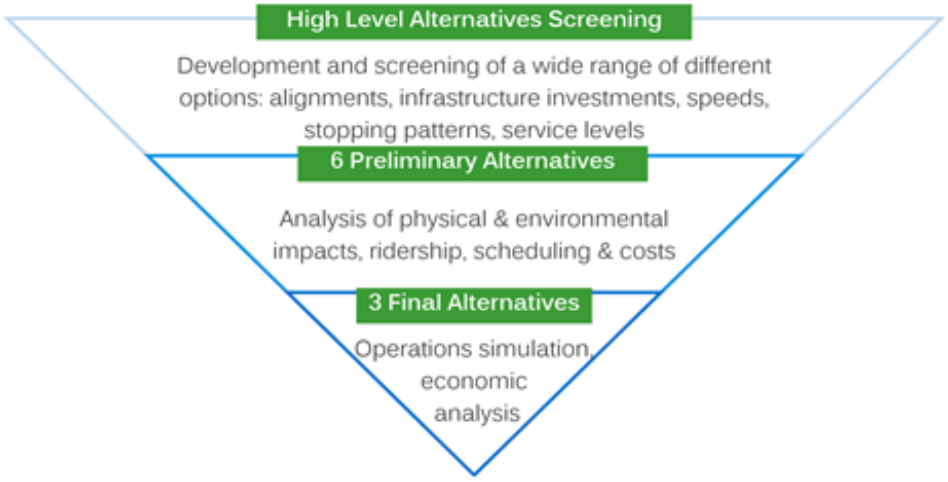
4. Alternatives Development and Analysis

The alternatives analysis is the central component of the study's technical analysis. As seen in Figure 4-1, the process begins with the development of the universe of alternatives, followed by a screening to identify six Preliminary Alternatives, an evaluation of those alternatives, and a refined re-evaluation of the three Final Alternatives to determine the study's findings. The Preliminary and Final Alternatives are designed to address the study's goals and are assessed based on a set of evaluation criteria that reflect its objectives.

Figure 4-1 – Study Process & Overview



4.1. Guiding Principles and Universe of Alternatives

The study's Preliminary Alternatives were developed to provide a representative range of different options for potential passenger rail service that connects communities along the East-West Corridor, spanning the full spectrum of speed, service, infrastructure, cost, and impacts. To achieve this, different options for the various infrastructure and service parameters were assembled in such a way that they balanced the key objectives that the alternatives are intended to deliver, which are outlined below. Many of these objectives are in tension with each other, or even in direct conflict.

Ridership Enhancing

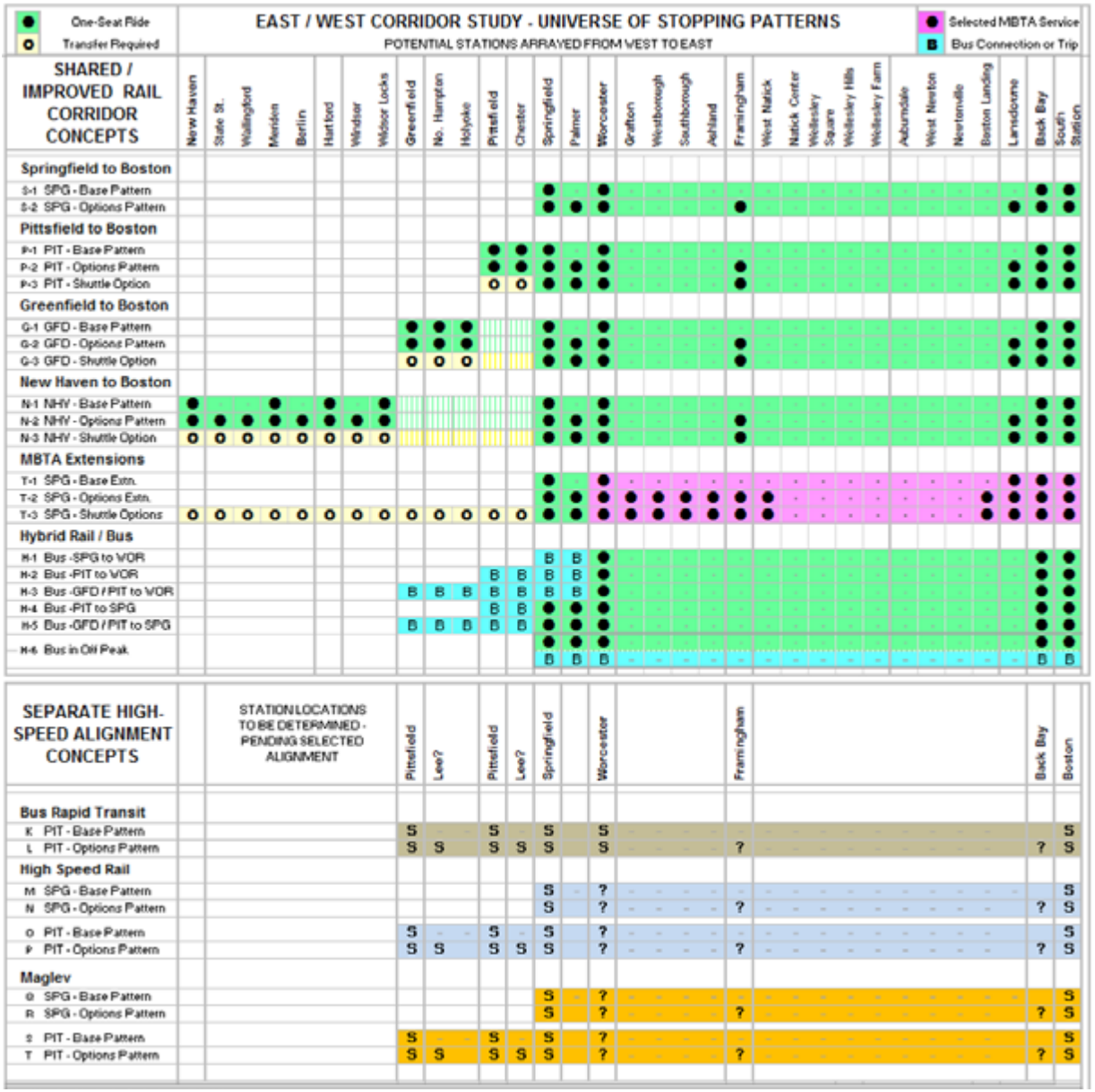
- **Maximize travel speeds/minimize travel time**
  - Minimize rail alignment curvature and grades
  - Enhance railroad infrastructure and speeds operated
  - Minimize interference between passenger and freight
  - Minimize number of station stops
- **Maximize service quality**
  - Maximize direct rail service to East – West Corridor communities
  - Minimize required transfers
  - Maximize train frequency

Ridership Dampening

- **Minimize cost**
  - Use existing infrastructure and property
  - Minimize new capital investment
  - Minimize number of new stations
  - Minimize frequency
- **Minimize environmental and community impacts**
  - Use existing infrastructure and property
  - Minimize new infrastructure
  - Minimize use of new alignments

To develop the universe of potential alternatives for passenger rail service along the East-West Corridor, a multi-layered approach was used, with different classes of alternatives defined first by the corridor type used, then by technology or mode employed, followed by major markets served, and finally service or stop pattern. This hierarchical or nested approach is conceptualized in Figure 4-2, and described in greater detail in the following section.

Figure 4-2 – Universe of Alternatives Considered



1. **Corridor Type:** Existing Shared Corridor (Upgrade Existing Shared Passenger-Freight Track or Build New Passenger-Only Track) and Separate Corridor
2. **Technology / Mode:** Conventional Rail, High Speed Rail, Maglev, Hybrid Rail-Bus, and Bus Rapid Transit
3. **Major Markets Served:** Springfield – Boston, Pittsfield – Boston, Greenfield – Boston, New Haven – Boston, Existing MBTA Commuter Rail Worcester Line Stations
4. **Service Pattern:** Base (Major Markets), Options (All Corridor Stations), and Shuttle (All Corridor Stations with Extensions West of Springfield)

Although one subset of alternatives explored new service stopping at all MBTA Commuter Rail stations served by Worcester-based trains, each of the Preliminary Alternatives proposes intercity service that would operate over long distances with limited stops, such as Amtrak's Northeast Regional or its high speed Acela Express Service.

4.2. Alternatives Development

This section describes the study's general approach to identifying the Preliminary Alternatives for further study and evaluation. To develop the alternatives, it is necessary to define the key parameters that will determine the defining characteristics for the Preliminary Alternatives and serve as differentiating features for assessing each alternative's benefits, costs, and impacts. These key parameters comprise the following elements:

- Infrastructure Elements
  - Corridor Type
  - Infrastructure Improvements
  - Corridor Constraints
  - Potential Speeds
- Service Elements
  - Extent of Rail Service
  - Stations Served
  - Frequency

Corridor Type. Two central parameters that help to determine many of the other corridor characteristics are the corridor's alignment and the configuration of the rail line within that alignment. As summarized in Table 4-1 on the next page, this study evaluated three main approaches to defining the future passenger rail service's corridor and alignment, providing a critical framework for the development of alternatives.

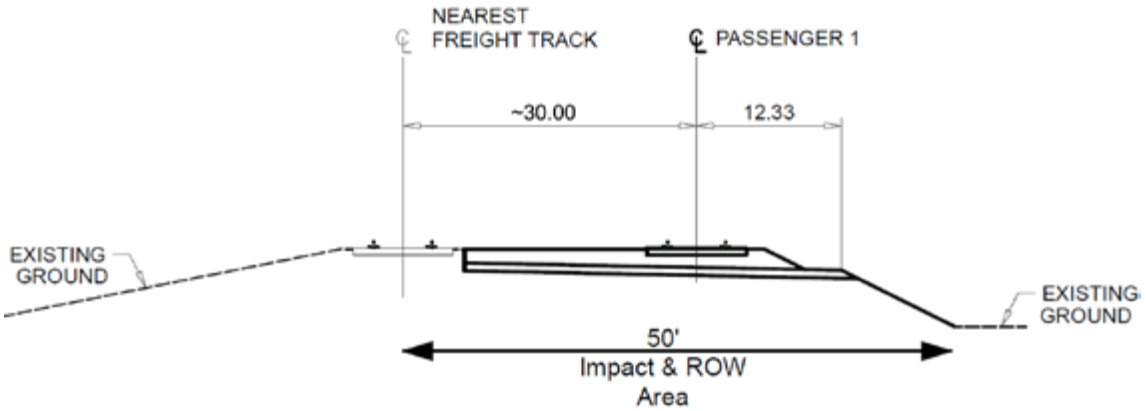
- **Shared Track and Corridor.** The most straightforward alignment approach is one in which the new passenger service traverses the existing Boston – Albany mainline rail corridor on the same tracks that are used by freight trains. Under this alignment approach, the new passenger service could be the easiest to implement and require the lowest capital investment as it would utilize the existing right-of-way. This corridor would, however, be limited by the existing rail layout's geometry and infrastructure. Operations would also be constrained by the presence of freight traffic, which would take precedence over passenger trains. While the least physically-involved, this approach could result in the longest travel times. Because the rail line is privately-owned west of Worcester, it would require careful coordination with CSX Transportation, the owner and operator of the tracks. For context, this shared corridor/shared track approach was utilized within NNEIRI's preferred alternative.
- **Separated Track in a Shared Corridor.** The next level of corridor alignment improvement would entail a new, separate rail alignment and track within the existing rail corridor. In this alignment approach, the passenger service could operate on a new passenger-only single track between Springfield and Worcester that remains primarily within the existing CSX-owned right-of-way.

Table 4-1 – Corridor Characteristics of Potential Alternatives

CORRIDOR TYPE / ALIGNMENT	SPRINGFIELD – WORCESTER SEGMENT	PROS	CONS
SHARED CORRIDOR / EXISTING ALIGNMENT	Runs along the existing CSX corridor, sharing the same tracks used by freight trains. Restores full double-track operation	• Easiest to implement • Lowest capital cost	• Contending with freight traffic • Existing infrastructure • Existing geometry
SHARED CORRIDOR / SEPARATE ALIGNMENT	Remains primarily within CSX-owned ROW, but uses a new passenger-only track where feasible that can also feature key realignments	• Higher speeds • Much lower operational impacts relative to the entirely new alignment and corridor	• Overall corridor geometry still limits maximum speeds • Additional ROW and capital costs required
SEPARATE CORRIDOR / NEW ALIGNMENT	Parallels the I-90 ROW, deviating back to existing corridor only to serve downtown rail stations	• Highest speeds • No interference to existing railroad usage	• Highest capital cost • Most ROW and community impacts

The new rail layout could enable the passenger trains to operate separately from freight trains and to achieve higher speeds and faster travel times. However, maximum operating speeds would still be constrained by the overall geometry of the historic corridor, which winds through river valleys and was laid out in the early 19th century. This approach is only feasible between Springfield and Worcester, and would entail significant infrastructure investment. Between Pittsfield and Springfield, the CSX-owned right-of-way is significantly narrower, and more constrained by steep topography and environmentally sensitive natural features such as major sections of the Westfield River. Between Worcester and Boston, the rail corridor is narrower and much more constrained by private property and buildings; a separate rail alignment is also not feasible in this segment. Between Springfield and Worcester, it is also feasible to construct the new track alignments to straighten the tightest curves and further reduce travel times through sustained high-speed operations. Figure 4-3 provides a typical cross section showing the location of the separate track(s) from the existing freight tracks.

Figure 4-3 – Typical Cross Section for Separated Track in a Shared Corridor



- **New Track Alignment in a Separate Corridor.** The Boston – Albany rail mainline's overall corridor alignment and geometry are not compatible with very high-speed passenger service. Therefore, a high-speed rail service would require a fully-separated corridor that utilizes an entirely new alignment. The I-90 corridor was the only feasible corridor identified that would enable the connections required and allow a straighter alignment with significantly higher speeds, while limiting the environmental and community impacts relative to those that would be associated with a new high-speed rail alignment in the East – West Corridor. It should be noted that this approach would still have much higher capital cost and much greater environmental and property impacts than any of the alternatives that make use of the existing rail corridor.

Infrastructure Improvements. The different approaches to the overall corridor and railroad alignment for the Preliminary Alternatives entail different types of infrastructure improvements.

- **Track Improvements.** Improvements to the existing railroad infrastructure to comply with federal standards and permit higher speeds. New track construction would also meet the higher speed standards.
- **Double-Track Restoration.** Historically, the Boston – Albany mainline provided a minimum of two continuous railroad tracks. However, as the infrastructure aged and rail traffic decreased, some segments of second track were removed to save on both capital and maintenance costs. These missing double-track segments would need to be restored for any of the alternatives that would provide service on a shared track configuration.
- **New Railroad Alignment.** Preliminary Alternatives that do not rely upon existing tracks would require new track construction. This may be parallel to the rail line within the CSX-owned corridor; on a new, straighter rail alignment outside the CSX-owned corridor; or on an entirely new rail alignment in the I-90 corridor.
- **Other Infrastructure Investments.** The Preliminary Alternatives also entail other improvements needed to support operation of the rail service.
  - **Train Control/Signal Systems.** Federal regulations require use of a compliant train control/signal system to operate trains at the speeds identified in any of the alternatives. Depending on whether existing or new rail alignments are used, the Preliminary Alternatives would provide upgraded or new train control/signal systems between Pittsfield and Boston. This would include improvements to warning devices at highway-rail grade crossings as well as at interlockings (specialized rail facilities that allow controlled train movements to cross from one track to another). The extent and location of additional signal improvements would be based on planned freight and passenger train frequencies and changes in operating speed. Full signalization systems would need to be installed in any segments with new passenger tracks. All signal systems would need to provide Positive Train Control (PTC), as required by federal law.
  - **Layover and Maintenance Facility.** Train operations require facilities for train storage, safety inspections, restocking, and light maintenance, as well as facilities for train crews: briefing rooms, locker rooms, and break rooms, etc. Each of the Preliminary Alternatives is assumed to require (and include) construction of a new layover and maintenance facility near Springfield and/or Pittsfield. Existing or expanded facilities at Boston are assumed to be adequate to meet East-West train servicing needs. Tracks would need to be configured long enough to accommodate the new layovers. New facilities, including the addition of switches, lighting, access aisles,

ground power (480v), water stations, inspection, servicing, fueling and sanding facilities, staff support building(s), parking and security facilities, etc., would also be necessary.

- **Electrification of Routes.** The operations analysis for each scenario considered the use of electric locomotives for propulsion in lieu of diesel-electric locomotives that now operate on the East-West Corridor. Their use was not required to achieve the planned travel times except for High-Speed Scenario #2. Nevertheless, recognizing the environmental and social benefits electrification offers, electrification over the Boston-Worcester rail section owned by the Commonwealth or over the Worcester-Springfield section in scenarios where independent passenger tracks are constructed is not precluded. CSX policy guidance will not permit electrification of the Springfield-Pittsfield section.

Corridor Constraints. The overall corridor approach (shared rail corridor vs. separate corridor, shared rail line vs. separate rail line) strongly influences the geometric constraints and property impacts that would be associated with each alternative. As discussed in Section 3, the Boston – Albany rail mainline has different basic characteristics and constraints in its three distinct segments: the Pittsfield – Springfield segment has the greatest geometric and topographic challenges; the Springfield – Worcester segment has more moderate horizontal and vertical curvature challenges; and the fully double-tracked Worcester – Boston segment currently has the least challenging rail alignment due to the most moderate topography and significant investments to improve the geometry and infrastructure made over many years to support the high level of passenger service currently offered. Study alternatives that add new track segments to the existing rail corridor (i.e. through the restoration of double-track or the creation of new rail alignments or new sidings) may result in impacts to property, environmental, and community resources. The I-90 corridor provides a straighter alignment than the existing rail corridor, but would entail greater property impacts, especially at “transition” segments where the new service migrates between the I-90 corridor and existing rail stations in downtown Springfield and Worcester.

Travel Speeds. Attaining higher travel speeds and lower travel times for the East – West Passenger Rail service is a key pursuit within the study, and is therefore a key parameter for developing the Preliminary Alternatives. The travel speeds that could be attainable for a given alternative are closely related to the corridor type and corridor constraints. To understand the range of potential passenger rail speeds for the alternatives, different corridor scenarios were evaluated for their impact on maximum and lower average speeds that ultimately determine the travel time, as summarized in Table 4-2 on the following page.

- The **Base Speed Scenario** assumes no modifications to geometry or infrastructure conditions, with maximum passenger train speeds of 60 mph (Federal Railroad Administration (FRA) Class 3) west of Worcester. In this scenario, the service could operate like a typical passenger train sharing the railroad corridor with freight trains.
- The **Medium Speed Scenario** could enable significant speed increases while still relying on existing corridor geometry. Although geometry would remain unchanged and the service could continue to rely on a shared corridor, maximum speeds could rise to 80 or 90 mph (FRA Class 4 or 5) via significant infrastructure upgrades. These adjustments could allow for an increase in the degree of superelevation and unbalance permitted as trains pass through horizontal curves, and a decrease in the number of non-geometric speed restrictions.

Table 4-2 – Speed Characteristics of Potential Alternatives

SPEED SCENARIO	CORRIDOR TYPE / ALIGNMENT	MAXIMUM PASSENGER TRAIN SPEED (*)	REQUIRED FRA TRACK CLASS	SOURCE OF SPEED IMPROVEMENTS
BASE	Shared Corridor / Existing Alignment	60 mph 80 mph	Class 3 Class 4	• Existing Pittsfield to Worcester • Existing Worcester to Boston
MEDIUM	Shared Corridor / Existing Alignment	80 / 90 mph	Class 4 / 5	• Reduction in non-geometric/signal speed restrictions • Increased superelevation and unbalance
HIGH #1	Shared Corridor / Separate Alignment	110 mph	Class 6	• Elimination of non-geometric/signal speed restrictions • Significant realignment of horizontal curves (vertical grades maintained)
HIGH #2	Separate Corridor / New Alignment	160 mph	Class 8	• Elimination of non-geometric/signal speed restrictions • Corridor-wide electrification and the use of electric trainsets

- **High-Speed Scenario #1** requires a new separate passenger-only track running adjacent to the existing corridor, along with significant realignment of sharp horizontal curves, to achieve maximum speeds of 110 mph (FRA Class 6).
- **High-Speed Scenario #2** requires a new rail corridor adjacent to the I-90 ROW, which has fewer horizontal curves than the existing railroad, to realize maximum speeds of 160 mph. Since modern diesel trainsets cannot operate faster than approximately 125 mph, this highest speed scenario would require electrification of the entire corridor.
- **High-Speed Scenario #2** requires a new rail corridor adjacent to the I-90 ROW, which has fewer horizontal curves than the existing railroad, to realize maximum speeds of 160 mph. Since modern diesel trainsets cannot operate faster than approximately 125 mph, this highest speed scenario would require electrification of the entire corridor.

