

Transit Capacity Evaluation

Because the project site will be integrated with the existing transit station, public transit plays an important role in how people will get to and from the site. As such, an in-depth analysis of the existing transit system and its ability to accommodate future passenger demands was prepared. This section contains the following information:

- › Methodolgy
- › Existing MBTA Green (D) Line Capacity
 - Planned MBTA Green Line (D) Improvements
- › Existing MBTA Bus Service Capacity
- › Current and Future Transit Operations
- › Projected Ridership and Distribution of Project Generated Transit Trips
- › Future Transit Service Capacity Analysis

Methodolgy

In an effort to understand the potential for additional ridership, available capacity was estimated on transit lines that could be utilized for access to and from the site. For this study, the MBTA Green Line rapid transit (subway) line and the MBTA Route 558 bus service were evaluated for project impacts on passenger capacity.

The capacity analysis results in a comparison of the expected demand for transit to the planned capacity of the service. Thus, for the subway and bus lines, we first identify the service segments that are expected to be used by riders generated by the proposed development project. For each service, we identify the peak passenger load point – the service segment that is most crowded, based on existing ridership, by time of day (for buses it's by trip; for subway, it's by 30-minute service period). These passenger loads are compared against the service's capacity.

The capacity of the transit services is based on the MBTA's *Service Delivery Policy*.¹ For the passenger comfort standard, which is based on vehicle capacity and riders, the standard sets the level of passenger crowding that is acceptable by transit mode and time period (or trip). Generally, the vehicle load assumes all seats on the vehicle will be occupied and some passengers may stand as well, before the condition is determined to be "over crowded." The standard varies by service period: generally, high-volume (peak periods) have a higher threshold than low-volume (off-peak periods).

The intent of applying this method is to identify segments in the MBTA system that need additional service to address overcrowding. These transit capacity analyses are performed consistent with MassDOT and MBTA analysis methods.

To estimate the expected growth in transit ridership between the Existing Condition and the future No-Build Condition, we apply an average annual passenger growth rate based on the

¹ Service Delivery Policy; Massachusetts Bay Transportation Authority; January 23, 2017.

Boston MPO's CTPS Regional Travel Demand Model projections for daily ridership by transit service. (These are reported in the Boston MPO's long-range regional transportation plan.) The calculated average annual growth rates are applied to existing ridership (data² provided by the MBTA). These are detailed in the future condition analysis sections.

Existing MBTA Green (D) Line Capacity

The capacity of the Green Line service is determined by the number, type, and frequency of trains in service during each service period. As shown in Table 1, at a peak service time, the D Line is expected to handle 1,000 passengers per each 30-minute period during the peak periods, when trains are scheduled to run 6-minute headways. During the midday and evening periods, those capacity loads are lower as a result of fewer trains in service.

