Assessment of Dudley South Corridor Bus Service and Potential Improvements

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EXECUTIVE SUMMARY

The Dudley South corridor covers the service area of Route 23 and Route 28 in the MBTA bus system. Both of these routes run between Dudley Station and Grove Hall on Warren Street and Blue Hill Avenue. The two routes split at Grove Hall, with Route 23 running between Grove Hall and Ashmont Station on Washington Street, Talbot Avenue, and Dorchester Avenue while Route 28 remains on Blue Hill Avenue between Grove Hall and Mattapan Station. Several other bus routes travel through portions of the corridor.

The corridor serves neighborhoods that are characterized by high population densities, significant percentages of minority populations, young average ages, and low per-capita income levels. The modeled travel patterns for all modes exhibit traditional commute patterns, with a majority of the peak period home-based work trips being made to and from the downtown Boston area. This work-based pattern also characterizes modeled transit usage in the corridor. While there appear to be few intra-corridor trips based on work, according to the MPO travel model, the largest percentage of corridor non-work trips in both the peak and non-peak time periods stay within the corridor. Transit does not appear to be particularly successful in capturing these intra-corridor trips.

A service assessment of the Dudley South corridor brings up several topics for consideration. Both Route 23 and Route 28 face consistent difficulties adhering to their scheduled running times, and as delay for one bus often results in the subsequent bus's running ahead of schedule, a common problem is bus bunching. Passenger crowding is another issue that often results from either poor schedule adherence or the boarding of crush loads of passengers. Bus speeds, which are affected by numerous factors, including passenger crowding, general traffic speed, and intersection performance, vary throughout the corridor depending on the location, direction, and time of day. In general, outbound bus speeds are slower than inbound speeds, and Route 23 has slower average speeds in both directions than Route 28.

The average distance between stops also varies throughout the corridor. Perhaps in correlation with slower average speeds, the average distance between stops is shorter in the outbound versus the inbound direction and along Route 23 compared to Route 28. There also appear to be several stops with a small number of passenger boardings or alightings. The stops with the fewest passengers are concentrated on Route 23. Shelters are located at most but not all of the most-used stops. Finally, the fact that, like the systemwide bus average, approximately 40 percent of all fares on Route 23 and Route 28 are paid with either cash onboard or CharlieTickets undoubtedly increases boarding times.

A passenger survey on Route 23 and Route 28 asked riders questions about their trip's origin, destination, purpose, and transfer activity. Both routes appear to be used largely for trips to neighborhoods in the corridor. While a significant portion of trips involve a transfer to or from another transit mode, the majority of trips do not require transfers. Considering the high percentages of passengers whose transit access and egress involve walking, it appears likely that these routes are the only mode of transportation used by many riders. Moreover, given the low reported rates of vehicle licenses and availability, and the relatively high rates of transit usage during the week and on weekends, it appears that these routes, and MBTA service more generally, provide the sole means of transportation for many riders to and from this corridor. The passenger survey also asked passengers to rate MBTA bus service according to several measures of service quality. A majority of ratings on each route fell between "below average" and "average." The measures that were ranked as the worst on both routes were frequency of service and availability of seating. The measures rated the most important by riders were reliability, safety and security, and frequency of service.

The potential improvements recommended by this study belong to a form of transit commonly known as bus rapid transit, or BRT. A transit mode rapidly growing in popularity throughout the world, BRT generally combines elements of rail rapid transit with bus routes to improve passenger capacity, travel speeds, and schedule adherence, among other characteristics. As BRT can be implemented at the surface level with varying levels of physical construction, it also provides levels of service similar to those of light rail at a reduced cost. The BRT improvements described in this study include segregating rights-of-way for buses, establishing a procedure for pre-paid boarding, instituting traffic signal priority for bus routes, enhancing frequency of service, and consolidating stops.

Because of differences in road width and other characteristics between the various segments of the corridor, several different conceptual recommendations are presented:

- Between Dudley Station and Grove Hall, the recommended concept includes a busway in one direction and a system of queue jumps in the other. Between Dudley Station and Townsend/Quincy Streets, the busway would run in the outbound direction, and between Grove Hall and Townsend/Quincy Streets, the busway would run in the inbound direction.
- Between Grove Hall and Ashmont Station (Route 23), limited street capacity rules out the construction of a full busway in either direction. However, stop consolidation and queue jumps could be used to improve running times along this segment.
- Finally, Blue Hill Avenue between Grove Hall and Mattapan Station (Route 28) does offer, for the most part, sufficient available roadway width for BRT in the form of a median. The recommended concept for this segment is therefore to replace the median with two busways.

While some attempt is made to consider the traffic implications of these conceptual recommendations, it should be made clear that this study suggests conceptual solutions, and does not attempt to present full and complete designs. The recommendations are rather intended to be useful reference points as the community and the MBTA consider how best to improve bus service in the Dudley South corridor.

INTRODUCTION

The objective of this study is to conduct an assessment of the Route 23 and Route 28 bus corridor south of Dudley Station as well as potential improvements to the corridor or routes. Several tasks were conducted as part of this assessment. From an operational perspective, various performance measures were collected for Routes 23 and 28. Specifically, information on bus frequency, maximum loads, and schedule adherence is provided using CTPS trip summary and load profile reports of the routes produced in the fall 2007 quarter. In addition, as part of the MBTA systemwide passenger survey, CTPS tabulators surveyed riders' trip characteristics. This passenger survey also provides information on ridership demographics. Finally, other more general travel and demographic characteristics from the U.S. Census, the MPO travel model, the Congestion Management Process, and automated farebox collection data are summarized.

These various analyses are presented throughout the study. The first section will define the Dudley South corridor and summarize several travel and demographic characteristics of the corridor. The second section will discuss some of the issues and problems confronting bus service in the corridor, specifically focusing on schedule adherence, crowding, frequency, average travel speeds, and intersection performance for Routes 23 and 28. Route attributes such as the distance between stops, boarding and alighting totals, the number of shelters, and the method of fare payment will also be presented. The third section will summarize the trip and demographic characteristics of riders on these two routes. The fourth section will present several potential bus improvement measures, and the final section will discuss the conceptual application of these measures to the corridor.

CHARACTERISTICS OF THE DUDLEY SOUTH CORRIDOR

This section presents a basic description of the demographic and travel characteristics of what is herein referred to as the "Dudley South corridor." Data was compiled from the 2000 U.S. Census and the MPO travel model.

Physical Description

In this study, the Dudley South corridor is generally assumed to be the Census tracts within 0.25 miles of Route 23 and Route 28. Figure 1 presents an orthographic photo of the general area with the Census tract boundaries, and Figure 2 shows the transportation infrastructure of the corridor. The tracts include the Roxbury area south of Dudley Square and a large percentage of Dorchester, essentially from Franklin Park to Dorchester Avenue. Also included in the corridor are the areas just south of Mattapan and Ashmont Stations. The Red Line and the Mattapan High-Speed Line serve the corridor in the east and south, respectively, and the Silver Line Washington Street serves the corridor from the north. The Fairmont commuter rail line also passes through the Dudley South corridor, stopping at Morton Street, and future stations on this line in the corridor are planned at Washington Street-Geneva Avenue/Four Corners, Talbot Avenue, and Blue Hill Avenue.

The corridor extends southward from Dudley Station in Roxbury along Warren Street to Grove Hall and the intersection with Blue Hill Avenue, where it splits in two directions: southeast along Washington Street, Talbot Avenue, and Dorchester Avenue to Ashmont Station in Dorchester and south along Blue Hill Avenue to Mattapan Station. Figure 3 depicts the corridor in terms of the six segments that will be analyzed. The first two make up the outbound and inbound travel between Dudley Station and Grove Hall. Both Route 23 and Route 28, along with Routes 14, 19, and 25, use these segments. The third and fourth segments are the outbound and inbound paths traveled by Route 23 on Washington Street and Talbot Avenue to Ashmont Station. Routes 22 and 26 also share the portion of these segments on Talbot Avenue. The fifth and sixth segments are the outbound and inbound paths traveled by Route 28 on Blue Hill Avenue to Mattapan Station. Several other MBTA bus routes share portions of these segments, including Routes 14, 22, 25, 29, and 31.

Table 1: Dudley South Corridor Segments

Segment	Direction	From	To	Distance (miles)
1	Outbound	Dudley Station	Grove Hall	1.50
2	Inbound	Grove Hall	Dudley Station	1.55
3	Outbound	Grove Hall	Ashmont Station	2.15
4	Inbound	Ashmont Station	Grove Hall	2.15
5	Outbound	Grove Hall	Mattapan Station	3.07
6	Inbound	Mattapan Station	Grove Hall	2.91

Figure 1: Corridor Boundaries

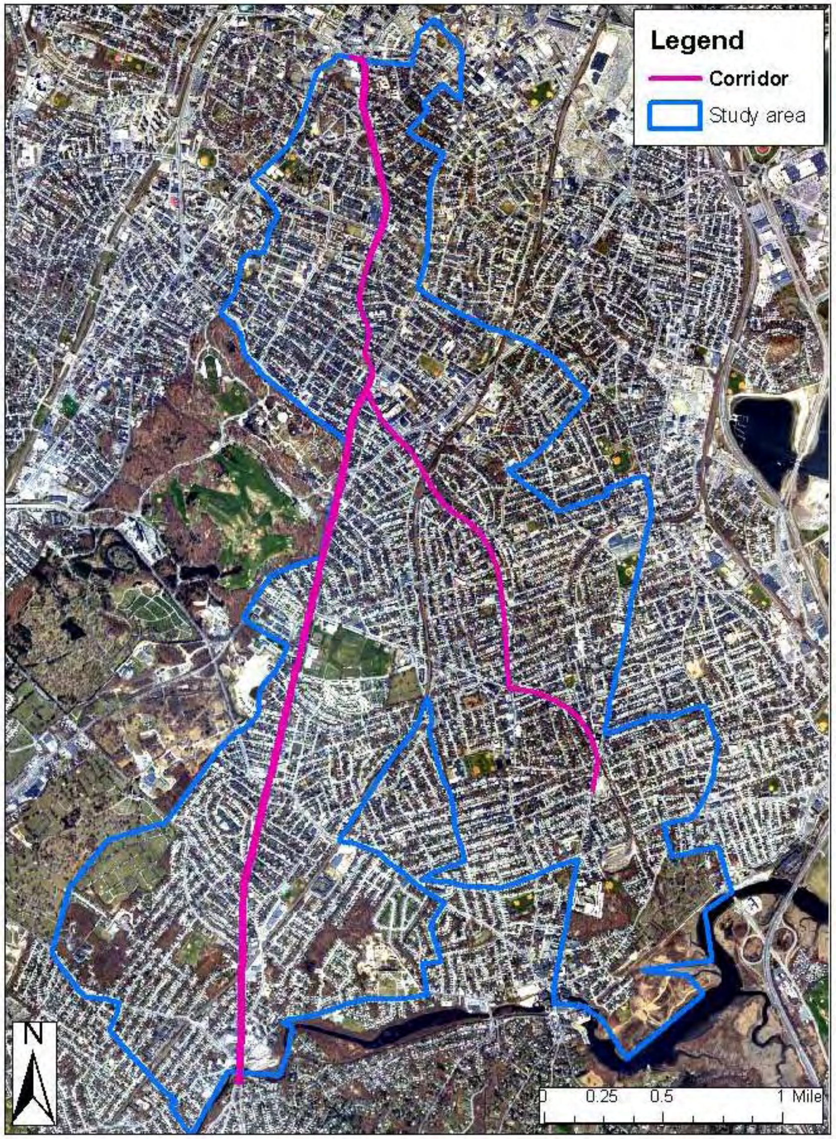


Figure 2: Fixed Transportation Infrastructure

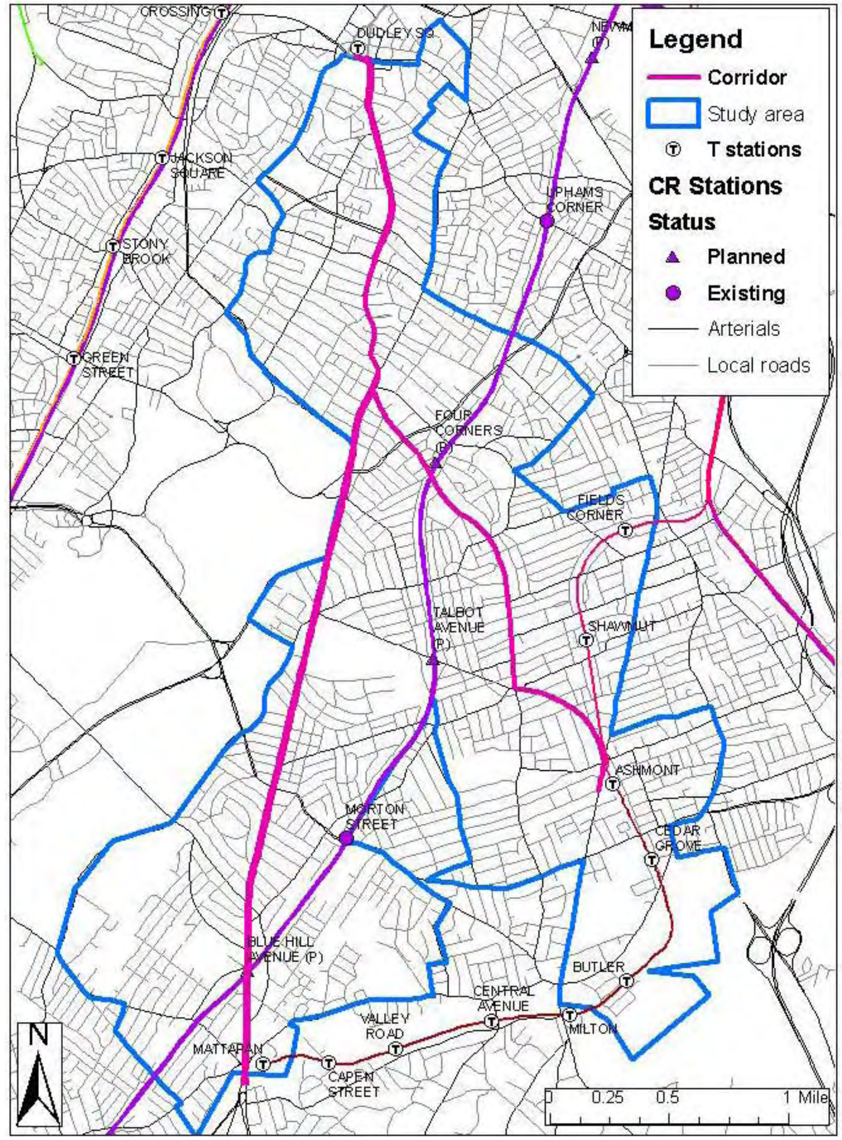
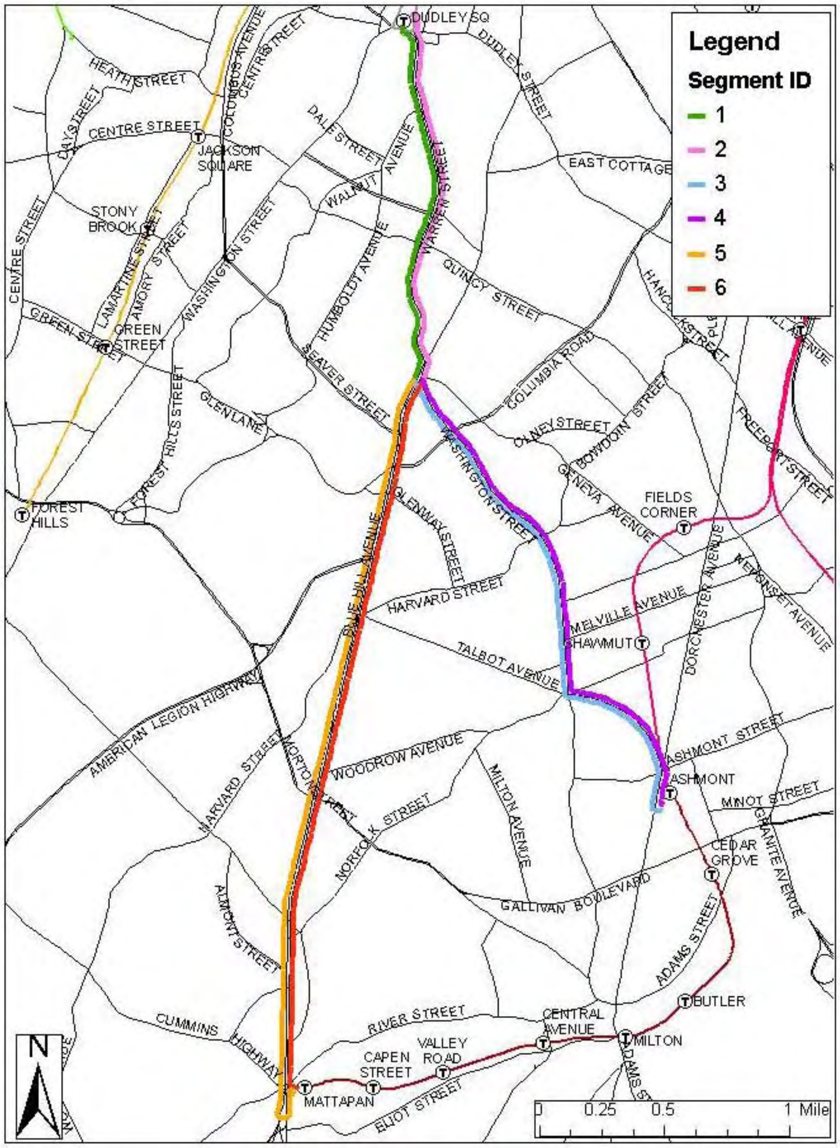


Figure 3: Segment ID



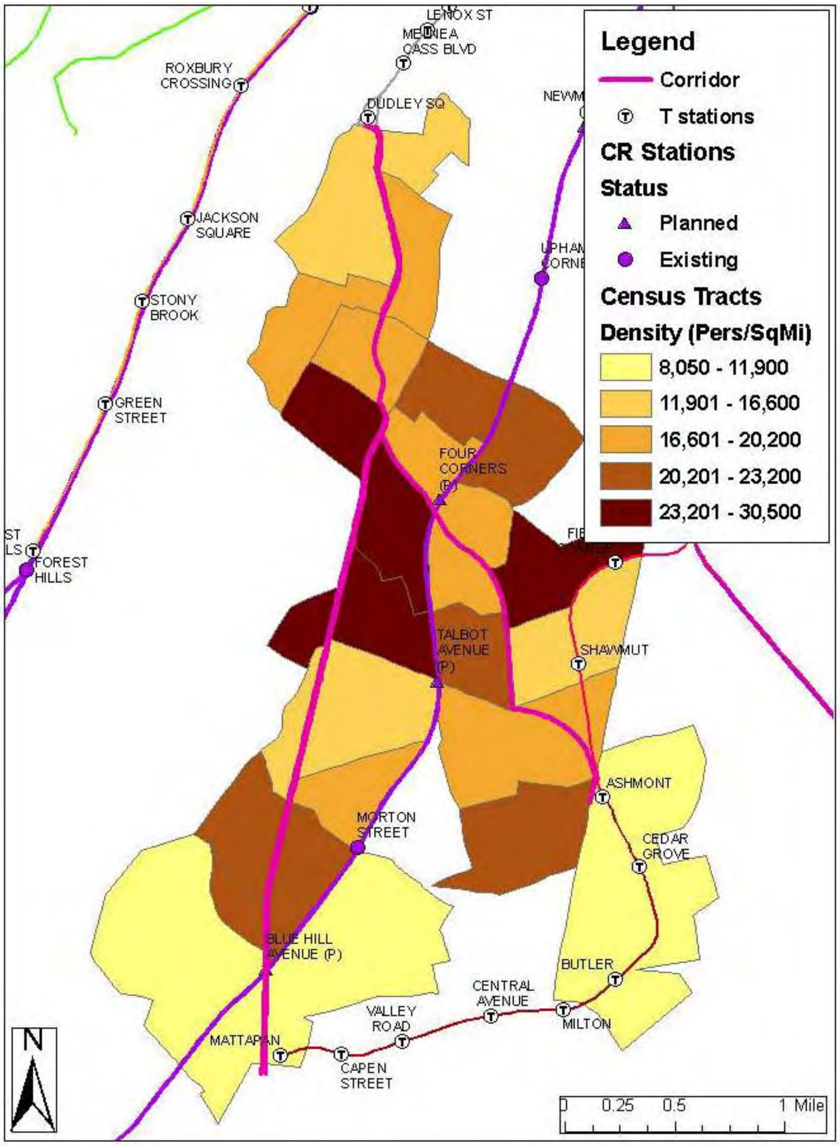
Demographic Characteristics

This section presents various demographic characteristics of the Dudley South corridor, both for the corridor as a whole and at the geographic level of the Census tract. Data is from the 2000 U.S. Census.

Population Density

Total population in 2000 in the Dudley South corridor was 99,155. Average population density across the entire corridor was 17,592 persons per square mile. Figure 4 shows population density by Census tract. Most areas have densities at or above 16,600 persons per square mile. Only the neighborhoods south of Ashmont Station and north of Mattapan Station have population densities less than 11,912. The average population density for the city of Boston in 2006, according to the Census, was 12,166.

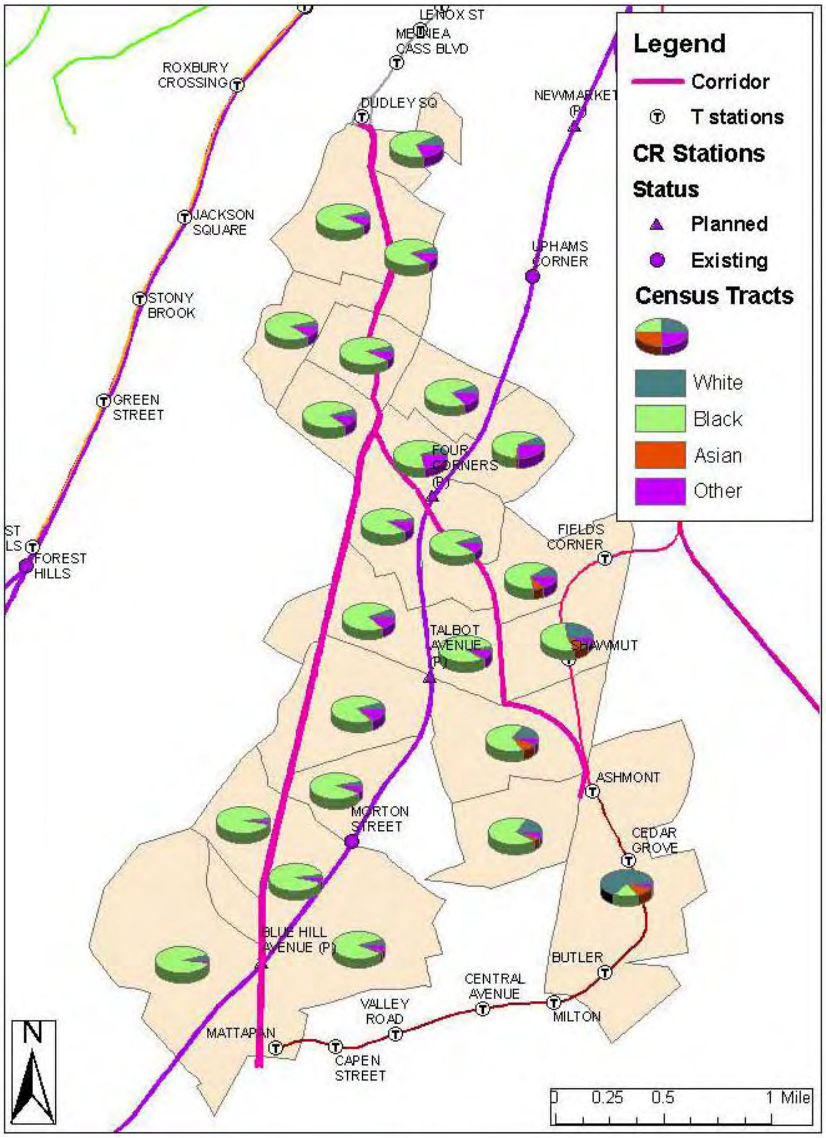
Figure 4: Population Density



Race

In terms of race, more than three-quarters, or 76.9 percent, of the corridor's population is black, followed by 10.5 percent white, 9.7 percent other, and 2.9 percent Asian. From Figure 5, one can see that there are some differences in racial composition across the corridor. The populations along the western half of the corridor, and particularly towards Mattapan Station, are mostly black. The Asian population, where it exists in the corridor, is mostly concentrated in the southeastern corner, around Fields Corner, Shawmut, and Ashmont Stations. These tracts also appear to have the largest concentrations of white residents in the corridor, with the tract south of Ashmont Station being the only tract without a majority black population. Residents with a race designated as "Other" are spread throughout the corridor, though the greatest percentages appear to be in the area to the southwest of Uphams Corner.

Figure 5: Race



Nearly 15 percent of the population in the entire corridor is of Hispanic or Latino origin. The relative percentages per tract are presented in Figure 6. As seen in the figure, there are areas with significant Hispanic populations, as much as 31.3 percent. These areas are concentrated in the middle and northern sections of the corridor. In the southern portion of the corridor, the percent Hispanic population is as low as 4.6 percent.

Age

The population of the Dudley South corridor is decidedly young, with nearly one-half of all residents in 2000 being under the age of 30. The largest age group is those aged under 18, who make up 32.1 percent of the population, followed by 18- to 30-year-olds, with 17.5 percent, and 30- to 40-year-olds, with 15.8 percent. Only 11.4 percent of the population is aged 60 and above, and several Census tracts have average ages below 29 years. As a result, the average age across the corridor is quite low, never exceeding 40.

Figure 6: Hispanic Residents

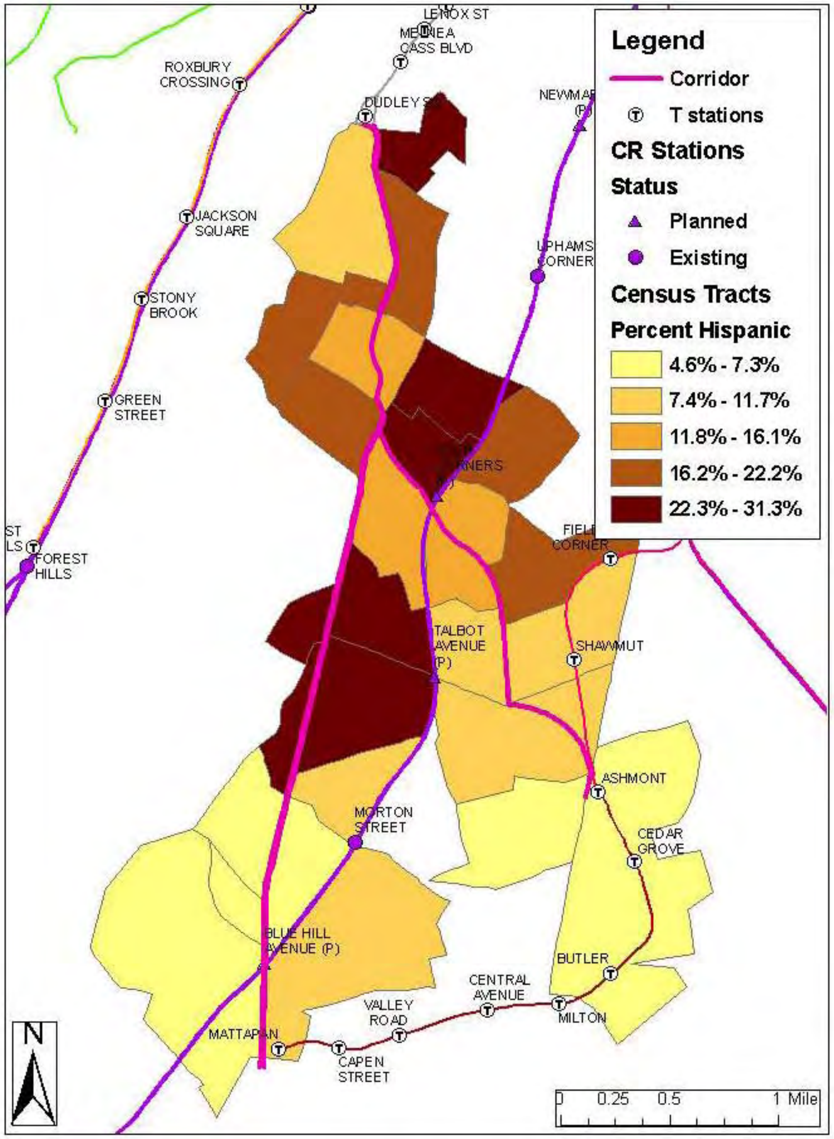
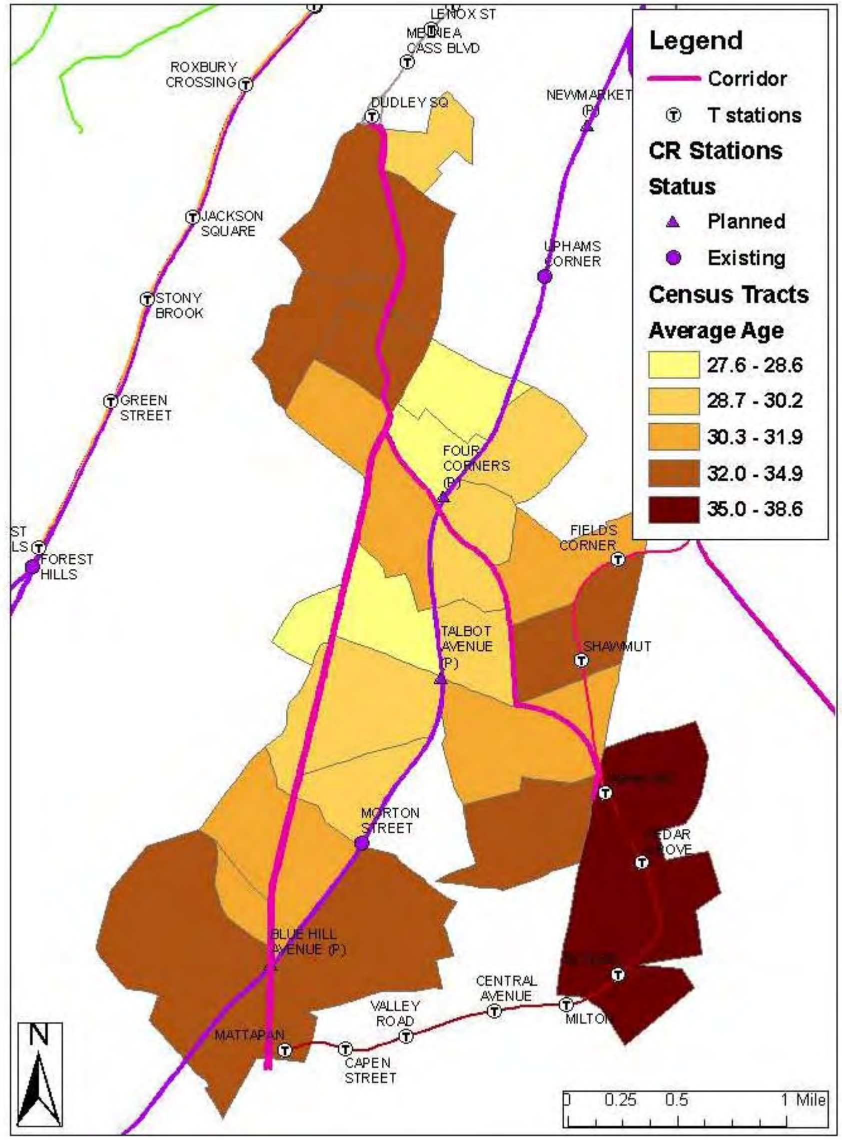


Figure 7: Average Age



Language and Foreign Nationality

In terms of housing, there were slightly more than 34,000 households in 2000, and 36,500 housing units. Of the households in the Dudley South corridor, 69.1 percent speak English as their primary language, followed by 14.7 percent Spanish-speaking households, 13.0 percent who speak another European language, and 3.3 percent who speak another, non-European language. Foreign-born residents make up 27.7 percent of the corridor's population. Figures 8 and 9 break down by tract the relative percentage of households by their primary language and the percent of foreign-born population.

Figure 8: Primary Household Language

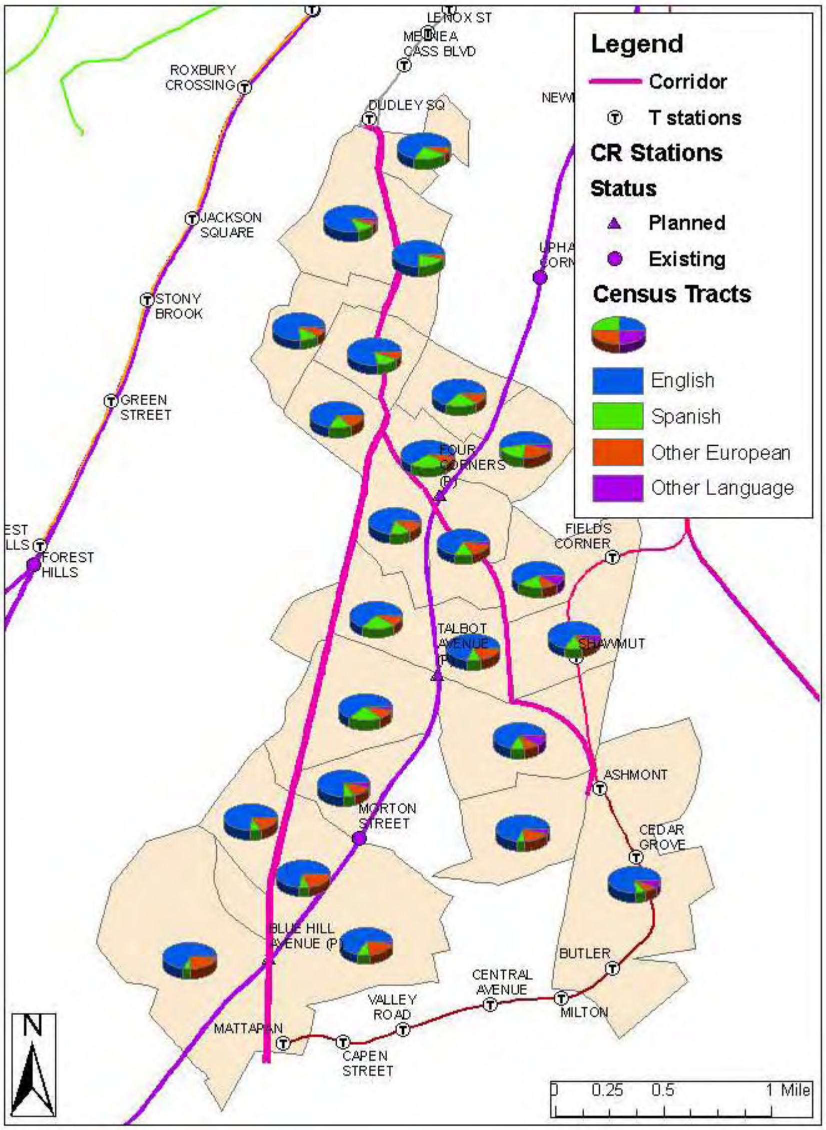
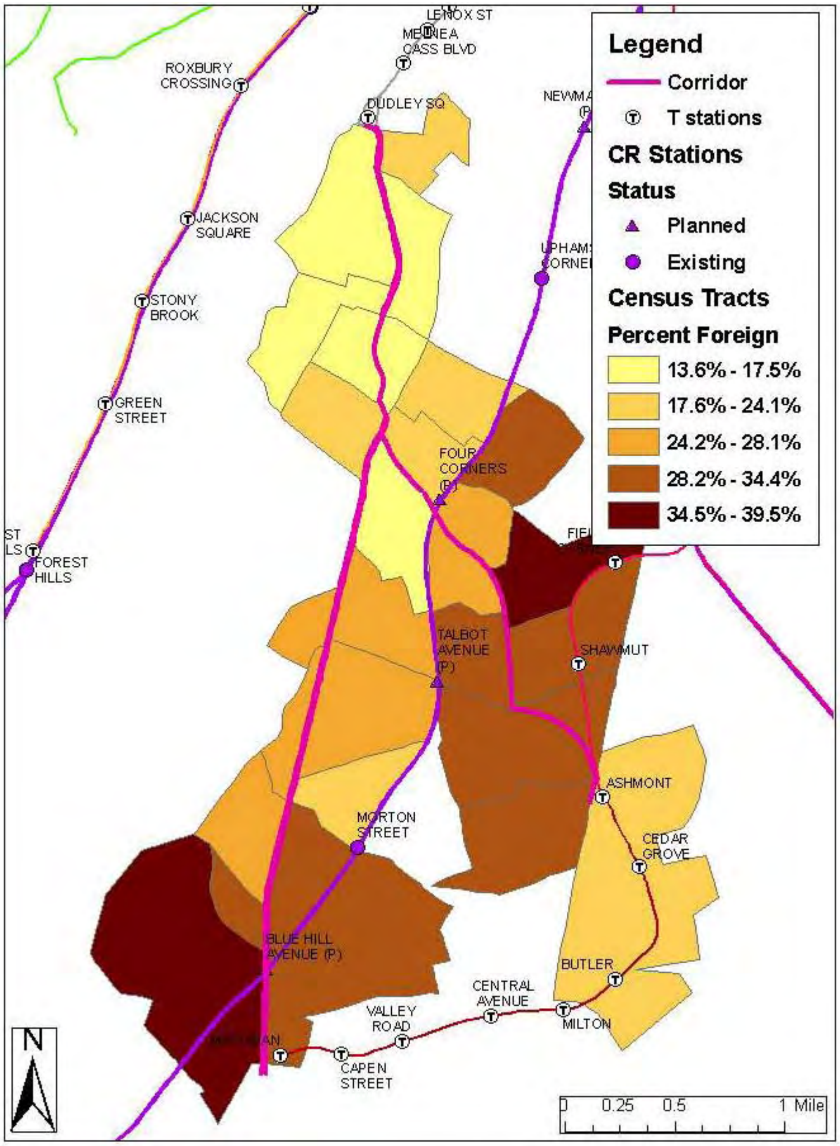


Figure 9: Foreign-Born Residents



Income and Vehicle Access

Income and poverty levels vary across the Dudley South corridor. Figure 10 shows the per capita income in 1999 dollars by Census tract, and Figure 11 shows the percentage of the population living below the poverty line. Tracts with low per capita income and high poverty rates are located primarily in the southern portion of the corridor. The highest poverty levels are in tracts directly served by Routes 23 or 28. As seen in Figure 12, the tracts with the highest percentages of residents without private vehicle access are located in the middle of the corridor. The lowest per capita income levels and highest poverty rates also characterize these tracts, indicating a correlation between the three metrics.

Figure 10: Per Capita Income (1999 $)

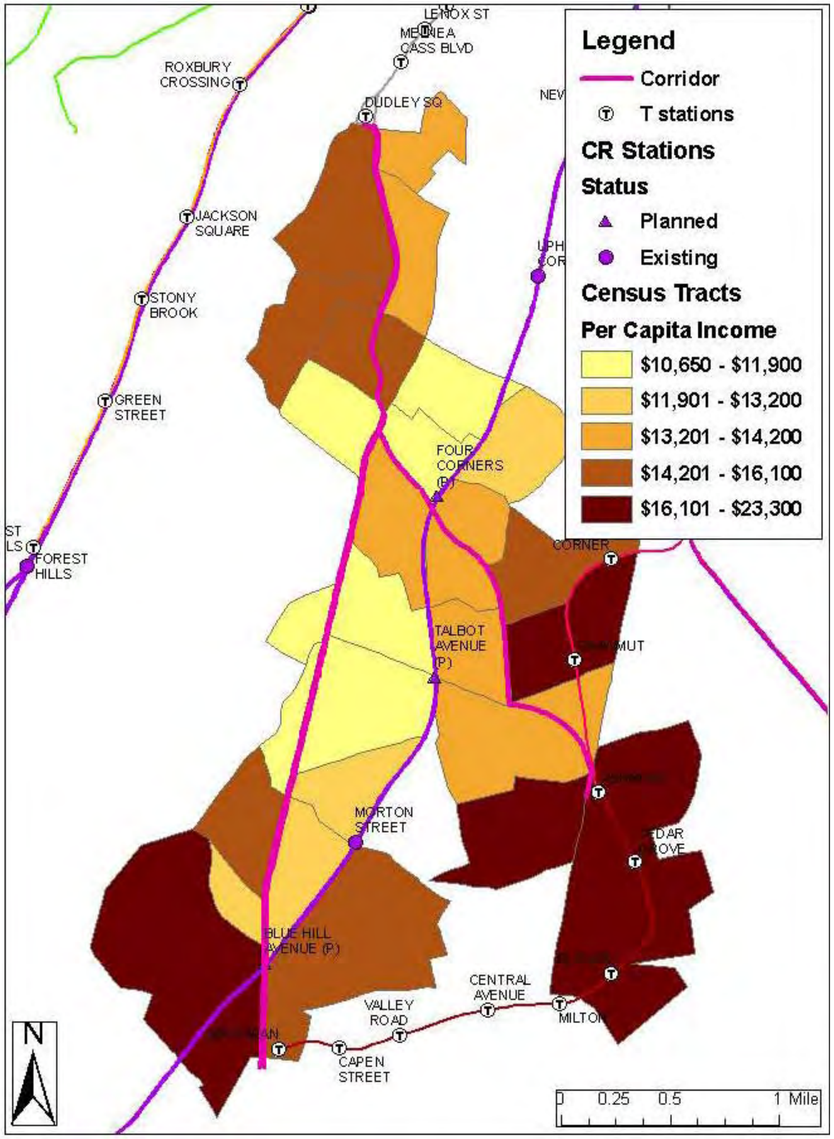


Figure 11: Population below Poverty Line

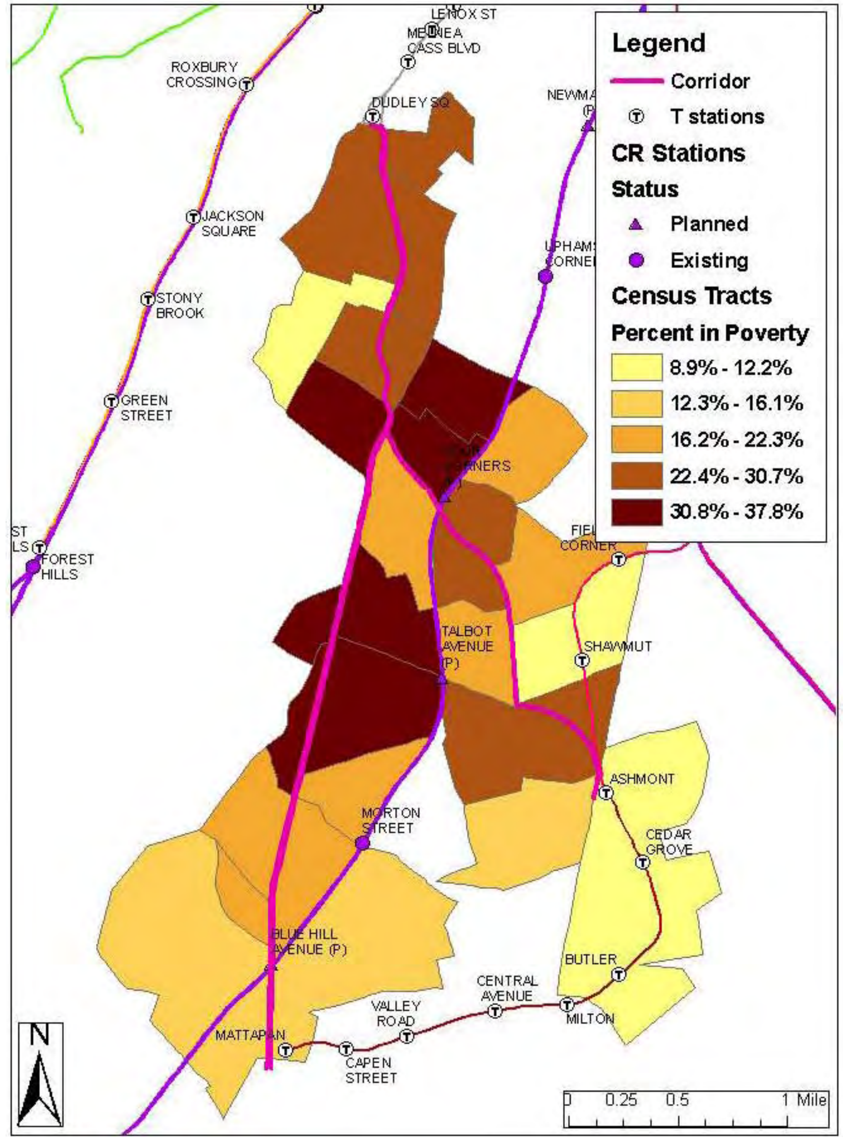
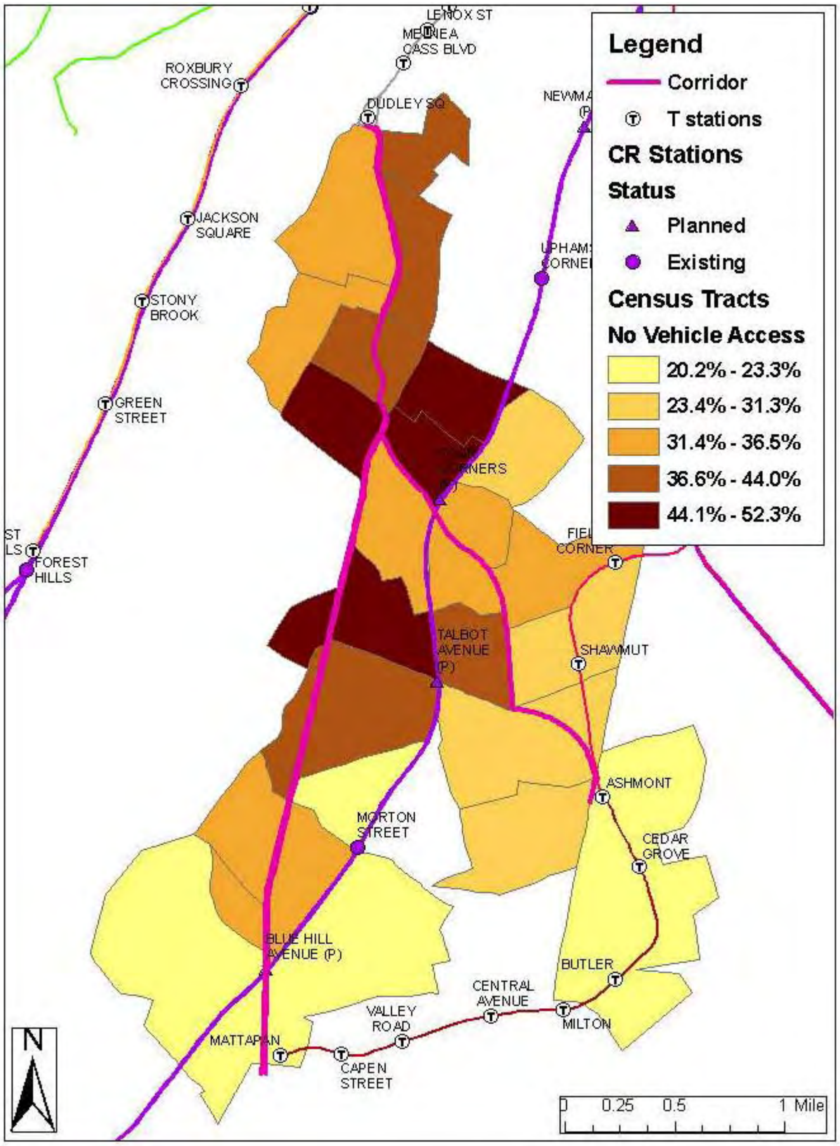


Figure 12: Population with No Private Vehicle Access

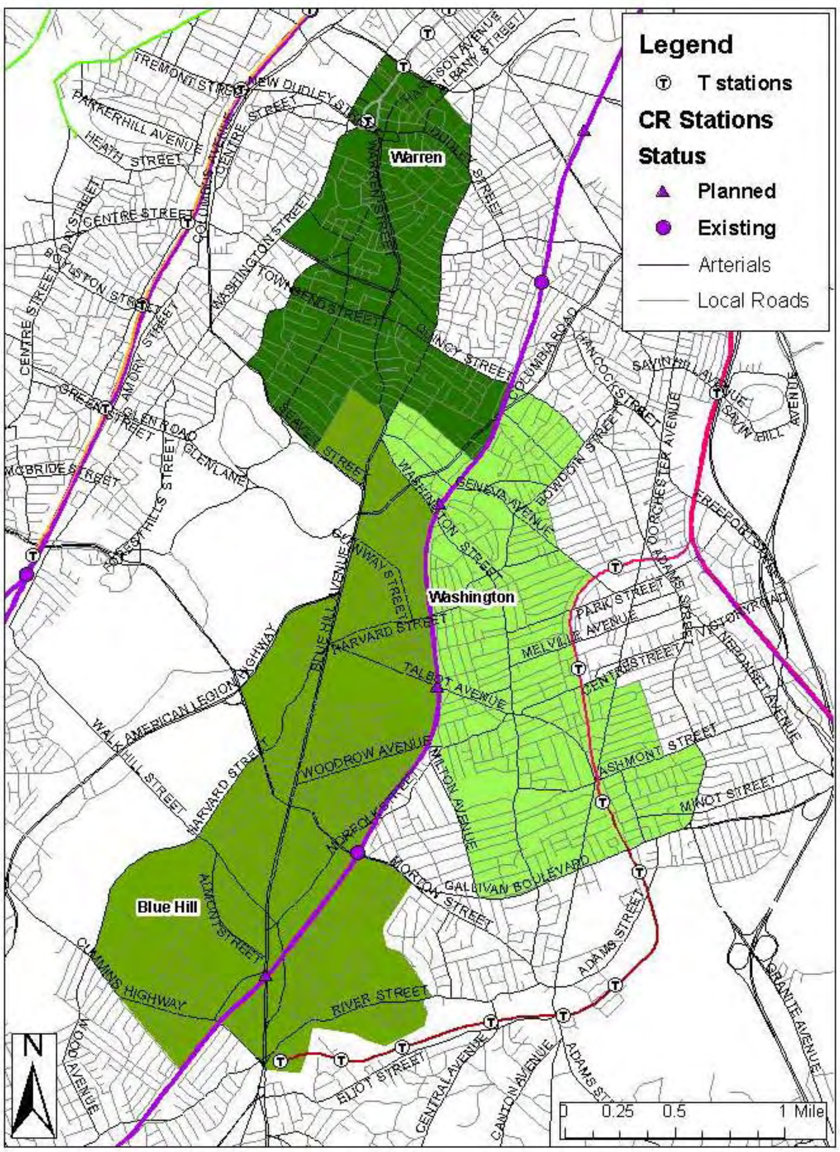


The Dudley South corridor, as evidenced by the various summaries of demographics of Census tracts in the corridor, exhibits many of the characteristics traditionally associated with high rates of urban bus transit usage. The corridor is characterized by high population densities, a majority of non-white residents, a large number of residents aged under 18, significant percentages of households with a primary language other than English and foreign-born residents, and high percentages of the population without access to a private vehicle. One of the most important markets for transit is the so-called "transit-dependent" population. These residents, who have no access to any private means of motorized transportation, must often rely on public transportation to access jobs, school, shopping, and other destinations. The characteristics listed above often correlate with limited private mobility and high public transportation usage. Therefore, there is likely a significant population served by the Dudley South corridor that is transit dependent, as well as a large number of "choice" riders for whom public transportation offers the least costly mode of travel.

Modeled Travel Patterns

The Boston Region MPO maintains a regional travel model in which, according to various model parameters, the number of trips between all pairs of transportation analysis zones (TAZ) is estimated. The model was used in this analysis to estimate the existing number of trips between three groupings of TAZs in the Dudley South corridor – Warren (Segments 1 and 2), Washington (Segments 3 and 4), and Blue Hill (Segments 5 and 6) – and all other TAZs. Figure 13 shows the geographic coverage of the various TAZ groupings. The modeled parameters are the same as those used to estimate demand under a Silver Line Phase III scenario.

Figure 13: Transportation Analysis Zone Groupings



Tables 1 through 4 present the modeled number of trips between the Dudley South corridor TAZ groupings (including the corridor as a whole) and other groupings of TAZs. Each table corresponds to a certain type of trip. These types are peak home-based work trips, peak all trips (including home-based work), non-peak all trips, and daily transit trips. Note that Tables 1 through 3 include all types of modal trips, while Table 4 includes only transit trips. The top five pairings are presented for each trip type.

Table 1: Peak Home-Based Work Trips

Trip Pairings Between TAZ Groupings		% trips	Trip Pairings Between TAZ Groupings		% trips
Warren	Allston, Brighton, Brookline	14%	Washington	Downtown Boston	19%
Warren	Downtown Boston	13%	Washington	Dorchester excl. Corridor, South Boston	10%
Warren	Dorchester excl. Corridor, South Boston	7%	Washington	Allston, Brighton, Brookline	9%
Warren	Roxbury excl. Corridor, Jamaica Plain	6%	Washington	Mattapan excl. Corridor, Milton, Quincy	7%
Warren	Back Bay, South End	6%	Washington	Back Bay, South End	6%
Blue Hill	Downtown Boston	16%	Corridor	Downtown Boston	17%
Blue Hill	Allston, Brighton, Brookline	10%	Corridor	Allston, Brighton, Brookline	11%
Blue Hill	Dorchester excl. Corridor, South Boston	7%	Corridor	Dorchester excl. Corridor, South Boston	8%
Blue Hill	Mattapan excl. Corridor, Milton, Quincy	7%	Corridor	Mattapan excl. Corridor, Milton, Quincy	7%
Blue Hill	West Roxbury, Dedham	6%	Corridor	Back Bay, South End	6%

Table 2: All Peak Trips (incl. Home-Based Work Trips)

Trip Pairings Between TAZ Groupings		% trips	Trip Pairings Between TAZ Groupings		% trips
Warren	Warren	20%	Washington	Washington	21%
Warren	Roxbury excl. Corridor, Jamaica Plain	16%	Washington	Dorchester excl. Corridor, South Boston	18%
Warren	Allston, Brighton, Brookline	11%	Washington	Mattapan excl. Corridor, Milton, Quincy	9%
Warren	Dorchester excl. Corridor, South Boston	8%	Washington	Blue Hill	7%
Warren	Blue Hill	5%	Washington	Downtown Boston	6%
Blue Hill	Blue Hill	24%	Corridor	Blue Hill	13%
Blue Hill	West Roxbury, Dedham	11%	Corridor	Washington	12%
Blue Hill	Mattapan excl. Corridor, Milton, Quincy	9%	Corridor	Dorchester excl. Corridor, South Boston	11%
Blue Hill	Dorchester excl. Corridor, South Boston	8%	Corridor	Mattapan excl. Corridor, Milton, Quincy	8%
Blue Hill	Washington	7%	Corridor	Roxbury excl. Corridor, Jamaica Plain	8%

Table 3: All Non-Peak Trips (incl. Home-Based Work Trips)

Trip Pairings Between TAZ Groupings		% trips	Trip Pairings Between TAZ Groupings		% trips
Warren	Warren	25%	Washington	Washington	25%
Warren	Roxbury excl. Corridor, Jamaica Plain	17%	Washington	Dorchester excl. Corridor, South Boston	18%
Warren	Allston, Brighton, Brookline	9%	Washington	Mattapan excl. Corridor, Milton, Quincy	10%
Warren	Dorchester excl. Corridor, South Boston	8%	Washington	Blue Hill	8%
Warren	Blue Hill	6%	Washington	Roxbury excl. Corridor, Jamaica Plain	6%
Blue Hill	Blue Hill	21%	Corridor	Washington	13%
Blue Hill	West Roxbury, Dedham	13%	Corridor	Blue Hill	12%
Blue Hill	Mattapan excl. Corridor, Milton, Quincy	11%	Corridor	Dorchester excl. Corridor, South Boston	12%
Blue Hill	Dorchester excl. Corridor, South Boston	8%	Corridor	Mattapan excl. Corridor, Milton, Quincy	9%
Blue Hill	Washington	8%	Corridor	Warren	9%

Table 4: All Daily Transit Trips (incl. Home-Based Work Trips)

Trip Pairings Between TAZ Groupings		% trips	Trip Pairings Between TAZ Groupings		% trips
Warren	Allston, Brighton, Brookline	23%	Washington	Downtown Boston	25%
Warren	Downtown Boston	16%	Washington	Cambridge	12%
Warren	Back Bay, South End	10%	Washington	Dorchester excl. Corridor, South Boston	11%
Warren	Dorchester excl. Corridor, South Boston	8%	Washington	Allston, Brighton, Brookline	10%
Warren	Roxbury excl. Corridor, Jamaica Plain	7%	Washington	Back Bay, South End	9%
Blue Hill	Downtown Boston	20%	Corridor	Downtown Boston	21%
Blue Hill	Allston, Brighton, Brookline	13%	Corridor	Allston, Brighton, Brookline	15%
Blue Hill	Roxbury excl. Corridor, Jamaica Plain	11%	Corridor	Dorchester excl. Corridor, South Boston	10%
Blue Hill	Back Bay, South End	10%	Corridor	Back Bay, South End	9%
Blue Hill	Dorchester excl. Corridor, South Boston	9%	Corridor	Cambridge	8%

Downtown Boston represents the top pairing for peak home-based work trips with the TAZ groupings of Washington, Blue Hill, and the corridor as a whole and the second largest pairing with the Warren TAZ grouping (see Table 1). This reflects the large number of jobs in the downtown Boston area to which residents of the corridor travel for work. A significant portion of corridor residents in each TAZ grouping also appears to travel to Allston, Brighton, or Brookline for work. Notably, none of the three TAZ groupings in the Dudley South corridor appear in the list of the top five peak home-based work trip pairings. However, areas of Roxbury, Dorchester, and Mattapan outside of the corridor do compose significant percentages of the modeled pairings.