The travel times for the Preliminary Alternatives are based upon the construction of detailed train schedules that "fit" East – West trains into available schedule "slots" that reflect existing passenger and freight operations. These detailed operations plans modelled operating speeds for East – West trains taking into account acceleration/deceleration rates and maximum speed capabilities of actual high-speed locomotive and car designs and considering each Preliminary Alternative's modifications to horizontal and vertical track alignment to reflect maximum and restricted speed areas. Schedules for the new passenger service are also planned to offer convenient arrival and departure times for commuters reporting to employment sites located in the major East – West Corridor cities.

Extent of Rail Service. A key characteristic of the Preliminary Alternatives is the extent of the coverage of rail service within the East – West Corridor. Given the study's purpose and need, the corridor geography, and the high population of the Springfield metropolitan area, it was assumed that new rail service would be uniformly provided between Springfield and Worcester. Population along the corridor west

of Springfield is significantly lower, and corridor constraints are generally greater. In order to evaluate the benefits relative to the costs of providing rail service, some of the Preliminary Alternatives provide rail service in the western segment of the corridor, while others provide enhanced bus service with connections to rail service in Springfield.

Stations Served. A critical service parameter is the number and location of station stops. While more stops would provide a greater level of access to the new service, end-to-end travel times would increase. On many rail corridors, express service is necessary to take advantage of higher operating speeds and maximize the efficiency of train services. The station stops designated for the Preliminary Alternatives were evaluated relative to population, geography, existing and proposed intermodal connections, and commercial activity. The following existing stations are included in all Preliminary Alternatives: Pittsfield (Joseph Scelsi Intermodal Transportation Center), Springfield (Union Station), Worcester (Union Station), and Boston (Lansdowne, Back Bay, and South Station). These stations serve the major markets along the East – West Corridor and could be able to attract the highest number of potential riders. Other stations considered for inclusion in the Preliminary Alternatives are potential new stations along the existing rail corridor at Chester and Palmer, and new stations along the I-90 corridor in Lee and Blandford, which would be served by some of the Preliminary Alternatives. New stations in Chester and Palmer were included in the analysis as a result of local and regional advocacy efforts, as well as Palmer's previous inclusion within the NNEIRI study. New stations at existing interchanges along the I-90 corridor were selected to serve a similar set of communities while balancing stop spacing between Pittsfield and Springfield. The determination to include or not include the additional stations was to evaluate the travel time benefits and ridership changes to the overall service with or without the station stops.

Service Frequency. Service frequency is a critical determinant of an alternative's capacity to carry passengers and the convenience of the service's schedule. Frequency for the alternatives and for individual stations would vary based on the level of capital investment in rolling stock, anticipated demand, travel times, stopping patterns, and transfer patterns. The service frequency provided was aimed to optimize ridership by taking advantage of the scale of capital investments and infrastructure improvements. Alternatives with lower capital cost investment and infrastructure improvements that are limited to the upgrades of the existing tracks would operate with lower service frequency, while alternatives with higher capital investments and infrastructure improvements that include track realignment or new track construction would be able to operate at faster speeds and higher frequency.

4.3. Preliminary Alternatives

This section describes each Preliminary Alternative and provides a summary graphic of the infrastructure improvements, scheduled speeds, and extent of service proposed. Table 4-3 and Table 4-4 on the following pages provide an overview of each alternative's service characteristics, including frequency, travel times, speeds, and other important metrics. Three of the evaluated Alternatives include portions of the route being served through complementary connecting bus service, similar to many other corridor services in the nation. The bus schedules were designed to provide convenient connections to each train and could operate in a dedicated service to ensure the connecting bus was always present in the event of off-schedule train operations.

Table 4-3 – Passenger Rail Service Characteristics (Preliminary Alternatives)

METRIC /	ALTERNATIVE	NO-BUILD	1	2	3	4	5	6
CORRIDOR TYPE	ALIGNMENT	SHARED + EXISTING	SHARED + EXISTING	SHARED + EXISTING	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE	SEPARATE + NEW
FREQUENCY	RAIL ROUND TRIPS	1	5	7	8	10	10	18
SPEEDS	MAX. PERMITTED (MPH)	80	80	80	90	110	110	150
TRAVEL TIMES RANGE +	PITTSFIELD – BOSTON	3:50	3:55 – 4:10	3:35 – 3:50	3:05 – 3:20	2:55 – 3:10	2:55 – 3:10	2:15 – 2:30
TRAVEL TIMES RANGE +	SPRINGFIELD – BOSTON	2:28	2:40 – 2:55	2:10 – 2:25	1:50 – 2:05	1:40 – 1:55	1:30 – 1:45	1:15 – 1:30
EAST-WEST STATIONS ++	PITTSFIELD	√	(Bus)	(Bus)	√	√	(Bus)	√
EAST-WEST STATIONS ++	LEE	-	(Bus)	(Bus)	-	-	(Bus)	√
EAST-WEST STATIONS ++	CHESTER	-	-	-	√	√	-	-
EAST-WEST STATIONS ++	BLANDFORD	-	(Bus)	(Bus)	-	-	(Bus)	√
EAST-WEST STATIONS ++	SPRINGFIELD	√	√	√	√	√	√	√
EAST-WEST STATIONS ++	PALMER		√	√	√	√	-	√
EAST-WEST STATIONS ++	WORCESTER	√	√	√	√	√	√	√
EAST-WEST STATIONS ++	LANSDOWNE	√	√	√	√	√	√	√
EAST-WEST STATIONS ++	BACK BAY	√	√	√	√	√	√	√
EAST-WEST STATIONS ++	SOUTH STATION	√	√	√	√	√	√	√
TRANSFERS	PITTSFIELD	Direct Rail	Bus Transfer at SPG	Bus Transfer at SPG	Direct Rail	Direct Rail	Bus Transfer at SPG	Direct Rail
TRANSFERS	SPRINGFIELD	Direct Rail	Rail Transfer at WOR	Direct Rail	Direct Rail	Direct Rail	Direct Rail	Direct Rail
TRANSFERS	CTrail HARTFORD LINE / AMTRAK VERMONTER	Rail Transfer at SPG	Rail Transfer at SPG	Rail Transfer at SPG	Rail Transfer at SPG	Rail Transfer at SPG	Rail Transfer at SPG	Rail Transfer at SPG

+ SCHEDULED TRAVEL TIMES RANGE

++ RAIL STATIONS SERVED BY EAST-WEST TRAINS

Table 4-4 – Operations, Equipment, Fleet & Maintenance Characteristics (Preliminary Alternatives)

METRIC /	ALTERNATIVE	NO-BUILD	1	2	3	4	5	6
CORRIDOR TYPE	ALIGNMENT	SHARED + EXISTING	SHARED + EXISTING	SHARED + EXISTING	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE	SEPARATE + NEW
FREQUENCY	TRAIN ROUND TRIPS	1	5	7	8	10	10	18
FREQUENCY	BUS ROUND TRIPS	0	4	4	0	0	11	0
AVERAGE SPEED (MPH)	PITTSFIELD-BOSTON	39.3	37.4	41.3	47.8	50.5	50.1	65.2
AVERAGE SPEED (MPH)	SPRINGFIELD-BOSTON	39.9	35.5	44.0	50.4	55.1	62.7	74.3
TRAVEL TIME (BOSTON) +	PITTSFIELD	3:50	4:02	3:39	3:09	2:59	3:00	2:18
TRAVEL TIME (BOSTON) +	LEE	-	3:27	3:04	-	-	2:25	2:04
TRAVEL TIME (BOSTON) +	CHESTER	-	-	-	2:38	2:28	-	-
TRAVEL TIME (BOSTON) +	BLANDFORD	-	3:07	2:44	-	-	2:05	1:47
TRAVEL TIME (BOSTON) +	SPRINGFIELD	2:28	2:46	2:14	1:57	1:47	1:34	1:19
TRAVEL TIME (BOSTON) +	PALMER	-	2:27	1:55	1:40	1:31	-	1:03
TRAVEL TIME (BOSTON) +	WORCESTER	1:15	1:21	1:03	0:53	0:53	0:53	0:44
EQUIPMENT ASSUMPTIONS	TRAINSETS	2	3	5	7	8	5	10
EQUIPMENT ASSUMPTIONS	TRAINSET TYPE	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Electric
EQUIPMENT ASSUMPTIONS	BUSES	0	2	2	0	0	3	0
FLEET REQUIREMENTS	TOTAL RAIL CARS	8	11	31	31	35	22	44
FLEET REQUIREMENTS	TOTAL BUSES	0	2	3	0	0	4	0
DAILY REVENUE MILES	TRAIN MILES	400	832	1,400	2,196	2,588	2,164	4,804
DAILY REVENUE MILES	RAIL CAR MILES	3,600	4,160	10,000	12,278	14,540	10,820	25,620
DAILY REVENUE MILES	BUS MILES	0	848	624	0	0	2,200	0
LAYOVER ++	PITTSFIELD	0	0	0	3	3	0	5
LAYOVER ++	SPRINGFIELD	0	1	1	0	1	2	0
LAYOVER ++	BOSTON	1	0	3	3	3	2	4

+ SCHEDULED TRAVEL TIMES TO/FROM BOSTON (AVERAGE)
++ OVERNIGHT LAYOVER LOCATION (TRACKS)

Alternative 1: Passenger Rail, Springfield – Worcester, on Upgraded Existing Railroad Tracks (Bus Service West of Springfield)

Alternative 1 represents the lowest capital cost concept studied and would make track and signal improvements to introduce a new direct passenger rail service between Springfield and Worcester along the shared corridor, with an intermediate stop in Palmer. Passengers would be required to transfer between the new passenger service and existing MBTA Framingham / Worcester Line trains at Worcester's Union Station. A new bus service would enable passengers located near Pittsfield, Lee, and Blandford to connect with rail services in Springfield and Worcester, as shown in Figure 4-4 on the next page.

Alternatives 1 would restore three missing double-track segments; develop a new passing siding near the Spencer-East Brookfield border; and upgrade signal systems along the Springfield to Worcester segment. These enhancements would effectively increase the amount of operating space within this shared passenger-freight corridor.

Alternative 1 rail service would comprise up to four new weekday rail round trips between Springfield and Worcester. Connecting with the existing Heart to Hub MBTA Commuter Rail express service would produce one weekday round trip with Pittsfield to Boston travel times similar to existing Amtrak Lake Shore Limited operations. However, for the other three round trips, the need to transfer trains at Worcester Union Station, coupled with serving local stops along the MBTA Worcester Line, would produce a service that, on average, takes 15 minutes longer than the Lake Shore Limited between Springfield and South Station (2:46).

The rail service would be supplemented by up to four weekday round trip bus connections that allow customers coming to and from existing bus stops located in Pittsfield (Joseph Scelsi Intermodal Transportation Center) and Lee (Premium Outlets), as well as a new bus stop near the I-90 Blandford Service Plaza, to connect with rail services in Springfield and Worcester.

Alternative 2: Passenger Rail, Springfield – Boston, on Upgraded Existing Railroad Tracks (Bus Service West of Springfield)

Alternative 2 would utilize the same set of infrastructure and signal improvements included in Alternative 1 to provide a new direct passenger rail service along the shared corridor between Springfield and Boston (South Station), with intermediate stops in Palmer, Worcester, and Boston (Lansdowne and Back Bay). The service would utilize extensions of selected existing MBTA trains to Springfield which was considered the maximum realistic distance a commuter-type train could be extended to. To complement the up to six new weekday rail round trips, passengers coming to or from markets west of Springfield would use up to four new bus round trips serving Pittsfield, Lee, Blandford, and Springfield, as seen in Figure 4-5 on page 47.

Since the corridor's existing alignment and its track classification would remain unchanged in both Alternatives 1 and 2, maximum permitted speeds would remain at existing levels. Nevertheless, the improvements between Springfield and Worcester, when coupled with removing the transfer at Worcester, would save 15 minutes for trips between Springfield and South Station (2:14) relative to existing Lake Shore Limited travel time. Capitalizing on the improvements to the central segment, trips between Pittsfield and South Station would be approximately 10 minutes faster (3:39).

Figure 4-4 – Alternative 1 – Passenger Rail, Springfield – Worcester, on Upgraded Existing Railroad Tracks (Bus Service West of Springfield)

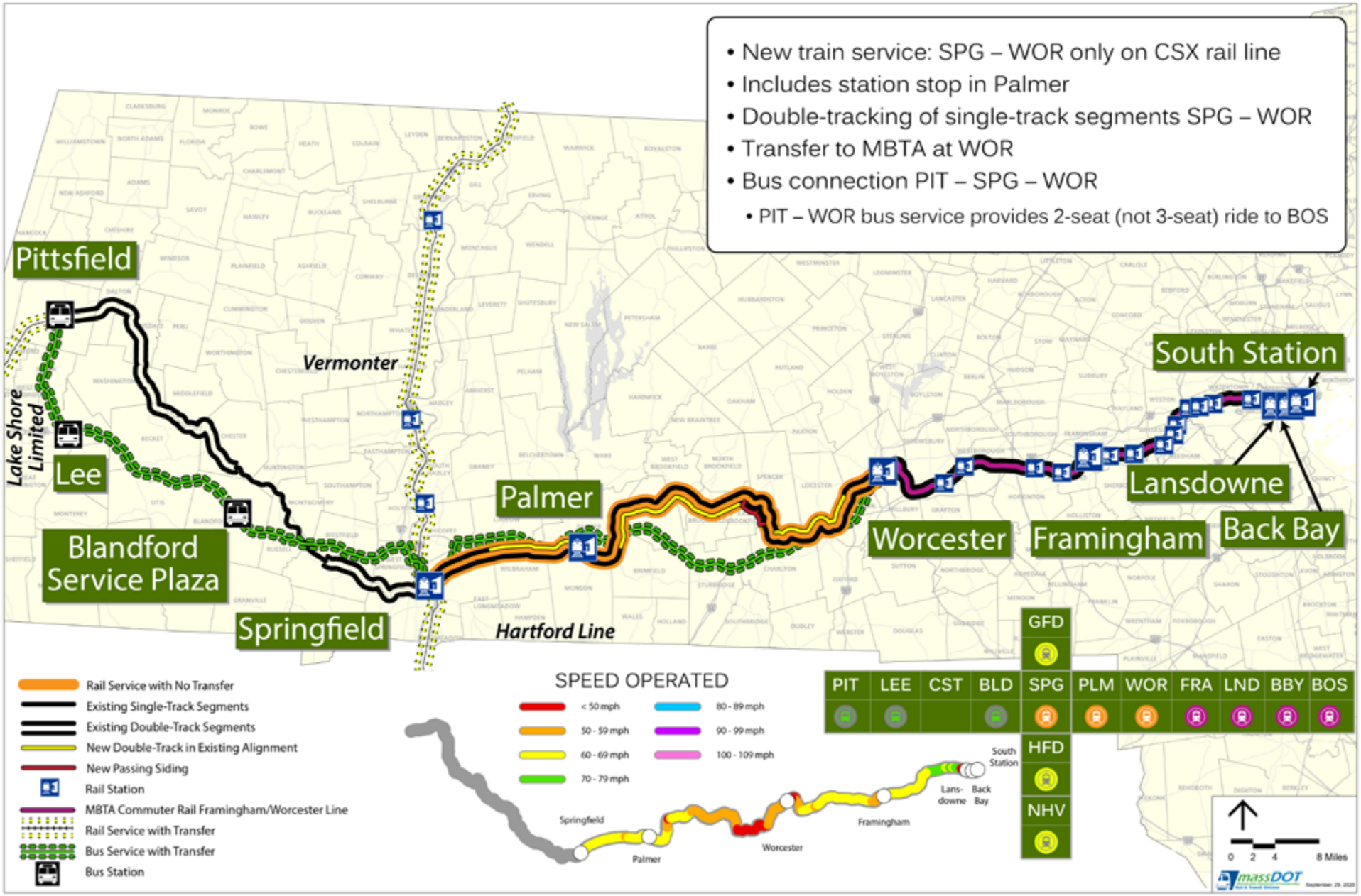
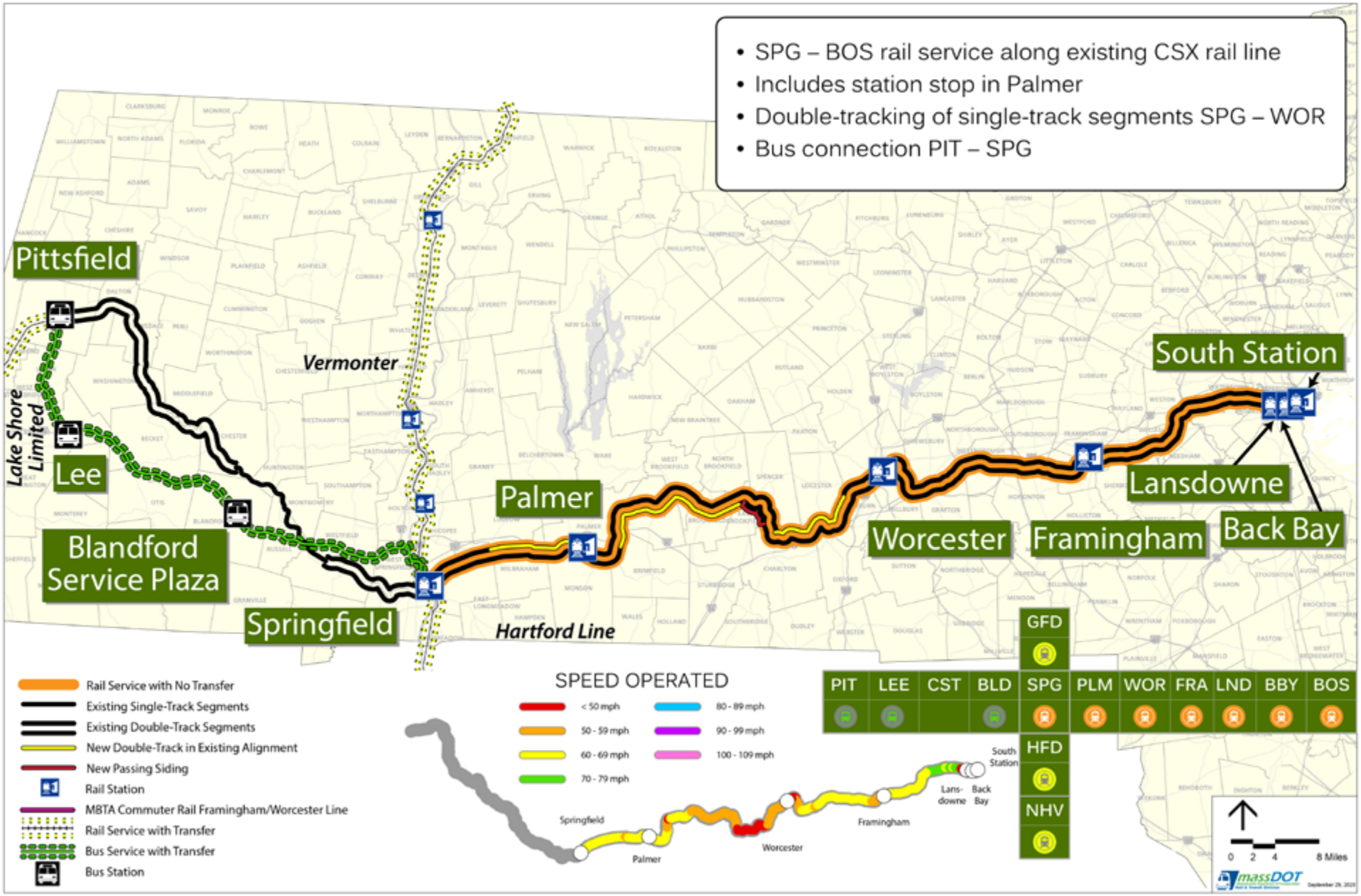


Figure 4-5 – Alternative 2 – Passenger Rail, Springfield – Boston, on Upgraded Existing Railroad Tracks (Bus Service West of Springfield)



Alternative 3: Passenger Rail, Pittsfield – Boston, on Upgraded Existing Railroad Tracks

Alternative 3 would provide a new direct passenger rail service along the shared corridor between Pittsfield and Boston (South Station), with intermediate stops in Chester, Springfield, Palmer, Worcester, and Boston (Lansdowne and Back Bay). As indicated in Figure 4-6 on the following page, the service would include up to seven new weekday rail round trips between Pittsfield and South Station, with service provided at every rail station along the existing corridor.