Table 1 MBTA D Line Capacity by Service Period

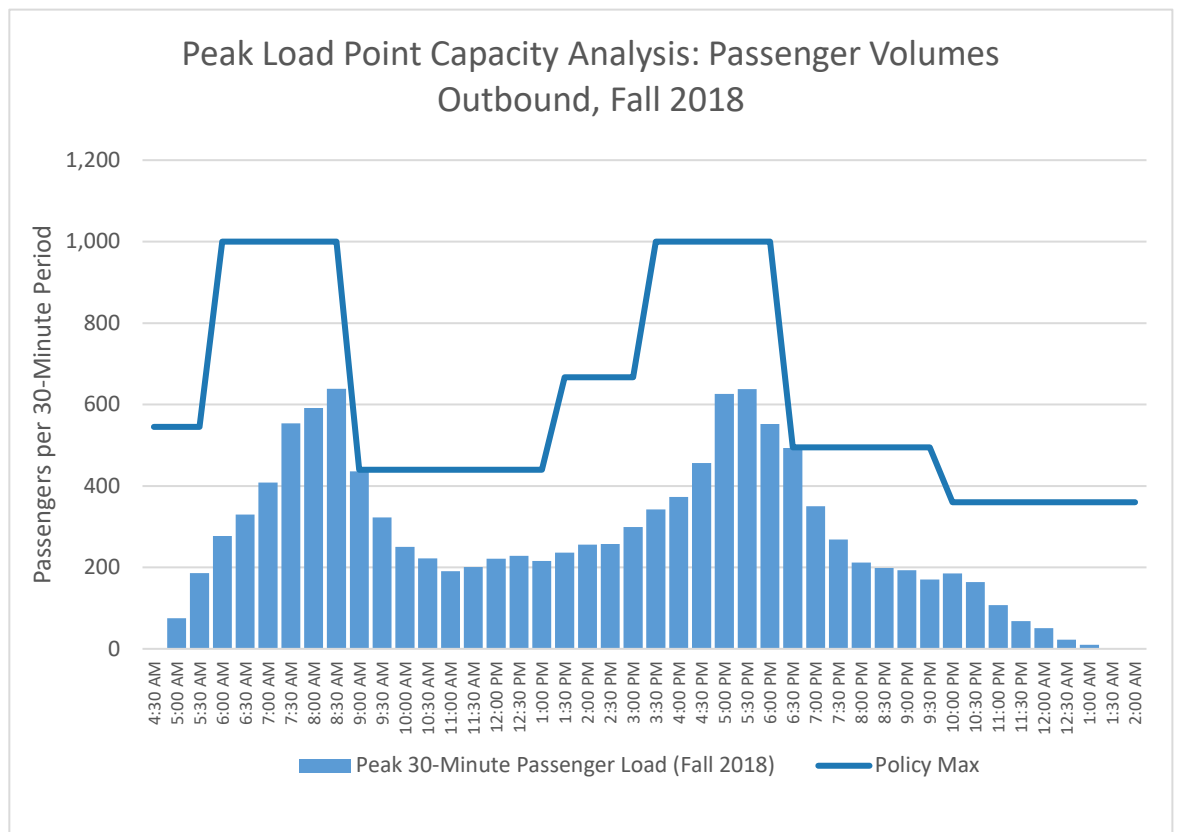
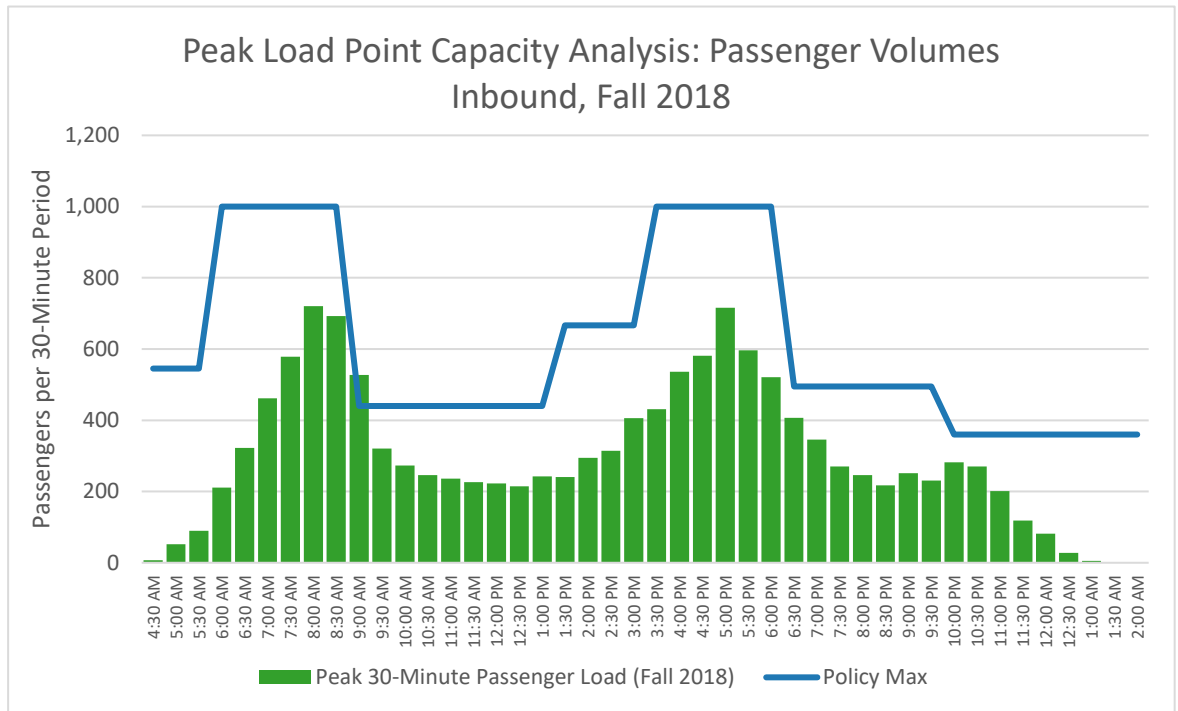
Period	Time	MBTA Policy Max Passenger Load/Car ¹	Cars/ Train	MBTA Policy Max Passenger Load/Train	Train Headways (minutes) ²	Trains per 30- Minutes	MBTA Policy Max Load/30- Minute
Sunrise	3:00 AM - 5:59 AM	100	2	200	11	2.7	545
Early AM	6:00 AM - 6:29 AM	100	2	200	6	5.0	1,000
Early AM (Rush Hr)	6:30 AM - 6:59 AM	100	2	200	6	5.0	1,000
AM Peak	7:00 AM - 8:59 AM	100	2	200	6	5.0	1,000
Midday Base	9:00 AM - 1:29 PM	66	2	132	9	3.3	440
Midday School	1:30 PM - 3:29 PM	100	2	200	9	3.3	667
Midday School (Rush Hr)	3:30 PM - 3:59 PM	100	2	200	6	5.0	1,000
PM Peak	4:00 PM - 6:30 PM	100	2	200	6	5.0	1,000
Evening	6:30 PM - 9:59 PM	66	2	132	8	3.8	495
Late Evening	10:00 PM - 11:59 PM	66	2	132	11	2.7	360
Night	12:00 AM - 2:59 AM	66	2	132	11	2.7	360

Sources:

1. For Green Line vehicle Type 7/Type 8, per MBTA Service Delivery Policy (2017), Table B2 "Vehicle Load On Light Rail, Heavy Rail"
2. MBTA Rapid Transit Schedule, Effective September 3, 2017 - December 30, 2017. Peak period frequencies based on FMCB Presentation on 11/20/17.

VHB reviewed the MBTA's data reflecting Fall 2018 Green Line Load Profiles to perform a transit capacity (line haul) analysis. The capacity analysis is based on the maximum load point on the entire line; the maximum load point is defined as the point along the line that carries the greatest number of passengers. (See figures below.)