When the number of peak trips expands to include all trip purposes (see Table 2), the influence of work trips on the percentages of trip pairings between TAZ groupings is diminished. Unlike the pairings for peak work trips, the top pairing in each corridor TAZ grouping lies within the corridor. Moreover, the majority of other groupings are with areas of Roxbury, Dorchester, or Mattapan outside of the corridor. This pattern is repeated for all non-peak trips (see Table 3).

While all peak and non-peak trips (which include all types of modal trips) appear to be weighted towards inter-corridor travel, all daily transit trips do not exhibit this same pattern. Transit trips actually demonstrate a pattern much more similar to that of the peak home-based work trips, in which areas such as downtown Boston, Allston, Brighton, Brookline, Back Bay, and the South End compose the major pairings. None of the TAZ groupings within the corridor are major pairings; however, pairings with areas of Roxbury, Dorchester, or Mattapan outside of the corridor do lie within the top five groupings.

According to the regional travel model, the majority of trips served by transit appear to be home-based work trips to downtown Boston. Indeed, the model estimates that approximately 63.4 percent of all trips between the corridor and downtown Boston are served via transit. The following table shows the top-20 mode share percentages for transit trips between the specified zone and the Dudley South corridor.

Table 5: Transit Mode Shares for Trips to/from Dudley South Corridor

TAZ Grouping	Transit Mode Share
Downtown Boston	63.4%
Cambridge	39.9%
Back Bay, South End	38.3%
East Boston	37.0%
Allston, Brighton, Brookline	26.5%
Somerville	18.3%
Charlestown, Chelsea, Revere, Winthrop	14.2%
Roxbury excl. corridor, Jamaica Plain	11.9%
Chelsea, Revere, Winthrop	11.0%
Dorchester excl. corridor, South Boston	9.9%
Mattapan excl. corridor, Milton, Quincy	6.2%
West Roxbury, Dedham	6.2%
Lynn, Saugus	5.4%
Warren	5.4%
Arlington, Belmont, Watertown	5.2%
Blue Hill	4.4%
Salem, Beverly, Hamilton	4.1%
Newton	3.7%
Washington	3.2%
Canton, Randolph, Stoughton	3.1%

The highest transit mode share percentage for all intra-corridor trips is with the Warren TAZ grouping, with 5.4 percent of trips. The TAZ groupings for Blue Hill and Washington have transit mode shares of 4.4 percent and 3.2 percent, respectively. Therefore, there exists a significant percentage of intra-corridor trips, as well as trips to transit-accessible destinations in Roxbury, Dorchester, and other areas of Boston, that are not currently using transit. This represents a potential market for improved transit services in the corridor.

SERVICE ASSESSMENT

Routes 23 and 28 are two of the most heavily traveled routes in the MBTA bus system. In the fall 2007 quarter, when both Route 23 and Route 28 were last ridechecked, 11,142 daily weekday boardings were counted on Route 23 and 10,607 daily weekday boardings were counted on Route 28. These ridership totals are among the largest in the MBTA bus system, with only Route 1, Route 39, and the Silver Line Washington Street having greater daily ridership totals.

The MBTA routinely collects performance data on each route in the system. The following sections summarize the performance of Routes 23 and 28 for the following measures: schedule adherence, crowding, and speed. Summaries of the average distance between stops, the number of boardings and alightings at each stop, the number of shelters, and the method of fare payment are also presented.

Schedule Adherence

The MBTA assesses schedule adherence based on an average of on-time performance at the departure, mid-route, and arrival points. The following analysis considers, for simplicity of presentation, only bus on-time performance at departure and arrival points.

As seen in the following tables, the majority of both departures and arrivals on outbound and inbound trips throughout the day on Route 23 do not adhere to the schedule. Route 28 performs slightly better with regards to departures but has worse schedule adherence in terms of arrivals.

Table 6: Route 23 Weekday Schedule Adherence

Outbound Trips	Departures	Arrivals	Inbound Trips	Departures	Arrivals
Early	1.5%	4.6%	Early	8.3%	4.5%
On Time	47.7%	42.3%	On Time	37.9%	35.6%
Late	50.8%	53.1%	Late	53.8%	59.8%

Table 7: Route 28 Weekday Schedule Adherence

Outbound Trips	Departures	Arrivals	Inbound Trips	Departures	Arrivals
Early	1.7%	6.9%	Early	2.4%	5.7%
On Time	56.0%	32.8%	On Time	54.5%	32.5%
Late	42.2%	60.3%	Late	43.1%	61.8%

Schedule adherence on Routes 23 and 28 also varies considerably throughout the day. As seen in Figures 14 and 15, schedule adherence for departures and arrivals on Route 23 in both directions is below 40 percent during and between the AM peak and PM peak time periods. During the PM peak, the percentage of trips with on-time departures and arrivals actually drops below 20 percent in both directions. Route 28 weekday schedule adherence follows a different pattern from Route 23. Departures generally have a much better on-time percentage than arrivals, indicating that buses are experiencing unscheduled delay in the course of traveling the corridor. The worst period for schedule adherence on Route 28 appears to be the midday school and PM peak time periods, when on-time performance falls below 40 percent for departures and arrivals in both directions.

A comparison of scheduled to actual run times can indicate the extent to which unscheduled delay is causing late arrival times even when departures are occurring on time. In addition, actual run times that oscillate around the scheduled run time are likely indicators of bus bunching. Bus routes running in general traffic with headways below 10 minutes are often confronted with this problem. In essence, buses that fall slightly behind schedule for whatever reason will fall progressively further behind schedule, as more passengers are likely to queue at future stops, requiring the bus to make more frequent stops with longer boarding and alighting times. At the same time, the next scheduled bus, even if it departs on time, will get progressively further ahead of schedule, since many of its regularly scheduled passengers will have boarded the first bus due to its delay. Eventually, the two buses will bunch together – the first with a high load and the second with a small load, and the second bus may actually pass the first.

Figure 14: Route 23 Weekday Percent On-Time Arrivals and Departures

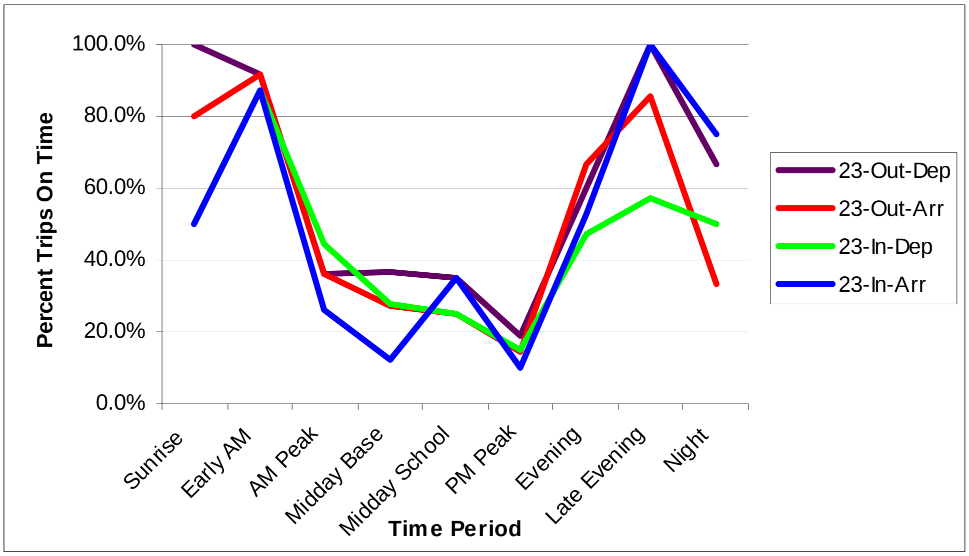
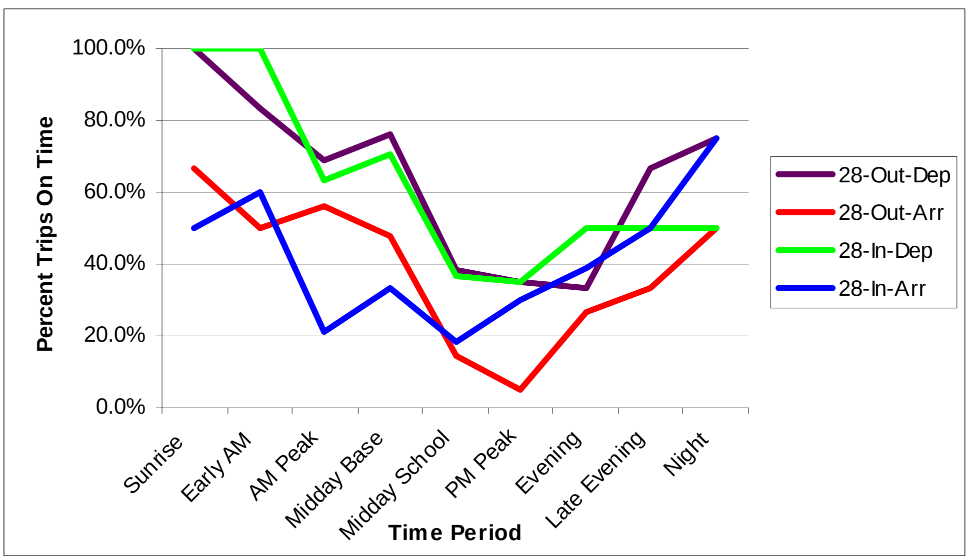


Figure 15: Route 28 Weekday Percent On-Time Arrivals and Departures



As seen in Figures 16 and 17, Route 23 is characterized by this oscillating pattern in actual run times. One trip with a long actual run time is typically followed by a trip with a short actual run time. Not surprisingly, boardings follow this same general pattern, as buses with long actual run times also tend to have large boarding totals, and small ridership totals on buses are correlated with short actual run times. The inbound direction of Route 23 appears to have more instances of large swings in run times throughout the day, as well as actual run times that are consistently longer than the scheduled times. However, the largest swing in run times occurs in the outbound direction during the midday school time period (1:00 PM to 3:30 PM).

Figure 16: Scheduled vs. Actual Run Times – Route 23 Inbound

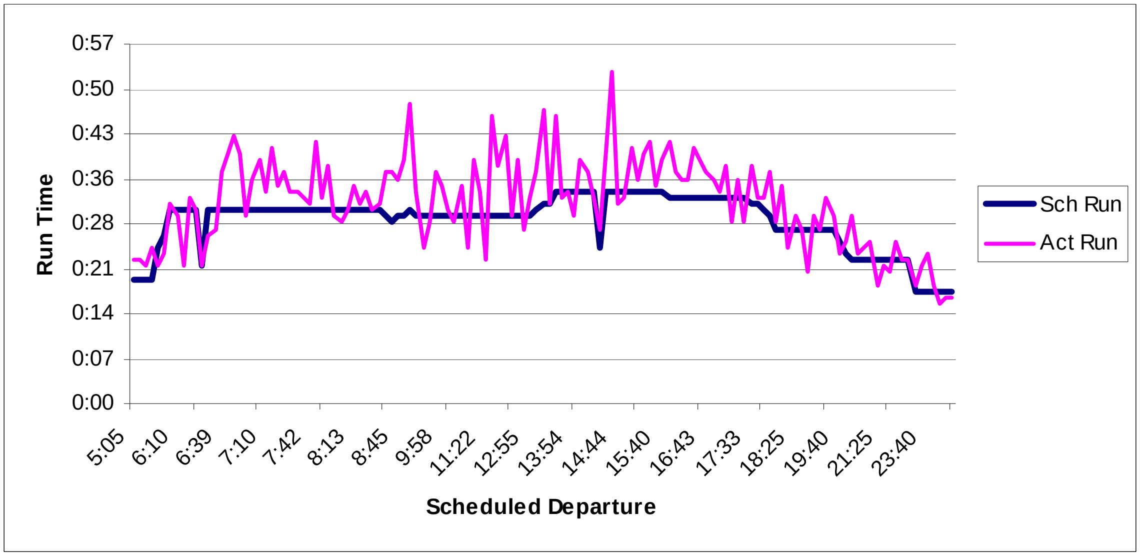
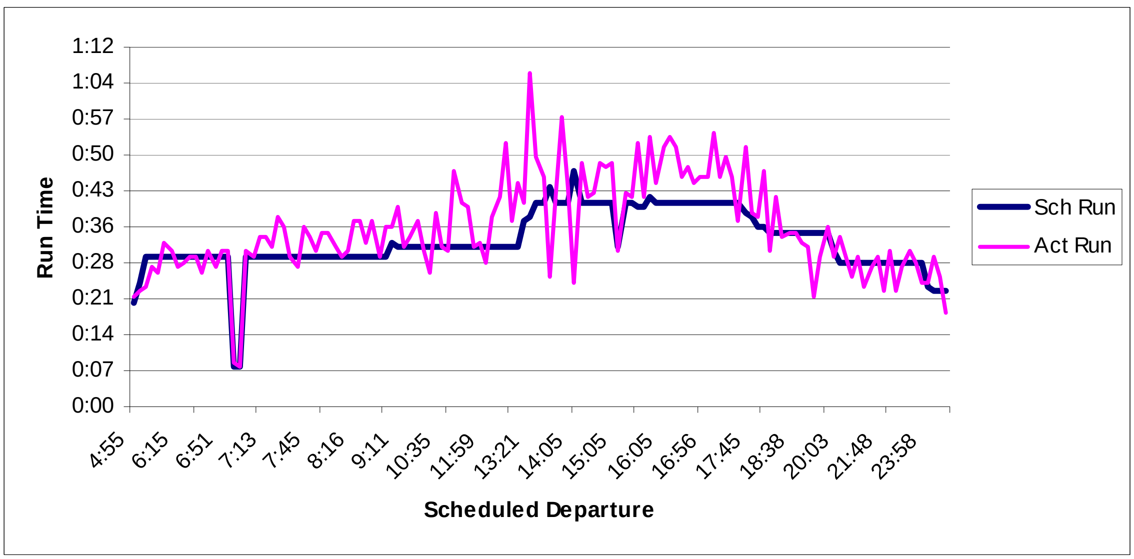


Figure 17: Scheduled vs. Actual Run Times – Route 23 Outbound



Route 28 also appears to be affected by varying run times, though not quite to the same extent as Route 23. As is the case with Route 23, the inbound direction appears to have more instances of oscillating actual run times consistently greater than the scheduled run times. The greatest discrepancies in actual run times in the inbound direction occur during the Midday School time period. Outbound run times have the greatest discrepancies during the PM Peak time period, which is also the only time during the day that run times are constantly longer than what is scheduled.

Figure 18: Scheduled vs. Actual Run Times – Route 28 Inbound

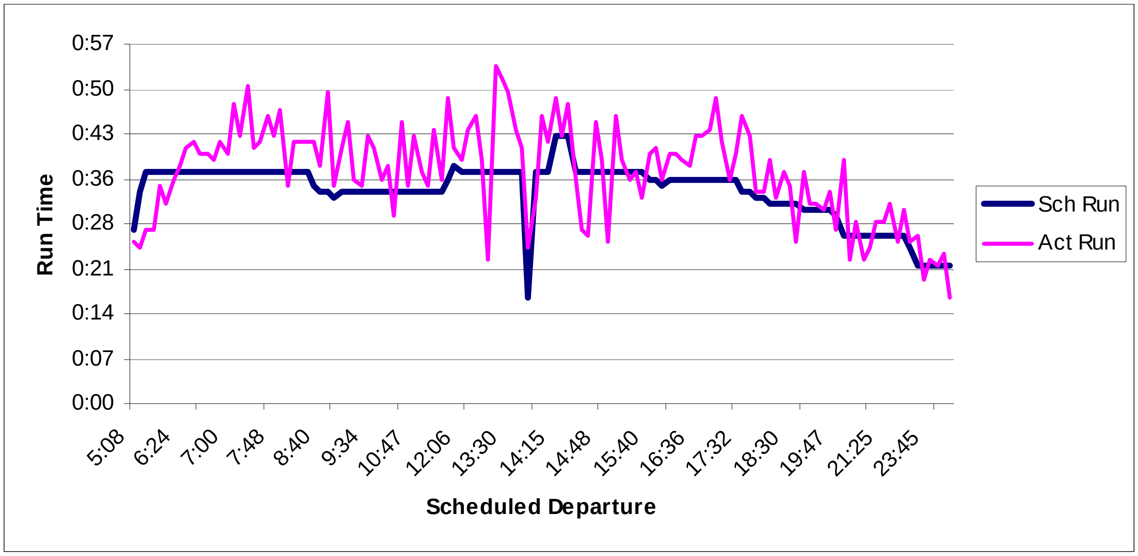
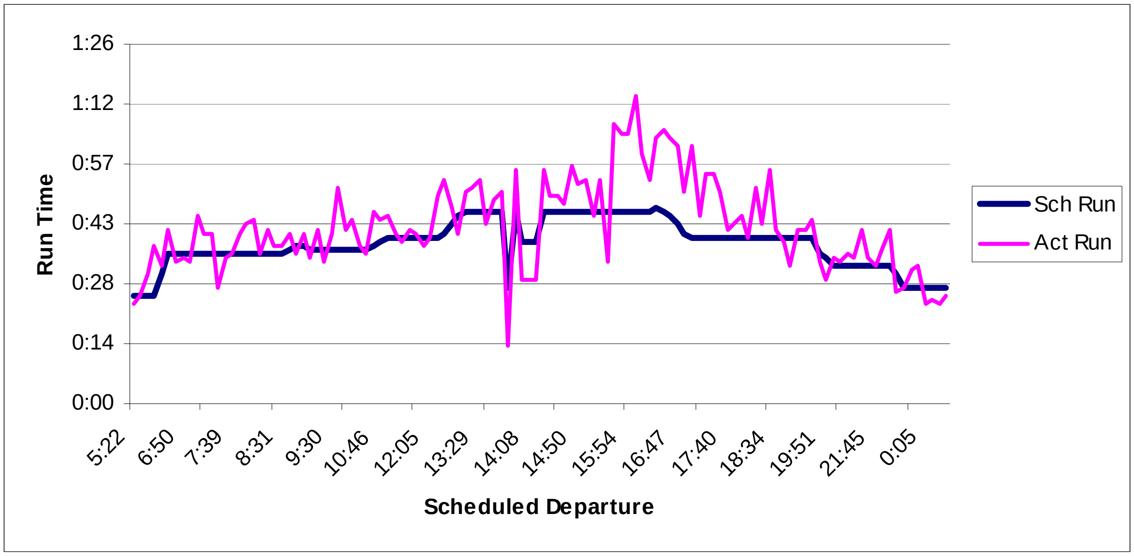


Figure 19: Scheduled vs. Actual Run Times – Route 28 Outbound



Crowding

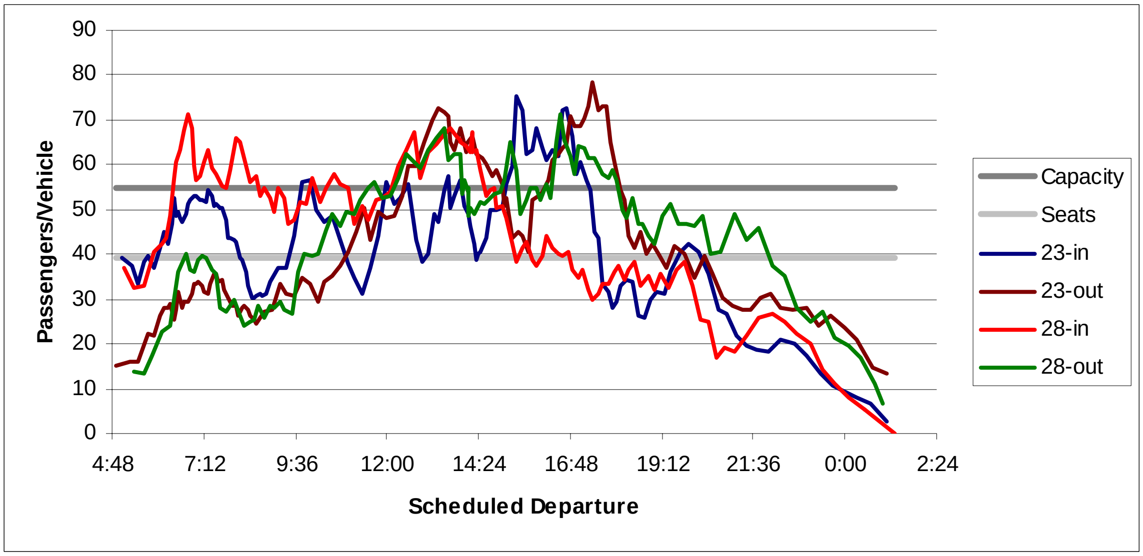
Passenger crowding, or excessive vehicle loads, is also a common problem on these two routes. With passenger seating limited to 39 on the non-articulated low-floor buses serving Routes 23 and 28, the MBTA service delivery policy states that the number of passengers over a rolling 30-minute average should not exceed 140 percent of seated capacity during the peak periods and 100 percent during the non-peak periods. The following table presents the peak 30-minute average maximum load on the two routes in both directions and the load factor (the ratio of passengers to seated capacity). As seen in the table, the outbound direction of Route 23 and the inbound direction of Route 28 fail the vehicle load standard of 1.40 passengers per seat.

Table 8: Peak 30-Minute Average Maximum Loads

Route	Direction	Peak 30-Min. Avg. Max. Load	Load Factor
23	Outbound	57.6	1.48
23	Inbound	52.3	1.34
28	Outbound	48.5	1.24
28	Inbound	55.0	1.41

Figure 20 demonstrates the extent to which weekday Route 23 and Route 28 hourly passenger loads exceed 39 and 55 passengers per vehicle, the seated capacity and 140 percent of the seated capacity, respectively. While these are the same load standards used by the MBTA to analyze crowding, their application differs in the figure. As seen in Figure 20, these capacity levels are shown across the entire service day, while the MBTA applies different load standards depending on the time of day. Hourly loads with consistent load measures are used in the figure for simplicity of presentation. Each combination of route and direction seems to have a slightly different pattern, though each exceeds 55 passengers per vehicle at least once during the day. Route 23 inbound, while exceeding the seated capacity several times in the AM peak, Midday base, and Midday school time periods, does not exceed 55 passengers per vehicle until the first half of the PM peak period. In the outbound direction, however, Route 23 exceeds 55 passengers per vehicle twice – once in the midday base and school time periods and once in the latter half of the PM peak time period. Route 28 also generally follows this pattern in the outbound direction, while in the inbound direction, Route 28 exceeds 55 passengers per vehicle twice in the AM Peak, midday base, and midday school time periods but otherwise generally remains below the seated capacity.

Figure 20: Hourly Ratio of Passengers/Vehicle



As two of the most heavily traveled routes in the MBTA bus system, Routes 23 and 28 face significant problems in terms of schedule adherence and passenger crowding. These two problems often reinforce one another, as poor schedule adherence on a bus leads to a greater numbers of passengers waiting for the bus, which worsens crowding, slows boarding times, and further delays the bus. As part of this effort to improve service in the Dudley South corridor, therefore, this analysis will target the problems experienced by Routes 23 and 28 as indicative of those facing all buses serving the corridor.

Speed

Slow bus speeds are caused by a number of factors, from general traffic conditions to the frequency of stops. Slow bus speeds are not a problem, per se, to the extent that they can be anticipated and scheduled by setting bus frequencies to avoid issues of schedule adherence and crowding. However, passengers have an instinctively negative view of slow travel speeds. Moreover, slow bus speeds require a greater number of buses to serve the corridor.

Figures 21-24 present data obtained from the AVL (automatic vehicle location) technology with which all buses on Routes 23 and 28 are equipped. This GIS-based software allows the MBTA to track the arrival time of buses to individual time points located along a route. The calculated average speeds in terms of miles per hour (mph) are presented for both Route 23 and Route 28, with Route 23 represented along Warren Street by the inside lines (those adjacent to the street) and Route 28 represented by the outside lines. Figure 21 represents the average daily speeds, and Figures 22-24 depict average speeds for the AM Peak (6:00 to 9:00), Midday (13:00 to 16:00), and PM Peak (16:00 to 19:00). Table 9 lists the average speeds by various segment combinations.

As seen in Figures 21-24 and Table 9, Route 23 generally has slower average speeds over the course of the corridor than Route 28. The greatest delays to Route 23 appear to occur in the departure from Dudley Station and the approach to Codman Square in the outbound direction, and in the turn onto Blue Hill Avenue from Washington Street and north of Codman Square in the inbound direction. Only in the arrival to Mattapan Station does Route 28 have an average speed below 5 mph. Average speeds are the slowest during the midday period. As seen in Figure 23, the slower average speeds in the midday period are likely due to a few select areas of significant delay, as speeds elsewhere in the corridor appear to be faster than those occurring during the AM or PM Peak periods.

Table 10 lists the five timepoint segments with the slowest average speeds for each time period. Four of the segments are the same for all time periods: Dudley Station to Warren Street at Walnut Avenue in the outbound direction; Four Corners to Codman Square in the outbound direction; Codman Square to Four Corners in the inbound direction; and Washington Street at Columbia Road to Grove Hall in the inbound direction. In the AM and PM Peak periods, the fifth-slowest segment is between Franklin Park and Grove Hall in the inbound and outbound directions, respectively. During the midday period and in terms of the daily average, the fifth-slowest segment is between Grove Hall and Washington Street at Columbia Road. All but a few segments belong to Route 23, thus contributing to the slower average speed for the entire route.

Table 9: Average Speed (mph) by Segment and Segment Combinations

Segment	Description	Dir.	Average Speed (miles-per-hour)			
			Daily	AM Peak	Mid-Day	PM Peak
1	Dudley Station to Grove Hall	Out	7.3	9.5	5.8	6.4
2	Grove Hall to Dudley Station	In	11.2	11.1	9.8	11.4
3	Grove Hall to Ashmont Station	Out	8.4	9.6	6.8	7.4
4	Ashmont Station to Grove Hall	In	8.9	8.9	7.8	8.3
5	Grove Hall to Mattapan Station	Out	9.3	10.6	8.0	8.0
6	Mattapan Station to Grove Hall	In	9.7	9.3	8.6	9.3
1, 3, 5	Dudley Station to Ashmont and Mattapan Stations	Out	8.5	10.0	7.1	7.4
2, 4, 6	Ashmont and Mattapan Stations to Dudley Station	In	9.6	9.5	8.5	9.3
1, 3	Dudley Station to Ashmont Station (Route 23)	Out	8.1	9.7	6.4	7.2
1, 5	Dudley Station to Mattapan Station (Route 28)	Out	8.5	10.0	7.2	7.3
2, 4	Ashmont Station to Dudley Station (Route 23)	In	9.6	9.7	8.3	9.3
2, 6	Mattapan Station to Dudley Station (Route 28)	In	10.1	9.8	9.0	9.8

Table 10: Slowest Average Speeds (mph) between Timepoints by Time Period

Period	From	To	Route	Dir.	mph
Daily	Dudley Station	Warren St @ Walnut Ave	23/28	Out	3.9
	Four Corners	Codman Square	23	Out	6.2
	Codman Square	Four Corners	23	In	6.3
	Washington St @ Columbia Rd	Grove Hall	23	In	6.5
	Grove Hall	Washington St @ Columbia Rd	23	Out	7.1
AM Peak	Dudley Station	Warren St @ Walnut Ave	23/28	Out	5.0
	Washington St @ Columbia Rd	Grove Hall	23	In	6.5
	Codman Square	Four Corners	23	In	6.8
	Four Corners	Codman Square	23	Out	7.6
	Franklin Park	Grove Hall	28	In	7.8
Midday	Dudley Station	Warren St @ Walnut Ave	23/28	Out	3.0
	Four Corners	Codman Square	23	Out	4.8
	Codman Square	Four Corners	23	In	5.5
	Washington St @ Columbia Rd	Grove Hall	23	In	5.6
	Grove Hall	Washington St @ Columbia Rd	23	Out	5.7
PM Peak	Dudley Station	Warren St @ Walnut Ave	23/28	Out	3.4
	Four Corners	Codman Square	23	Out	5.3
	Washington St @ Columbia Rd	Grove Hall	23	In	5.8
	Codman Square	Four Corners	23	In	5.9
	Grove Hall	Franklin Park	28	Out	6.6

Figure 21: Daily Average Speed between Timepoints

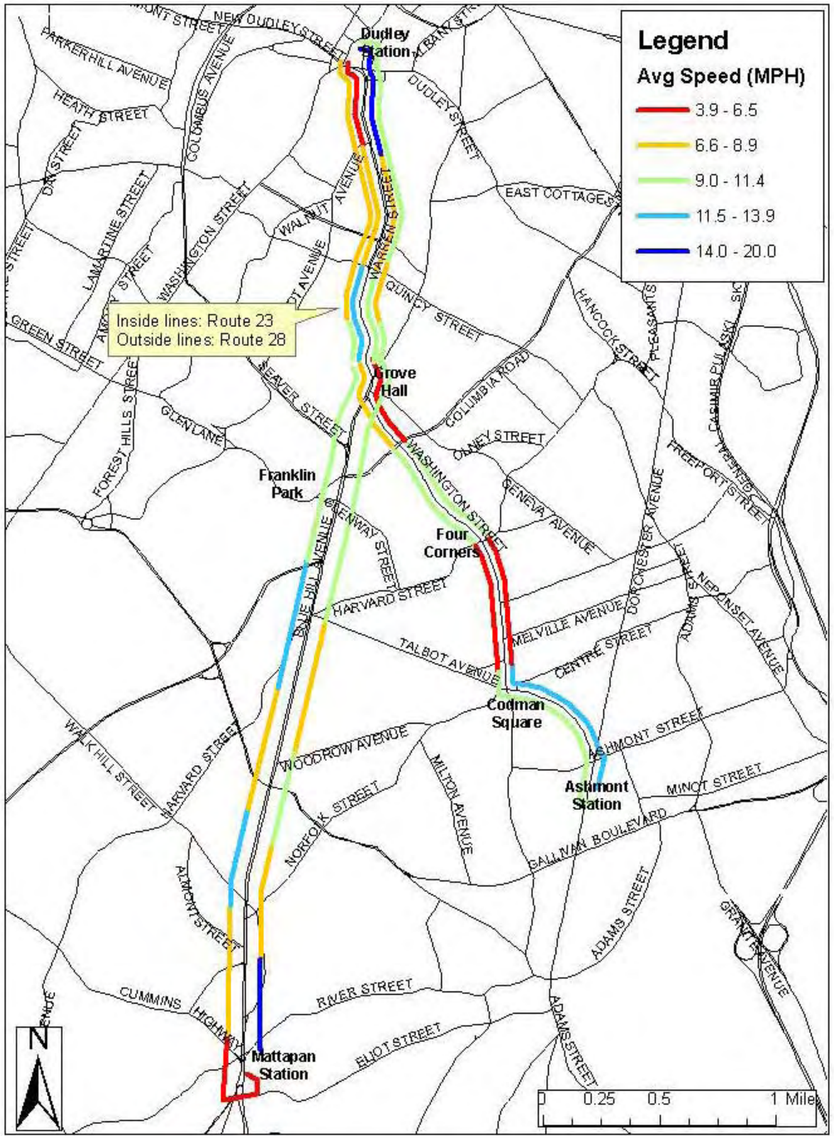


Figure 22: AM Peak Average Speed between Timepoints

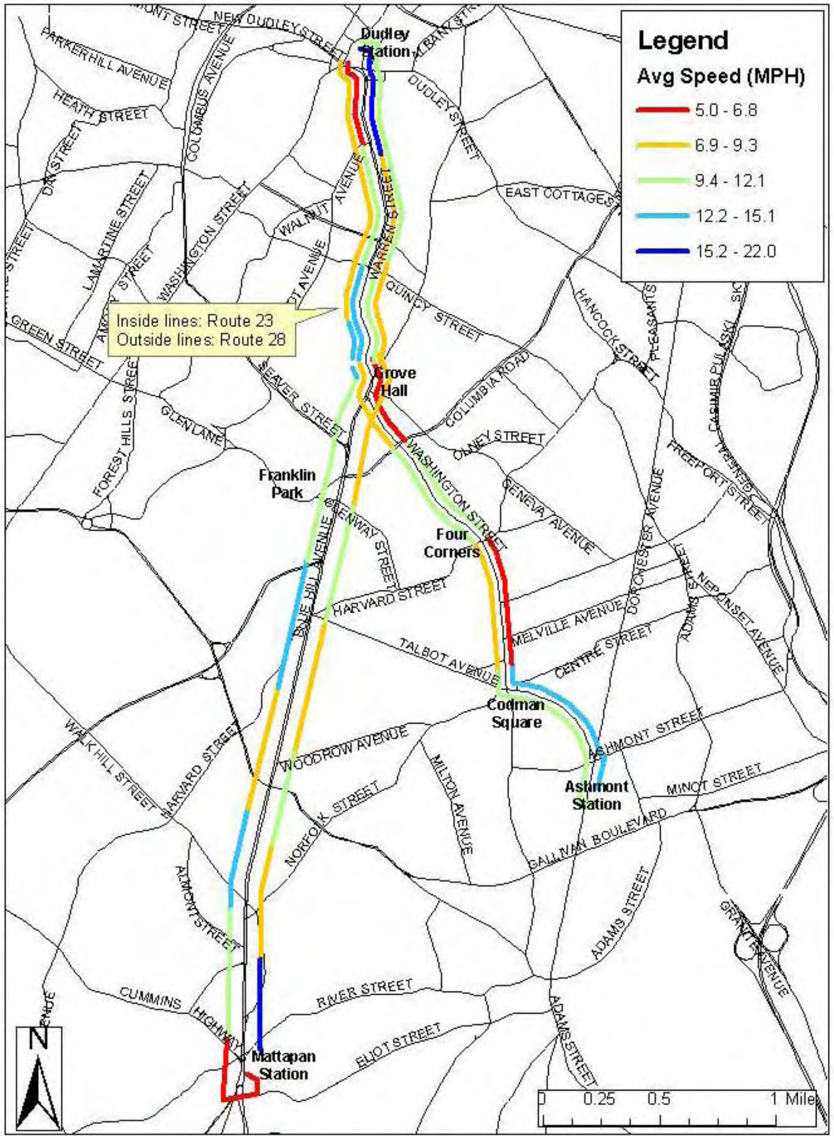


Figure 23: Midday Average Speed between Timepoints

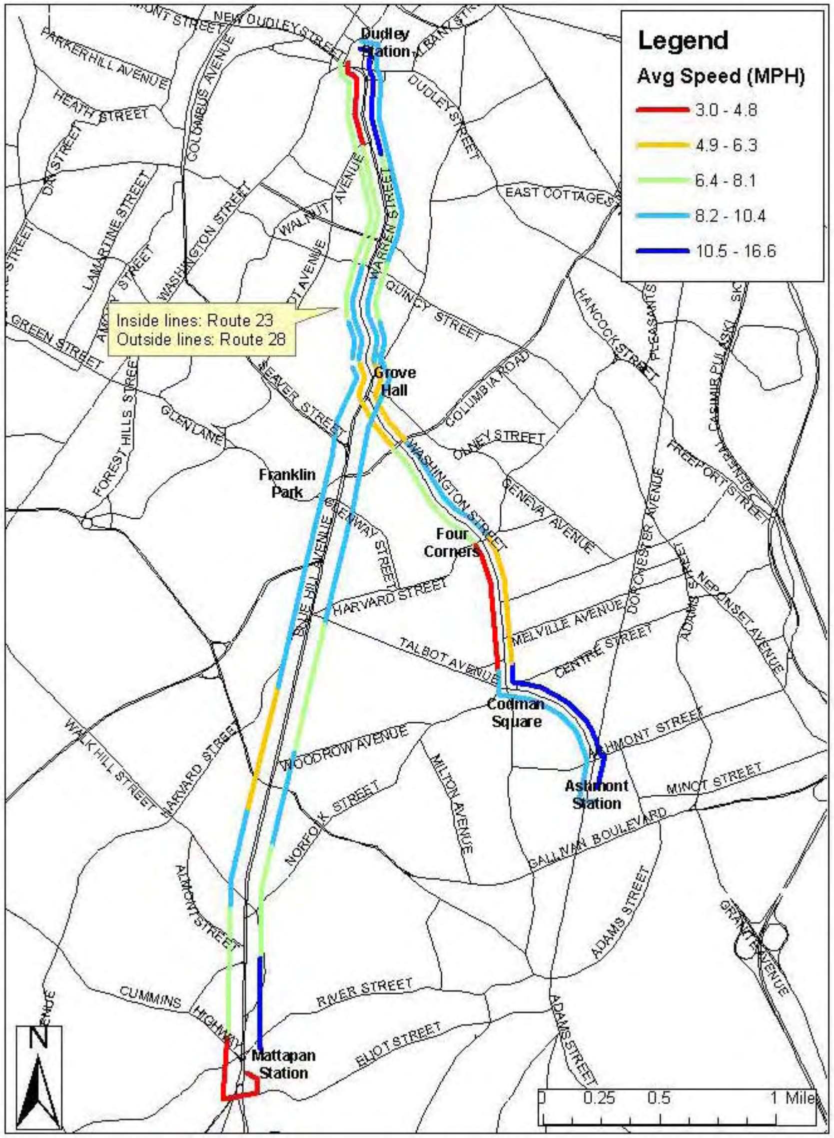
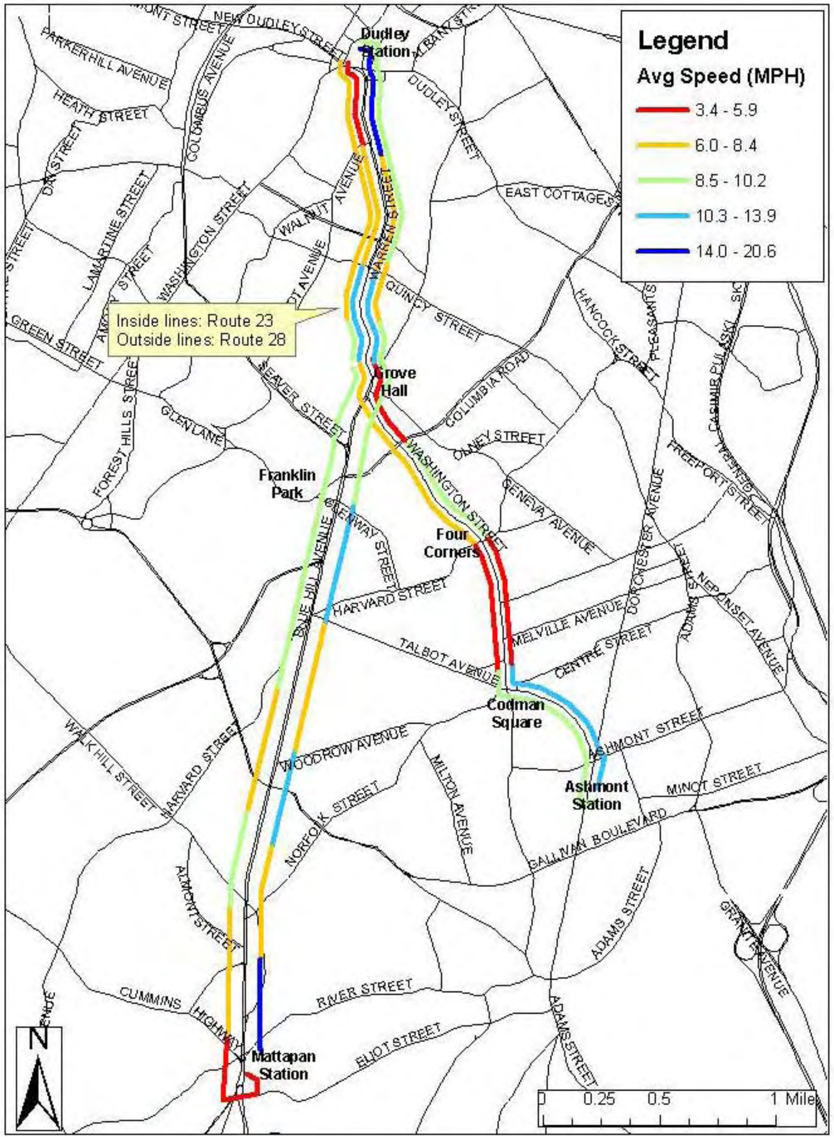


Figure 24: PM Peak Average Speed between Timepoints



For buses running in mixed traffic, the general travel conditions, particularly on roads with periods of significant congestion such as Warren Street, Washington Street, and Blue Hill Avenue, can affect bus travel speeds. Figure 25 presents the average traffic speeds from the Boston Region MPO Congestion Management Process (CMP) along Blue Hill Avenue, and Figure 26 shows the Route 28 daily speed over this same segment.

The speeds in these two figures appear to be loosely correlated. The comparison is somewhat difficult to make, given that slow bus travel speeds do not appear to be a major problem on Blue Hill Avenue, particularly when compared to Washington Street. However, the faster general-traffic speeds south of Morton Street may contribute to slightly faster average bus speeds in this area. Similarly, the congestion that seems to exist north of Morton Street may be correlated with the slightly slower average bus speeds over this area. The average bus speed over segments south of Morton Street is 11.9 MPH, versus 9.76 MPH for segments north of Morton Street.

Intersection Performance

The performance of intersections in the Dudley South corridor influences the speeds of both general traffic and buses. One task in this study focused on seven signalized intersections located along Blue Hill Avenue at the following streets:

- Warren Street
- Washington Street/Cheney Street
- Seaver Street (Route 28)
- Columbia Road/Circuit Drive
- Glen Lane/Glenway Street
- American Legion Highway
- Talbot Avenue/Harvard Street.

The seven signalized intersections studied in this task are the northernmost intersections along Blue Hill Avenue. Given the limited scope of this study, only a certain number of intersections were selected. Staff chose these intersections primarily because they carry higher traffic volumes than any other intersection along Blue Hill Avenue and are contiguous locations. The latter characteristic is very important for traffic signal coordination or transit signal priority considerations. In order for either of those types of measures to be implemented through the entire length of the corridor, the same data presented below for these seven intersections would need to be collected for all signalized intersections.

Note that several of the studied signals are already coordinated. Specifically, the intersections of Blue Hill Avenue with Warren Street and Washington Street currently have signal coordination, as do the intersections of Blue Hill Avenue with Seaver Street, Columbia Road, and Glenway Street. Furthermore, the intersections of Blue Hill Avenue with Talbot Avenue and Harvard Street are controlled by one signal.

Figure 25: General Traffic – Blue Hill Avenue Average Speeds

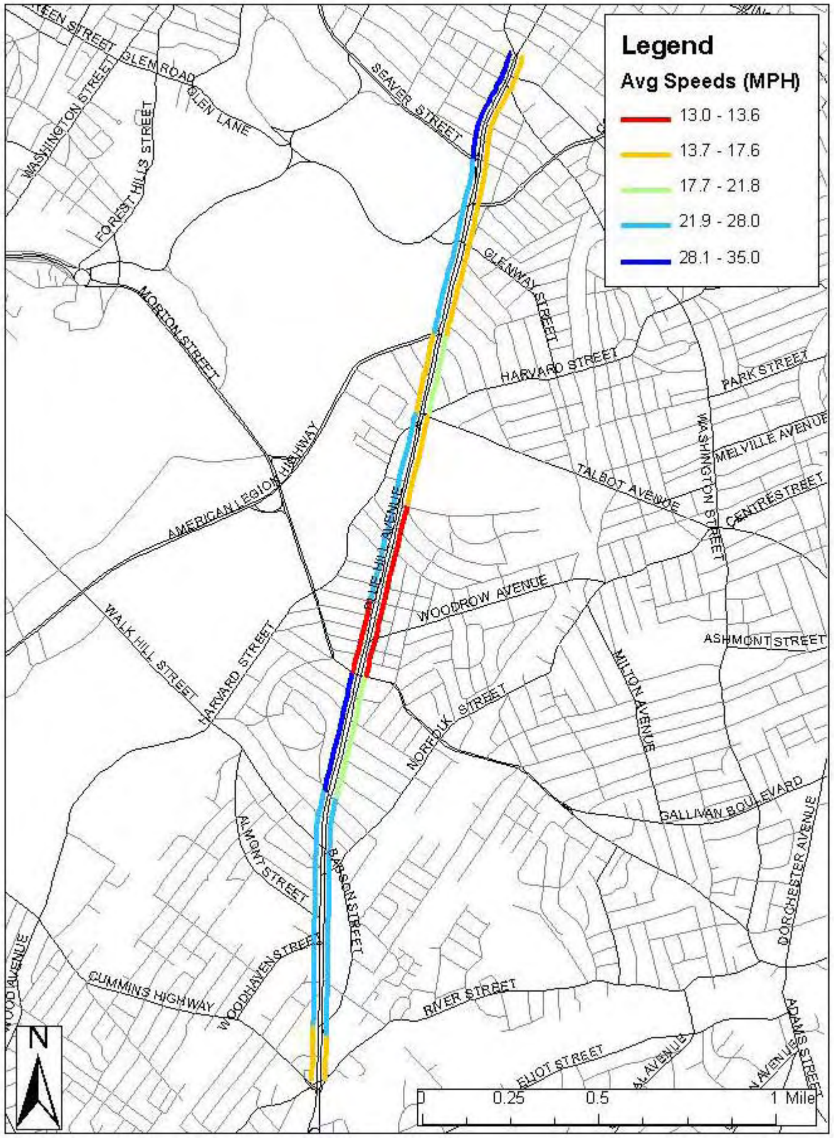
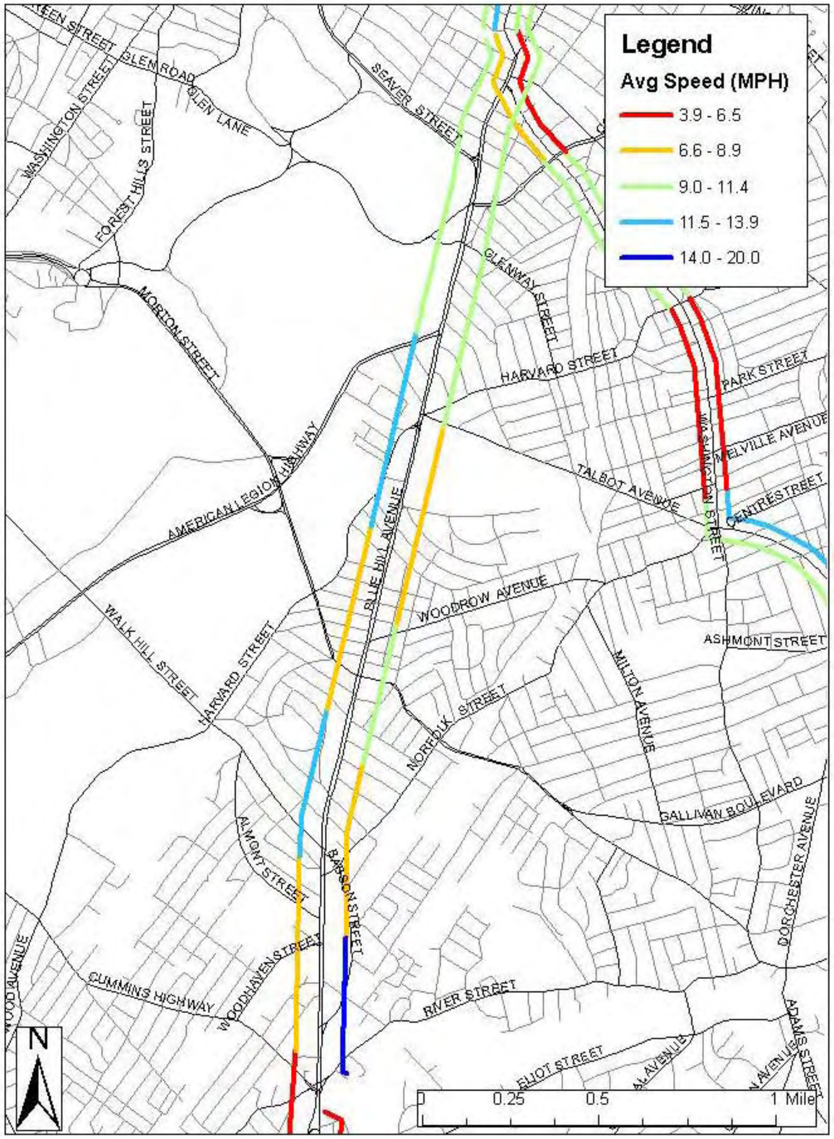


Figure 26: Route 28 – Blue Hill Avenue Average Speed



Along this section of the corridor, Blue Hill Avenue is primarily a six-lane, median-divided roadway. Turning lanes are provided at the signalized intersections and many of the unsignalized intersections as well. Staff obtained intersection data from several sources. The City of Boston's Transportation Department (BTD) provided signal timing and phasing information. CTPS staff collected counts of vehicle turning movements, including those previously collected as part of the ongoing Congestion Management Process (CMP). A description of the lane markings for each signalized intersection can be found in Appendix A.

The seven signalized intersections described above were analyzed using the SYNCHRO[1] travel model to determine their level of service (LOS), volume-to-capacity ratio (V/C), and intersection delay.

Capacity Analysis Methodology

The capacity analysis methodology is based on the concepts and procedures in the 2000 Highway Capacity Manual (HCM). LOS is a qualitative measure describing operational conditions within a traffic stream. A LOS definition provides a quality-of-flow index for traffic movements in terms of speed, travel time, freedom to maneuver, traffic interruptions, queues, delays, comfort, convenience, and safety.

There are six levels of service, given letter designations from A to F, with LOS A representing the best operating conditions and LOS F representing failing operations. For each type of transportation facility, from freeways to unsignalized intersections, a separate set of quantitative criteria defining the six levels of service has been established. General descriptions of each LOS follow:

- LOS A: conditions with little to no delay to motorists
- LOS B: a desirable level with relatively low delay to motorists
- LOS C: conditions with average delay to motorists
- LOS D: operations where the influence of congestion becomes noticeable to motorists; however, delays are still within an acceptable range
- LOS E: conditions with high delay values; considered to be the limit of acceptable delay
- LOS F: unacceptable to most drivers; at intersections, arrival flow rates exceed intersection capacity

The HCM calculates LOS for signalized intersections by assessing the effects of signal type, timing, phasing, and progression, and of vehicle mix and geometrics, to calculate average control delay. Average control delay includes deceleration delay, queue move-up time, stopped delay, and final acceleration delay. The following table presents the LOS criteria for signalized intersections.

[1] Synchro 7 with Simtraffic, version 7 (build 761).

Table 11: LOS Criteria for Intersections

LOS	**Signalized Intersection Criteria** Average Control Delay (seconds per vehicle)
A	≤ 10
B	> 10 and ≤ 20
C	> 20 and ≤ 35
D	> 35 and ≤ 55
E	> 55 and ≤ 80
F	> 80

Transportation Research Board, *Highway Capacity Manual 2000* (Washington, D.C.: 2000).

Results of Existing Conditions Analysis

Tables 12 and 13 show the analysis results for the intersections during the AM and PM peak hours, respectively. The tables summarize operations with the existing geometric conditions for the existing signal timings, for optimized signal timings, and for coordinated signal timings. Existing signal timings and phasing were taken from data provided by the City of Boston and reflect the current signal operations as they exist today. Optimized signal timings and phasing were developed using SYNCHRO to optimize the operations of each individual intersection by reducing the delays. Coordinated signal timings and phasing were applied to several groupings of intersections to allow platoons of vehicles at certain speeds to continue through each grouping without stopping. As several of the seven analyzed intersections are already coordinated, the coordinated signal timings only represent modifications to the optimized signal timings to improve upon the existing level of coordination.

The results of the analysis along Blue Hill Avenue at these seven signalized intersections indicate that traffic operations with the existing signal timings range within acceptable levels of delay. The overall LOS ranges from C to D in both the AM and PM peak hours, except at the Seaver Street intersection in the PM peak, when the LOS is E. Queuing is only problematic at the northernmost two intersections, Blue Hill Avenue at Warren Street and Washington Street, due to their close proximity to each other. Based on the analysis, the demand of northbound left-turning traffic from Blue Hill Avenue onto Warren Street is greater than the space provided by the protected left-turn bay.

Given that the existing signal timings along the stretch of Blue Hill Avenue between Warren Street and Harvard Street result in acceptable levels of delay, it does not appear that bus operations are being unduly affected by poor intersection performance. Future analyses should undoubtedly review the remainder of the intersections in the corridor, however, before ruling out the potential for signal coordination and optimization to have a positive impact on bus performance. Finally, the impact of any bus improvement measures on LOS should be considered.