Between Pittsfield and Springfield, Alternative 3 would restore the missing double-track segment and upgrade signals to increase maximum permitted speeds from 50 to 70 mph west of Springfield in some sections. Relative to existing conditions, these improvements would save 10 minutes for journeys along the western segment.

In addition to incorporating the infrastructure and signal improvements proposed in Alternatives 1 and 2, Alternative 3 would increase maximum permitted speeds between Springfield and Worcester by making significant rail upgrades along the full central segment. This would raise the minimum track classification from Class 3 (with a limit of 60 mph for passenger operations) to either Class 4 (80 mph) or Class 5 (90 mph). Relative to Alternative 2, the addition of these track upgrades would produce a roughly 5-minute travel time savings for trips between Springfield and Worcester (10 minutes relative to existing conditions), with typical travel times along the central segment near an hour (1:04). The use of track classifications to describe the speed capability of the line segment is based upon the minimum class needed to comply with the regulations and is not intended to imply the actual maintenance standards CSX or the MBTA apply to the route. While specific asset conditions were not available for this study, it is assumed the entire route is well-maintained in excess of the minimum Track Class standards needed to operate at the posted speeds.

When taken together, Alternative 3's improvements along the three segments would produce a roughly 40-minute end-to-end travel time savings relative to existing conditions (3:09). The savings of 35 minutes between Springfield and Boston would reduce travel times to below two hours (1:57).

Alternative 4: Passenger Rail, Pittsfield – Boston: Upgraded Existing Rail (PIT – SPG), New Rail in CSX Corridor (SPG – WOR)

Alternative 4 would offer a new direct passenger rail service between Pittsfield and Boston (South Station), with intermediate stops in Chester, Springfield, Palmer, Worcester, and Boston (Lansdowne and Back Bay). Beyond Alternative 3's improvements along the western segment, Alternative 4 could enable faster travel times through the construction of a new passenger-only track between Springfield and Worcester within the CSX-owned rail corridor, but offset from the existing railroad alignment, as shown in dark red within Figure 4-7 on page 50.

This exclusive track would provide speed and reliability benefits by separating passenger trains from freight movements along the CSX mainline. It would enable higher maximum permitted speeds, with construction of the new track designed for FRA Track Class 6 (110 mph). Three new passing sidings, each providing 3,000 feet of tangent track and spaced roughly 15 miles apart, would be installed along the south side to enable efficient train scheduling and safe passing of trains traveling in opposite directions. Extending the separate passenger track west of Springfield was evaluated and determined not feasible. The mountainous topography and significant sections of the route being located within environmentally sensitive lands effectively prevents construction along a separated alignment. Therefore, Alternative 4 assumes the same infrastructure improvements between Springfield and Pittsfield identified for Alternative 3.

Figure 4-6 – Alternative 3 – Passenger Rail, Pittsfield – Boston, on Upgraded Existing Railroad Tracks

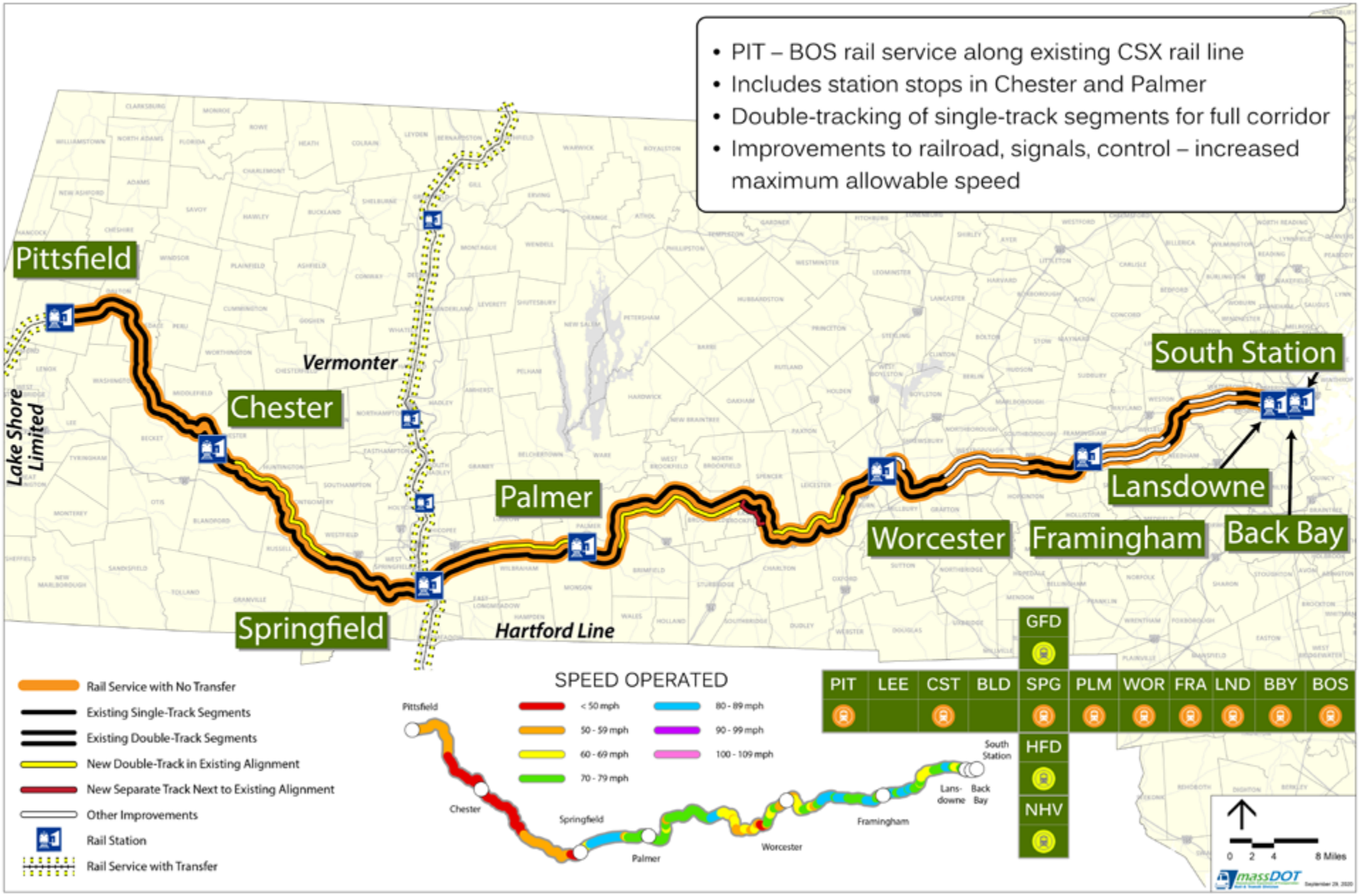


Figure 4-7 – Alternative 4 – Passenger Rail, Pittsfield – Boston: Upgraded Existing Rail (PIT – SPG), New Rail in CSX Corridor (SPG – WOR)

To complement the higher level of infrastructure investment, rail service frequencies under Alternative 4 would increase to a total of up to nine new weekday round trips Pittsfield and South Station. End-to-end trip times would decrease by 50 minutes relative to the No-Build Alternative (2:59), with a 40-minute savings between Springfield and Boston (1:47).

Alternative 5: Passenger Rail, Springfield – Boston: New Rail with Priority Realignments (SPG – WOR), Bus Service West of Springfield

Alternative 5 would establish a new direct passenger rail service between Springfield and Boston (South Station), with intermediate stops in Worcester and Boston (Lansdowne and Back Bay). To connect with up to nine new weekday passenger rail round trips at Union Station, passengers in markets west of Springfield could use up to 11 new weekday bus round trips serving Pittsfield, Lee, and Blandford, as seen in Figure 4-8 on the next page.

Alternative 5 introduces the most dramatic infrastructure improvements found within any alternative along the CSX corridor to reduce overall travel times. Between Springfield and Worcester, Alternative 5 would include seven curve realignments to mitigate speed constraints presented by the challenging existing horizontal and/or vertical profiles. The new curve alignments permit sustained high-speed (95-105 mph) operation in order to achieve substantive travel time reductions. Since they deviate from the existing corridor, these shortcut segments present additional impacts in the communities of Warren, West Brookfield, East Brookfield, Charlton, Oxford, and Auburn. Relative to Alternative 4, these adjustments, coupled with not stopping at Palmer, would save over 10 minutes along the central segment (30 minutes overall), with travel times between Springfield and Worcester approaching 40 minutes.

In Alternative 5, trips between Springfield and Boston would take nearly an hour less (55-minute savings), with journeys approaching an hour and a half (1:34). Although trip times between Pittsfield and Boston are still 50 minutes shorter than in existing conditions, reliance on connecting bus services west of Springfield offsets the travel time savings generated along the central segment, with trips between Pittsfield and Boston remaining similar to Alternative 4 (3:00).

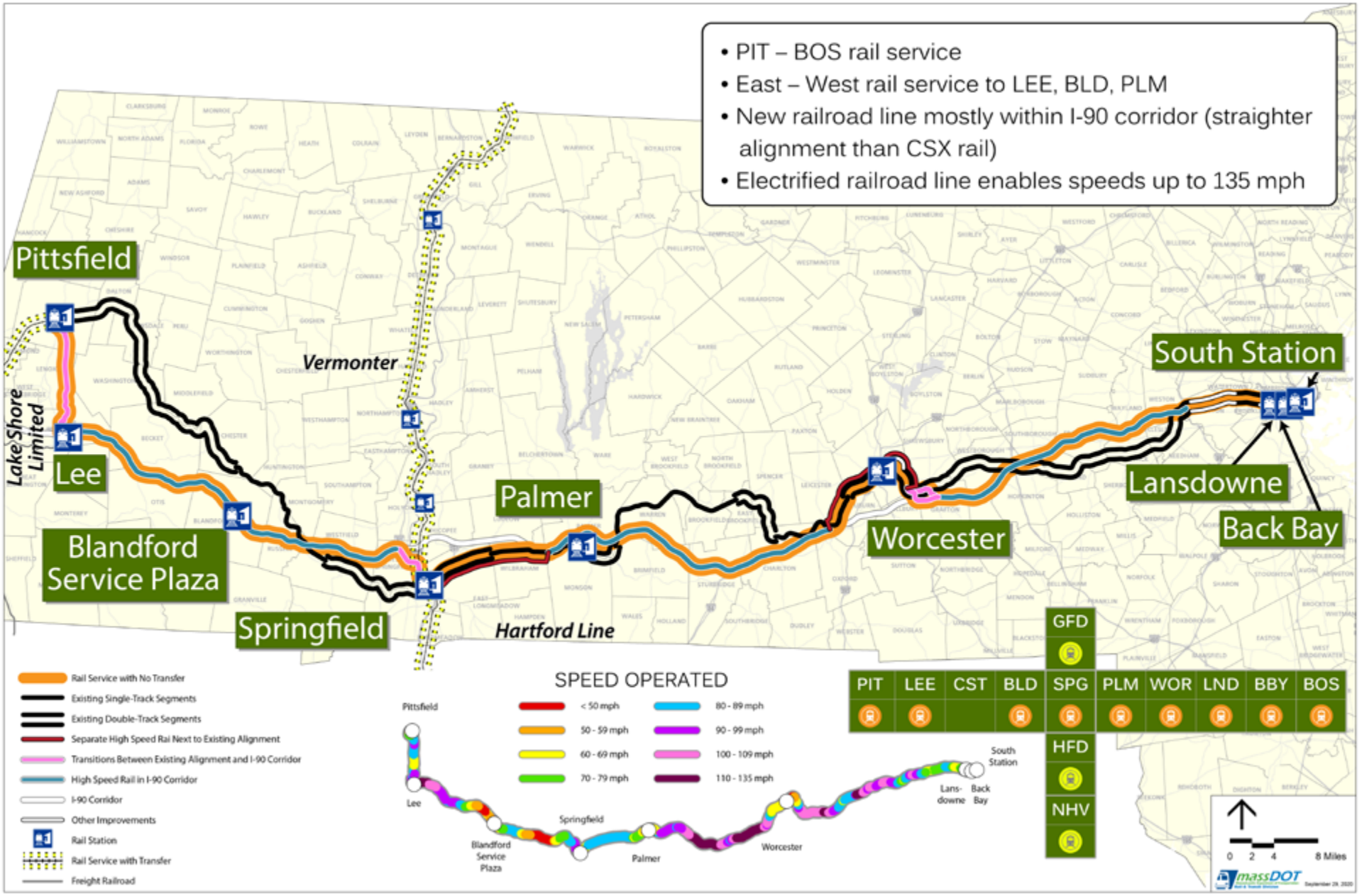
Alternative 6: High-Speed Passenger Rail, Pittsfield – Boston, with New Rail Alignment in Separate I-90 Corridor

Alternative 6 would provide a direct high-speed passenger rail service between Pittsfield and Boston (South Station), with intermediate stops in Lee, Blandford, Springfield, Palmer, Worcester, and Boston (Lansdowne and Back Bay), primarily via a new alignment running parallel to or along Commonwealth-owned transportation assets (i.e. I-90 and the Housatonic Railroad), as indicated in Figure 4-9 on page 53. This would entail construction of an entirely new railroad line that is principally at-grade, but with significant segments of elevated rail viaduct to overcome property constraints and conflicts with roadway crossings. Consistent with the significantly greater infrastructure investment, service frequencies would be substantially increased, with up to 17 new weekday rail round trips between Pittsfield and South Station.

The use of state-owned ROWs along existing or historic transportation corridors would enable higher passenger train speeds by avoiding significant horizontal and vertical curves west of Worcester found in the rail corridor and also improve reliability by minimizing conflicts from freight and other passenger traffic operating along the CSX mainline. This alternative seeks to balance the desire to develop new passenger rail service along a freight-free corridor while minimizing impacts to the natural and built environment, and community impacts from right-of-way takings.

Figure 4-8 – Alternative 5 – Passenger Rail, Springfield – Boston: New Rail with Priority Realignments (SPG – WOR), Bus Service West of Springfield

Figure 4-9 – Alternative 6 – High-Speed Passenger Rail, Pittsfield – Boston, with New Rail Alignment in Separate I-90 Corridor



Alternative 6 would follow the Housatonic Railroad between Pittsfield and the I-90 corridor. Between approximately Exit 2 and Route 128/ Riverside, the service would run generally along the south side of the I-90 corridor. It would serve new, highway-adjacent rail stations in Lee, Blandford, and Palmer. It would also serve the existing downtown railroad stations in Springfield and Worcester; maintaining service at these downtown rail stations would require the development of new connections between the I-90 rail alignment and the existing railroad corridor. This would entail creation of new passenger-only track in the CSX-owned rail corridor using a separated rail alignment, as in Alternatives 4 and 5. Like the other Preliminary Alternatives, Alternative 6 would operate along the MBTA-owned rail ROW east of Route 128/ Riverside.

Between Pittsfield and Springfield, the development of high speed passenger track along the Housatonic and I-90 corridors would allow for a significant rise in maximum permitted speeds from 50 to 150 mph, with trips between Pittsfield and Springfield taking under an hour (0:59). Between Springfield and Worcester, Alternative 6 could enable maximum permitted speeds to increase from 60 to 150 mph, and between Worcester and Route 128/Riverside, maximum permitted speeds could increase from 80 to 150 mph.

Combining the travel time benefits across the segments, journeys between Springfield and South Station would be reduced by nearly half relative to existing conditions (70-minute savings), with travel times under an hour and a half (1:19). Similar travel time benefits would accrue for trips between Pittsfield and South Station, with a 90-minute savings relative to existing conditions and end-to-end travel times under two and a half hours (2:18).

Unlike the other alternatives, which make use of the existing rail corridor and its infrastructure, Alternative 6 would require installation of a completely new signal system. In addition, modern diesel trainsets can only reach maximum speeds of 125 mph; higher speeds require use of electric locomotives. To adequately leverage the high-speed track proposed, Alternative 6 would require electrification along the corridor, as well as the procurement of electric trainsets.

4.4. Evaluation Criteria

A set of quantifiable metrics was developed to enable the comparative evaluation of the Preliminary Alternatives. These evaluation criteria are based upon the project's purpose and need, study goals, and objectives of the alternatives. The following evaluation criteria capture the key benefits, costs, and impacts of the Preliminary Alternatives.

Ridership

The level of projected ridership is among the most critical metrics for evaluating the total potential benefits of a given alternative. The central goals of the East – West Passenger Rail project are to provide travelers with improved travel options, enable them to better meet their personal travel needs, and realize economic benefits at both the terminating and intermediate station stops from these improved travel opportunities.

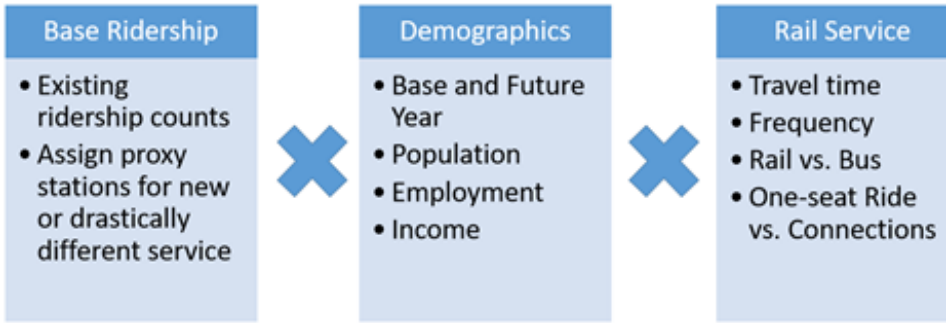
- **Modeled Geography & Services.** The evaluation of alternative alignments and project impacts is focused on the corridor that encompasses the East – West communities. However, the ridership forecasting makes use of demographic data and travel behavior information for a broader area that spans all of Massachusetts, Connecticut, and Rhode Island, as well as the New York metro area (New York City, eastern New York State, Long Island, and northern New Jersey). The East – West ridership forecasting model also reflects connections with and competition from the other rail services listed below.

- Amtrak
  - Northeast Regional trains originating in Boston providing service to Providence, New Haven, and New York via the Northeast Corridor, continuing to Washington, D.C.
  - Northeast Regional and Amtrak Shuttles operating on the Hartford Line from Springfield to New Haven via Hartford
  - Lake Shore Limited trains originating in Boston providing service to Springfield, continuing to Chicago, IL
  - Vermonter trains originating in St Albans, VT providing service to Vermont stations, Springfield, Hartford, and New York
- CT*rail* Hartford Line trains operating between Springfield and New Haven
- MBTA Commuter Rail trains operating between Boston and Worcester
- Greyhound and Peter Pan bus services

- **Ridership Forecasting Methodology.** Ridership forecasts for the preliminary alternatives were made using the same rail ridership model that was used for the Northern New England Intercity Rail Initiative (NNEIRI) study. Like the NNEIRI forecasts, this study employs an incremental ridership model that only forecasts rail ridership, as opposed to total travel by all modes. However, the influence of other modes, such as driving, is accounted for within the base ridership levels. The model pivots off of actual ridership counts by correlating origins and destinations ("station pairs") in the East – West Corridor with a proxy station pair on an existing passenger railroad service that has similar demographic and service characteristics (e.g., distance between stations, market size, trains per day). Train-to-train and bus-to-train connections are explicitly modeled and factored to reflect the lower appeal of a required transfer. Each train is modeled separately, which allows for time-of-day factoring for both departure and arrival times.

  Ridership forecasts are unconstrained with regards to train capacity and parking capacity. The potential riders for each Preliminary Alternative are assumed to be drawn from a 20-mile radius around each proposed station, with residents and jobs located closer to the station assumed to have a higher likelihood of using the service. The proxy station pair's actual ridership counts are then adjusted to account for differences in demographics, market size, and rail service characteristics to make ridership forecasts for the proposed service. Therefore, it is important to ensure that the base railroad service and base station pair are appropriate for forecasting ridership for the proposed service. Figure 4-10 provides an overview of the incremental ridership model.

