	2	3	0	11	4	11	2	9	4	2	13
Head-on	3	2	1	0	0	0	0	0	0	0	0	0	4	0	2	0	2	0	0	0
Rear-end	7	9	1	2	0	3	1	2	6	4	1	0	4	3	0	8	9	3	2	1
Rear-to-Rear	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sideswipe, opposite direction	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Sideswipe, same direction	6	3	0	0	0	1	0	0	1	0	0	0	0	1	0	1	3	0	2	0
Single vehicle crash	5	9	1	0	0	0	0	0	1	2	1	0	4	0	0	1	3	1	1	6
Unknown/ Not Reported	2	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Total	41	43	6	2	2	10	2	4	14	9	5	0	23	8	13	12	26	8	7	20
Crash Severity																				
Fatal injury	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-fatal injury	15	13	2	1	1	2	1	2	8	4	2	0	9	2	4	5	8	1	4	5
Property damage only (none injured)	26	29	4	1	1	8	1	2	6	4	2	0	14	6	9	7	17	7	3	14
Not Reported/Unknown	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	1
Total	41	43	6	2	2	10	2	4	14	9	5	0	23	8	13	12	26	8	7	20
Time of Day												0								
Weekday, 7:00 AM - 9:00 AM	5	7	0	0	0	3	0	1	1	1	0	0	3	0	0	3	5	0	3	5
Weekday, 4:00 PM - 6:00 PM	4	7	3	0	0	0	1	0	4	1	1	0	2	0	2	1	6	2	0	6
Saturday, 11:00 AM - 2:00 PM	2	2	0	0	0	0	0	1	0	0	0	0	0	2	1	0	0	0	0	2
Weekday, other time	24	20	3	1	0	6	1	2	7	5	4	0	11	3	7	5	13	2	2	4
Weekend, other time	6	7	0	1	2	1	0	0	2	2	0	0	7	3	3	3	2	4	2	3
Total	41	43	6	2	2	10	2	4	14	9	5	0	23	8	13	12	26	8	7	20
Pavement Conditions																				
Dry	36	37	3	2	2	8	1	3	9	7	4	0	20	8	11	10	23	7	6	16
Wet	5	5	3	0	0	2	0	1	4	2	1	0	1	0	2	2	3	1	1	4
Snow	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ice	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Sand, mud, dirt, oil, gravel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water (standing, moving)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slush	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Not Reported/Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	41	43	6	2	2	10	2	4	14	9	5	0	23	8	13	12	26	8	7	20
Non Motorist (Bike, Pedestrian)																				
Total	6	9	1	0	0	1	0	0	2	1	0	0	4	1	1	1	0	0	1	0

Source: MassDOT Crash Database 2011-2013

As presented in Table 2-19, no fatalities were recorded at any of the study area intersections. Out of the 20 study area intersections, five locations have crash rates that exceed the District 6 average crash rate. This means that the crash incidents at the remaining 15 locations are similar to other intersections in District 6 when adjusted for traffic volume. The majority of the reported crashes were angle and rear-end collisions that occur during weekday non-peak hours in dry weather. Angle and rear-end crashes are more common at intersections (as opposed to roadway segments) and could be reflective of inattentive driver behavior, frequent lane changes (which are observed at signalized intersections along Arsenal Street), or inadequate (based on current standards) clearance phases at traffic signals. It is notable that these crashes primarily occur outside of peak commuting periods without inclement weather influence, which generally indicates physical roadway characteristics are not a substantive contributing factor. The intersections of Galen Street at Nonantum Road/ Watertown Street and Main Street/ Arsenal Street at Galen Street/ Mount Auburn Street/ Charles River Road, which have the highest level of pedestrian activity within the Local Study Area, account for most of the non-motorist collisions (bike, pedestrian).

For the locations that exceed the crash average, the following observations are noted:

- **Galen Street at Watertown Street/ Nonantum Road** – left-turning vehicles in either direction along Galen Street cause significant back-up, were observed to turn during unacceptable gaps in traffic, and require through motorists to sometimes quickly change lanes. Left-turns are prohibited during peak commuting hours, but this prohibition is widely ignored when a police officer is not present, further contributing to congestion and driver frustration. These left-turns are a likely contributor to the high number of angle crashes occurring. A second contributing factor may be left-turns from Watertown Street, which are permitted against through traffic A high number of bicyclists and pedestrians, at times crossing against the traffic signal or outside of the designated crossing area may require drivers to react to multiple unexpected situations at the same time. MassDOT has recently completed a Roadway Safety Audit at this location.
- **Mount Auburn Street/ Main Street/ Arsenal Street/ Charles River Road** – Particularly along the Mount Auburn Street approaches, vehicles are frequently observed making illegal lane changes and movements from the wrong lane (i.e. right turn movements from an inside through lane or through movements from a left-turn lane). These illegal lane changes are a likely contributor to the high number of angle crashes occurring.
- **Arsenal Street/Arsenal Mall Unsignalized Driveway** – based on the available crash data, which show four head on collisions, crashes at this location seem to be caused by vehicles attempting to take a right-turn out of this driveway and then take an immediate left-turn into the Watertown Mall. This movement, while not expressly prohibited, requires a driver to turn right and cross two lanes of traffic within 200 feet. Another possible contributor

could be vehicles attempting to turn left from the driveway, although crash data do not specifically suggest this.

- **Arsenal Street/Elm Street** – Although the crash rate at this location marginally exceeds the District average, there are no indications or trends in the crash data suggesting crash cause. Left-turning traffic from Elm Street, crossing four travel lanes and a median may contribute to the high number of angle accidents at this location.
- **Arsenal Street/Greenough Boulevard (south)** – Left-turning traffic from Greenough Boulevard to Arsenal Street crosses four travel lanes at this often-congested location. Vehicles are often observed to accept gaps in traffic that are shorter than acceptable for turning left. This may factor into the higher than average number of crashes, particularly angle and rear end.

MassDOT 2013 Top Crash Locations Report

MassDOT published a 2013 Top Crash Locations Report in August of 2015, ranking the Top 200 Intersection Locations based on crash data from the years 2011-2013. In order to determine an intersection's ranking, MassDOT created a comprehensive method to locate crash clusters. This method uses a 25 meter (roughly 82 feet) search distance to locate adjacent crashes, and then merges the areas together to create a crash cluster. The clusters are then named based on the first and second highest functional classification roadways within the cluster and ranked by the number of Equivalent Property Damage Only (EPDO) crashes; where fatal crashes are weighted by 10, injury crashes are weighted by 5, and property damage only and non-reported crashes are weighted by 1. Therefore, each cluster can contain multiple intersections or segments of roadway located near the main intersection. The intersection of Galen Street at Nonantum Road/ Watertown Street is ranked 178 in the 2011-2013 Statewide Top 200 Intersection Crash List.

Highway Safety Improvement Program (HSIP)

The Highway Safety Improvement Program (HSIP) was established under the 'Moving Ahead for Progress in the 21st Century Act (MAP-21) as a Federal-aid funding program to achieve significant reduction in fatalities and serious injuries on all public roads. Projects using HSIP funding are selected based the top five percent regional crash location list and identified in the Strategic Highway Safety Plan (SHSP). An HSIP-eligible cluster is one in which the total number of "equivalent property damage only[6] "crashes in the area is within the top 5 percent of all clusters in that region. Being HSIP-eligible makes the location eligible for FHWA and MassDOT funds to address the identified safety issues at these locations. The intersections of Arsenal Street at Arsenal

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

Mall (EPDO: 59) and Arsenal Street at Greenough Boulevard (south) (EPDO: 48) are listed as an HSIP-eligible vehicle clusters in the 2011-2013 HSIP cluster listing. Watertown Square (including the entire Charles River bridge crossing and the intersection at the Watertown Yard) is listed as an HSIP-eligible pedestrian and bicycle cluster. An additional HSIP-eligible bicycle cluster is identified along Arsenal Street and Western Avenue in the vicinity of Birmingham Parkway. This includes the entire Charles River bridge crossing located at the eastern end of the Local Study Area.

Environmental and Social Justice

Natural Resources

Environmental resources in the Study Area include wetlands, waterways and open space. These resources are not only important to the environmental health of the area but also create constraints that are subject to a number of state and federal laws. In the vicinity of the Study Area, the most prominent environmental feature is the Charles River. Within the Study Area the Charles River is contained within a well-defined channel with limited areas of bordering vegetated wetland.

Initial environmental resource mapping for the corridor study and feasibility analysis was developed primarily using Massachusetts Geographic Information System (MassGIS) data[7], which is a part of the Executive Office of Energy and Environmental Affairs (EEA). Once mapping was prepared from the GIS data, field investigations were then conducted by environmental scientists with VHB, to further refine resource area boundaries within the Local Study Area. Resource area mapping included review of wetlands and waterways, floodplains, Bio Map (high priority ecosystems), Living Waters (waterbodies that are viable for freshwater biodiversity), wildlife and protected species habitat, water resources, and hazardous material disposal and release sites.

Wetlands and Waterways

Wetland and waterways resource systems in the Study Area include the Charles River between Galen Street and Arsenal Street at Western Ave, wooded swamps, emergent marshes, streams, ponds, floodplain and floodways. Identified resource areas are depicted in Figure 2-21. The Charles River is the predominate wetland feature in the Study Area. The river has well defined banks and ranges in width from 67 feet wide to almost 900 feet wide. The water level in the Charles River is controlled both by the Amelia Earhart Dam, approximately 5.5 miles downstream of the Western Ave Bridge, and by the Watertown Dam located 900 feet north of Galen Street. Sawins Pond, located between Elm Street and Coolidge, passes under Arlington and Coolidge

▼

[7] http://www.mass.gov/anf/research-and-tech/it-serv-and-support/ application-serv/office-of-geographic-information-massgis/datalayers/ layerlist.html

Streets before outletting to the Charles at the limit of the project area. Vegetated wetlands including wooded wetlands and marshes, are present along the Sawins Pond and in limited areas of the Charles River although development has altered the extent of wetlands that remain.

