Green Line Extension Project

Analysis of the Boston Engine Terminal

for

The Purposes of Siting a Light Rail Vehicle Support Facility

During the alternatives analysis process for the Green Line Extension project, MassDOT and the MBTA evaluated the possibility of using a portion of the site of the existing Boston Engine Terminal (BET), which serves as the maintenance facility for the MBTA Commuter Rail fleet, for the construction of a new light rail vehicle support facility. The construction of such a facility is required for the successful implementation of the Green Line Extension project. The 'BET concept' was embraced by a number of project stakeholders, who felt that the conjoining of two MBTA vehicle support facilities would be preferable to the construction of a second, separate light rail support facility. In addition, some stakeholders sought to avoid the commercial property impacts required for the 'Option L' location, the location preferred and recommended by MassDOT and the MBTA. While MassDOT and the MBTA had, as part of the original alternatives analysis, considered and rejected the BET site as a viable alternative, MassDOT and the MBTA agreed to re-examine the issue.

The purpose of this white paper is to re-examine, in more depth, the ramifications of making use of a portion of the current BET site – either in conjunction with all of the current elements of the BET facility or by relocating certain elements – to construct a new light rail vehicle maintenance and storage facility that can support the Green Line Extension project. The paper provides an overview of the current BET site and operations, the functional and geographic needs of the new light rail support facility, and the overwhelming challenges of trying to co-locate the two vehicle support facilities on the existing BET site. This paper has been structured around a series of core questions related to the location of a light rail vehicle support facility within the existing BET site.

Additionally, this white paper serves to provide some background on the need for a light rail vehicle maintenance facility and the importance of siting the facility within the Green Line Extension corridor.

1. **Why does the light rail vehicle support facility need to accommodate 70-80 vehicles when only 24 new Green Line vehicles are needed to make the Green Line Extension operate?**

When planning a new transit service or extension of existing transit service, there are many important factors that influence the siting and design of a new vehicle maintenance facility, including its necessary size, orientation, location, proximity to the service, costs, operational impacts, impacts to abutting communities and natural resources, as well as others. Understanding current maintenance capacity constraints well as the impact that a new service will have on the existing maintenance system is also critical.

The existing Green Line vehicle fleet is currently stored at the following facilities: Reservoir (in Brookline), Riverside (in Newton), Lake Street (in Brighton), and Lechmere (in East Cambridge).

Maintenance support is only available at the Reservoir, Riverside and Lake Street facilities, all located on the west end of the Green Line system. There are currently no maintenance facilities located on the northeast side of the system in proximity to the proposed corridor of the Green Line Extension project. The existing facilities are operating beyond their planned capacity and expansion of these facilities to accommodate the Green Line Extension project is impractical in terms of logistics, service reliability and operating costs. In fact, until very recently, vehicles were stored in the subway tunnel tracks at the Brattle Loop in Government Center so as to alleviate overcrowding at the existing storage facilities. In order to balance operations, these vehicles should be stored on the northeast side of the Green Line so as to have sufficient storage capacity on both ends of the system. Negative impacts to the operations of the Green Line caused the MBTA to cease using the Brattle Loop as a storage location; those vehicles are now stored at Riverside and Reservoir, thereby exacerbating an already overcrowded condition.

The following table compares the number of vehicles each facility is designed to accommodate and to the number of vehicles currently stored at each facility:

Storage Facility	Design Capacity	# of Vehicles Stored
Reservoir	90	**102**
Riverside	51	**62**
Lake Street	22	**25**
Lechmere	17	20
TOTAL	180	209

The entire MBTA system currently includes a total overnight storage capacity of 180 cars, while the current fleet totals 209 cars. The identified storage capacity for revenue cars assumes free movement about the yard. In order to accommodate the present fleet, which exceeds the calculated capacity, cars are stored on active servicing and switching tracks at these facilities. This type of storage complicates and delays servicing and maintenance operations. For example, the Lechmere Loop is used to store 20 cars, as compared to its capacity of 17, thereby blocking the station tracks. This situation is further exacerbated by the need to accommodate non-revenue cars, specifically maintenance and construction rail cars. Simply stated, the existing facilities are operating beyond their intended capacity and, thusly, do not allow for any additional service expansions to the Green Line system.

As the only vehicle support facility located on the northeast side of Green Line system, Lechmere Station requires special discussion here. There are currently 20 Green Line cars stored at Lechmere Station. These cars, plus the 14 cars which were previously stored within the Brattle Loop, must be relocated to enable the implementation of the Green Line Extension project (with the construction of the Green Line Extension, the Brattle Loop will no longer be available to the MBTA for vehicle storage). In addition, and in order to accommodate the level of service anticipated on both branches of the Green Line Extension, the MBTA plans to purchase an additional 24 Green Line vehicles. These new vehicles must also be accommodated at the new light rail vehicle support facility on the day the Green Line Extension becomes operational.

The MBTA must also think about the potential for future growth on the northeast side of the Green Line system. As the demand for Green Line service in the Somerville-Medford corridor increases over time,

additional vehicles may be needed. In addition, future projects may further extend the Green Line to Route 16/Mystic Valley Parkway or to a connection at Porter Square. These expansions would require additional vehicles and therefore additional space at a storage and maintenance facility. A reasonable planning approach is to size the facility with those types of future needs in mind; to fail to plan for these future developments would limit our ability in the future to make these improvements.

In light of all of these realities, the MBTA is planning, as part of the GLX project, to build a light rail support facility to accommodate 70-80 vehicles. While the MBTA may, as part of the engineering process, ultimately reduce the proposed size of the facility somewhat, we believe at this point that it is prudent to plan for a facility of this size.

2. **Why is a new maintenance facility needed? Why can't the existing Green Line vehicle support facilities be expanded to accommodate the vehicles proposed to be stored in the new facility?**

The MBTA requires a Green Line support facility that would serve the proposed Green Line Extension to Medford and Union Square for the purposes of:

- Storage of Green Line cars;
- Inspection, light maintenance and repair of Green Line cars;
- Provision of a base for the maintenance and repair of the track, power, and signals systems for the Extension; and
- To address the current shortage of Green Line Storage on the northeast side.