Figure 4-10 – Incremental Ridership Model Overview



The CT*rail* Hartford Line was initially chosen as the proxy service and proxy station pairs for the Preliminary Alternative ridership forecasts because it is in the same service area that was used as the base for key route segments in the NNEIRI ridership forecasts. The Hartford Line has cities/towns with comparable demographics to East – West stations and also serves one of this study's major markets – Springfield / Western Massachusetts.

The model was then adjusted to account for the new territory between Pittsfield and Springfield, and the introduction of higher-speed alternatives evaluated in the East-West Study compared to

NNEIRI. After establishing the refined model, calibration runs were undertaken and compared with available NNEIRI forecasts for the common proxy station pairs between Springfield and Boston. The ridership modeling for the Preliminary Alternatives result in East-West ridership forecasts that are slightly higher than the NNEIRI model between the common points.

Members of the Advisory Committee, the public, and other stakeholders questioned that the ridership forecasts for the Preliminary Alternatives seemed too low when compared to actual ridership on other passenger rail services. The ridership forecasts and model were thoroughly reviewed and subsequently adjusted to better reflect the magnitude of the downtown Boston market. The updated model included enhancements to the selected station proxies and an entirely new service /station proxy route to evaluate the potential travel market with a range of modeled attributes.

For the Final Alternatives, two different proxy rail services were used, resulting in two ridership forecasts for each alternative. The Hartford Line was retained as a proxy, but with revised assumptions that enhanced the attractiveness of the East – West service for potential riders to/from Boston. The Downeaster Line rail service, which connects Brunswick, Maine with Boston, was added as a second proxy service for ridership forecasting. As a result, the ridership forecasts for the Final Alternatives were significantly higher than for the Preliminary Alternatives. This is discussed in detail in Section 4.7, Evaluation of Final Alternatives, Ridership.

Costs

The projected costs, both initial capital cost of project implementation and ongoing annual costs of operations and maintenance, are critical metrics for evaluating each Preliminary Alternative.

- **Capital Costs Development.** The capital cost estimates reflect one-time investments in new infrastructure (e.g., new/upgraded stations, track, bridges, yards, utility relocation, signals, including Positive Train Control equipment), as well as the acquisition of any properties intersected by each alignment (including the cost of the property and any required compensation or mitigation activities), vehicle procurement, and professional services.

Table 4-5 on the next page includes a summary of the specific components included within the capital cost estimates, as well as the extent to which they influence the overall cost of the alternatives. The cost components are organized by Standard Cost Category (SCC), which is an approach used by the FRA and Federal Transit Administration (FTA) that allows for reliable comparisons of capital costs across with various elements of different transportation projects. These categories include many elements, but two of them – bridge structures and utility relocations – exert a particularly large influence on the overall project. Relative to NNEIRI, the East – West costs are higher due the use of different assumptions for utility relocations and bridges. The NNEIRI preferred alternative contemplated double-tracking, which was assumed to occur without any utility conflicts or major impacts to existing bridges that could not be addressed simply through rehabilitation efforts. In contrast, Alternatives 4 through 6 contemplate improvements beyond the existing rail corridor (i.e., implementing a separate passenger-only track parallel to existing or along an entirely new rail corridor) that would generate impacts to utility structures and existing bridges. Therefore, this study assumed utility relocations, which experience with other similar projects has shown can be substantial, and that any existing bridge impacted would need to be reconstructed, not rehabilitated.

Table 4-5 – Overview of FRA/FTA Standard Cost Category (SCC) Elements

STANDARD COST CATEGORY (SCC)	SCOPE	DRIVING ELEMENTS
CONSTRUCTION COSTS	Construction, including materials and labor, for all proposed infrastructure elements	Incorporates all cost elements not related to acquisitions and displacements, vehicle procurement, professional services, and unallocated contingency.
10 GUIDEWAY & TRACK ELEMENTS	All track, guideway preparation, and railroad (or undergrade) bridges	There are many existing undergrade bridges, particularly between Springfield and Worcester. These would either need to be replaced to meet current design standards, or, for new alignments, entirely new bridges and bridge approaches.
20 STATIONS, STOPS & TERMINALS	All elements of railroad stations	Serving stations that require a new or significantly rehabilitated facility.
30 SUPPORT FACILITIES	All maintenance and layover facilities, as well as any additional administration buildings, crew quarters, parts storage, or similar elements	Adequate layover facilities are proposed in Pittsfield, Springfield, and/or Boston (expansion of existing), depending on the alternative.
40 SITEWORK & SPECIAL CONDITIONS	Civil, site, and other miscellaneous infrastructure items (e.g., demo, grubbing, mitigation, site roadways, parking lots, and utility relocations)	The quantity of utility relocations and overhead bridge replacements are based on the location, length, and type of new track. Generally, alternatives with higher amounts of new track construction, especially in areas beyond existing ROW, have higher costs.
50 SYSTEMS	Train signalization, traction power systems, roadway signalization, fare collection, and central control and dispatch technologies	Due to the need to supply electrical traction power to achieve the high speeds within Alternative 6, this item is at least five times greater than any other alternative.
CONSTRUCTION CONTINGENCY	Recognizes and sets aside funding to address uncertainties given the current level of design and engineering	35% of construction costs (SCC 10-50), which is common for this high-level conceptual analysis
60 ROW, LAND & EXISTING IMPROVEMENTS	Land acquisition costs, regardless of ROW type, based on SF of impact, as well as relocation assistance for all business and residents whose buildings would be permanently occupied.	Length of new alignment. It should be noted that payments stemming from temporary impacts to private properties that would be experienced during construction are not included in this estimate.
70 VEHICLES	Procurement of the trainsets and buses that would be required to operate the proposed rail and bus frequencies.	Frequency of service proposed. Alternatives 1-5 contemplate diesel-powered trains while Alternative 6 would require fully-electric propulsion systems.
80 PROFESSIONAL SERVICES	General project start-up, including project development, design/ engineering, project and construction management, liability and insurance, legal fees, external agency costs, surveys, testing, etc.	30% of SCC 10-50, including Allocated Contingency, consistent with FRA guidance
90 UNALLOCATED CONTINGENCY	Recognizes that, until construction is finished, uncertainties will remain	10% of SCC 10-80, including Allocated Contingency
100 FINANCE CHARGES	“Cost of capital” that would be associated with bond repayment or other borrowing costs	Given the present level of design and engineering, finance charges were not estimated.

- **Operations & Maintenance Costs.** The operations and maintenance (O&M) costs associated with each preliminary alternative were developed using different assumptions for the rail and bus mode. Based on a review of O&M costs incurred by similar passenger rail services, as well as the level of rail service proposed in each alternative, the rail-based O&M costs include the following components:
  - Labor costs for train crew and equipment maintenance staff;
  - Fuel costs for the trains;
  - Station operations and maintenance cost;
  - Train equipment maintenance costs;
  - Access fees to account for management of the train services (dispatching, policing, supervisory costs, emergencies, etc.)
  - Routine ROW maintenance; and
  - General administrative functions.

  The bus-based O&M costs were developed by reviewing 2018 National Transit Database (NTD) O&M cost data for similar commuter bus operations, and then applying an average cost per vehicle revenue hour to the level of bus services proposed in Alternatives 1, 2, and 5.

Environmental and Community Impacts

The Preliminary Alternatives would each cause environmental and community impacts. These include impacts to land associated with potential property takings. These would result in permanent impacts to publicly-held and/or privately-owned properties that either abut the existing rail corridor or lie along a new rail alignment. Determining these impacts requires accounting for appropriate track curvature and grades and adherence to current CSX standards. Based on the infrastructure improvements proposed (e.g., number of new passenger tracks or sidings) and varying assumptions of passenger operations and corridor ownership (e.g., new shared passenger-freight or passenger-only track in CSX corridor, or new passenger-only track in separate corridor), impact buffers or required right-of-way widths for different segments of track were developed for each of the Preliminary Alternatives.

- **Environmental Impacts.** Each Preliminary Alternative would have environmental impacts from fuel emissions, noise, vibration, and property impacts to natural lands.
  - **Air Quality.** Air quality is regulated and protected by the federal Clean Air Act (CAA) of 1963, federal Clean Air Act Amendment (CAAA) of 1990, the Massachusetts Clean Air Act, and federal and state standards and permit programs administered by the U.S. Environmental Protection Agency and MassDEP. At the federal level, the CAA sets National Ambient Air Quality Standards (NAAQS) for six major “criteria” pollutants: carbon monoxide, lead, nitrogen dioxide, ground-level ozone, sulfur dioxide, and particulate matter. At the state level, the 2008 Massachusetts Global Warming Solutions Act (GWSA) created a framework for reducing heat-trapping greenhouse gas (GHG) emissions to minimize the worst effects of global warming, requiring a 25 percent reduction by 2020 and an 80 percent reduction by 2050 relative to 1990 baseline emission levels. Though the magnitude of the change would vary based on key service characteristics of a new passenger rail service (e.g., travel times, frequency, stations, transfers, relative appeal of other available travel options), changes in air quality would occur across all alternatives because of two factors – increases in rail-based VMT and changes in auto-based VMT from both passenger vehicles and any connecting bus services.
  - **Noise & Vibration.** The FRA and FTA publish technical guidance to evaluate the impacts of transit and railroad noise

and vibration.[6] These factors have impacts on a general corridor level, as well as on specific sensitive receptors (such as residences, schools, churches, hospitals, and users of uses with vibration-sensitive equipment).

- **Water Resources (Waterways, Wetlands, and Waterbodies).** Surface water and wetlands are protected by the federal Clean Water Act (CWA) and the Massachusetts Wetlands Protection Act (MWPA). Any actions that might have impacts on these resources must adhere to federal and state water quality standards and comply with federal, state, and local permit programs. These programs include CWA Sections 404 and 10 permits administered by the U.S. Army Corps of Engineers, the CWA Section 401 Water Quality Certification administered by the Massachusetts Department of Environmental Protection (MassDEP), and the MWPA, administered by host municipalities. To understand how each Preliminary Alternative would affect river and stream crossings, as well as wetlands and open water (i.e., lakes and ponds) features, MassDEP data was used to identify the number of water crossings and the total area of impact to wetland and waterbodies for each alternative.[7] The greatest potential for impact to these protected resources is sedimentation and erosion during construction, and to a lesser extent, the potential for spills of fuel or other contaminants associated with construction equipment or operating the service.
- **Floodplains.** Floodplains provide an important function in storing stormwater and protecting people and property from flood hazards. They are protected by the MWPA, the federal CWA, and the federal Flood Disaster Protection Act. The evaluation of impacts to floodplains assessed the new impervious area that each alternative would create in low-lying and groundwater recharge areas located within federally-designated 100-year floodplains. An assessment was performed using National Flood Hazard and Q3 Flood Zone geospatial data, which was published by the U.S. Federal Emergency Management Authority (FEMA) and retrieved from MassGIS.
- **Areas of Critical Environmental Concern.** The Massachusetts Department of Conservation and Recreation (DCR) administers the Commonwealth's Areas of Critical Environmental Concern (ACEC) program. An ACEC is a place that has received special recognition due to the quality, uniqueness, and significance of its natural and cultural resources. Designation of an ACEC increases environmental oversight and state permitting standards by elevating performance standards and lowering thresholds for review.
- **Protected Species Habitats.** The federal Endangered Species Act and the Massachusetts Endangered Species Act protect rare species and their habitats. An assessment of impacts to areas that foster and nourish these protected species was conducted using geospatial data pertaining to Estimated Habitats of Rare Wildlife and Priority Habitats of Rare Species published by the Massachusetts Natural Heritage & Endangered Species Program (NHESP) within the 14th Edition

[6] Transit Noise and Vibration Impact Assessment Manual, FTA Report No. 0123, September 2018; High-Speed Ground Transportation Noise and Vibration Impact Assessment, Report No. DOT/FRA/ORD-12/15, September 2012. The guidance is similar, with the FTA guidance applying to moderate speeds and the FRA guidance applying to speeds greater than 90 miles per hour.

[7] The analysis of rivers (2014 Integrated List of Waters) and permanent/non-intermittent streams (1:25,000 Hydrography) relied on geospatial data provided by MassDEP and published on MassGIS.

of the Massachusetts Natural Heritage Atlas. Priority Habitats are defined as protected wetland, upland, or marine habitats where state-listed rare species have been observed within the past 25 years. Estimated Habitats contain a subset of Priority Habitats but do not include any rare plant or rare upland-bound wildlife species.

- **Protected Lands.** Using statewide geospatial data for Protected and Recreational Open Spaces, coupled with the impact profile of each Preliminary Alternative, an assessment was conducted to determine the total number of affected resources that are subject to protections under state and/or federal regulations. Since these resources often consist of smaller components, the total number of individual parcels impacted was also determined.
  - **Massachusetts Article 97 Lands.** Article 97 of the Amendments to the Massachusetts Constitution protects land that has been acquired by agencies of the Commonwealth for the purposes of conservation or agricultural preservation through either a fee simple acquisition or a conservation easement. Article 97 stipulates that any disposition of a state agency's interests in such lands requires a two-thirds vote of the state legislature for the change to be authorized.
  - **Federal Section 4(f) and 6(f) Lands.** Section 4(f) of the U.S. Department of Transportation (USDOT) Act of 1966 governs the use of protected lands and other resources for transportation purposes. This regulation compels USDOT agencies to avoid the use of publicly-owned parks, recreation areas, wildlife and waterfowl refuges, and public and private historic properties whenever a "feasible and prudent alternative" exists. When such an option does not exist, Section 4(f) requires these agencies to incorporate all possible planning (e.g., mitigation measures) to minimize the harm to those properties that would otherwise result from the proposed transportation use. Section 6(f) of the federal Land and Water Conservation Fund (LWCF) Act protects public outdoor recreation areas that have been purchased or improved using LWCF funding. Section 6(f) requires approval from the Secretary of the Interior, acting through the National Park Service, to convert such land to another use. Such conversion typically requires replacement of the land and/or improvements.

- **Community Impacts.** Community impacts result from property taking that affects public or private property.
  - **Cultural Resources & Historic Properties.** Historic, archaeological, and tribal resources are protected by the National Historic Preservation Act and local historic bylaws. Each Preliminary Alternative's potential impacts to national and local historic properties (which include districts, properties, building and archaeological sites) was assessed using geospatial data developed by the Massachusetts Historical Commission (MHC) within its statewide Cultural Resource Information System (MACRIS).
  - **Transportation Infrastructure.** The Preliminary Alternatives also have impacts on existing transportation infrastructure, in particular roadways that cross the railroad alignment, either at-grade or in a grade-separated profile above or below the railroad.
    - **At-Grade Crossing Warning/Safety Systems.** At-grade crossings are the only legal intersections where trains have the potential to conflict with other traffic streams (e.g., automobiles, pedestrians). Since collisions at these facilities can result in serious injuries or death, ensuring

safe and protected passage for both train and person traffic alike is important. While a certain level of risk always exists wherever there is the potential for fast-moving trains weighing several hundred tons to collide with lighter objects, appropriate design measures and proactive steps can be taken to mitigate such risk when a substantial change in train volumes and/or speeds along the corridor occurs. The FRA Railroad Crossings Inventory database and a follow-up visual scan of recent aerial imagery were used to determine the count and location of all at-grade crossings along the existing rail corridor.

- **Bridges.** The National Bridge Inventory database was paired with recent aerial imagery to determine how each alternative would interface with existing overhead (e.g., highway overpass) and undergrade (e.g., river or stream crossing) bridge structures along the existing rail corridor. For alternatives that develop a new alignment in an entirely different corridor, at-grade crossings were identified by reviewing aerial imagery and noting intersections between the proposed alignment and all existing roadways (public and private) and railroads.

- **Property and Buildings.** Some of the Preliminary Alternatives have alignments that would have impacts to buildings in developed areas. All review and evaluation of railroad alignment impacts to ROW, property, and buildings relied on the use of publicly-available GIS parcel and assessors' data. As a result, the findings presented would be subject to refinement based on detailed geospatial survey that would be required for project design and engineering.

4.5. Evaluation of Preliminary Alternatives

The six Preliminary Alternatives have been evaluated to determine the benefits, costs, and impacts that are expected to result from each set of service and infrastructure improvements for enhanced passenger rail service between Boston, Springfield, and Pittsfield. The key metrics evaluated are projected ridership, environmental and community impacts, and costs (both capital costs and operating/maintenance costs).

Ridership

The ridership is the central metric that represents the benefits offered by each of the Preliminary Alternatives. Table 4-6 on the following page provides the annual one-way boardings utilizing the original forecasting model in 2040 for each Preliminary Alternative, broken down at a station-level, along with projected changes in auto- and rail-based vehicle miles traveled (VMT) in the year 2040.

Note: "One-way boardings" measures passenger ridership based on a single direction of travel. For instance, a round trip between Springfield and Boston, with the rider boarding an East-West train both times, is counted as two (2) one-way boardings (one in Springfield, one in Boston). The following is a summary of the key takeaways from the ridership forecasts.

- In general, the level of infrastructure investment, travel speed, and service frequency increase as one progresses through the Preliminary Alternatives, from Alternative 1 to Alternative 6. The projected ridership generally increases in tandem with increases in these other parameters.
- The exception to this trend is Alternative 4 versus Alternative 5. Alternative 4 has higher ridership, which is attributable to the fact that it provides direct rail service for Pittsfield and destinations west

Table 4-6 – Ridership Results (Preliminary Alternatives) – 2040 Annual One-Way Boardings and Change in Vehicle Miles Traveled

METRIC / STATION	ALTERNATIVE TYPE	1 SHARED + EXISTING	2 SHARED + EXISTING	3 SHARED + EXISTING	4 SHARED + SEPARATE	5 SHARED + SEPARATE	6 SEPARATE + NEW
PITTSFIELD	DIRECT ACCESS	2,000	2,150	6,400	9,950	7,150	21,500
LEE	DIRECT ACCESS	200	400	--	--	1,950	5,200
CHESTER	DIRECT ACCESS	--		950	1,600	--	--
BLANDFORD	DIRECT ACCESS	400	400	--	--	1,850	4,950
SPRINGFIELD	TRANSFERS (HARTFORD LINE)	650	3,950	5,100	5,300	6,500	9,950
SPRINGFIELD	DIRECT ACCESS	2,300	11,650	16,750	28,750	29,300	53,650
PALMER	DIRECT ACCESS	450	2,950	3,900	6,700	-	11,150
WORCESTER	TRANSFERS (MBTA)	1,950	2,850	5,150	5,800	6,700	12,650
WORCESTER	DIRECT ACCESS	1,900	9,700	13,000	22,650	23,950	49,850
FRAMINGHAM	LAKE SHORE LIMITED	100	750	700	700	650	950
BOSTON, BACK BAY & LANSDOWNE	DIRECT ACCESS	1,200	13,200	20,300	35,650	37,000	77,850
ALL STATIONS	TOTAL ONE-WAY BOARDINGS	11,150	48,000	72,250	117,100	115,050	247,700
ALL STATIONS	ANNUAL VMT CHANGE – AUTO	(303,819)	(1,861,523)	(3,169,632)	(5,164,066)	(5,230,464)	(11,535,774)
ALL STATIONS	ANNUAL VMT CHANGE – RAIL	129,600	300,000	538,800	656,400	529,200	1,321,200

of Springfield, while Alternative 5 requires a bus connection.

- Direct, one-seat rail service is more convenient, generally faster, and more attractive to riders than a trip that requires transfers and a bus component. This preference can be seen among Pittsfield—Springfield projections between the alternatives.
- Aside from Boston, Springfield generates the majority of East – West ridership for all alternatives, accounting for the following percentage of riders:
  - Alternative 1 52.9 %
  - Alternative 2 65.0 %
  - Alternative 3 60.5 %
  - Alternative 4 58.2 %
  - Alternative 5 62.2 %
  - Alternative 6 51.4 %
- As noted in Section 4.4, Evaluation Criteria, the ridership forecasts for the Preliminary Alternatives were subsequently revised for the Final Alternatives (see Table 4-15 on page 82). However, the forecasts for the Preliminary Alternatives are still useful for evaluating the relative attractiveness of each alternative.