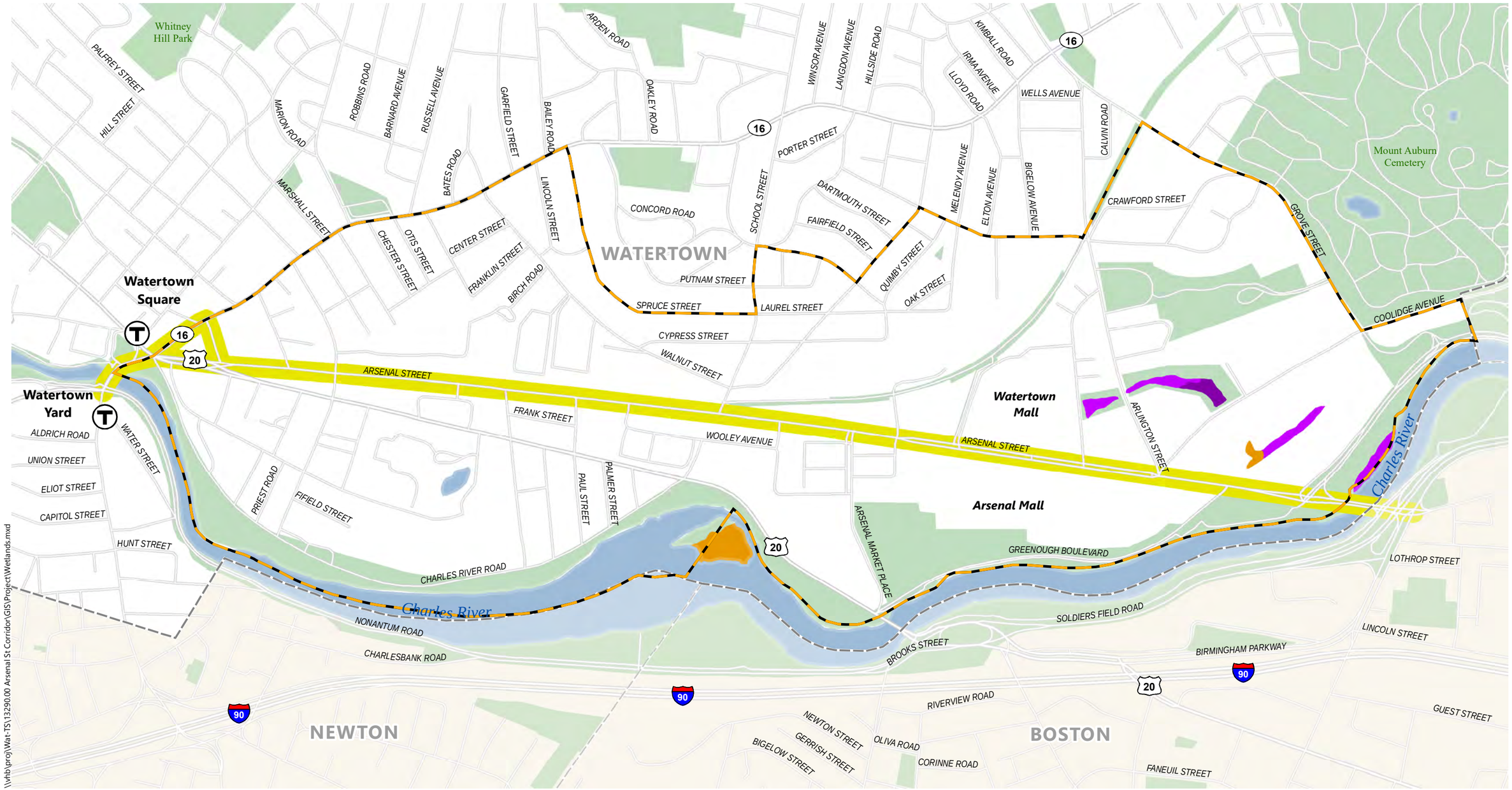
Wetland resources in the Study Area are subject to regulation by the Massachusetts Wetlands Protection Act and include Bordering Vegetated Wetland (BVW), Bank, Land Under Water Bodies and Waterways (LUWW), and Riverfront Area. The WPA establishes a 100-foot buffer zone from the limit of BVW and bank, associated with these wetland systems. Additionally, the WPA establishes a 200-foot Riverfront Area from the limit of the mean annual high water line of perennial streams and rivers. The wetland and water resources are also subject to federal jurisdiction pursuant to the Clean Water Act. Any alteration or loss of wetlands or waters will require review and approval from the Watertown Conservation Commission, the Massachusetts Department of Environmental Protection and the U.S. Army Corps of Engineers.

Floodplain

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) identify the zone AE at elevation 4 feet in the Study Area (Figure 2-22). The floodway follows the banks of the Charles River. The 100-year floodplain is regulated by the WPA as Bordering Land Subject to Flooding.

Bio Map and Living Waters

Natural Communities, Supporting Natural Landscapes, Core Habitat and Living Waters data layer from MassGIS was reviewed for the Study Area. No Living Waters or areas of Biomap significance were noted in the vicinity of the Study Area.



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0 200 400 800 Feet

Wetlands

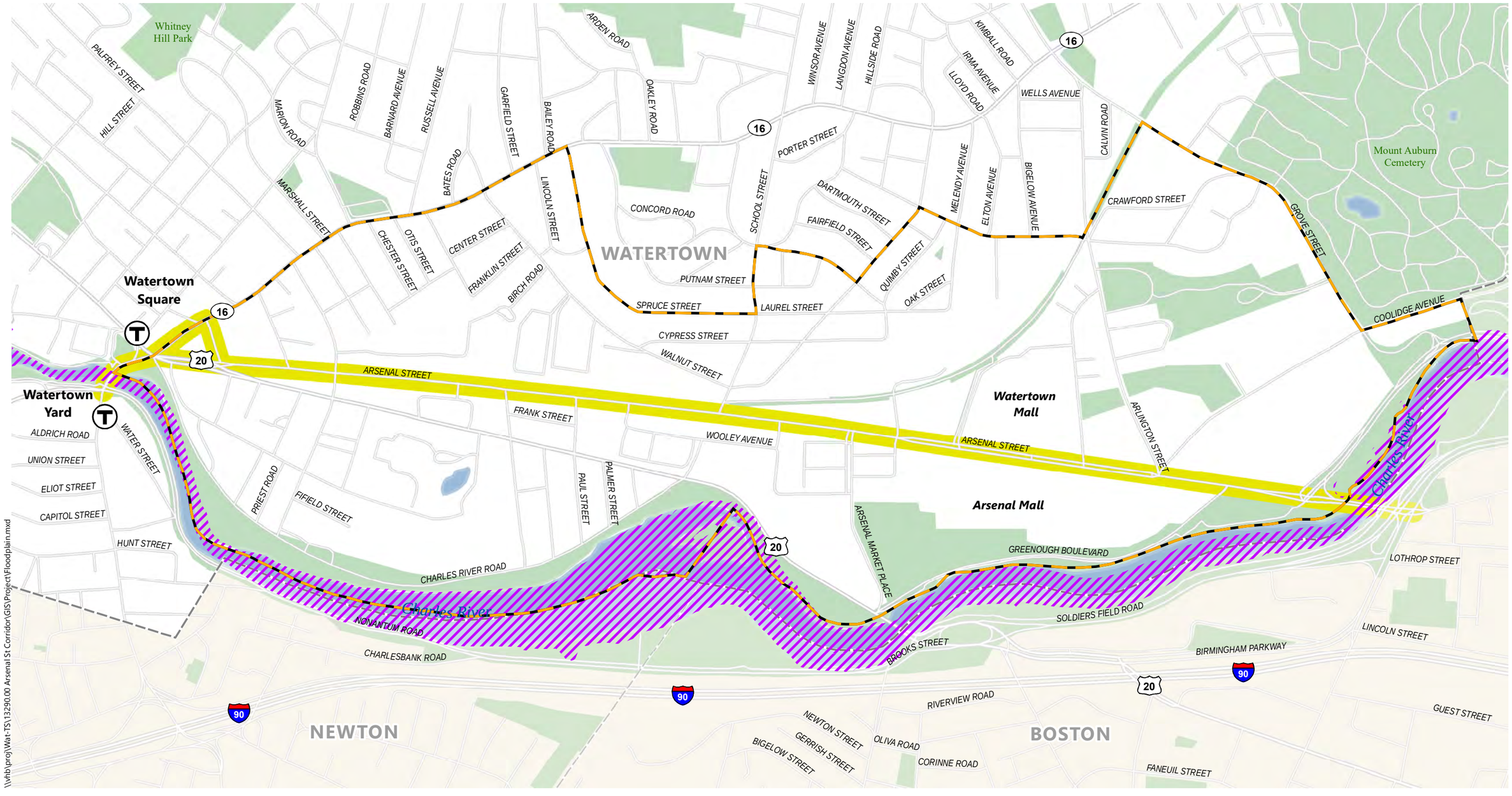
- Deep Marsh
- Open Water
- Shallow Marsh Meadow or Fen
- Wooded Swamp Deciduous