² Green Line Load Profile (aka Rail flow data), Weekday, September 2018, representing the most recently available fall activity data; provided by the MBTA Service Planning Department.



Based on existing conditions, on the Inbound direction, MBTA is not meeting their current Policy Max thresholds. From 9 AM to 9:30 AM, Green Line (D) ridership exceeds policy max levels by 20%.

Planned MBTA Green Line (D) Improvements

The MBTA has plans for substantial investment in the MBTA system in the next ten-to-twenty years, including enhancements to the Green Line and the Riverside Station D trains. These initiatives are outlined in the MBTA's *Focus40 Plan*³. The the Focus40 plan calls for up-to a 50 percent increase in capacity along the Green Line's central subway core by 2040 with redesigned larger vehicles and modernized infrastructure. The plan identifies a host of improvements to get there, including several phases of improvements. Phase I State of Good Repair (SGR) projects are geared toward Green Line track, signals and power infrastructure upgrades. Phase II Planning and Early Action; Fleet Procurement includes new Type 9 vehicles, which are currently arriving to the D Line, and by 2030 new Type 10 vehicles will replace the existing cars on the Green Line. Phase III improvements will expand capacity on D and E Branches via additional infrastructure changes. The aim of this phase is to operate new, larger trains as single cars on B and C Branches and as two-car sets on D (Riverside) and E Branches to achieve a Green Line capacity gain of approximately 50 percent.

As detailed in the Green Line Transformation project materials, the Type 10 "Supercar" vehicles will have more capacity per vehicle than the older vehicles (about 80 percent more), which will accommodate growth needs on the line (and, according to the MBTA's materials, will provide a 10-15 percent more peak core capacity in the central subway).⁴

In the short term there are 24 new trolleys (Type 9 cars) that are being deployed to the Riverside D branch. The first one was deployed in December of 2018 and the remaining 23 will be deployed periodically through 2019. These are supporting the Green Line Extension project.

The impact of how the replacement of Green Line train cars with the Type 10 "Supercar" will have on passenger capacity are explored later under the future conditions evaluation.

³ *Focus40, Positioning the MBTA to Meet the Needs of the Region in 2040*; MBTA; March 2019.

⁴ Source: MBTA presentation on the *Green Line Transformation* (Public Meeting, September 2019), slide 17, available at <https://cdn.mbta.com/sites/default/files/2019-09/GLT-public-meeting-presentation-accessible-v2.pdf>

Existing MBTA Bus Service Capacity

The Route 558 bus is the only MBTA bus route serving the Project Site. Route 558 operates only on weekdays and provides irregular and infrequent service.

In the inbound direction:

- AM inbound service departs from Riverside at 6:25 AM, 7:35 AM, 8:00 AM, and 9:05 AM.
- There is then a gap in service until 1:15 PM, when six trips operate approximately 70 minutes apart until the last departure at 7:12 PM. The first three of these trips operate to Newton Corner, and the last three operate to downtown Boston.

In the outbound direction:

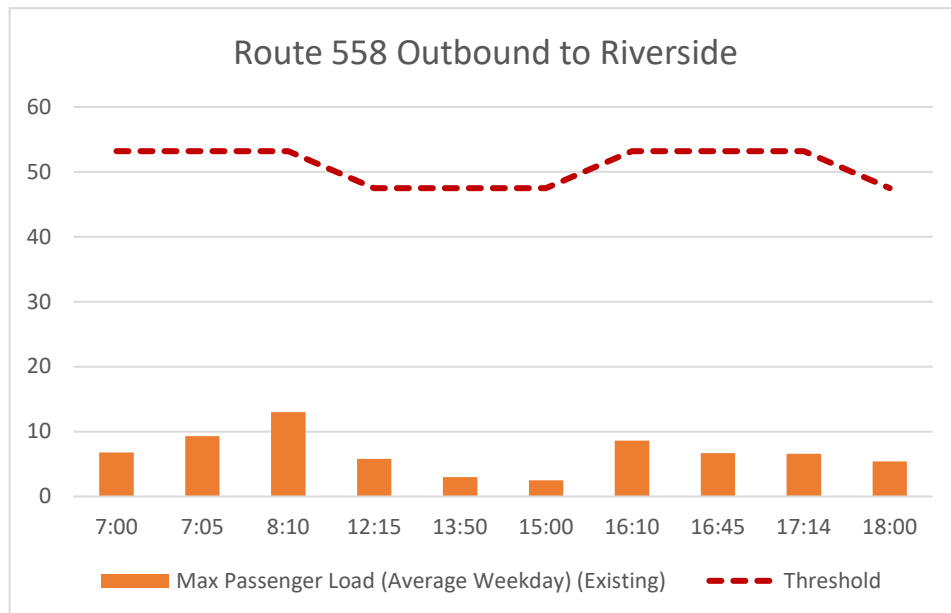
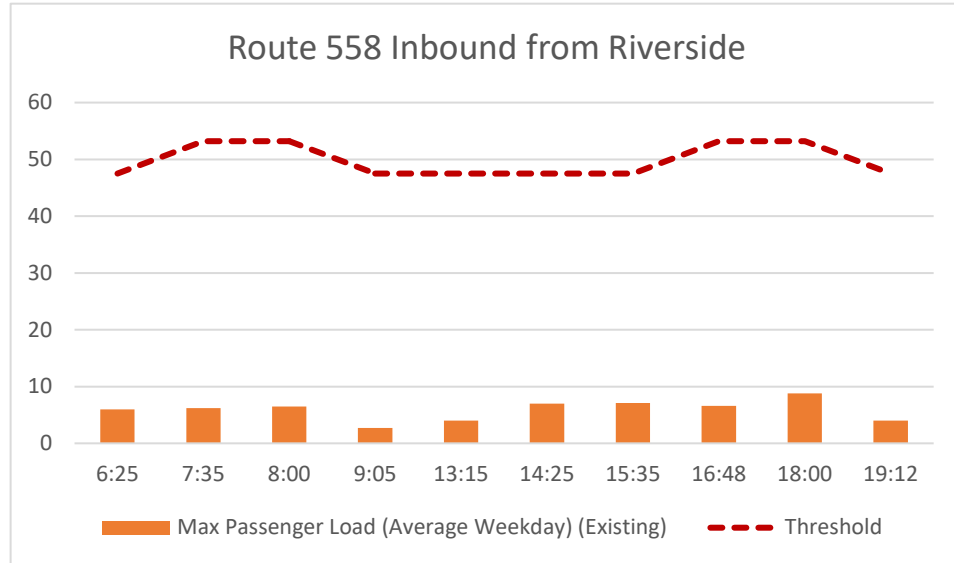
- Three outbound trips serve Riverside in the morning: 7:00 AM (from Newton Corner), 7:05 AM and 8:10 AM from downtown Boston.
- In the early to mid afternoon, four trips serve Riverside, with frequencies roughly every 70 minutes. In the late afternoon, three additional trips serve Riverside, with the final trip arriving at Riverside around 7:00 PM