Costs

Each of the major capital spending categories (e.g., guideway, stations, land, vehicles) was reviewed in Table 4-5 on page 57. Table 4-7 shows the capital costs associated with each Preliminary Alternative, along with the total capital costs by geographic segment and annual O&M costs for all rail and bus services proposed.

Table 4-7 – Summary Capital cost by Standard Cost Category (SCC) and Segment, and Annual Operations & Maintenance Costs (2020 Million Dollars)

METRIC /	ALTERNATIVE	1	2	3	4	5	6
COST BASIS	TYPE	SHARED + EXISTING	SHARED + EXISTING	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE	SEPARATE + NEW
CAPITAL BY STANDARD	10 GUIDEWAY & TRACK ELEMENTS	$474.722	$474.722	$631.487	$972.301	$1,312.215	$8,774.271
CAPITAL BY STANDARD	20 STATIONS, STOPS, TERMINALS	$21.373	$21.373	$24.720	$28.325	$12.618	$69.422
CAPITAL BY STANDARD	30 SUPPORT FACILITIES	$18.540	$18.540	$31.930	$31.930	$18.540	$31.930
CAPITAL BY STANDARD	40 SITEWORK & SPECIAL CONDITIONS	$449.656	$449.656	$619.524	$1,059.032	$1,140.416	$3,604.780
CAPITAL BY STANDARD	50 SYSTEMS	$27.980	$27.980	$75.974	$91.628	$78.432	$445.461
CAPITAL BY STANDARD	CONSTRUCTION SUBTOTAL (10-50)	$992.270	$992.270	$1,383.635	$2,183.216	$2,562.221	$12,925.864
CAPITAL BY STANDARD	CONSTRUCTION CONTINGENCY (35%)	$347.295	$347.295	$484.272	$764.126	$896.777	$4,524.052
CAPITAL BY STANDARD	CONSTRUCTION TOTAL	$1,339.565	$1,339.565	$1,867.907	$2,947.342	$3,458.999	$17,449.916
CAPITAL BY STANDARD	60 ROW, LAND, EXISTING IMPROVEMENTS	$12.198	$12.198	$16.605	$41.645	$37.538	$101.402
CAPITAL BY STANDARD	70 VEHICLES	$20.909	$142.398	$131.840	$155.736	$82.194	$370.800
CAPITAL BY STANDARD	80 PROFESSIONAL SERVICES (30%)	$401.869	$401.869	$560.372	$884.203	$1,037.700	$5,234.975
CAPITAL BY STANDARD	SUBTOTAL (10-80)	$1,774.541	$1,896.029	$2,576.723	$4,028.925	$4,616.430	$23,157.094
CAPITAL BY STANDARD	90 UNALLOCATED CONTINGENCY (10%)	$177.454	$189.603	$257.672	$402.892	$461.643	$2,315.709
CAPITAL BY STANDARD	100 FINANCE CHARGES	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
CAPITAL BY STANDARD	TOTAL PROJECT COST (10-100)	$1,951.995	$2,085.632	$2,834.396	$4,431.817	$5,078.073	$25,472.803
CAPITAL BY SEGMENT	PIT-SPG	$17.399	$17.399	$649.493	$652.262	$17.399	$7,166.684
CAPITAL BY SEGMENT	SPG-WOR	$1,924.316	$2,057.954	$2,120.686	$3,715.339	$4,996.458	$11,620.694
CAPITAL BY SEGMENT	WOR-BOS	$10.280	$10.280	$64.216	$64.216	$64.216	$6,685.425
ANNUAL O&M BY MODE	RAIL	$26.162	$40.891	$51.603	$65.714	$47.380	$86.108
ANNUAL O&M BY MODE	BUS	$1.203	$0.933	$0.000	$0.000	$1.629	$0.000
ANNUAL O&M BY MODE	TOTAL	$27.365	$41.824	$51.603	$65.714	$49.009	$86.108

These detailed capital cost estimates have been developed using geographically-accurate railroad alignment plans to estimate quantities for project construction, along with costs for these quantities that are based on a range of industry-standard cost information. These cost assumptions are based on actual construction costs for comparable projects that have been recently built in New England, with a heavy emphasis on Massachusetts projects.

- Capital costs generally increase as the infrastructure investments and impacts increase progressively across the Preliminary Alternatives.
- The project elements that entail the greatest costs are for railroad bridges and for utility reconstruction.
- For each Preliminary Alternative, the greatest infrastructure and cost is associated with the Springfield – Worcester segment.

Operations and maintenance costs are principally determined by the number of vehicle-miles and vehicle-hours. Therefore, O&M costs increase with length of service and frequency of service. O&M costs increase across the Preliminary Alternatives in unison with increases in train frequency.

Environmental and Community Impacts

Most of the environmental and community impacts of the Preliminary Alternatives result from the alignment of the railroad tracks proposed, and their impacts to land resources.

- **Existing Alignment in a Shared Corridor.** The railroad track construction requirements for Alternatives 1 through 3 would entail restoration of missing double-track rail segments between Springfield and Worcester, as well as between Pittsfield and Springfield in Alternatives 3. These alternatives would provide a continuous two-track, shared passenger-freight rail alignment, with an impact width of 27 feet wide to the north or south of the existing single-track segment, depending on the location of the missing double-track.
- **Separate Alignment in a Shared Corridor.** Between Springfield and Worcester, Alternatives 4 and 5 would provide an entirely new, passenger-only rail alignment that is principally within the existing CSX rail corridor, but fully separated from the existing shared passenger – freight rail alignment. This passenger-only alignment would provide a single-track rail line, with frequent passing sidings to accommodate two-way traffic. It would entail an impact width of 50 feet (63 feet for the segments with sidings) to the north or south of the adjacent existing track segment's centerline. Alternative 4 would rely upon restoration of missing double-track rail segments between Pittsfield and Springfield.
- **New Rail Alignment in a Separate Corridor.** For most of the Alternative 6 alignment, passenger rail service would operate on a new double-track, passenger-only rail line within or adjacent to either the I-90 corridor, the Housatonic Rail Corridor, or a transition corridor that connects these new corridors to the existing rail corridor. The impact area for most of the Alternative 6 alignment would be 83 feet wide, to accommodate the two tracks, catenary, and any grading or drainage features.

The improvements proposed for Alternatives 1 through 3 would primarily fall within the existing railroad ROW, so they would have lower community impacts. The introduction of new separate passenger-only track segments and sidings in Alternatives 4 and 5 would increase these impacts, while Alternative 6's use of an entirely different corridor to build a high-speed service would result in much greater impacts to properties outside the transportation corridor. Table 4-8 on the following page shows the impact buffer width associated for the Preliminary Alternatives, which, along with the general location of the alignment, is a key determinant of the impacts presented.

Table 4-8 – Impact Buffer / Required Right-of-Way Based on Passenger Train Speeds and Corridor Ownership

CORRIDOR TYPE + ALIGNMENT	PRELIMINARY ALTERNATIVE	CORRIDOR OWNER	MAX. PERMITTED PASSENGER SPEED (MPH)	NEW PASSENGER TRACKS	NEW SIDINGS	IMPACT BUFFER / RIGHT-OF-WAY (FT)
SHARED + EXISTING	1, 2 & 3	CSX	80-90	1	0	27
SHARED + SEPARATE	4, 5 & 6	CSX	90-110	1	0	50
SHARED + SEPARATE	4, 5 & 6	CSX	90-110	1	1	63
SEPARATE + NEW	6	MassDOT	150	2	0	83

- **Environmental Impacts**. Total environmental impacts by resource area for each Preliminary Alternative are provided in Table 4-9 on the next page.
  - **Water Resources (Waterways, Wetlands, and Open Water Features)**
    - Alternatives 1 through 3 would entail the same alignment between Springfield and Worcester – utilizing the existing rail alignment with the most limited improvement profile – so they would have the fewest and shortest-running impacts to rivers and streams, with a total of 36 crossings. Along this central segment, these alternatives would traverse a total of 10 unique wetland resources totaling 0.4 acres and four open water bodies totaling 0.7 acres
    - The restoration of double-track along the western segment Alternatives 3 and 4 would also affect another seven waterbodies, two wetland areas, and one waterbody between Pittsfield and Springfield.
    - Between Springfield and Worcester, Alternatives 4 and 5 would each affect 41 rivers or streams; however, Alternative 5 would introduce further impacts to one additional wetlands resource at 1.14 acres (59 total resources) and 17 open water features (31 total resources) beyond Alternative 4.
    - Because Alternative 6 would entail construction of an entirely new rail alignment it would affect 101 crossings, 188 wetland areas (nearly 50 acres), and 23 open water features (over 10 acres).
  - **Floodplains**
    - The narrow and relatively limited extent of improvements proposed for Alternatives 1 and 2 would result in the lowest impacts, with 24 floodplain encroachments across nearly 13 acres.
    - Implementation of double-track between Pittsfield and Springfield would result in 19 encroachments covering 6.67 acres under Alternatives 3 and 4.
    - Along the Springfield – Worcester segment, Alternative 4's implementation of a parallel passenger-only track would result in 34 additional encroachments (58 total) and over 16 more acres (28.95 total) relative to Alternative 3.
    - The realignments included in Alternative 5 would touch another seven floodplain zones (65 total) to impact an additional 2.12 acres (31.07 total).
    - Although Alternative 6 would have the highest floodplain impacts, with 103 encroachments totaling nearly 112 acres, most of these impacts would be in the Pittsfield – Springfield and Worcester – Boston segments.

Table 4-9 – Environmental Impacts (Preliminary Alternatives)

	ALTERNATIVE	1 & 2	3	4	5	6
IMPACT TYPE	METRIC	SHARED + EXISTING	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE	SEPARATE + NEW
WATER CROSSINGS	COUNT	36	43	48	41	101
WETLANDS	COUNT	10	12	60	59	188
WETLANDS	TOTAL AREA (ACRES)	0.43	0.45	7.73	8.85	49.69
OPEN WATER	COUNT	4	5	15	31	23
OPEN WATER	TOTAL AREA (ACRES)	0.72	0.93	4.02	4.69	12.88
100-YEAR FLOODPLAINS	COUNT	24	43	77	65	103
100-YEAR FLOODPLAINS	TOTAL AREA (ACRES)	12.65	19.32	35.63	31.07	111.86
ACEC	COUNT	0	0	0	0	3
ACEC	TOTAL AREA (ACRES)	0	0	0	0	106.73
ARTICLE 97 LANDS	COUNT (RESOURCES)	3	5	9	9	29
ARTICLE 97 LANDS	TOTAL AREA (ACRES)	0.06	3.03	9.87	11.61	62.34
PRIORITY HABITAT	COUNT	6	8	13	21	15
PRIORITY HABITAT	TOTAL AREA (ACRES)	20.07	35.79	58.57	43.29	78.14

        - The highest impacts to floodplain areas would be located along the Springfield – Worcester segment for all alternatives except for Alternative 6.
        - Along the Pittsfield – Springfield segment, Alternatives 3 and 4 would result in 19 encroachments while Alternative 6 would require 37. Aside from the central segment, floodplain impacts within the eastern and western segments of Alternative 6 would total just under 100 acres, a level of impact that would be higher than any other Preliminary Alternative assessed.
    - **Areas of Critical Environmental Concern**
        - Only Alternative 6 would involve impacts to ACECs. Of approximately 107 acres of ACEC impacts, nearly three-quarters of this area is concentrated between Pittsfield and Springfield where the alignment would run near the Upper Housatonic River (Lenox, Lee & Pittsfield). The remaining quarter of Alternative 6's ACEC impacts would occur along the Worcester – Boston segment due to Cedar Swamp (Hopkinton) and the Miscoe, Warren and Whitehall Watershed (Westborough, Upton & Grafton).
    - **Protected Lands**
        - **Article 97.** The number of Article 97 protected recreational and open space properties impacted would range from a minimum of three facilities, with an impact area less than 0.06 acres across four parcels (Alternatives 1 and 2), to a maximum of 29 facilities

encompassing over 62 acres across 43 parcels (Alternative 6).

- **Section 4(f).** Most of the open space and recreational resources protected by Article 97 would also be subject to federal Section 4(f) protection.
  - Alternatives 1 through 3 would have minimal impacts to Section 4(f) protected recreational and open space properties.
  - Alternatives 3 and 4 would affect two Article 97-listed properties between Pittsfield and Springfield for just under three acres of impact across four parcels, primarily the Tekoa Mountain Wildlife Management Area (WMA) in Russell (2.96 acres) but also a small portion of the Chester-Blandford State Forest in Chester.
  - Alternatives 4 and 5 would entail an order of magnitude increase in impacts along the central segment compared to Alternative 3 (three resources at 0.06 acres), with the impacted area under Alternative 4 growing by a factor of over 100 (seven resources covering 6.90 acres) and Alternative 5 nearly doubling that expanded area (nine resources at 11.61 acres).
  - Alternative 6 is the only option that would introduce impacts to protected recreational and open space resources between Worcester and Boston (16 resources totaling 12.21 acres). Unlike Alternatives 4 and 5, which have the majority of their impacts along the central segment, the majority of the impacts under Alternative 6 would occur along the western segment where it would affect nine resources totaling 46.88 acres.
- **Section 6(f).** None of the open space resources that would be impacted were funded through the federal Land and Water Conservation Fund. Therefore, lands impacted would be protected under Section 6(f).

- **Protected Species Habitats**
  - Implementation of double-track between Pittsfield and Springfield within Alternatives 3 and 4 would result in nearly 16 additional acres of impact across two priority habitats located along the western segment compared to Alternatives 1, 2, and 5.
  - Along the central segment, Alternatives 1 through 3 would result in the lowest impacts to priority habitats (six habitats affected totaling just over 20 acres).
  - Implementing the passenger-only track between Springfield and Worcester in Alternative 4 would increase impacts by five resources (11 total) and 23 acres along the central segment relative to Alternative 3.
  - Compared to the other preliminary build alternatives, Alternative 6's use of the I-90 corridor would generate higher impacts to priority habitat impacts along all segments except for Springfield-Worcester, where this option would present the lowest impacts.
  - Alternative 6 has the highest impacts on protected species habitat. Using the Housatonic Rail Corridor would result in the highest segment-level impacts (11 priority habitats totaling nearly 53 acres between Pittsfield and Springfield) across all alternatives. Developing a new corridor between Worcester and Route 128/Riverside would result in nearly 13 acres of priority habitat impacts.
- **Air Quality**
  - As the projected ridership increases through the progression of Preliminary Alternatives, automobile

vehicle-miles traveled (VMT) correspondingly decrease.
    - However, because modern automobiles have low "criteria" emissions (e.g. sulfur and nitrogen oxides) while diesel locomotives have relatively high levels of such emissions, all Preliminary Alternatives would produce a net increase in these emissions.[8]
    - Alternatives 1, 2, and 5 terminate at Springfield rather than Pittsfield, so they produce lower train-based diesel emissions than other alternatives.
    - Alternatives 1, 2, and 5 provide bus connections in Pittsfield, Lee, Blandford, and Springfield that balance the ridership and automobile VMT impacts of terminating rail at Springfield.
- **Noise & Vibration**
    - Overall exposure to noise increases with both speed and frequency of service. Within the existing CSX corridor east of Springfield, relative noise impacts tend to increase as one moves from Alternative 1 to Alternative 5.
    - Longer routes affect a greater number of noise sensitive receptors (more opportunity for exposure) and more noise sensitive receptors fall within urban and densely-developed suburban locations than in rural and less densely-developed suburban areas. Alternatives with direct rail connections to Pittsfield would have greater absolute impacts than those that terminate in Springfield.
    - The same incremental increase in noise may be considered a "significant" impact where there is a high level of existing noise (urban setting), and not be considered "significant" in an area with a low level of existing noise (rural setting).[9]
    - The Alternative 5 realignments would present relatively higher noise impacts because the additional noise would occur outside of an established transportation corridor.
    - For most of its length, Alternative 6 would introduce an additional noise source along an established transportation corridor (I-90). However, in areas where the alignment transitions between I-90 and the existing rail corridor to serve downtown stations in Springfield and Worcester, Alternative 6 would present noise impacts of a similar nature to Alternative 5's realignments.

- **Community Impacts.** Table 4-10 on the next page summarizes community impacts by resource area for each Preliminary Alternative.
    - **Cultural Resources & Historic Properties.** Historic properties and historic districts are subject to historic protections by virtue of being listed on the federal National Register of Historic Places.
        - Alternative 6 would generate impacts to the highest number of historic sites (five) while the central segment between Springfield and Worcester would contain the highest concentration of impacted historic sites (up to three in any alternative).

[8] Since simulating electrified train operations is not supported within TREDIS, emissions results for Alternative 6 reflect the worst-case scenario (i.e., a diesel-based service operating 17 new weekday round trips per day).

[9] Because sound is expressed on a logarithmic scale in decibels (dB), a doubling of the number of identical noise sources increases noise levels by only 3 dBA; thus, two noise sources each emitting a noise level of 50 dBA yield a combined noise level of 53 dBA. A tenfold increase in the number of identical noise sources will add 10 dBA to the overall noise level (i.e., 60 dBA combined).

Table 4-10 – Community Impacts (Preliminary Alternatives)

	ALTERNATIVE	1	2	3	4	5	6
IMPACT TYPE	METRIC	SHARED + EXISTING	SHARED + EXISTING	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE	SEPARATE + NEW
2040 ANNUAL CHANGE IN VMT	AUTO	(303,819)	(1,861,523)	(3,169,632)	(5,164,066)	(5,230,464)	(11,535,774)
2040 ANNUAL CHANGE IN VMT	RAIL	129,600	300,000	538,800	656,400	529,200	1,321,200
HISTORIC SITES	COUNT	1	1	2	3	2	5
HISTORIC PROPERTIES	COUNT	1	1	2	5	4	9
HISTORIC PROPERTIES	TOTAL AREA (ACRES)	2.05	2.05	4.01	6.77	4.66	8.17
TRANSPORTATION INFRASTRUCTURE	IMPROVED AT-GRADE CROSSING	0	0	30	30	11	4
TRANSPORTATION INFRASTRUCTURE	UNDERGRADE BRIDGES (FT)	5,300	5,300	6,800	10,670	16,370	114,338
TRANSPORTATION INFRASTRUCTURE	OVERHEAD BRIDGES	20	20	25	42	37	9

Note: Negative values reflect a decrease in VMT or emissions for a given mode/alternative.

- Between Pittsfield and Springfield, three sites listed on the National Register would be impacted. Alternatives 3 and 4 would intersect a historic Boston & Albany (B&A) Railroad bridge near Basket Street in Huntington, while Alternative 6 would two historic properties in this segment.
- Within the central segment between Springfield and Worcester, seven unique National Register sites would be impacted by one or more alternatives. Alternatives 1 through 3 would impact another historic B&A bridge in West Brookfield. Alternative 4 would impact two historic properties, while Alternative 5 would impact these two and one additional property. Alternative 6 would impact one historic building, as well as two sites along the Providence & Worcester (P&W) Railroad in Worcester, an embankment and a bridge.
- As with historic sites, Alternative 6 would result in impacts to the highest number of historic districts (nine); however, most of the districts impacted under Alternative 6 lie within the Worcester to Boston segment (six), which would not be impacted under any other alternatives.
- Between Pittsfield and Springfield, two historic districts would be impacted. Alternatives 3 and 4 would intersect with the Huntington Village Historic Commercial District, while Alternative 6 would impact the Eaton, Crane and Pike Company Factory industrial complex in Pittsfield.
- Within the central segment, there are three unique historic districts that would be affected. Alternatives 1 through 5 would result in varying degrees of impact to the West Brookfield Center Historic Commercial District. Under Alternatives 4 through 6, two other districts would be affected – the Downtown Springfield Railroad District and the Holy Name of Jesus Complex in Worcester.
- As the Preliminary Alternatives contemplate an increase in passenger trains moving near or through these historic pedestrian-oriented areas, ensuring safe mobility for all may require safety improvements at potential

intersections, such as installing new active warning devices at at-grade crossings where such measures do not currently exist.