- Local Study Area Boundary
- Arsenal Street Corridor

Arsenal Street Corridor Study | Watertown, Massachusetts

Wetland and Waterways Resource Systems

Source: MassGIS



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FEMA 100-year Floodplain

Local Study Area Boundary

Arsenal Street Corridor

Arsenal Street Corridor Study | Watertown, Massachusetts

FEMA 100-year Floodplain

Source: MassGIS

Water Resources

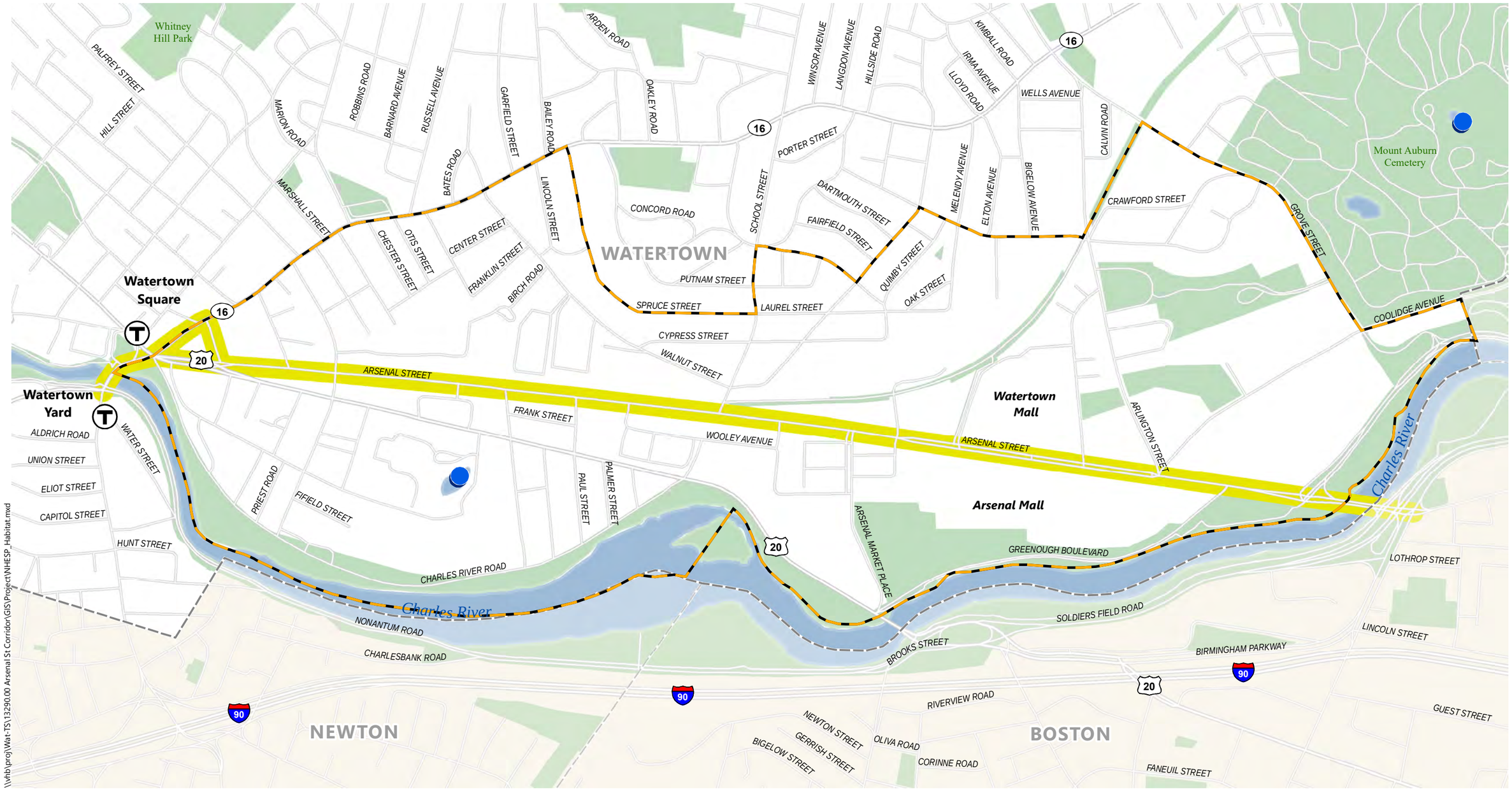
Wellhead protection areas (Zone II) are important for protecting water quality in recharge areas that support public water supplies. Certain land uses may be prohibited or restricted in Zone IIs and aquifer areas and stormwater management measures are more stringent. Based on mapping maintained by MassGIS there are no Zone IIs in the Study Area.

Wildlife and Protected Species Habitat

The Natural Heritage and Endangered Species Program (NHESP), part of the Massachusetts Division of Fisheries and Wildlife is responsible for the conservation and protection of endangered, threatened, and species of special concern. Rare species are important for biodiversity and represent elements of an ecological system that are unique or few in number. Rare species are protected by both federal and state laws and include both plants and animals and their critical habitats.

According to the most recently published edition of the Massachusetts Natural Heritage Atlas[8] (October 2008), there are no Priority Habitat of Rare Species, Estimated Habitat of Rare Wildlife that occur within the Local Study Area. One Vernal Pool was noted (in addition to a second just outside the study area boundary), as shown in Figure 2-23.

[8] NHESP, 2008. *Massachusetts Natural Heritage Atlas*. 13th Edition.



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Potential Vernal Pools

Local Study Area Boundary

Arsenal Street Corridor

Note: NHESP Priority Habitat, Estimated Habitat, and Certified Vernal Pools do not fall within the study extents.

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Rare and Endangered Species

Source: MassGIS

Environmental Justice

The project study considers Environmental Justice (EJ) to enable a fair distribution of any environmental benefits or impacts that could be associated with the recommendations herein. Whether, and to what extent, planned transportation related actions within the Local Study Area may impact minority, low-income or other so designated populations within the Local Study Area are considered, noting the following:

- **Executive Order 12898** indicates that "*its purpose is to focus federal attention on the environmental and human health effects of federal actions on minority and low-income populations with the goal of achieving environmental protection for all communities.*"
- **Executive Order 13166** "*requires Federal agencies to examine the services they provide, identify any need for services to those with limited English proficiency (LEP), and develop and implement a system to provide those services so LEP persons can have meaningful access to them.*"
- **Title VI of the Civil Rights Act of 1964** "*protects people from discrimination based on race, color and national origin in programs and activities receiving federal financial assistance.*" In response, the Federal Transit Administration (FTA) works to ensure non-discriminatory transportation in support of their mission to enhance the social and economic quality of life for all Americans.

Specifically, if the proposed development actions could negatively impact these populations and their quality of life, appropriate mitigation measures must be considered.

The Local Study Area includes a mix of commercial and residential land uses, along with public green and open space. In-field observations noted nominal vacancy and several projects currently under construction or otherwise planned for construction. The Corridor offers both on- and off-street parking and major intersections are signalized. The existing development, as well as that which is under construction and planned, will continue to place demands on public infrastructure. Conversations with representatives of the Watertown Community Development and Planning Department indicate that each of the "new" projects, as part of their permitting and approvals process, are subject to traffic engineering analyses and possible mitigation.

The Massachusetts Executive Office for Administration and Finance indicates that Census 2010 benchmarks for minority population include those block groups where 25 percent or more of the total population reports themselves as a race other than White[9]. If 25 percent or more of the population in the block group meets this benchmark, the block group is an EJ block group. Based on these metrics, the only

[9] Persons reporting themselves as being of Hispanic heritage are reporting an ethnicity, not a race.

block group in the Local Study Area that is classified as an EJ block group for minority population is census tract/block group 3703.003 with a 25.3 percent minority population in 2010.

The reported statewide 2010 median household income was $62,133 and any household reporting a median income of $40,673 or less is considered an EJ household. If the median household income of a block group or $40,673 or less, the block group is considered an EJ block group. In 2010, all Local Study Area block groups reported median household incomes exceeding $40,673; therefore, none of the block groups in the Local Study Area are benchmarked as a low-income population.

A household in which no person 14 years or older speaks only English and no person 14 years or older who speaks a language other than English speaks English "very well" is classified as "linguistically isolated." All members of a linguistically isolated household are tabulated as isolated, including members under 14 years old who may speak only English. Based on this metric, none of the block groups in the Local Study Area are considered linguistically isolated.

Detailed socioeconomic indicators and other metrics relative to Environmental Justice are presented in greater detail in the Appendix and key statistics include:

- The racial and cultural diversity of the Local Study Area and the Region are very similar, although the Local Study Area has a nominally lesser representation of persons' not-of-color. The overall population of the Local Study Area is 79.8 percent White, compared with 76.6 percent in the Region. As a result, while the Corridor population accounts for 6.1 percent of the total Region population, it accounts for 6.3 percent of the Region's White population.
- At 15.6 percent of the population, the Local Study Area population aged 65 and older is marginally greater than the 13.2 percent in the Region. The Local Study Area accounts for 7.2 percent of the Region population aged 65 and older.
- The number of households in the Local Study Area accounts for 6.7 percent of Region households, a representation slightly greater than the population. This is likely attributed to a higher percentage of renter occupied households in the Local Study Area (at 59.2 percent) when compared with the Region (at 55.5 percent).
- The median household income in the Local Study Area is approximately $75,700, on par with the Region median household income of $78,800. The percentage of households in the Local Study Area earning less than $35,000, at 23 percent, is similar to the Region at 22.5 percent.