Table 12: AM Peak Hour Intersection Operations

Approach/Movement		Existing Signal Timings			Optimized Signal Timings			Coordinated Signal Timings		
		LOS	V/C	Delay (sec)	LOS	V/C	Delay (sec)	LOS	V/C	Delay (sec)
Blue Hill Avenue and Warren Street										
Blue Hill Ave NB	Left	D	0.89	38.0	C	0.82	30.1	C	0.82	28.0
Blue Hill Ave NB	Thru/Right	A	0.43	7.7	A	0.42	3.0	A	0.42	2.9
Blue Hill Ave SB	All	D	0.66	42.2	D	0.72	42.2	D	0.72	42.2
Warren St SE	Left/Right	E	0.80	58.7	E	0.87	67.0	E	0.87	67.0
Warren St SE	Right	D	0.15	39.3	D	0.15	36.9	D	0.15	36.9
Plaza Driveway WB	Left	D	0.46	43.0	D	0.48	40.2	D	0.48	40.2
Plaza Driveway WB	Right	E	0.80	60.3	E	0.84	62.7	E	0.84	62.7
	Overall	**C**	**0.79**	**33.2**	**C**	**0.81**	**30.8**	**C**	**0.81**	**30.4**
Blue Hill Avenue and Washington Street										
Blue Hill Ave NB	All	A	0.33	9.9	A	0.48	6.4	A	0.48	7.1
Blue Hill Ave SB	Left	A	0.44	6.6	C	0.63	29.8	C	0.63	25.1
Blue Hill Ave SB	Thru	A	0.17	4.6	B	0.24	14.8	B	0.24	11.9
Washington St WB	Left	D	0.66	53.5	C	0.28	23..4	C	0.28	23.4
Washington St WB	Right	D	0.14	44.3	D	0.14	42.4	D	0.14	42.4
Cheney St EB	All	D	0.40	43.5	E	0.95	55.9	E	0.95	55.9
	Overall	**B**	**0.47**	**15.9**	**C**	**0.74**	**24.9**	**C**	**0.74**	**24.3**
Blue Hill Avenue and Seaver Street										
Blue Hill Ave NB	Left	F	1.09	100.2	B	0.79	15.5	B	0.79	15.8
Blue Hill Ave NB	Thru/Right	A	0.38	4.6	A	0.40	2.7	A	0.40	2.9
Blue Hill Ave SB	Left	B	0.02	18.3	B	0.03	16.1	B	0.03	16.5
Blue Hill Ave SB	Thru	C	0.25	20.7	B	0.38	17.4	B	0.38	18.0
Blue Hill Ave SB	Right	A	0.13	0.2	A	0.13	0.2	A	0.13	0.2
Seaver St EB	Left	F	0.72	80.8	E	0.63	56.0	E	0.63	56.0
Seaver St EB	Thru	D	0.61	54.1	D	0.54	41.7	D	0.54	41.7
Seaver St EB	Right	C	0.37	25.0	B	0.48	15.0	B	0.48	15.0
	Overall	**D**	**0.64**	**42.3**	**B**	**0.60**	**12.4**	**B**	**0.60**	**12.6**
Blue Hill Avenue and Columbia Road										
Blue Hill Ave NB	Left	B	0.28	12.3	A	0.23	3.5	A	0.23	2.7
Blue Hill Ave NB	Thru/Right	B	0.71	18.9	A	0.60	4.7	A	0.60	3.8
Blue Hill Ave SB	Left	C	0.22	26.6	B	0.19	11.6	B	0.19	12.3
Blue Hill Ave SB	Thru/Right	C	0.42	21.6	A	0.32	8.5	A	0.32	9.4
Columbia Rd WB	Left	C	0.48	34.0	D	0.85	51.4	D	0.85	51.4
Columbia Rd WB	Thru	D	0.69	40.1	F	1.22	164.7	F	1.22	164.7
Columbia Rd WB	Right	C	0.19	30.7	D	0.25	36.5	D	0.25	36.5
	Overall	**C**	**0.70**	**23.6**	**C**	**0.72**	**26.9**	**C**	**0.72**	**26.6**
Blue Hill Avenue and Glen Lane										
Blue Hill Ave NB	Thru	C	0.70	22.6	C	0.73	28.4	C	0.60	20.7
Blue Hill Ave NB	Right	E	1.02	65.5	F	1.07	80.5	C	0.88	34.8
Blue Hill Ave SB	Left	F	1.68	344.0	C	0.74	34.4	E	0.96	62.6
Blue Hill Ave SB	Thru	B	0.51	14.4	A	0.42	4.7	A	0.42	6.8
Glen Lane EB	Left/Thru	C	0.83	32.2	F	1.08	99.0	F	1.08	99.0
Glen Lane EB	Right	B	0.14	17.2	C	0.17	27.4	C	0.17	27.4
	Overall	**D**	**1.26**	**50.8**	**D**	**1.00**	**38.6**	**C**	**0.97**	**32.0**
Blue Hill Avenue and American Legion										
Blue Hill Ave NB	Left	B	0.40	19.0	A	0.32	5.7			
Blue Hill Ave NB	Thru	C	0.65	23.7	A	0.54	6.1			
Blue Hill Ave SB	Thru	C	0.52	31.9	B	0.39	13.3		**Not Coordinated**	
Blue Hill Ave SB	Right	C	0.32	30.1	C	0.32	21.6			
American Legion EB	All	C	0.77	23.9	D	0.93	42.1			
	Overall	**C**	**0.71**	**25.5**	**C**	**0.71**	**20.9**			

Table 12: AM Peak Hour Intersection Operations – cont.

Approach/Movement		Existing Signal Timings			Optimized Signal Timings			Coordinated Signal Timings		
		LOS	V/C	Delay (sec)	LOS	V/C	Delay (sec)	LOS	V/C	Delay (sec)
Blue Hill Avenue and Talbot Avenue										
Blue Hill Ave NB	Thru	B	0.90	12.9	B	0.90	10.6			
Blue Hill Ave NB	Right	A	0.21	0.1	A	0.20	1.0			
Blue Hill Ave SB	Left	C	0.48	21.6	E	0.70	60.6			
Blue Hill Ave SB	Thru	B	0.21	15.6	C	0.24	26.1		**Not Coordinated**	
Harvard St WB	All	D	0.67	54.5	D	0.60	43.1			
Talbot St WB	All	E	1.07	63.5	D	0.97	48.4			
	Overall	**C**	**0.78**	**22.9**	**C**	**0.73**	**23.6**			
Blue Hill Avenue and Harvard Street										
Blue Hill Ave NB	Left	C	0.03	22.3	C	0.04	22.5			
Blue Hill Ave NB	Thru	E	1.02	67.4	E	1.02	61.7			
Blue Hill Ave SB	Thru	B	0.30	13.6	B	0.34	12.1			
Blue Hill Ave SB	Right	A	0.14	6.2	A	0.13	4.9		**Not Coordinated**	
Harvard St EB	All	E	0.89	79.0	E	0.80	55.9			
	Overall	**D**	**0.88**	**49.7**	**D**	**0.84**	**43.8**			

Table 13: PM Peak Hour Intersection Operations

Approach/Movement		Existing Signal Timings			Optimized Signal Timings			Coordinated Signal Timings		
		LOS	V/C	Delay (sec)	LOS	V/C	Delay (sec)	LOS	V/C	Delay (sec)
Blue Hill Avenue and Warren Street										
Blue Hill Ave NB	Left	D	0.87	50.5	F	1.04	91.0	F	1.03	86.9
Blue Hill Ave NB	Thru/Right	B	0.35	11.0	B	0.39	14.8	B	0.38	14.3
Blue Hill Ave SB	All	E	0.98	70.6	F	1.07	87.5	F	1.05	81.9
Warren St SE	Left/Right	E	0.85	58.7	D	0.87	53.3	D	0.87	52..9
Warren St SE	Right	D	0.22	36.6	C	0.22	27.9	C	0.22	27.6
Plaza Driveway WB	Left	D	0.40	44.1	C	0.36	31.8	C	0.38	32.1
Plaza Driveway WB	Right	E	0.73	57.0	D	0.59	36.0	D	0.62	37.6
	Overall	**D**	**0.87**	**45.7**	**D**	**0.92**	**52.3**	**D**	**0.92**	**50.3**
Blue Hill Avenue and Washington Street										
Blue Hill Ave NB	All	B	0.35	17.0	B	0.51	14.4	B	0.51	14.4
Blue Hill Ave SB	Left	B	0.52	14.2	A	0.64	8.9	B	0.58	11.5
Blue Hill Ave SB	Thru	B	0.28	11.7	A	0.34	5.6	A	0.34	5.6
Washington St WB	Left	D	0.51	41.0	B	0.41	17.1	B	0.42	17.1
Washington St WB	Right	D	0.14	37.2	B	0.14	17.7	B	0.14	17.7
Cheney St EB	All	D	0.75	50.2	B	0.60	19.4	B	0.61	19.4
	Overall	**C**	**0.56**	**21.5**	**B**	**0.61**	**12.1**	**B**	**0.56**	**12.4**
Blue Hill Avenue and Seaver Street										
Blue Hill Ave NB	Left	D	0.75	45.7	A	0.51	8.3	C	0.61	21.1
Blue Hill Ave NB	Thru/Right	A	0.28	5.2	A	0.31	4.6	A	0.33	6.2
Blue Hill Ave SB	Left	B	0.06	18.8	C	0.10	26.2	C	0.10	20.8
Blue Hill Ave SB	Thru	C	0.49	24.2	D	0.84	40.5	D	0.88	36.9
Blue Hill Ave SB	Right	A	0.09	0.1	A	0.09	0.1	A	0.09	0.1
Seaver St EB	Left	F	0.92	106.2	E	0.79	58.5	D	0.73	41.4
Seaver St EB	Thru	F	0.93	85.0	D	0.79	46.7	C	0.74	32.9
Seaver St EB	Right	F	1.31	187.8	E	1.04	60.2	F	1.13	89.9
	Overall	**E**	**0.87**	**71.6**	**C**	**0.96**	**31.8**	**D**	**1.03**	**39.5**

Table 13: PM Peak Hour Intersection Operations – cont.

Approach/Movement		Existing Signal Timings LOS	Existing V/C	Existing Delay (sec)	Optimized Signal Timings LOS	Optimized V/C	Optimized Delay (sec)	Coordinated Signal Timings LOS	Coordinated V/C	Coordinated Delay (sec)
Blue Hill Avenue and Columbia Road										
Blue Hill Ave NB	Left	C	0.44	22.9	B	0.47	11.2	D	0.53	38.5
Blue Hill Ave NB	Thru/Right	B	0.52	17.9	A	0.43	1.8	B	0.50	14.4
Blue Hill Ave SB	Left	C	0.21	24.2	A	0.17	9.3	C	0.24	21.2
Blue Hill Ave SB	Thru/Right	C	0.85	34.2	B	0.66	11.7	C	0.78	25.8
Columbia Rd WB	Left	C	0.67	34.7	F	1.29	178.2	D	0.76	37.5
Columbia Rd WB	Thru	C	0.47	31.0	E	0.90	62.8	C	0.54	32.3
Columbia Rd WB	Right	C	0.10	26.5	C	0.09	31.0	C	0.13	27.4
	Overall	**C**	**0.78**	**28.6**	**D**	**0.74**	**40.8**	**C**	**0.72**	**24.9**
Blue Hill Avenue and Glen Lane										
Blue Hill Ave NB	Thru	C	0.77	29.0	B	0.66	10.3	B	0.74	19.6
Blue Hill Ave NB	Right	D	0.77	35.6	B	0.66	13.1	C	0.74	25.0
Blue Hill Ave SB	Left	F	1.19	149.9	C	0.62	22.1	C	0.75	29.3
Blue Hill Ave SB	Thru	E	1.05	59.1	A	0.80	6.1	B	0.91	19.4
Glen Lane EB	Left/Thru	C	0.62	22.0	E	0.95	59.4	D	.089	38.2
Glen Lane EB	Right	B	0.38	18.5	C	0.57	29.9	B	0.52	19.5
	Overall	**D**	**0.90**	**47.0**	**B**	**0.84**	**14.5**	**C**	**0.90**	**22.0**
Blue Hill Avenue and American Legion										
Blue Hill Ave NB	Left	B	0.57	18.3	A	0.46	5.6	**Not Coordinated**		
Blue Hill Ave NB	Thru	B	0.39	13.2	A	0.34	4.5			
Blue Hill Ave SB	Thru	C	0.79	30.7	C	0.67	22.2			
Blue Hill Ave SB	Right	C	0.70	31.1	F	0.63	92.5			
American Legion EB	All	C	0.77	31.3	E	1.02	71.1			
	Overall	**C**	**0.76**	**26.0**	**D**	**0.75**	**44.1**			
Blue Hill Avenue and Talbot Avenue										
Blue Hill Ave NB	Thru	B	0.77	19.8	A	0.72	8.3	**Not Coordinated**		
Blue Hill Ave NB	Right	A	0.46	0.6	A	0.40	1.0			
Blue Hill Ave SB	Left	C	0.59	22.2	F	1.05	85.5			
Blue Hill Ave SB	Thru	C	0.45	21.0	B	0.58	11.4			
Harvard St WB	All	F	1.04	117.1	D	0.81	50.2			
Talbot St WB	All	F	0.97	82.5	D	0.79	43.6			
	Overall	**C**	**0.81**	**34.7**	**C**	**0.99**	**23.3**			
Blue Hill Avenue and Harvard Street										
Blue Hill Ave NB	Left	C	0.21	25.8	D	0.33	39.3	**Not Coordinated**		
Blue Hill Ave NB	Thru	D	0.92	52.9	D	0.86	37.4			
Blue Hill Ave SB	Thru	B	0.68	18.3	B	0.87	18.0			
Blue Hill Ave SB	Right	A	0.18	2.9	A	0.18	1.3			
Harvard St EB	All	F	1.10	137.2	E	0.87	57.8			
	Overall	**D**	**0.89**	**40.9**	**C**	**0.91**	**27.3**			

Distance between Stops

The distance between stops can indicate how a transit route balances access with speed. Short distances between stops improve access by reducing the distance customers must walk to the service. Greater distances between stops improve speed, as the bus is required to stop less frequently, even though dwell times may increase to accommodate greater numbers of boardings and alightings per stop. Surface MBTA bus routes are, on average, spaced by approximately 0.08-0.12 miles.

Along segments 1 (Dudley Station to Grove Hall, outbound) and 2 (Grove Hall to Dudley Station, inbound), there is an average distance of 0.095 miles and 0.123 miles between stops, respectively. Further out in the outbound direction, segment 3 (Grove Hall to Ashmont Station) has an average of 0.110 miles between stops, while segment 5 (Grove

Hall to Mattapan Station) has an average of 0.128 miles between stops. Further out in the inbound direction, segment 4 (Ashmont Station to Grove Hall) has an average of 0.117 miles between stops, while segment 6 (Mattapan Station to Grove Hall) has an average of 0.136 miles between stops. As demonstrated by these figures, there is, on average, greater distance between stops along segments 5 and 6 (Route 28) than segments 3 and 4 (Route 23). Over the entire corridor, the average outbound (segments 1, 3, and 5) distance between stops is 0.115 miles, and the average inbound (segments 2, 4, and 6) distance between stops is 0.124 miles. In the outbound direction, the stops served by Route 23 occur more frequently (0.104 miles between stops) than those served by Route 28 (0.117 miles between stops). In the inbound direction, Route 28 also has a larger average distance between stops (0.131 miles) than Route 23 (0.119 miles).

Table 14: Average Distance between Stops by Segment

Segment	Description	Direction	Average Distance between Stops (miles)
1	Dudley Station to Grove Hall	Out	0.095
2	Grove Hall to Dudley Station	In	0.123
3	Grove Hall to Ashmont Station	Out	0.110
4	Ashmont Station to Grove Hall	In	0.117
5	Grove Hall to Mattapan Station	Out	0.128
6	Mattapan Station to Grove Hall	In	0.136

Table 15: Average Distance between Stops by Segment Combination

Segments	Description	Direction	Average Distance between Stops (miles)
1, 3, 5	Dudley Station to Ashmont and Mattapan Stations	Out	0.115
2, 4, 6	Ashmont and Mattapan Stations to Dudley Station	In	0.124
1, 3	Dudley Station to Ashmont Station (Route 23)	Out	0.104
1, 5	Dudley Station to Mattapan Station (Route 28)	Out	0.117
2, 4	Ashmont Station to Dudley Station (Route 23)	In	0.119
2, 6	Mattapan Station to Dudley Station (Route 28)	In	0.131

Figure 27 graphically depicts the average miles-per-stop calculations presented in the above tables. As seen in the figure, a larger percentage of segments exclusively on Route 23 have a red or orange color, indicating smaller distances between stops, and a smaller percentage of segments have a blue color, indicating greater distances between stops, than on Route 28. Tables 16 and 17 list the 15 smallest and largest distances between stops along the corridor. Most of the shortest distances between stops are located on segments 1, 2, 3, or 4, while segments 5 and 6 have more than half of the largest distances between any two stops. Short distances (red) between stops appear to be interspersed throughout the corridor, but are not generally adjacent to longer distances (dark blue). Indeed, shorter distances between stops tend to border other shorter distances and longer distances border longer distances. One-half of the distances coded as red border a distance coded as red or orange. Only 13 percent of red and orange distances border a distance coded as light blue or dark blue. Conversely, light blue and dark blue colors border 38 percent of the distances coded as dark blue. There is only one instance of the shortest-distance color (red) bordering the longest-distance color (dark blue).

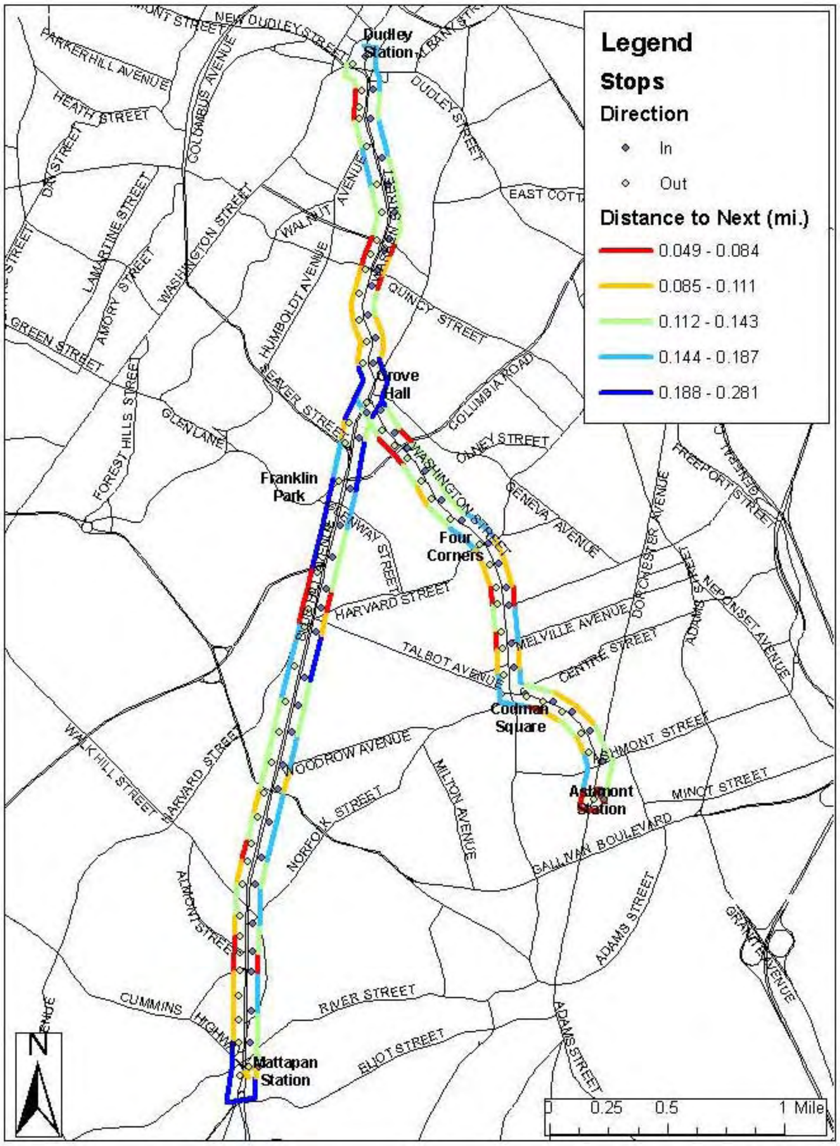
Table 16: Shortest Distances between Stops

Segment	Street	From Stop ID	To Stop ID	Distance (mi.)
1	Warren St	St James St	Dabney Pl	0.049
2	Warren St	Savin St	Maywood St	0.054
4	Dorchester Ave	Ashmont Station	Opp. Fuller St	0.058
3	Dorchester Ave	Fuller St	Ashmont Station	0.060
1	Warren St	ML King Blvd	Hazelwood St	0.067
2	Warren St	Holburn St	Quincy St	0.068
5	Blue Hill Ave	Tennis Rd	Almont St	0.070
1	Warren St	Hazelwood St	Quincy St	0.070
3	Talbot Ave	Lithgow St	Brent St	0.071
3	Washington St	Wheatland Ave	Rosedale St	0.073
1	Warren St	Kearsarge Ave	St James St	0.074
3	Washington St	Opp. School St	Park St	0.075
4	Washington St	Park St	School St	0.075
5	Blue Hill Ave	Angell St	Harvard St	0.075
5	Blue Hill Ave	Almont St	Woodhaven St	0.077

Table 17: Longest Distances between Stops

Segment	Street	From Stop ID	To Stop ID	Distance (mi.)
5	Blue Hill Ave	Crawford St	Wayne St	0.281
5	Blue Hill Ave	Mattapan Sq	Mattapan Station	0.269
6	Blue Hill Ave	Castlegate Rd	Sunderland St	0.229
4	Washington St	Blue Hill Ave	Sunderland St	0.220
6	Blue Hill Ave	Ellington St	Pasadena St	0.220
5	Blue Hill Ave	Columbia Rd	Opp. Charlotte St	0.202
6	Blue Hill Ave	Westview St	Opp. Health Ctr.	0.199
5	Blue Hill Ave	Opp. Charlotte St	American Leg. Hwy	0.197
3	Washington St	Crawford St	Blue Hill Ave	0.187
3	Talbot Ave	Dorchester St	Fuller St	0.178
5	Blue Hill Ave	Harvard St	Paxton St	0.175
2	Warren St	Montrose St	Dabney Pl	0.173
3	Washington St	Southern Ave	Lithgow St	0.173
6	Blue Hill Ave	Norfolk St	Wilmore St	0.168
3	Washington St	Vassar St	Harvard St	0.167

Figure 27: Distance between Stops



Boardings and Alightings by Stop

Figures 28 through 39 show the average number of weekday boardings and alightings at stops along the corridor (all bus routes serving the designated stops, not just Routes 23 and 28) measured by route ridechecks conducted in the fall 2007 quarter. The stop totals are layered over the distance between stops from Figure 27. Tables 18 and 19 list the 20 stops with the greatest and least respective total passenger activity (boardings plus alightings).

Predictably, the stops with the largest boarding and alighting totals are those towards the ends of the corridor – Dudley Station, Mattapan Station, and Ashmont Station – where transfers to other transit routes are available. Dudley Station has large boarding and alighting totals in both the inbound and outbound direction, as many passengers are heading toward or traveling from Ruggles Station. However, the balance between boardings and alightings is skewed depending on the direction. In the inbound direction, boardings are 56 percent greater than alightings; while in the outbound direction, alightings outnumber boardings by 58 percent. This makes sense if one assumes that a majority of trips are between home and work, and that most homes lie in the southern portion of the corridor while work is located in the northern portion or in connecting points from Dudley or Ruggles Stations.

The distribution of boardings and alightings is also much more even across the corridor in the direction in which the relative total is greater. That is, as would be expected if home-based work trips compose the majority of trips in the corridor, home locations are much more diffuse than work locations. Thus, while most inbound alightings (destined for work) occur at Dudley or Ruggles Stations, inbound boardings (originating from home) occur throughout the corridor. The opposite is true for the outbound direction, in which boardings would represent trips from work and alightings would represent trips to home.

The extent of ridership dispersion across stops can be demonstrated by comparing the median boardings or alightings per stop to the average. For example, inbound boardings per stop have a median value of 207, compared to an average of 320. The difference between the two is 35 percent, compared to a 54 percent difference for inbound alightings. This reflects the observation that inbound boardings are much more evenly spread throughout the corridor than alightings. Conversely, in the outbound direction, alightings are more evenly distributed than boardings, as demonstrated by a 34 percent difference between the median and average for alightings versus a 59 percent difference for boardings.

Stops with the largest activity totals (boarding plus alightings) are spread relatively evenly between the shared segment of Routes 23 and 28 along Warren Street and the paths traveled individually by the two routes. Stops with activity totals below 100 boardings and alightings per average weekday, however, are primarily located along Route 23's corridor. Route 28's individual corridor also has several stops along Blue Hill Avenue with activity totals between 100 and 140 boardings and alightings. Only two stops in the shared portion of Routes 23 and 28 along Warren Street are included in the list of stops with the least passenger activity.

Table 18: Greatest Passenger Activity (Boardings + Alightings): Counts by Stop and Direction

Stop Name	Direction	Route(s)	Boardings	Alightings	Total Activity
Dudley Station	Inbound	23/28	1,330	5,435	6,765
Dudley Station	Outbound	23/28	4,602	670	5,272
Ashmont Station	Inbound	23	2,347	0	2,347
Blue Hill Ave @ Mattapan Sq	Inbound	28	1,551	5	1,556
Blue Hill Ave @ Mattapan Sq	Outbound	28	3	1,408	1,411
Blue Hill Ave @ Ellington St	Inbound	28	668	388	1,056
Talbot Ave @ Dorchester Ave	Outbound	23	0	1,012	1,012
Talbot Ave @ Centre St	Inbound	23	757	227	984
Warren St @ Quincy St	Inbound	23/28	472	429	901
Blue Hill Ave Opp. Columbia Rd	Outbound	28	456	438	894
Ashmont Station	Outbound	23	0	811	811
Warren St @ Crawford St	Outbound	23/28	288	490	778
Warren St @ Sunderland St	Inbound	23/28	529	216	745
Dorchester Ave @ Fuller St	Outbound	23	0	736	736
Warren St @ Townsend St	Outbound	23/28	360	361	721
Mattapan Station	Inbound	28	634	56	690
Blue Hill Ave @ Morton St	Outbound	28	208	473	681
Blue Hill Ave @ Angell St	Outbound	28	279	396	675
Talbot Ave @ Lithgow St	Outbound	23	280	353	633
Warren Ave Opp. Woodbine St	Outbound	23/28	174	446	620

Table 19: Least Passenger Activity (Boardings + Alightings): Counts by Stop and Direction

Stop Name	Direction	Route(s)	Boardings	Alightings	Total Activity
Talbot Ave @ Argygle St	Inbound	23	26	13	39
Talbot Ave Opp. Argyle St	Outbound	23	12	39	51
Talbot Ave @ Brent St	Outbound	23	20	38	58
Washington St @ School St	Outbound	23	15	72	87
Blue Hill Ave @ River St	Outbound	28	1	88	89
Washington St @ Norwell St	Inbound	23	51	40	91
Talbot Ave @ Brent St	Inbound	23	59	35	94
Washington St @ Norwell St	Outbound	23	42	65	107
Washington St Opp. School St	Inbound	23	67	44	111
Blue Hill Ave Opp. Clarkwood St	Outbound	28	11	100	111
Blue Hill Ave Opp. Babson St	Outbound	28	2	112	114
Blue Hill Ave @ Hansborough St	Outbound	28	24	104	128
Warren St @ Montrose St	Inbound	23/28	56	75	131
Warren St @ Dabney Pl	Outbound	23/28	66	66	132
Blue Hill Ave @ Almont St	Outbound	28	33	100	133
Blue Hill Ave @ Calder St	Outbound	28	39	97	136
Blue Hill Ave @ Tennis Rd	Outbound	28	39	100	139
Washington St @ Vassar St	Inbound	23	104	38	142
Washington St @ Jeremia Burke HS	Outbound	23	50	94	144
Blue Hill Ave @ Arbutus St	Outbound	28	115	29	144

Figure 28: Avg. Weekday Boardings – Corridor

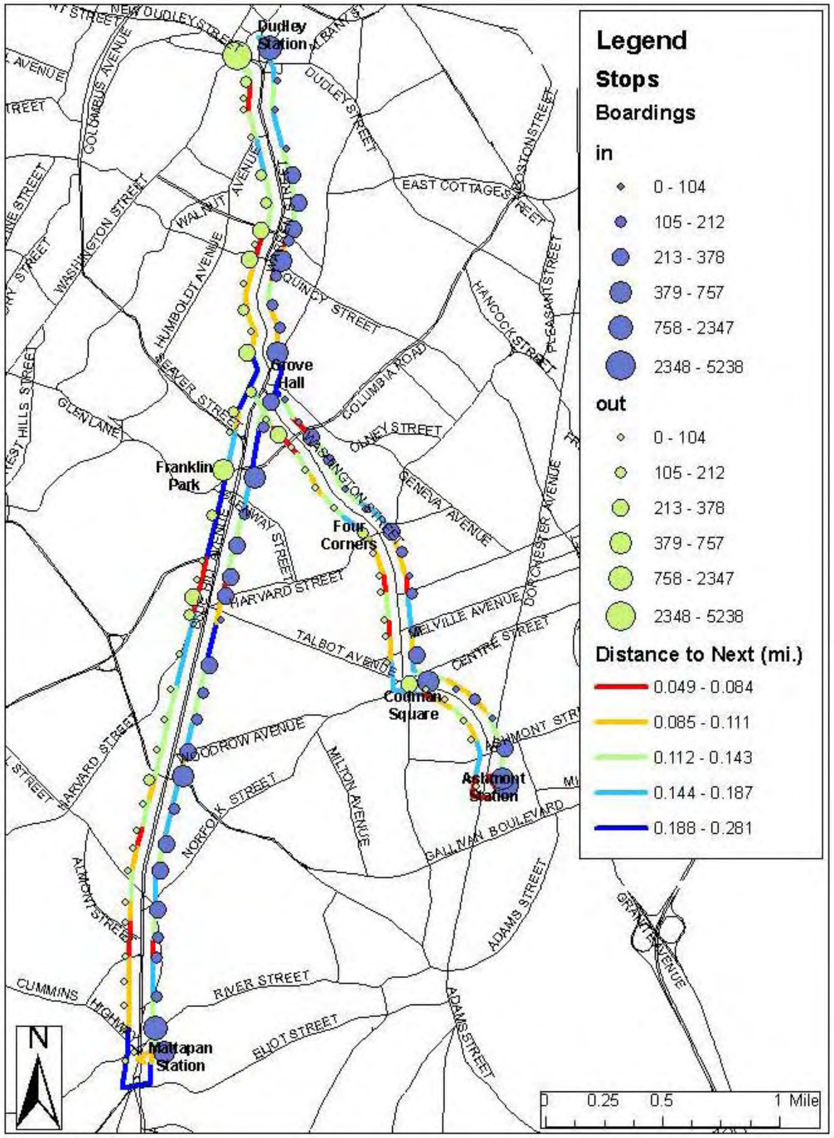


Figure 29: Avg. Weekday Alightings – Corridor

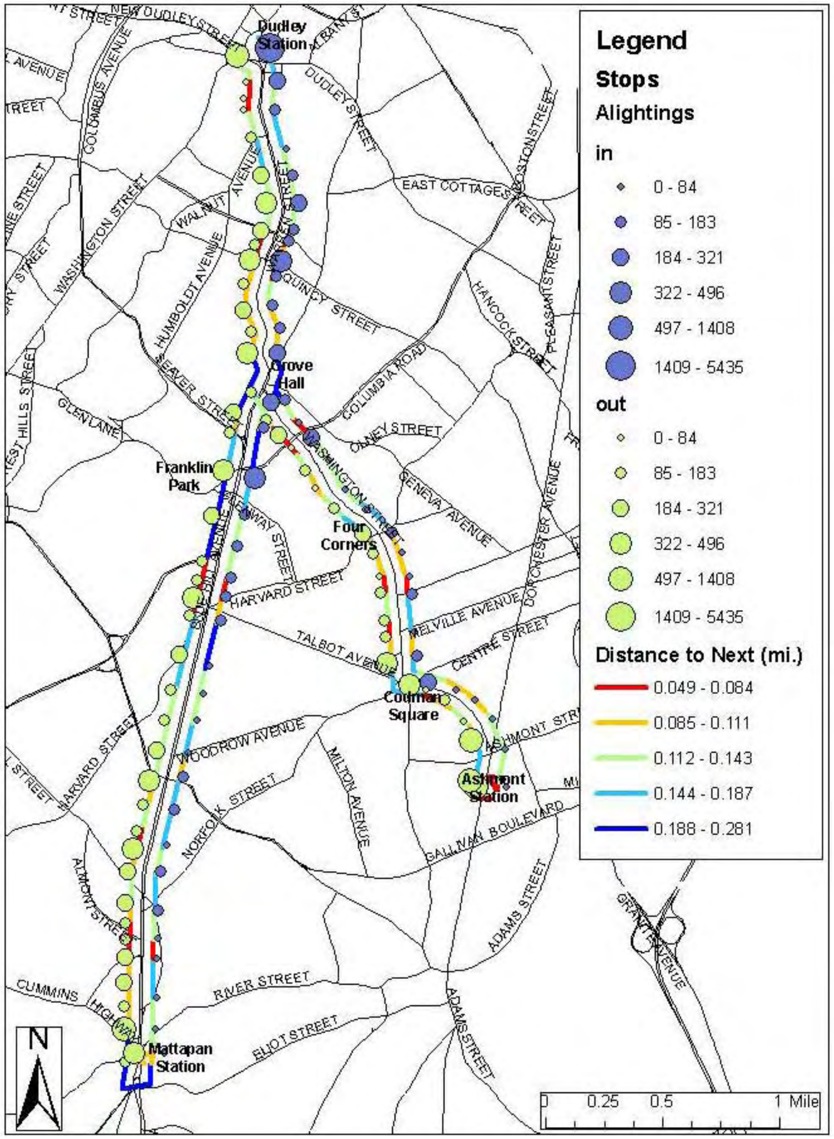


Figure 30: Avg. Weekday Boardings – Warren St.

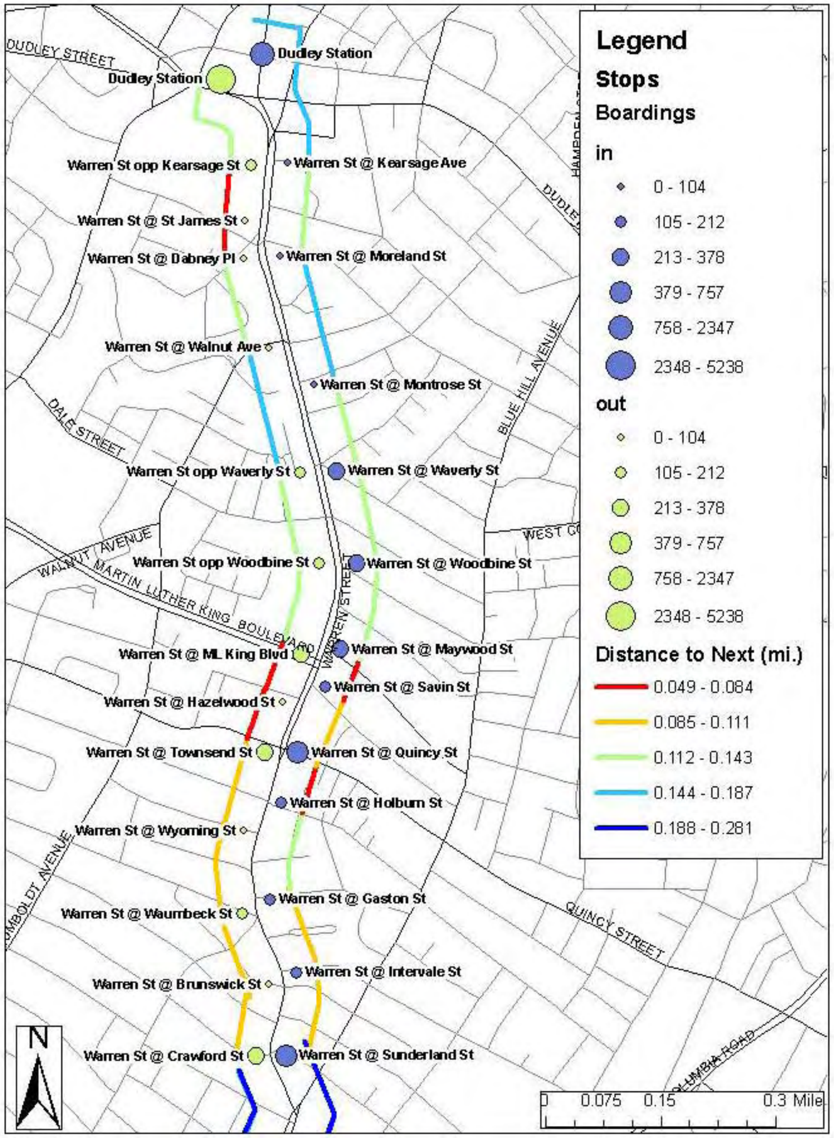


Figure 31: Avg. Weekday Alightings – Warren St.

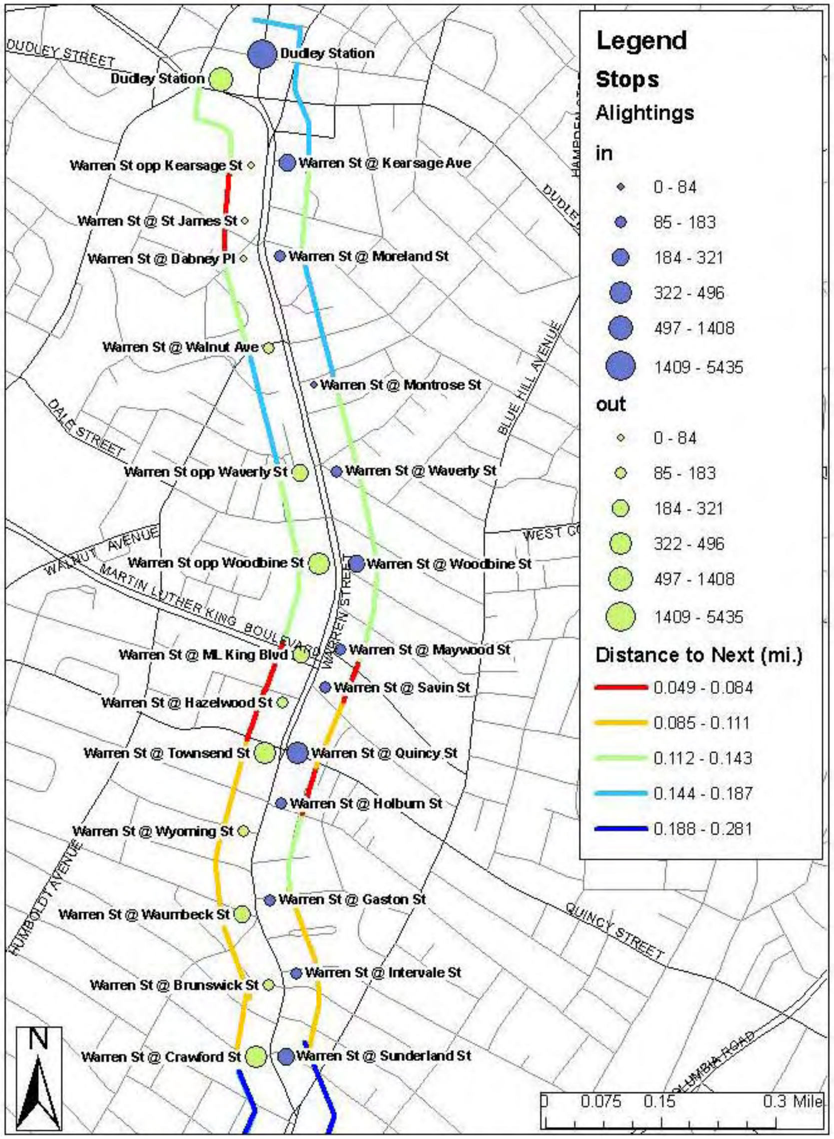


Figure 32: Avg. Weekday Boardings – Washington St.

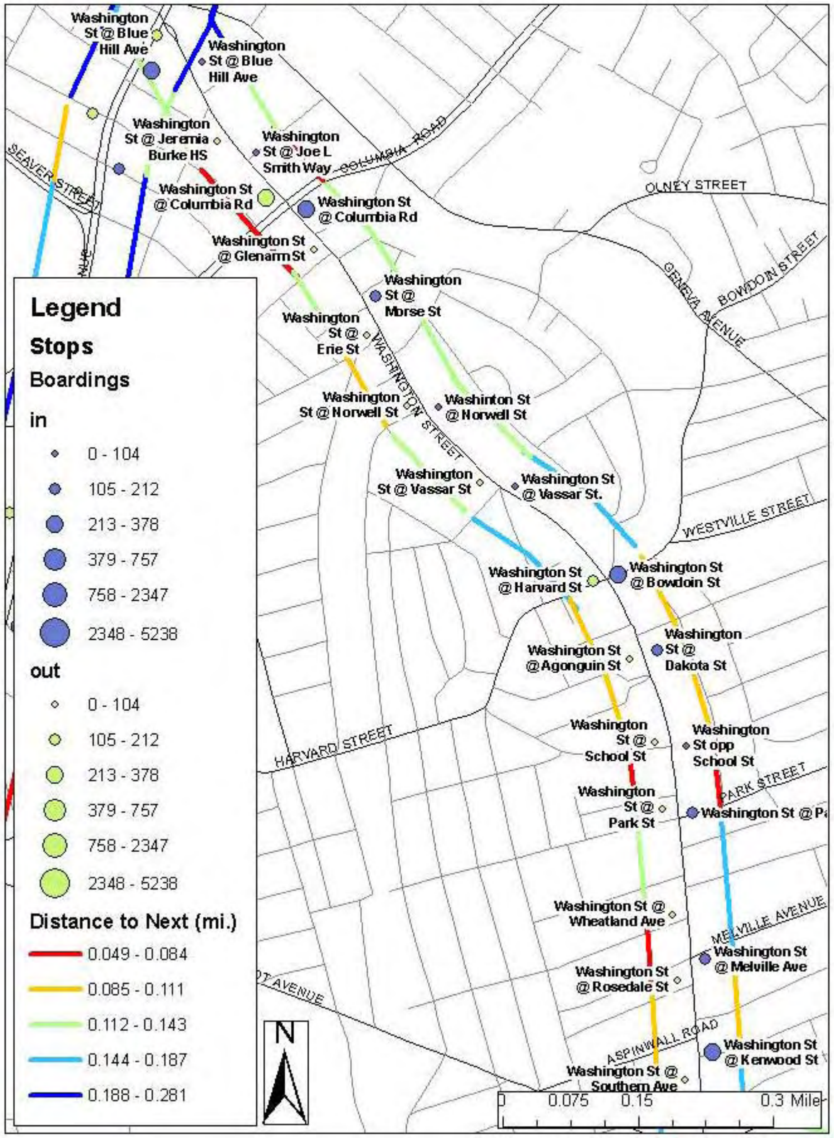


Figure 33: Avg. Weekday Alightings – Washington St.

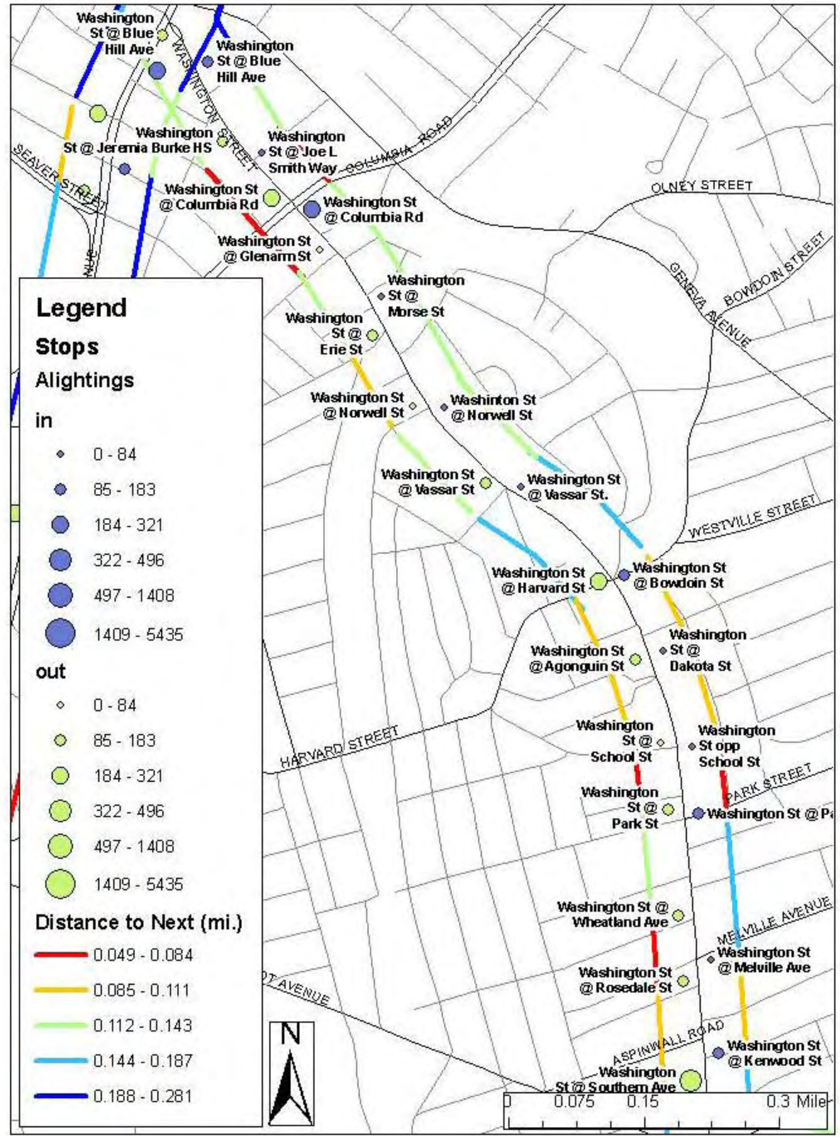


Figure 34: Avg. Weekday Boardings – Talbot/Dorchester Ave.

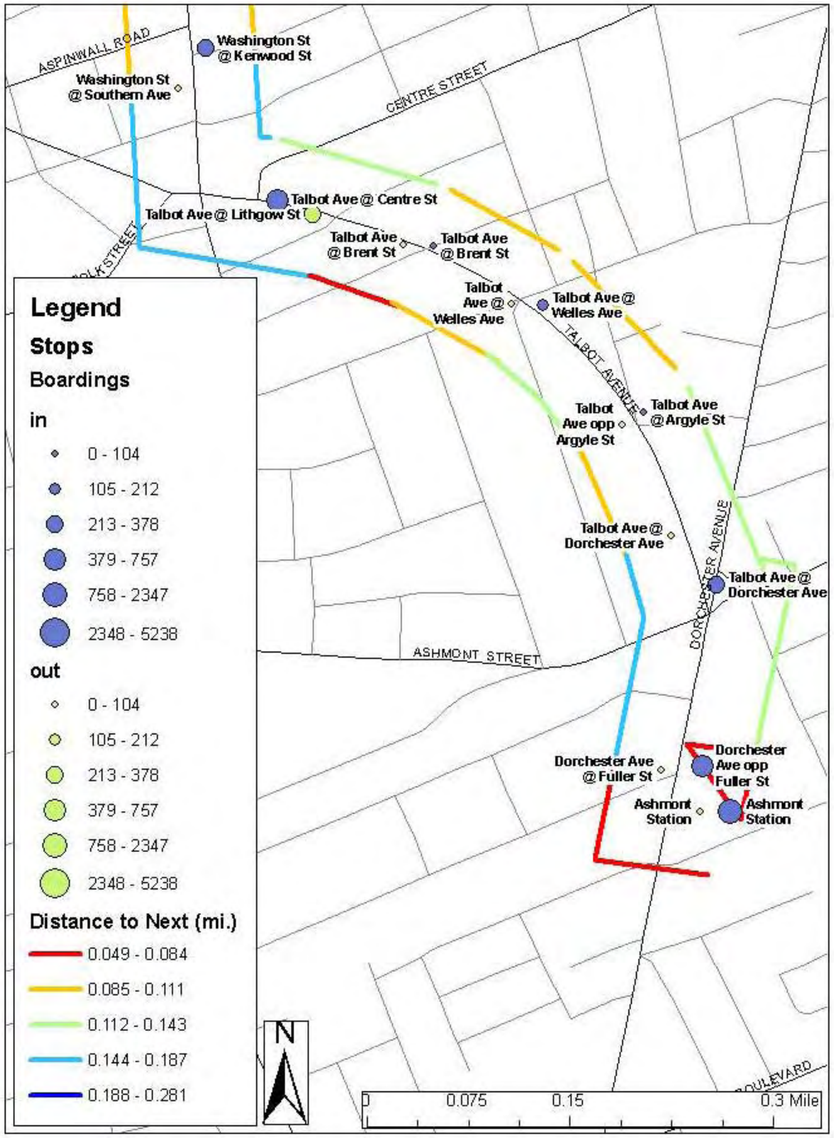


Figure 35: Avg. Weekday Alightings – Talbot/Dorchester Ave.