The buses serving this route each have a seated capacity of 38 passengers and, using the vehicle load standard dictated by MBTA Service Delivery Policy⁵, have an average policy capacity (hereafter referred to as the recommended passenger crowding threshold) equal to 53 passengers during the peak periods and equal to 47 passengers during off-peak periods.⁶

⁵ MBTA, *Service Delivery Policy, 2017 Update*, Approved January 23, 2017.

⁶ MBTA, *Average Fleet Seating – CY2017*. Note that the capacities displayed are rounded down to the nearest whole number and maximum loads displayed are rounded to the nearest whole number. All calculations (including sums) do not round maximum loads so may differ from the numbers displayed.

An investigation of average weekday passenger loads (Fall 2018 ridership data) at the peak load point for the bus Route 558 (for the analysis segment connecting Riverside and the Waltham Center and commuter rail station) indicates that none of its trips in the inbound or outbound service exceed the passenger crowding threshold. (See figures below.)



Futhermore, the MBTA *Service Delivery Policy* (SDP) defines a passenger comfort standard for the percent of passenger travel time experienced in comfortable conditions that includes a minimum of 92 percent of travel time per bus passenger and target of 96 percent of travel

time per bus passenger experienced in comfortable conditions.⁷ In Fall 2018, Route 558 had an SDP metric of 98.52% comfortable this metric is based on weekday service.⁸ This route exceeds (meets) the MBTA's standard for this metric; in other words, this route is deemed to be in an acceptable range for passenger comfort conditions.

Transit Ridership: Future Projections

Future transit service projections have been developed in order to evaluate the likely impacts and the transit needs of the Riverside Redevelopment Project. This section examines the potential impact of expected transit ridership generated by employees and residents of the Project.

Transit Trip Generation

For the traffic impact analysis, the future projections for Site-generated trips assume that 5 percent of the office-generated person trips and 25 percent of the residential-generated person trips will arrive to the Site via transit modes. (These mode share assumptions and traffic trip generation are presented in the *Future Conditions* chapter of this report.) It was assumed that no retail traffic will arrive to the Site via transit modes. These are conservative assumptions from a traffic perspective, as discussed previously.

However, we expect that the actual mode splits will likely reflect a higher reliance on transit than what those assumptions indicate. Using the expected trip distribution for the project-generated trips, geographically it indicates that no more than 15 percent of the office-generated person trips would be via transit and no more than 35 percent of the residential-generated person trips would be via transit.

Therefore, we applied two different sets of transit mode share assumptions to use for the transit capacity analyses: (1) a *conservative* assumption, under which we apply the same mode splits used in the traffic analyses, and (2) a *realistic* assumption, to reflect a more likely mode share expected for a transit-oriented development at this site, which also serves as an upper level of transit activity. We assume that retail uses will not generate transit trips. These assumptions are presented in the table below.

Table 2 Applied Transit Mode Shares for Capacity Analysis

Land Use	Conservative ¹	Realistic ²
Office	5%	15%
Residential	25%	35%

Notes: 1. These reflect the transit mode share applied to the traffic impact analysis. 2. These reflect the transit mode share applied to the upper bound of transit trip generation.

This results in setting an upper and lower bound of transit use. Furthermore, for simplicity as a conservative approach (i.e., higher project-generated ridership level), we assume that 100

⁷ MBTA, *Service Delivery Policy, 2017 Update*, Approved January 23, 2017.

⁸ Metric provided by MassDOT OPMI; calculations as of September 4, 2019.

percent of site-generated transit trips take the Green Line and that an additional five percent of site transit trips use the Route 558 bus (allocating 105% of projected transit generated trips to the network).