- There are fewer households (as a percent of total households) in the Local Study Area with no vehicles available when compared with the Region, at 14.3 percent and 16 percent, respectively.
- The MassDOT Title VI interactive map[10] indicates that English is by far the primary language spoken in the Town of Watertown. Armenian is the only language spoken by more than 5 percent of the Watertown population (primarily located in East Watertown).

The selected socioeconomics of the Local and Regional Study Areas are reasonably similar across most metrics, although there is a slightly higher concentration of renter-occupied housing in the Local Study Area. Considering the development projects that are currently under construction in the Local Study Area, as well as those that are known and planned, this variance may increase in the near term[11].

Based on the findings identified above, there is not currently an imbalance in the socioeconomic "make-up" of the Local Study Area when compared with the Region, as the diversity and composition of their respective populations are similar regarding racial and ethnic composition, as well as relative incomes. Improvements to the corridor in the form of traffic and/or public transportation enhancements would be expected to improve accessibility to the residential, employment centers, health and hospital services, public space, commerce and hospitality uses in the area, irrespective of the socioeconomic profile of Local Study Area residents and establishments.

Historic and Cultural Resources

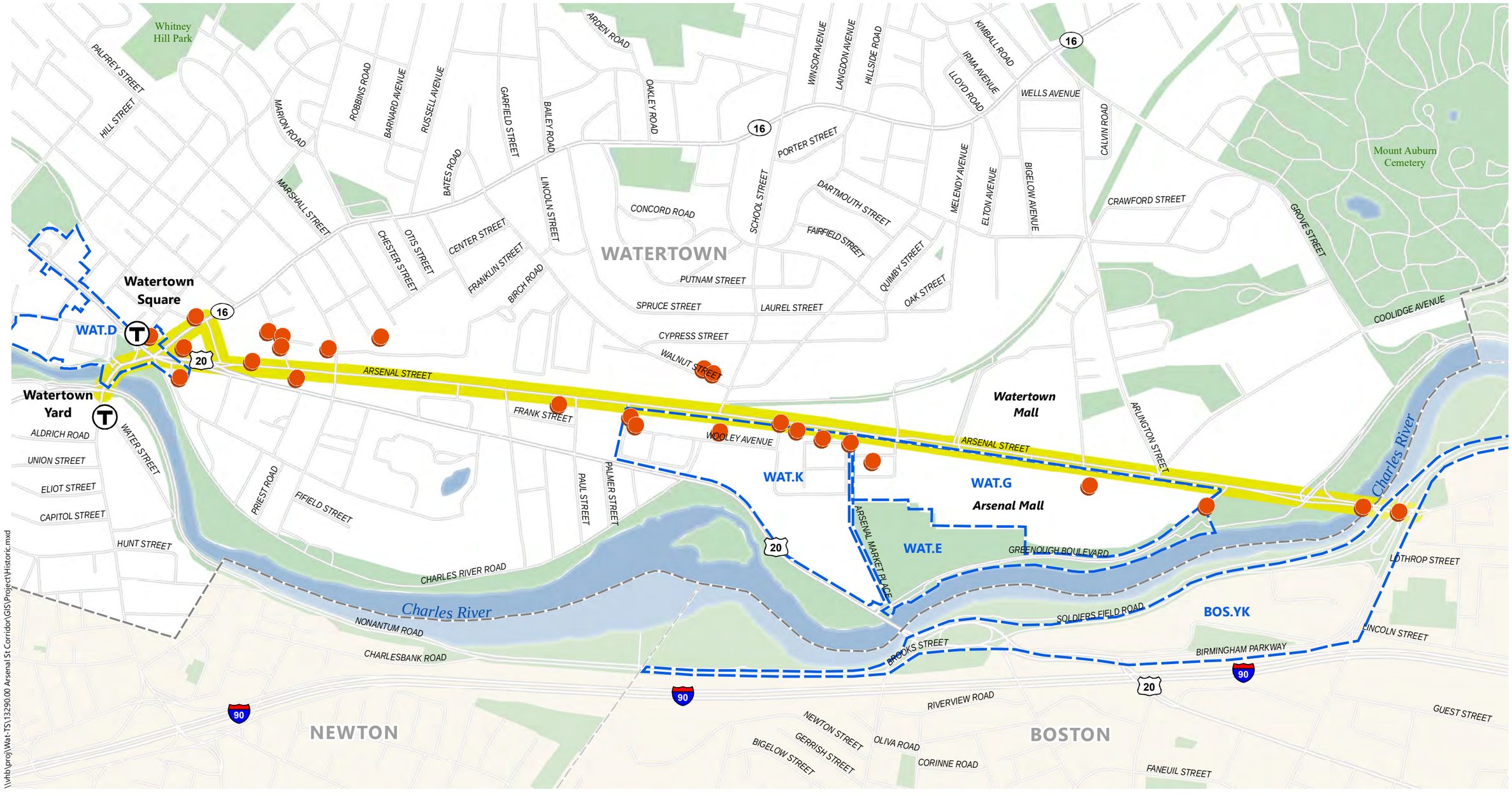
The review of existing resources within the local study area includes identifying properties that are either in the Inventory of Historic and Archaeological Assets of the Commonwealth (Inventory) or listed in the National or State Registers (NR or SR) of Historic Places that are within the Arsenal Street Corridor (Local Study Area) or are within proximity. A search of the Massachusetts Historical Commission's (MHC) Massachusetts Cultural Resource Information System (MACRIS) database and mapping tool (MACRIS Maps) was completed to identify previously recorded above-ground and archaeological resources located on or adjacent to the Project Corridor. The findings of this search are provided in the Appendix.

In summary, there are inventoried properties within the Project vicinity, including some listed in the National Register of Historic Places. As shown in Figure 2-24, the majority of properties are located on the south side of the Arsenal Street corridor. Effects to the properties would be minimal if work occurs on the north side of the corridor. If project work occurs within the existing paved roadway and sidewalk, effects will be minimal as well.

▼

[10] http://services.massdot.state.ma.us/maptemplate/languagetracts

[11] In-field observations, and confirmation with representatives of the Watertown Community Development and Planning Department indicate that there are currently 297 rental units under construction (with 30 as affordable) and an additional 282 rental units (with 35 as affordable) proposed – both with frontage and immediate access to Arsenal Street.



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0 200 400 800 Feet

Historic Site within Study Area

Historic District within Study Area

Arsenal Street Corridor

Arsenal Street Corridor Study | Watertown, Massachusetts

Cultural Resources

Sources: MassGIS, MACRIS

Oil and Hazardous Materials

Based on a review of the Massachusetts Department of Environmental Protection (MassDEP) Bureau of Waste Site Cleanup (BWSC) online database, a total of 118 state-listed disposal sites were identified in the Local Study Area. The presence of a disposal site indicates that a release of oil and/or hazardous materials (OHM) has been reported to MassDEP. The approximate locations (the disposal site is mapped on the portion of the street closest to the geocoded address rather than the actual release location) of the disposal sites are depicted on Figure 2-25A through Figure 2-25D. The results of the OHM review are included in the Appendix.

Regulatory Significance

Potential impacts to the environmental or social constraints associated with this project have regulatory implications. Several regulatory reviews and permits will be needed to allow the project to proceed.

National Environmental Policy Act

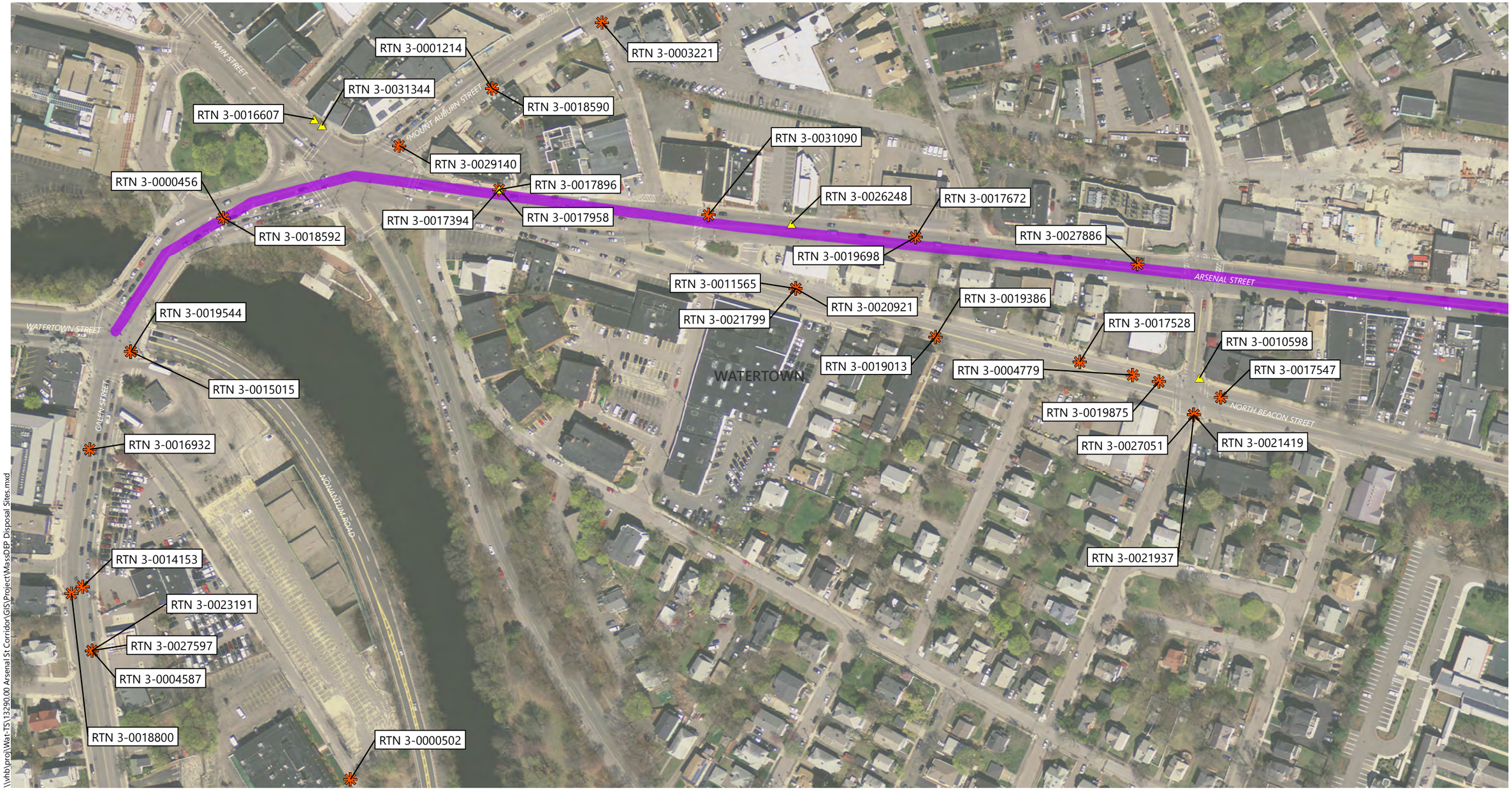
If federal funding is likely to be used for the construction of any recommended improvement projects, compliance with the federal National Environmental Policy Act (NEPA) will be required. This will warrant the preparation of a Categorical Exclusion (CE) or an Environmental Assessment (EA). The need for an Environmental Impact Statement (EIS) is not anticipated. Provided the project impacts are found to be acceptable and appropriate and mitigation is provided, a Finding of No Significant Impact (FONSI) will be needed from the lead federal agency to allow the Project to proceed.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) regulates alterations to wetlands pursuant to Section 404 of the Clean Water Act and work in navigable waters pursuant to Section 10 of the Rivers and Harbors Act. The Charles River is a federally navigable waterway in Massachusetts. Any construction in the water and adjacent wetlands may require a Section 10/404 permit from the USACE.