For the Green Line Extension to operate efficiently and cost-effectively, it is essential to store a number of Green Line vehicles on the northeast side of the MBTA Green Line network in order to provide cars for morning start-up, to provide a convenient location for overnight and off-peak storage as cars come out of service, and to minimize the distance a disabled train has to travel to reach a support facility. Without a northeast-side facility, the MBTA would need to otherwise move cars to the west-side facilities each night and back to the northeast in the early morning, which could interfere with critical overnight maintenance work for track, signal, and power systems. Additionally, car storage is not only required for the overnight storage of cars but also for day-time storage between the morning and evening peak hours. Furthermore, when a Green Line car becomes disabled, it is essential that the car be moved to the closest support facility to get it out of the way of revenue service trains and to a location where it can be properly serviced. In order to provide transit service on the Green Line Extension that is reliable, cost-efficient, and does not adversely impact the remainder of the Green Line system – that effectively leverages the investment represented by the Extension project – it is necessary that a vehicle support facility be provided on the northeast side of the system.

Of critical concern is the ability to adequately store and service vehicles as part of the daily operating routine. Appropriate vehicle storage is vital for service quality, reliability, and operating costs for both existing and any new services.

With the proposed Extension in place, it would be impractical to depend on the existing west-side support facilities (Riverside, Reservoir, and Lake Street). Without a northeast-side support facility it would be necessary to:

- "Dead-head" cars from Newton to Medford Hillside and Union Square for the morning start of service;
- "Dead-head" cars from Medford Hillside and Union Square back to Newton for the nighttime end of service;
- Tow or push cars that become disabled northeast of Lechmere back through the entire length of the Central Subway which will have an impact on Green Line operations. .

The long travel times would add to operating costs and lack of operational flexibility (e.g., the ability to add a car in service to replace a disabled car), all translating into less reliable service for the MBTA's patrons of the Green Line. Negative impacts associated with increased dead-heading are:

- Operating costs, such as maintenance and transportation;
- Additional "wear and tear" on vehicles and track infrastructure;
- Noise impacts in the early morning and evening;
- Limits on time available for critical infrastructure and vehicle maintenance.

Therefore, it is essential to store a number of cars on the northeast-side of the proposed Green Line Extension, in order to provide cars for start-up in the morning, provide a convenient location for overnight and off-peak storage as cars come out of service, and minimize the distance a disabled train has to travel to reach a support facility. This will also eliminate much of the need to otherwise move cars to the west-side facilities each night and back to the Medford and Union Square termini in the early morning, which could interfere with critical overnight maintenance work for track, signal, and power systems.

Due to insufficient storage and maintenance capacity at Lechmere, MBTA Green Line Operations currently moves four cars twice daily between Reservoir and Lechmere. These trains are operated in revenue service from Reservoir onto the Heath St.-Lechmere E Line route (termed "revenue dead-heading") and then remain in service on the E Line route. However, if Lechmere provided sufficient storage for the four "Reservoir cars" and the 14 cars previously stored on the Brattle Loop, Green Line Operations would avoid approximately $50,000 annually, as well as an extra 20,000 miles per year, in "dead-heading" costs.

As shown in the table below, the travel time from Lechmere Station to the west-end support yards would range from 38 minutes to 1 hour. An additional 5 to 9.5 minutes travel time is required between Union Square or College Avenue and Lechmere. Therefore, without a northeast-end support facility:

- It would take 50 to 70 minutes for a train coming out of service at College Avenue to "dead-head" back to a west-side yard;
- It would take 50 to 72 minutes for a train coming out of service at Mystic Valley Parkway/Route 16 (if this option is implemented in the future) to "dead-head" back to a west-side yard;
- It would take considerably longer to tow or push a disabled train over these routes at "restricted speed," thereby slowing down the Green Line service. This delay cascades through the system and causes extensive delays which can be particularly difficult in the rush hour.

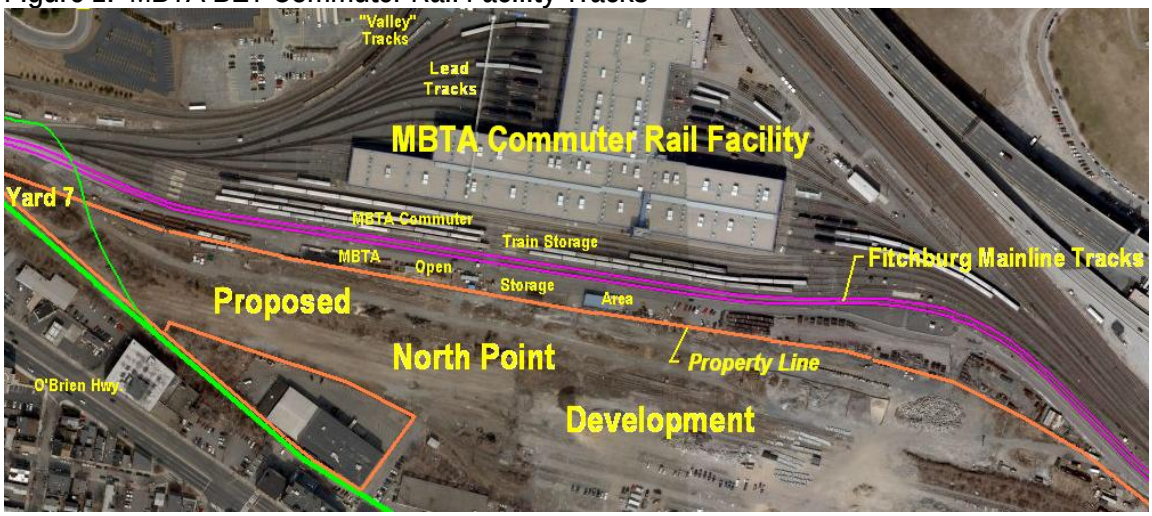
Location	Route	Peak Hour Travel Time
North of Lechmere	College Avenue to Lechmere	9.5 min.
North of Lechmere	Mystic Valley to Lechmere	12 min
	Union Square to Lechmere	5 min.
West of Lechmere	Lechmere to Riverside	60 min.
	Lechmere to Reservoir via Beacon Street	48 min.
	Lechmere to Reservoir via Highland Branch	38 min.
	Lechmere to Lake St.	56 min.