The transit trips generated by the different uses are likely to be complimentary: Office trips using public transportation to access the Site will be a reverse commute (e.g., travelling outbound in the morning and inbound in the evening) relative to the residential trips. Riverside is the terminus for both the Green (D) Line and bus Route 558; thus, all trips entering the Site will travel outbound on each of the two transit lines while all trips exiting the Site will travel inbound on each of the two transit lines.

The resulting transit trip generation under the two mode share scenarios are as follows:

Table 3 Weekday Daily Transit Trips by Trip Generator

Direction	Residential Trips	Office Trips	Retail Trips	Total Trips
<i>Conservative (5% Office - 25% Residential)</i>				
Enter (to Site)	377	83	0	460
Exit (from Site)	403	77	0	480
Total	780	160	0	940
<i>Realistic (15% Office - 35% Residential)</i>				
Enter (to Site)	527	248	0	775
Exit (from Site)	564	232	0	796
Total	1091	480	0	1571

The daily transit trips are distributed by time of day to each of the transit modes. For the Green Line, trips are distributed by 30-minute period throughout a weekday service period, following the ridership pattern that closely matches current boarding levels. For the Route 558, the daily transit trips are distributed to each of the scheduled bus trips.

Future Transit Service Capacity

To estimate the impacts of the additional Site-generated transit trips on the Green Line and MBTA bus route 558 and identify any potential capacity constraints in the existing public transportation system serving the Project site, future transit capacity analyses were conducted. The analysis requires estimating future passenger activity and establishing assumptions for future transit service levels.

Future Transit Passenger Activity

The future condition transit analyses are based on the Build year 2029. The analysis applies a Green Line growth in passengers of approximately 1.29 percent annually between now and 2029 and a bus Route 558 growth in passengers of approximately 0.68 percent annually, based on the projections expressed by the Boston Region Metropolitan Planning

Organization (MPO) regional travel demand model maintained by CTPS.⁹ (Note that the projected growth rate for the local bus system was applied to bus Route 558 instead of projected growth rate for the express bus system in order to provide a more conservative, i.e., higher ridership, estimate.) These growth rates were applied to the Fall 2018 passenger volumes to create a future 2029 No-Build condition. For the 2029 Build condition, the project's Site-generated transit trips were added to the future expected riders of the Green (D) Line and MBTA bus Route 558. (The estimated project-generated transit trips are presented in the section *Transit Trip Generation*).

To assign project trips on the MBTA Green (D) Line, *residential* trips departing the site in the morning were proportionally distributed amongst all 30-minute time periods in the AM whereas all *residential* trips arriving at the site were proportionally distributed amongst all 30-minute time periods in the PM. Opposite to residential, *office* trips entering the site were assigned proportionally during AM time periods and *office* trips departing the site were assigned proportionally during PM time periods. To estimate a worst-case scenario for bus, all estimated trips were assigned to the single highest trip in the AM and PM.

Future Transit Service Levels

For future service conditions, VHB assumed that the existing transit routes serving the site would continue to operate the same service:

- The Route 558 would continue service based on today's trip schedule and using the same type of bus.
- The Green Line's D Branch would operate at the same frequency of service (train headways) by period as today's service; however, with the planned replacement of the train cars with the Type 10 "Supercar" trains by the year 2030, each Green Line train will provide 80 percent additional capacity.¹⁰ (For comparison in the analysis, both today's capacity and the expected future capacity are shown. The resulting capacity by service period is shown in Table 4.)

⁹ Annual average growth rate for the Green Line was calculated based on weekday ridership growth forecasted by the regional travel demand model, as reported in the report *Core-Capacity Constraints: Accommodating Growth on Greater Boston's Congested Roads and Crowded Transit System*, Central Transportation Planning Staff (CTPS) of the Boston Region MPO, 2016. The conditions used in that study investigated the impacts of intensifying development in the metropolitan region's urban core. This rate is higher than the expected 1.01 percent annual growth rate presented in the more recent *Destination 2040: Long-Range Transportation Plan: Model Results (2019)*. Annualized growth rate for bus was calculated from *Charting Progress to 2040: The Long-Range Transportation Plan of the Boston Region Metropolitan Planning Organization*; Central Transportation Planning Staff (CTPS); July 2015. This rate is higher than the expected 0.22 percent annual growth rate for local bus presented in the more recent *Destination 2040: Long-Range Transportation Plan: Model Results (2019)*.

¹⁰ Source: MBTA presentation on the *Green Line Transformation* (Public Meeting, September 2019), slide 17, available at <https://cdn.mbta.com/sites/default/files/2019-09/GLT-public-meeting-presentation-accessible-v2.pdf>

Table 4 MBTA Green Line D Branch Capacity by Service Period: Existing and Expected Future with Type 10 Train Cars in Operation