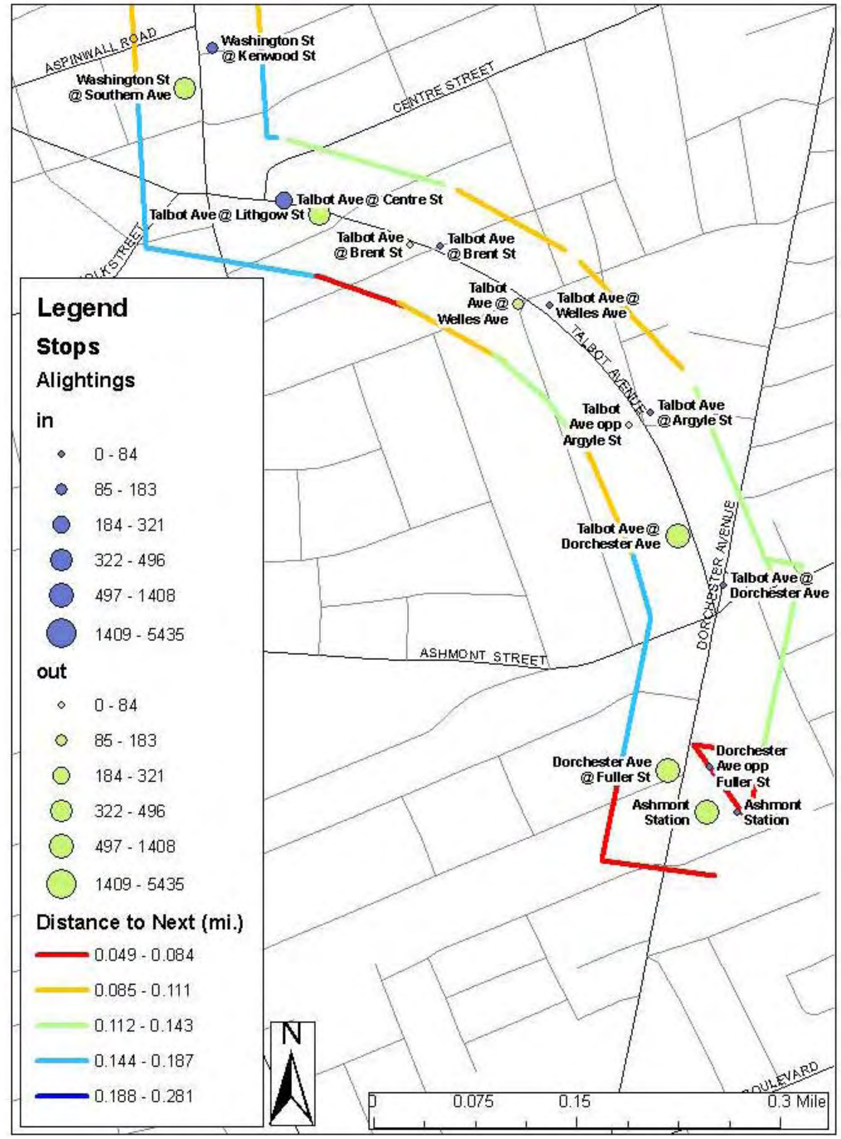


Figure 36: Avg. Weekday Boardings – Blue Hill Ave. (North)

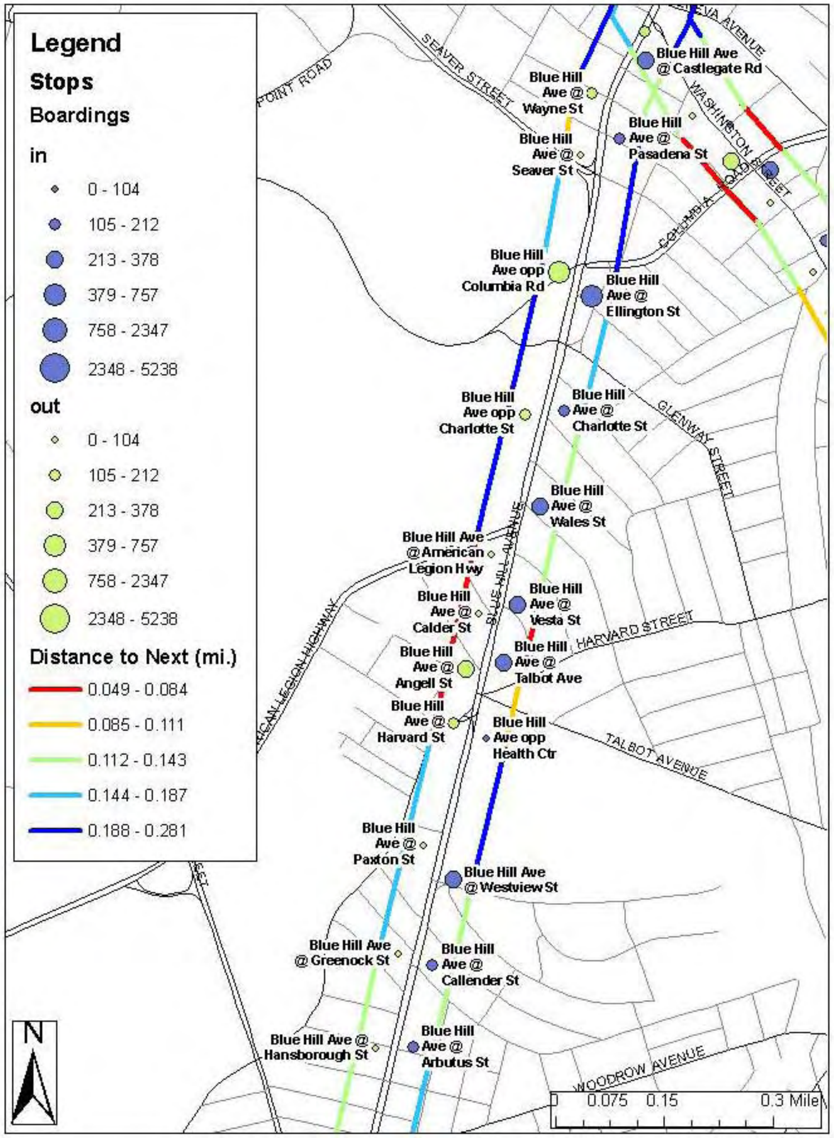


Figure 37: Avg. Weekday Alightings – Blue Hill Ave. (North)

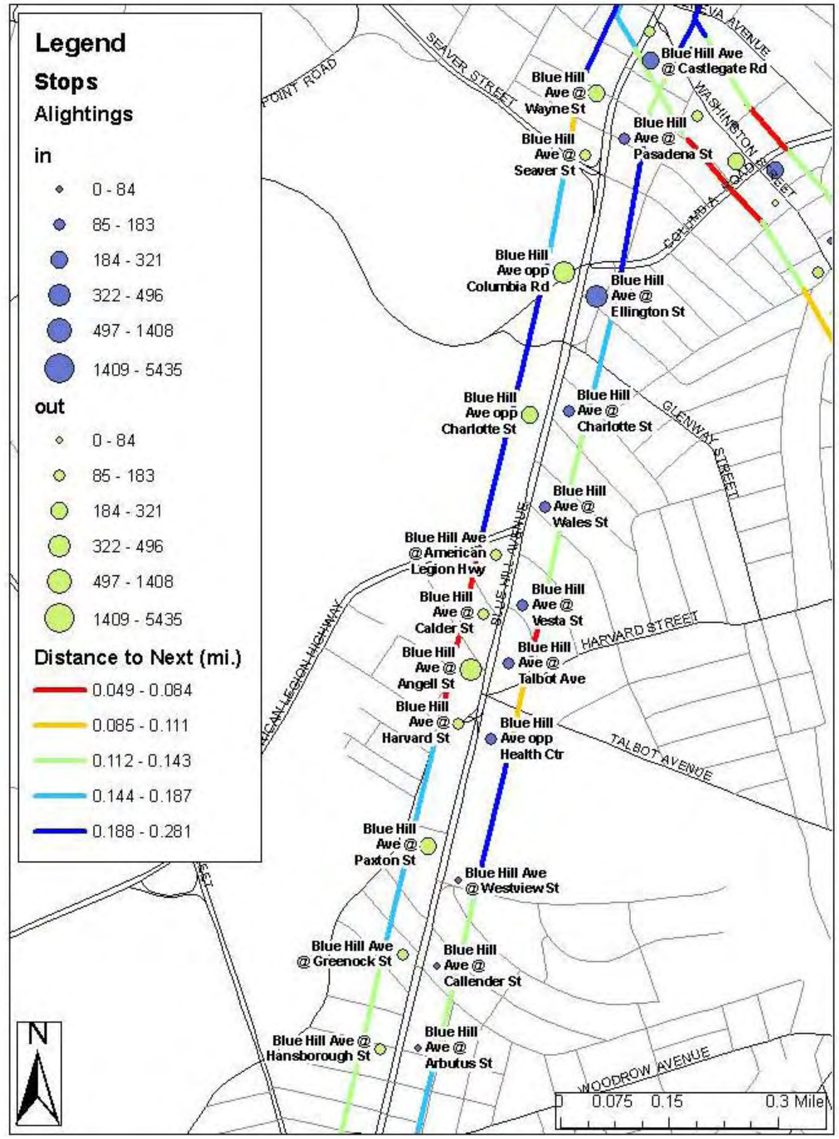


Figure 38: Avg. Weekday Boardings – Blue Hill Ave. (South)

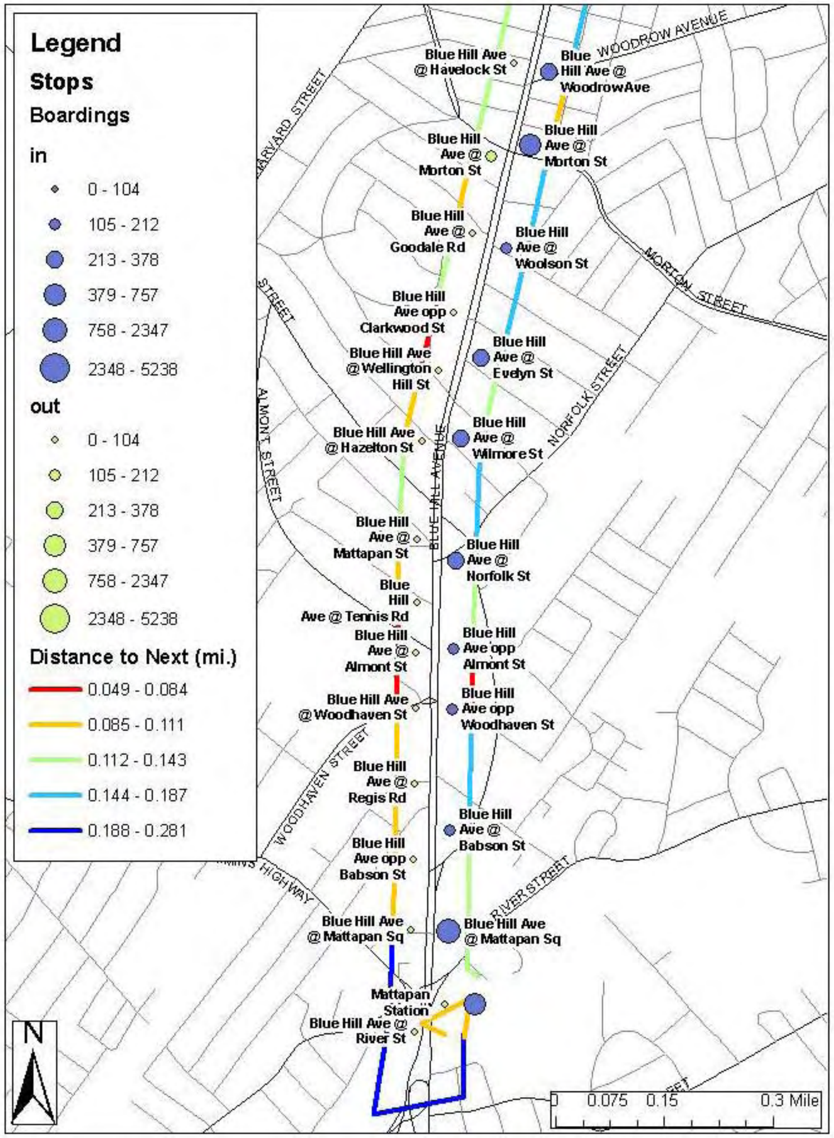
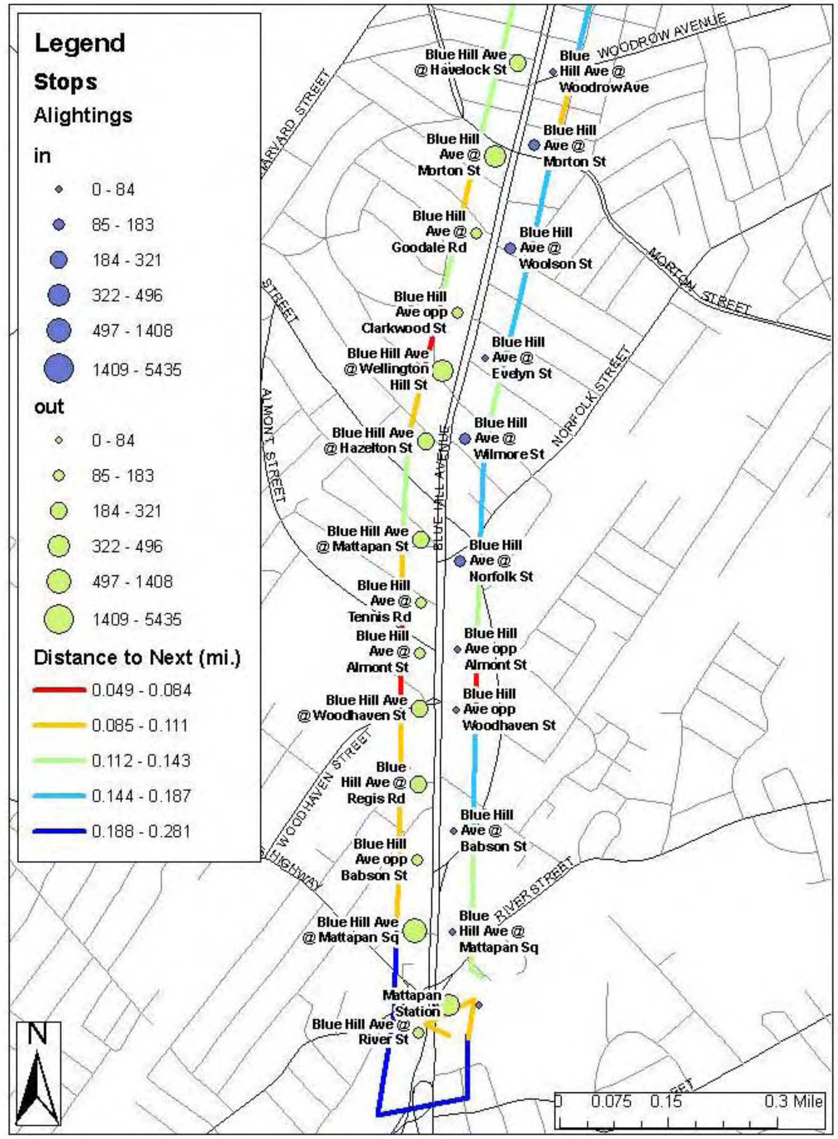


Figure 39: Avg. Weekday Alightings – Blue Hill Ave. (South)



Shelters

In the last fiscal year (July 2008 through June 2009), the average of systemwide weekday boardings at all stops with shelters was 249. Sixty average daily boardings is the threshold the MBTA uses for shelter placement. Table 20 lists all of the shelters in the Dudley South corridor along with their average weekday boarding totals. Table 21 lists those stops with boarding totals at or above 249 that do not have shelters. Figures 40 through 42 show the current distribution of shelters as well as whether the average daily boarding total for each stop is at or above 60 or 249.

Table 20: Shelter Locations and Boardings

Stop Location	Route(s)	Direction	Boardings
Dudley Station	23/28	Out	1,656
Ashmont Station	23	In	2,347
Dudley Station	23/28	In	1,330
Talbot Ave @ Centre St	23	In	757
Mattapan Station	28	In	634
Warren St @ Quincy St	23/28	In	472
Blue Hill Ave Opp. Columbia Rd	28	Out	456
Warren St @ Townsend St	23/28	Out	360
Blue Hill Ave @ Westview St	28	In	308
Blue Hill Ave @ Vesta St	28	In	297
Warren St @ Crawford St	23/28	Out	288
Washington St @ Bowdoin St	23	In	281
Talbot Ave @ Lithgow St	23	Out	280
Blue Hill Ave @ Talbot Ave	28	In	278
Blue Hill Ave @ Woodrow Ave	28	In	262
Talbot Ave @ Dorchester Ave	23	In	249
Blue Hill Ave @ Castlegate Rd	28	In	248
Washington St @ Columbia Rd	23	In	225
Blue Hill Ave Opp. Woodhaven St	28	In	212
Blue Hill Ave @ Woolson St	28	In	207
Blue Hill Ave @ Babson St	28	In	186
Blue Hill Ave @ Callender St	28	In	184
Blue Hill Ave @ Harvard St	28	Out	120
Blue Hill Ave @ Arbutus St	28	In	115
Blue Hill Ave Opp. Charlotte St	28	Out	113
Blue Hill Ave @ Wellington Hill St	28	Out	102
Blue Hill Ave Opp. Health Ctr.	28	In	75
Blue Hill Ave @ Greenock St	28	Out	62
Blue Hill Ave @ Hansborough St	28	Out	24
Ashmont Station	23	Out	0
Mattapan Station	28	Out	0

There are 16 shelters currently located at stops with weekday boarding totals at or greater than 249, 12 stops with that magnitude of boardings that do not have shelters, and 15 existing shelters located at stops with weekday boarding totals below 249. There are 55 stops without shelters that have weekday boarding totals at or above 60. The MBTA should consider placing shelters at the stops that have weekday boarding totals at or above 249 or 60, particularly given the number of stops with lower boarding totals that do have shelters.

Table 21: Stops without Shelters with Boardings at or above 249

Stop Location	Route(s)	Direction	Boardings
Blue Hill Ave @ Mattapan Sq	28	In	1,551
Blue Hill Ave @ Ellington St	28	In	668
Dorchester Ave opp. Fuller St	23	In	537
Warren St @ Sunderland St	23/28	In	529
Blue Hill Ave @ Morton St	28	In	464
Washington St @ Kenwood St	23	In	378
Warren St @ Woodbine St	23/28	In	319
Warren St @ Waverly St	23/28	In	303
Blue Hill Ave @ Norfolk St	28	In	293
Blue Hill Ave @ Angell St	28	Out	279
Blue Hill Ave @ Evelyn St	28	In	261
Warren St @ Maywood St	23/28	In	254

Figure 40: Shelters and Stop Boardings – Warren St.

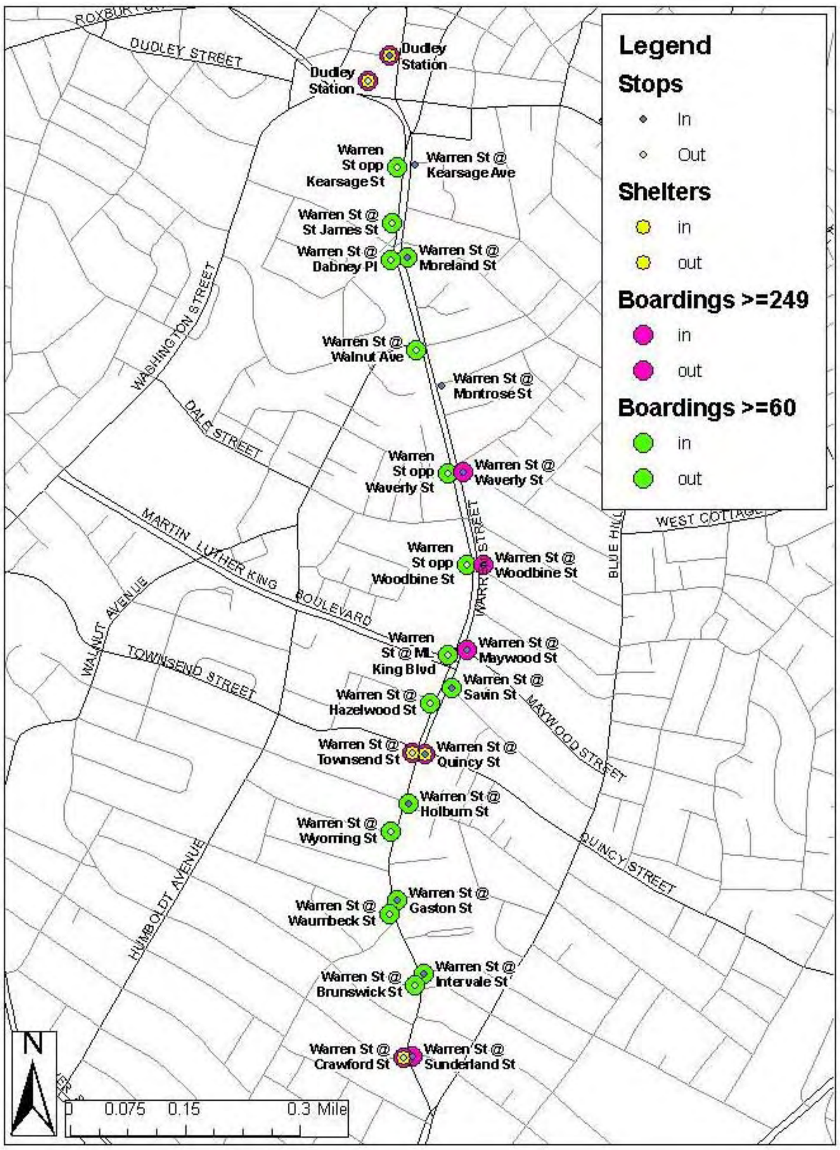


Figure 41: Shelters and Stop Boardings – Washington/Talbot Sts.

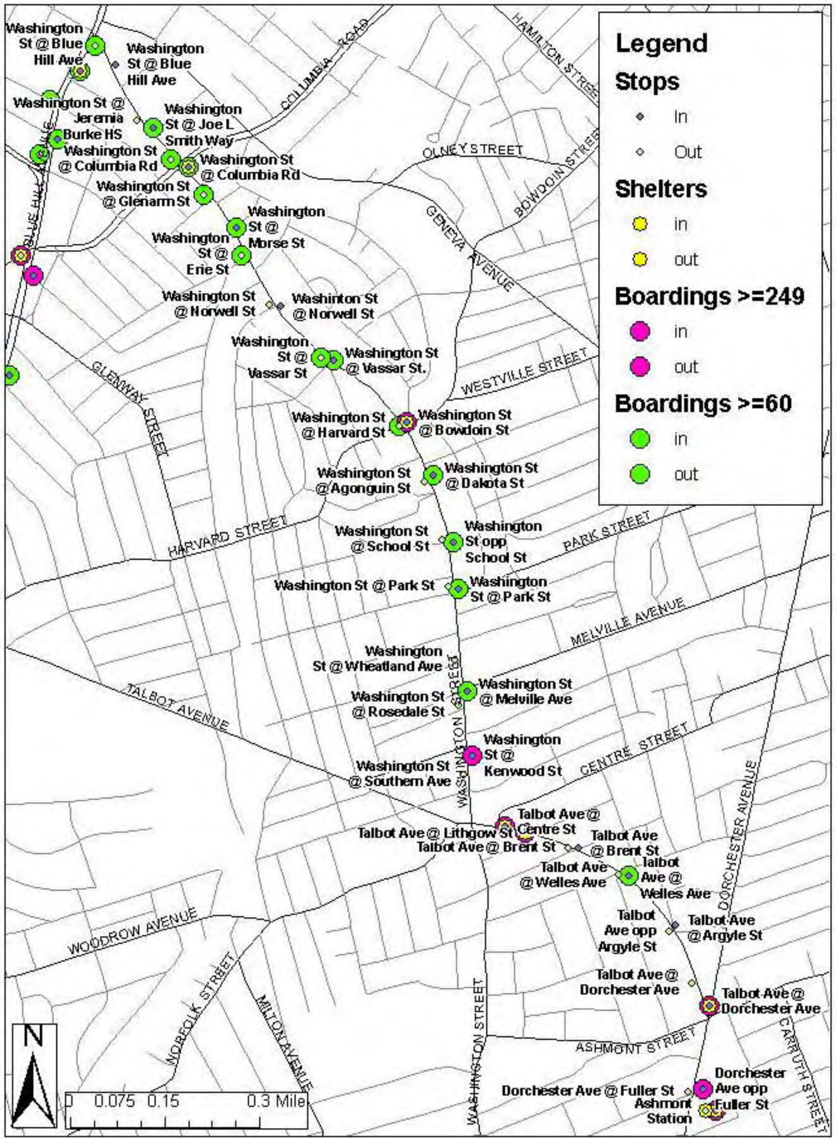
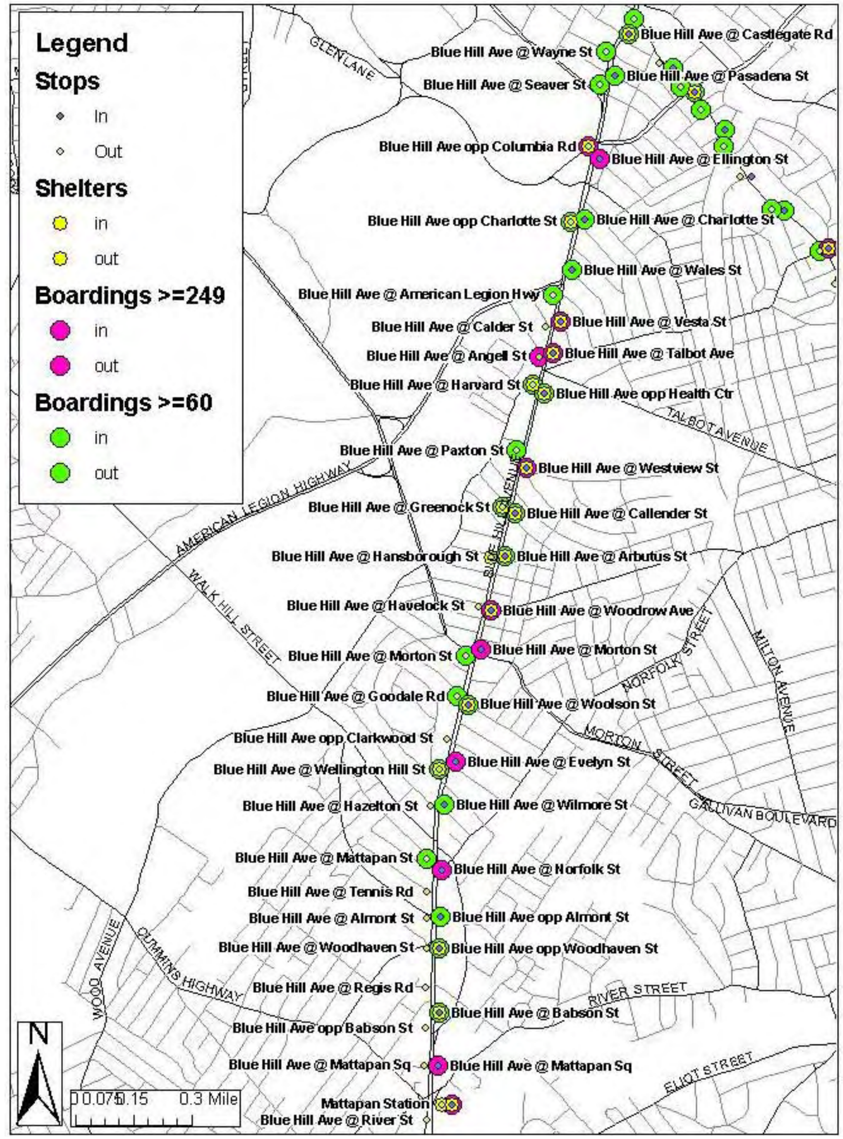


Figure 42: Shelters and Stop Boardings – Blue Hill Ave.



The following table presents the percentage of stops with a shelter in each corridor segment and combination of segments. Route 28 has a greater coverage of shelters (percentage of stops with a shelter) than Route 23. This is due, in large part, to the high shelter coverage in segment 6 (inbound Route 28 from Mattapan Station to Grove Hall). Inbound stops also, in general, have greater shelter coverage than those in the outbound direction. This is perhaps appropriate, given that inbound boardings are much more evenly distributed across the corridor than outbound boardings. Indeed, there is only one outbound stop location with boardings greater or equal to 249 that does not have a shelter, while there are 11 of these stops in the inbound direction.

Table 22: Shelter Coverage by Segment and Segment Combination

Segment(s)	Description	Direction	Shelter Coverage (% Stops with a Shelter)
1	Dudley Station to Grove Hall	Out	20%
2	Grove Hall to Dudley Station	In	8%
3	Grove Hall to Ashmont Station	Out	10%
4	Ashmont Station to Grove Hall	In	26%
5	Grove Hall to Mattapan Station	Out	27%
6	Mattapan Station to Grove Hall	In	55%
1, 3, 5	Dudley Station to Ashmont and Mattapan Stations	Out	19%
2, 4, 6	Ashmont and Mattapan Stations to Dudley Station	In	33%
1, 3	Dudley Station to Ashmont Station (Route 23)	Out	14%
1, 5	Dudley Station to Mattapan Station (Route 28)	Out	24%
2, 4	Ashmont Station to Dudley Station (Route 23)	In	19%
2, 6	Mattapan Station to Dudley Station (Route 28)	In	37%

Fare Payment

According to the Post-Fare Increase Impacts Analysis (conducted by CTPS for the MBTA), which used automated fare collection (AFC) data to compile statistics on ridership in calendar year 2007, annual ridership on Routes 23 and 28 was 2,004,459 and 2,198,130, respectively. One goal of the AFC system when it was implemented was to provide a more accurate method for counting trips. While AFC has undoubtedly improved passenger counting, there are several problems that have been identified. First, during busy operations, a significant percentage of passengers will board via the rear doors or even the front door without interacting with the farebox. They may not be evading their fare, per se, but their trip will not be counted by AFC. Second, given the time it takes the bus farebox to scan a CharlieTicket, many operators, again during busy times of the day, accept "flashes" of CharlieTicket passes in order to speed boarding. Again, these trips will not be counted by AFC.

Another major goal of the AFC system was to speed boarding times. Indeed, customers paying with a CharlieCard need only tap their card on the bus farebox. CharlieTickets take considerably more time. Customers paying for their trip with cash onboard the bus take even more time. When a bus is running behind schedule, as more passengers queue at each bus stop waiting to board the bus, the extent to which passengers attempt to pay their fare with cash onboard or CharlieTickets can further exacerbate the delay.

With regards to the method of payment, according to AFC farebox records for calendar year 2007 and as reported in the Post-Fare Increase Impacts Analysis, 46 percent of trips on Route 23 were single-ride trips, 11 percent were transfer trips, and 43 percent were pass trips. On Route 28, 50 percent of trips were single-ride trips, 9 percent were transfer trips, and 40 percent were pass trips. On Route 23, 62 percent of trips were made using a CharlieCard, 19 percent with a CharlieTicket, and 20 percent with cash onboard. On Route 28, 59 percent of trips were made using a CharlieCard, 18 percent with a CharlieTicket, and 23 percent with cash onboard.

Bicycling Conditions

CTPS staff conducted a qualitative evaluation of bicycling conditions in the late summer of 2008 along the corridor. None of the corridor's roadways currently have bike lanes or any other facilities designed to encourage bicycle use. The different qualities of the roadways in the corridor also lead to various levels of perceived comfort with regard to bicycling. In general, high vehicle speeds discourage bicycle travel in the roadway, instead leading bicyclists to travel on the sidewalk. As bicyclists who do use the roadway will typically use the right-hand travel lane, there exists the frequent danger of bicyclists' being hit by the opening doors of motorists exiting parallel-parked cars. Pavement conditions throughout the corridor are also less than ideal for bicycles, particularly those of the high-speed road variety. In addition, frequent bus stops pose an issue for bicyclists, as stopped buses will often force bicycles further into the right-hand travel lane.

The relatively slower average speed of general traffic in both directions on Warren Street makes bicycling along this segment of the corridor feel less dangerous. While bicyclists must be vigilant when crossing lanes, the slower speeds of motor vehicles mean that there usually exists enough time for bicyclists to merge into left-hand turn lanes when necessary. The ample street widths combined with two travel lanes in each direction on Warren Street also mean that motor vehicles can typically pass bicyclists with sufficient space. However, with parallel parking generally existing throughout the corridor in both directions, bicyclists must remain watchful of opening car doors.

Washington Street is similar to Warren Street in that slower vehicle travel speeds make bicycling more acceptable. Unlike Warren Street, however, Washington Street has only one travel lane in each direction. Motor vehicles therefore need to momentarily cross into a portion of the opposite direction's travel lane in order to pass a bicyclist with sufficient space between the motor vehicle and the bicycle. As a result, there will sometimes be queues behind a bicycle when the volume of traffic in the opposing direction does not permit passing. A potentially dangerous situation exists when motor vehicles attempt to pass bicycles using only the one travel lane. When bicyclists are aware of passing vehicles being too close, they will typically move closer to parked cars. However, as parallel parking exists throughout Washington Street, this heightens the potential for conflicts with opening doors.

Talbot Avenue has the same lane arrangement as Washington Street (two travel lanes and two parallel parking lanes), with slightly larger travel lane widths. As a result, bicyclists can take advantage of the greater lane width to travel, and motor vehicles do not need to cross into the opposite lane when passing bicycles. However, Talbot Avenue also generally has faster general traffic speeds, which can be intimidating to some bicyclists, thereby forcing them onto the sidewalks.

Blue Hill Avenue, with its multiple travel lanes, fast motor vehicle travel speeds, and frequent parallel parking, poses the most inhospitable environment for bicyclists in the corridor. While the capacity of the road usually permits motor vehicles to change lanes or use a portion of another travel lane when passing bicyclists, the speeds at which motor vehicles operate are very intimidating to slower-traveling bicyclists. As bicyclists increase their speeds to try to stay with the flow of traffic, moreover, pavement imperfections also become potentially more dangerous. Consequently, some bicyclists were observed choosing to bike along Blue Hill Avenue using the sidewalks. Large sidewalk widths generally allow for sufficient space for both pedestrians and bicyclists, but bicyclists should be discouraged from using sidewalks based on the potential for conflicts with pedestrians.

Summary

An assessment of the current service being provided in the Dudley South corridor shows many potential areas for improvement. Both Route 23 and Route 28 face consistent problems with schedule adherence, as actual run times oscillate throughout the day, often leading to bus bunching. Poor schedule adherence undoubtedly contributes to issues with passenger crowding; however, there are times during the day in which the 30-minute or hourly loads exceed 140 percent of the seated capacity, indicating that buses would be crowded (given the current frequencies) even if they ran on schedule.

Buses operate at different speeds throughout the corridor, depending on the location, direction, and time of day. For instance, Route 23 and Route 28 buses experience a midday outbound average speed from Dudley Station to Grove Hall of 5.8 mph, while the PM peak average speed in the reverse direction is 11.4 mph. Outbound speeds are generally slower than inbound speeds, and Route 23 has slower average speeds in both directions compared to Route 28. The intersections studied on Blue Hill Avenue generally have acceptable levels of performance, and lane assignments meet the needs of traffic. The distance between stops is likely an important factor in the average speed. For instance, the average distance between stops in the outbound direction from Dudley Station to Grove Hall is the shortest in the corridor. Outbound stop locations are closer together in every segment than inbound stop locations. The average distance between stops is greater for Route 28 than Route 23. While boardings and alightings are distributed across the corridor in different ways depending on the direction, there are several minor stops with perhaps excessively small amounts of daily weekday passenger activity. Shelters, while serving a majority of the larger stops, are not located at all stops with significant numbers of boardings. One-fifth of all trips taken on Routes 23 and 28 are made using cash onboard, a fare payment method that dramatically slows boarding, and approximately 40 percent of trips use either a CharlieTicket or cash onboard to pay their fare. These circumstances on a bus route that experiences significant crowding usually mean that many passengers are not interacting with the farebox.

PASSENGER SURVEY

This section describes the results from the MBTA Systemwide Passenger Survey for Routes 23 and 28. The two routes were surveyed during the fall 2008 quarter. The data presented herein includes summaries of passenger origins and destinations, transfer activity, modes of transit access and egress, trip purpose, frequency of use, modal alternatives, demographic characteristics, reasons for use, and ratings of service quality. Results are presented for each route by direction. Note that Route 25 data was combined with that of Route 28, as Route 25 essentially represents a shorter version of Route 28 running to Franklin Park.

Figures 43 and 44 depict the zones referenced in this section. The first shows the area of the Dudley South corridor and the second shows the neighborhoods of downtown Boston. From Dudley Station to Grove Hall, the corridor lies in Roxbury. Route 23 then stays entirely within South Dorchester, though it does share a border with North Dorchester along Washington Street between Blue Hill Avenue and Erie Street. After Grove Hall, the remaining northern portion of Route 28 also lies within South Dorchester, sharing a boundary with Roxbury to Seaver Street and with Jamaica Plain to the American Legion Highway. After crossing Morton Street, Route 28 remains in Mattapan.

Origins and Destinations

Table 23 shows, for each combination of route and direction, the percentage of origins and destinations reported for each zone. As would be expected, the vast majority of inbound riders on Routes 23 and 28 originate from the areas served by these routes. The same is true for outbound destinations. For Route 23, more than half of inbound/outbound riders have their trip origins/destinations in South Dorchester, while the inbound origins and outbound destinations for Route 28 are more diffuse due to its routing through several zones. For the opposite combinations (inbound destinations and outbound origins), trips are decidedly more dispersed. However, Roxbury is the major inbound destination and outbound origin for both routes.

Figure 43: Corridor Passenger Survey Zones

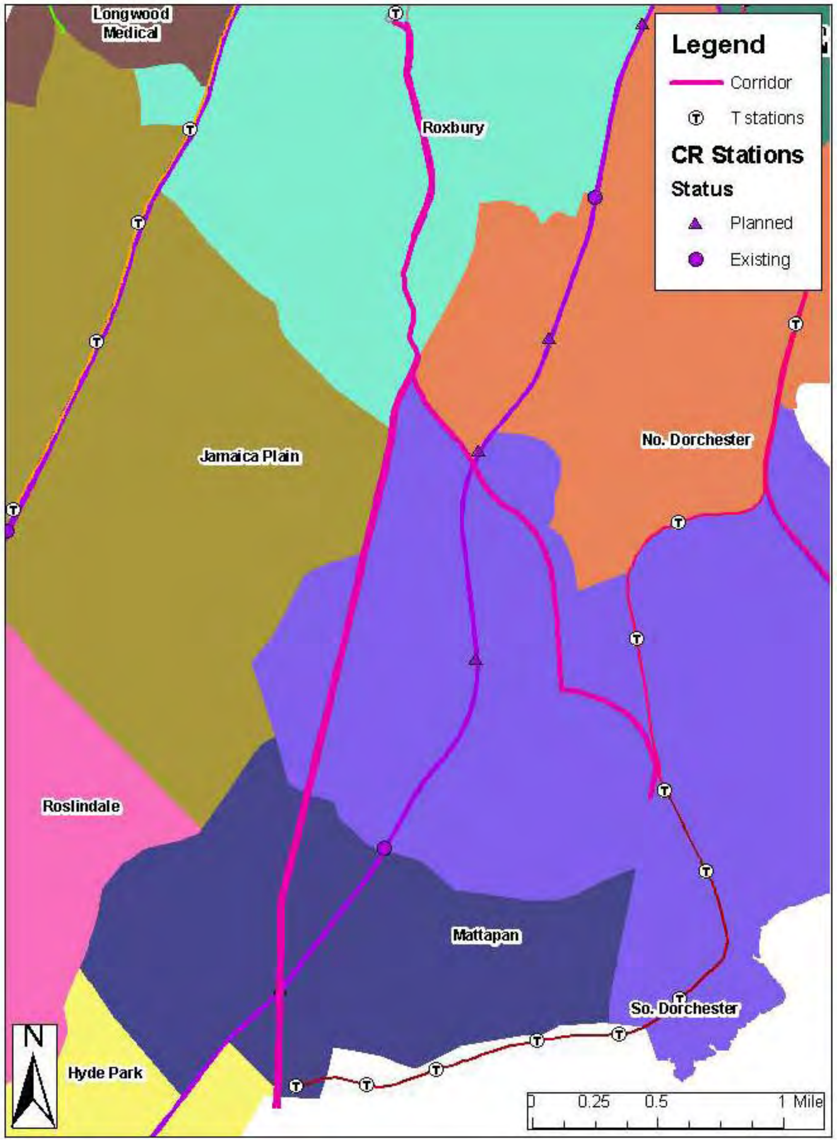


Figure 44: Downtown Boston Passenger Survey Zones

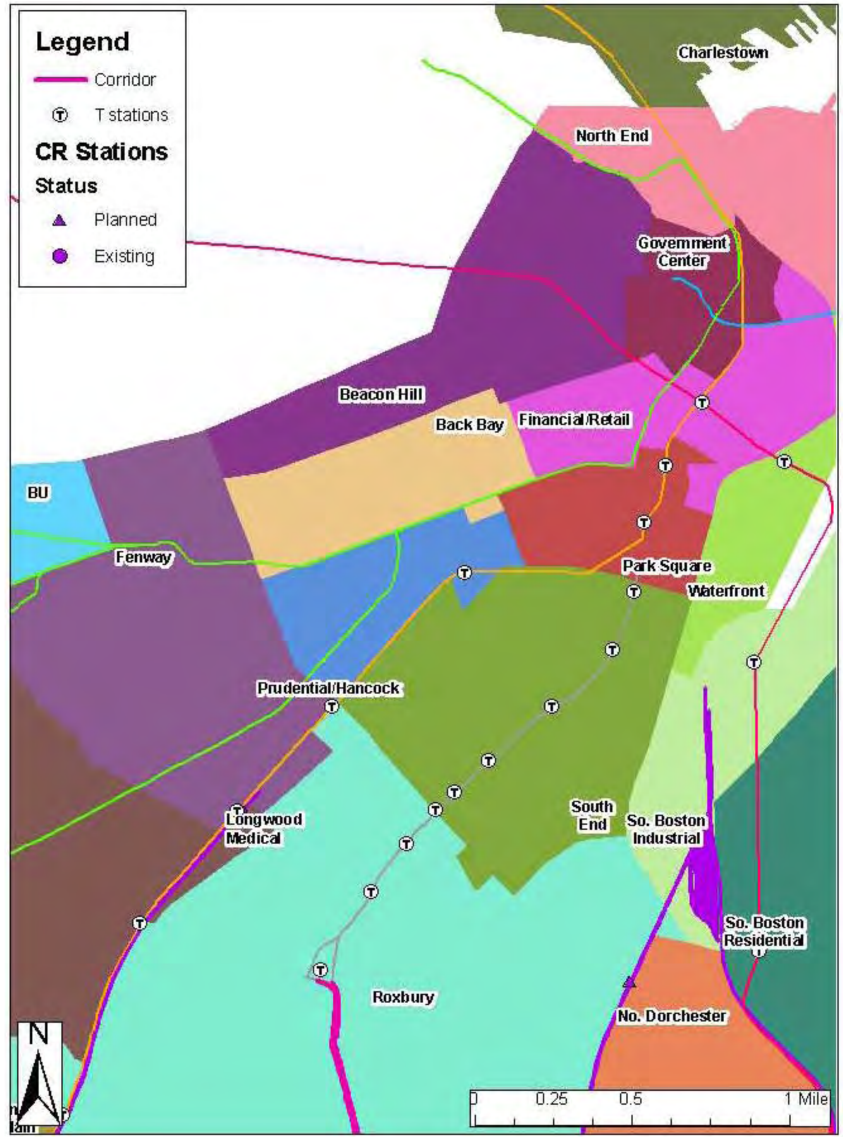


Table 23: Zone Origins and Destinations

Route 23 Inbound				
Origin	% Trips		Destination	% Trips
South Dorchester	55.0%		Roxbury	37.7%
North Dorchester	22.8%		Longwood Medical Area	16.6%
Roxbury	14.7%		North Dorchester	10.4%
Other	3.8%		South Dorchester	6.1%
Other	3.8%		South End	4.9%
			Other	18.7%
			Other	5.5%
Route 23 Outbound				
Origin	% Trips		Destination	% Trips
Roxbury	43.6%		South Dorchester	62.8%
North Dorchester	11.1%		Roxbury	19.4%
South Dorchester	8.0%		North Dorchester	9.3%
Prudential/Hancock	6.3%		Government Center	3.4%
South End	5.6%		Other	5.2%
Allston	4.9%			
Other	11.1%			
Other	9.4%			
Route 28 Inbound				
Origin	% Trips		Destination	% Trips
Mattapan	36.4%		Roxbury	40.6%
Roxbury	29.6%		Financial/Retail	9.7%
South Dorchester	22.8%		South End	9.7%
North Dorchester	4.3%		Fenway	6.6%
Other	3.9%		South Dorchester	6.1%
Other	2.9%		North Dorchester	4.6%
			Other	20.7%
			Other	1.9%
Route 28 Outbound				
Origin	% Trips		Destination	% Trips
Roxbury	34.8%		Mattapan	37.0%
South End	11.4%		Roxbury	31.1%
North Dorchester	7.9%		South Dorchester	16.7%
South Dorchester	6.3%		North Dorchester	8.6%
Fenway	5.9%		Hyde Park	3.4%
Charlestown	6.3%		South End	1.7%
Longwood Medical Area	4.9%		Other	1.5%
West Roxbury	4.7%			
Other	14.3%			
Other	6.1%			

Table 24 lists the five origin-destination pairs with the highest percentage of trips for each route in each direction. For Route 23, the highest percentage of trips in both directions is between South Dorchester and Roxbury. For Route 28, Mattapan to Roxbury has the highest percentage of trips in the inbound direction while Roxbury to South Dorchester is the largest percentage in the outbound direction. However, the percentage of trips from Roxbury to Mattapan is only slightly less. In summary, the top three origin-destination pairs for each route in each direction lie in zones served directly by Routes 23 and 28.

Table 24: Top 5 Origin-Destination Pairs

Route 23 Inbound				**Route 23 Outbound**		
Origin	Destination	% Trips		Origin	Destination	% Trips
South Dorchester	Roxbury	19.2%		Roxbury	South Dorchester	27.0%
North Dorchester	Roxbury	10.7%		Roxbury	Roxbury	9.1%
South Dorchester	North Dorchester	8.5%		North Dorchester	South Dorchester	8.4%
South Dorchester	Longwood	8.0%		Prudential	South Dorchester	6.1%
South Dorchester	South End	4.7%		South End	Roxbury	5.4%
Route 28 Inbound				**Route 28 Outbound**		
Origin	Destination	% Trips		Origin	Destination	% Trips
Mattapan	Roxbury	15.2%		Roxbury	South Dorchester	10.3%
South Dorchester	Roxbury	8.3%		Roxbury	Mattapan	9.2%
Roxbury	Roxbury	5.3%		North Dorchester	Mattapan	7.5%
Mattapan	South End	3.6%		Roxbury	North Dorchester	4.6%
South Dorchester	South End	3.6%		South Dorchester	Mattapan	4.6%

Transfer Activity

The previous section demonstrated that a majority of trips are entirely contained within the various zones that are part of the Dudley South corridor, particularly in the outbound direction. This means that a large percentage of passengers are traveling solely within this corridor; i.e., they are neither transferring from another mode to reach the corridor from their origin nor transferring to another mode from the corridor to reach their destination. As seen in Figures 45 and 46, the passenger survey seems to confirm, particularly with regard to inbound origins and outbound destinations, that no more than 15 percent of trips require a transfer. For the reverse combinations (outbound origins and inbound destinations), a higher percentage of trips include transfers. Transfers from or to another bus are the most common, though transfers from rapid transit (RTL) in the outbound direction and transfers to rapid transit in the inbound direction make up between 6 percent and 16 percent of trips.

Figure 45: Transfer Percentages to Route, by Direction

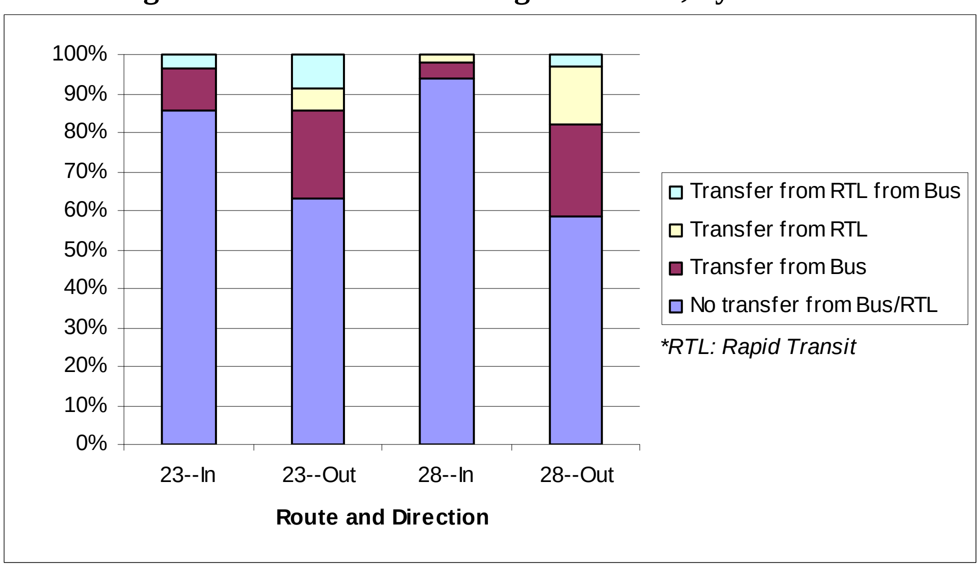
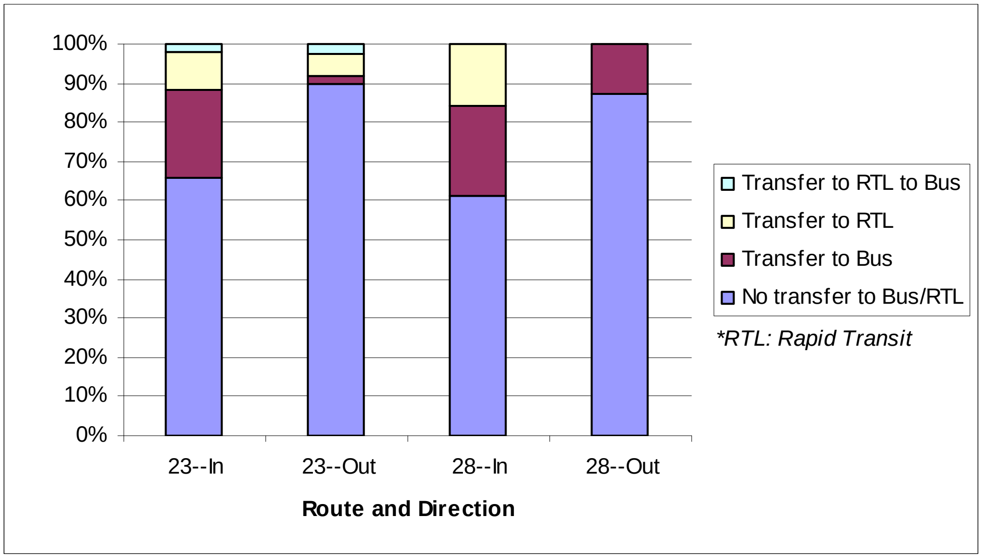


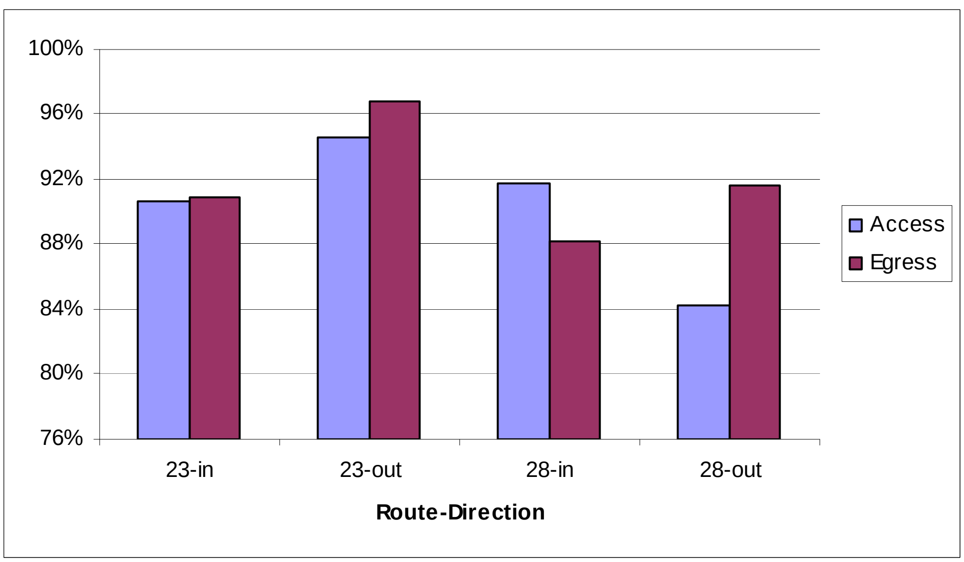
Figure 46: Transfer Percentages from Route, by Direction



Access and Egress

The vast majority of passengers on Routes 23 and 28 access and egress the transit network (be it these routes or some other transit mode) by walking. The smallest walk access and egress percentages appear to occur in the outbound and inbound directions, respectively, of Route 28. However, in no route-direction combination does the walk access or egress percentage fall below 84 percent.

Figure 47: Percent Transit Access/Egress by Walking



Trip Purpose

The passenger survey was conducted from 6:00 AM to 3:30 PM to capture each passenger once and only once. It therefore does not include responses from the PM peak travel period, in which many passengers are commuting home from work. Nevertheless, as seen in Table 25, for each route in each direction, home is the most frequently occurring origin, particularly in the inbound direction. The top destination for three of the four combinations of route and direction is work. However, destinations are typically much more diffuse than origins, particularly in the outbound direction, probably because PM peak trips are not reflected in the survey.

Table 25: Trip Purpose Origins and Destinations

Route 23 Inbound				
Origin	% Trips		Destination	% Trips
Home	81.6%		Work	51.6%
Store	6.5%		School	17.8%
Other	6.0%		Doctor/personal	9.3%
Work	3.8%		Work-related	6.9%
Doctor/personal	2.2%		Home	6.3%
			Other	5.7%
			Social/recreation	2.3%
Route 23 Outbound				
Origin	% Trips		Destination	% Trips
Home	58.0%		Work	28.0%
Work	15.2%		Home	25.2%
School	12.2%		School	15.8%
Store	6.1%		Other	12.2%
Other	5.4%		Doctor/personal	6.5%
Doctor/personal	3.0%		Store	6.5%
			Work-related	3.2%
			Social/recreation	2.5%
Route 28 Inbound				
Origin	% Trips		Destination	% Trips
Home	69.8%		Work	34.7%
School	9.4%		School	13.5%
Work	5.4%		Doctor/personal	12.9%
Store	5.4%		Other	12.6%
Work	5.4%		Home	10.7%
Other	1.7%		Store	8.5%
Doctor/personal	0.9%		Social/recreation	4.1%
Social/recreation	0.9%		Work-related	3.0%
Work-related	0.9%			
Route 28 Outbound				
Origin	% Trips		Destination	% Trips
Home	34.1%		Home	45.7%
Work	19.7%		Work	19.9%
School	15.6%		Other	11.2%
Doctor/personal	9.3%		School	7.2%
Other	7.8%		Doctor/personal	6.4%
Store	6.2%		Store	6.4%
Social/recreation	4.3%		Work-related	3.2%
Work-related	3.1%			

Given that home and work compose the most origins and destinations, respectively, it is not surprising that they also compose the top origin-destination pair for each route in each direction. The home-to-work trip purpose is by far the largest pairing in the inbound direction for Route 23. This is also the major pairing for inbound Route 28, though the difference between it and the next pairing (home-to-school) is smaller for Route 28 that for Route 23. Despite the fact that the passenger survey was conducted from 6:00 AM to 3:30 PM and the typical time during which home-to-work commute trips take place occurs later in the day, the reverse pattern of work-to-home is actually the largest pairing for Route 28 in the outbound direction.

Table 26: Top 5 Origin-Destination Pairs

Route 23 Inbound				**Route 23 Outbound**		
Origin	Destination	% Trips		Origin	Destination	% Trips
Home	Work	44.1%		Home	Work	26.3%
Home	School	16.5%		Home	School	14.8%
Home	Work-related	6.4%		Work	Home	9.1%
Home	Doctor/personal	4.3%		School	Home	6.1%
Home	Other	3.2%		Home	Other	5.4%
Route 28 Inbound				**Route 28 Outbound**		
Origin	Destination	% Trips		Origin	Destination	% Trips
Home	Work	25.9%		Work	Home	17.8%
Home	School	12.3%		Home	Work	15.9%
Home	Other	10.5%		School	Home	10.7%
Home	Doctor/personal	8.7%		Doctor/personal	Home	6.1%
School	Home	4.0%		Home	School	5.6%

Frequency of Use

The following two figures present the frequency of use on Routes 23 and 28 by direction. Figure 48 shows the percentage of survey respondents who use the route on the specified number of days. Predictably, the largest percentage of respondents (36 percent to 49 percent) uses the route five days per week. The second-largest response (between 22 percent and 30 percent) was for seven days. At least 75 percent of riders on each route use the route five or more days per week.

Figure 48: Days of Use per Week

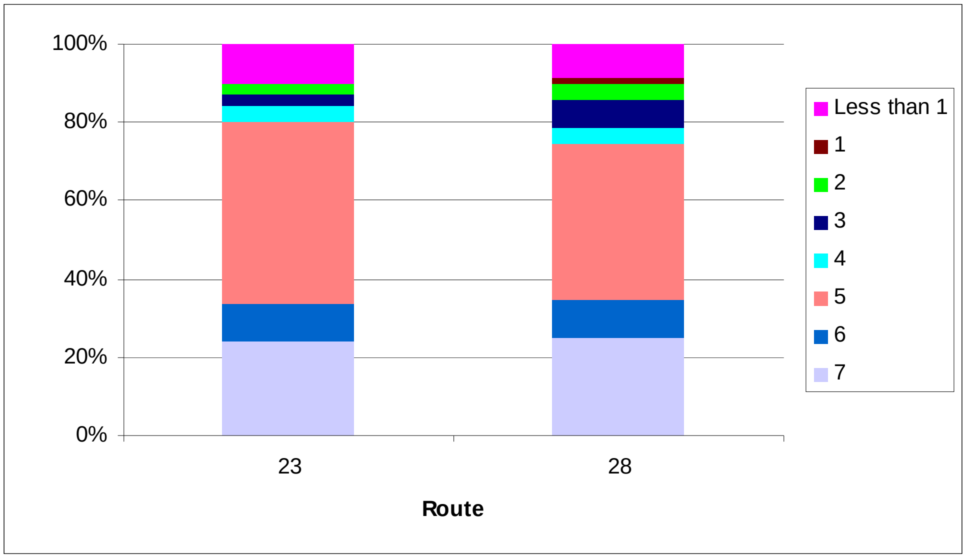
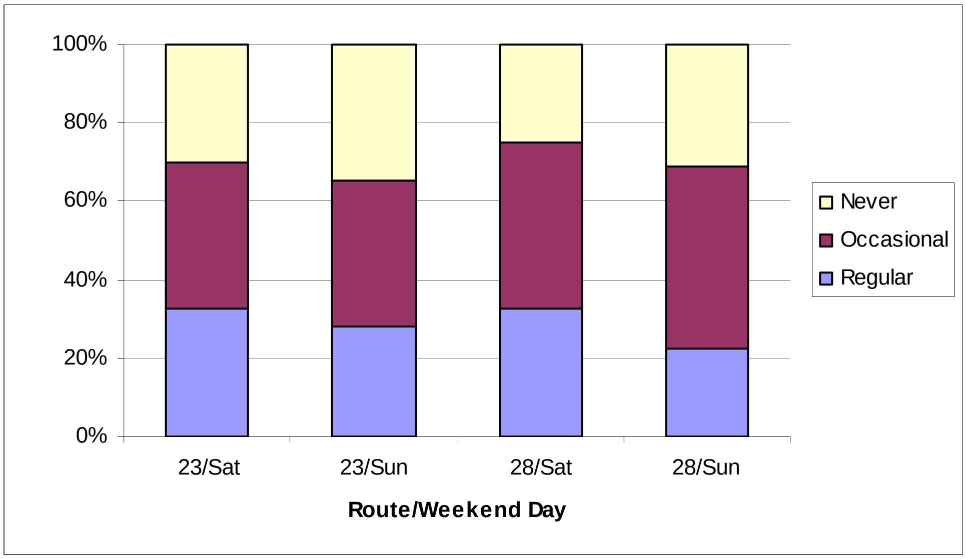


Figure 49 shows the percentage of survey respondents who use Routes 23 and 28 on the weekend. Saturday use seems to be slightly greater than Sunday use on both routes. Occasional weekend users make up between 37 percent and 46 percent of survey respondents, while regular weekend users make up between 23 percent and 33 percent of survey respondents.

Figure 49: Weekend Use



Alternative Means

This section of the passenger survey asked respondents how or if they would make the same trip using alternative means of transportation at their disposal. On Route 23 and Route 28, 41 percent and 44 percent, respectively, of respondents said that they would not make this trip using other means of transportation. For the rest of the respondents, another MBTA service was the most commonly listed alternative means. Route 28 riders reported a higher percentage of drive alone as an alternative than riders on Route 23 – 10 percent versus 5 percent.

License and Vehicle Availability

The passenger survey asked respondents if they had a valid driver's license and access to a private vehicle in their household. The summary of the responses, presented in Figures 50 and 51, confirms that, for many Route 23 and 28 riders, public transportation is their only means of transportation. A larger percentage of Route 28 respondents reported not having a driver's license (61 percent versus 47 percent on Route 23), while the percentage of respondents with no access to a private vehicle was similar on both routes (84 percent on Route 23 versus 82 percent on Route 28).