Massachusetts Environmental Policy Act

Proposed projects may exceed review thresholds of the Massachusetts Environmental Policy Act (MEPA). Documentation will require the filing of an Environmental



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Legend

- Approximate Site Location
- Former NPL Site

MassDEP Disposal Sites

- Unlikely to Impact Project
- Potential to Impact Project

0 100 200 400 Feet

Arsenal Street Corridor Study | Watertown, Massachusetts

MassDEP Disposal Sites

Source: MassGIS 2013 Imagery;
MassDEP Disposal Site Database

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Legend

- Approximate Site Location
- Former NPL Site

MassDEP Disposal Sites

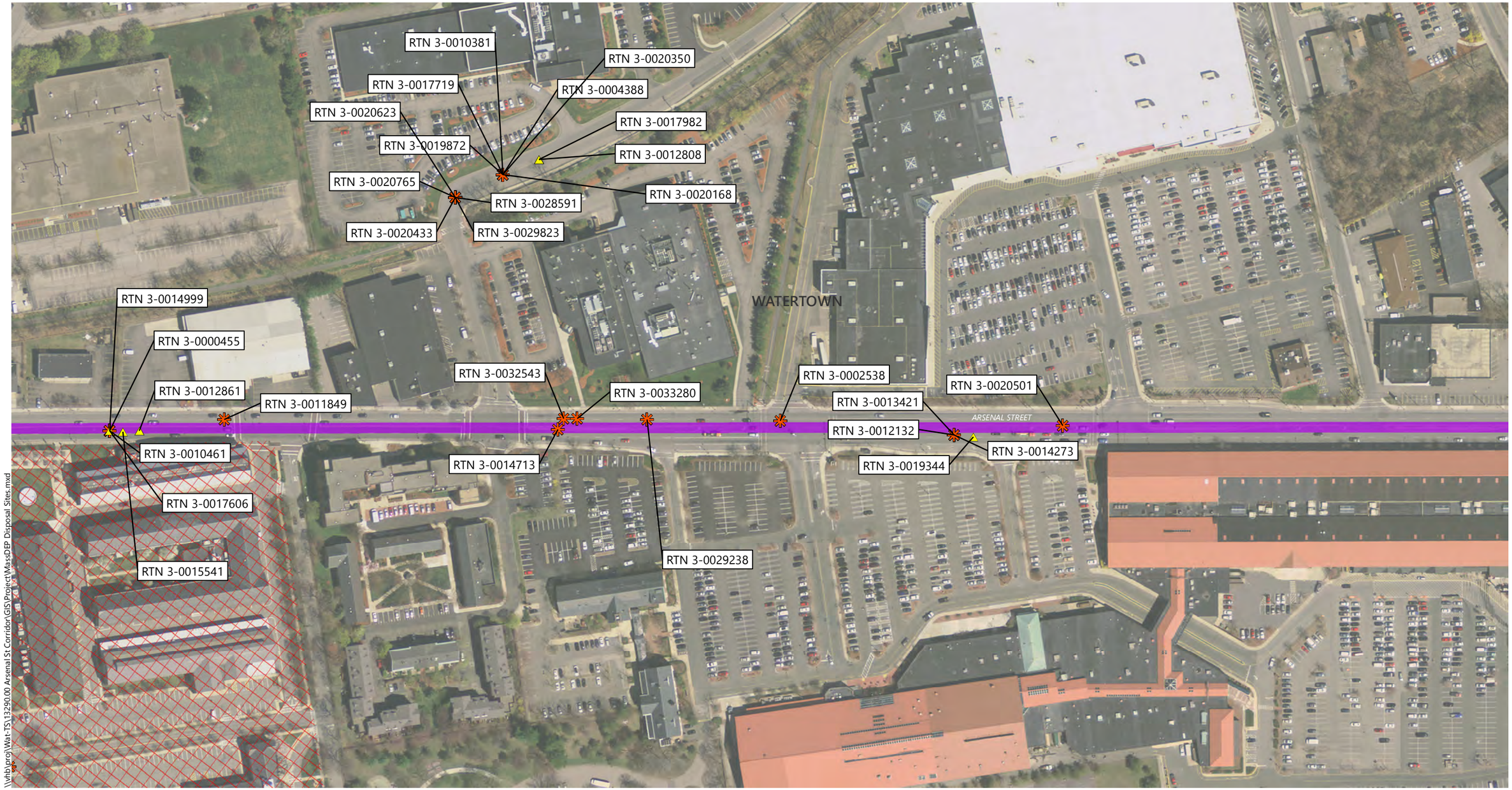
- Unlikely to Impact Project
- Potential to Impact Project

0 100 200 400 Feet

Arsenal Street Corridor Study | Watertown, Massachusetts

MassDEP Disposal Sites

Source: MassGIS 2013 Imagery;
MassDEP Disposal Site Database



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Legend

- Approximate Site Location
- Former NPL Site

MassDEP Disposal Sites

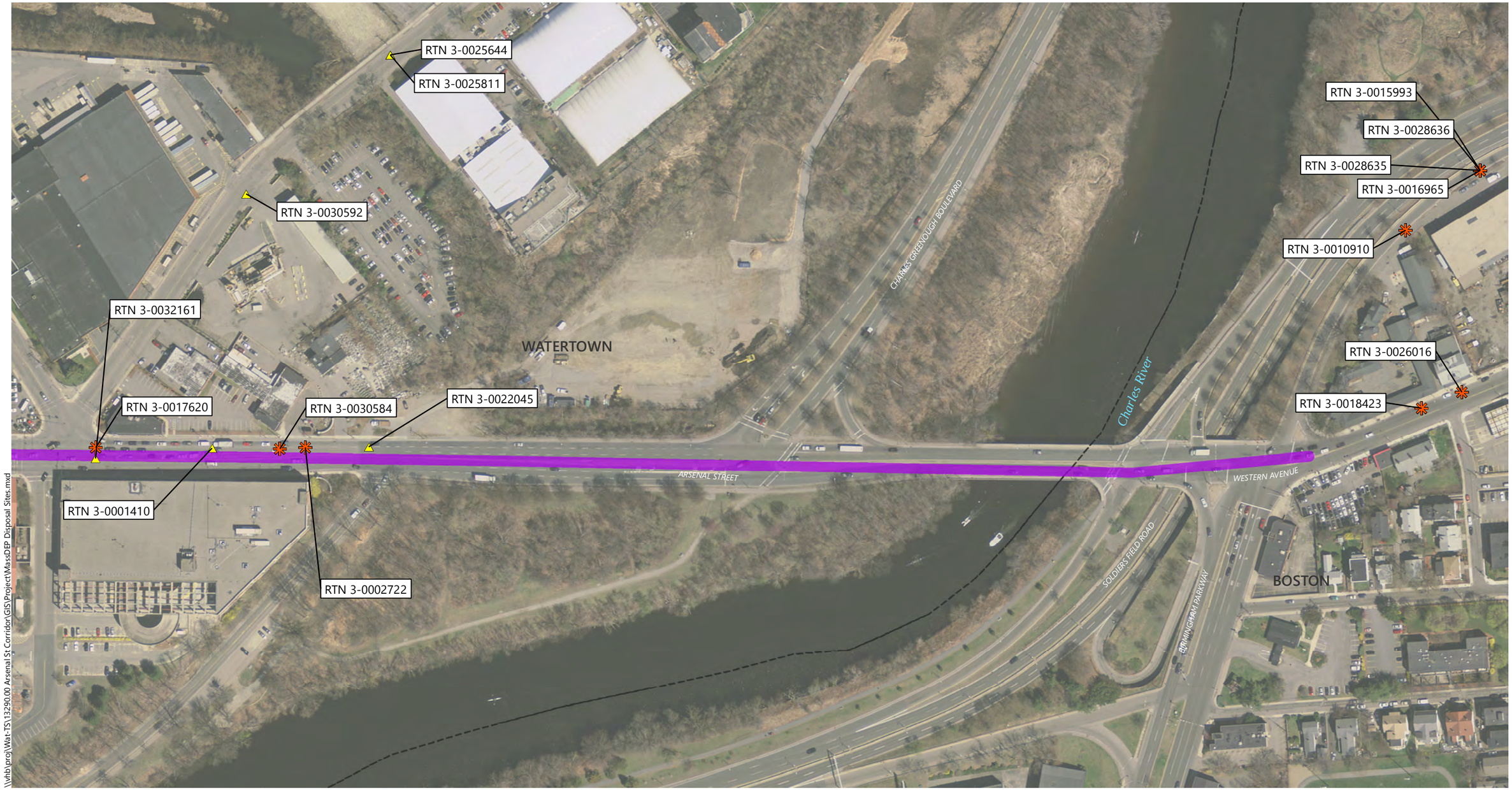
- Unlikely to Impact Project
- Potential to Impact Project