		Today's Green Line Operations				Operations with Supercar Trains
Weekday Service Period	Time	MBTA Policy Max Passenger Load/Train ¹	Train Headways (minutes) ²	Trains per 30 Minutes	Policy Max Passenger Load per 30-Minute	Policy Max Passenger Load per 30-Minute ³
Sunrise	3:00 AM - 5:59 AM	200	11	2.7	545	982
Early AM	6:00 AM - 6:29 AM	200	6	5.0	1,000	1,800
Early AM (Rush Hr)	6:30 AM - 6:59 AM	200	6	5.0	1,000	1,800
AM Peak	7:00 AM - 8:59 AM	200	6	5.0	1,000	1,800
Midday Base	9:00 AM - 1:29 PM	132	9	3.3	440	792
Midday School	1:30 PM - 3:29 PM	200	9	3.3	667	1,200
Midday School (Rush Hr)	3:30 PM - 3:59 PM	200	6	5.0	1,000	1,800
PM Peak	4:00 PM - 6:30 PM	200	6	5.0	1,000	1,800
Evening	6:30 PM - 9:59 PM	132	8	3.8	495	891
Late Evening	10:00 PM - 11:59 PM	132	11	2.7	360	648
Night	12:00 AM - 2:59 AM	132	11	2.7	360	648

Sources:

1. For Green Line vehicle Type 7/Type 8, per MBTA Service Delivery Policy (2017), Table B2 "Vehicle Load On Light Rail, Heavy Rail". Assumes 2-car operation.
2. MBTA Rapid Transit Schedule, Effective September 3, 2017 - December 30, 2017. Peak period frequencies based on an FMCB presentation on 11/20/17.
3. MBTA presentation on the *Green Line Transformation* (Public Meeting, September 2019), slide 17: Although it states "running two-Supercar trains would effectively double the Green Line capacity", the max passenger loads noted are 200 for today's operation using Type 7, 8, 9 cars and 360 for Type 10 Supercars, which corresponds to an 80-percent increase. Capacity assumes same train headways and use of 2-car trains as applied to today's operations.

Future Transit Capacity Analysis: Green Line (D Branch)

The charts below illustrate the expected future passenger loads at the peak load point relative to the planned service capacity for the Green Line's D Branch.¹¹ The charts present both project-generated transit trips under a *conservative* and a *realistic* mode-choice scenario.

At future ridership levels with the project-generated growth the MBTA Green Line (D) does not trigger any new exceedances above the MBTA's policy capacity thresholds than what is experienced today. At future ridership levels and the capacity enhancements gained with the Type 10 train cars, the MBTA Green Line (D) is expected to be in compliance with the MBTA's policy capacity thresholds.

¹¹ The peak load point on the Green Line varies by time period. For the D Line, Inbound, the peak load point is most often occurs between Fenway and Kenmore in the mornings, and at varying points between Hynes and Park Street in the afternoon. Outbound, the peak load point occurs at varying points between Government Center and Arlington in the mornings and early afternoon, and between Hynes and Kenmore in the mid-afternoon and evening periods.

Figure Inbound Green Line Service: Average Peak Load Point Capacity Analysis, Future Condition, Under Two Growth Scenarios