Figure 50: Alternative Means of Trip Making

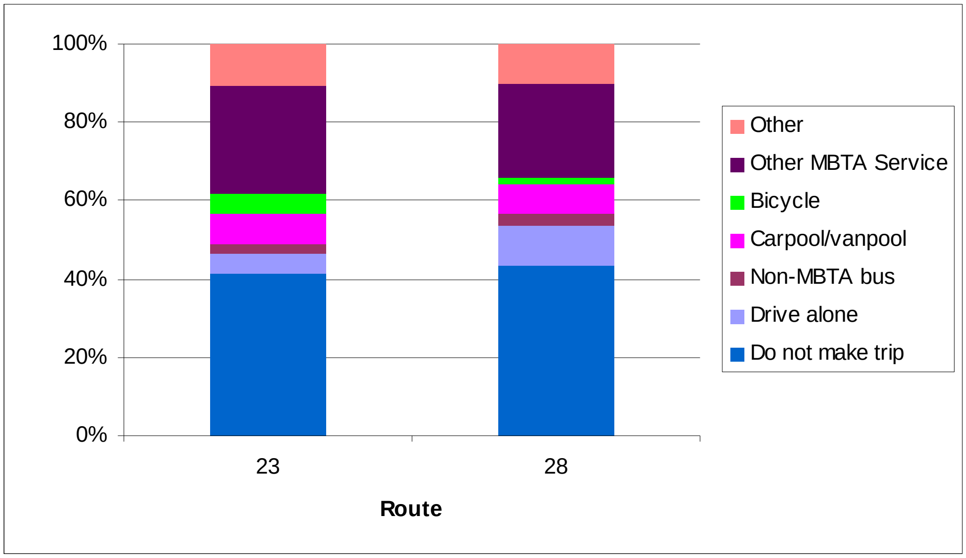
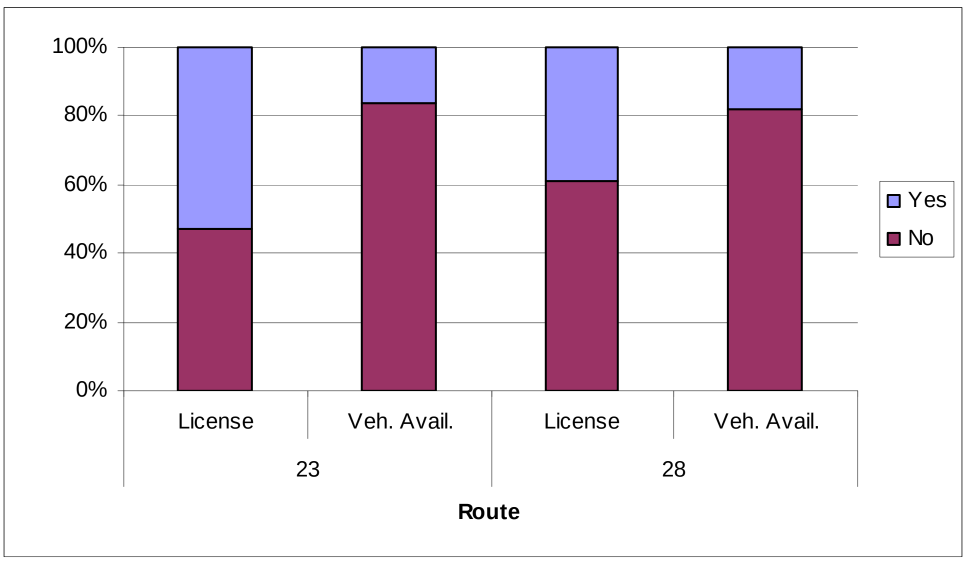


Figure 51: License and Vehicle Availability



Demographic Characteristics

The following tables and figures summarize the survey respondents' gender, age, annual household income, race, and Hispanic origin. Of note in Table 27 is the large discrepancy between the percentages of female and male respondents to the survey. It is uncertain whether this discrepancy is truly indicative of ridership on these routes, or merely the probability of women versus men responding to the survey.

Table 27: Percent Respondents by Gender

	23-in	23-out	28-in	28-out
Male	37.1%	27.7%	32.6%	26.2%
Female	62.9%	72.3%	67.4%	73.8%

In terms of age groups, as seen in Figure 52, riders are fairly well distributed among them. Approximately 40 percent of riders on each route-direction combination are in the three groups aged less than 35. The largest age group riding these two routes is 45-64, composing 33 percent of Route 23 riders and 40 percent of Route 28 riders. An annual income of less than $20,000 composes the largest percentage of riders on both Route 23 and Route 28, though Route 23 does appear to have a relatively greater percentage of riders with annual incomes above $40,000 (see Figure 53). The majority of riders on both routes identified themselves as black or African American (see Figure 54). The greater percentage of riders who identified themselves as Hispanic or Latino is on Route 23 (see Table 28).

Figure 52: Percentage of Respondents by Age

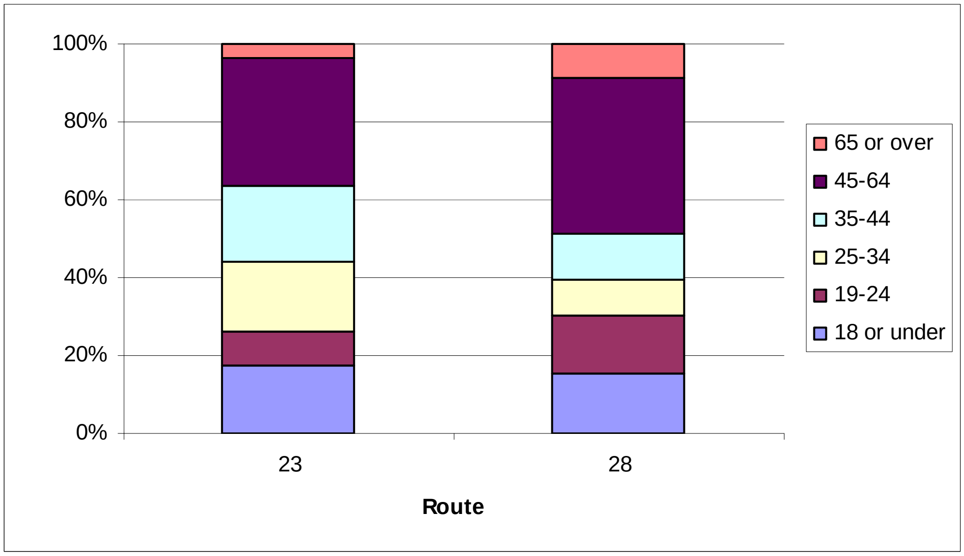


Figure 53: Percentage of Respondents by Income

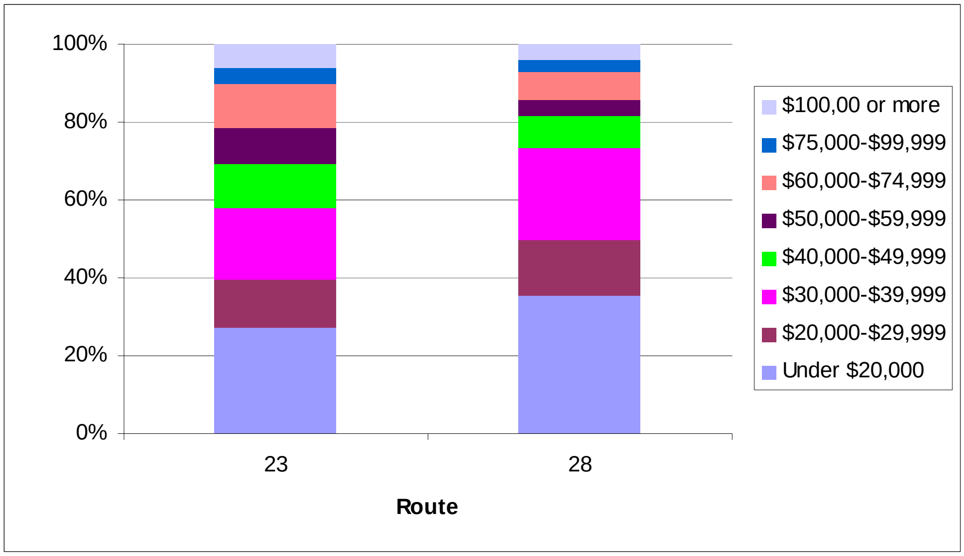


Figure 54: Percentage of Respondents by Race

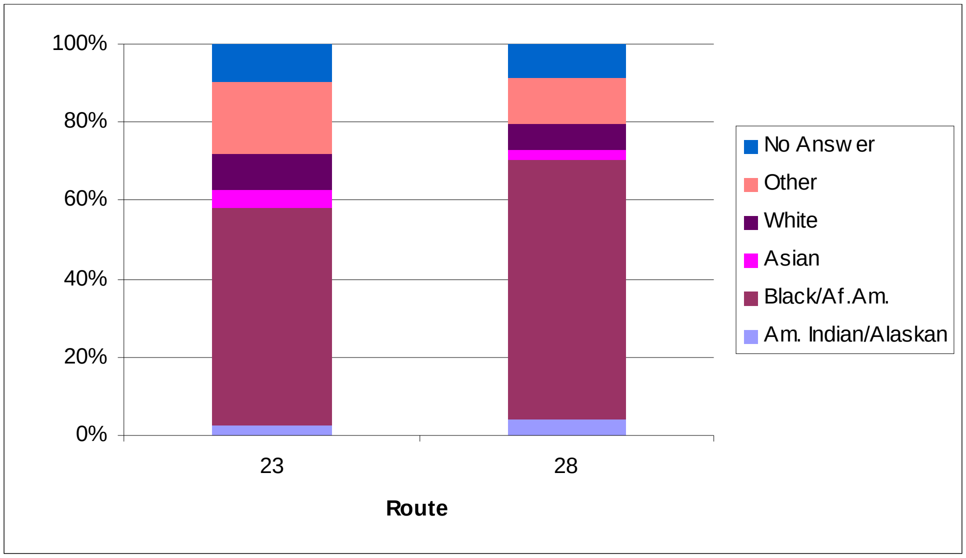


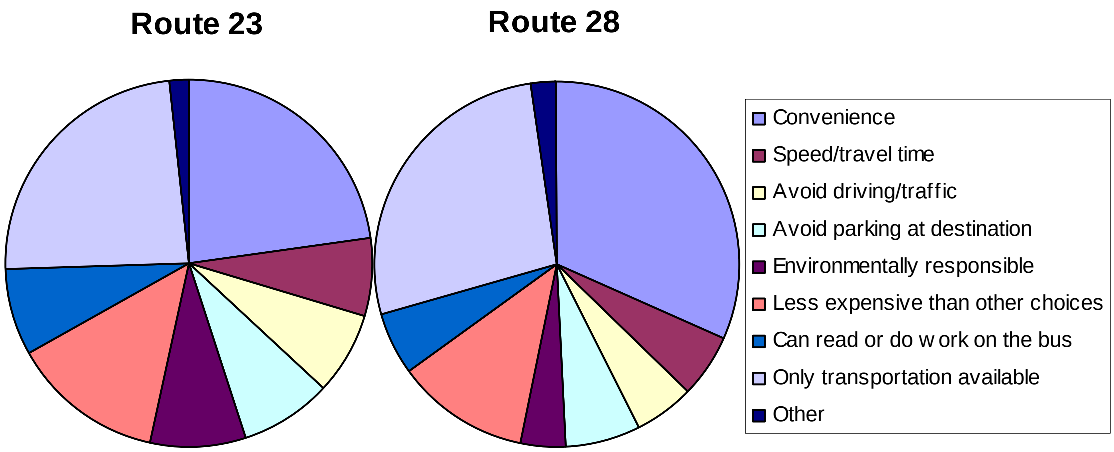
Table 28: Percent Respondents by Hispanic Origin

	Route 23	Route 28
Hispanic	18.8%	11.3%
Not Hispanic	69.0%	71.9%
No Answer	12.2%	16.8%

Reasons for Use

The passenger survey asked riders to check their main reasons for using MBTA bus service. The summarized results for each route are presented in the two pie charts of Figure 55. For both routes, the two greatest responses are “convenience” and “only transportation available.” With 24 percent of Route 23 and 27 percent of Route 28 respondents listing “only transportation available” as a main reason for using the bus, this would further confirm the high percentage of riders on both routes who have no alternative means of transportation. The third-most frequent response for both routes is “less expensive than other choices.” This would seem to indicate the cost-consciousness of many riders on these routes and their sensitivity to price.

Figure 55: Reasons for Bus Use



Service Quality Measures

Finally, the passenger survey asked respondents to rate MBTA bus service according to several measures of service quality: announcement of stops, availability of seating on buses, cleanliness/condition of vehicles, courtesy of drivers, fare collection system, frequency of service, parking availability, reliability (on-time performance), safety and security, signage on vehicles, stop amenities (shelters, benches), and travel time/speed. For Routes 23 and 28, respectively, Table 29 and Table 30 list these measures, their average ranking (with 1 representing “poor,” 3 representing “average,” and 5 representing “excellent”), and the percentage of responses for each ranking. Riders were also asked to indicate which measures are most important to them. The last column in Tables 29 and 30 shows the relative importance to respondents of the service quality measures, and the next-to-last column indicates how many respondents found each important. The service quality measures are sorted in the tables by their relative importance.

For both Route 23 and Route 28, survey respondents rated reliability, measured by on-time performance, as the most important measure of service quality. Safety and security, and frequency of service were two other service quality measures that were listed by riders on both routes among the top four most important measures. The mean score for reliability on both routes was between “below average” and “average.” For most of the measures, most respondents placed both routes in the “average” category. Safety and security scored higher than reliability on both routes. Frequency of service scored slightly lower than reliability on Route 23 and higher on Route 28.

Table 29: Route 23 Customer Service: Ratings by Survey Respondents

Service Quality Measures	Mean Score	% Poor Ratings (1)	% Below Average Ratings (2)	% Average Ratings (3)	% Above Average Ratings (4)	% Excellent Ratings (5)	Importance Votes	Importance Ranking
Reliability (on-time performance)	2.6	18.0%	22.8%	38.4%	19.7%	1.1%	1,645	1
Courtesy of drivers	2.8	17.2%	20.1%	34.9%	18.8%	9.0%	860	2
Safety and security	2.9	17.0%	20.2%	33.1%	20.2%	9.6%	710	3
Frequency of service	2.5	22.0%	22.2%	37.9%	16.3%	1.6%	577	4
Fare collection system	3.0	20.3%	11.7%	31.3%	17.1%	19.6%	544	5
Cleanliness/condition of vehicles	2.7	18.6%	17.2%	39.7%	23.5%	1.0%	524	6
Travel time/speed	2.9	12.3%	14.2%	52.3%	13.3%	8.0%	396	7
Availability of seating on buses	2.5	24.5%	21.1%	38.5%	14.7%	1.3%	260	8
Announcement of stops	3.3	17.3%	5.4%	32.5%	20.1%	24.6%	135	9
Parking availability	2.6	21.4%	18.1%	38.6%	20.1%	1.8%	0	10
Stop amenities (shelters, benches)	2.6	21.5%	17.0%	40.4%	18.5%	2.6%	0	10
Signage on vehicles	3.2	5.4%	14.5%	41.9%	27.0%	11.2%	0	10

Table 30: Route 28 Customer Service: Ratings by Survey Respondents

Service Quality Measures	Mean Score	% Poor Ratings (1)	% Below Average Ratings (2)	% Average Ratings (3)	% Above Average Ratings (4)	% Excellent Ratings (5)	Importance Votes	Importance Ranking
Reliability (on-time performance)	2.7	18.4%	17.2%	42.2%	16.2%	6.1%	1,413	1
Safety and security	3.0	14.0%	15.6%	36.8%	26.8%	6.8%	846	2
Frequency of service	3.0	14.5%	19.5%	29.6%	26.0%	10.3%	732	3
Cleanliness/condition of vehicles	2.5	24.2%	23.8%	31.3%	17.7%	3.1%	474	4
Courtesy of drivers	3.0	14.7%	15.5%	36.1%	27.4%	6.3%	428	5
Travel time/speed	3.0	11.8%	15.6%	39.2%	26.2%	7.2%	348	6
Availability of seating on buses	2.7	19.7%	21.8%	33.1%	19.2%	6.2%	298	7
Fare collection system	3.0	18.7%	15.5%	24.2%	26.1%	15.5%	202	8
Announcement of stops	3.5	11.5%	7.1%	26.4%	25.8%	29.3%	174	9
Parking availability	3.0	17.6%	13.4%	38.9%	16.3%	13.8%	89	10
Signage on vehicles	3.2	15.7%	7.2%	35.9%	24.0%	17.2%	77	11
Stop amenities (shelters, benches)	2.7	21.0%	21.2%	32.1%	14.6%	11.1%	41	12

The mean scores for the various service quality measures were generally slightly lower on Route 23 compared to those on Route 28. The measures with the lowest scores were generally the same, however. These included reliability, cleanliness/condition of vehicles, availability of seating on buses, and stop amenities. One significant difference between the two routes was the lower mean score for frequency of service on Route 23 compared to Route 28. Route 23 riders also rated parking availability lower than Route 28 riders. The announcement of stops, signage on vehicles, and the fare collection system all received mean scores at or above "average" on both routes.

Summary

The results of the passenger survey of Route 23 and Route 28 indicate that the riders on both of these routes exhibit similar patterns. Both groups of riders use the routes for trips to neighborhoods in the corridor, though a significant portion of riders do appear to require a transfer to or from another transit mode or route to complete their trip. However, given the majority of passengers who do not require a transfer from or to the corridor to complete their trip, and the high percentages of passengers whose access and egress to and from the corridor involve walking, it appears likely that Routes 23 and 28 serve as the only mode of transportation frequently used by many riders. Indeed, given the low reported rates of vehicle licenses and availability, and the relatively high rates of transit usage during the week and on weekends, it appears that these routes, and MBTA service more generally, provide the sole means of transportation for many riders.

Although many riders appear to depend on Routes 23 and 28 for their mobility, they generally tend to rate service quality between "below average" and "average." While they rank reliability, safety and security, and frequency of service as among the most important measures of service quality, reliability and frequency of service receive some of the lowest overall scores. Passengers are clearly aware of the schedule adherence and crowding problems identified in the previous section. With the high levels of ridership on Route 23 and Route 28 and the transit-dependent nature of the population served, therefore, improvements in service quality in this corridor could result in significant benefits to a large number of some of the most dedicated riders of the MBTA system.

BUS SERVICE IMPROVEMENT OPTIONS

The recommendations that will be presented later in this report are usually described as belonging to a class of transit known as bus rapid transit, or BRT. A transit mode rapidly growing in popularity throughout the world, BRT generally combines elements of rail rapid transit with bus routes to improve passenger capacity, travel speeds, and schedule adherence, among other characteristics. As BRT can be implemented on the surface with varying levels of physical construction, under certain design conditions it can provide levels of service similar to those of light rail at a reduced cost. This section describes the BRT components that were considered in this study for potential application to the Dudley South corridor.

Segregated Right-of-Way

This is perhaps the most defining characteristic of successful BRT systems throughout the world. A common problem facing local bus routes serving corridors with significant traffic volumes is that buses must compete for space with private vehicles. Segregated rights-of-way remove buses from general traffic, allowing them to skip queues and other delays in vehicle travel lanes and therefore operate at a constant speed and schedule throughout the day regardless of general traffic conditions.

Segregated rights-of-way can take several forms. The most complete is an entire travel lane dedicated solely to buses, or a busway. Busways may also be used to bypass specific traffic bottlenecks, while the bus travels in general traffic in less congested areas. A common configuration for busways places them in the center median. This configuration reduces conflicts with right-turning vehicles while limiting opportunities for left turns. Median lanes are the easiest to segregate from other traffic, thus reducing conflicts between buses and general traffic. However, as pedestrians are required to cross the street to access the busway, the likelihood of pedestrian conflicts may increase. Curbside lanes, unless segregation is strictly enforced, are more subject to potential conflicts with general traffic such as right-turning vehicles, stopping taxis, and delivery vehicles. However, existing roadway right-of-way and capacity constraints may prevent the construction of median lanes where insufficient space exists for two bus travel lanes and stations. Curbside lanes also have the advantage of placing stations on sidewalks. Figure 56 presents examples of roadway configurations with dedicated bus lanes.

On-street-parking impact is also a consideration when dedicating bus rights-of-way. With median lanes, parking is not an issue, except with regard to road width. With curbside lanes, parking can be placed either directly on the curb or between a curbside busway and the general traffic lanes. The latter configuration reduces conflicts between parking vehicles and buses. However, in order to ensure pedestrian safety, setting the parking away from the curb necessitates providing a pedestrian pathway along the busway to avoid having pedestrians cross the busway. When taking this pedestrian pathway into account, the total road width is nearly that of the median busway configuration. Placing the parking lane between the curbside bus lane and the general traffic lanes does, however, greatly assist in ensuring that the busway remains relatively free of conflict.

Figure 56: Busway Lane Configurations and Widths

Median busways and station, 4 general-traffic lanes, and parking

↓	↓	↓				↑	↑	↑
8 feet	12 feet	12 feet	12 feet	16 feet	12 feet	12 feet	12 feet	8 feet
Parking	General Traffic	General Traffic	Buses	Station	Buses	General Traffic	General Traffic	Parking

2 median bus lanes and station = 40 feet

2 median bus lanes, station, and 4 lanes general traffic = 88 feet

2 median bus lanes, station, 4 lanes general traffic, and parking = 104 feet

Curbside busways, 4 general-traffic lanes, and parking inside road

↓		↓	↓	↓	↑	↑	↑		↑
12 feet	6 feet	8 feet	12 feet	12 feet	12 feet	12 feet	8 feet	6 feet	12 feet
Buses	Ped. Path	Parking	General Traffic	General Traffic	General Traffic	General Traffic	Parking	Ped. Path	Buses

2 curbside bus lanes, 4 lanes general traffic, 2 lanes parking, and pedestrian paths = 100 feet

Curbside parking and busways and 4 general-traffic lanes

↓	↓	↓	↓	↑	↑	↑	↑
8 feet	12 feet	12 feet	12 feet	12 feet	12 feet	12 feet	8 feet
Parking	Buses	General Traffic	General Traffic	General Traffic	General Traffic	Buses	Parking

Curbside parking, 2 bus lanes, and 4 lanes general traffic = 88 feet

Curbside busways and 4 general-traffic lanes without parking

↓	↓	↓	↑	↑	↑
12 feet	12 feet	12 feet	12 feet	12 feet	12 feet
Buses	General Traffic	General Traffic	General Traffic	General Traffic	Buses

2 bus lanes, 4 lanes general traffic = 72 feet

As a large portion of travel delay often occurs in the queue leading to an intersection, "queue jump" lanes can also be dedicated to buses, allowing them to advance to the front of the queue. Queue jumps can be interspersed with parking using the same lane, thus reducing the required roadway width. The queue jump is used to both avoid intersection queues and put the bus at the front of a vehicle cohort leaving an intersection, such that it will be the first to arrive at the subsequent intersection.

Figure 57: Queue Jump Lane Configuration and Widths

↓	↓	↑	↑
12 feet	12 feet	12 feet	12 feet
Queue Jump/ Parking	General Traffic	General Traffic	Queue Jump/ Parking

2 queue jump/parking lanes, 2 lanes general traffic = 48 feet

The desirable length for a queue jump lane varies depending on the traffic volume of the cross street. Based on observations of aerial photographs of the study area, 300 feet would generally ensure that a bus is not prevented from entering the queue jump lane by a long queue in the general traffic lane. A greater queue jump distance is desirable when high traffic volume on the cross street demands significant green time, thus leading to longer queues on the primary street. Queue jump lanes of 200 feet (about double the length of bus stops) are likely adequate for intersections with smaller cross streets.

Expedited Boarding

Another essential characteristic of BRT is expedited boarding. Large passenger boarding volumes can dramatically increase bus stop dwell times and lower a route's average speed, particularly if several passengers attempt to pay their fare or load value to their CharlieCard with cash at the bus farebox. Bus boarding time is another significant contributor to travel delay on buses, particularly as all boarding customers must enter through the front door and filter throughout the bus to avoid crowding at the front of the bus. Fare evasion and non-interaction with the bus farebox often result from bus operators trying to load passengers as quickly as possible.

There are several potential options to expedite boarding, all of which involve the establishment of some sort of "fare zone." One type of fare zone involves the placement of stationary validators at bus stops, as the MBTA currently does for surface stops of the D Branch on the Green Line. Passengers would be required to obtain a printed validation from the machines before boarding, and inspectors would periodically check buses to ensure compliance. The use of validators would allow bus operators to open all doors for boarding. Alternatively, BRT routes could be turned into non-cash services, in which passengers would be required to use either a CharlieCard or CharlieTicket and would be prohibited from loading cash onto a CharlieCard onboard the buses. Fare zones at every stop would contain stationary fare vending machines on which passengers could add value or purchase pass products. While this option would reduce fare evasion and expedite fare payment, it would still require passengers to board through the front door.

Pre-paid boarding allows passengers to enter the bus from any door and avoids the requirement for passengers to pay onboard. In order to work, however, a segregated fare payment zone must be established into which entry is limited to those having paid their fare. Faregates are sufficient for permitting access to the fare payment zone, though some combination of gate attendants or camera recording device is often necessary to discourage fare evasion. The fare payment zone is, in effect, a miniature station, sufficient in size to hold all waiting passengers. Buses pull up to the station, aligning doors open by remote control, and passengers board and alight. Station lengths should accommodate the distance from the front to the rear door of the non-articulated buses currently serving the corridor. Station widths should be no less than 10 feet and preferably 12 feet, and there should be no setback from the street for sidewalk stations, as buses would need to pull up directly to the curb to enable direct boarding and alighting. Passengers could board and alight through either the front or rear door at stations. It is more important to have pre-paid-fare stations at stops with large boarding totals, and less important at stations with large alighting totals.

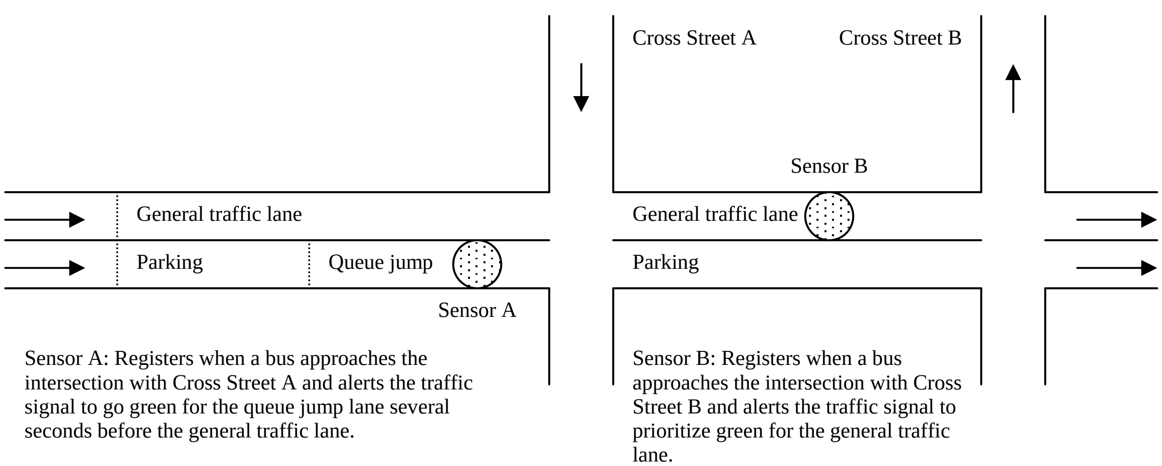
Traffic Signal Priority

A third important aspect of BRT is the ability to provide buses with traffic signal priority (TSP) through intersections. In the most common application of TSP, as a bus approaches an intersection, the signal registers that approach through a sensor placed before the intersection (the placement depends on the assumed speed of the bus and the distance to the intersection) and grants directional priority. Based on various set traffic signal priority strategies, priority is given to the approaching bus, thereby permitting it through the intersection with little or no queue delay time. This application also serves to improve general traffic flow in the direction of the buses. However, the potential application of TSP must also consider the effect on side-street traffic flows. Note that priority differs from preemption. Whereas the former attempts to allocate the green light to the selected direction given the traffic conditions of the cross street and the stage in the signal phasing, the latter grants the green light regardless of other conditions.

Signal priority can also be used in conjunction with segregated rights-of-way such as queue jump lanes. After the queue jump ushers a bus to the front of the queue at an intersection, sensors register the bus's arrival at the intersection and grant lane priority. Priority is given to an exclusive signal for the bus lane, turning the signal green several seconds in advance of the other lanes when all lanes are queued with vehicles waiting for a green light. This ensures that the bus can cross back into the general-traffic lane without conflict and at the front of the cohort of vehicles departing the intersection. This is the application of queue jump lanes that is suggested throughout this report when dedicated busways are infeasible.

These two applications of TSP can complement each other. For instance, a bus enters a queue jump lane, moves to the front of the queue at a red light, and is released from the intersection several seconds before the rest of the vehicle cohort. This allows the bus to easily pull back into the general-traffic lane. As the bus travels in this lane, it triggers a sensor midway through the block that alerts the upcoming signal to prioritize green in the bus's direction, thus allowing the bus and the cohort of vehicles traveling with the bus to pass through this intersection without stopping.

Figure 58: Applications of Traffic Signal Priority



Stop Consolidation

While small distances between stop locations provide greater access, they do so at the cost of reduced speed, as buses must often make frequent stops in which a small number of passengers board or alight. BRT systems generally favor the reverse, and stop consolidation is an effective means of improving travel speeds. Distances between stops in BRT systems generally approach those in surface light rail systems, with a minimum of 0.25 miles up to a maximum of 0.50 miles between stops. Stop consolidation must consider not only distance between stops, but also the relative activity of existing stops. Stops with low activity are more likely to be consolidated than stops with high activity.

Stop Location

The location of stops in relation to intersections can also affect BRT service. There is less general agreement as to the preferable location for stops in BRT systems, as each location option has its own pros and cons. The degree of importance of stop location in a given case depends largely on the extent of lane segregation. Where an entire travel lane is dedicated to a busway, for example, the only stop location that would be inadvisable would be the near side of the intersection, as this would prevent buses from utilizing TSP through the approach to signalized intersections ("near side" refers to the approach to an intersection while "far side" refers to the departure). But whether the stop is located mid-block or far side in busways matters little, as the bus does not need to contend with general traffic. If insufficient space exists to place a pre-paid-fare station on the sidewalk, a bulb-out (or curb extension) could be built for the station. As the bulb-out would infringe upon the street, parking would likely need to be eliminated to create the necessary space.

Where this study recommends the use of queue jumps, it also calls for a mix of near-side and mid-block stop locations. That is, the recommendations call for locating a stop approximately 200 feet before the intersection and dedicating the lane between the stop and the intersection to bus-only travel. In this way the bus can board and discharge passengers at its stop and then trigger TSP upon leaving the stop. Then, at the intersection, the queue jump lane will be granted a green light several seconds before the other travel lanes. The following diagram presents the recommended stop locations for the two types of segregated rights-of-way.

Figure 59: Busway Stop Location

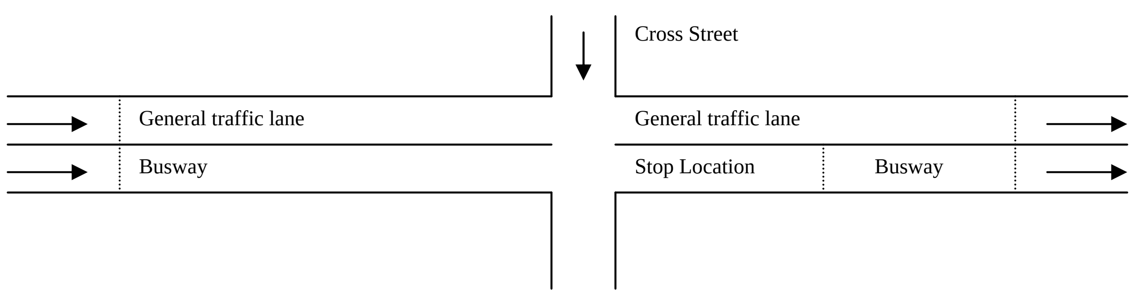
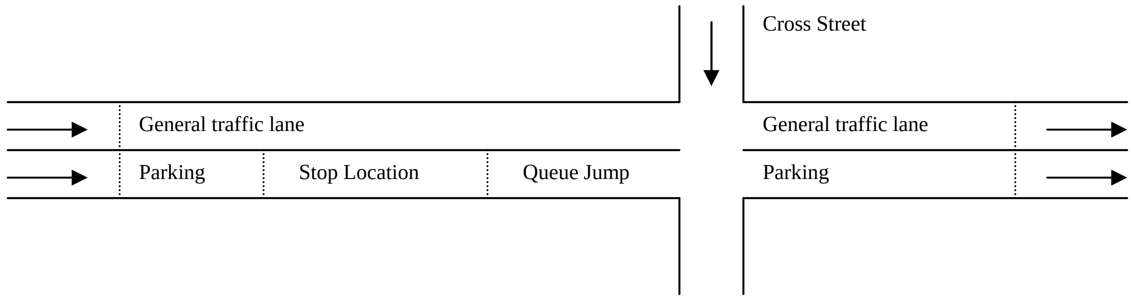


Figure 60: Queue Jump Stop Location



Headways

High-frequency buses are another common component of BRT systems. If BRT is to appear to potential users to be comparable to rail, then the headways of the two should be comparable. Routes 23 and 28 currently run at scheduled headways of 10 minutes or less in the peak periods and as much as 20 minutes in the non-peak periods. Ideally, headways on the two routes would approach those currently scheduled on the Silver Line Washington Street. As the two routes share the same corridor along Warren Street, headways of 8 minutes for each route during the peak periods would be appropriate. Headways of 10-minutes in the evening and 15 minutes late at night would also be sufficient for this corridor.

Summary

Table 31 lists various combinations of segregated right-of-way, traffic signal priority ("directional priority" indicates that traffic signal preference is given to the direction in which a bus is traveling and "lane priority" indicates that advance green time is given to the lane in which a bus is queued), and stop location, ranking the combinations by how each would perform. The highest-performance BRT configuration would combine a dedicated busway with directional priority and have its stops located anywhere except the near side of the intersection. Second in preference would be queue jump lanes with lane priority. This is the only case where near-side stop locations are advisable. Dedicated bus lanes with no TSP rank higher than queue jumps with no TSP. However, segregated rights-of-way of any kind would be preferable to no segregation and directional priority.

Table 31: Potential Combinations of BRT Elements, Ranked by Performance

Rank	Segregated Right-of-Way	Traffic Signal Priority	Stop Location
1	Dedicated Busway	Directional Priority	Far side or Mid-Block
2	Queue Jump	Lane Priority	Near side
3	Dedicated Busway	None	Far side or Mid-Block
4	Queue Jump	None	Far side or Mid-Block
5	None	Directional Priority	Far side or Mid-Block

When the decision on whether to introduce any one or combination of BRT elements is made, the potential impacts on existing road conditions must be taken into consideration. The relationship between parking, pedestrian access to those parked cars, and the relative location of dedicated busways must be clearly understood. Moreover, if the construction of busways necessitates the removal of parking, the implications of drivers parking on side streets should be considered. Queue jumps will also come at the expense of parking, though stop consolidation should add parking spaces. The implementation of BRT elements will also affect general-traffic LOS, with implications for road safety, traffic flow on side streets and the main street, turning-movement permissions, and general intersection performance. These implications must also be clearly understood.

CONCEPTUAL RECOMMENDATIONS

This section considers the potential application of the previously discussed bus improvement measures. It is important to note that the following recommendations and ideas are conceptual in nature. While some consideration is given to the implications of the proposed bus improvement measures on traffic operations, this analysis does not present a definitive answer as to the applicability of the recommendations, only to their conceptual potential. In the actual application of various BRT components to improve bus performance, it would be important to consider their impacts on traffic operational conditions.

Specifically, when dedicating busways or queue jump lanes or granting traffic signal priority to buses, one would need to take into account available roadway widths, the effect on parking, and existing rights-of-way, traffic patterns, signal conditions, and queue lengths. Plans for construction of fare zones must consider available sidewalk or median capacity. When planning bus frequency, one should consider the implications for cross street traffic of many buses receiving TSP. In addition to impacts on traffic operations, impacts on BRT components on pedestrians should also be considered. Such impacts could result primarily from stop consolidation. Finally, the safety and comfort of bicyclists should also be considered – though the recommendations of the present study would not be expected to impact bicyclists significantly.

Note that the measurements of road and lane width used here are based only on visual inspection (both in the field and online) and have not been confirmed. Suggestions to add or merge lanes, take roadway width from medians, or establish fare zones on sidewalks are preliminary and are made for the purpose of providing useful reference points in discussion of the potential for bus service improvement along the Dudley South corridor.

The following discussion presents a general vision for each of three segments of the corridor. It describes the general roadway alignment of the segment and the strategy for improving bus service in terms of the potential BRT elements that have been explained. More-specific design ideas are included in Appendices B through E. Appendix B discusses the application of the general concepts presented in the study to the specific features of the corridor. Appendix C considers the portion of Routes 23 and 28 between Dudley and Ruggles Stations and the transfer implications of potentially merging Route 28 into the Silver Line Washington Street. Appendix D presents a conceptual design for bus circulation in and around Dudley Station. Appendix E presents data on and suggests possible improvements to passenger circulation in Dudley Station.

The three segments discussed are: (1) Warren Street from Dudley Station (note that recommendations for Dudley Station bus circulation are located in Appendix D) to Grove Hall and the intersection of Blue Hill Avenue and Washington Street; (2) Washington Street, Talbot Avenue, and Dorchester Avenue from Grove Hall to Ashmont Station, on which only Route 23 operates; and (3) Blue Hill Avenue from Grove Hall to Mattapan Station, on which only Route 28 operates.

Warren Street Summary

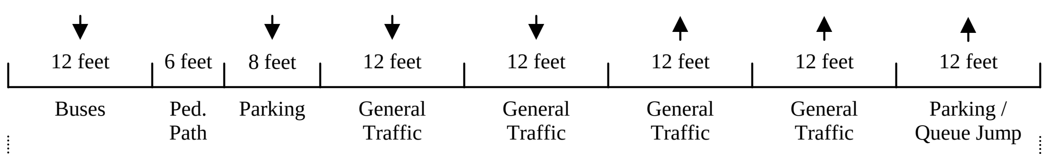
In general, this study recommends two different roadway configurations for the two directions on Warren Street. It does not appear as though sufficient width is universally available on Warren Street to construct two bus-only lanes. However, the existing median on Warren Street appears large enough to allow for one busway to be constructed. The busway would run curbside, with fare zones or shelters placed on the sidewalk, and a pedestrian pathway accompanying parking would adjoin the busway, providing a barrier between the busway and the general traffic lanes. Four lanes (including a lane for parking) are generally available for whichever direction has the busway; at intersections where left-turn lanes are introduced, some parking spaces would be removed. The other direction would have three lanes allocated to it – two for general traffic and one alternating between parking and a queue jump lane dedicated to buses. TSP would be used for buses traveling in the busway in one direction and using the queue jump lanes in the other direction. Figure 62 is an aerial view of a segment of Warren Street showing the existing street configuration.

It is recommended that the busway be constructed in the southbound (outbound) lanes of Warren Street between Kearsarge Avenue and Townsend Street and the northbound (inbound) lanes between Blue Hill Avenue and Quincy Street. This suggestion stems primarily from the relative average speeds in the two directions on Warren Street. As has been described, where the busway exists in one direction, the other would be served by a series of queue jump lanes. Figure 61 presents a diagram of the proposed configurations (accounting for various combinations).

Warren Street appears, from the aerial photography in the Commonwealth's pictometry database, to have a width of approximately 82-84 feet. With this width, the proposed configurations would be slightly too large. Possible adjustments might include taking a foot or two from general traffic lanes, reducing the width of the parking/queue jump lane or the left-turn lane, or implementing a system of queue jump lanes in both directions.

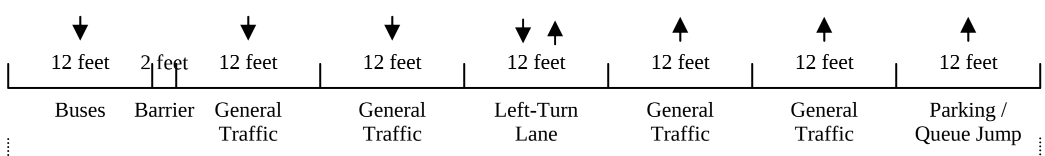
Figure 61: Warren Street Lane Configurations and Widths

General proposed configuration (North View)



Curbside busway and parking and path outbound; 4 lanes general traffic; curbside parking/queue jump inbound = 86 feet

Proposed configuration with left-turn lanes (North view)

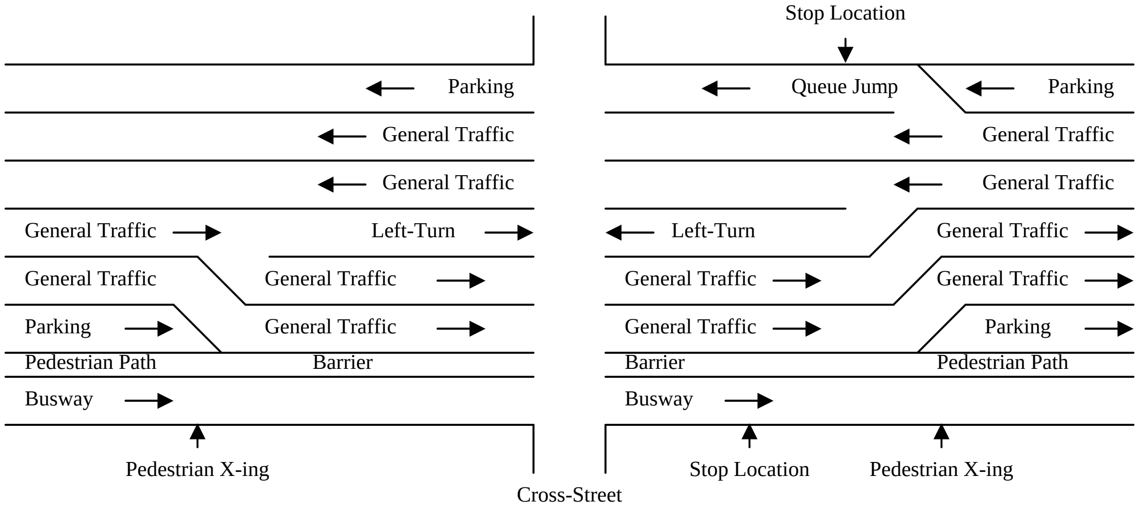


Curbside busway and barrier; 4 lanes general traffic; left-turn lane; curbside parking inbound = 86 feet

Figure 62: Warren Street between St. James Street and Circuit Street

Figure 63 presents a potential configuration of an intersection with left-turn lanes, a busway in one direction, and a queue jump lane in the other direction. The two general traffic travel lanes in the direction of the busway shift one lane to the right to accommodate a left-turn lane in either direction. As a result, parking is eliminated for the duration of any left-turn lane. Note that the stop location for the busway is on the far side of the intersection, while the stop location for the queue jump is on the near side of the intersection. A pedestrian crossing links the pedestrian path with the sidewalk.

Figure 63: Warren Street Intersection Configuration (East View)



Washington Street-Talbot Avenue-Dorchester Street Summary

Virtually the entire length of the corridor associated with Route 23 along Washington Street, Talbot Avenue, and Dorchester Street is restricted to two travel lanes and two curbside parking lanes. Left-turn only lanes do not exist in this corridor. Figure 64 presents an aerial photograph of a section of the corridor characterized by this lane configuration.

Given the restrictions imposed by the road width, the opportunities for BRT-type improvements are limited. The general recommendations for lane configuration in this corridor, therefore, call for traffic signal priority at all signalized intersections and queue jump lanes to be used at the near side of intersections where bus stops are located. Stop consolidation, to the extent possible, is also recommended. Figure 65 presents an example diagram of the proposed lane configuration with associated lane widths. Figure 66 describes the basic configuration of an intersection and approach to an intersection with queue jumps.

Figure 64: Washington Street between Lyndhurst Street and Talbot Avenue

Figure 65: Washington Street Lane Configuration and Widths

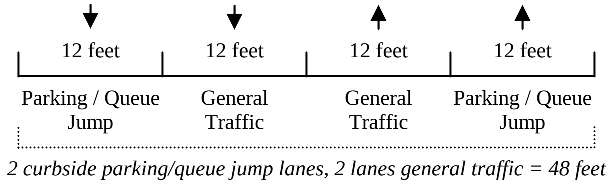
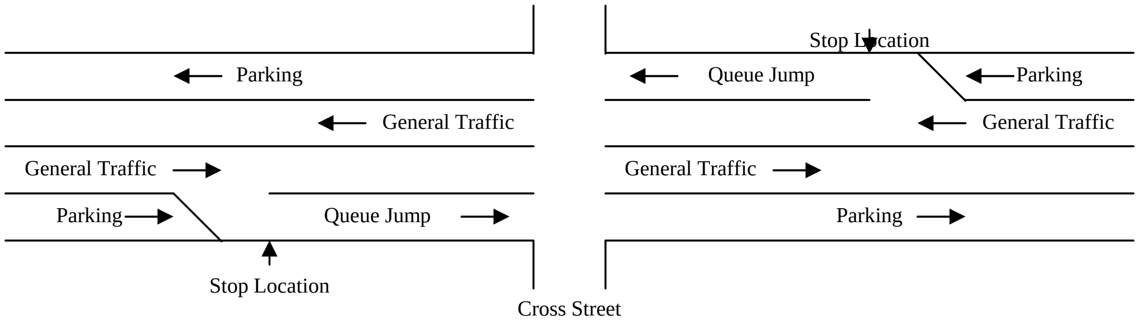


Figure 66: Washington Street Intersection Configuration



The current road width exceeds 48 feet throughout the corridor, so this lane configuration would not necessitate any roadway expansion. Entrances to queue jump lanes would need to be clearly marked, and a barrier would need to be erected in order to prevent access from the general traffic lane except at the entrance. In terms of traffic signal priority, separate traffic signals for queue jump lanes would need to be introduced at all intersections with such lanes, and the sensors necessary to activate either lane priority or directional priority would need to be inserted into the road. In the case of lane priority, queue jump lanes would receive green time in advance of the general traffic lanes.

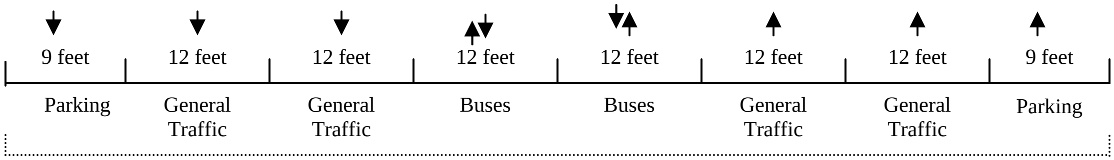
Blue Hill Avenue Summary

South of the intersection with Washington Street, Blue Hill Avenue widens to approximately 90 feet. The existing configuration includes two curbside lanes of parking, four travel lanes, and a median approximately 24 feet in width. Where left-turn-only lanes occur, they have been created by taking one-half of the median. Further south of the American Legion Highway, Blue Hill Avenue expands to a greater width, but the configuration does not change. Figure 69 shows an aerial photograph of a section of Blue Hill Avenue south of the American Legion Highway.

The general recommendations for lane configuration on this section of Blue Hill Avenue call for two lanes of parking, four general traffic lanes, and two median busway lanes. The busway could use regular or contraflow lanes. On the segments of the road in which stations are located (in the median, always on the far side of the intersection), parking would be eliminated and the sidewalk would be extended slightly. Figure 67 presents potential lane configurations along with associated lane widths. The reconfiguration of intersections to accommodate busway stations would necessitate significant capital investment for the stations themselves, including fare gates and automatic doors, as well as changes to the sidewalk and to road lane markings. The general replacement of the median with the busway, while requiring construction of the lanes and the barriers to restrict access, would be less complex.

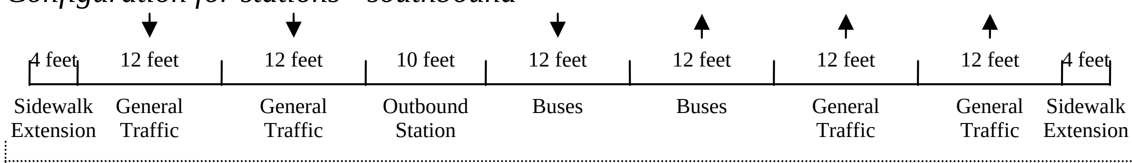
Figure 67: Blue Hill Avenue Lane Configurations and Widths

Configuration for travel lanes (regular or contraflow bus lanes)



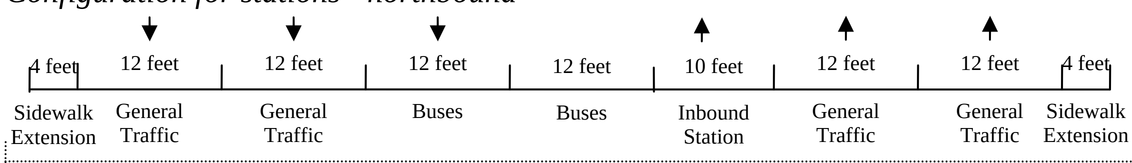
2 curbside parking lanes, 4 lanes general traffic, 2 median bus lanes = 90 feet

Configuration for stations - southbound



4 lanes general traffic, 2 median bus lanes, outbound station, sidewalk extensions = 90 feet

Configuration for stations - northbound

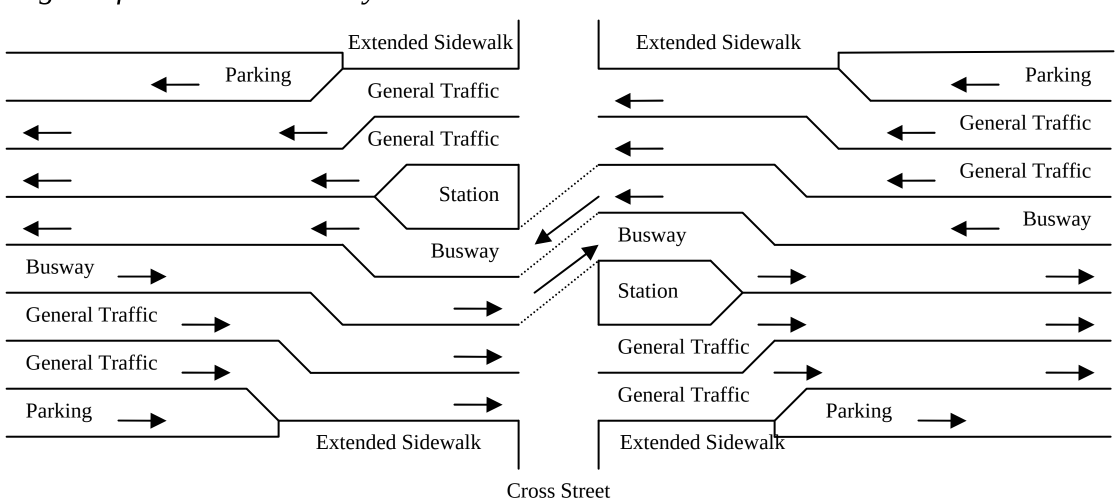


4 lanes general traffic, 2 median bus lanes, outbound station, sidewalk extensions = 90 feet

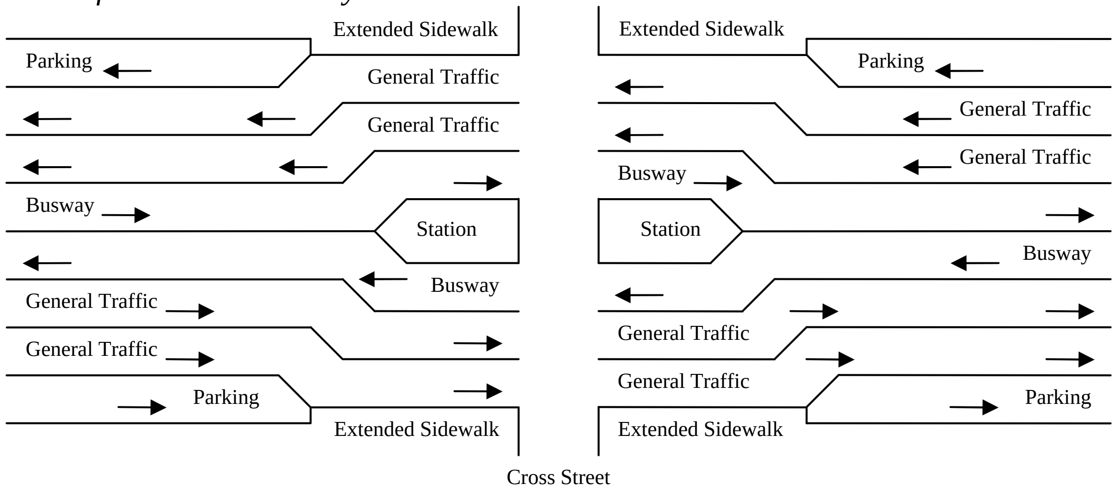
Figure 68 presents two potential configurations of an intersection and approach to an intersection with two median busways. The first shows regular flow busway lanes and the second shows contraflow busway lanes. In both cases, the station should be located on the far side of the intersection.

Figure 68: Blue Hill Avenue Intersection Configurations

Regular flow median busway lanes

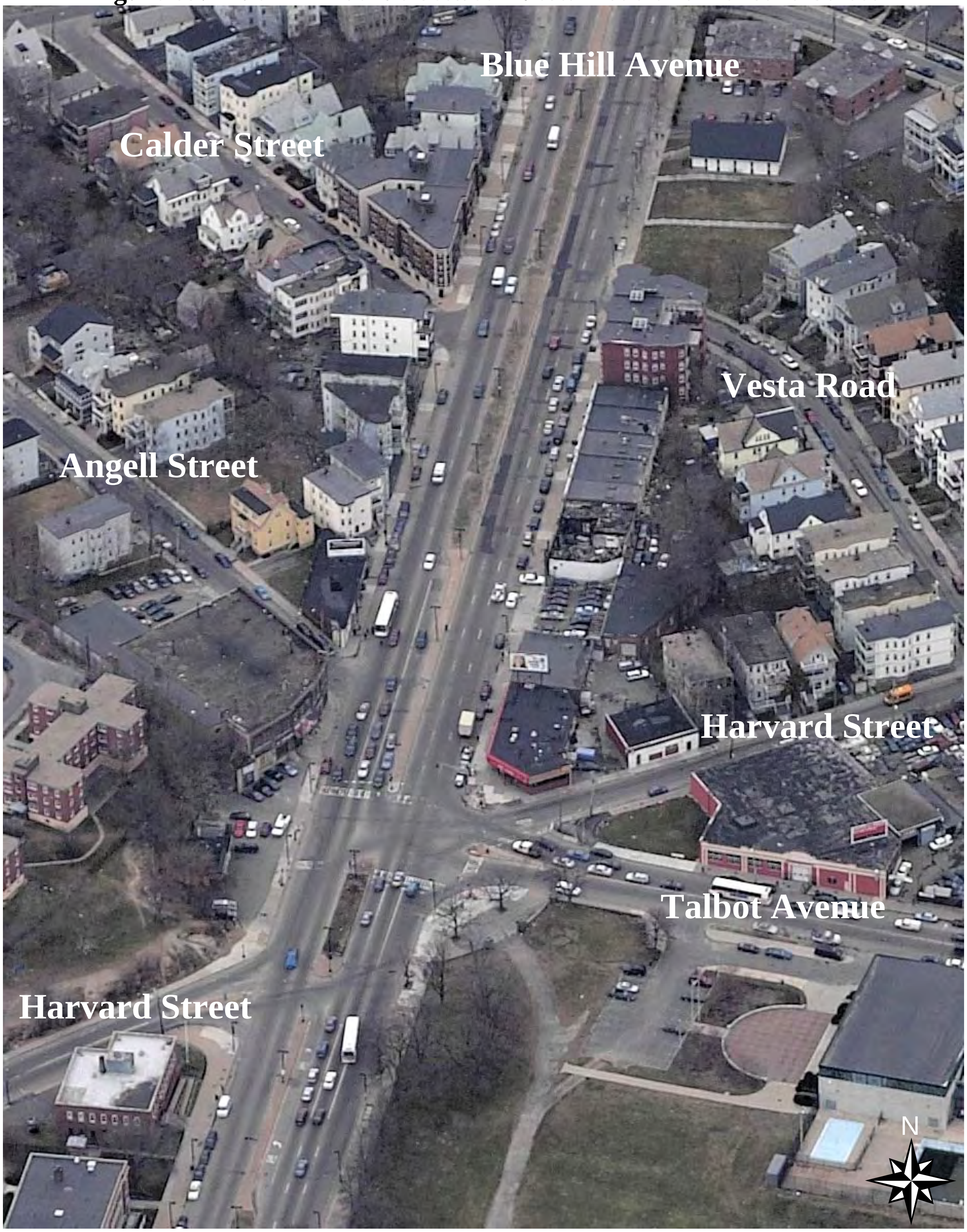


Contraflow median busway lanes



Based on the general characteristics of the Blue Hill Avenue section of the corridor, it seems that this is an ideal section to test for TSP treatments along its entire length. This is because this segment of the corridor is a multi-lane roadway with buses, bus stops, and on-street parking that does not affect general traffic significantly. In other words, general traffic would not impede the implementation of TSP strategies at the signalized intersections studied in this task of the study.