0 100 200 400 Feet

Arsenal Street Corridor Study | Watertown, Massachusetts

MassDEP Disposal Sites

Source: MassGIS 2013 Imagery;
MassDEP Disposal Site Database



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Legend

- Approximate Site Location
- Former NPL Site

MassDEP Disposal Sites

- Unlikely to Impact Project
- Potential to Impact Project

0 100 200 400 Feet

Arsenal Street Corridor Study | Watertown, Massachusetts

MassDEP Disposal Sites

Source: MassGIS 2013 Imagery;
MassDEP Disposal Site Database

Notification Form (ENF) with the MEPA Office and may require an Environmental Impact Report (EIR) for review by the Secretary of Energy and Environmental Affairs.

State and Local Wetlands Programs

Wetlands resources are protected by several state and local regulatory programs. Wetland resource areas exist within the vicinity of the Study Area, which are protected by these regulatory programs. These programs include:

- The Massachusetts Wetlands Protection Act (WPA), MGL Chapter 131, Section 40 and its implementing regulations, 310 CMR 10.00;
- Water Quality Certification pursuant to Section 401 of the Clean Water Act (CWA) and its implementing regulations, 314 CMR 9.00;
- Massachusetts Waterways Program (310 CMR 9.00); and
- Watertown Wetlands Ordinance.

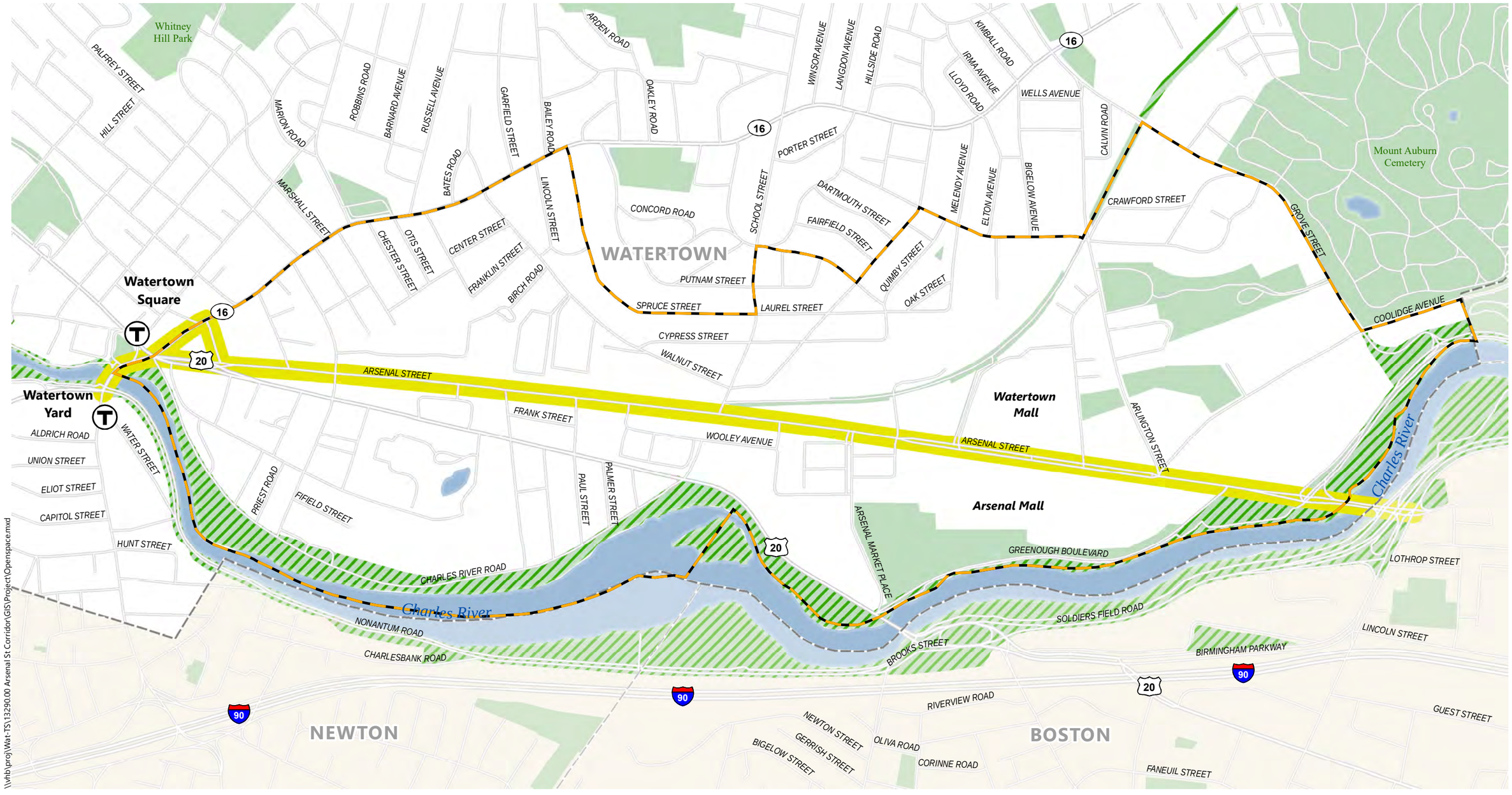
Depending on the final improvement recommendations and impacts (if any) to wetland resources, these permitting programs may apply to the Project and will require issuance of permits for construction.

Parkland and Open Space

Article 97 of the State Constitution protects public lands taken for wildlife conservation, open space protection, parks and historic sites and districts. Change of use of these areas requires a 2/3 vote from the state legislature and requires replacement of the area taken. Several parcels of state or local parkland are in the vicinity of the project and any alignment that requires use of these lands will require release through the Article 97 process. Open Space within the project area is depicted on Figure 2-26.

Environmental Justice

As discussed above, a portion of the local study area falls within an Environmental Justice block group, therefore the Executive Order 12898 pertains to this project. Suggested recommendations cannot disproportionally, adversely affect these block group areas and an Environmental Justice screening will be included in the alternatives analysis presented in Chapter 5.



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- DCR Owned
- Protected and Recreational Open Space
- Local Study Area Boundary
- Arsenal Street Corridor

Arsenal Street Corridor Study | Watertown, Massachusetts

Open Space Location Map

Source: MassGIS

Public Health Assessment

The way transportation infrastructure is designed impacts public health and wellbeing in terms of air quality, noise, mobility and connectivity - and hence levels of physical activity, public safety, and land use/economic development.

To analyze existing health conditions along the corridor, available baseline data on child and adult obesity, chronic heart disease, asthma, diabetes and mental health issues (although not directly influenced by transportation) were collected and synthesized to help identify major health concerns. Data was collected from the following public sources:

- Massachusetts Community Health Information Profile (MassCHIP)
- Massachusetts Department of Public Health/Bureau of Environmental Health (BEH) Environmental Public Health Tracking Portal.
- Mount Auburn Hospital 2015 Community Health Needs Assessment Report

Due to limited health information available at the Corridor level, community-wide public health data were used to profile the general health conditions along the Arsenal Street Corridor. While these data do not specifically correlate with transportation issues or opportunities along the corridor, understanding the public health benefits or impacts of transportation options is a key consideration of planning for a successful transportation corridor that serves the needs of all users and the surrounding community.

Baseline Public Health Profile

The Mount Auburn Hospital (MAH) 2015 Community Health Needs Assessment Report analyzed public health needs in seven communities: Watertown, Arlington, Belmont, Cambridge, Lexington, Medford, Somerville and Waltham. According to the report, the top three health concerns affecting the Town of Watertown are obesity and inactive living, poor self-management of chronic diseases, and mental health[12].

Listed below are summaries of the top health concerns identified for Watertown and key statistics comparing Watertown's public health baseline conditions with the State average.