- **Transportation Infrastructure**
  - **At-Grade Crossing Warning/Safety Systems**
    - These junctions are the site of potential conflicts between new East-West trains and other forms of traffic moving along the public ROW. As the frequency and speed of new passenger trains along the Corridor increases, the need for enhanced protective equipment to strongly reinforce safe train, automobile, and pedestrian behavior also increases.
    - Based on the relatively modest level of increase in train volumes and scheduled speeds, capital funding to support a large at-grade crossing enhancement program was not included in Alternatives 1 and 2. However, this approach was predicated on the notion that, as any project advances further into design, a detailed engineering analysis of each at-grade crossing would be undertaken to determine exactly what types of improvements would be necessary.
    - As train speed and service frequency increase, Alternatives 3 through 6 would require modifications to existing at-grade crossings to ensure safe passenger rail operations while achieving higher speeds.
    - Of the 38 at-grade crossings along the existing rail corridor, Alternatives 3 and 4 would implement improvements at 30 crossings, including 18 locations along the western segment and four between Springfield and Worcester. Alternatives 3 through 5 each propose improvements to the same eight at-grade crossings located between Worcester and Boston.
    - Along the Springfield to Worcester segment, Alternative 5 would require improvements at a total of 11 crossings.
    - Alternative 6 would require grade crossing improvements along the “shared” segments that would run parallel to the existing CSX alignment connecting with downtown stations in Springfield and Worcester.
  - **Bridges**
    - Each Preliminary Alternative would entail rehabilitation or construction of undergrade or overhead bridges along the proposed rail alignment.
    - Most of the undergrade bridge impacts for each Preliminary Alternative would occur between Springfield and Worcester. In this segment, the development of a separate passenger-only track would result in substantially higher undergrade bridge impacts than simply restoring the double-track.
      - Alternatives 3 and 4 include 0.22 miles of undergrade bridge impacts within the western segment while Alternative 6 would generate 7.24 miles.
      - Alternative 6 has long segments of elevated rail viaduct, resulting in the fewest impacts to overhead bridges (nine).
      - While the restoration of double-track between Pittsfield and Springfield would affect five overhead bridges in Alternatives 3 and 4, Alternative 6’s alignment would only impact one bridge along the western segment.

    - » The use of a new corridor for passenger rail service between Worcester and Route 128/ Riverside would cause impacts to six existing overhead bridges in Alternative 6.
- **Property and Building Impacts**
    - Property impacts range from a minimum of 72 parcels across 124 acres under Alternatives 1 and 2 to a maximum of 1,202 parcels covering over 1,300 acres in Alternative 6.
    - The Pittsfield-Springfield segment in Alternatives 3 and 4 would generate impacts to 28 properties over nearly 45 acres while Alternative 6's alignment would result in 518 acres of total impact.
    - Compared to Alternative 3 (72 parcels at 123.6 acres), property impacts between Springfield and Worcester under the shared corridor, separate track alternatives would be much higher, with Alternative 4 carrying 531 parcels at 329.2 acres and Alternative 5 touching 486 parcels at 319.9 acres.
    - Alternative 6 impacts the most parcels, as it has the largest footprint outside an established transportation corridor, and has several transition segments that are not adjacent to existing transportation ROW. This includes sections in West Springfield, Lee, Springfield, and Millbury, where it connects to the existing rail line from the Turnpike alignment.
    - Preliminary Alternatives 1 through 3 entail only the restoration of missing double-track segments and development of new passing sidings, which would not result in any direct impacts to existing buildings.
    - For Alternatives 4 through 6, the magnitude of the building impacts parallels the parcel impacts, with the alternatives that would have greater parcel impacts having correspondingly higher building impacts. These building impacts are concentrated in older built-up areas around Pittsfield, Springfield, Palmer, Warren, and Worcester. This is especially true in Springfield and Worcester, where all the alternatives are adjacent to the existing track and where industrial development has historically been located near the railroad.
        - Alternative 6 is the only Preliminary Alternative that would have building impacts west of Springfield and east of Worcester.

4.6. Final Alternatives

The Preliminary Alternatives and the results of the alternatives evaluation were presented to the Advisory Committee, East – West Corridor stakeholders, and members of the public at the series of meetings held in 2019 and 2020. The feedback and priorities from these study participants, which were central to developing the three Final Alternatives, are summarized below.

- Strong opposition to a bus service for communities west of Springfield
    - Bus service is not an acceptable substitute to new rail connections along any part of the Corridor
    - Alternatives that do not serve Pittsfield and other towns west of Springfield are not acceptable
- Direct rail service to smaller corridor communities (e.g., Chester and Palmer) is important
- Preference for fast and frequent service
- Desire to launch the service as soon as possible
- Re-examine ridership forecasts and methodologies and to include any modifications in the Final Alternatives

As a result of the consensus opposition to bus service west of Springfield, Alternatives 1, 2, and 5 were eliminated from consideration for the Final Alternatives.

Further, Advisory Committee members, residents, and stakeholders expressed a preference for Final Alternatives that make use of the Boston – Albany rail corridor. Although Alternative 6 would deliver higher speeds and more than twice as many boardings as Alternatives 4 and 5, implementing a new electrified rail line would entail capital spending that is more than five times greater than the next costliest alternative (Alternative 5). In addition, this alternative would also generate land-based environmental and community impacts that would typically be two to three times as high as Alternative 4. Relative to other Preliminary Alternatives, Alternative 6 would require a greater level of effort and coordination to secure any federal, state, and local permits that may be necessary to advance the project. Given the much greater increase in cost and impacts relative to the increase in benefits, Alternative 6 was not advanced for further evaluation.

Advancing the Final Alternatives

The three Final Alternatives evaluated in the second phase of alternatives analysis all have the following characteristics:

- Rail operations for the full East – West Corridor, from Pittsfield to Boston, via the Boston – Albany railroad mainline.
- Service to all stations in the Corridor, including the smaller intermediate communities: Pittsfield, Chester, Springfield, Palmer, Worcester, Lansdowne, Back Bay, and South Station.

The Final Alternatives comprise:

- Final Alternative 3 (same as Preliminary Alternative 3)
- Final Alternative 4 (same as Preliminary Alternative 4)
- A new hybrid alternative – Final Alternative 4/5 – that combines elements of Preliminary Alternative 4 (i.e. rail service to the Pittsfield – Springfield segment, service to all stations) with elements of Preliminary Alternative 5 (i.e. additional travel time savings along the Springfield – Worcester segment)

The resulting three Final Alternatives have the same alignment and infrastructure improvements for two out of three major Corridor segments: Pittsfield – Springfield and Worcester – Boston. The three Final Alternatives have capital costs, environmental impacts, and community impacts that are identical for these segments.

Therefore, when comparing the Final Alternatives, any change in cost or land-based environmental and community impacts is due to the use of a different infrastructure approach along the central Springfield – Worcester segment. Although ridership is tied to service frequency, which varies among Alternative 3 (seven new weekday round trips) and Alternatives 4 and 4/5 (nine new weekday round trips), travel times are another key influencing factor and they are also based on the alignments and infrastructure proposed for each Final Alternative.

On the next page, Table 4-11 provides an overview of the key service characteristics for each of the Final Alternatives, while Table 4-12 (page 74) shows average travel times to/from Boston, along with key service and maintenance assumptions.

Final Alternatives 3 and 4 were described in detail in Section 4.3, Preliminary Alternatives. A small number of refinements were made to the Preliminary Alternative capital costs, environmental and community impacts and incorporated into the Final Alternatives. For convenience and ease of comparison, the summary graphics are re-presented on pages 75 and 76 for Alternatives 3 and 4. The new Final Alternative, Alternative 4/5, is described and similarly summarized beginning on page 78.

Table 4-11 – Passenger Rail Service Characteristics and Scheduled Travel Times (Final Alternatives)

METRIC /	ALTERNATIVE	EXISTING	3	4	4/5 HYBRID
CORRIDOR TYPE	ALIGNMENT	SHARED + EXISTING	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE
FREQUENCY	RAIL ROUND TRIPS	1	8	10	10
PITTSFIELD – BOSTON	AVERAGE END-TO-END SPEED (MPH)	39.3	47.8	50.5	53.5
PITTSFIELD – BOSTON	END-TO-END TRAVEL TIME RANGE	3:50	3:05 – 3:20	2:55 – 3:10	2:45 – 3:00
SPRINGFIELD – BOSTON	AVERAGE END-TO-END SPEED (MPH)	39.9	50.4	55.1	60.8
SPRINGFIELD – BOSTON	END-TO-END TRAVEL TIME RANGE	2:28	1:50 – 2:05	1:40 – 1:55	1:30 – 1:45
TRAVEL TIME (BOSTON)+	PITTSFIELD	3:50	3:09	2:59	2:49
TRAVEL TIME (BOSTON)+	LEE	-	-	-	-
TRAVEL TIME (BOSTON)+	CHESTER	-	2:38	2:28	2:18
TRAVEL TIME (BOSTON)+	BLANDFORD	-	-	-	-
TRAVEL TIME (BOSTON)+	SPRINGFIELD	2:28	1:57	1:47	1:37
TRAVEL TIME (BOSTON)+	PALMER	-	1:40	1:31	1:23
TRAVEL TIME (BOSTON)+	WORCESTER	1:15	0:53	0:53	0:53
TRANSFERS	PITTSFIELD	Direct Rail	Direct Rail	Direct Rail	Direct Rail
TRANSFERS	SPRINGFIELD	Direct Rail	Direct Rail	Direct Rail	Direct Rail
TRANSFERS	CTrail HARTFORD LINE / AMTRAK VERMONTER	Rail Transfer at SPG	Rail Transfer at SPG	Rail Transfer at SPG	Rail Transfer at SPG

+ AVERAGE TRAVEL TIME TO/FROM BOSTON (Hours: Minutes)

Table 4-12 – Operations, Segment-Level Metrics, Equipment, Fleet & Maintenance Characteristics (Final Alternatives)

METRIC /	ALTERNATIVE	EXISTING	3	4	4/5 HYBRID
CORRIDOR TYPE	ALIGNMENT	SHARED + EXISTING	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE
FREQUENCY	TRAIN ROUND TRIPS	1	8	10	10
FREQUENCY	BUS ROUND TRIPS	0	0	0	0
PITTSFIELD – SPRINGFIELD	MAX. SCHEDULED SPEED (MPH)	50	65	65	65
PITTSFIELD – SPRINGFIELD	AVERAGE SEGMENT SPEED	38.3	43.7	43.7	43.7
PITTSFIELD – SPRINGFIELD	AVERAGE SEGMENT TRAVEL TIME	1:22	1:12	1:12	1:12
SPRINGFIELD – WORCESTER	MAX. SCHEDULED SPEED (MPH)	60	85	100	105
SPRINGFIELD – WORCESTER	AVERAGE SEGMENT SPEED	44.4	50.6	60.0	73.6
SPRINGFIELD – WORCESTER	AVERAGE SEGMENT TRAVEL TIME	1:13	1:04	0:54	0:44
WORCESTER – BOSTON	MAX. SCHEDULED SPEED (MPH)	75	85	85	85
WORCESTER – BOSTON	AVERAGE SEGMENT SPEED	35.4	50.2	50.2	50.2
WORCESTER – BOSTON	AVERAGE SEGMENT TRAVEL TIME	1:15	0:53	0:53	0:53
EQUIPMENT ASSUMPTIONS	TRAINSETS	2	7	8	8
EQUIPMENT ASSUMPTIONS	TRAINSET TYPE	Diesel	Diesel	Diesel	Diesel
EQUIPMENT ASSUMPTIONS	BUSES	0	0	0	0
FLEET REQUIREMENTS	TOTAL RAIL CARS	8	31	35	35
FLEET REQUIREMENTS	TOTAL BUSES	0	0	0	0
DAILY REVENUE MILES	TRAIN MILES	400	2,196	2,588	2,553
DAILY REVENUE MILES	RAIL CAR MILES	3,600	12,278	14,540	14,365
DAILY REVENUE MILES	BUS MILES	0	0	0	0
LAYOVER+	PITTSFIELD (TRACKS)	0	3	3	3
LAYOVER+	SPRINGFIELD (TRACKS)	0	1	1	1
LAYOVER+	BOSTON (TRACKS)	1	3	3	3

+ OVERNIGHT LAYOVER LOCATIONS (TRACKS)

Figure 4-11 – Final Alternative 3 – Passenger Rail, Pittsfield – Boston, on Upgraded Existing Railroad Tracks

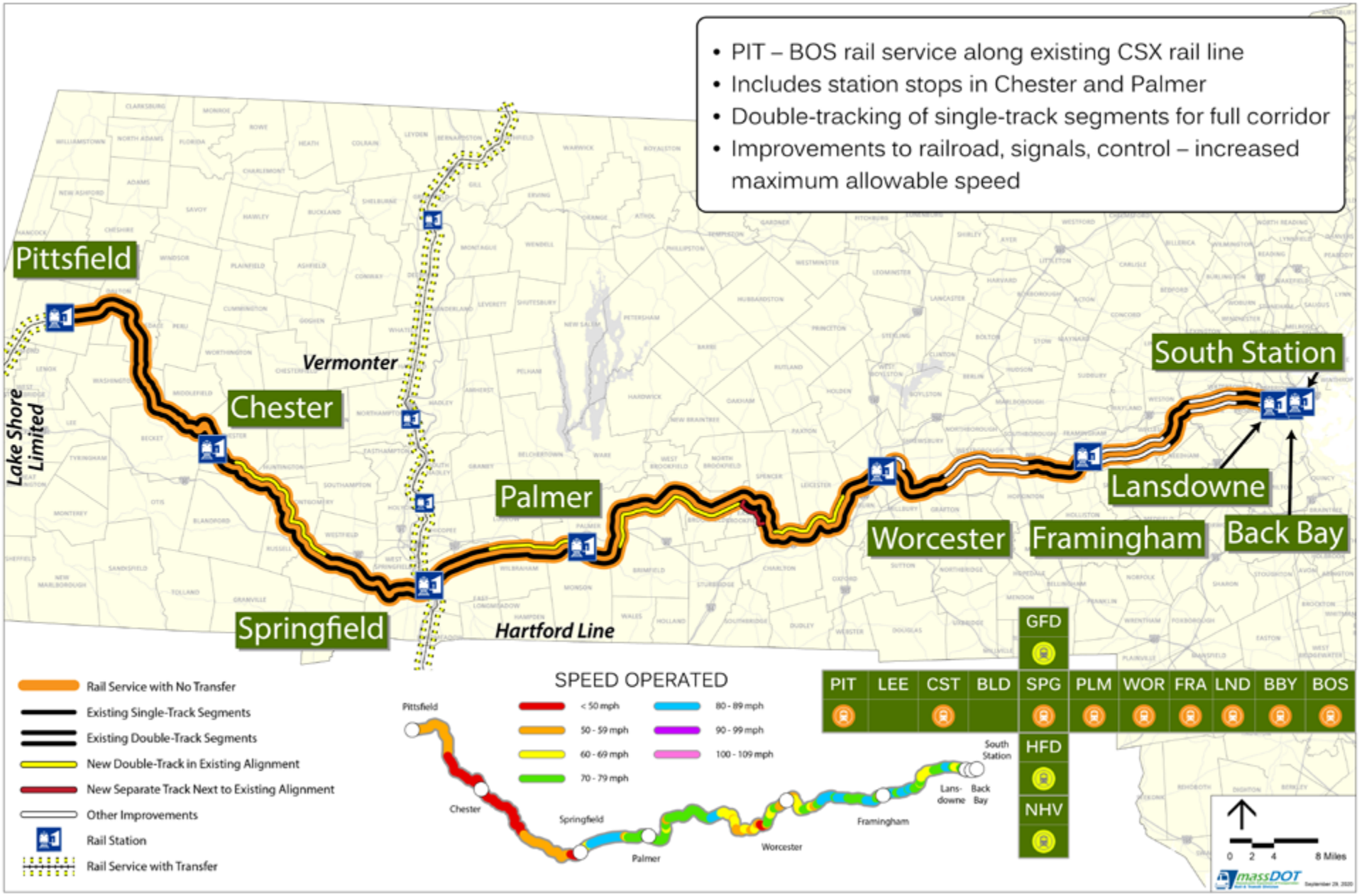


Figure 4-12 – Final Alternative 4 – Passenger Rail, Pittsfield – Boston: Upgraded Existing Rail (PIT – SPG), New Rail in CSX Corridor (SPG – WOR)

Alternative 4/5 Hybrid: Passenger Rail between Pittsfield and Boston with New Track and Priority High-Speed Realignments

The hybrid alternative combines advantages of Preliminary Alternative 4 and Preliminary Alternative 5, while addressing concerns expressed by the Advisory Committee, residents, and other stakeholders. Final Alternative 4/5 provides the same direct rail connections west of Springfield, as well as at Palmer, as in Alternative 4. Final Alternative 4/5 would realize an additional 10-minute travel time savings between Springfield and Worcester by including the seven high-speed curve realignments (shortcuts) and grade crossing consolidations identified within Preliminary Alternative 5, offering Springfield – Boston travel times that approach 1:30 and Pittsfield – Boston journeys typically completed in 3:00 hours.

Figure 4-13 on page 78 shows the proposed infrastructure improvements and key characteristics of Final Alternative 4/5. These improvements would decrease travel times by straightening the slowest, most problematic curves in the central segment of the railroad, enabling sustained high-speed operations over long stretches of the rail line as opposed to frequently decelerating and accelerating through the slow speed curves that greatly reduce the total capability to travel quickly. The hybrid alternative also improves multimodal safety by converting three at-grade crossings into two overhead bridges (i.e., road runs above railroad).

Table 4-13 (page 79) presents a summary of key metrics for each proposed shortcut or improvement while Figure 4-14 shows a map of the approximate locations for these segments.

Aside from the changes between Springfield and Worcester, all key infrastructure and service characteristics, including the provision of up to nine new weekday rail round trips, would be identical under both Alternative 4/5 Hybrid and Alternative 4 to facilitate reasonable comparisons among alternatives with similar levels of infrastructure investment.