3. **Can the existing BET site be used as a location for the Green Line Maintenance Facility?**

The MBTA's Boston Engine Terminal (BET) Commuter Rail Maintenance Facility includes a large maintenance building surrounded by yard tracks, parking, and material storage areas. The BET was constructed in 1997 to serve as the main repair, maintenance, and inspection facility for the MBTA's commuter rail system. The building was constructed on the site of the former BET, which has been in railroad use since the mid-nineteenth century. Some Green Line Extension project stakeholders have suggested that the BET appears to be underutilized; that is, that there appears to be significant extra (un-used) land area at the BET that could be used to accommodate a Green Line vehicle maintenance facility. The BET is, however, not an underutilized space. When the facility first opened in 1997, the commuter rail coach fleet numbered 363. Since construction, commuter rail service has been inaugurated on the three Old Colony Lines and service enhancements and fleet expansions continue to be implemented throughout the commuter rail system. As a result, the facility is now responsible for supporting the operations of a fleet of 410 coaches, as well as a fleet of 83 locomotives. As a result of the continued expansion in commuter rail services, the facility is operating at or beyond capacity.

Some stakeholders have also commented that the outside storage yards at BET appear to be underutilized. The yards, however, are well used during the day (between the AM peak period and the PM peak period), when trains are frequently queued up to go in and out of the maintenance facility for service. The storage yards are also used to store trains not needed for midday service. The yard tracks, in their current configuration, are a critical element of the BET functionality. Only some trains are stored at the BET yards at night, since most trains are stored overnight at remote layover facilities at the end of the commuter rail lines. During the day, however, the entirety of the BET facility is heavily used and critical to MBTA operations.

Figure 1: MBTA BET Commuter Rail Facility Tracks



The BET is a large facility which performs multiple maintenance, repair, inspection, and storage functions for the MBTA commuter rail fleet, including both the northeast-side and south-side services. The current facility as shown in Figure 1 includes the following:

a. Maintenance Building and Lead Tracks

The maintenance building floor plate can be divided into the component functions in each area as shown in Figure 1, starting at the northeast end:

- The shops perform repairs on components removed from coaches and locomotives. The stores contain spare parts and equipment used in repair work.
- Truck repairs include bays with lifts where coaches and locomotives can be lifted so that the trucks (the wheel assembly) can be removed for repairs or replacement.
- Coach repairs include bays where the coaches receive major repair work.
- Locomotive repairs include bays where repairs are made to the four types of locomotives used for revenue service.
- The periodic inspection bays include pits where a train can be inspected.
- The service and repair bays are for regularly scheduled servicing and minor repair work.

b. Storage, Layover, and Lay-up Tracks

There are five tracks south of the maintenance building used for temporary storage, layover, or lay-up of commuter rail equipment. Temporary storage includes coaches awaiting service, inspection, and/or repair work at the maintenance building. Layover refers to overnight storage of train sets. Lay-up refers to storage of train sets between runs. More trains reach North Station in the morning peak hours than are needed until afternoon peak hours. Excess equipment is stored on the lay-up tracks.

c. Valley Tracks

There are four tracks in a crescent alignment to the west of the maintenance building, known as the "Valley Tracks" (as they appear to be in a valley between the elevated MBTA Lowell commuter rail Line to the north and the embankment of the Yard 8 and Yard 7 tracks approaching Red Bridge to the south). These tracks connect to the Fitchburg Line and Grand Junction Branch to the south and to the Eastern and Western Main Lines to the north. They are not used for MBTA revenue commuter rail operations. However, they are the principal operating routes for freight movements by both CSX and Pan Am Railways (PAR, formerly Guilford Rail System). The Valley Tracks are part of CSX's Grand Junction Branch from Beacon Park Yard in Allston to Everett and typically sees one round-trip per day between these end points.

The Valley Tracks are a key node for PAR's freight operations. PAR operates up to four to six trains daily, including the "gravel train" serving Boston Sand and Gravel near the BET and local freight serving all customers from Boston to Peabody via the Eastern Route. These trains travel east through the Valley Tracks to reach the Eastern Route, next to I-93. PAR also parks its Boston-based locomotives on the Valley Tracks.

The MBTA uses the Valley Tracks to park its maintenance-of-way (MOW) trains, as well as for some movements into and out of the maintenance facility.

d. Fitchburg Line Tracks

South of the layover and lay-up tracks are the two Fitchburg Line tracks, used for all commuter rail revenue service on the MBTA Fitchburg Line. These tracks are separated from the yard tracks by a fence.

e. Employee Parking Lot

The 242-space employee parking lot is located northwest of the maintenance building and serves both BET employees and visitors.

4. How Could a Green Line Vehicle Support Facility Be Added to BET?

There are three families of scenarios that could be considered for adding a Green Line vehicle storage facility to the current BET facility. Each of these scenarios has various challenges and consequences, which are described below. These categories include:

- **Joint Use** of the existing BET facility, in which the commuter rail maintenance bays, storage tracks, and equipment are also used by Green Line vehicles.
- **Dedicated Green Line Facilities** at the existing site, which would require creating dedicated space for Green Line vehicles at the existing BET site, including separate maintenance bays and storage tracks. Any infrastructure to be used by Green Line vehicles would need to be fully segregated from any commuter rail infrastructure. In this category, some of these scenarios require the reduction and relocation of existing commuter rail activities at the BET, while others would not.

- **Relocation** of some or all of the existing BET commuter rail operations to a new site to accommodate the construction of a Green Line vehicle support facility at the current BET site.

a. Joint Use of Existing BET Facility

This option requires Green Line vehicles to share the existing BET facilities, including storage tracks and maintenance bays, with commuter rail equipment. To determine if this is a feasible option, it is important to review safety and capacity requirements at the site, as well as operations and staffing capabilities.