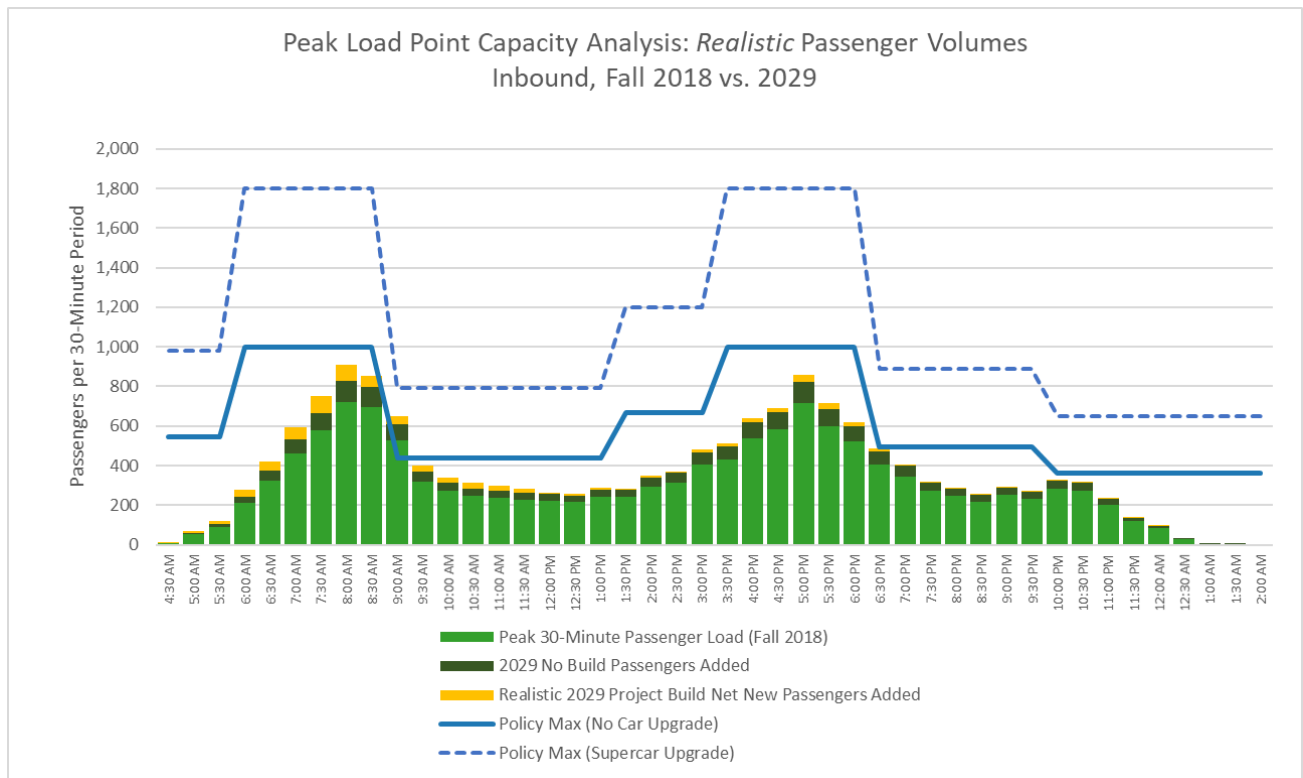
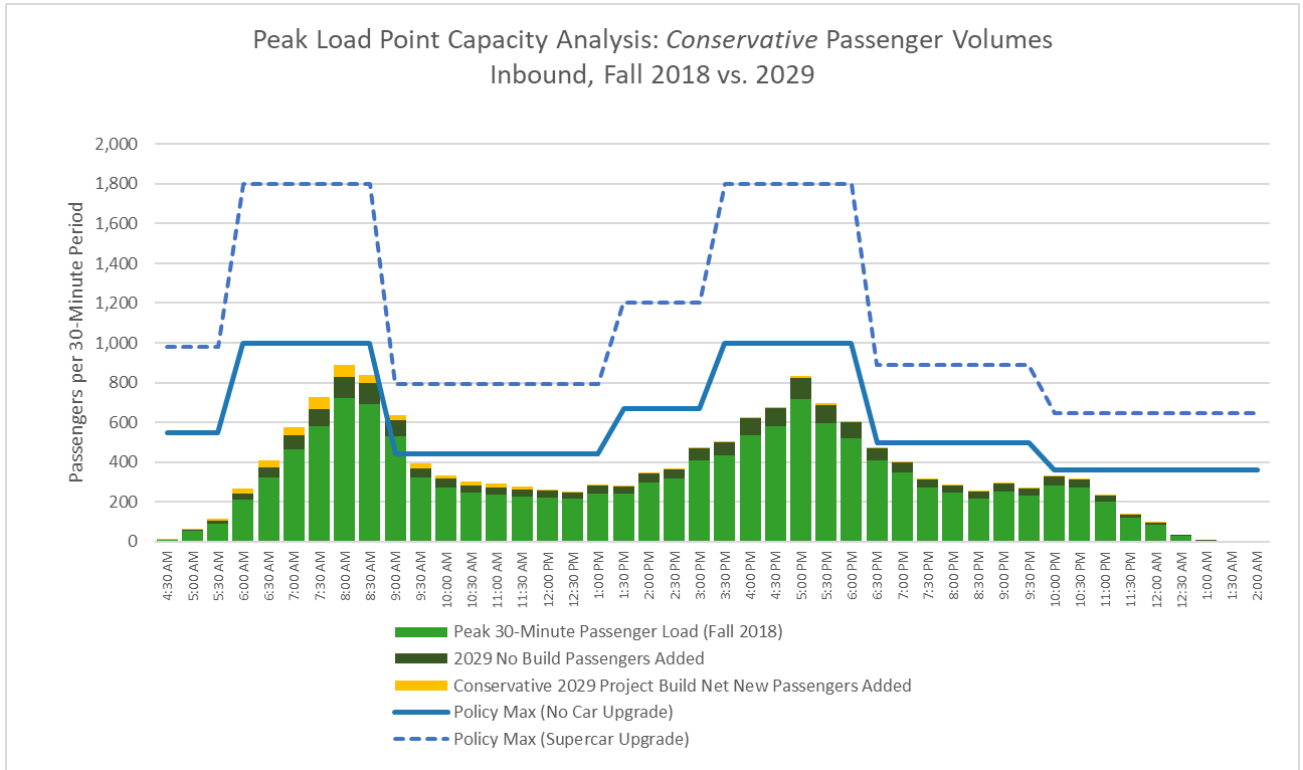
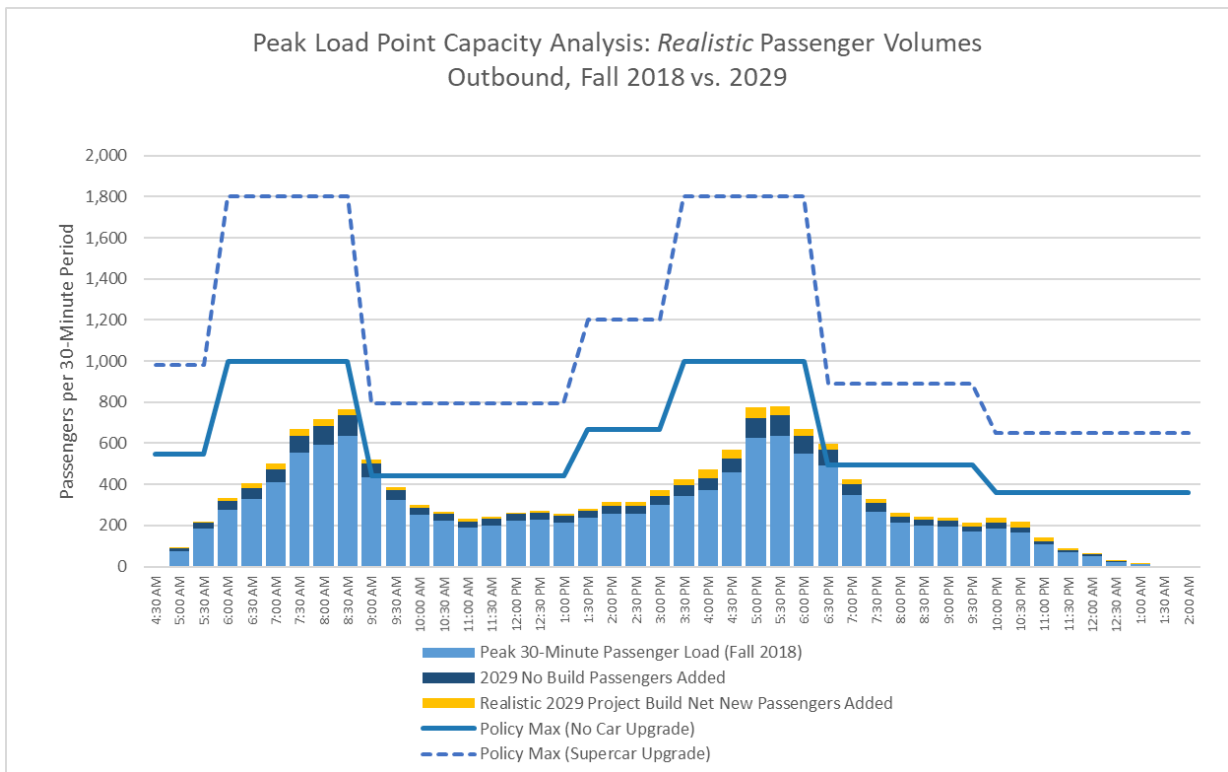
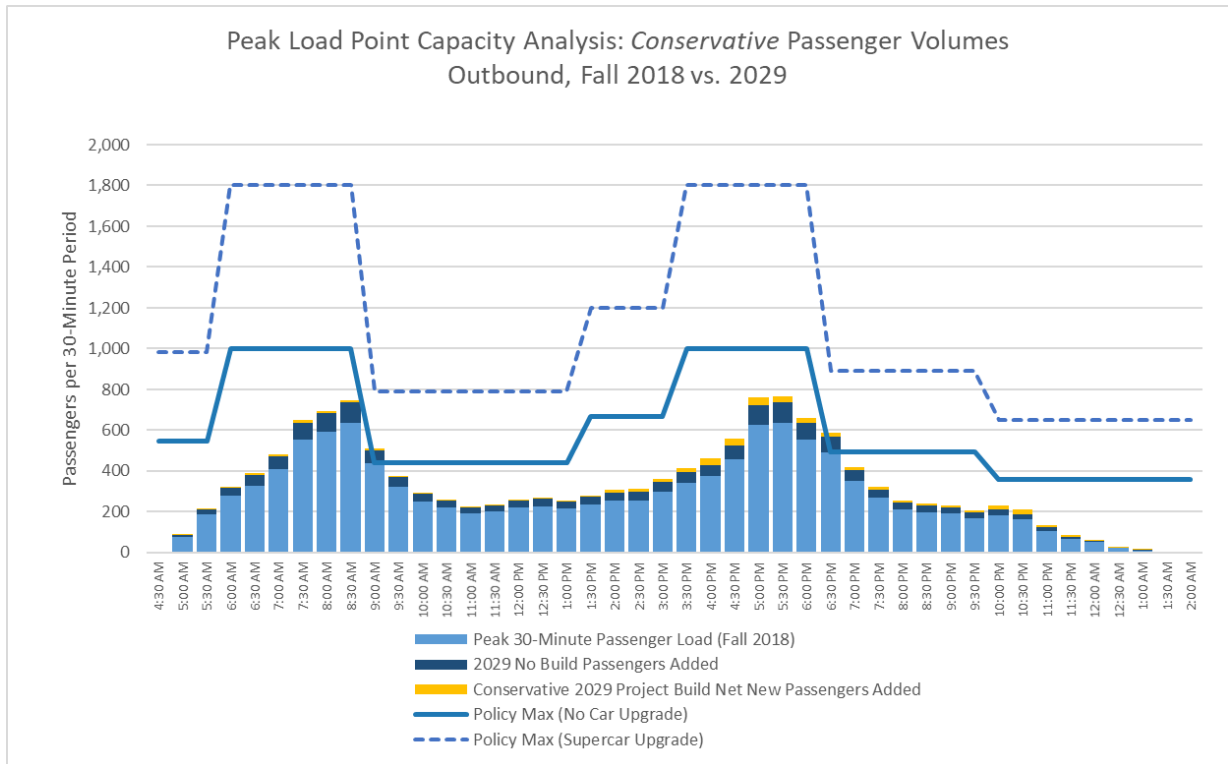


Figure Outbound Green Line Service: Average Peak Load Point Capacity Analysis, Future Condition, Under Two Growth Scenarios



Future Transit Capacity Analysis: MBTA Route 558

The charts below illustrate the expected future passenger loads relative to the expected transit service capacity for the Route 558 bus. Both project-generated transit trips under a *conservative* and a *realistic* scenario is presented.

At future ridership levels and expected service levels, the MBTA Route 558 bus service is expected to be in compliance with the MBTA's policy capacity thresholds.

Route 558 Passenger Loads vs. Policy Capacity