Figure 4-13 – Final Alternative 4/5 Hybrid – Passenger Rail, Pittsfield – Boston: Upgraded Existing Rail (PIT – SPG), New Rail with Priority Realignments (SPG – WOR)

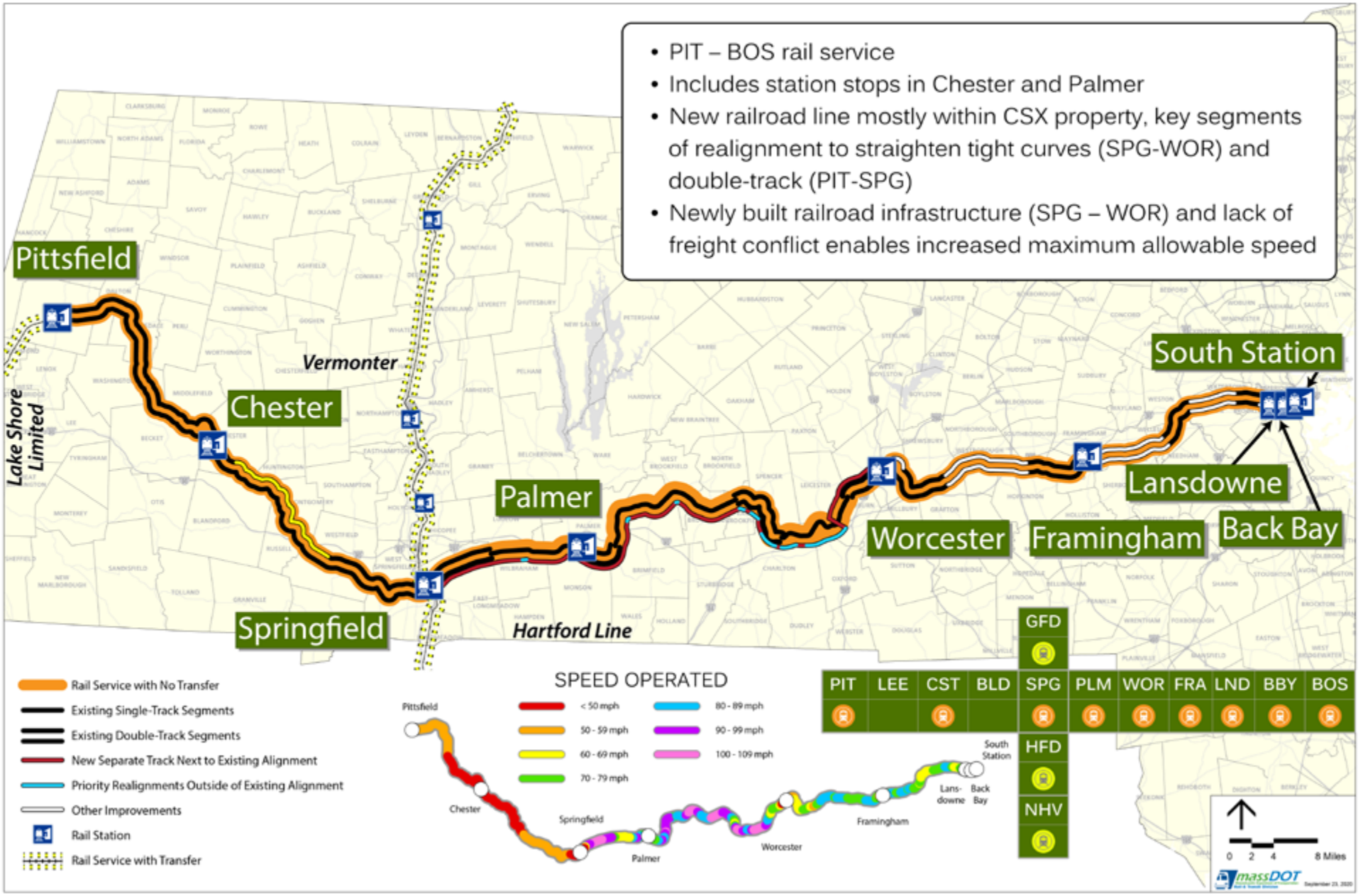
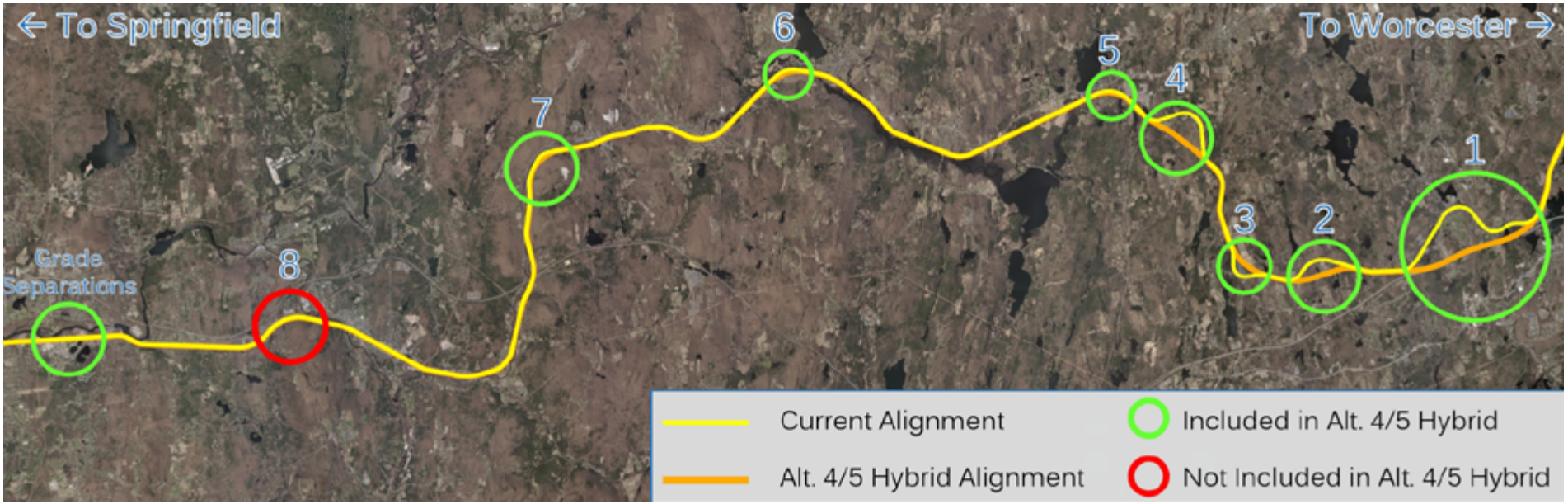


Table 4-13 – Key Metrics for Shortcuts Considered in Final Alternative 4/5 Hybrid

SHORTCUT	LOCATION	LENGTH DECREASE (MI)	TRAVEL TIME SAVINGS	NET COST ($2020 M)	RATE ($M/min)
1	Auburn, Oxford, Charlton	0.64	03:58	$199	$50
2	Charlton	0.14	00:13	$61	$269
3	Charlton	0.24	01:32	$86	$56
4	Spencer	0.47	01:35	$330	$209
5	East Brookfield	0.04	00:28	$52	$110
6	West Brookfield	0.04	00:28	$6	$12
7	Warren	0.05	01:14	$5	$4
8	Monson (*Not Feasible)	NA	NA	NA	NA
GRADE SEPARATE CROSSINGS	Wilbraham (Consolidate 3 Crossings into 2 Overhead Bridges)	0.00	00:52	$27	$30

** - Note: The realignment in Monson is classified as "not feasible" because while the track could be realigned, doing so would not offer benefit because an adjacent curve (that cannot be straightened) prevents the trains from going any faster through that segment.*

Figure 4-14 – Map of Shortcuts Considered for Final Alternative 4/5 Hybrid



4.7. Evaluation of Final Alternatives

During the evaluation of the Preliminary Alternatives, members of the Advisory Committee, residents, and stakeholders inquired about differences between the ridership and capital costs developed for the East – West study Preliminary Alternatives and the ridership and capital cost estimates developed for the previous NNEIRI study. Study participants noted the NNEIRI analysis had indicated higher total ridership at a lower capital cost for the section of the East – West Corridor common to both studies (i.e., Springfield – Boston). The NNEIRI process was discussed in Section 2.3; these differences in ridership and cost resulted from the following differences in the study analysis:

- Geographic Coverage
  - NNEIRI had a much larger geographic extent and focused on longer distance high-speed rail trips between Boston and Montreal, Boston and New York, and Montreal and New York. The higher NNEIRI ridership forecasts were mostly due to these longer trips, especially from those made along the New York City/ Hartford Line segment. When comparing only the same geographic connections, the ridership estimates for NNEIRI and the initial ridership estimates for the East – West Preliminary Alternatives are nearly identical.
  - NNEIRI did not consider an alternative that extended west of Springfield. This segment, where the corridor winds through mountainous terrain and crosses the Westfield River 22 times, adds significant costs.
- Bridge Reconstruction Costs – NNEIRI's alignments and cost estimates did not reflect CSX's guidelines for physical separation of restored double-track segments. These standards necessitate reconstruction rather than rehabilitation of many bridges, at a much higher cost. In addition, NNEIRI did not reflect utility relocation costs, which are another major expense.

In evaluating the Final Alternatives, elements of the East – West study's technical approach to estimating ridership and capital costs were reviewed and refined.

Ridership Forecasts. Members of the Advisory Committee, residents, and stakeholders expressed concerns that the ridership forecasts for the Preliminary Alternatives were low relative to other rail lines in the region, such as the Downeaster Line from Brunswick, Maine to Boston and the newly launched CTrail Hartford Line between New Haven, Connecticut and Springfield. The feedback included questions about specific modeling assumptions, such as the distance from which each station can draw potential riders, and whether the ridership forecasts include "induced demand," which is an increase in total travel demand that results from improved access or convenience acting as a catalyst to further economic activity.

As discussed in Section 4.4, Evaluation Criteria, coefficients in the travel forecasting model were adjusted to better reflect the downtown Boston market's demand and a second proxy service was added to provide a range of potential forecasts . The ridership forecasting for the Final Alternatives evaluation was re-run, with the following adjustments:

- Two ridership forecasts were conducted for each Final Alternative, yielding a lower-end and a higher-end forecast range
- The ridership forecasts used two different base proxy railroad services: an enhanced Hartford Line (same route but with refined attributes as the Preliminary Alternatives) and a Downeaster Line proxy.
- Both of the ridership models were carefully calibrated with specific adjustments to enhance the validity of the assumptions

Table 4-14 on the next page provides a summary of the review and the updates made in the ridership forecasting model for the evaluation

of Final Alternatives. Under the "Enhanced" Hartford Line scenario, the initial proxy station pairs used to forecast ridership for Preliminary Alternatives were adjusted to better reflect the large pull of the Boston market and to factor in a level of induced demand into the estimates. For the Downeaster proxy, the existing service to North Station already captured the attractiveness of the Boston central business district with respect to travel demand. Since Downeaster Service has been operating for a decade, it was considered matured with any induced demand effects already present in the level of travel. Therefore, no additional induced demand was applied to the proxy forecasts.

The 2040 annual ridership forecasts for each Final Alternative, with "Enhanced" Hartford Line and Downeaster Line modeling assumptions, are shown in Table 4-15 on the following page, along with the change in annual auto and rail trips and vehicle miles traveled (VMT) in 2040.

- As with the Preliminary Alternatives, ridership increases in concert with level of infrastructure investment, travel speed, and service frequency. Final Alternative 4/5 has higher forecast ridership compared to Alternative 4, which in turn has more boardings than Alternative 3.
- For each alternative, the Downeaster scenario has higher forecast ridership compared to the "Enhanced" Hartford Line, with increases ranging between 19 to 29 percent and gains at all stations except Framingham. The strongest relative gains occur in Chester, Pittsfield, Springfield (Hartford Line Transfers), and Worcester (Direct Access).
- For the "Enhanced" Hartford Line, approximately 85 percent of ridership is forecasted to occur within the Springfield-Boston market, followed by approximately seven percent of ridership between the Palmer-Boston and Pittsfield-Chester markets and six percent between Palmer-Boston and the Hartford Line.

Table 4-14 – Summary of Refinements to Ridership Modeling (Final Alternatives)

MARKET / MODEL FACTOR	"ENHANCED" HARTFORD LINE	DOWNEASTER
BOSTON REPRESENTATION	Adjusted to better reflect the large pull of Boston employment	Included directly in Downeaster baseline
MARKET COMPETITION	Adjusted for Hartford Line having more medium or large competitive markets (i.e., New York, Hartford, New Haven)	Adjusted for Downeaster not having any other medium or large competitive markets (only Boston)
TRIP DISTANCE	Switched to longer-distance station pairs to reflect a better mix of intercity and commuter travel	Long trip distances match well with Downeaster station pairs
MARKET TYPES / PROXY PAIRS	Refined station pairs to better match on market types (rural, urban, demographics, etc.)	Refined station pairs to better match on market types (rural, urban, demographics, etc.)
DEMOGRAPHIC BUFFERS	Released constraint on Springfield buffer to reduce required rail transfers and incorporate additional communities, like the 5 Colleges Area.	Released constraint on Springfield buffer to reduce required rail transfers and incorporate additional communities, like the 5 Colleges Area.
INDUCED DEMAND	Added into final forecast	Assumed included in Downeaster baseline proxy ridership

Table 4-15 – Ridership Results (Final Alternatives) – 2040 Annual One-Way Boardings and Change in Vehicle Miles Traveled

METRIC / STATION	ALTERNATIVE / BOARDING TYPE	3 "ENHANCED" HARTFORD LINE	3 DOWNEASTER	4 "ENHANCED" HARTFORD LINE	4 DOWNEASTER	4/5 HYBRID "ENHANCED" HARTFORD LINE	4/5 HYBRID DOWNEASTER
PITTSFIELD	DIRECT ACCESS	11,400	27,650	13,650	31,500	14,650	33,400
LEE	DIRECT ACCESS	--	--	--	--	--	--
CHESTER	DIRECT ACCESS	1,400	4,200	1,700	4,700	1,850	5,000
BLANDFORD	DIRECT ACCESS	--	--	--	--	--	--
SPRINGFIELD	TRANSFERS (HARTFORD LINE)	10,250	22,200	10,500	21,150	11,250	23,600
SPRINGFIELD	DIRECT ACCESS	105,700	116,750	135,700	140,600	152,400	159,500
PALMER	DIRECT ACCESS	4,950	6,550	6,050	7,100	6,500	8,000
WORCESTER	TRANSFERS (MBTA)	6,400	9,450	7,250	9,550	8,100	11,350
WORCESTER	DIRECT ACCESS	19,300	35,250	23,250	39,500	25,500	43,250
FRAMINGHAM	LAKE SHORE LIMITED	1,550	650	1,550	450	1,750	800
BOSTON, BACK BAY & LANSDOWNE	DIRECT ACCESS	117,350	135,550	149,700	161,500	169,200	184,100
ALL STATIONS	TOTAL ONE-WAY BOARDINGS	278,300	358,250	349,350	416,050	391,200	469,000
ALL STATIONS	ANNUAL VMT CHANGE – AUTO	(23,371,876)	(31,234,674)	(29,497,986)	(36,318,653)	(33,042,389)	(40,831,308)
ALL STATIONS	ANNUAL VMT CHANGE – RAIL	509,540	509,540	798,620	798,620	785,845	785,845

Note: Negative values reflect a decrease in VMT for a given mode/alternative.

- For the Downeaster modeling assumptions, between 70 and 74 percent of ridership occurs in the Springfield-Boston market, followed by 15 percent between the Palmer-Boston and Pittsfield-Chester markets and about 10 percent between Palmer-Boston and the Hartford Line.
- Within each alternative, the two modeling scenarios generally estimate a similar number of trips for the Springfield-Boston market. However, the relative proportions differ because the Downeaster scenario's total ridership is substantially higher and, more importantly, much of its forecasted ridership occurs along longer segments (i.e., Pittsfield-Chester to Palmer-Boston or Palmer-Boston transfers to the Hartford Line) relative to the results for the "Enhanced" Hartford Line scenario.
- The number of transfers between the Hartford Line and East-West service in Springfield stays approximately the same across alternatives for a given modeling scenario, as do the MBTA

Commuter Rail transfers in Worcester.

- For each Final Alternative, direct access trips at Springfield (90 percent) and Worcester (80 percent) accounted for most of the boardings, not transfers to/from the Hartford Line (10 percent) or MBTA Commuter Rail (20 percent). The strong proportion of direct access trips to these stations reflects the model's built-in assumption of a transfer penalty. Since passengers must spend additional time switching between East-West trains and MBTA or Hartford Line services, there is a relatively lower demand for connections between these services than if they were modeled as thru-running trains (e.g., if a one-seat rail journey was offered between Hartford and Worcester).
- Comparing the scenarios, the Downeaster Line is approximately twice as long as the Hartford Line and its longer segments tend to align better with the spacing between the markets considered along the East-West Corridor. In terms of market size, the Downeaster includes many small communities connecting to a major market (Boston) while the Hartford Line consists primarily of medium-sized markets connecting either with each other or gravitating towards the nation's largest market (New York City).

Project Costs

The Final Alternatives analysis entailed a review and refinement of the cost estimates. In response to the comments from study participants, capital costs for the Preliminary Alternatives – including quantities of infrastructure investment, costs assumptions for each unit of those investments, and contingency assumptions – were all thoroughly reviewed and clarified as appropriate. The revised capital cost estimate for each Final Alternative is presented in Table 4-16 on the next page, including the cost for each major cost component (SCC) and geographic segment, along with annual O&M costs.

- **Capital Cost Estimates.** The review and refinement of capital costs resulted in the following revisions to the capital costs:
  - The unit cost for track realignment in the Worcester to Boston segment was refined based on a reevaluation of the degree of improvement required. The cost estimates for the Preliminary Alternatives priced the proposed upgrades to existing track like new track. In the revised costs, a new, lower cost assumption was introduced to more appropriately account for the upgrades.
  - Utility relocation unit costs were broken out into urban and rural utility upgrades. The cost estimates for the Preliminary Alternatives treated all utility relocation costs the same and used a higher "urban" utility relocation costs. However, considering the reduced density and complexity of utilities in more rural areas, the utility relocation cost was broken down to include a lower "rural" utility relocation cost.
  - Retaining wall costs were refined to reflect the difference in complexity of construction for retaining walls built adjacent to existing shared passenger/freight tracks vs. retaining walls built for new passenger-only track.

The Unallocated Contingency, which is a cost increment to reflect general uncertainty and unknown factors in project development, was reduced from 10 percent to 5 percent. Both are generally consistent with FRA guidance, which calls for 5 to 8 percent Unallocated Contingency, but the new assumption results in a capital cost that is relatively lower than that presented previously for the same suite of improvements.

Table 4-16 – Summary Capital Costs by Standard Cost Category (SCC) and Segment, and Annual Operations & Maintenance Costs (2020 Million Dollars)

METRIC /	ALTERNATIVE	3	4	4/5 HYBRID
COST BASIS	TYPE	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE
CAPITAL BY CATEGORY	10 GUIDEWAY & TRACK ELEMENTS	$643.059	$972.301	$1,358.746
CAPITAL BY CATEGORY	20 STATIONS, STOPS, TERMINALS	$24.720	$28.325	$28.325
CAPITAL BY CATEGORY	30 SUPPORT FACILITIES	$31.930	$31.930	$31.930
CAPITAL BY CATEGORY	40 SITEWORK & SPECIAL CONDITIONS	$449.700	$857.987	$889.435
CAPITAL BY CATEGORY	50 SYSTEMS	$75.974	$91.628	$88.973
CAPITAL BY CATEGORY	CONSTRUCTION SUBTOTAL (10-50)	$1,225.383	$1,982.171	$2,397.409
CAPITAL BY CATEGORY	CONSTRUCTION CONTINGENCY (35%)	$428.884	$693.760	$839.093
CAPITAL BY CATEGORY	CONSTRUCTION TOTAL	$1,654.266	$2,675.931	$3,236.503
CAPITAL BY CATEGORY	60 ROW, LAND, EXISTING IMPROVEMENTS	$16.605	$41.644	$41.867
CAPITAL BY CATEGORY	70 VEHICLES	$131.840	$155.736	$155.736
CAPITAL BY CATEGORY	80 PROFESSIONAL SERVICES (30%)	$496.280	$802.779	$970.951
CAPITAL BY CATEGORY	SUBTOTAL (10-80)	$2,298.991	$3,676.091	$4,405.056
CAPITAL BY CATEGORY	90 UNALLOCATED CONTINGENCY (5%)	$114.950	$183.805	$220.253
CAPITAL BY CATEGORY	100 FINANCE CHARGES	$0.000	$0.000	$0.000
CAPITAL BY CATEGORY	TOTAL PROJECT COST (10-100)	$2,413.940	$3,859.895	$4,625.309
CAPITAL BY SEGMENT	PIT-SPG	$527.409	$527.409	$527.409
CAPITAL BY SEGMENT	SPG-WOR	$1,825.234	$3,271.189	$4,036.603
CAPITAL BY SEGMENT	WOR-BOS	$61.297	$61.297	$61.297
ANNUAL O&M	RAIL	$27.900	$34.094	$33.895

These were the only significant changes to the unit costs, but each of these refinements resulted in a modest reduction in capital costs. As a result of these revisions, the capital cost of Final Alternative 3 is approximately 15 percent lower than that of Preliminary Alternative 3, while the capital cost of Final Alternative 4 is about 13 percent lower than Preliminary Alternative 4.

Since Preliminary Alternative 5 did not include passenger rail service west of Springfield, the overall capital cost for Final Alternative 4/5 is not directly comparable to any of the Preliminary Alternatives. However, along the Springfield to Worcester segment, the revised capital costs for Final Alternative 4/5 are nearly 19 percent less than Preliminary Alternative 5.

As noted above, in comparing the Final Alternatives, all differences in capital costs are due to variations in infrastructure in the Springfield – Worcester segment of the Corridor. The following are key takeaways related to incremental differences in capital costs among the Final Alternatives.