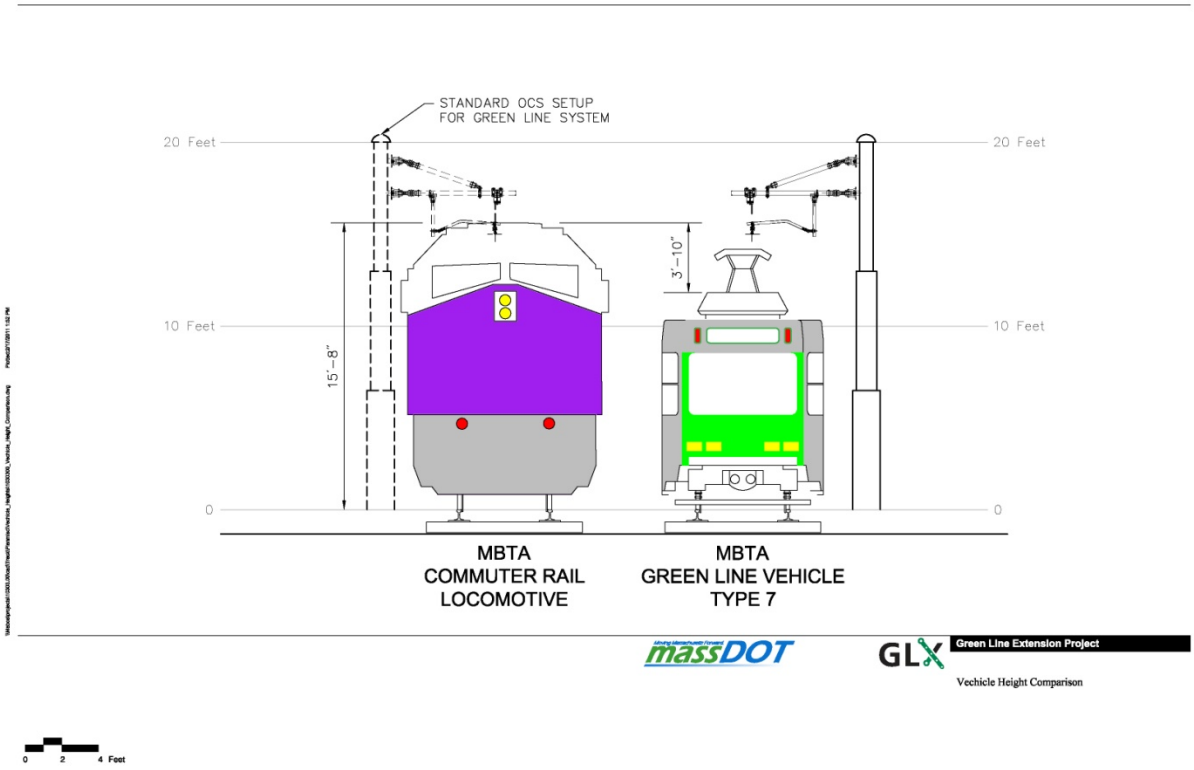
In rail operations, safety is always the most important consideration. The safety of a transit system is conditional on many factors, one of which is the operating characteristics of the transit vehicle. Most urban rail transit systems, such as the MBTA, operate isolated from the FRA-regulated railway system. With the MBTA, each of the four lines (Red, Blue, Orange, and Green) is, in effect a "closed track" where each line's cars operate only with similar cars on its own line. There is no interoperation between lines. For example, the Green Line cars remain on the tracks of the Green Line and do not use the tracks of the Orange or Blue Lines; nor can Orange Line trains use Red Line tracks. The main reason for this separation is the incompatibility of the vehicles of each line. Each line's cars are different – and incompatible – in terms of weight, width, height, floor height, and length.

Not only are the Green Line vehicles not compatible with other vehicles on other MBTA transit lines (Orange, Blue, and Red), they are not compatible with commuter rail equipment. While the Green Line vehicles and commuter rail vehicles have comparable track gauge sizes, the commuter rail cars and locomotives are wider, taller, heavier, and have a higher floor height than the Green Line cars.

The most fundamental difference between a Green Line vehicle and a commuter rail vehicle is its power source. The Green Line, like all light rail systems, relies on overhead catenary lines (overhead wires) to transmit electrical energy to the trolley at a distance from the energy supply point. The MBTA commuter rail system, however, utilizes a locomotive as a power source to pull the train. This simple difference in the motive power used by the two modes results in an extraordinary array of operational and safety requirements and considerations of which there are many examples, mutually exclusive and in direct conflict with one another.

The electric overhead catenary system requires permanent installation at a height of 14 feet above the height of the rail. This height requirement is driven by the existing height of the Green Line vehicles (11' 10" above the top of rail), plus the range of the overhead pantograph (the device that collects electric current from overhead lines and transmits it to the Green Line vehicle). The pantograph is flexible and has the ability to be raised and lowered within a range of 3 feet.

The height of the highest point of a commuter rail locomotive, however, is 15' 8". thereby more than 2½ feet higher than the electric catenary used by the Green Line. Because of this height differential, no commuter rail track can cross a light rail track at grade, nor can a commuter rail train operate on the same track. Simply put, if either were to occur, the commuter rail train would tear down the catenary, thereby eliminating the power source for the Green Line. The graphic below shows the comparative relationship of a commuter rail vehicle and a Green Line light rail vehicle.