Figure 69: Blue Hill Avenue between Vesta Road and Harvard Street



CONCLUSION

The area south of Dudley Station between Ashmont and Mattapan Stations is one of the most important transit corridors in the MBTA bus system. Many local bus lines serve the area. However, surface bus routes face the same problems as general traffic, and given that many of these routes serve highly populated areas using major roadways, bus service is often characterized by crowding and poor schedule adherence.

This study has proposed several conceptual recommendations for improving bus service in the Dudley South corridor. These recommendations borrow from a list of measures typically characterizing a class of transit called bus rapid transit (BRT). Providing bus rapid transit in the Dudley South corridor would improve service on two of the MBTA's most heavily patronized routes as well as other routes that share segments with the corridor. Indeed, the measures suggested in this study could potentially be applied to other bus routes and other corridors. It would be appropriate, however, to begin the process of introducing BRT services in one of the most important bus corridors in the MBTA system.

This study was conducted with the intention of informing discussion about the potential for improving bus service in the Dudley South corridor. The MBTA, the Executive Office of Transportation and Public Works, or other organizations with an interest in improving public transportation can use the ideas and concepts presented in this study for more detailed feasibility studies. Stakeholder meetings, final design proposals, and the procurement of the necessary permits and construction contracts would follow as the next steps in the process.

As part of a thorough feasibility analysis for implementing BRT improvements to bus service in the corridor, the impacts of the proposed elements on parking and the level of service for roadways and intersections would need to be considered. Microsimulation of traffic signal improvements, thorough design plans for roadway configuration, detailed assessments of costs for capital construction and operations, and finalized operational plans for routing, scheduling, and stop consolidation and location should also be incorporated into any feasibility study. Next steps should also include consulting with the public, the City of Boston, and advocacy organizations in order to obtain community support and City coordination.

It may be possible that some of the potential measures presented in this study, such as stop consolidation, intersection signal coordination, scheduling improvements, or other general traffic improvements, could be effected in the short term. These elements could provide immediate benefits to the corridor while BRT concepts are being examined in greater detail.

APPENDIX A: DESCRIPTION OF SIGNALIZED INTERSECTIONS

The seven signalized intersections described in this appendix are the northernmost intersections along Blue Hill Avenue in the Dudley South corridor. Given the limited scope of this study, only a certain number of intersections were selected. Staff chose these intersections primarily because they carry higher traffic volumes than all other intersections along Blue Hill Avenue and are contiguous locations. The latter characteristic is very important for traffic signal coordination or transit signal priority considerations.

Blue Hill Avenue and Warren Street

Warren Street meets Blue Hill Avenue at a skewed angle. This three-approach signalized intersection also provides access to a retail shopping area. Georgia Street is a single-lane roadway that is one-way away from Blue Hill Avenue. The intersection operates under semi-actuated signal control. Pedestrian movements are also under signal control and operate concurrently with the traffic phases. According to BTD signal permits, this intersection operates in coordination with the Washington Street intersection. The Warren Street approach consists of two general-purpose lanes that provide left turns, offset through, and right turns. Blue Hill Avenue northbound has one left-turn lane and two general-purpose lanes. The Blue Hill Avenue southbound approach also has two general-purpose lanes. The entrance to the shopping plaza has two exit lanes.

Blue Hill Avenue and Washington Street/Cheney Street

The Blue Hill Avenue and Washington Street/Cheney Street intersection has four approaches and is also under signal control. As mentioned above, it is in coordination with the Warren Street intersection. Pedestrian movements are accommodated at the intersection by an exclusive pedestrian phase, which allows movements across all streets. The northbound Blue Hill Avenue approach has three through lanes, with right turns sharing the rightmost through lane. The southbound approach to the intersection has two through lanes and one left-turn lane. The Cheney Street approach has one general-purpose lane and is one-way towards the intersection. Washington Street has two lanes, one left-turn lane and one right-turn lane.

Blue Hill Avenue and Seaver Street (Route 28)

This intersection is heavily used, with Seaver Street (Route 28) north of the intersection, a primary arterial, continuing into Roxbury and then into downtown Boston. Heavy turning movements onto and from Seaver Street and the intersection lane configuration reflect the classification of Seaver Street. On Blue Hill Avenue northbound, there are two exclusive left-turn lanes to accommodate the heavy traffic movement to Seaver Street. Conversely, Seaver Street has an exclusive right-turn lane that is median-divided and is under signal-control. Pedestrian movements at the intersection are accommodated concurrently with the traffic signal phases.

The Blue Hill Avenue northbound approach to the intersection has two left-turn lanes and two through lanes. Right turns share one of the through lanes. The southbound approach has one left-turn lane, two through lanes, and a short right-turn lane. The Seaver Street approach from the west has one left-turn lane and one left/through lane. The right turns have an exclusive right-turn lane that is median-divided and is under signal control. This right turn enters Blue Hill Avenue southbound onto its own lane, thus eliminating conflicts with Blue Hill Avenue southbound through movements.

Blue Hill Avenue and Columbia Road/Circuit Drive

This intersection not only connects the busy Columbia Road with Blue Hill Avenue, but also provides access to Franklin Park. According to the traffic signal permit, this signal is interconnected with the Seaver Street intersection for coordination. An exclusive pedestrian phase is provided in the signal phasing to allow all pedestrian movements. The Blue Hill Avenue northbound approach has one exclusive left-turn lane and three through lanes, with the right turns sharing a through lane. The southbound lane also has an exclusive left-turn lane and three through lanes. The Columbia Road approach has two left-turn lanes, one through lane, and one right-turn lane. Circuit Drive is one-way away from the intersection.

Blue Hill Avenue and Glen Lane/Glen Way Street

This intersection provides the primary exit from the Franklin Park Zoo and also provides access to a cut-through to Columbia Road via Old Road. Pedestrians are accommodated by an exclusive phase. The northbound approach to the intersection consists of three through lanes and one exclusive right-turn lane. Blue Hill Avenue on the southbound approach has three through lanes, one right-turn lane, and an exclusive left-turn lane. Circuit Drive is one-way into the intersection and has two lanes. Glenway Street is one-way away from the intersection.

Blue Hill Avenue and American Legion Highway

This location is a three-way signalized intersection, with the American Legion Highway entering from the west at a skewed angle. There is an exclusive pedestrian phase to accommodate pedestrian movements. The American Legion Highway approach to the intersection consists of an exclusive left-turn lane and one shared left/right-turn lane. The northbound Blue Hill Avenue approach has an exclusive left-turn lane and three through lanes. The southbound approach has one right-turn lane and two through lanes.

Blue Hill Avenue and Talbot Avenue/Harvard Street

This last location is actually two offset intersections that operate as a single intersection. The signal permit provides information on the simultaneous operation. The traffic signal is under fully actuated control, which allows great flexibility to accommodate the many traffic movements at the intersection. An exclusive pedestrian phase serves all pedestrian movements. The northbound approach has one left-turn lane, two through lanes, and one right-turn lane at Talbot Avenue. The southbound approach has an exclusive left-turn lane to Talbot Avenue and three through lanes, with the rightmost lane then becoming a right-turn lane at Harvard Street. The Harvard Street approach from the west has a single general-purpose lane. The Harvard Street eastbound approach is single-lane. The Talbot Avenue approach has one left-turn lane and one shared left/right-turn lane.

Figure A-1: Signalized Intersections Analyzed for Performance

APPENDIX B: DESIGN CONCEPTS

This appendix applies the conceptual recommendations presented in the body of the report by proposing more-specific design ideas for various segments of the Dudley South corridor. Once again, it is important to note that the following recommendations and ideas are conceptual in nature. While some consideration is given to the implications of the proposed bus improvement measures on traffic operations, this analysis does not claim to present a definitive answer as to the applicability of the recommendations, but only to indicate their conceptual potential. Note that the measurements of road and lane widths used here are unconfirmed estimates based on visual inspection (both in the field and online). Suggestions to add or merge lanes, take roadway width from medians, or establish fare zones on sidewalks are initial thoughts that require much more analysis.

Warren Street

Dudley Station – Kearsarge Avenue

<u>Outbound</u>

Per the recommendations in Appendix D, buses exiting Dudley Station and turning onto Warren Street southbound should not have to deal with any general traffic. The only possible conflict before the first stop, opposite Kearsarge Avenue, is with southbound traffic on Harrison Avenue when it merges with Warren Street; however, this traffic merges into the left lane of Warren Street, so buses traveling in the right lane should seldom encounter conflict. All parking along Warren Street across from the library could be eliminated to avoid potential conflicts between buses and parking vehicles, particularly as there appears to be ample parking behind the library.

The right-hand lane of Warren Street is large enough that it could almost encompass a bus-only lane and another general traffic lane. Indeed, taking a portion of the center median and shifting the lane from Harrison Avenue over could accomplish this. This could permit three lanes on Warren Street – one 12-foot lane marked as an exclusive busway and two 12-foot lanes for general traffic. The beginning of the bus lane could be marked coming out of the turn from Dudley Street onto Warren Street, with general traffic directed to use the left-hand lanes.

The stop opposite Kearsarge Avenue at the library could stay at its current location, as it is a relatively well-used stop (182 daily boardings, 56 daily alightings outbound) serving the library. Enough sidewalk space exists that a pre-paid fare payment zone or a protected space for a fare vending machine or stationary validator could be established. However, building a shelter in front of the library could sufficiently serve demand if there is no stop consolidation. On the other hand, with stop consolidation (see the following recommendations), considerable numbers of passengers who formerly used the eliminated stops may use the stop opposite Kearsarge Avenue. If passengers boarding at St. James Street and Dabney Place walked to Kearsarge Avenue, the total daily boardings would come to 327 passengers. In this case, the establishment of some sort of fare zone for pre-payment, validation, or the loading of value onto CharlieCards/CharlieTickets would be advisable. In addition, the stop could be moved mid-block, back to the start of the busway. It is currently located on the near side, and this would prevent traffic signal prioritization from working properly to facilitate buses' travel through the traffic signal at the Kearsarge Avenue intersection.

<u>Inbound</u>

In the inbound direction, buses must cross to the left-hand lane before entering the intersection with Dudley Street. This movement could be facilitated by turning the distance between the stop and the Kearsarge Avenue intersection into a queue jump lane, and alerting the traffic signal to give the queue jump lane advance green time such that the bus could merge into the left-hand lane for Warren Street ahead of general traffic. The bus will also be at the front of traffic leaving the intersection, thus putting it towards the beginning of the vehicle cohort traveling towards the Dudley Street intersection. The stop at Kearsarge Avenue is a relatively well-used stop (26 daily boardings and 306 daily alightings inbound) serving a popular destination. While there does not appear to be enough space or demand to allow or justify a fare zone of any kind, a shelter could be installed in front of the church, moved back slightly from the current stop location to provide sufficient space for the queue jump lane. A few parking spaces in front of the lane would need to be eliminated for the queue jump lane.

Kearsarge Avenue – Waverly Street

<u>Outbound</u>

The three stops along Warren Street at St. James Street, Dabney Place, and Walnut Avenue could be eliminated. Each stop has less than 100 daily boardings and, except for Walnut Avenue, less than 100 daily alightings. St. James Street and Dabney Place are separated by less than 0.05 miles and the total distance between Kearsarge Avenue and Walnut Street is 0.41 miles. This is a reasonable distance between BRT stops. Not stopping at these three stops could save buses considerable travel time.

South of Kearsarge Avenue, by taking a portion of the median for a curbside lane and shifting the parking lane and two travel lanes one lane to the left, the dedicated busway could be maintained. Where left-turn lanes occur, the two travel lanes could shift one lane to the right and the parking could be eliminated. Such a situation occurs just north of the intersection at Regent Street. The lane of curbside parking south of the intersection from Regent Street to Walnut Avenue could also be converted into a dedicated bus lane to accommodate the northbound left-turn lane. There appears to be little demand for parking in this corridor segment, as most of the surrounding land uses are residential buildings with their own parking.

South of Walnut Avenue, southbound parking along the length of the northbound left-turn lane would need to be eliminated to continue the busway. However, parking could be provided when the left-turn lane in the northbound direction ends, by taking a portion of the median and shifting the travel lanes over such that a parking lane could be placed between the general traffic lanes and the busway.

Figure B-1: Dudley Station to Montrose Street via Warren Street (North View)

Through the intersection with Waverly Street, this situation continues. As Warren Street approaches Waverly Street, the left-hand lane could become a left-turn-only lane, thus necessitating that the two travel lanes shift one lane to the right and eliminating parking on that approach. The busway could continue in the curbside lane.

<u>Inbound</u>

A queue jump lane could be inserted beginning about 200 feet before the intersection with Waverly Street. A type of fare zone could be established at this stop. After boarding is complete, if the light at the intersection is red, the bus would move up to the stop line, triggering a sensor to give the bus lane green time in advance of the general traffic lanes. The bus could merge into the general traffic lane bordering parking at the front of the vehicle cohort leaving the intersection.

The stops at Montrose Street and Moreland Street could be eliminated. Both have less than 100 daily boardings. The total distance between the stops at Waverly Street and Kearsarge Avenue would be 0.41 miles. This is a reasonable distance between BRT stops.

Queue jump lanes could be constructed at each signalized intersection. This includes Whiting Street and Moreland Street. In each of these cases, the queue jump lane could replace parking beginning approximately 200 feet prior to the intersection. TSP could register buses' arrival and grant them green time in advance of the general traffic lanes if the light is red. Alternatively, if the recommendations for stop consolidation were adopted, there would no longer be any stops at these intersections, and traffic signals could employ traditional TSP to prioritize the green signal for all lanes on Warren Street at signalized intersections when buses are approaching. However, this type of signal priority is already potentially being used in the outbound direction in conjunction with the busway. Given the number of buses traveling this segment, TSP in two directions would probably be unworkable. For this reason, it is recommended that queue jumps be used in the inbound approaches to signalized intersections even in the absence of stops located at the intersection.

Waverly Street – Townsend Street / Quincy Street

<u>Outbound</u>

In the southbound/outbound direction, the lane markings could continue from the previous segment: busway, pedestrian path, parking, and two lanes of general traffic. South of the intersection with Dale Street, with the introduction of a left-turn-only lane in the northbound/inbound direction, as described above, the southbound/outbound parking lane could be eliminated and the two general traffic lanes could shift one lane to the right. The same configuration could occur at the entrance to the Washington Park mall, where, once again, a left-turn lane occurs in the northbound direction.

It is recommended that elimination of the stop at Woodbine Street be considered, as it is only 0.12 miles from Waverly Street. The stops at M. L. King Boulevard and Hazelwood Street could also be eliminated, as there is greater passenger activity at Townsend Street.

Figure B-2: Montrose Street to Townsend Street via Warren Street (South View)

The resultant distance between the stops at Waverly Street and Townsend Street would total 0.38 miles. The current shelter at the far side of Townsend Street could be turned into some type of fare zone.

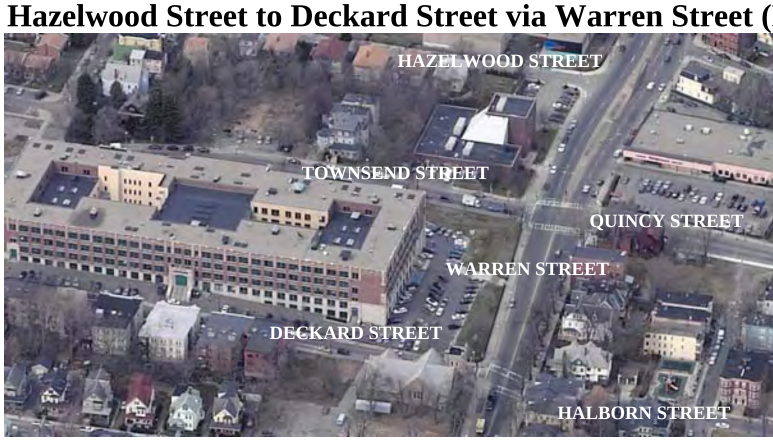
Inbound

The total number of lanes on Warren Street before Quincy Street drops by two. As recommended in the subsequent segment, this study suggests providing a busway between Blue Hill Avenue and Quincy Street on the northbound/inbound side of Warren Street. Thus, while the southbound/outbound direction is granted the busway between Kearsarge Avenue and Townsend Street due to the low average speeds on this segment, the northbound/inbound direction could be granted the busway between Blue Hill Avenue and Quincy Street due to the relatively higher passenger boarding totals (1,466 daily boardings in the inbound direction versus 574 in the outbound direction).

This study considers three possible approaches to dealing with the stop at Quincy Street. If the inbound/northbound busway continues up to Quincy Street, the stop could be moved to the far side of the intersection. Alternatively, if the busway ends before Quincy Street, a queue jump lane could be inserted and the stop kept in its current location. Both of these suggestions could necessitate turning the northbound left-turn lane into a shared lane and changing the signalization of the intersection, likely reducing its capacity. The third option is to stop the busway about 200 feet before the intersection with Quincy Street and then open the lane to general traffic. The bus could therefore queue behind vehicles, but only for a maximum of 200 feet. The stop could be moved to the far side of the intersection. TSP could be employed to prioritize north-south traffic on Warren Street to the extent possible when buses approach.

Between Quincy Street and Waverly Street, the above system of queue jumps could still be employed. Stops at Savin Street, Maywood Street, and Woodbine Street could be eliminated, resulting in a distance between Quincy Street and Waverly Street of 0.38 miles. The right-hand lane between Savin Street and M. L. King Boulevard could be turned into a queue jump lane. The lane could be returned to parking after M. L. King Boulevard. Similarly, a queue jump could be added in front of Clifford Street.

Figure B-3: Hazelwood Street to Deckard Street via Warren Street (North View)



Townsend Street / Quincy Street – Blue Hill Avenue

Outbound

As described above, the width of Warren Street decreases from approximately 82 feet north of Townsend Street to about 42 feet south of Townsend Street. There are now four lanes – two for general traffic and two for parking. Any busway would have to be accompanied by an elimination of parking. Since bus speeds are relatively high in the southbound/outbound direction and passenger boardings are much greater in the northbound/inbound direction, it would seem reasonable to eliminate the busway in the outbound lane but insert it in the inbound lane south of Townsend Street.

Since there are no traffic lights between Townsend Street and Crawford Street, there is no need for queue jump lanes in the southbound/outbound direction. Indeed, the parking can remain and buses can flow with general traffic. If the stops at Wyoming Street, Waumbeck Street, and Brunswick Street were eliminated, the resulting distance between the stops at Townsend Street and Crawford Street would total 0.41 miles. A fare zone could be established at the current stop location for Crawford Street.

South of the stop at Crawford Street, as buses approach Blue Hill Avenue, it is likely too much to ask to request that the right-hand lane be turned into a busway, particularly since, unlike the parking lane in the northbound/inbound direction, the lane in this direction is a travel lane heading into the intersection. However, parking on Warren Street before the intersection could be replaced by a bus-only lane starting at the stop at Crawford Street and continuing through approximately half the block, perhaps to the edge of the park at the corner of Warren Street and Crawford Street. At the end of the bus lane, general traffic could be permitted to merge from the left lane into the right lane. This would ensure that, if buses must queue behind general vehicle traffic at the intersection with Blue Hill Avenue, they would only be behind eight or so vehicles at a maximum.

Inbound

A busway could replace the parking lane between Blue Hill Avenue and Quincy Street. The stop at Sunderland Street could remain at its current location and a type of fare zone be established in its place. As in the outbound direction, it is recommended that the elimination of the stops between Sunderland Street and Quincy Street be considered. These are Intervale Street, Gaston Street, and Holburn Street. The distance between Sunderland Street and Quincy Street would be 0.41 miles.

Warren Street – Washington Street

Outbound

Upon turning off of Warren Street onto Blue Hill Avenue, it is recommended that a busway replace the parking on this block and that all buses – even Routes 19 and 23, which turn left onto Washington Street – use this busway. Then, at the intersection with Washington Street, the bus lane could receive a dedicated light and traffic signal priority.

Inbound

In the northbound/inbound approach to the intersection of Washington Street and Warren Street, there are three lanes: left turn only, straight only, and straight/right-turn. Buses turning onto Warren Street must merge into the left-turn-only lane beginning approximately 135 feet before the intersection. Predictably, at times of heavy traffic volume, when the left-turn queue fills the lane or it is difficult to cross two lanes, buses have a difficult time making it into the left-turn lane. The recommendation is, therefore, to claim the middle lane as a bus-only lane approximately 175 feet in length from Geneva Avenue to the intersection. This would allow about 95 feet to indicate to all other vehicles in this lane to merge either to the left or the right depending on their intended direction of travel. The bus lane could receive the same signal as the left-turn lane and merge into the busway recommended for Warren Street.

Figure B-4: Consolidated Stops – Warren Street

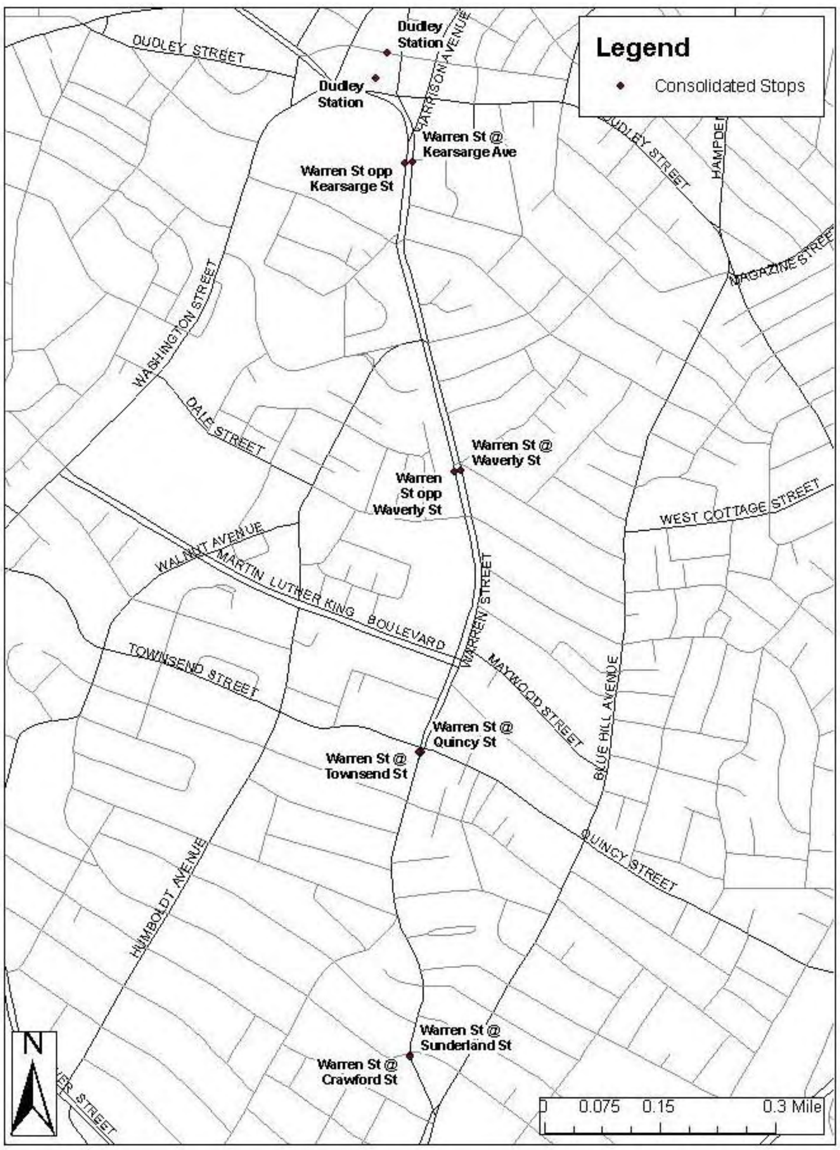
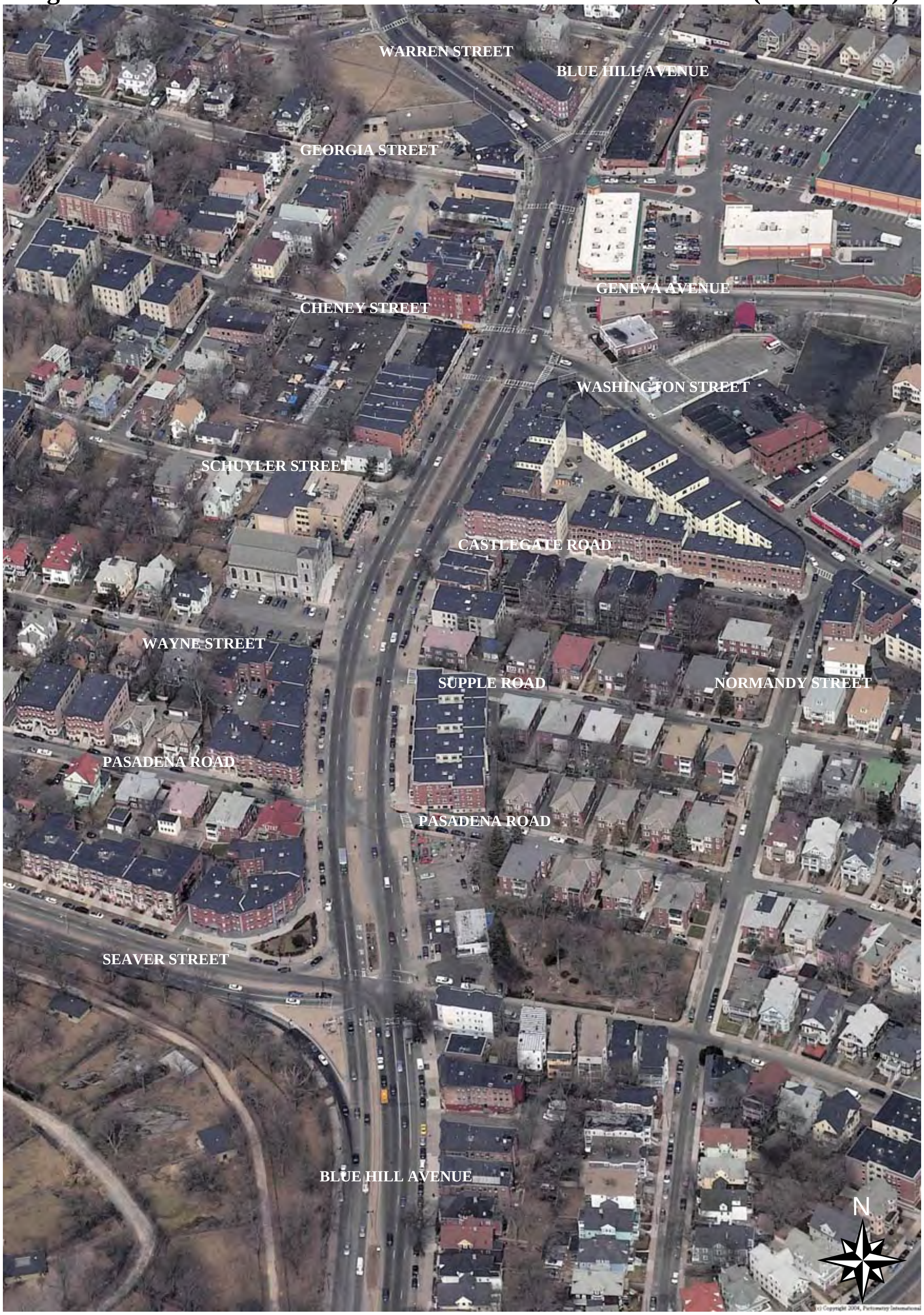


Figure B-5: Quincy Street to Blue Hill Avenue via Warren Street (North View)

Figure B-6: Warren Street to Seaver Street via Blue Hill Avenue (North View)



Washington Street-Talbot Avenue-Dorchester Avenue

Blue Hill Avenue – Columbia Road

Outbound

According to the recommendations in the Warren Street section of this report, buses could approach the intersection with Washington Street on Blue Hill Avenue in a curbside bus-only lane. This lane could receive its own dedicated green light, allowing buses to turn left onto Washington Street in advance of other left-turning general traffic from Blue Hill Avenue. In this way, buses would be at the front of the vehicle cohort entering Washington Street from Blue Hill Avenue in the southbound direction.

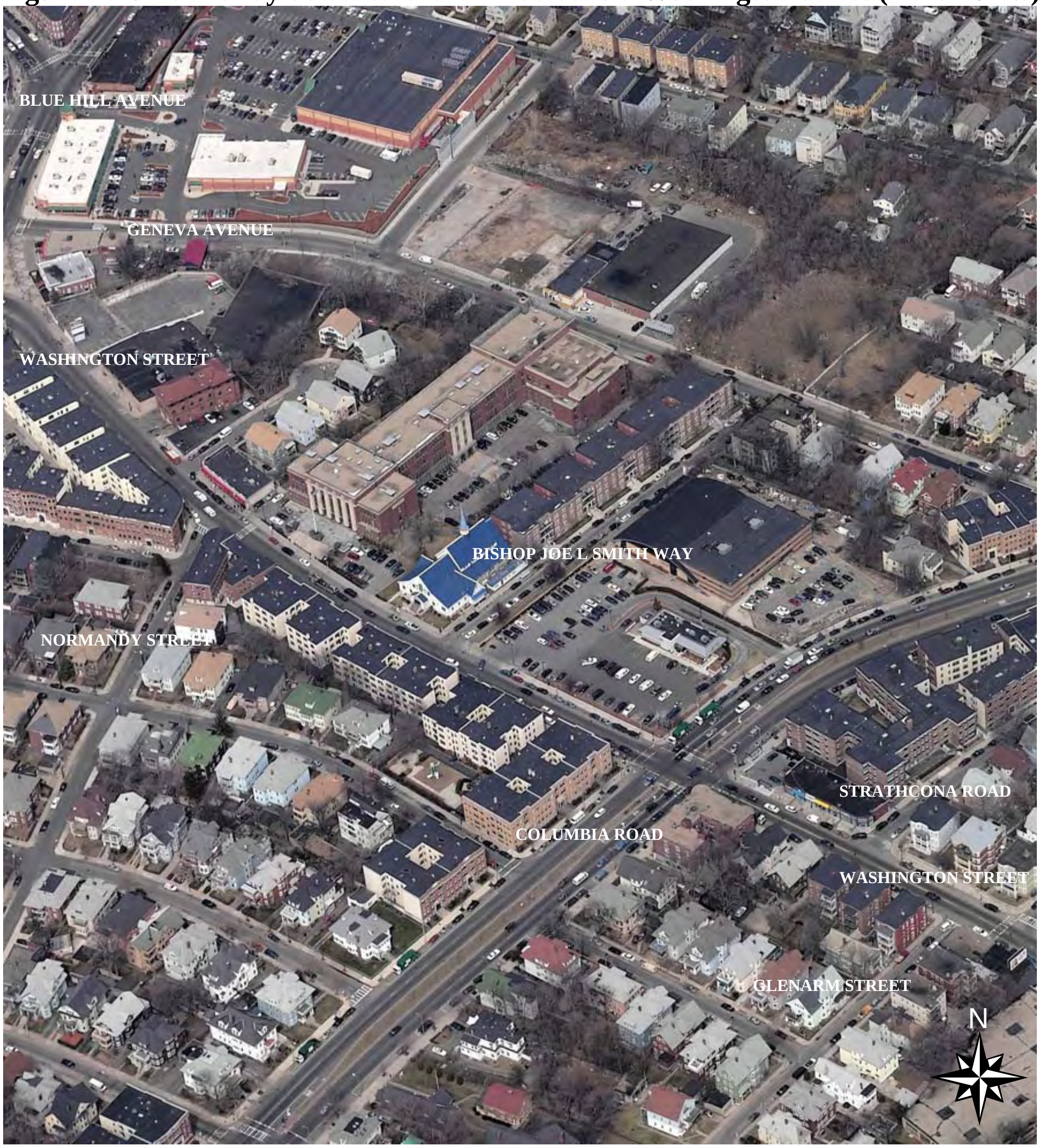
Due to the high level of activity at the first stop on Washington Street just south of this intersection, it is recommended that this stop remain in its current location, despite the fact that it lies less than 0.20 miles from the previous stop at Warren Street and Crawford Street. However, it is recommended that the elimination of the following stop at Jeremia Burke High School be considered. The resultant distance to the next stop, at Columbia Road, would be 0.22 miles. The current stop on the near side of the intersection with Columbia Road could be moved back slightly such that a queue jump lane could be built in the 200-300 feet leading up to the intersection. Sufficient space exists on the sidewalk of Washington Street to construct some type of fare zone.

Inbound

In the northbound/inbound direction, the current stop at the near side of the intersection with Columbia Road could be moved back slightly and the curbside lane of the entire block between Columbia Road and Strathcona Road – approximately 165 feet – be turned into a queue jump lane. In the approach to Blue Hill Avenue, a queue jump lane could start at the alleyway and, if a portion of the bulb-out were taken at the intersection, continue to the intersection while leaving two lanes in which general traffic could queue. Giving buses their own queue jump lane could allow for coordination of signals at the intersection such that all buses heading north on Blue Hill Avenue from Washington Street and Blue Hill Avenue could enter the intersection at the same time and have an unobstructed path to the middle bus lane on Blue Hill Avenue.

It is recommended that the elimination of the stop between Columbia Road and Blue Hill Avenue at Jeremia Burke High School be considered. The resulting distance between the two stops would be approximately 0.20 miles, with an additional 0.22 miles to the stop on Warren Street at Sutherland Street. Sufficient space exists on the sidewalk of Washington Street to construct pre-paid-fare stations or another type of fare zone. This segment of the corridor has one of the worst average speeds for buses. Stop consolidation and queue jump lanes could significantly improve travel times.

Figure B-7: Normandy Street to Glenarm Street via Washington Street (North View)



Columbia Road – Harvard Street/Bowdoin Street

Outbound

The next signalized intersection after Columbia Road is with Vassar Street. It is recommended that the elimination of all three current stops between these intersections be considered, for a total distance between stops of approximately 0.40 miles. The eliminated stops would be Glenarm Street, Erie Street, and Norwell Street. As there are no traffic lights and therefore no queues on this segment of Washington Street, there should be no need to build any dedicated right-of-way for buses, as they will either lead the cohort out of the Columbia Road intersection or follow along in the flow of traffic on Washington Street. It is recommended that the current stop at Harvard Street remain, despite the fact that it lies only 0.17 miles from Vassar Street, as it is one of the major boarding and alighting stops in the corridor. Buses on this segment already have decent travel speeds. Consolidating several stops could help to further improve bus travel times.

In the approach to Vassar Street, the current bus stop could be moved back slightly, though it will be difficult to find enough space on the sidewalk to construct a type of fare zone. The entire segment of the block between Vassar Street and the repair shop's parking lot could be marked as a queue jump lane. Similarly, the approach to Harvard Street could also be marked as a queue jump lane, and the bus stop could be moved from the far side of the intersection to a stop set back from the near side of the intersection.

Inbound

As with the outbound direction, the stop at Bowdoin Street (opposite from Harvard Street) could be moved from the far to the near side of the intersection and a queue jump lane constructed in the approach to the intersection. The same recommendations apply to the northbound approach to Vassar Street. As in the outbound direction, the elimination of the inbound stops at Norwell Street and Morse Street could be considered, for a total distance between Vassar Street and Columbia Road of 0.39 miles. To avoid queues in Washington Street because of left-turning traffic at non-signalized intersections, it may be advisable to remove parking in the approach to Norwell Street and Erie Street, shift the general traffic lane into the former parking lane, and insert a left-turn/through lane.

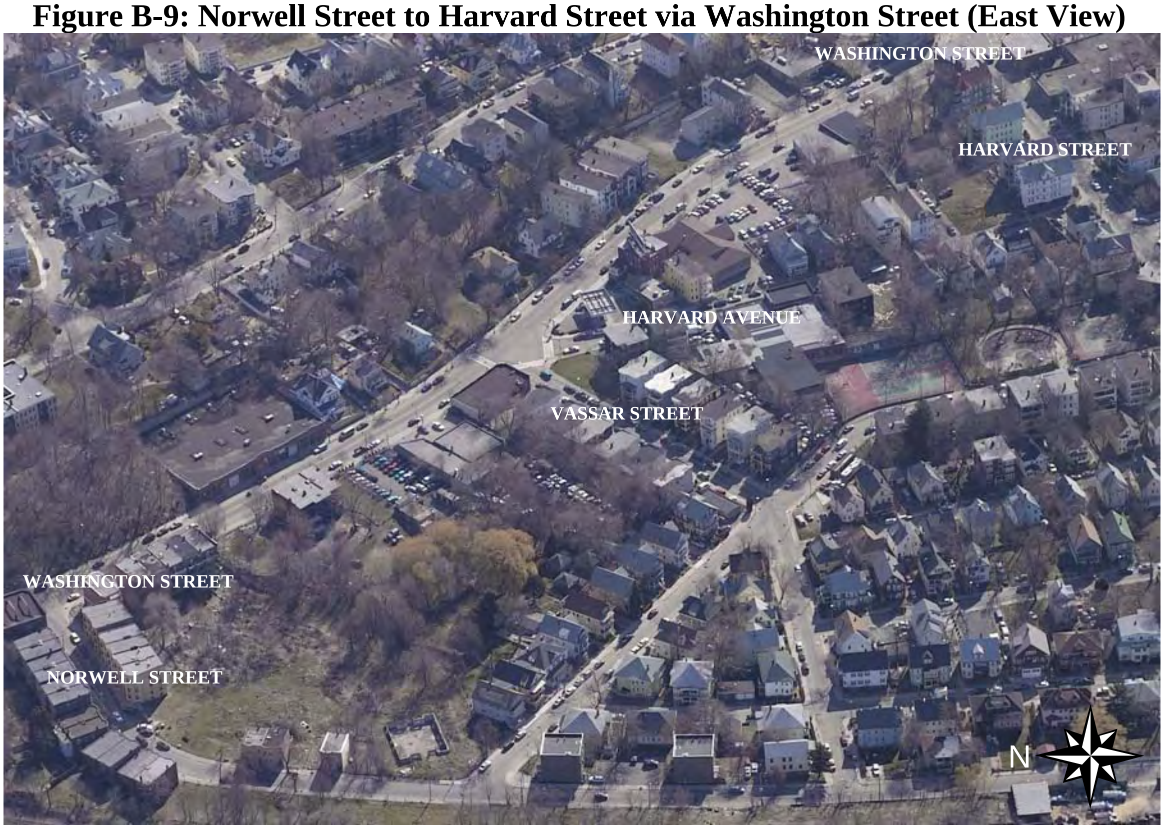
Harvard Street/Bowdoin Street – Codman Square

Outbound

After Harvard Street, the next signalized intersection is with Park Street. It is recommended that the elimination of all stops between these two streets be considered. This would include the stops at Agonguin Street and School Street. The total distance between Harvard Street and Park Avenue would come to approximately 0.27 miles. Another traffic light exists at the intersection with Dunlap Road. However, no stop is recommended for this intersection, as it lies less than 0.20 miles from the previous recommended stop. Instead, traffic signal priority could be given to Washington Street when buses approach the intersection. The next stop could be north of Codman Square.

Figure B-8: Glenarm Street to Norwell Street via Washington Street (East View)

Figure B-9: Norwell Street to Harvard Street via Washington Street (East View)



The current stop before Southern Avenue could be moved to the far side of Southern Avenue, and the entire block to Talbot Avenue could have a curbside queue jump lane. The total distance between a stop placed here and the previous stop at Park Street would be about 0.31 miles.

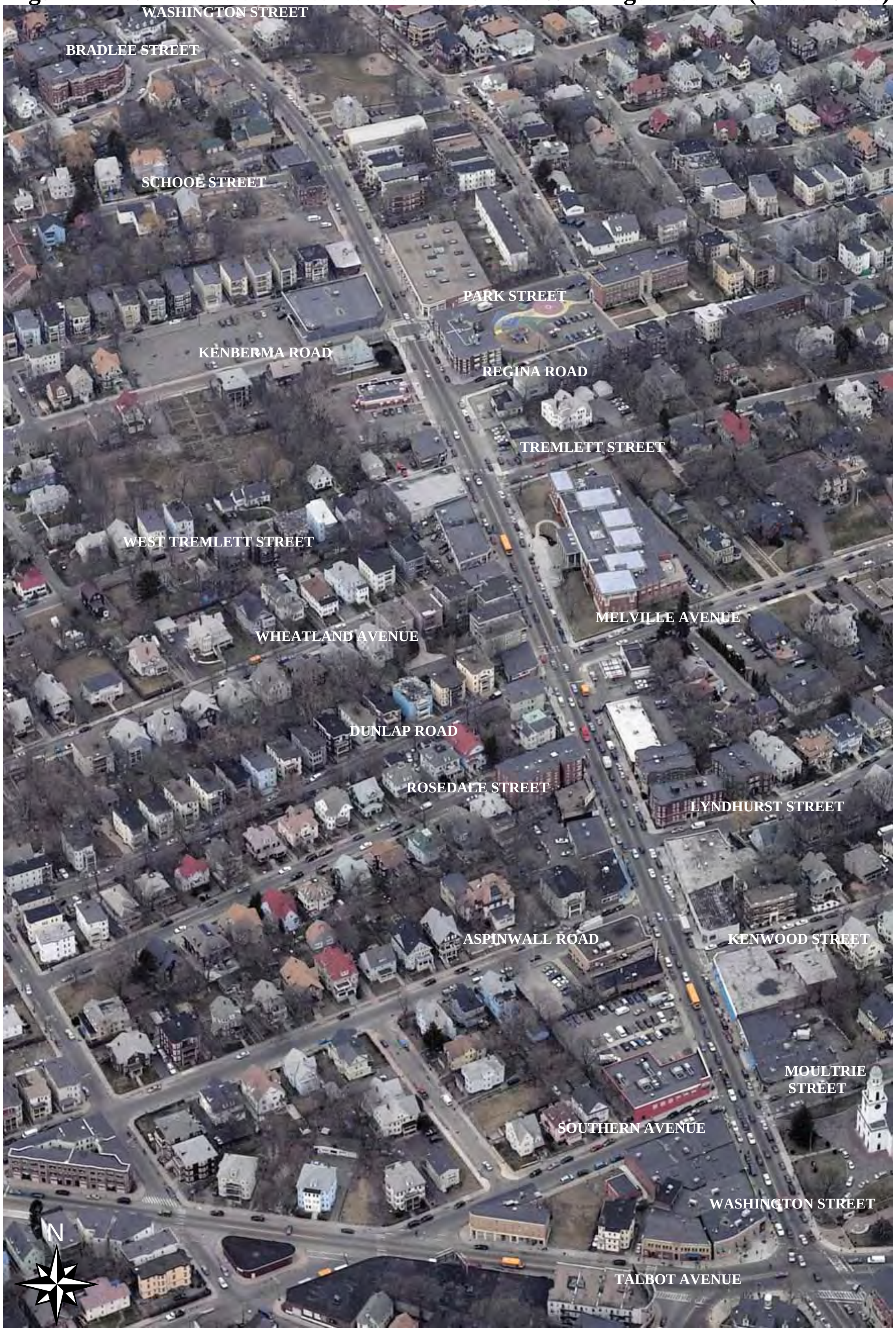
Inbound

It does not appear possible to place a queue jump lane in the approach to Washington Street on Talbot Avenue. Both lanes in the inbound direction are already being used for general traffic – the left lane for left-turning and through traffic and the right lane for right-turning and through traffic.

The stop at Kenwood Street could be moved closer to Codman Square. While the recommendation for stops on Washington Street has, to this point, been to place the stop on the near side of the intersection, because of the large size of Codman Square, and the difficulty of building a queue jump lane in the approach to Washington Street on Talbot Avenue, it is recommended that the placement of a stop opposite the outbound stop with no dedicated right-of-way be considered. However, the stop could still be marked in the same manner as queue jump lanes in order to maintain a consistency in approach to dedicated bus spaces that is immediately evident to motorists. From this stop to Bowdoin Street, it is recommended that the consolidation of all stops except for the one on the near side of the intersection with Park Street be considered. This would result in distances between the stops of approximately 0.30 miles for Codman Square and Park Street and 0.28 miles for Park Street and Bowdoin Street. The block between Regina Road and Park Street could be dedicated to buses as a queue jump lane, and the traffic signal at Melville Avenue could use traffic signal prioritization for the direction of approaching buses.

Figure B-10: Harvard Street to Bradlee Street via Washington Street (East View)

Figure B-11: Bradlee Street to Talbot Avenue via Washington Street (North View)



Codman Square – Dorchester Avenue

Outbound

Despite moving the stop north of Codman Square closer to the intersection, the demand at the subsequent stop on Talbot Avenue at the intersection with Lithgow Street justifies its location. Thus, while the stop at Lithgow Street could remain, it is recommended that the elimination of the stop at the intersection of Talbot Avenue with Brent Street be considered, with the next stop being located at Welles Avenue at a distance of approximately 0.17 miles from the stop at Lithgow Street. The curbside approach to Welles Avenue could be turned into a queue jump lane. The same configuration could be used in the approach on Talbot Avenue to Dorchester Street. The stop location is appropriate, but a queue jump lane could replace the parking between the stop and the intersection. The total distance between the stops at Welles Avenue and Dorchester Street would be approximately 0.21 miles after eliminating the stop at Argyle Street. It would not be necessary to construct a fare zone at Dorchester Avenue, or at Welles Avenue for that matter. Both of these stops in the outbound direction have very few boardings, and most of the stop activity is composed of alightings.

Inbound

As was the case with the intersection at Codman Square, the intersection with Dorchester Avenue is so large that placing the inbound stop on the near side of the intersection (i.e., on Dorchester Avenue) could greatly inconvenience those wishing to board on Talbot Avenue. The current stop on Talbot Avenue is one of the major boarding points in the corridor, with 349 daily boardings. Therefore, it is recommended that the stop on Talbot Avenue north of the intersection with Dorchester Street remain at its current location. However, the stop could be marked in the same fashion as queue jump lanes. The next stop, at Welles Avenue, could return to the standard queue jump configuration, with the stop located on the near side of the intersection. Both of these stops could have fare zones, though the sidewalk capacity at Welles Avenue is constricted. The next stop, at Centre Street, lies approximately 0.20 miles from Welles Avenue. It is therefore recommended that elimination of the stops at Argyle Street and Brent Street be considered.

Dorchester Avenue – Ashmont Station

Outbound

Construction at Ashmont Station is still ongoing, but when it is completed the station will have a new busway and loading area with an entrance just south of Fuller Street and an exit at Bailey Street. The car and taxi drop-off area will be moved north of Bailey Street on Dorchester Avenue. The existing stop at Fuller Street will therefore likely be removed. It is recommended that one of the southbound/outbound lanes of Dorchester Avenue between Talbot Avenue and the entrance to Ashmont Station be dedicated to buses and that a traffic signal be placed at the entrance to the station with a dedicated light and turning movement for the busway.

Figure B-12: Washington Street to Argyle Street via Talbot Avenue (West View)

<u>Inbound</u>

Buses will exit Ashmont Station north of Bailey Street once construction is finished. There will no longer be any need, therefore, for a stop opposite Fuller Street. The two lanes of traffic on Dorchester Avenue approaching the intersection with Talbot Avenue should likely remain open to all vehicles, and it does not appear as though the road has enough capacity to create an additional lane that could be dedicated to buses. Buses currently do not appear to have a difficult time leaving Ashmont Station and turning left onto Talbot Avenue. The recommendation is therefore to largely leave the configuration as it will be after the work on Ashmont Station is completed.

Figure B-13: Consolidated Stops – Washington Street, Talbot Avenue, Dorchester Avenue

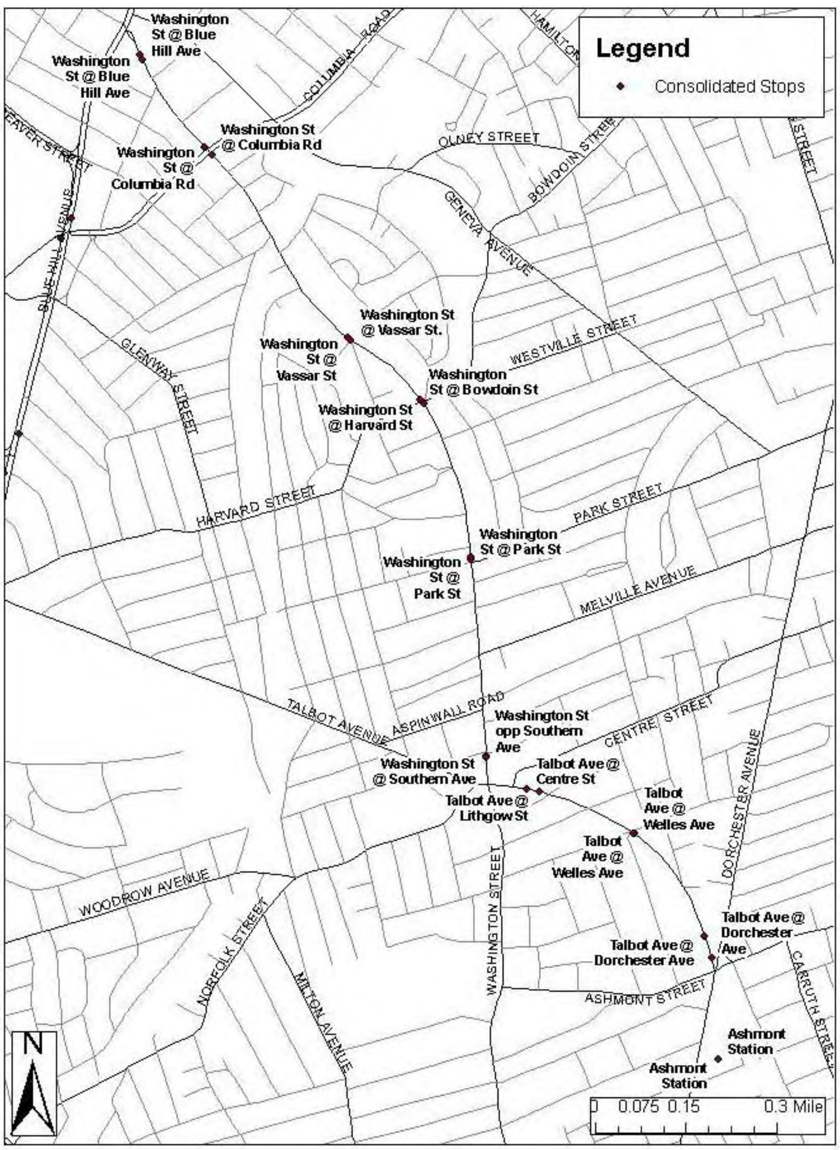


Figure B-14: Argyle Street to Ashmont Station via Talbot Avenue and Dorchester Avenue (North View)

Blue Hill Avenue

Washington Street – Seaver Street

Outbound

The basic Blue Hill Avenue lane configuration in the report begins after the intersection with Washington Street. Buses would cross two lanes of traffic to enter the recommended median busway, with enough time to do so granted by the bus-only phase of the traffic signal. Routes turning onto Washington Street would take a left, while routes staying on Blue Hill Avenue would continue straight.

The prohibition of all left-turn and through movements across intersections without a traffic light could be considered to prevent vehicles from crossing the median bus lanes in an unregulated manner. Of course, impacts to traffic should be examined prior to eliminating the right-of-way across non-signalized intersections. Alternate routes would need to be identified and analyzed. For example, left turns could potentially be prohibited from Castlegate Road onto Blue Hill Avenue. On the other hand, some currently non-signalized intersections could receive traffic signals in order to allow for left turns and through movements. As in the case of prohibiting these movements through intersections, the introduction of a signal at an intersection should be justified based on traffic volumes, crash data, pedestrian volumes, etc. Supple Road, for example, could potentially receive a traffic light.

All traffic signals could be programmed to prioritize travel on Blue Hill Avenue when buses approach. Current left-turn-only lanes could be eliminated with the conversion of the median to bus lanes. Therefore, the left lane in the two general traffic lanes, when appropriate, could be turned into a left-turn or through lane. This would be the case at Supple Road. Additionally, the left-turn lane on Blue Hill Avenue to Pasadena Road could be eliminated if movements across the intersection without traffic lights were prohibited. If this were the case, all southbound traffic wishing to enter the neighborhood east of Blue Hill Avenue via Blue Hill Avenue would need to do so at the intersection with Supple Road.

The stop at Wayne Street could remain, though it could be moved to the far side of Wayne Street. The stop at Seaver Street could be eliminated, as it is less than a tenth of a mile from Wayne Street and has fewer than 100 daily boardings. Since no stop is located at the intersection of Blue Hill Avenue and Seaver Street, the lane of parking in the northbound direction could be eliminated, allowing the two northbound lanes of general traffic and the two bus lanes to shift over one lane, permitting a left-turn-only lane in the southbound direction.

Inbound

As in the outbound direction, it is recommended that the prohibition of movements across intersections except at traffic lights be considered. Therefore, no left turns could be allowed onto Nazing Street. However, a traffic light could be introduced on Schuyler Street, and if the median were moved north approximately 100 feet, left turns could be permitted by the traffic light. All northbound traffic wishing to enter the neighborhood west of Blue Hill Avenue via Blue Hill Avenue could potentially do so at the intersection with Schuyler Street. The current stops at Pasadena Street and Castlegate Road could be merged and put on the far side of the intersection with Supple Road. This would result in a distance of approximately 0.34 miles to the next stop, at Sunderland Road.

As mentioned above, the lane of parking on the far side of Blue Hill Avenue at Seaver Street could be eliminated to make room for a left-turn-only lane in the southbound direction.

Seaver Street – American Legion Highway

<u>Outbound</u>

Two lanes of general traffic currently merge with a right-turn lane from Seaver Street heading south on Blue Hill Avenue to form three lanes. The leftmost of these three lanes could be turned into the busway, forcing the turn from Seaver Street to merge into the right-hand lane. A light could be inserted on this turn and coordinated with the green light for traffic on Seaver Street. In this way, right-turning traffic could merge into the right lane without conflict. Also, an entry in the busway could be created to allow Routes 22 and 29 into the busway. Buses could continue in the busway through the intersection with Columbia Road to a stop on the far side of the intersection, where the current stop, opposite from Columbia Road at the entrance to the Franklin Park Zoo, is located. The distance to the next stop is only approximately 0.25 miles, but the demand for this stop is among the greatest of the corridor (456 daily boardings, 438 daily alightings).