- Exchanging the restoration of double-track along a shared freight-passenger corridor (Alternative 3) in favor of developing a separate passenger-only track between Springfield and Worcester parallel to the existing alignment (Alternative 4) is estimated to increase construction costs by $1,022 M when the 35% contingency is included.
- Introducing seven curve realignments and consolidating three at-grade crossings in Wilbraham into two overhead bridges (Alternative 4/5 Hybrid) would require an additional $561 M in construction costs, inclusive of the 35% contingency, beyond simply developing a parallel passenger-only track (Alternative 4).
- The "fully-loaded" costs associated with each individual shortcut, as well as the estimated travel time savings, length, and cost-efficiency were provided in Table 4-13 on page 79. It should be noted that the construction-based costs cited above were used to allow for comparisons between Final Alternatives with different service levels (and therefore vehicle requirements).
- As a means of benchmarking the East – West capital cost estimates, they were compared to capital costs for the South Coast Rail project, for which MassDOT recently awarded a construction contract. Both the East – West Passenger Rail Study and the ongoing South Coast Rail project use a common set of Massachusetts-specific source projects for establishing the unit costs. The South Coast Rail designer's estimate for construction costs came within 1.3 percent of the awarded construction bid, suggesting a high degree of accuracy in these cost estimates.
- The resulting per-mile capital cost for the East – West Final Alternatives is also in a comparable range to the per-mile capital cost for South Coast Rail. The South Coast Rail project entails $1.14 billion in capital costs to upgrade 36 miles of track, a rate of $31.7 million per mile. For the 151-mile length of the East – West project, the following are the capital costs and per-mile cost for the East – West Final Alternatives.
  - Alternative 3 $2.41 billion, $16.0 million per mile
  - Alternative 4 $3.86 billion, $25.6 million per mile
  - Alternative 4/5 $4.63 billion, $30.6 million per mile

- **Operating Cost Estimates.** The additional train trips proposed within Alternatives 4 and 4/5 Hybrid result in more mileage and higher annual O&M expenses relative to Alternative 3. The realignments proposed for Final Alternative 4/5 Hybrid produce a slightly shorter route between Springfield and Worcester, which results in a minor decrease in annual O&M spending compared to Alternative 4.

Environmental and Community Impacts

Since the shortcuts included within Alternative 4/5 establish new transportation corridors within the central segment, it would present a comparatively greater level of impact relative to Alternative 4, particularly within Auburn, Oxford, Spencer, East Brookfield, West Brookfield, Warren, and Charlton, which is home to three of the seven proposed shortcuts. The initial 0.64-mile shortcut spans segments of Auburn, Oxford, and Charlton.

- **Environmental Impacts.** Table 4-17 on the following page summarizes potential impacts to environmental resources, including waterways and waterbodies, flood-prone areas, and sensitive areas like wetlands, ACECs, and priority habitat.

Table 4-17 – Environmental Impacts (Final Alternatives)

	ALTERNATIVE	3	4	4/5 HYBRID
IMPACT TYPE	METRIC	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE
WATER CROSSINGS	COUNT	43	48	48
WETLANDS	COUNT	12	60	61
WETLANDS	TOTAL AREA (ACRES)	0.45	7.73	8.87
OPEN WATER	COUNT	5	15	32
OPEN WATER	TOTAL AREA (ACRES)	0.93	4.02	4.91
FLOODPLAINS+	COUNT	43	77	84
FLOODPLAINS+	TOTAL AREA (ACRES)	19.32	35.63	37.74
ACEC	COUNT	0	0	0
ACEC	TOTAL AREA (ACRES)	0	0	0
HABITAT++	COUNT	8	13	23
HABITAT++	TOTAL AREA (ACRES)	35.79	58.57	59.01

+ 100-YEAR FLOODPLAINS
++ PRIORITY HABITAT

- **Water Resources (Waterways, Wetlands, and Open Water Features)**
  - For each Final Alternative, the restoration of double-track between Pittsfield and Springfield would impact seven rivers or streams, two wetland resources, and one open water feature.
  - On the west side of Worcester, the Quaboag River would be affected under each Final Alternative; however, each alternative would impact the resource in different locations. Alternative 4/5 would present the highest impacts to this resource among the Final Alternatives.
  - Along the Springfield – Worcester segment, the comparatively limited profile of improvements for Alternative 3 would result in the lowest impacts, affecting a total of 36 rivers or streams, 10 wetland resources and four open water bodies.
  - Relative to Alternative 3, Alternative 4's development of a parallel passenger-only track along the central segment would result in increased impacts to water resources, including a total of 41 rivers or streams (five more), 58 wetland resources (48 more), and 14 open water features (10 more).
  - Compared to Alternative 4, the shortcut realignments included in Alternative 4/5 would produce increases in both the area of impacted wetlands resources (1.14 acres of additional impact to one additional resource relative to Alternative 4) and the number of impacted open water features (more than doubles to a total of 32 open water bodies).
  - The seven shortcuts in Alternative 4/5 affect 10 additional wetlands that are not affected by Alternative 3 or Alternative 4. These resources are located in Spencer, West Brookfield, Warren, East Brookfield, Auburn, Oxford and Charlton.
- **Floodplains**
  - In each Final Alternative, the implementation of double-track between Pittsfield and Springfield would result in 19 encroachments into the 100-year floodplain, covering nearly seven acres.

- Impacts to floodplains would be most prominent along the central segment where Alternative 3 would affect a total of 24 floodplain zones covering over 12 acres.
- Between Springfield and Worcester, the development of a passenger-only track would increase impacts, with the count of floodplains impacted rising to a total of 58 areas (34 more than Alternative 3) and the total area affected more than doubling (29 additional acres compared to Alternative 3).
- Alternative 4/5 carries another seven encroachments totaling 2.12 acres beyond Alternative 4.

○ **Areas of Critical Environmental Concern**

- None of the Final Alternatives anticipate impacts to any properties currently listed as an Area of Critical Environmental Concern.

○ **Protected Species Habitats**

- Alternative 3 would present the lowest impacts to priority habitats (eight habitats affected totaling over 35 acres) while Alternative 4/5 would exert the highest (23 habitats affected totaling 59 acres).
- Each Final Alternative would affect two primary habitat resources that located along the western segment for a total of nearly 16 acres of impacts. These facilities span portions of Montgomery, Huntington, Chester (PH 1375) and Westfield, Montgomery, and Russell (PH 1107). None of the Final Alternatives would result in impacts to priority habitats located along the eastern segment.
- Between Springfield and Worcester, impacts to priority habitats range from a low of eight habitats totaling 20 acres under Alternative 3 to a high of 21 habitats totaling over 43 acres in Alternative 4/5.
- Although the incremental impact associated with the hybrid's shortcuts only amounts to 0.14 acres of land, Alternative 4/5 has a higher level of encroachment, generating impacts to 10 more habitats between Springfield and Worcester than Alternative 4.

○ **Air Quality**

- Each of the Final Alternatives would generate a net increase in emissions despite a substantial decrease in 2040 annual auto-based VMT, as shown in Table 4 18 on the next page.
- The decrease in emissions from automobiles would not be sufficient to offset the additional emissions stemming from running diesel locomotives at the frequencies proposed.

○ **Noise & Vibration**

- Overall exposure to noise increases with both speed and frequency of service. Since Alternatives 4 and 4/5 proposed higher scheduled speeds and two new weekday rail round trips beyond Alternative 3, noise impacts would be relatively higher.
- Since they would introduce additional noise outside of an established transportation corridor, the shortcuts included within Alternative 4/5 would present relatively higher noise impacts than Alternative 4 despite operating the same service frequencies and similar scheduled speeds.

Table 4-18 – 2040 Annual Change in VMT and Associated Emissions Impacts (Final Alternatives)

METRIC / 2040 ANNUAL NET CHANGE	ALTERNATIVE TYPE / SCENARIO	3 "ENHANCED" HARTFORD LINE	3 DOWNEASTER	4 "ENHANCED" HARTFORD LINE	4 DOWNEASTER	4/5 HYBRID "ENHANCED" HARTFORD LINE	4/5 HYBRID DOWNEASTER
VMT	AUTO	(23,371,876)	(31,234,674)	(29,497,986)	(36,318,653)	(33,042,389)	(40,831,308)
VMT	RAIL	509,540	509,540	798,620	798,620	785,845	785,845
EMISSIONS (METRIC TONS)	CO2	8,433.21	7,023.03	14,497.05	13,273.78	13,544.84	12,147.92
EMISSIONS (METRIC TONS)	NOX	154.24	154.11	241.87	241.76	237.93	237.80
EMISSIONS (METRIC TONS)	PM	4.80	4.77	7.54	7.52	7.41	7.38
EMISSIONS (METRIC TONS)	SOX	0.08	0.07	0.14	0.13	0.13	0.12
EMISSIONS (METRIC TONS)	VOC	7.39	7.37	11.60	11.58	11.41	11.38

Note: Negative values reflect decreases in associated emissions (benefit) while positive values represent resulting increases in emissions (disbenefit).

- **Community Impacts.** Table 4-19 on the following page summarizes impacts to historic sites and districts, recreational and open space resources protected under Article 97, and existing at-grade crossings and bridges for the Final Alternatives.
  - **Cultural Resources & Historic Properties.** Historic properties and historic districts are subject to historic protections by virtue of being listed on the federal National Register of Historic Places.
    - Alternative 3 would generate the lowest impacts to historic sites (two) and districts (two) while Alternatives 4 and 4/5 would each entail impacts to a total of three sites and five districts.
    - Each Final Alternative would impact a historic Boston and Albany (B&A) Main Line bridge in West Brookfield (Long Hill Road) and at least one additional feature. Alternatives 3 and 4 would also impact another B&A Railroad bridge, this time along the western segment in Huntington (Basket St).
    - Alternatives 4 and 4/5 would both impact Palmer's historic Union Station. The hybrid alternative would also entail impacts to another historic site along the central segment – Cutler Company Grain Warehouse (West Brookfield).
    - For historic areas, each Final Alternative would impact one district between Pittsfield and Springfield (Huntington Village) and another along the central segment (West Brookfield Center). The separate track alternatives would also affect the Downtown Springfield Railroad District and two resources in Worcester (Holy Name of Jesus Complex and Blackstone Canal Historic District).
  - **Protected Lands**
    - **Article 97.** The number of Article 97 protected recreational and open space properties impacted would range from five resources spread over eight parcels at just over three acres (Alternative 3) to a maximum of 11 resources over 30 parcels at over 14 acres (Alternative 4/5).

Table 4-19 – Community Impacts (Final Alternatives)

METRIC /	ALTERNATIVE	3	4	4/5 HYBRID
IMPACT TYPE	METRIC	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE
HISTORIC SITES	COUNT	2	3	3
HISTORIC PROPERTIES	COUNT	2	5	5
HISTORIC PROPERTIES	TOTAL AREA (ACRES)	4.01	6.77	6.62
ARTICLE 97 LANDS	COUNT (RESOURCES)	5	9	11
ARTICLE 97 LANDS	TOTAL AREA (ACRES)	3.03	9.87	14.57
TRANSPORTATION	IMPROVED AT-GRADE CROSSING	30	30	27
TRANSPORTATION	UNDERGRADE BRIDGES (FT)	6,800	10,670	16,100
TRANSPORTATION	OVERHEAD BRIDGES	25	42	42

- Along the western segment, each Final Alternative would impact two Article 97-listed resources along the western segment spread across four parcels with just under three acres of impact, mainly the Tekoa Mountain WMA in Russell (2.96 acres) but also an area of the Chester-Blandford State Forest in Chester.
- Between Springfield and Worcester, Alternative 3 would have very limited impacts, touching three resources spread over four parcels covering just 0.06 acres. Each of the Final Alternatives would affect these resources, which include the Quaboag WMA (East Brookfield), Spencer State Forest (Spencer) and Bloomberg Patrick APR (Charlton).
- The development of a passenger-only track along the central segment increases impacts to Article 97 properties, with the impacted area under Alternative 4 increasing by a factor of over 100 (0.06 to 6.90 acres) and the number of affected resources rising from three to seven (four more) relative to Alternative 3.
- Alternative 4 would introduce impacts to Spectacle Pond Park (Wilbraham), Conservation Area (owned and managed by Town of Auburn), Fountain Enterprises Inc APR (West Brookfield), Railroad Park (Spencer), and additional portions of the Quaboag WMA (Brookfield) that would not be affected under Alternative 3.
- Although Alternative 4/5 would only touch two additional resources between Springfield and Worcester beyond Alternative 4, the realignments cause the total area impacted to grow by 68 percent (4.71 acres).
- Compared to Alternative 4, the hybrid would affect additional resources, including the Stafford Street Conservation Area (Charlton) and an unnamed area owned and managed by the Town of Auburn, and also affect new parcels that are portions of the Bloomberg Patrick APR (Charlton), Conservation Area (Auburn),

and a publicly-held portion of the Spencer State Forest owned by the Department of Conservation and Recreation (DCR).

- **Section 4(f).** Most of the open space and recreational resources protected by Article 97 would also be subject to federal Section 4(f) protection.
  - Alternative 3 would have minimal impacts to Section 4(f) protected recreational and open space properties.
  - The use of a passenger-only track in Alternatives 4 and 4/5 would entail an order of magnitude increase in impacts between Springfield and Worcester, which would make these options more difficult to advance compared to Alternative 3.
- **Section 6(f).** None of the open space resources that would be impacted were funded through the federal Land and Water Conservation Fund. Therefore, recreational and open space lands impacted would not be subject to protections under Section 6(f).

- **At-Grade Crossing Warning/Safety Systems**
  - Of the 38 at-grade crossings along the existing rail corridor, Alternatives 3 and 4 would implement improvements at 30 crossings, including 18 locations along the western segment, four between Springfield and Worcester, and eight from Worcester to Boston.
  - In addition to the shortcuts, Alternative 4/5 also includes the consolidation of three closely spaced at-grade crossings in Wilbraham into two overhead bridges.
  - While full grade separation comes at significant additional cost compared to installing or upgrading existing crossing protection infrastructure, this approach would reduce potential conflicts due to a proximate residential subdivision and two industrial properties that routinely rely on heavy vehicles with lower acceleration rates.
- **Bridges**
  - Each of the Final Alternatives includes the restoration of double-track between Pittsfield and Springfield, which would entail impacts to 0.22 miles of undergrade bridges and five overhead bridges along the western segment.
  - Between Springfield and Worcester, each of the Final Alternatives would generate undergrade bridge impacts that are higher than the previous alternative, with impacts ranging from 1.00 mile (Alternative 3) to 2.76 miles (Alternative 4/5).
  - Along the central segment, the hybrid's shortcuts carry an additional 1.03 miles of incremental impacts to undergrade bridges beyond Alternative 4.
  - With the move to a separate passenger-only track, impacts to overhead bridges located along the central segment increase by 85 percent, moving from 20 structures to 37 for both Alternative 4 and 4/5.
  - Each of the Final Alternatives includes 0.07-miles of adjustments to nine undergrade bridge structures located between Worcester and Boston.
- **Property and Building Impacts.** Table 4-20 on the following page summarizes right-of-way and building impacts under the three Final Alternatives. The improvements proposed for Alternative 3 would primarily fall within the existing railroad ROW, so they would have lower property impacts relative to the other two Final Alternatives which contemplate new separate passenger-only track segments and sidings.
  - Property impacts range from a minimum of 100 parcels across 168 acres under Alternative 3 to a maximum of 559 parcels covering nearly 374 acres in Alternative 4.
  - The Pittsfield-Springfield segment would generate

Table 4-20 – Property & Building Impacts (Final Alternatives)

METRIC /	ALTERNATIVE	3	4	4/5 HYBRID
PARCEL TYPE	METRIC	SHARED + EXISTING	SHARED + SEPARATE	SHARED + SEPARATE
ALL	COUNT	100	559	514
ALL	TOTAL AREA (ACRES)	168.4	373.9	364.6
NON-RAIL/ROAD	COUNT	47	423	400
NON-RAIL/ROAD	TOTAL AREA (ACRES)	16.5	77.3	99.2
BUILDINGS	RESIDENTIAL	0	26	34
BUILDINGS	COMMERCIAL	0	54	52
BUILDINGS	OTHER	0	12	12
BUILDINGS	TOTAL	0	92	98

impacts to 28 properties over nearly 45 acres. No impacts are anticipated along the eastern segment between Worcester and Boston.

- Along the central segment connecting Springfield and Worcester, property impacts range from a low of 72 parcels at nearly 124 acres in Alternative 3 to a maximum of 531 parcels totaling 329 acres for Alternative 4.
- Property impacts for the passenger-only track alternatives are higher than Alternative 3, with the count of parcels impacted increasing by a factor of five and the total area of impact growing by a factor of two.
- The realignments proposed within Alternative 4/5 avoid property impacts to 45 parcels and over nine acres of land between Springfield and Worcester, which would otherwise be impacted under Alternative 4, for a total of 486 parcels across 320 acres along the central segment.
- Each Final Alternative would result in property impacts to parcels under railroad, public, and private ownership. Although Alternative 4/5 appears to be less impactful than Alternative 4, it more or less transfers a similar area of total impacts to a more controversial form of ownership – privately-held parcels.
- While Alternative 4 only includes an additional nine acres relative to the hybrid, it has nearly 45 acres more land within the railroad-owned category. The use of the shortcuts in Alternative 4/5 effectively diverts impacts from railroad-owned parcels to an additional 22 acres of privately-owned land and 12 acres of public ROW compared to a parallel separate track.

Benefit-Cost Analysis. Based on the refined ridership forecasts and cost estimates, Table 4-21 on the next page shows the cumulative transportation-related benefits and costs anticipated for each Final Alternative after 30 years of operations (at a seven percent discount rate). The table also shows travel time savings, net present value, and benefit-cost ratio. The benefit-cost ratio, shown in the bottom row,

reflects the public sector's return on a given investment, with a value greater than one indicating that the project would generate societal benefits that are higher than the investment cost. The analysis follows current federal guidelines and formula to be compliant with established funding eligibility criteria. While other non-transportation metrics may be worthy of consideration in their own right, they have not been formally integrated into federal evaluations.

Table 4-21 – Benefit-Cost Summary at 7% Discount Rate (Final Alternatives)

	ALTERNATIVE	3	3	4	4	4/5 HYBRID	4/5 HYBRID
CATEGORY	TYPE / SCENARIO	"ENHANCED" HARTFORD LINE	DOWNEASTER	"ENHANCED" HARTFORD LINE	DOWNEASTER	"ENHANCED" HARTFORD LINE	DOWNEASTER
2040 TRAVEL TIME SAVINGS	PER RIDER (MIN)	27.7	22.6	35.8	30.9	42.8	37.8
2040 TRAVEL TIME SAVINGS	ANNUAL (HRS)	128,178	134,910	208,195	214,542	278,752	295,829
30-YEAR BENEFITS	TRAVEL TIME	$19	$20	$31	$32	$41	$44
30-YEAR BENEFITS	SAFETY	$64	$87	$81	$100	$91	$113
30-YEAR BENEFITS	VEHICLE COSTS	$62	$83	$79	$97	$88	$109
30-YEAR BENEFITS	PAVEMENT DAMAGE	$0.1	$0.2	$0.2	$0.2	$0.2	$0.3
30-YEAR BENEFITS	EMISSIONS	($25)	($24)	($39)	($39)	($38)	($38)
30-YEAR BENEFITS	RESIDUAL VALUE	$40	$40	$64	$64	$77	$77
30-YEAR BENEFITS	TOTAL BENEFITS	$162	$207	$215	$255	$259	$306
CUMULATIVE COSTS	CAPITAL	($1,669)	($1,669)	($2,678)	($2,678)	($3,208)	($3,208)
CUMULATIVE COSTS	O&M	($112)	($112)	($161)	($161)	($160)	($160)
CUMULATIVE COSTS	TOTAL COSTS	($1,781)	($1,781)	($2,839)	($2,839)	($3,368)	($3,368)
COST-EFFECTIVENESS	NET PRESENT VALUE	($1,619)	($1,574)	($2,624)	($2,585)	($3,109)	($3,063)
COST-EFFECTIVENESS	BENEFIT-COST RATIO	0.09	0.12	0.08	0.09	0.08	0.09

Note: Positive values represent net social improvements (benefits) while negative values reflect a net cost (disbenefit) to society.

The Final Alternatives could generate several transportation-related benefits, including:

- Travel time savings for passengers that would no longer be subject to automobile congestion, and for existing rail travelers that would experience faster speeds;
- Emissions reductions, vehicle operating cost savings, and reduced pavement damage, as travelers shift from driving to rail;
- Enhanced safety as vehicle miles traveled reductions lead to fewer automobile collisions; and
- Residual capital value remaining at the end of the analysis period.

However, in each of the six cases, the transportation-related benefits, by themselves, would not be sufficient to offset the capital investment required to implement a Final Alternative. It is important to note that the non-transportation benefits listed below were not investigated and are also generally not included in a transportation analysis. However, these topics may be worthy of exploring in greater detail during subsequent phases.

- Economic impacts of project, including increases in jobs, GDP, etc.
- Benefits to freight service
- “Transfers” in the form of fares, tolls, etc.