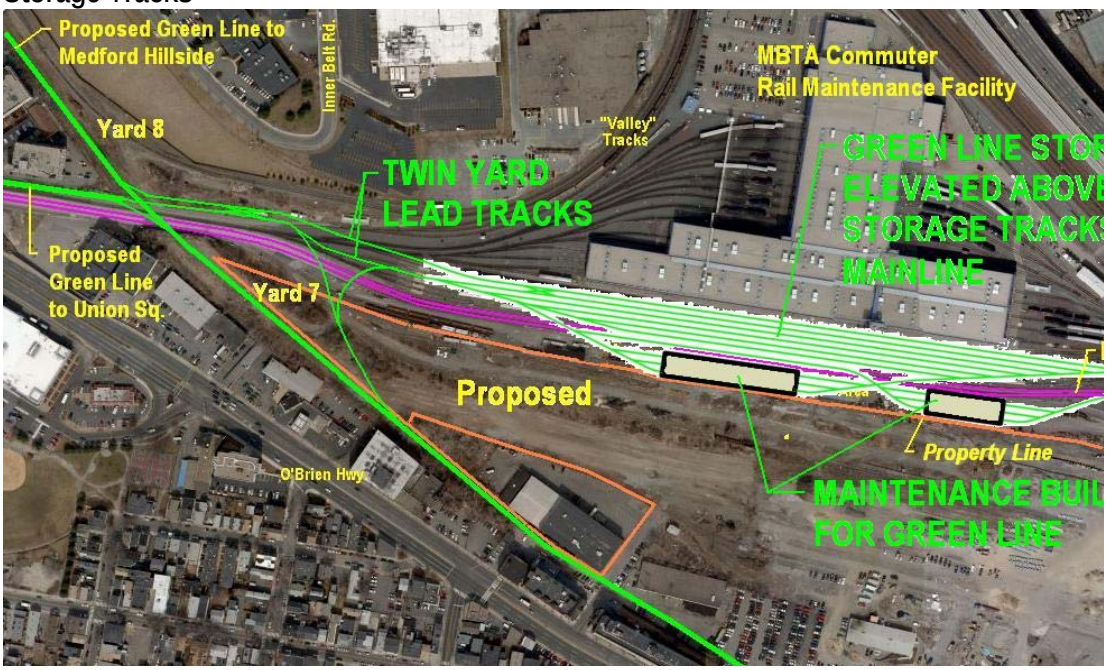
This direct conflict between Green Line vehicles and commuter rail vehicles is a **fatal flaw** for any plan that would promote the joint use of a Green Line/commuter rail maintenance facility. In addition, there are many other factors that would make it difficult or expensive to try to create a combined light rail/commuter rail support facility. For example, Green Line and commuter rail vehicles cannot be serviced utilizing the same maintenance bays, since most mechanical equipment on Green Line vehicles are on the top of the car whereas equipment for commuter rail coaches is mostly located under the car floor. The maintenance bays needed for one type of vehicle are not well-suited for maintenance of other type of cars. This long list of issues and difficulties is not further addressed here, because while it may be possible to mitigate or assuage some of these conflicts (albeit at significant cost and/or impact to MBTA operations), the conflict between the commuter rail locomotives and the Green Line catenary cannot be successfully resolved. Therefore, any scenarios that require a 'joint use' facility is fatally flawed and cannot be further considered.

A. b. Dedicated Green Line Facilities at the Existing BET Site

While a facility that is jointly used by Green Line and commuter rail vehicles cannot be made feasible for the reasons described above, a facility that provides separate tracks and maintenance bays for each type of vehicle –still within the same overall facility – was considered. Given the critical functions performed at the BET, the preferred scenario would be a design which did not diminish or compromise current BET activities. The second set of less-preferred scenarios requires that some BET functions be relocated to a new location and Green Line maintenance functions be built in their place.

c. Scenarios which do not replace BET functions with Green Line functions

Figure 2: Elevated Green Line Storage/Support Facility over Existing Commuter Rail Storage Tracks



As previously noted, the current maintenance capacity at BET is barely adequate to maintain the existing commuter rail fleet. There is no excess capacity at the BET to dedicate some of the maintenance bays for other uses (such as Green Line maintenance), nor can the BET afford to lose track yard or vehicle storage space. Therefore, the first analysis would be of a dedicated Green Line facility that would co-exist with the existing BET facility without any reductions in size and/or operational functions of the BET. Given the layout of the BET, the only way to add Green Line functions to the site without reducing capacity would be to construct a double-decker facility on top of the existing BET or on top of the BET storage tracks. Constructing a double-deck Green Line storage facility elevated over the existing commuter rail facility was proposed and analyzed.

The Fitchburg Line and Valley Tracks lie between the BET Building and the proposed Green Line Extension alignment. For Green Line tracks to reach the BET maintenance building, they would need to cross the Fitchburg and/or Valley Tracks. As described above, the safety issues associated with an at-grade crossing of an electric catenary track system intersecting with a commuter rail track system or the joint use of tracks makes none of those scenarios viable. Therefore, a bridge structure or a flyover would be required. To bridge over the Fitchburg and Valley Tracks, the Green Line tracks would have to be approximately 25 feet higher than the commuter rail tracks. This concept eliminates the need for any transitional ramp-downs, as the Green Line tracks would connect to the elevated yard at a height above the Fitchburg and/or Valley Tracks. A conceptual layout has been developed for this proposal. See Figure 2 above.

In order to achieve this configuration, the storage yard would be constructed at a level above the existing BET building. As the commuter rail vehicles currently serviced in the BET are diesel powered, the existing facility is designed with a ventilation system through the roof. A Green Line maintenance

facility constructed over the commuter rail facility would require a new building-wide ventilation system that would ultimately ventilate through the roof of the Green Line facility. A new lighting system for the commuter rail facility would also be required. Many of the other mechanical elements currently located on the BET roof (elevator, controls, etc.) would also need to be moved or reconfigured as well.

Due to size constraints, the double-deck facility would be single-ended with a single tail track, meaning that all vehicles would enter and exit the maintenance facility on the same track. Because this would be an elevated facility, the Green Line maintenance buildings would have all their service, inspection, and repair bays at an elevation approximately 25 feet above the existing ground level. These bays would be located on the third floor of the building.

This configuration raises the following concerns for the MBTA:

- A single-ended facility with a single tail track would greatly limit the operations in and out of the facility. Twin tracks are generally provided for operational flexibility and redundancy. With a single track, only one vehicle could move in and out of the facility at a time. In the event of a disabled train on a single track, all movements in and out of the facility would be halted until the disabled vehicle could be moved.
- This type of configuration could potentially accommodate a maintenance facility but could not accommodate storage of vehicles, which is a critical component of the GLX program. A discussion of potential alternative storage areas is further discussed below.
- The construction of an elevated maintenance facility (including provision of ventilation and lighting for the commuter rail tracks below) would be prohibitively expensive. To limit the size of footings and the structural support system needed for a maintenance facility, a maintenance building would typically have its service, inspection, and repair bays located on the ground floor. Locating them on the third floor would add considerable complexity and cost to the building.
- Construction of the elevated maintenance facility (including supports and footings) would have operating impacts on the existing MBTA Fitchburg Line and within the existing commuter rail maintenance facility. These impacts add a significant level of risk and complexity to the construction. This typically results in a longer construction period and higher costs to alleviate the risk of building on top of an operating rail yard.
- Construction of the Green Line maintenance building would preclude future realignment of the Fitchburg Line to allow for additional commuter rail storage tracks to be added in the future.

In the alternative, a maintenance facility could be built over the BET storage tracks only. Such a configuration would have similar ramifications to those described above. There are two distinct differences, however:

- While the structure above the commuter rail tracks would need to be ventilated to accommodate the diesel trains below, the extent and the degree of complexity of the ventilation system is not as great as would be needed if the facility was on top of the BET itself.
- This second configuration could allow for Green Line maintenance and storage functions, whereas the scenario above the BET building would accommodate maintenance only.