Along the eastern border of Franklin Park, the outbound lane configuration could remain three lanes of southbound general traffic, a busway with two bus-only lanes, three lanes of northbound general traffic, and a lane of parking. If this configuration does not quite fit, one of the middle travel lanes could be converted to a median with little likely effect on traffic flow. Under this scenario, the traffic light at Glen Lane would be the only opportunity for southbound traffic to turn left and cross the busway until the intersection with the American Legion Highway. It is recommended that the elimination of the stop opposite Charlotte Street be considered. Upon crossing the intersection with the American Legion Highway, the stop could be located on the far side of the intersection. This stop would be located 0.40 miles from the stop at Columbia Road.

<u>Inbound</u>

The stop currently located between the intersections of the American Legion Highway and Wales Street could remain. The busway could then continue north to the traffic light at the intersection with Glen Lane. As mentioned above, per the recommendations, this would be the only opportunity for southbound traffic to turn left and cross Blue Hill Avenue between Columbia Road and the American Legion Highway. The next northbound stop could be located to the far side of the intersection with Columbia Road, approximately 0.40 miles from the stop at the American Legion Highway.

Figure B-15: Seaver Street to Ellington Street via Blue Hill Avenue (East View)

Figure B-16: Ellington Street to McLellan Street via Blue Hill Avenue (East View)

Figure B-17: McLellan Street to Esmond Street via Blue Hill Avenue (East View)

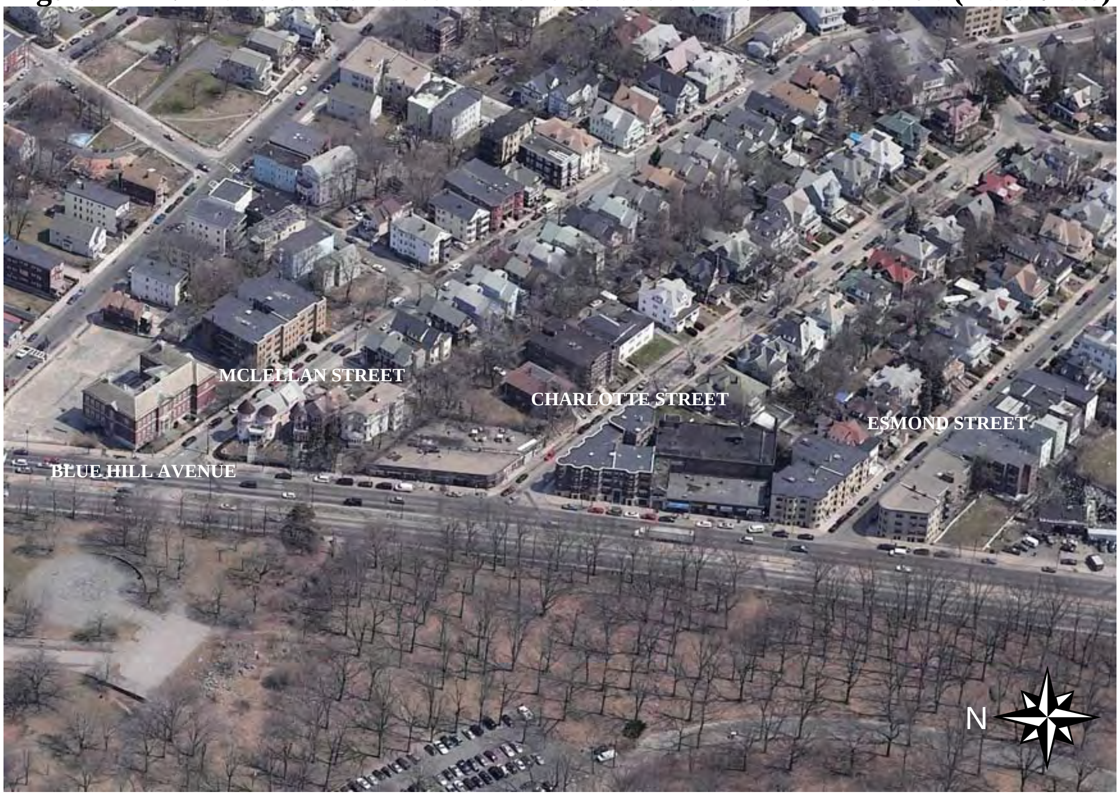
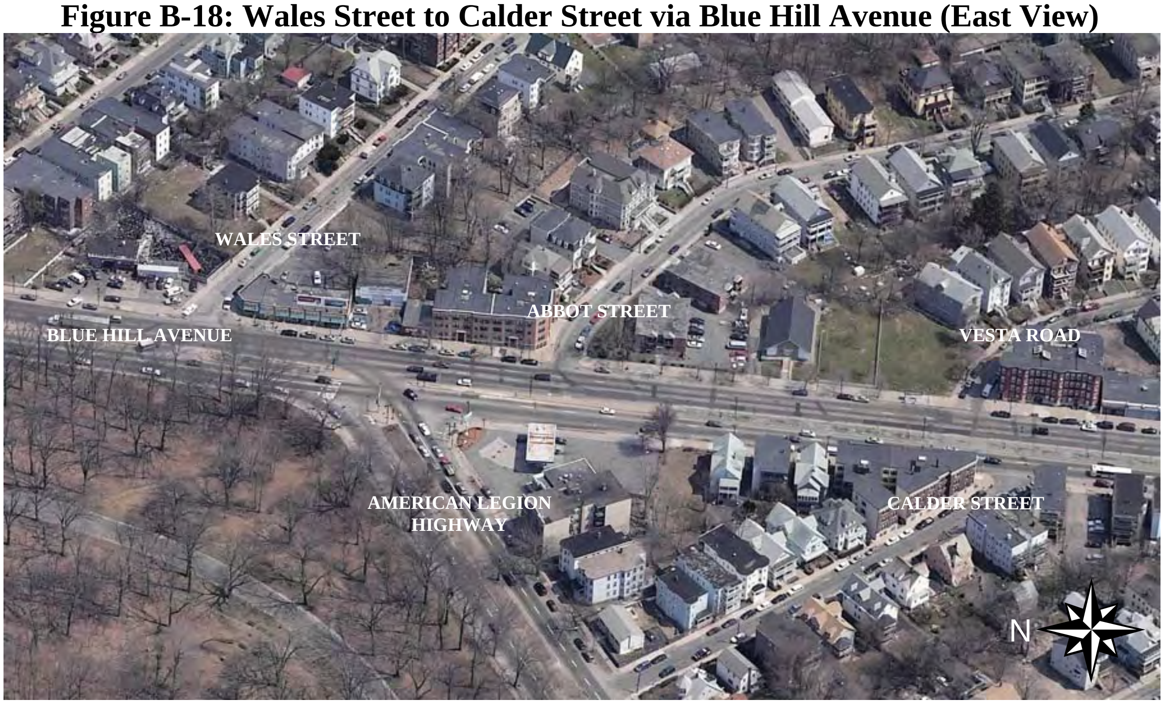


Figure B-18: Wales Street to Calder Street via Blue Hill Avenue (East View)



American Legion Highway – Morton Street

Outbound

South of the stop at the American Legion Highway, the next appropriate stop, given the proximity of the signalized intersections at Talbot Avenue and Harvard Street, could be to the far side of the intersection with Harvard Street. It is recommended, therefore, that the elimination of the stops at Calder Street and Angell Street be considered, for a total distance of 0.24 miles between the two outbound stops. The left-turn-only lane at Talbot Avenue could come out of the median between the two directions and adjoin the busway that could replace one of the northbound travel lanes.

South of Talbot Avenue, as Blue Hill Avenue continues to the west of Harambee Park, so too could the busway. The next stop could be located to the far side of the intersection with Paxton Street. The subsequent intersection at Westview Street could be given a traffic light to permit left turns from Blue Hill Avenue onto Westview Street. The total distance between the stops at Harvard Street and Paxton Street would be approximately 0.33 miles. The next stop would be placed on the far side of the intersection with Callender Street, at a distance from Paxton Street of approximately 0.19 miles. A traffic light could also be installed at this intersection. The current stop at Havelock Street could also remain, though it could be moved to the near side of the intersection, to maintain a sufficient distance to the traffic signal at Woodrow Avenue. The distance from the stop at Callender Street would be 0.23 miles. It is recommended that the prohibition of all other left-turning or through movements at Blue Hill Avenue from the intersecting streets between Westview Street and Morton Street be considered, meaning that the busway would eliminate the existing median turning spaces at Callender Street, Johnston Road/Balsam Street, Wilcock Street/Ansel Road, and Baird Street/Woodrow Avenue. The next stop, on the far side of the intersection with Morton Street, would be approximately 0.15 miles from Havelock Street.

Inbound

In the reverse of the configuration in the outbound direction, a stop could be located at the far side of the intersection with Talbot Avenue. The distance to the stop at the American Legion Highway would be about 0.24 miles. The subsequent stops, at the intersections with Westview Street, Callender Street, Woodrow Avenue, and Morton Street, could all be placed on the far side of the intersections.

Morton Street – Mattapan Station

Outbound

South of Morton Street, the elimination of stops at Goodale Road and Clarkwood Street could be considered. The next stop would be located approximately 0.30 miles from Morton Street at Wellington Hill Street. Per the recommendations, this would be the only point between these two intersections where movements across Blue Hill Avenue would be permitted, unless a traffic light were added at the intersection with Goodale Road.

Figure B-19: Calder Street to Greenock Street via Blue Hill Avenue (North View)

Figure B-20: Greenock Street to Morton Street via Blue Hill Avenue (North View)

Traffic lights could possibly be added at the intersections of Blue Hill Avenue with Walk Hill Street and Norfolk Street. Again, justification for the introduction of traffic signals needs to be ascertained. These two intersections are close enough that they could be coordinated such that vehicle queues do not form between them. Placing a traffic light at each intersection could permit the location of a stop at the far side of Norfolk Street, at a distance of approximately 0.30 miles from Wellington Hill Street.

The subsequent six stops to the south are all separated by 0.10 miles or less. It is therefore recommended that their consolidation into two stops be considered. The stop at Woodhaven Street lies in the middle, about 0.25 miles from Norfolk Street and 0.30 miles from the stop at Mattapan Square. It is recommended that a traffic light be added to the intersection of Blue Hill Avenue and Woodhaven Street and that a stop be inserted in the outbound direction at the far side of the intersection. Parking on the bridge before Woodhaven Street could probably be eliminated to provide sufficient room for a pre-paid fare station or other type of fare zone on the bridge.

The next outbound stop could be placed in the heart of Mattapan Square, at the far side of the intersection with Fairway Street. Parking in Mattapan Square is currently angled. Parking could need to be parallel and sidewalk bulb-outs reduced to allow the busway, any fare zone, and two general traffic lanes to fit around the Fairway Street intersection. However, given the pedestrian nature of Mattapan Square, it may be advisable to reduce the number of general traffic lanes to one in each direction and maintain parallel parking and the sidewalk bulb-outs.

The intersection with River Street could be reconfigured to allow buses in the busway to make a direct turn into the station. Buses queuing at the intersection could receive their own dedicated light permitting a left turn into a widened busway into Mattapan Station. The traffic signal at the entrance to the station could be coordinated with the River Street traffic signal to provide for uninterrupted flow between the median busway and Mattapan Station.

<u>Inbound</u>

As in the outbound direction, it is recommended that the elimination of stops at Evelyn Street and Woolson Street be considered. The current stop at Wilmore Street could be moved back such that it lies at the far side of the intersection with Fessenden Street. The distance from this stop to Morton Street would be approximately 0.30 miles.

The next stop could be located on the far side of the intersection with Babson Street. As discussed in the outbound section, traffic lights could be introduced at the intersections with Babson Street and Norfolk Street and coordinated to avoid any queues forming between the streets. The stop on the far side of Babson Street would be approximately 0.30 miles from the stop at Fessenden Street. The previous inbound stop at Woodhaven Street lies 0.25 miles from Babson Street and a further 0.30 miles from Mattapan Square.

The inbound station in Mattapan Square could lie to the far side of the intersection with Fairway Street. Similar modifications to those suggested for the outbound direction could be made north of Fairway Street as well. A busway from Mattapan Station could link to the median busway on Blue Hill Avenue through two coordinated traffic lights, one at the station exit and one at River Street. Buses should not queue in the busway before River Street.

Figure B-21: Morton Street to Hosmer Street via Blue Hill Avenue (East View)

Figure B-22: Hosmer Street to Wellington Hill Street via Blue Hill Avenue (East View)

Figure B-23: Wellington Hill Street to Woodhaven Street via Blue Hill Avenue (South View)

Figure B-24: Woodhaven Street to Rexford Street via Blue Hill Avenue (North View)

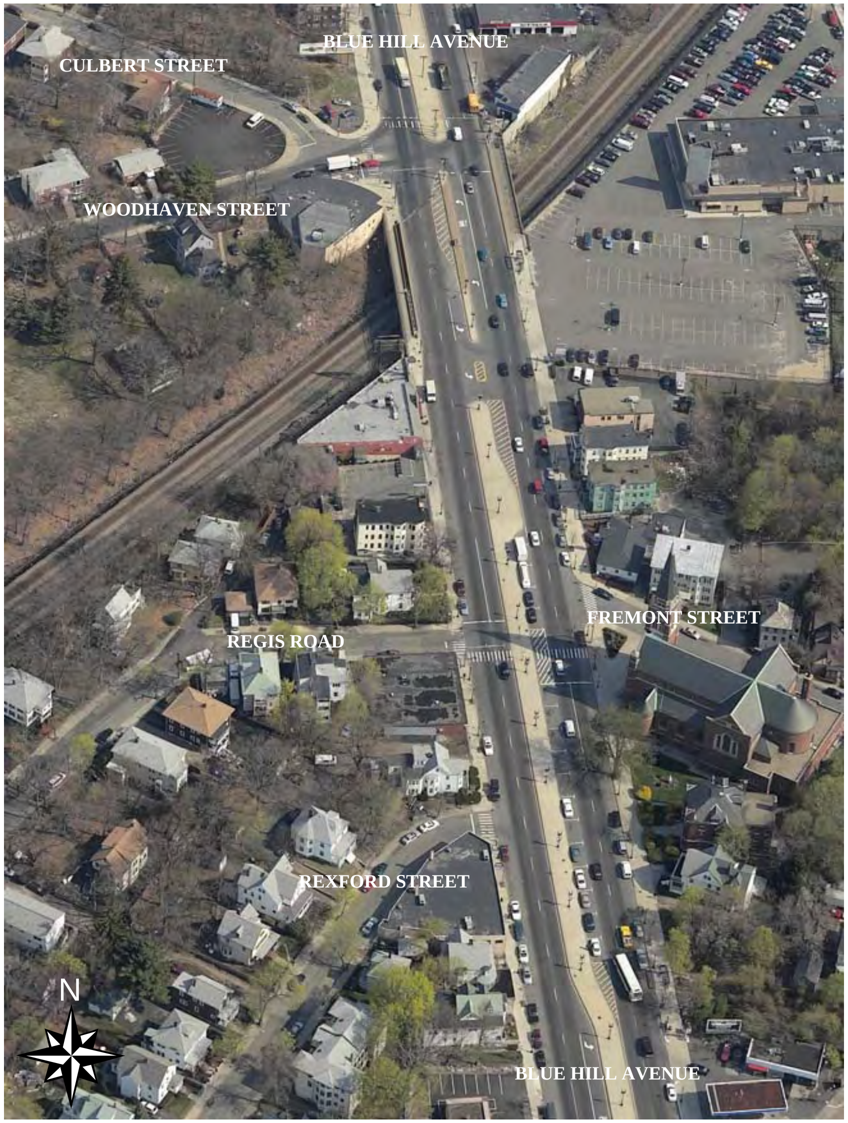


Figure B-25: Babson Street to Mattapan Station via Blue Hill Avenue (South View)

Figure B-26: Consolidated Stops – Blue Hill Avenue (North)

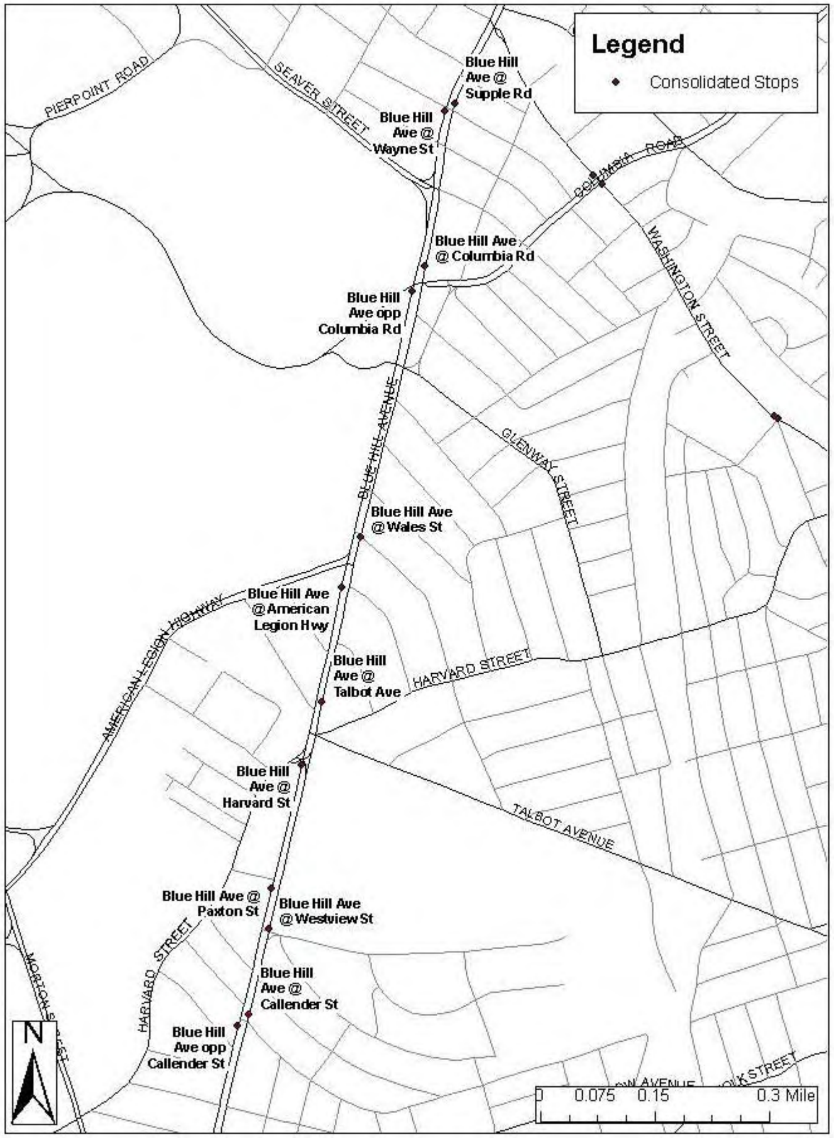
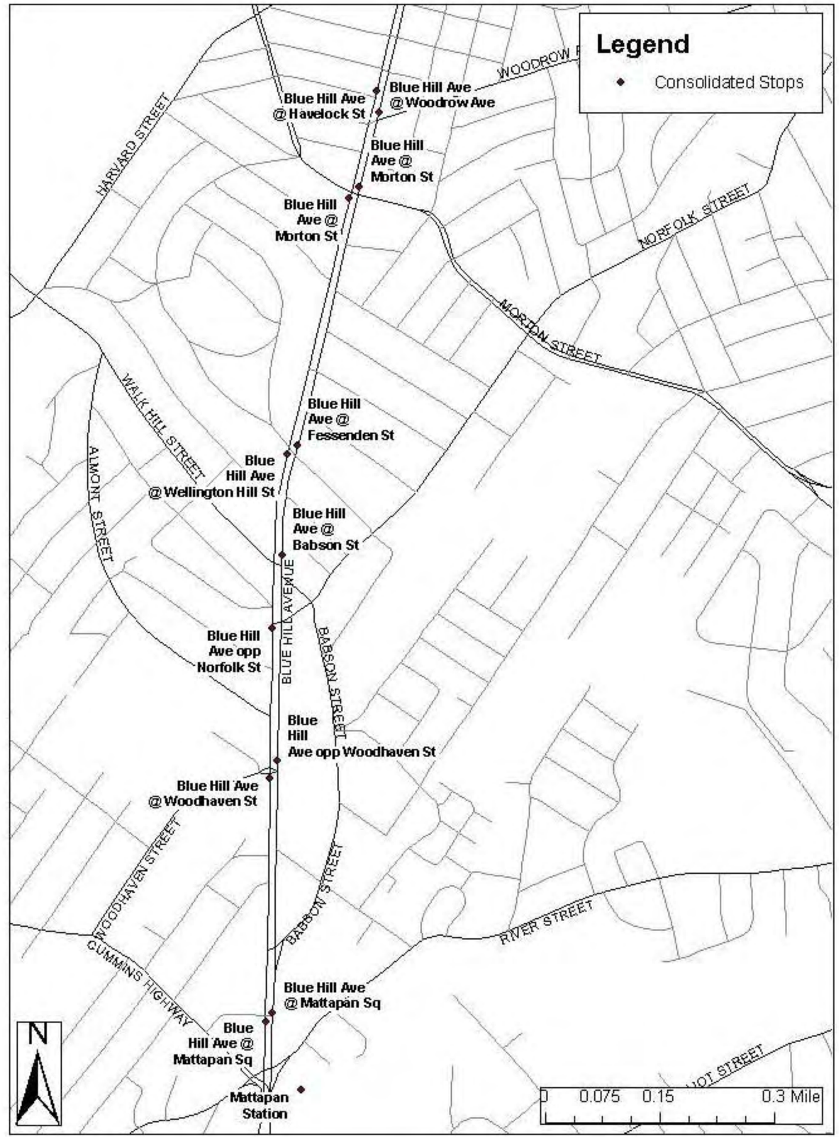


Figure B-27: Consolidated Stops – Blue Hill Avenue (South)



APPENDIX C: DUDLEY-RUGGLES CORRIDOR CONCEPTUAL IMPROVEMENTS

This appendix considers the rationale and potential for improving bus service between Dudley Station and Ruggles Station. This analysis will consider Route 28's existing ridership patterns, the potential for replacing Route 28 with through-routed Silver Line Washington Street service, ridership between Dudley Station and Ruggles Station, and possible stop consolidation between these two stations.

Existing Ridership Patterns on Route 28

The 2005 survey of Silver Line Washington Street passengers conducted by CTPS found that 215 inbound Silver Line passengers transferred from Route 28 between 6:00 AM and 3:30 PM. These 215 passengers would gain a single-seat ride if the Silver Line were extended to replace Route 28. However, the fall 2007 Route 28 ridecheck, for the same time period, found a total of 752 passengers traveling on inbound Route 28 buses from locations south of Dudley to locations north of Dudley. These 752 passengers would have to transfer at Dudley if the Silver Line replaced Route 28. Replacing Route 28 with an extension of the Silver Line to Mattapan would therefore require, on net, 537 more transfers at Dudley Station for inbound Route 28 passengers.

Per fall 2007 CTPS ridechecks of bus Route 28, there were 5,439 total inbound riders. Of this total, 396 boarded in the segment between Dudley and Ruggles that is shared with five other routes. Of the 5,043 remaining passengers boarding south of Dudley, 2,162 left the bus before Dudley Station, 1,859 left the bus at Dudley Station, and 1,022 were traveling from points south of Dudley to points north of Dudley. Thus, of the 5,043 south-of-Dudley boardings, 20 percent traveled to locations north of Dudley. Depending on their final destination, these Route 28 passengers would have to transfer at Dudley to a Ruggles-bound bus if Route 28 were completely replaced by an extension of the Silver Line to Mattapan.

While 20 percent of inbound Route 28 passengers continued to points north of Dudley, 37 percent alighted at Dudley Station. There is no way to tell from ridecheck data alone how many of these passengers transferred to the Silver Line Washington Street. However, according to the 2005 survey of Silver Line Washington Street passengers, as mentioned above, 215 inbound Route 28 passengers transferred to the Silver Line Washington Street between 6:00 AM and 3:30 PM. According to the fall 2007 CTPS ridechecks of Route 28 for the same time period, a total of 1,451 passengers alighted at Dudley. Thus, 15 percent of inbound Route 28 passengers (1,451 divided by 215) could be assumed to transfer to the Silver Line Washington Street. Fifteen percent of the 1,859 total daily Dudley alightings comes to 279 passengers. Compared to the 1,022 inbound passengers boarding south of Dudley, therefore, replacing Route 28 with an extension of the Silver Line to Mattapan would require, on net, 743 more transfers.

In the outbound direction, 1,601 daily passengers board Route 28 between Ruggles Station and Dudley Station. While 411 of these passengers alight in this same segment and 241 alight at Dudley Station, 1,190 passengers, or 74 percent, continue through Dudley to points south.

Dudley-Ruggles Routes via Malcolm X Boulevard and Tremont Street Corridor

There are presently six bus routes that travel between Dudley Station and Ruggles Station via Malcolm X Boulevard and Tremont Street:

- Route 15 Ruggles-Kane Square or Fields Corner
- Route 23 Ashmont-Ruggles
- Route 25 Franklin Park-Ruggles (route only operates during the AM peak)
- Route 28 Mattapan-Ruggles
- Route 44 Jackson Square-Ruggles
- Route 45 Franklin Park-Ruggles

Routes 25 and 28 in only the outbound direction deviate from Routes 15, 23, 44, and 45 and operate via John Eliot Square. However, as part of the 2008 MBTA Service Plan, Routes 25 and 28 will be modified in April 2009 to travel via the same routing along Malcolm X Boulevard as Routes 15, 23, 44, and 45.

There are three additional routes (8, 19, and 47) which also travel between Dudley and Ruggles but which do not operate via Malcolm X Boulevard or Tremont Street. These routes operate via Washington Street and Melnea Cass Boulevard northbound and Ruggles Street and Shawmut Avenue southbound. Routes 14, 41, and 66 also operate along a portion of Malcolm X Boulevard but do not operate to Ruggles Station, while Route 22 also operates along Tremont Street in the segment from the intersection of Tremont and Malcolm X Boulevard to Ruggles, but does not operate to Dudley.

The total number of passengers, inbound and outbound, whose journey includes riding within the Dudley to Ruggles section of these six routes, is 12,484. This includes 6,271 inbound passengers and 6,211 outbound passengers. Of these totals, 1,978 inbound passengers and 1,145 outbound passengers traveled entirely within the route segment between Dudley and Ruggles and could use any of the six routes to complete their journey. The remaining passengers were traveling to or from locations south of Dudley Station and were traveling through Dudley Station.

Table C-1: Percent of Inbound Riders from South of Dudley traveling to Dudley Station or North of Dudley

Inbound	Route 15		Route 23		Routes 25		Route 28		Route 44		Route 45		All Routes	
	# Riders	% Riders from S. of Dudley	# Riders	% Riders from S. of Dudley	# Riders	% Riders from S. of Dudley	# Riders	% Riders from S. of Dudley	# Riders	% Riders from S. of Dudley	# Riders	% Riders from S. of Dudley	# Riders	% Riders from S. of Dudley
Boardings South of Dudley	3,123		5,253		150		5,043		1,633		1,501		16,703	
Alightings at Dudley	949	30.4%	1,691	32.2%	78	52.0%	1,859	36.9%	635	38.9%	445	29.7%	5,657	33.9%
Alightings North of Dudley	1,136	36.4%	1,284	24.4%	61	40.7%	1,022	20.3%	332	20.3%	458	30.5%	4,293	25.7%

Table C-2: Percent of Total Inbound Route Boardings between Dudley Station and Ruggles Station

Inbound	Route 15		Route 23		Routes 25		Route 28		Route 44		Route 45		All Routes	
	# Riders	% Riders	# Riders	% Riders	# Riders	% Riders	# Riders	% Riders	# Riders	% Riders	# Riders	% Riders	# Riders	% Riders
Total Route Ridership	3,599		5,657		172		5,439		1,914		1,900		18,681	
Boardings North of Dudley	476	13.2%	404	7.1%	22	12.8%	396	7.3%	281	14.7%	399	21.0%	1,978	10.6%
Alightings North of Dudley	1,136	31.6%	1,284	22.7%	61	35.5%	1,022	18.8%	332	17.3%	458	24.1%	4,293	23.0%

Table C-3: Percent of Outbound Riders from North of Dudley traveling to Dudley Station or North of Dudley

Outbound	**Route 15**		**Route 23**		**Routes 25**		**Route 28**		**Route 44**		**Route 45**		**All Routes**	
	# Riders	**% Riders from S. of Dudley**	**# Riders**	**% Riders from S. of Dudley**	**# Riders**	**% Riders from S. of Dudley**	**# Riders**	**% Riders from S. of Dudley**	**# Riders**	**% Riders from S. of Dudley**	**# Riders**	**% Riders from S. of Dudley**	**# Riders**	**% Riders from S. of Dudley**
Alightings South of Dudley	3,079		5,087		23		4,757		1,785		1,614		16,345	
Boardings at Dudley	1,263	41.0%	1,627	32.0%	13	56.5%	1,656	34.8%	699	39.2%	636	39.4%	5,894	36.1%
Boardings North of Dudley	1,362	44.2%	1,520	29.9%	5	21.7%	1,190	25.0%	336	18.8%	653	40.5%	5,066	31.0%

Table C-4: Percent of Total Outbound Route Alightings between Dudley Station and Ruggles Station

Outbound	**Route 15**		**Route 23**		**Routes 25**		**Route 28**		**Route 44**		**Route 45**		**All Routes**	
	# Riders	**% Riders**	**# Riders**	**% Riders**	**# Riders**	**% Riders**	**# Riders**	**% Riders**	**# Riders**	**% Riders**	**# Riders**	**% Riders**	**# Riders**	**% Riders**
Total Route Ridership	3,335		5,485		31		5,168		1,872		1,697		17,588	
Boardings North of Dudley	1,362	40.8%	1,520	27.7%	5	16.1%	1,190	23.0%	336	17.9%	653	38.5%	5,066	28.8%
Alightings North of Dudley	156	4.7%	398	7.3%	8	25.8%	411	8.0%	87	4.7%	85	5.0%	1,145	6.5%

Table C-5: Stop-by-Stop Activity North of Dudley Station

Inbound and Outbound	Route 15		Route 23		Route 25		Route 28		Route 44		Route 45		All Routes	
	Ons	**Offs**	**Ons**	**Offs**	**Ons**	**Offs**	**Ons**	**Offs**	**Ons**	**Offs**	**Ons**	**Offs**	**Ons**	**Offs**
Ruggles Station @ Lane 2	995	0	1,459	0	12	0	1,118	0	323	0	610	0	4,517	0
Malcolm X Blvd @ King St	253	7	273	21	1	0	189	20	60	3	92	4	868	55
Malcolm X Blvd @ Opp. Madison Park School	200	6	111	106	0	5	138	30	21	2	16	3	486	152
Malcolm X Blvd @ Opp. John D. O'Bryant School	62	7	61	37	0	0	63	15	17	5	17	0	220	64
Malcolm X Blvd @ Shawmut Ave	8	24	14	46	0	0	0	0	1	16	3	11	26	97
205 Roxbury St	0	0	0	0	0	0	39	41	0	0	0	0	39	41
42 Dudley St	0	0	0	0	0	0	37	38	0	0	0	0	37	38
Dudley St @ Shawmut Ave	0	0	0	0	0	0	5	26	0	0	0	0	5	26

Analysis of Stop Locations

There are five inbound stops between Dudley and Ruggles; four are located on Malcolm X Boulevard and one on Tremont Street. In the outbound direction, there is no corresponding stop on Tremont Street, and four stops on Malcolm X Boulevard. Routes 25 and 28 presently divert from Routes 15, 23, 44, and 45 after the third stop on Malcolm X Boulevard, and service John Eliot Square on Roxbury Street and Dudley Street. Routes 25 and 28 will no longer serve the stops with the Spring 2009 schedule change, and will be consistent with the other four routes.

The two inbound stops in the Dudley-Ruggles section with the lowest passenger activity are Tremont Street opposite Prentiss and Malcolm X Boulevard @ Shawmut Avenue. The stop on Tremont Street only had 140 alightings all day long and 13 boardings. The stop at Shawmut Avenue had 124 boardings and 173 alightings.

In the outbound direction, the Malcolm X @ Shawmut stop was the lowest volume stop between Ruggles and Dudley with 26 boardings and 97 alightings.

Table C-6: Distance Between Stops Dudley to Ruggles Inbound (1.41 miles total)

Stop	Distance to Next Stop
Dudley	0.168
Malcolm X Blvd @ Shawmut	0.133
Malcolm X Blvd @ O'Bryant Hs	0.093
Malcolm X Blvd @ Madison Park HS	0.185
Malcolm X Blvd @ Tremont	0.153
Tremont @ opp Prentiss	0.409
Ruggles	

Table C-7: Distance Between Stops Ruggles to Dudley outbound (1.18 miles total)

Stop	Distance to Next Stop
Ruggles	0.583
Malcolm X Blvd @ King St.	0.139
Malcolm X Blvd opp. Madison Park	0.093
Malcolm X Blvd opp. O'Bryant School	0.134
Malcolm X Blvd @ Shawmut Ave.	0.238
Dudley Station	

Eliminating the stop opposite Prentiss Street would allow Ruggles-bound buses to enter the left-turn lane for Ruggles Street earlier. Given the low activity at the stop at Shawmut Avenue, it also seems prudent to eliminate this stop to improve bus speeds on Malcolm X Boulevard.

APPENDIX D: DUDLEY STATION BUS CIRCULATION

Circulation and routing of buses through Dudley Station represents perhaps one of the primary issues to deal with when considering improvements that could be made to the Dudley South corridor. Not only would improvements to Dudley Station reduce travel times for Route 23 and Route 28, but such improvements should also be aimed at facilitating efficient circulation for all bus routes serving the station. Of particular concern is the current necessity of many bus routes, including Route 23 and 28, to loop through the station in the outbound direction.

This appendix presents several ideas for potentially improving circulation at and through Dudley Station. The primary objective of the suggestions is to eliminate looping to the extent possible. However, other changes to parking, intersection configuration, and street direction are also proposed. These ideas are meant to encourage discussion such that the planning for any improvements to Dudley Station will be well informed.

This appendix is presented in four sections. The first section describes the suggestions for altering and improving circulation in and around Dudley Station. It also describes the potential turning movements that would result from the adoption of the proposals. The second section presents these turning movements in graphical form and lists the bus routes that would travel upon various road segments. The third section shows the routing for each route or group of similar routes along with the related turning movements. The final section describes in greater detail the recommendation for creating an exit from Dudley Station onto Dudley Street.

Dudley Station Circulation

- It is recommended that the elimination of on-street parking on Roxbury Street in both directions be considered. This would effectively turn Roxbury Street into a bus-only lane, except for people needing to park at the lot at the corner of Roxbury Street and Malcolm X Boulevard. One lane of on-street parking on south side of street could be kept as a compromise.
- It is recommended that the creation of a left-turn-only lane on Malcolm X Boulevard in the southeast direction be considered. The lane could also include left-turn-only signalization. No signal priority is likely needed, unless for specific routes.
- It is recommended that the addition of a signal on Dudley Street at the Dudley Station busway exit be considered. Buses would receive their own signal to exit Dudley Station onto Dudley Street.
- It is recommended that the following lane markings at Dudley Station be considered:
    - Lower Zeigler Street becomes both directions, with the eastern portion for western travel and western portion for eastern travel;
    - Upper Zeigler Street remains a one-way east-only lane for all routes;
    - West north-south busway becomes south-only, right-turn-only;
    - East north-south busway becomes south-only, left-turn-only.

- Turning movements:

    - Buses coming from Roxbury Crossing Station bound for Warren Street/Dudley Street (15, 23, 28, 44, 45): turn left from Malcolm X Boulevard onto Roxbury Street; continue straight into Dudley Station at lower Zeigler Street; turn right onto east north-south busway, turn left onto Dudley Street; turn right onto Warren Street or continue straight on Dudley Street.
    - Buses coming from Centre Street bound for Warren Street/Dudley Street (14, 41): turn left on Shawmut Avenue onto Roxbury Street; continue straight through Malcolm X Boulevard into Dudley Station at lower Zeigler Street; turn right onto east north-south busway; turn left onto Dudley Street; turn right onto Warren Street or continue straight on Dudley Street
    - Buses coming from Warren Street/Dudley Street bound for Roxbury Crossing Station/Centre Street (14, 15, 23, 28, 41, 44, 45): continue straight through Dudley Street on Warren Street or turn right from Dudley Street onto Warren Street; turn left into Dudley Station at upper Zeigler Street; turn left onto Washington Street; turn right onto Roxbury Street; turn right onto Malcolm X Boulevard.

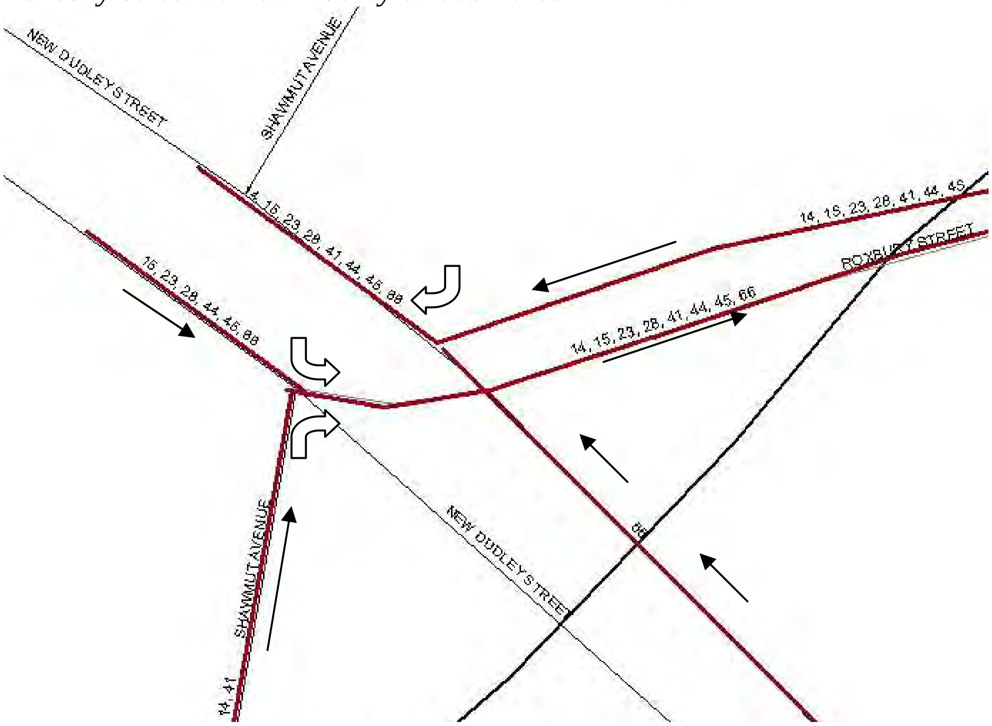
    - Buses coming from Roxbury Crossing Station bound for Dudley Station and returning to Roxbury Crossing Station (66): turn left from Malcolm X Boulevard onto Roxbury Street; continue straight into Dudley Station at lower Zeigler Street; turn right onto west north-south busway; turn right onto Dudley Street; continue straight through Washington Street on Malcolm X Boulevard.

    - Buses coming from Washington Street bound for Warren Street south (19): turn right from Vernon Street on to Washington Street; turn left into Dudley Station at lower Zeigler Street; turn right onto east north-south busway; turn left onto Dudley Street; turn right onto Warren Street.
    - Buses coming from Warren Street bound for Warren Street (19): continue straight through Dudley Street on Warren Street; turn left onto lower Zeigler Street; turn left onto east north-south busway; turn left onto Dudley Street; turn left onto Warren Street.

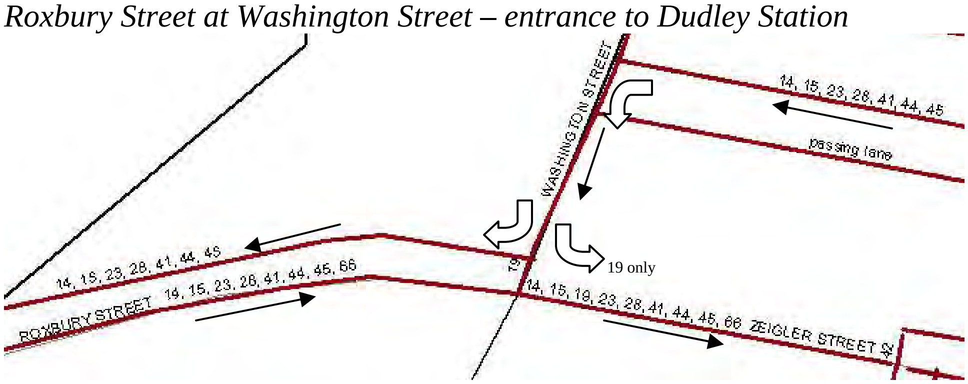
    - Buses coming from Washington Street bound for Warren Street north (Silver Line, 1, 8, 47): turn left from Washington Street into Dudley Station at upper busway lanes; Silver Line uses southern lanes and Routes 1, 8, and 47 use northern lanes; turn left onto Warren Street.

Turning Movement Diagrams

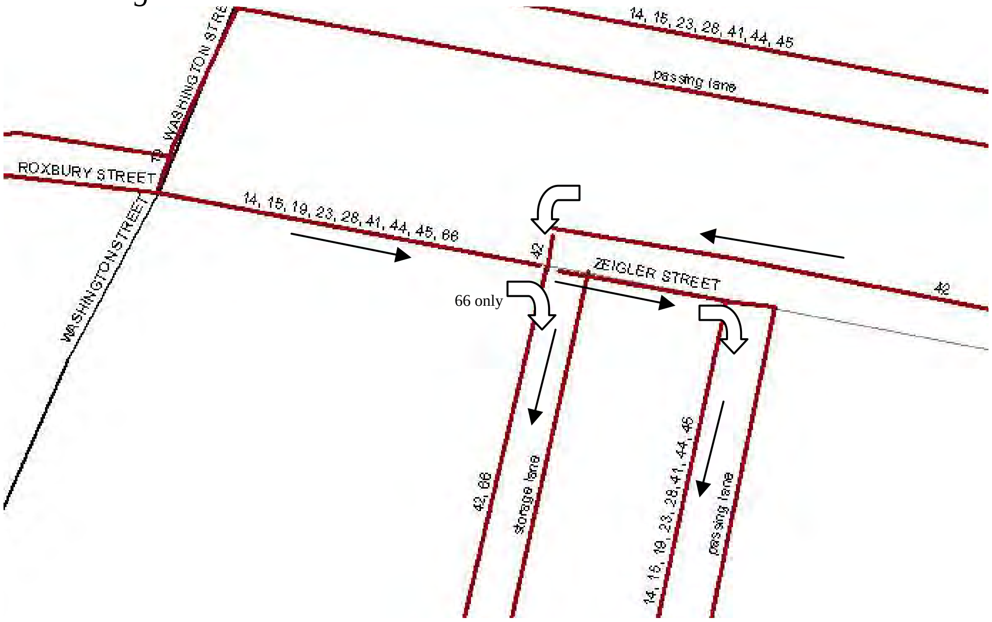
Roxbury Street at New Dudley Street/Malcolm X Blvd



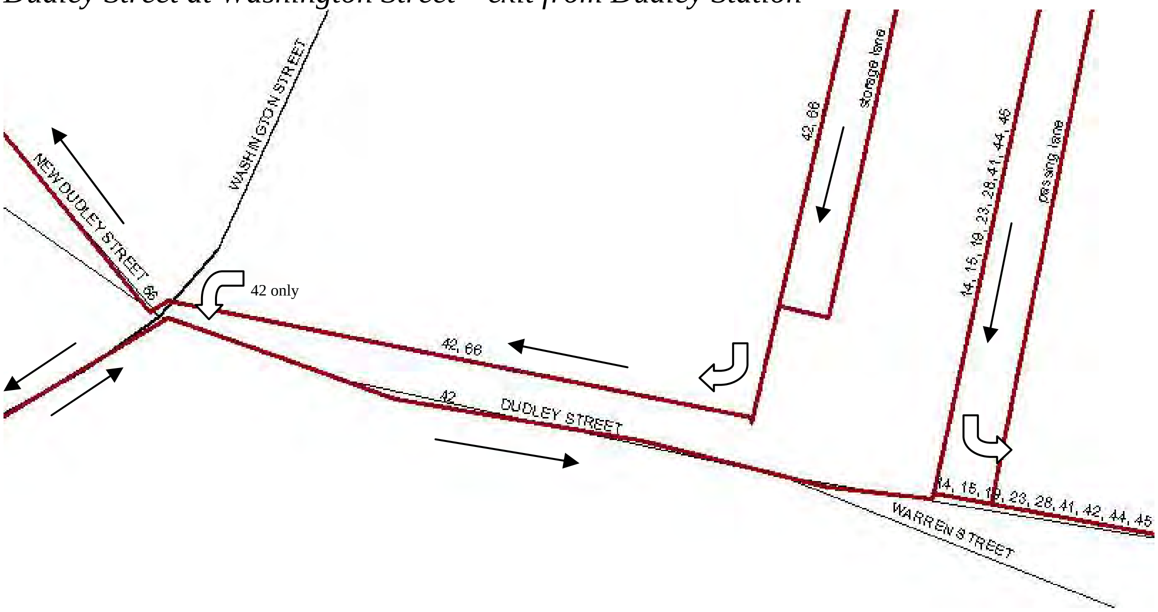
Roxbury Street at Washington Street – entrance to Dudley Station



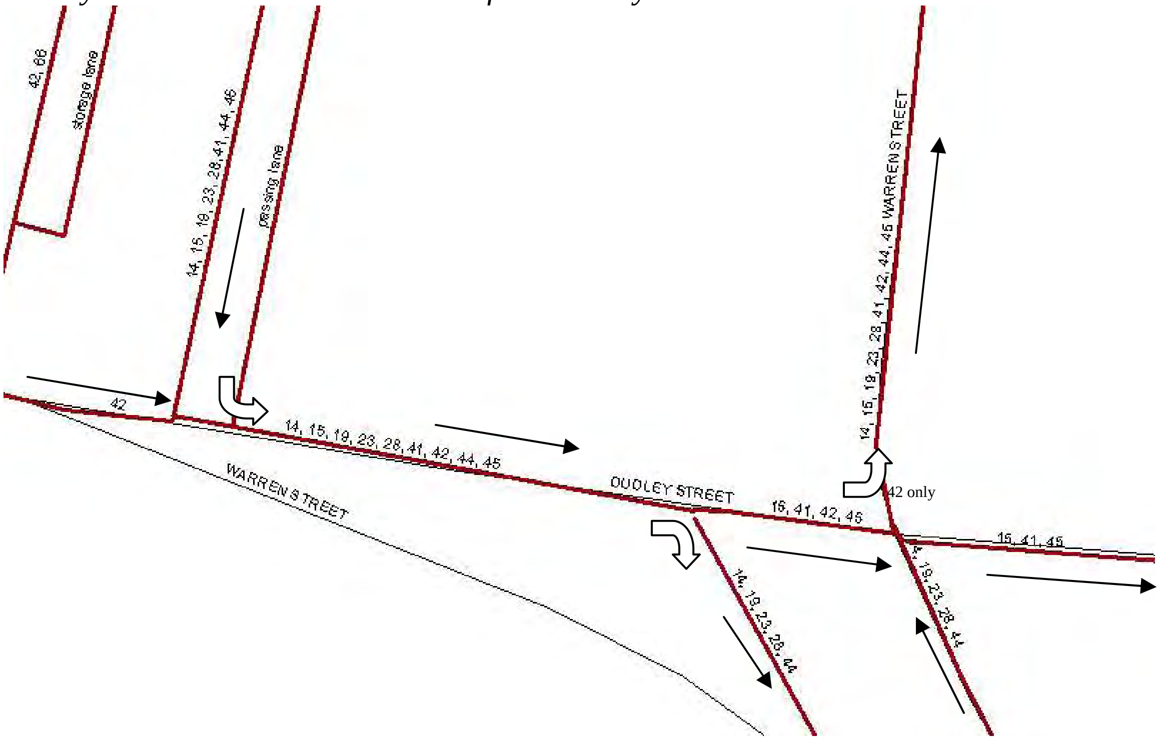
Lower Zeigler Street



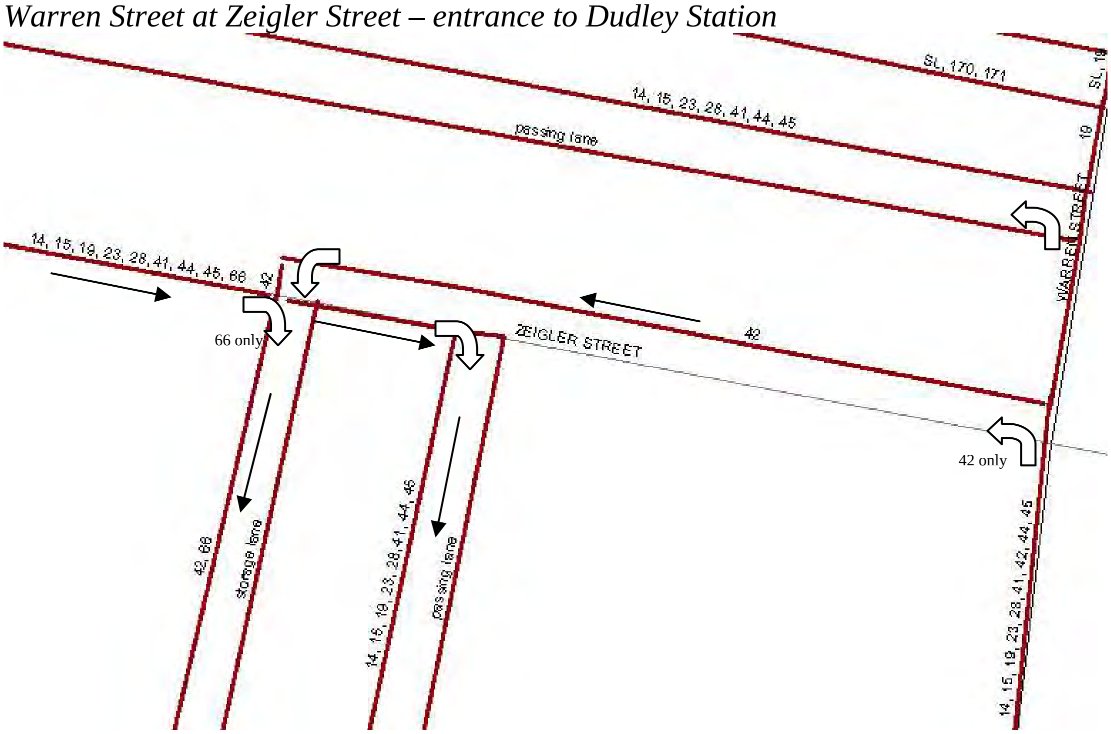
Dudley Street at Washington Street – exit from Dudley Station



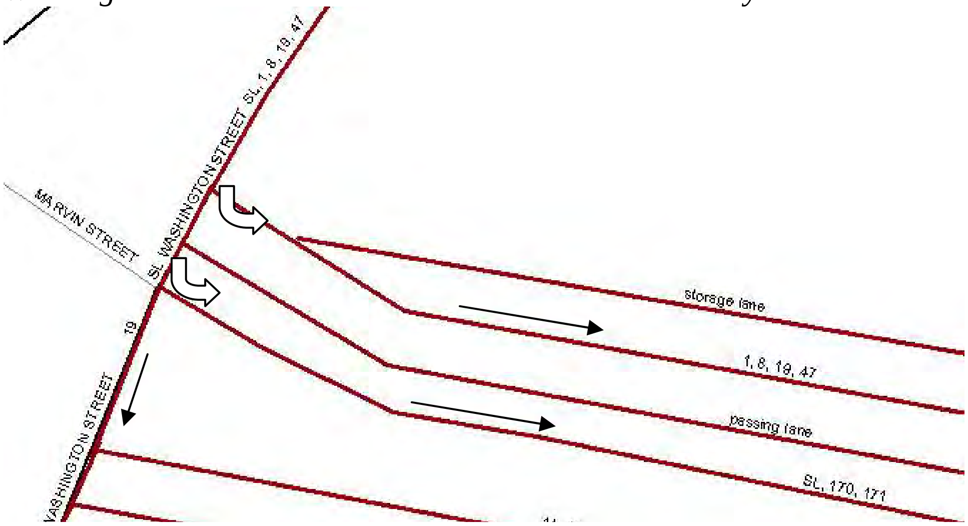
Dudley Street at Warren Street – exit from Dudley Station



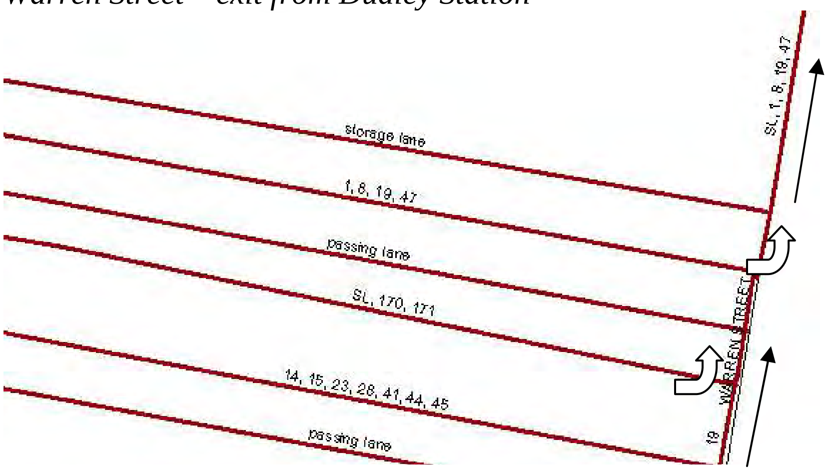
Warren Street at Zeigler Street – entrance to Dudley Station



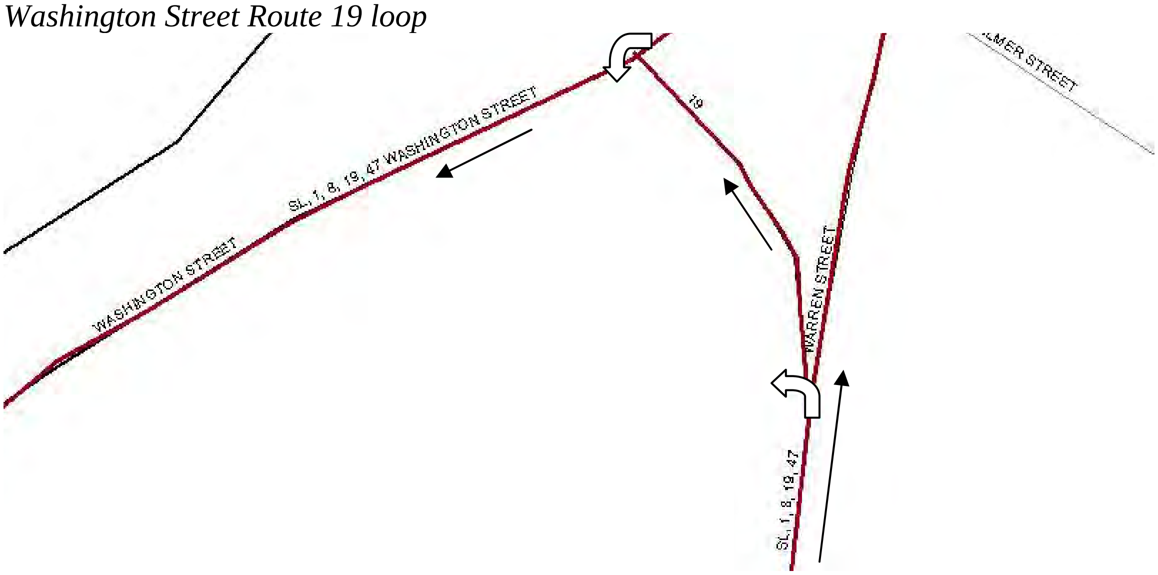
Washington Street and Marvin Street – entrance to Dudley Station