[12] https://www.mountauburnhospital.org/app/files/public/746/mount-auburn-hospital-community-health-needs-assessment-2015.pdf

1. Obesity and Inactive Living
   - Engaging in a healthy lifestyle is a primary health concern. There is a tie between obesity rate and inactive living and stress, mental health, and chronic disease.
   - Having better places to walk, such as better sidewalks and more green space to walk and exercise, is recognized as a common theme in promoting weight loss and more active living.
   - Watertown (33.4 percent) has a higher rate of overweight or obese students than the state average (31.3 percent)[13].
   - Among neighboring MAH communities[14], Watertown has high quantiles of three years average prevalence of obesity among adults (CY2008-2010) and five years average prevalence of lack of physical activity among adults (CY2001, 2003, 2005, 2007, 2009).
   - When compared to the state average, Watertown has a higher rate of unintentional fall injuries resulting in hospitalizations among older adults age 60 and plus[15].

2. Poor Self-Management of Chronic Disease
   - A lack of understanding of how to manage (and prevent) chronic disease is major concern, including lack of experience dealing with chronic disease, a lack of information about chronic disease and an expectation that chronic disease cannot be managed.
   - The Massachusetts Healthy Aging Data Report reveals that Watertown has several heathy aging indicators that are worse than the state average[16]. Among indicators related to transportation, these include percent of the population ever having a heart attack, with chronic heart disease, and with congestive heart failure.
   - Among other healthy aging indicators, the percentages of adults over 65 with diabetes and asthma are 29.4 percent and 9.4 percent, respectively in Watertown, which are better than the state average of 32.1 and 11.8 percent. These indicators show that to some degree Watertown is better positioned than the state average in baseline public health conditions, particularly for chronic diseases like diabetes and asthma that are known to be more directly impacted by environmental factors.

3. Mental Health Issues
   - The need to address and reduce the stigma, as well as an increase in primary and secondary prevention resources, are considered a priority to address mental health issues. There are close links between mental health and physical health and between mental health and social determents of poverty and homelessness. Also contributing to poor mental health are isolation, a lack of connectives, and a lack of social support.

▼

[13] http://www.mass.gov/eohhs/docs/dph/com-health/school/status-childhood-obesity-2014.pdf
[14] http://www.mass.gov/eohhs/researcher/community-health/masschip
[15] Ibid
[16] https://mahealthyagingcollaborative.org/data-report/explore-the-profiles

- Watertown has a higher percentage of elders with Alzheimer's disease or related dementias (15.3 percent) than the state (14.4 percent). Watertown (31.6 percent) has a higher percentage of people who reported ever being diagnosed with depression compared to state (28.6 percent)[17].

Built Environment and Public Health

It is well established that community design and the built environment affect human health and wellbeing[18]. According to the U.S. Department of Health and Human Services:

"in its broadest sense, environmental health comprises those aspects of human health, disease, and injury that are determined or influenced by factors in the environment. This includes not only the study of the direct pathological effects of various chemical, physical, and biological agents, but also the effects on health of the broad physical and social environment, which includes housing, urban development, land use and transportation, industry, and agriculture.[19]"

Creating healthy and activity-friendly community environments can improve public heath by:

- Increasing physical activity
- Reducing injury
- Increasing access to healthy food
- Improving air and water quality
- Minimizing the effects of climate change
- Decreasing mental health stresses
- Strengthening the social fabric of a community, and
- Providing fair access to livelihood, education and resources[20].

Different types of improvements or interventions to the built-environment offer varying ranges of public health benefits. Specific to the Arsenal Street Corridor Transportation Study, these could include creating a sustainable transportation system by promoting active transportation options, improving access to open space, parks and trails, and encouraging mixed land use and green urban design.

▼

[17] http://www.mass.gov/eohhs/researcher/community-health/masschip
[18] Designing Health Communities, Richard Jackson, M.D., 2011
[19] Department of Health and Human Services (US). Healthy People 2010. Volume 1. Washington: DHHS; November 2000.
[20] National Center for Environmental Health. About Healthy Places (2104). Centers for Disease Control and Prevention. Accessed at: http://www.cdc.gov/healthyplaces/about.htm

Creating a Sustainable Transportation System

A sustainable transportation system can include multiple components such as improved public transit services, adequate bicycle and pedestrian accommodations, improved mobility and traffic flow, and traffic calming measures.

- Increasing public transit opportunities helps encourage mode-share along the corridor and reduce auto-dependency. This results in environmental and economic benefits such as enhanced safety, improved air quality and reduced noise level due to less traffic delay, and enhanced retail sales at local stores due to increased pedestrian movements to and from transit nodes.
- Improving pedestrian and bicycle facilities helps promote walking, running and biking which is beneficial to both physical and mental health. More active bicycle and pedestrian circulation also introduces more opportunities for local business and enhances social interactions at the street and neighborhood levels.
- Improving mobility and traffic flow along the corridor promote environmental sustainability and mitigate stress factors affecting mental health by reducing traffic delays and congestion which result in less air pollution, noise, and road safety concerns.

Access to Open Space, Parks, and Trails

One of the derivative community benefits of creating a sustainable transportation system, as described above, is improved connectivity and access to recreational amenities such as open spaces, parks, and walking/biking trails on either side of the corridor.

- Presence, proximity, and accessibility of open space and parks in a community have been shown to have significant public health benefits. Access to parks promotes physical activities and contributes to the prevention and management of obesity and numerous chronic diseases such as heart disease, hypertension, and diabetes. Regular use of parks and green spaces also helps reduce mental stresses.
- Similar to open space and parks, good access to pedestrian and bike trails also help promote physical activity and mental health. It also contributes to safer non-vehicular traveling by providing dedicated travel ways. Improved trail connections also promotes more economic activity through increased pedestrian and bicycle circulation on local streets.

Mixed Land Use and Green Urban Design

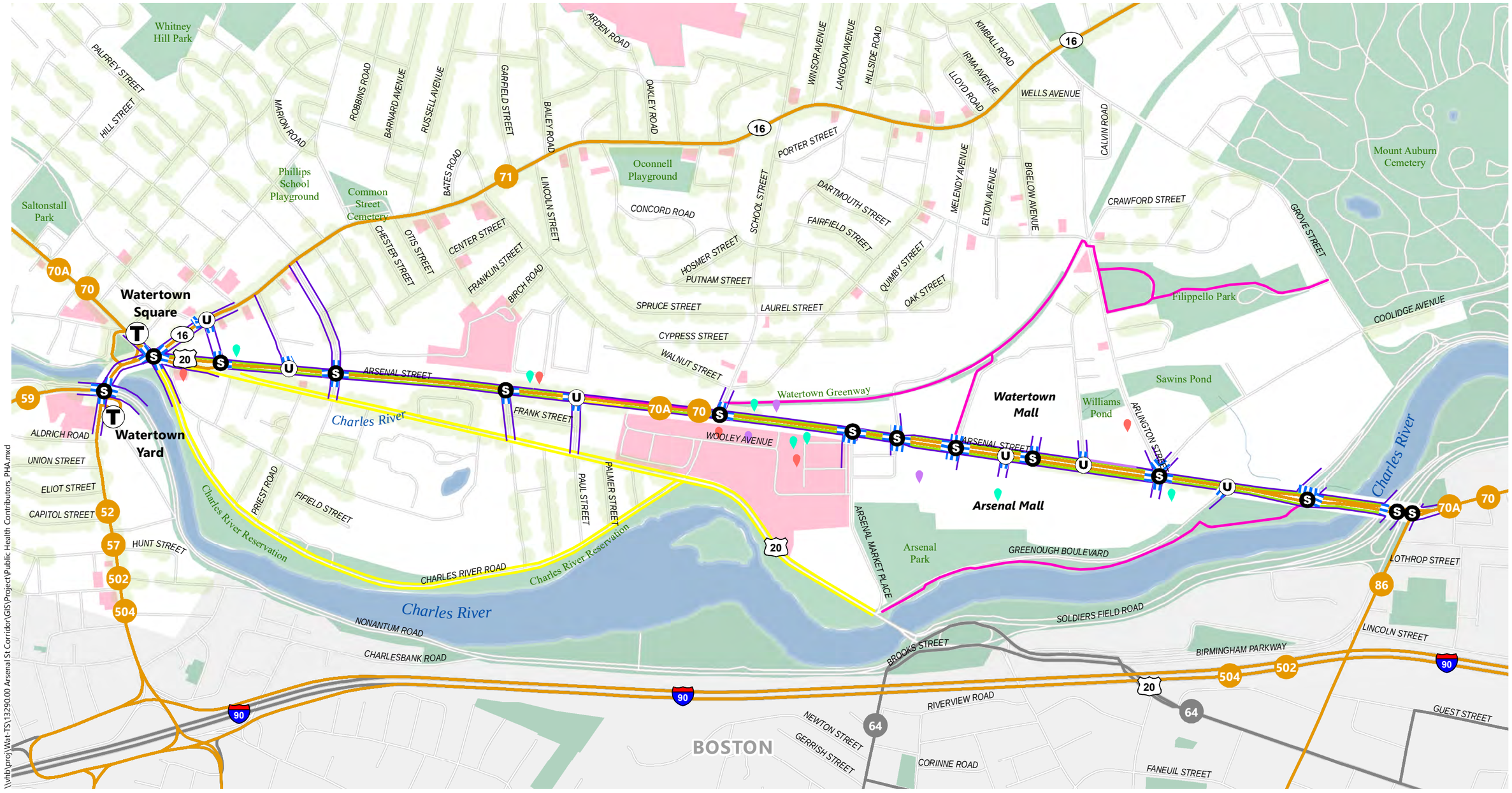
Mixed use development can help make people more likely to walk or use transit to run errands, go shopping or go to lunch than does spread-out, automobile-oriented,

single use development. Research has found that even a base minimum of physical activity can help combat obesity. People are more likely to walk to destinations such as home, transit, shopping or restaurants if these places are located within a quarter-mile or half-mile of their workplace. These potential land use changes can also improve public health in less direct ways.