In this scenario, storage can only accommodate 60 cars, instead of the 70 to 80 cars needed. A facility of this size would not allow for any expansion of Green Line capacity or an extension to Medford Hillside in the future.

This alternative scenario would be in direct conflict with the proposed Inner Belt/NorthPoint Bridge. There is not sufficient room for the storage tracks to come down to grade and underneath any future Inner Belt Bridge (at the current proposed elevation). The tail tracks leading into the Green Line facility would directly impact the bridge and preclude the bridge from being built. The bridge is proposed to extend down Inner Belt Road, travel on structure over the commuter rail tracks and tie into the future NorthPoint development. In order to accommodate this bridge, the Green Line would need to pass under it at approximately elevation 15. A Green Line maintenance facility on the BET property however, would require tracks to pass over the Valley Tracks at elevation 35. The short distance between the Valley Tracks and where the Green Line would need to pass under Inner Belt Road would result in a significant grade change over a short distance. This grade is beyond what would be considered safe operations of the Green Line.

Precluding the Inner Belt Bridge would have two significant ramifications for the City of Somerville. Firstly, the City of Somerville has identified this bridge as a critical link needed to fully enable the proposed build-out of the Inner Belt Road area for future development. Secondly, the Inner Belt Bridge is a proposed link for the extension of the Somerville Community Path into Cambridge and Boston. An increase in the height of the Inner Belt Road Bridge would result in steeper grades over the bridge and would therefore touchdown much further down the existing Inner Belt Road. This would have a direct impact on abutting properties.

d. Scenarios which replace current BET functions with Green Line functions

There are a number of possible scenarios in which the MBTA could choose to reduce the size of the current BET facility in order to fit some Green Line functions into the existing BET site. While these options would (1) significantly endanger the MBTA's ability to maintain its current and projected levels of commuter rail service and (2) come with significant impacts to the projected cost and schedule of the Green Line Extension project, they should still be reviewed here.

It is important to note that the MBTA could not simply reduce the size and functionality of the BET without replicating these functions at some other location. The ramifications of the relocation of these commuter rail activities are discussed at the end of this section.

There are essentially three concepts under which the BET could be reduced in size by relocating certain elements and replacing them with Green Line-related activities. These concepts include:

- Installation of Green Line maintenance bays inside of the existing BET (but fully segregated from the commuter rail operations);
- Construction of Green Line facilities in the current BET parking lot;
- Construction of Green Line facilities in other open areas at BET.

Each of these scenarios and their attendant ramifications is further discussed below.

i. Green Line maintenance bays inside of the existing BET:

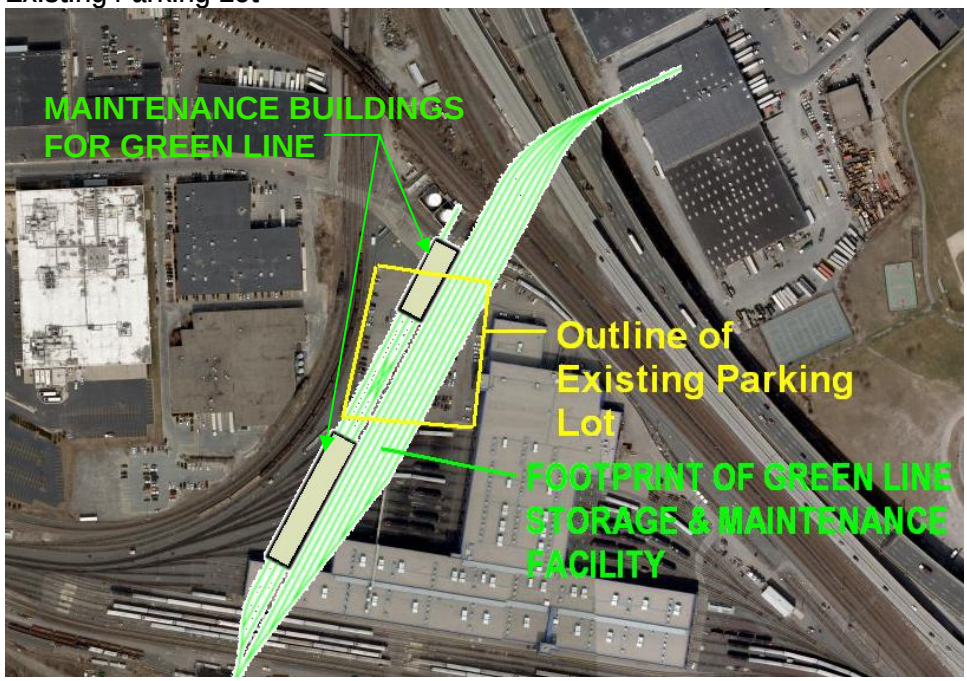
As previously described, the Fitchburg Line and Valley Tracks lie between the BET building and the proposed Green Line Extension alignment. For the new Green Line tracks to reach the BET building, they would need to cross the Fitchburg Line and the Valley Tracks. As also described above, the safety conflicts associated with (1) an at-grade electric catenary track system intersecting a commuter rail track system or (2) the joint use of tracks makes both not viable options. Similar to the scenarios in which the Green Line maintenance facility would be elevated over the existing BET operations, a bridge structure or a flyover would be required to allow Green Line maintenance within a portion of the existing BET site. To bridge over the Fitchburg Line and Valley Tracks, the Green Line tracks would have to be about 25 feet higher than the commuter rail tracks. Unlike in the scenarios involving an elevated facility, this scenario would require the Green Line to quickly return to grade so that the Green Line vehicles could enter the BET for maintenance. Given the necessary height, the Green Line flyover structure would need to be 25 feet long and would require a long ramp (about 500 to 600 feet) down to reach the building. As the Valley and Fitchburg Line Tracks are only 600 feet from the BET building, there is simply not sufficient distance between the BET building and the Valley and Fitchburg Line tracks to have the Green Line tracks ramp down. (A distance of 900 feet is required to transition from the bridge to the maintenance building.)