Warren Street – exit from Dudley Station

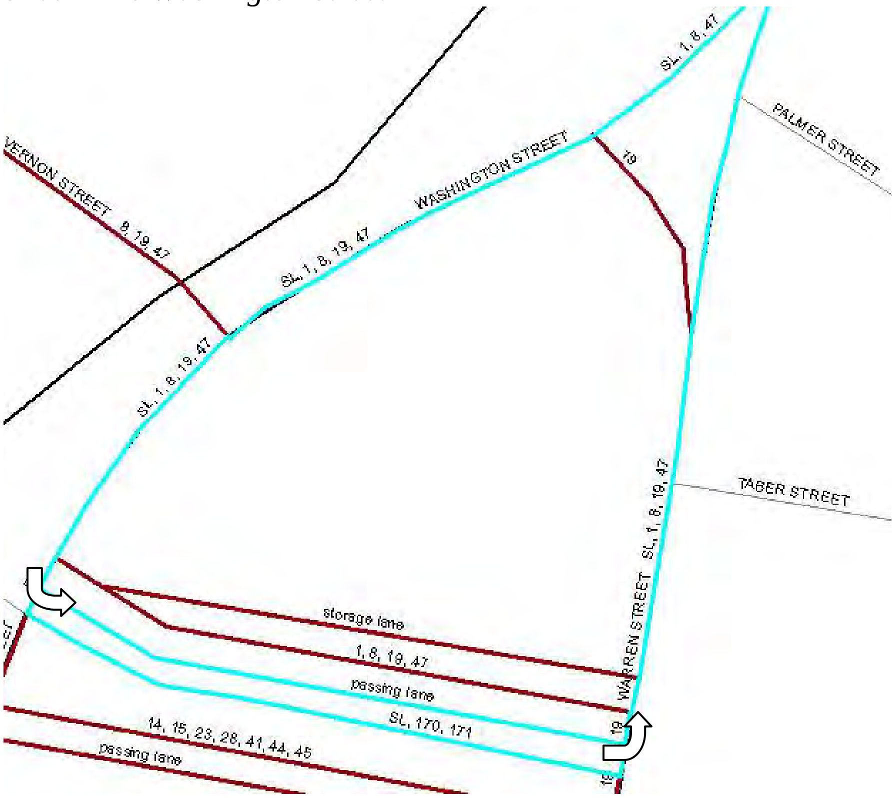


Washington Street Route 19 loop

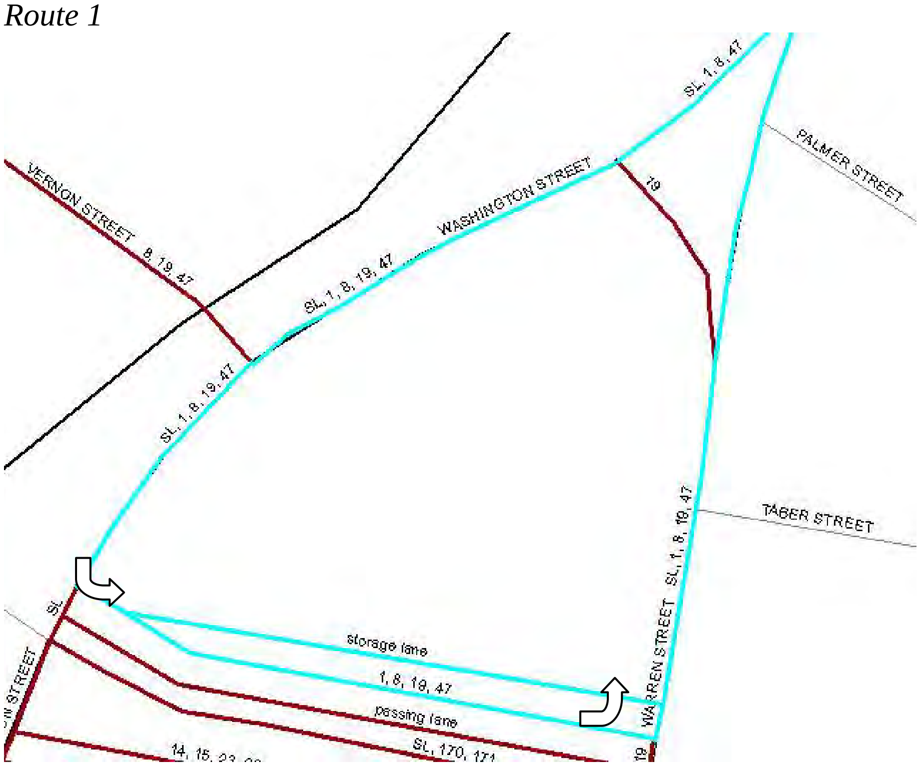


Route Descriptions

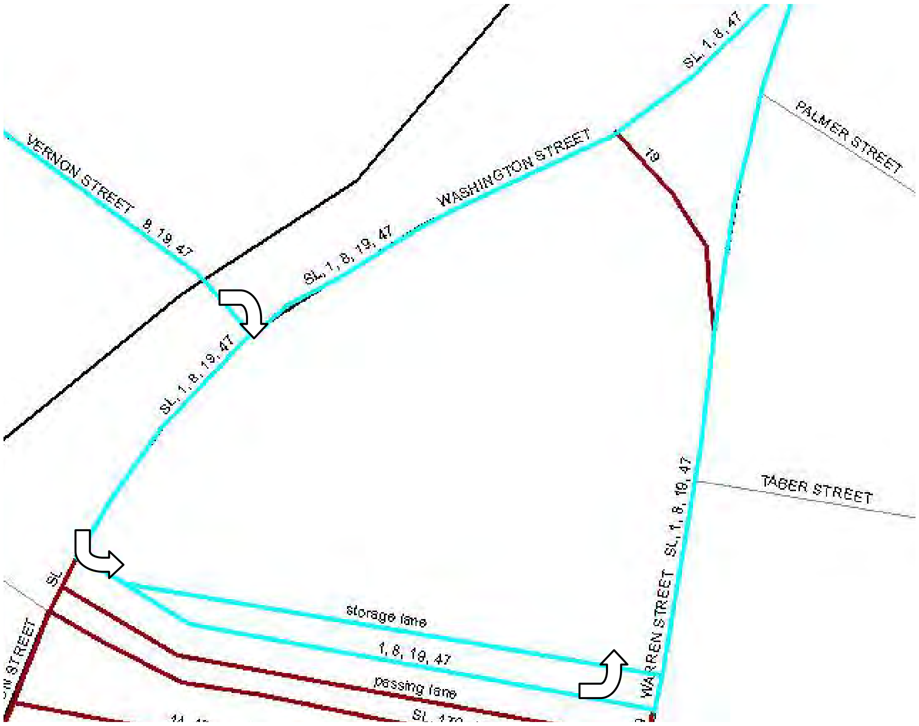
Silver Line Washington Street



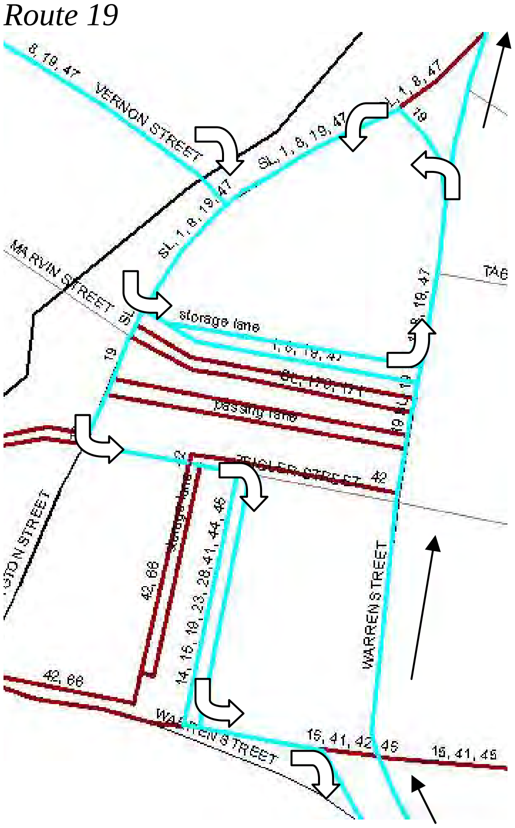
Route 1



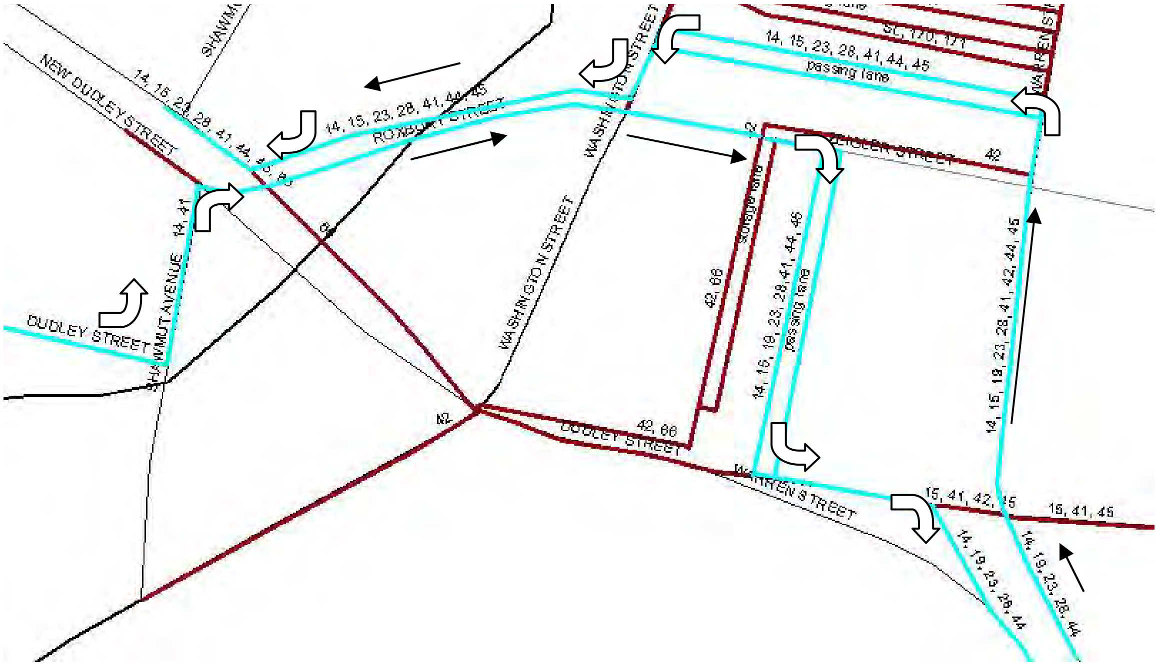
Routes 8 and 47



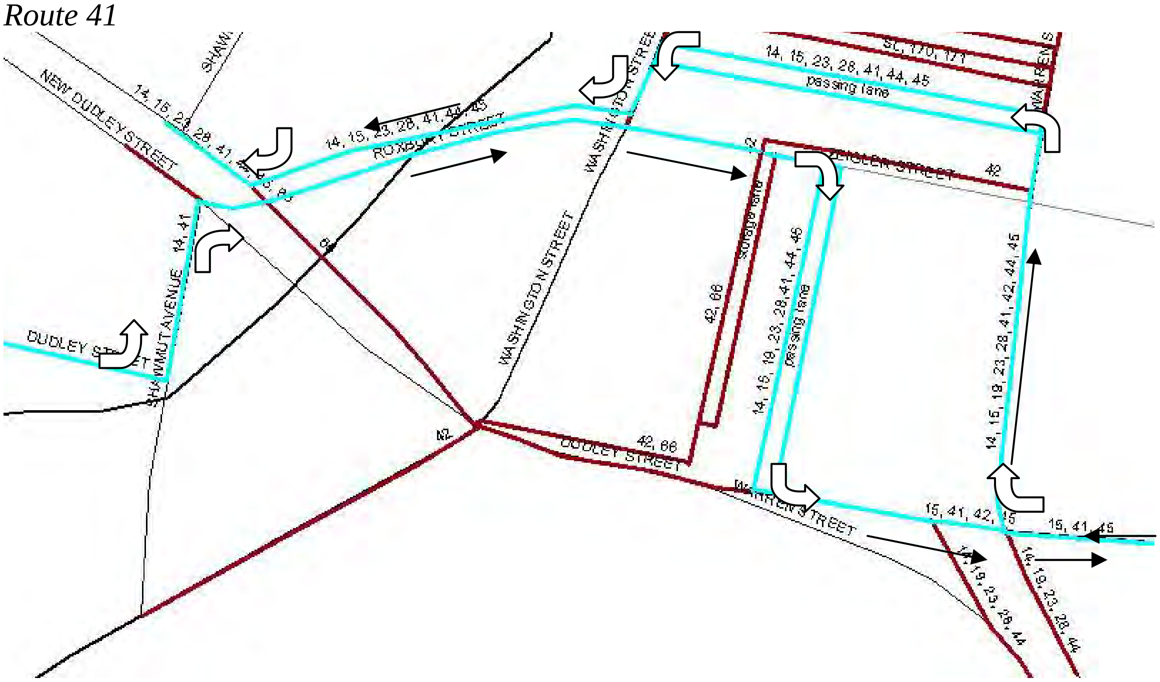
Route 19



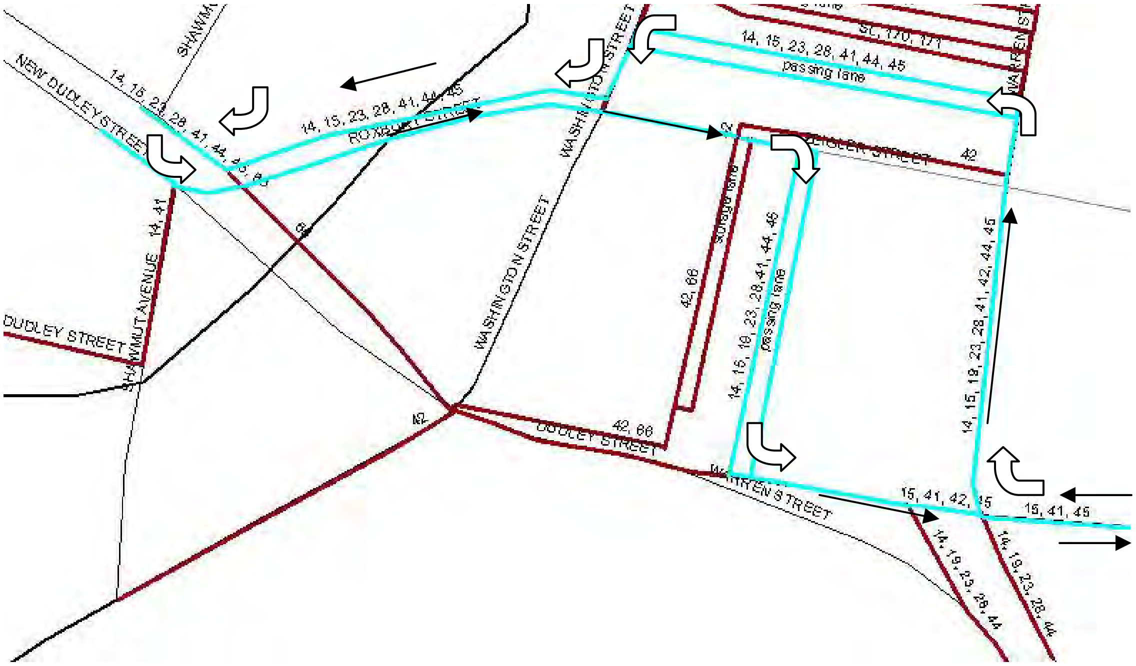
Route 14



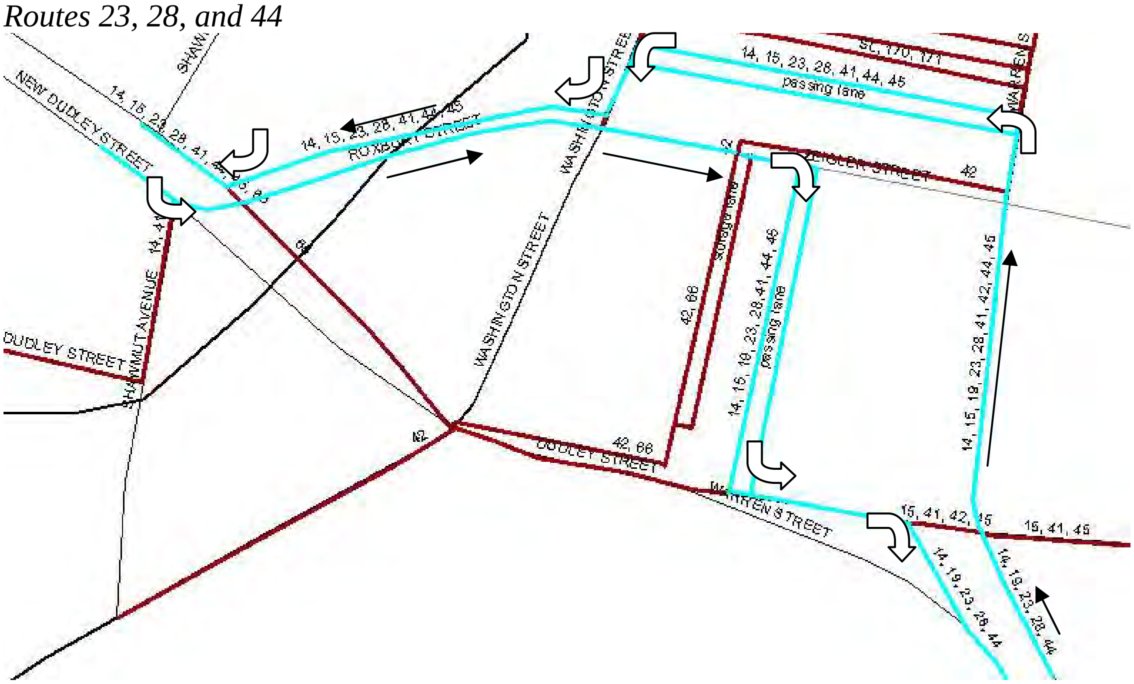
Route 41



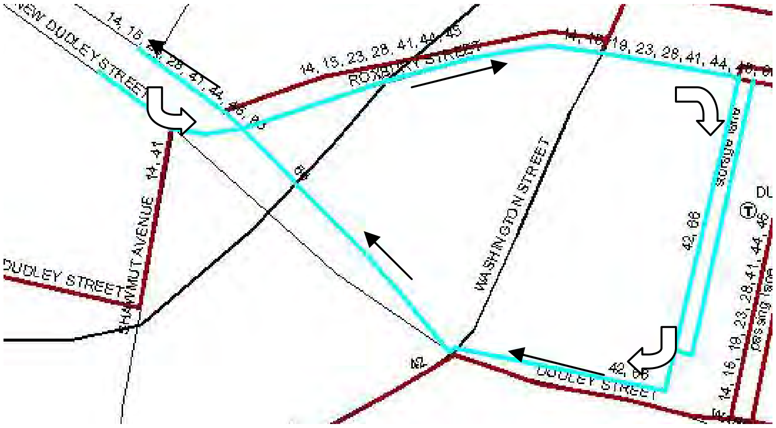
Routes 15 and 45



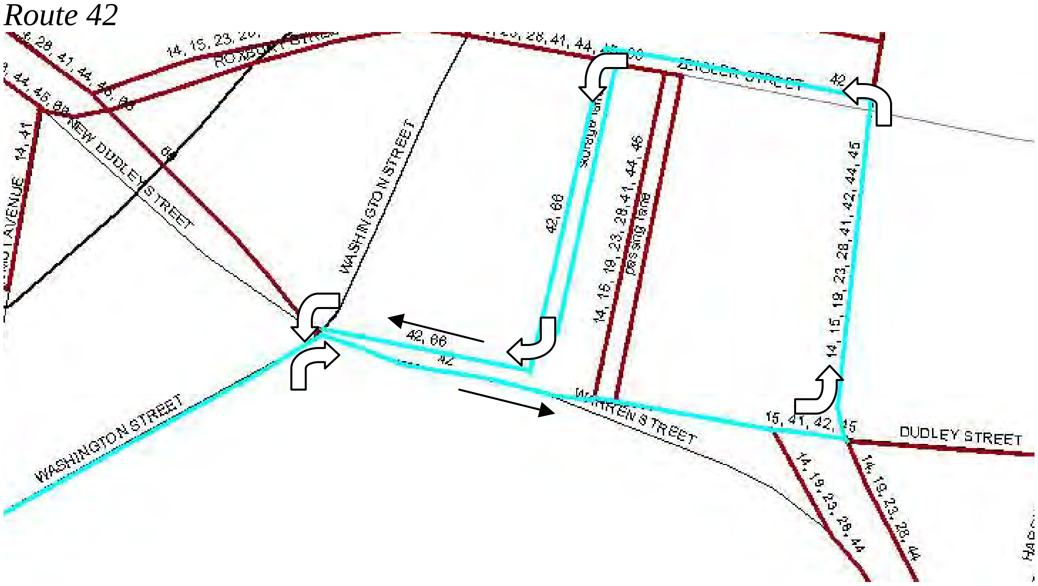
Routes 23, 28, and 44



Route 66



Route 42

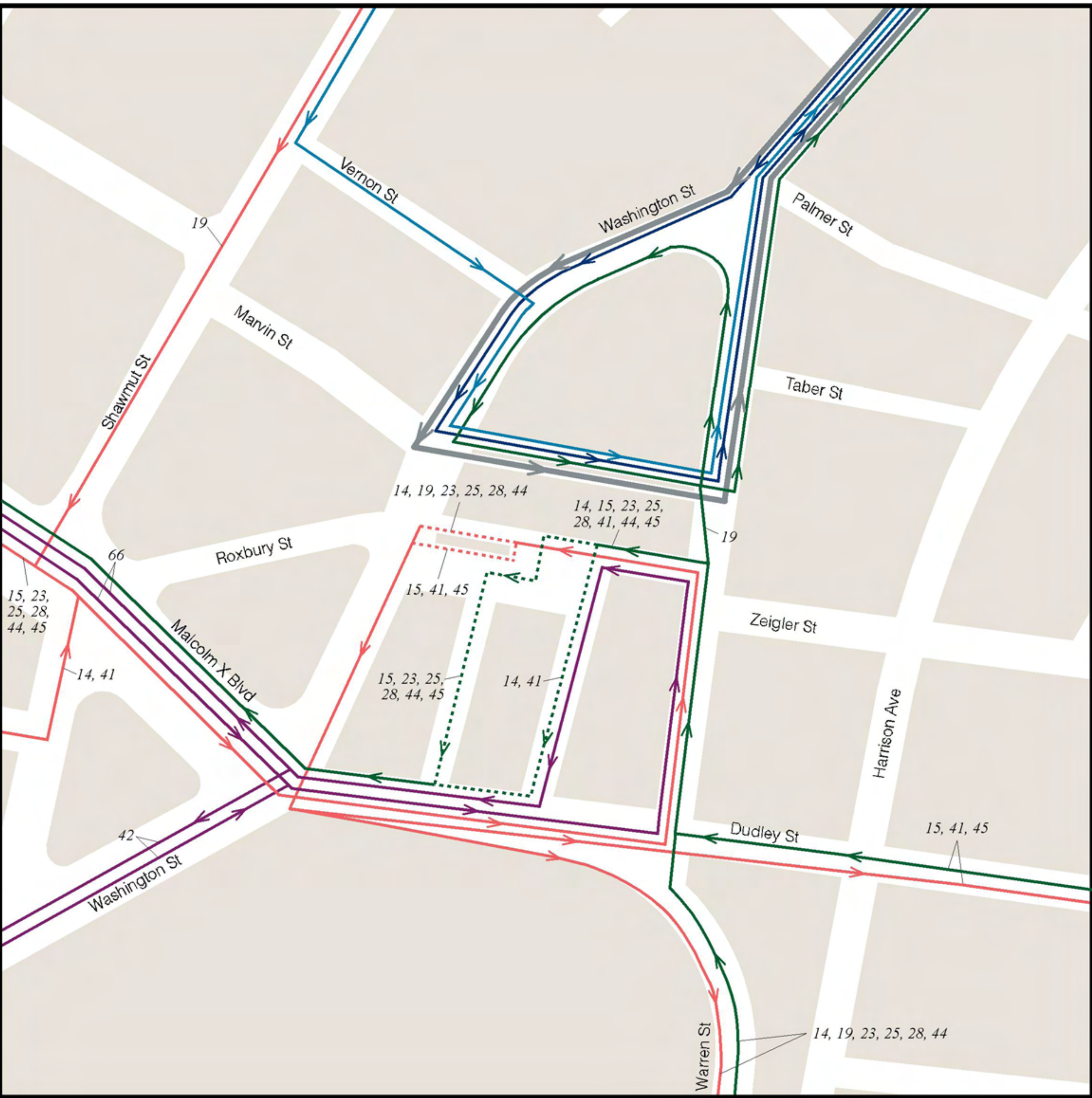


Exiting Dudley Station

Buses bound for either Warren Street or Dudley Street east of Warren Street, according to the bus circulation proposal described above, would exit Dudley Station from the east busway. A new traffic light, with two stopping lines approximately 36 feet in width, would need to be added on Dudley Street at this exit. This would eliminate approximately 284 feet of the eastbound existing queue capacity on Dudley Street (142 feet per lane multiplied by two lanes). The resulting eastbound queue capacity between Dudley Station and Washington Street is approximately 618 feet (206 feet per lane multiplied by three lanes) compared to an existing capacity of 696 feet (348 feet per lane multiplied by two lanes). Eastbound traffic on Dudley Street would have three queue lanes – the two north lanes marked as straight only and the one south lane marked as straight and right. Upon crossing the Dudley Station intersection, the north-most lane would be marked as left and straight. The middle lane would continue straight and the southern lane would have the option of turning right onto Warren Street or continuing straight. The traffic light at Dudley Station and Warren Street would be coordinated such that eastbound queues released from the Dudley Station stoplight would flow through the Warren Street intersection without stopping. These two traffic lights would also need to

Dudley Square Current Bus Circulation

Outbound	Inbound	Terminus
8, 47	8, 47	1
14, 15, 19, 23, 25, 28, 41, 44, 45	14, 15, 19, 23, 25, 28, 41, 44, 45	42, 66
		Silver Line



Dudley Square Proposed Bus Circulation

Outbound

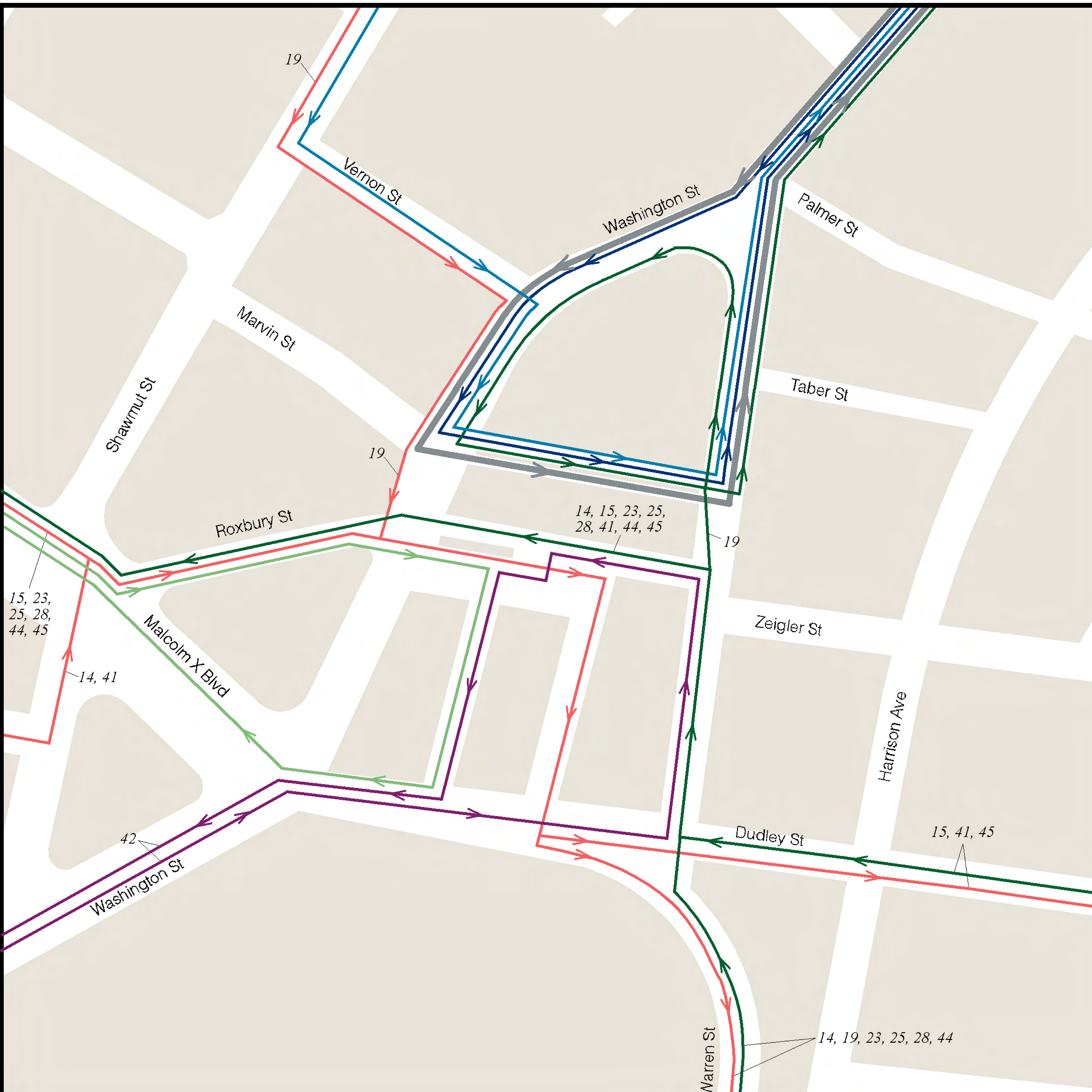
- 8, 47
- 14, 15, 19, 23, 25, 28, 41, 44, 45

Inbound

- 8, 47
- 14, 15, 19, 23, 25, 28, 41, 44, 45

Terminus

- 1
- 42
- 66
- Silver Line



Warren Street intersection without stopping. These two traffic lights would also need to be coordinated in the westbound direction, thereby preventing any queuing from occurring in this direction at the Dudley Station stoplight.

Buses exiting Dudley Station onto Dudley Street (Routes 14, 15, 19, 23, 25, 28, 41, 44, and 45) would get their own dedicated light. Signal priority for buses is not recommended as this could result in queues on Dudley Street greater than the lane capacity. Buses continuing east on Dudley Street (Routes 15, 41, and 45) would queue at the Warren Street intersection; however, when the stoplight at Dudley Station releases general traffic, these buses will be at the front of the queue. Buses headed south on Warren Street (Routes 14, 19, 23, 25, 28, and 44) would not pass through any stoplight upon exiting Dudley Station and turning right onto Warren Street.

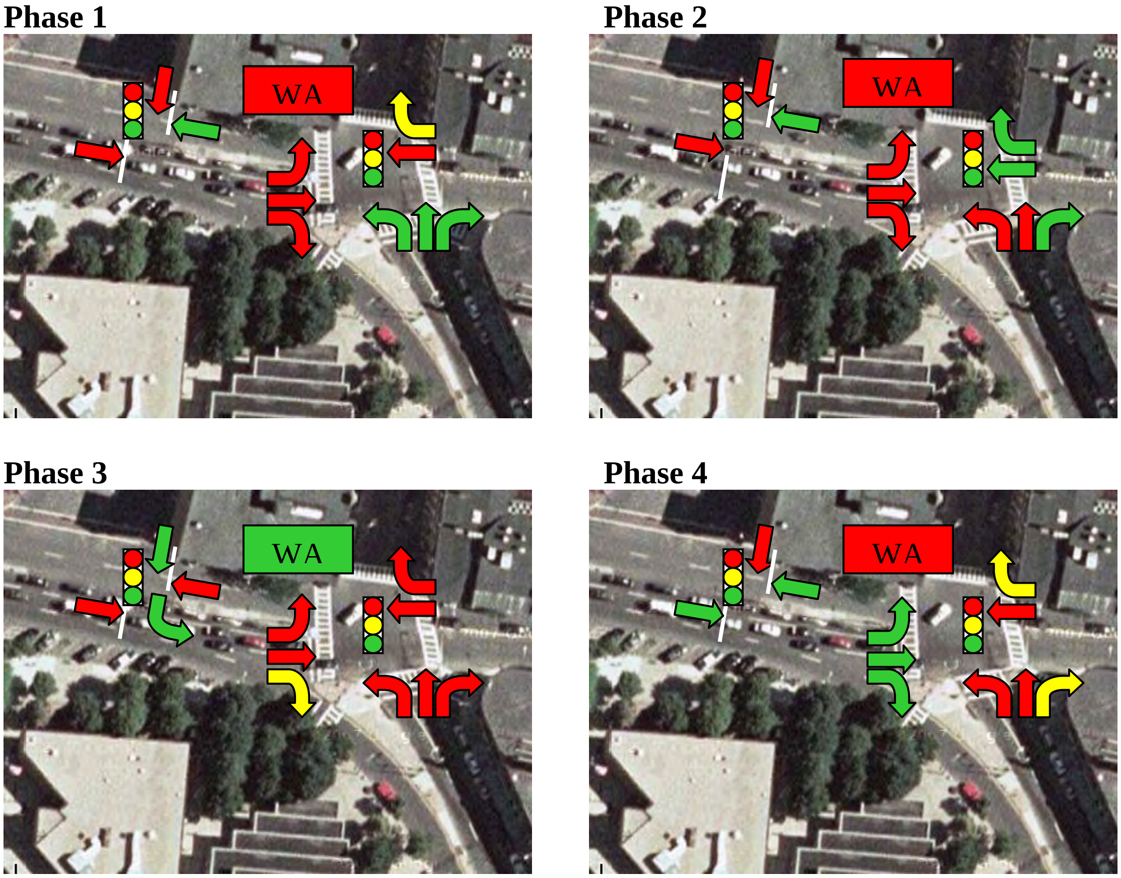
Figure D-1: Dudley Station Exit

Source: Google Maps

The green signal phasing at these two intersections would thus be the following:

1. Green to left, straight, and right turns from northbound Warren Street at Warren Street stoplight; coordinated green for westbound Dudley Street traffic at Dudley Station stoplight
2. Green to straight and right turns from westbound Dudley Street at Warren Street stoplight; coordinated green for westbound Dudley Street traffic at Dudley Station stoplight
3. Pedestrian walk signal at Warren Street stoplight; coordinated green for buses exiting Dudley Station at Dudley Station stoplight
4. Green to left, straight, and right turns from eastbound Dudley Street at Warren Street stoplight; coordinated green for eastbound Dudley Street traffic at Dudley Station stoplight

Figure D-2: Signal Coordination for Dudley Station Exit and Warren Street



Source: Google Maps

The change from green to red for westbound Dudley Street traffic at the two stoplights would need to be coordinated such that the Warren Street stoplight remains green a few seconds longer than the Dudley Station stoplight such that enough time exists to clear the lanes of traffic between the two stoplights. Even if a few vehicles run the red light at the Dudley Station stoplight and queue at Warren Street, as long as enough free space exists before the Warren Street stoplight such that buses exiting from Dudley Station can queue or turn left onto Warren Street, this would not severely disrupt the major intent of the Dudley Station stoplight. With a clear path to Warren Street for southbound Warren Street routes and to the front of the queue for eastbound Dudley Street routes, buses will be able to exit Dudley Station in a much more efficient manner.

APPENDIX E: DUDLEY STATION PASSENGER CIRCULATION

Dudley Station represents one of the major boarding, alighting, and transfer points in the MBTA bus network. Unlike bus alighting, where passengers can exit via multiple doors with no need to be counted, bus boarding typically requires boarding through the front door and interaction with the bus farebox. This poses an additional problem on buses when a large number of passengers pay with cash or CharlieTickets. Unlike the CharlieCard, which can be scanned in under a second, a CharlieTicket takes approximately 3-5 seconds to scan. Payment by cash onboard a bus, depending on the quality of dollar bills and number of coins, can significantly delay boarding.

The known delay in bus boarding caused by fare collection often leads to passengers boarding through rear doors, flashing a CharlieTicket pass to the operator, or being waved on by the operator. In each of these cases, the passenger is not counted by the farebox. This is particularly a problem on routes with high traffic and articulated buses.

This appendix discusses some of the specific issues with boarding, alighting, and transferring at Dudley Station. It then presents some suggestions for improving these passenger movements. These ideas are meant to encourage discussion such that the planning for any improvements to Dudley Station will be well informed.

Boarding, Alighting, and Transferring at Dudley Station

For bus routes serving Dudley Station, the station represents one of the major boarding and alighting stops. The following table shows the number of daily weekday passengers boarding and alighting at Dudley Station on each bus route as well as the percentage of the route's load leaving and arriving at Dudley Station that these boardings and alightings represent, respectively. For most routes in directions not destined for or coming from Ruggles Station, Dudley Station represents 50 percent or more of boardings or alightings to that point in the load. Even where the route originates from or terminates at Ruggles Station, boardings and alightings at Dudley Station respectively constitute on average 20 percent of the load.

Table E-1: Percent of Load by Route

Route (direction)	Boardings	Boardings Percent of Load	Alightings	Alightings Percent of Load
1 (both: Dudley – Harvard)	1,191	100.0%	1,033	100.0%
8 (in: Kenmore)	173	45.5%	208	50.1%
8 (out: UMass)	270	52.5%	131	34.9%
14 (in: Heath)	85	62.0%	214	80.5%
14 (out: Roslindale Sq)	237	77.5%	81	54.0%
15 (in: Ruggles)	389	25.5%	949	45.5%
15 (out: Kane Sq)	1,263	48.1%	112	7.6%
19 (in: Kenmore)	129	22.4%	513	53.4%
19 (out: Fields Corner)	370	51.7%	97	21.9%
23 (in: Ruggles)	262	16.9%	1,691	56.8%
23 (out: Ashmont)	1,627	51.7%	188	11.0%
25 (in: Ruggles)	18	22.8%	78	56.1%
25 (out: Franklin Park Zoo)	13	72.2%	3	37.5%
28 (in: Ruggles)	297	22.5%	1,859	64.5%
28 (out: Mattapan)	1,656	58.2%	241	16.8%
41 (in: JFK/UMass)	241	61.0%	149	49.2%
41 (out: Centre St)	204	47.8%	299	57.3%
42 (both: Dudley – Forest Hills)	844	100.0%	622	100.0%
44 (in: Ruggles)	226	40.5%	635	65.7%
44 (out: Jackson)	699	67.5%	60	15.2%
45 (in: Ruggles)	313	40.6%	445	49.3%
45 (out: Franklin Park Zoo)	636	49.3%	67	9.3%
47 (in: Broadway)	129	52.0%	124	51.0%
47 (out: Central Sq)	180	53.9%	158	50.6%
66 (both: Dudley – Harvard)	1,380	100.0%	954	100.0%
170 (both: Dudley – Oak Pk Dr)	6	100.0%	0	100.0%
171 (out: Airport)	14	100.0%	N/A	N/A
SL (both: Dudley – Temple Pl)	3,585	100.0%	3,075	100.0%
Total	16,437		13,986	

The largest number of boardings at Dudley Station occurs on the Silver Line. More than twice the number of passengers boards the Silver Line at Dudley Station than any other route. After the Silver Line, Route 23 and Route 28 have the next highest boarding totals. Route 1, Route 66, and Route 15 in the outbound direction are the three other routes serving Dudley Station to have daily weekday boarding totals greater than 1,000 passengers. In all, 16,437 daily weekday passengers board buses at Dudley Station.

As with boardings, the largest number of alightings at Dudley Station occurs on the Silver Line. Following the Silver Line, Route 28, Route 23, Route 1, Route 66, and Route 15 in the inbound direction have the next highest alighting totals. The total number of bus passengers alighting at Dudley Station on a typical weekday is 13,986. The following table shows the percentage of boardings and alightings contributed by each route.

Table E-2: Percent of Boardings/Alightings

Route	Percent of Dudley Station Boardings	Percent of Dudley Station Alightings
1	7.2%	7.4%
8	2.7%	2.4%
14	2.0%	2.1%
15	10.1%	7.6%
19	3.0%	4.4%
23	11.5%	13.4%
25	0.2%	0.6%
28	11.9%	15.0%
41	2.7%	3.2%
42	5.1%	4.4%
44	5.6%	5.0%
45	5.8%	3.7%
47	1.9%	2.0%
66	8.4%	6.8%
170	<0.1%	<0.1%
171	0.1%	N/A
SL	21.8%	22.0%

Several routes serving Dudley Station currently have different areas designated for alightings and boardings. Specifically, the Silver Line uses two east-west busway lanes and Routes 42, 66, and all other routes continuing on to Ruggles Station use the two north-south busway lanes to discharge alighting passengers first and then continue down the busway lane to pick up boarding passengers. Routes not bound for Ruggles Station discharge and pick up passengers in the same location. This slows the boarding process on these routes.

There are no statistics compiled for transfer activity at Dudley Station. However, given the large number of passengers boarding and alighting at the station, a significant percentage is likely transferring between bus routes. Between routes that serve Dudley Station, the opportunity exists to transfer to routes bound for downtown Boston (Silver Line), Cambridge (Routes 1, 47, 66), Brookline (Routes 47, 66), Mission Hill (14, 66), Jamaica Plain (41, 42, 44), Roslindale (14), and various parts of Roxbury and Dorchester.

Fare Collection

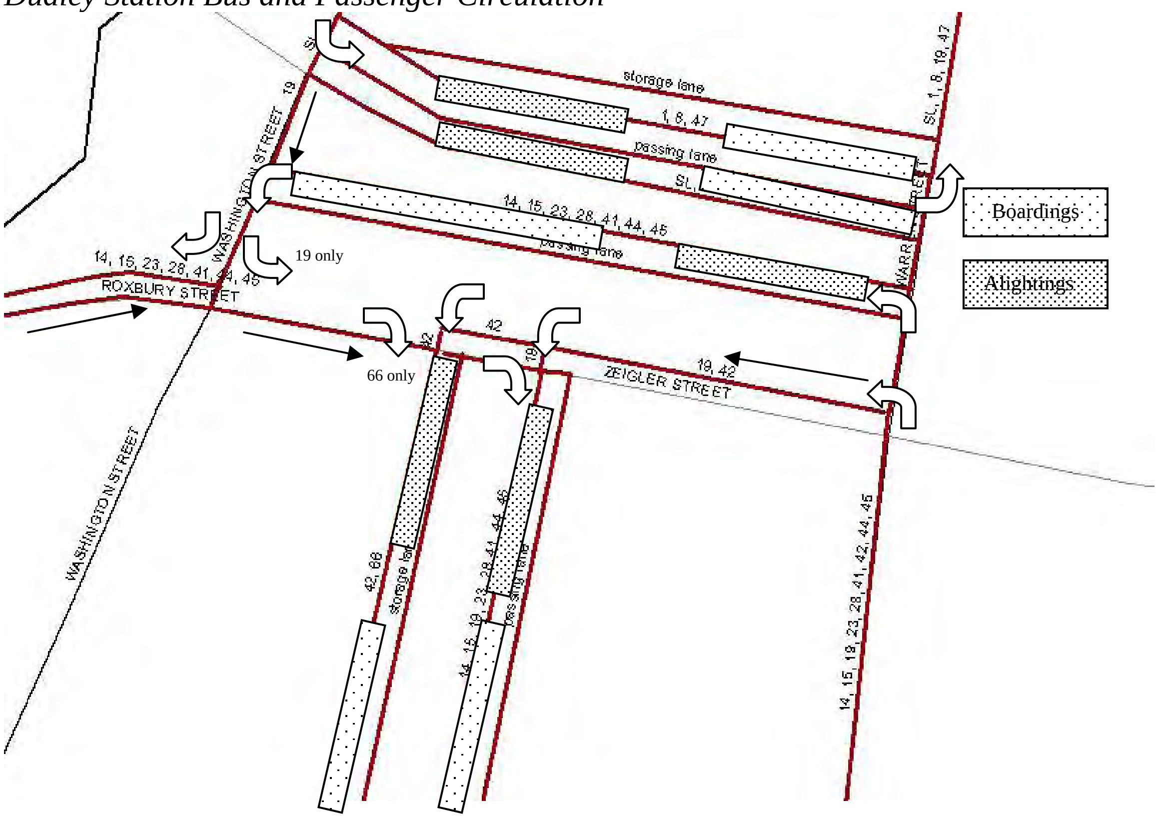
Fare collection can act as a severe obstacle to remaining on schedule where the number of passengers and the extent to which they pay their fare via CharlieTickets or cash onboard increases. Typically, maximum loads descend on Dudley Station in the morning for inbound traffic, in the early afternoon for school traffic, and in the early evening for outbound traffic. For routes with high daily numbers of boardings (Silver Line, Route 28, Route 23, Route 66, Route 15, and Route 1) these factors can significantly delay departure from the station. Articulated buses, and the larger loads they are expected to carry, face particular trouble when all passengers are expected to board through the front door to interact with the farebox. The Silver Line is the only route currently running articulated buses through Dudley Station.

When fare collection becomes too much of a hindrance to schedule adherence, many bus operators, with good reason, will open rear doors and wave through passengers without requiring them to interact with the farebox. While this expedites boarding, revenue from passengers who do not have a pass is not collected, and an accurate count of passengers on the route is lost.

Suggestions for Improving Passenger Movements in Dudley Station

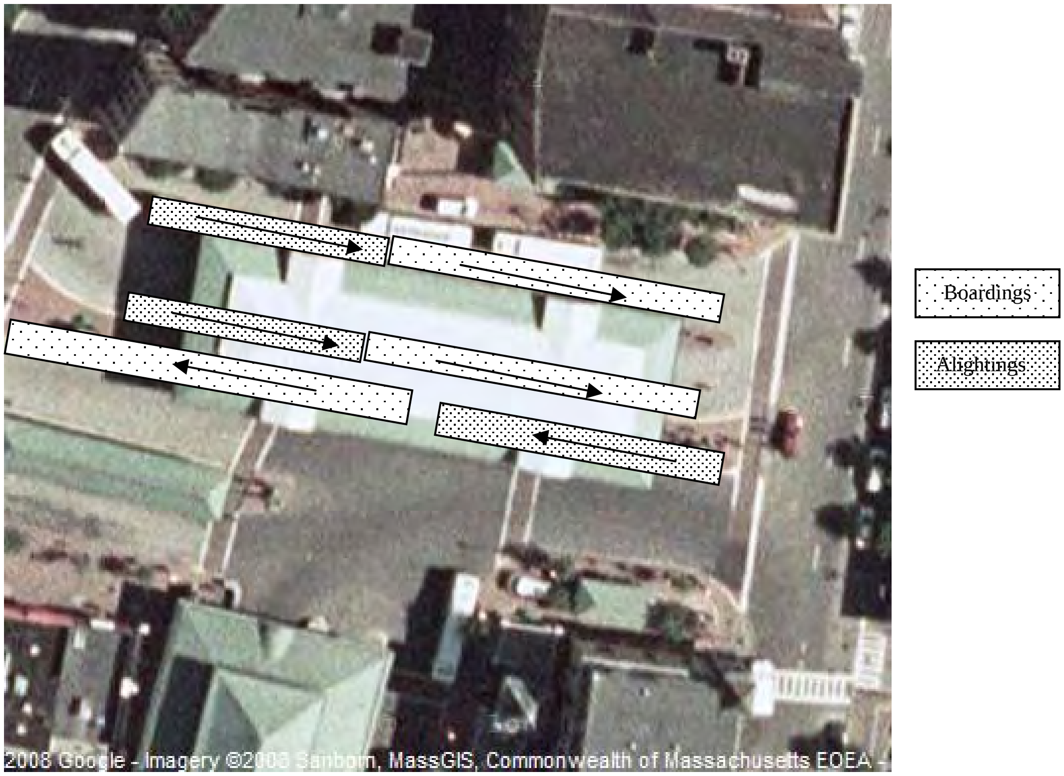
Where designated areas can be established for alightings and boardings, this can assist in not only grouping and thereby expediting passenger movements in one direction, but also in ensuring that no passenger evades paying their fare by boarding through a rear door. The following map presents the recommendations of a previous memo with regards to bus routing through Dudley Station and includes markings for potential boarding and alighting areas. As seen in the figure, the major change from the current routing is that lower Zeigler Street becomes a two-way busway, with the eastern portion dedicated to Routes 14, 15, 23, 28, 41, 44, and 45 from Roxbury Crossing or Ruggles Stations and the western portion dedicated to Routes 42 and 66. All routes bound for either Roxbury Crossing or Ruggles Station (except for Route 66) would use upper Zeigler Street.

Dudley Station Bus and Passenger Circulation

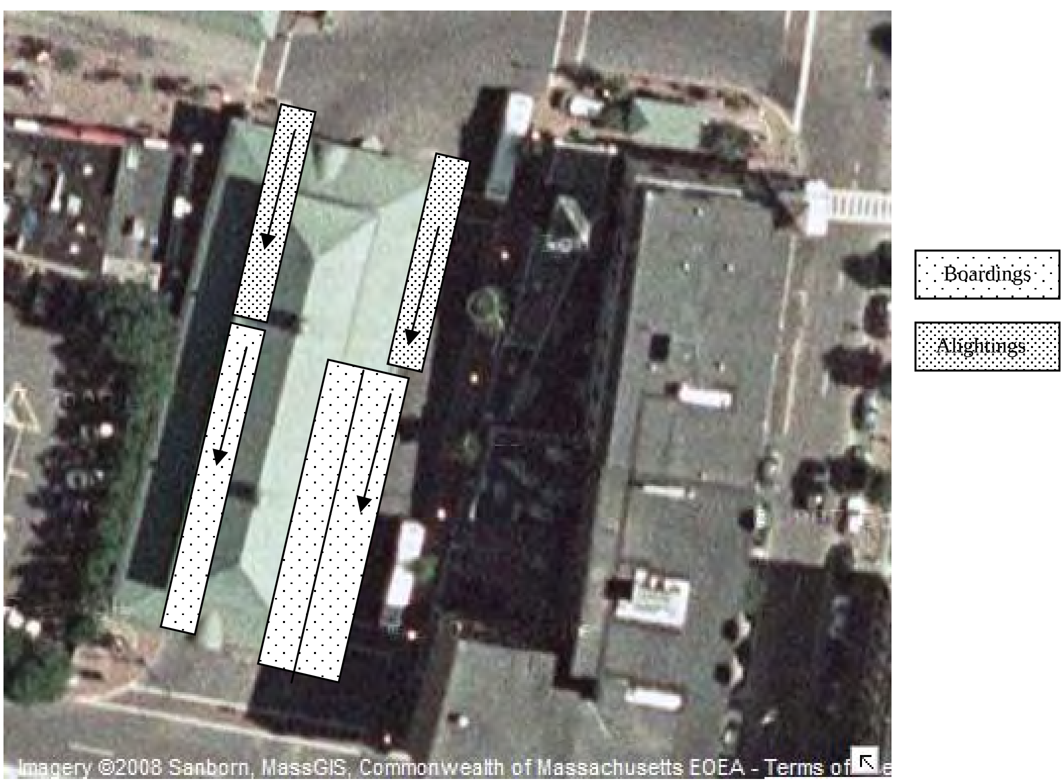


As seen above, every route passing through Dudley Station would discharge all alighting passengers in designated areas prior to moving forward and picking up boarding passengers. The following aerial photograph shows where in actual physical space these boarding and alighting areas could be located.

Upper Dudley Station Passenger Boarding and Alighting Areas



Lower Dudley Station Passenger Boarding and Alighting Areas



Source: Google Maps

The following table lists the approximate distances of lanes in Dudley Station and the possible breakdown of these lanes into designated boarding and alighting areas.

Table E-3: Approximate Lane Distances

Lane	Total Distance	Alighting Distance	Boarding Distance
Upper Busway	207	83	124
Silver Line Busway	207	69	138
Upper Zeigler Street	221	88	133
East Busway	158	53	106
West Busway	158	53	106

In the Upper Busway, served by Routes 1, 8, and 47, the alighting area should be long enough to accommodate two buses at any one time. This would leave enough boarding distance for a maximum of three buses at any one time. However, as Routes 8 and 47 serve Dudley Station in different directions, it is important to maintain separate boarding areas for the inbound and outbound routes. Note also that an additional lane of capacity exists to hold buses between their arrival and departure. The Silver Line Busway is the only lane where there are articulated buses. Little would change from the current set-up. Silver Line buses discharge passengers as they enter the busway (in approximately the first 69 feet) and pick up passengers in the area before Warren Street. A maximum of two Silver Line buses can sit in the boarding lane at any one time. As with the Upper Busway, an additional lane of capacity exists to hold buses.

Upper Zeigler Street serves inbound Routes 14, 15, 23, 28, 41, 44, and 45. From where buses enter Dudley Station at Warren Street to where they leave at Washington Street, a large amount of capacity exists. The alighting area on Upper Zeigler Street would need to be set in slightly from Warren Street, but enough space exists for two buses to discharge passengers at any one time. Buses would then travel down Upper Zeigler Street to pick up passengers. This boarding area could be large enough to accommodate three buses at any one time with an additional lane available for buses to pass one another.

The two north-south lanes, termed here as the East Busway (serving Routes 42 and 66) and West Busway (serving Routes 14, 15, 19, 23, 28, 41, 44, and 45), have the tightest capacity constraints. These busways would provide enough space for one bus to discharge passengers at any one time. An additional 96 feet also exist on Upper Zeigler Street before the turn-in to the north-south busways for buses to queue if necessary. Buses would then move into the extra storage lane (in the East Busway) or travel down the lane (in the West Busway) and pick-up passengers before Dudley Street. Enough capacity exists for two buses to pick up passengers at any one time. In the West Busway, buses could use the extra lane as a passing lane if necessary. In the East Busway, the divider between the unused middle busway could be removed to provide additional space for a passenger boarding area for the many bus routes using this berth.

In addition to separating boardings from alightings, transforming boarding areas into pre-paid fare zones through the use of faregates could dramatically expedite boardings. Access to these zones would be granted, much as in a subway station, by interaction between a faregate and either a CharlieCard or CharlieTicket. Walls would prevent unauthorized access to the zone, acting at the same time as a shelter against wind. Sliding doors, activated by a bus pulling up to them, would permit entry from the boarding area onto buses. The width of the sliding doors would need to accommodate the various dimensions of the different bus types used. By employing prepaid boarding areas, passengers would not need to interact with the bus farebox upon boarding the bus, and all bus doors could be opened for entry. Finally, fare vending machines would need to be located nearby such that customers could load value onto their CharlieCard or CharlieTicket with cash before interacting with the faregates.

Conclusion

Dudley Station is a major boarding, alighting, and transfer point in the MBTA bus network. Where the opportunity exists, therefore, to speed any of these passenger movements – either through designated boarding and alighting areas or pre-paid fare zones – these improvements will benefit travel times and service on all routes passing through Dudley Station.