- A variety of land uses, building types and public spaces can improve physical and social activity.
- Mixed use development can provide dynamic living, working, and playing environment and active street facades, both of which help encourage street level pedestrian activities and social interaction. Mixed use development can also reduce environmental footprints through more integrated and efficient land use patterns.
- Green urban design and streetscape improvements, which promote walkability and connectivity and provide more greenery and pedestrian amenities, are beneficial to more active and relaxed life styles that are closely related to improved public health.

Public Health Implications of the Study Area Existing Built Environments

Based on the existing conditions analysis presented in this chapter and the relationship between the built environment and public health identified above, the following contributors and barriers to public health have been identified along the Arsenal Street Corridor. These contributors and barriers are illustrated in Figure 2-27 and Figure 2-28 respectively.



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Arsenal Street Corridor Study | Watertown, Massachusetts

Intersections
- Signalized Study Intersection
- Unsignalized Study Intersection

Transit Route
- Study Area MBTA Bus Routes
- Other MBTA Bus/Trackless Trolley Routes

Sidewalks
- Existing Sidewalk
- Sidewalk Under Construction
- Existing Crosswalk

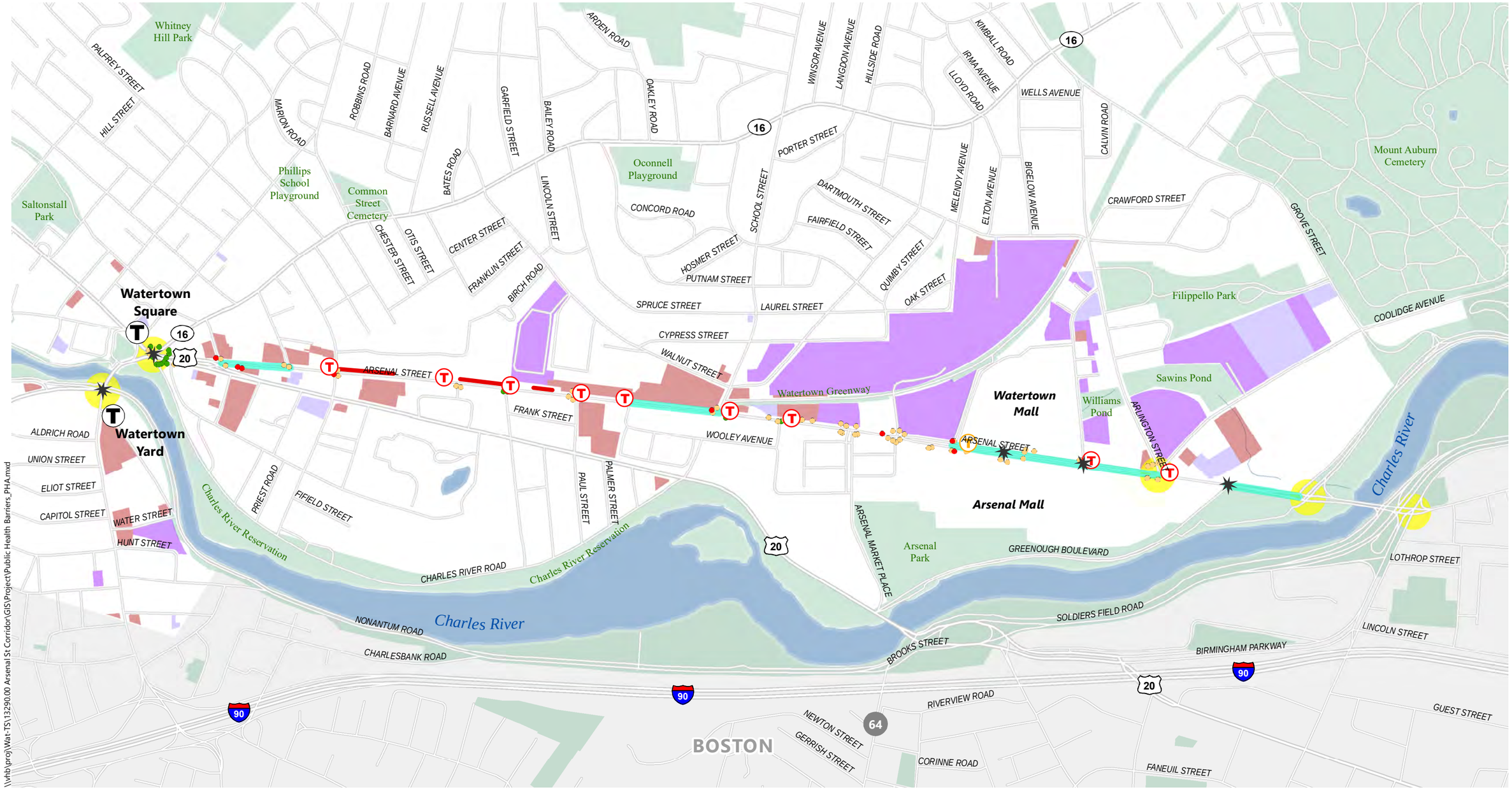
Bike Lanes
- Off-road Bike Lane
- On-road Bike Lane
- Shared Lane Bike Accomodation

Community Amenities
- Healthy Food Eatery
- Art and Fitness
- Health Care Institution

- Parks and Open Spaces
- Mixed Use Development
- Street Trees

Public Health Contributors

Source: MassGIS, Town of Watertown



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Arsenal Street Corridor Study | Watertown, Massachusetts

Bus Stops
- Single Post Bus Stop
- Bus Shelter

Wheelchair Ramp Conditions
- Sidewalk with Deficiencies
- Good
- Fair
- Poor

- High Crash Location
- High Traffic Volume Section
- *Intersection with More than One Minute Vehicle Delays (Morning Peak Hour)*

Land Uses Unconducive to Public Health
- Automotive Sales and Services
- Manufacturing and Processing
- Storage and Distribution Facilities

Public Health Barriers

Source: MassGIS, Town of Watertown

Primary Public Health Contributors

- Access to public transit options:
- Existing bus services provided by the MBTA along the Arsenal Street Corridor (Route 70 and 70A), connect the corridor to neighboring communities and employment destinations in Boston, Cambridge, Dedham, Needham, Newton, Somerville, and Waltham.
- Local bus service within the Study Area also provides connections to MBTA rapid transit and commuter rail.
- Express bus routes provide service between the Study Area and Downtown Boston.
- Access to pedestrian and bicycle facilities:
- Sidewalks are present on both sides of Arsenal Street, with exception of the section just east of Elm Street (under construction as of Fall 2016).
- Bicycle accommodations connecting to and along Arsenal Street include shared lanes, on-road bicycle lanes, off-road bicycle lanes and the Watertown Greenway.
- The majority of the major intersections along the corridor are signalized for traffic control.
- There is currently mixed use development in certain sections of the corridor, with additional mixed use development either planned or under construction.
- There are various parks and playgrounds (Arsenal Park, Filippello Park, etc.) and trails (Watertown Greenway, Charles River Greenway, etc.) on or near either side of the corridor.
- Street trees are present along the Arsenal Street Corridor in various segments, although the coverage has not reached the full length of the corridor due to various setback limitations and curb cuts.
- There are healthy food establishments21, community/cultural facilities and health institutions along the corridor.

[21] According the CDC, the Dietary Guidelines for Americans, 2010 may be used to develop definition for healthier foods. Generally healthier foods will include fruits, vegetables, whole grains, fat-free and low-fat dairy products, and seafood, as well as foods with less sodium (salt), saturated fats, trans fats, cholesterol, added sugars, and refined grains. Healthier beverages include fat-free or low-fat milk and milk products, fortified soy beverages and other lactose-free products, 100% juice, and water.

Primary Public Health Barriers

- Bus services such as Route 70 and 70A in the Study Area are currently at or over capacity during peak hours.
- There is a lack of bus stop amenities:
- Many of the bus stops located do not have formal shelters and consist of a posted sign along the sidewalk to designate the bus stop.
- In some locations, these bus stops are on narrow sidewalks which provide no additional space for waiting passengers outside the path of pedestrians.
- There are insufficient pedestrian safety features:
- There are uneven sidewalk surfaces in a number of locations along the corridor. In other locations, trees and telephone poles are located in the center of the sidewalk which are an inconvenience to pedestrians.
- There is a general lack of ADA compliant wheelchair ramps along the corridor.
- There are five locations along the corridor where the crash rates exceed the MassDOT District 6 average crash rate, though the majority of other intersections are considered safe or safer than similar intersections. The five locations include Galen Street at Watertown Street/Nonantum Road, Mount Auburn Street/Main Street/Arsenal Street/Charles River Road, Arsenal Street/Arsenal Mall unsignalized driveway, Arsenal Street/Elm Street, and Arsenal Street/Greenough Boulevard (south).
- There is traffic congestion and delay at several intersections along the corridor, including Watertown Square, Arlington Street, and Greenough Boulevard.
- As the primary east-west transportation corridor in Watertown, Arsenal Street carries a large traffic volume on a daily basis. For example, the average daily traffic (ADT) volume on Arsenal Street between Greenough Boulevard (north) and Greenough Boulevard (south) is 23,500 vehicles per day.
- The majority of the land use along the corridor is characterized by low density large format retail, automobile oriented service establishments, and vacant/underutilized parcels. The presence of these land use types creates barriers to a continuous and pleasant pedestrian environment due to numerous curb cuts, large surface parking lots, and general lack of human-scale building facades.