Even if the Green Line could return to grade using such a steep ramp structure, taking existing commuter rail facilities and converting them into Green Line facilities would be problematic. Green Line and commuter rail vehicles are different and cannot be serviced utilizing the same kinds of maintenance bays. Maintenance bays typically include work platforms designed to facilitate access to the car interior and to equipment on the car. Work platforms that would suit the commuter rail cars would be at the wrong height for Green Line cars and vice versa. The Green Line cars (particularly the 'Type 8' low-floor cars and the to-be-built 'Type 9' cars) have much of their equipment on the roof, and maintenance bays need to be set up with platforms to facilitate the inspection, removal, and installation of rooftop equipment. These platforms are not needed for commuter rail coaches, with which the equipment is mostly located under the car floor. Reuse of an existing maintenance bay would require substantial reconfiguration of all aspects of the bay, including work platforms, overhead cranes, etc.

ii. Use of the Parking Lot or other open areas as a potential site for a Green Line Maintenance Facility

The existing employee and visitor parking area is approximately 360 feet by 270 feet (just over two acres). It has been proposed that the existing parking lot could be relocated elsewhere on the site or onto a parking deck or into an underground garage to allow space for the necessary Green Line facilities. Preliminary analysis indicates that an underground garage would be unadvisable due to the high construction cost resulting from a high groundwater table. Additionally, the parking area is rectangular and not the elongated trapezoid shape that would best suit the maintenance facility. Figure 3 shows that the footprint of the parking lot is much smaller than the footprint of a maintenance facility and maintenance yard that would meet the program requirements.

Figure 3: Comparison of Footprint of Green Line Yard with Footprint of Existing Parking Lot



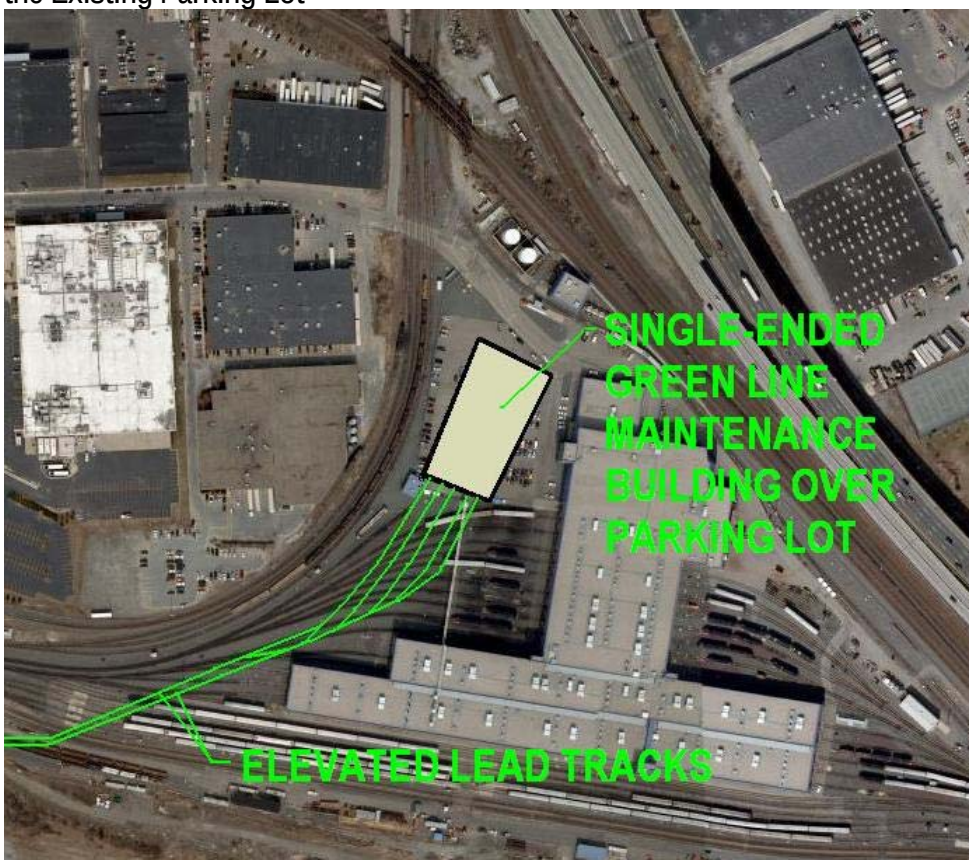
If the current parking lot area were used for a vehicle maintenance building, it would be a singled-ended facility, which would have similar limitations to those described above in the discussion of a 'double-decker' facility. The parking area is also distant from the Green Line Extension corridor and would require long lead tracks that bridge over the Valley Tracks and/or the west lead tracks, adding to the costs of this option. There is insufficient distance to bridge over the Fitchburg Line tracks as well as the Valley Tracks and then return to grade, so this configuration would result in a double-deck configuration with the maintenance building about 25 feet above the parking area. The ramifications of this configuration would be the same as those described in the double-decker scenario described above. The major exception to this would be that a Green Line facility on top of the BET would need to accommodate a completely new HVAC and exhaust system for the diesel engines inside the BET; this HVAC consideration would not apply to an elevated structure over the employee parking lot.

In addition to the employee parking lot, there are other open, paved areas on either side of the existing BET building that could also be considered for construction of dedicated Green Line facilities. These areas are even smaller than the existing parking area. Using these sites would require an elevated

approach and the use of these areas would be in the same double-deck configuration that the parking area would require, considerably adding to the cost and design challenge of this option.

There is an outside storage area and tracks south of the Fitchburg Line that could be evaluated as potential locations for dedicated Green Line facilities. This open storage area already has both existing and proposed future uses that are important to the operation and growth of the MBTA commuter rail system. The existing uses include storage of materials (e.g., ties) and work equipment (including work trains) for the maintenance of the MBTA commuter rail system. Future MBTA plans call for shifting the Fitchburg Line tracks to create an area between the relocated main line and the existing layover/lay-up yard tracks to provide more storage tracks, particularly for mid-day lay-up of trains. This additional storage will be needed to support ridership and service growth for the MBTA commuter rail system, particularly for the lines on the northeast side of the system.

Figure 4: Layout of a Single-Ended Green Line Maintenance Building over the Existing Parking Lot



A maintenance facility at this location would result in a difficult operating layout. While the length of the area is long enough to store about 80 cars, the width is tight and would result in a few very long tracks. To compensate for the atypically long storage tracks, intermediate crossovers would be needed so that it would be possible to remove cars in the middle of each long storage track.

Also, the facility would be single-ended in that only the west end would be able to connect to the main line tracks of the Green Line Extension. As noted previously, single-ended yards are undesirable and do not allow for operational flexibility. As such, in this alternative it would be necessary to dedicate one of the long tracks as a "run through" track with no car storage. This would allow for a second access to the storage tracks at the east end of the yard. Figure 4 above shows the configuration of a Green Line

storage yard in the open storage area. Note that the area is not large enough to fit the entire storage yard, without the acquisition of some land from the proposed NorthPoint development.

Additionally, there is no location suitable for the support building on MBTA property. This narrow strip of land is not wide enough for the support building and storage tracks. Land would need to be purchased from the Boston and Maine Railroad to accommodate a support building.

All of these potential scenarios (double decker, use of the employee parking lot, or the use of other open areas at the BET) result in similar ramifications for the Green Line maintenance facility, most notably:

- Single-ended layouts, which severely limit the operations of the facility and will hinder the MBTA's ability to maintain and efficiently store vehicles. This limitation directly results in limits on how service can be provided as well as how reliable that service can be.
- The size of the facility would be smaller than what the MBTA believes is needed to accommodate the extension of Green Line service to College Avenue and Union Square, as well as to accommodate possible future growth on the Green Line Extension or to appropriately balance Green Line maintenance and storage needs on the two sides of the Green Line system. Significant capital costs would be added to the current projected cost of the Green Line Extension maintenance facility since each of the scenarios described here would require a major elevated structure to be built over the existing railroad tracks. This type of construction is extremely expensive, given that commuter rail operations would need to be maintained throughout construction. Given the need to maintain operations, extensive night and weekend heavy construction would need to be scheduled over a two- to three-year construction period, thereby increasing costs as well as local impacts.
- Each of these scenarios would result in a reduction of the current BET commuter rail work areas. The MBTA cannot provide its current level of Commuter Rail service with a diminished maintenance area. Because of this, any scenario that reduces BET work areas would require that these functions be relocated to a new location. The cost of the relocation, as well as the time delay, will add significant costs and schedule of the Green Line Extension project.

e. Lack of Green Line Storage Capacity

Most importantly, however, is that most of these scenarios provide maintenance facility space (albeit limited) and not the storage capacity needed to support the Green Line Extension. The MBTA will need not only to maintain the Green Line vehicles that service the Extension, but space to store them overnight. Some vehicles can be stored inside the maintenance facility, but the majority of the vehicles will need to be stored outside in dedicated storage areas. None of the BET-based scenarios provide for sufficient, logical storage capacity. Therefore the MBTA would need to utilize some other parcel for the overnight storage of trains. The only real viable options for such storage would be to store the vehicles at the 'Yard 8' location originally considered for the location of the Green Line Extension maintenance and storage facility. Yard 8 is an approximately six-acre railroad yard located adjacent to the proposed Green Line alignment and accessed from Inner Belt Road in Somerville. The yard is partially owned by the MBTA and by Pan Am Railways. The Pan Am Railways portion of the yard is used for existing freight operations, while the MBTA portion of the yard is currently inactive. Over the course of the past two years, the City of Somerville and the neighbors adjacent to Yard 8 raised significant concerns about the

perceived impacts that the facility would have on the surrounding areas. This community involvement process resulted in a major new site review and the ultimate decision to move away from the Yard 8 site.

A Green Line Extension maintenance facility superimposed on the site of the existing BET would by necessity result in the storage of Green Line vehicles at Yard 8, a consequence that would presumably trigger many of the same community concerns raised when the Yard 8 proposal was originally made. Specifically, the City of Somerville feels that using Yard 8 would greatly hamper its ability to redevelop the Inner Belt area into the type of mixed-use, dynamic neighborhood that City officials would like to see in the area. Additionally, Green Line vehicles would have to be stored in a location that is directly adjacent to the Brickbottom Condominiums. There was significant opposition to this location by residents and artists at Brickbottom during the prior community planning process.

f. Relocation of Existing BET Operations to a New Site

Several of the scenarios described above would result in diminished functionality at the BET. Since the MBTA cannot support the current commuter rail operations with a diminished maintenance facility, these functions would need to be relocated to a new location. While it is technically feasible to relocate a portion of BET from its current location, it would not be practical to relocate the entire facility. The Periodic Inspections, Service & Repairs, and Train Storage components of BET must remain in close proximity to North Station to maximize the time available for the daily inspection and maintenance of coaches and locomotives. These components are a critical element of the daily operation of commuter rail service. Moving these activities to a facility that is significantly further from North Station would significantly hinder the MBTA's ability to maintain reliable commuter rail service.

Other components of the BET – including the heavy repair components (Shops & Stores, Truck Repairs, Coach Repairs, and Locomotive Repairs) – are critical to maintaining operations but could be relocated further away from North Station if necessary. These components are grouped on the northern side of the current BET facility and could, in principle, be removed without impacting the remaining BET components. If a new facility were located significantly further from North and South Stations, it would also increase operational costs.

Prior to removing the heavy repair components from BET, a new facility would need to be planned, located, permitted, designed, and constructed. Although this would require in-depth analysis, it can be assumed that process could take a minimum of three years and likely substantially more. Construction of the Green Line Extension would need to wait until this planning and environmental review was completed. The National Environmental Policy Act (NEPA) approval for the Green Line Extension project would also need to wait until the completion of the planning and environmental review for the relocated maintenance facility. The maintenance facility is inextricably linked to Green Line Extension operations and, as such, NEPA approval of the track and station systems – separate from the NEPA approval of the maintenance facility – would most likely result in an improper segmentation of the project. To avoid this, the MBTA would need to provide the FTA with a full assessment of the environmental impacts and consequences of the relocated commuter rail facility and for the new Green Line maintenance facility in conjunction with the assessment of the operations of the Green Line Extension revenue service. No federal funding, and certainly no construction on any element of the overall Green Line Extension project could be approved prior to the completion of the full NEPA

environmental assessment for the new BET facility. All of this assumes that a site could actually be identified and secured for a new commuter rail maintenance facility.

Once a new commuter facility is constructed and opened, the existing heavy repair components could be demolished or potentially retrofitted to allow for the construction of a light rail support facility at BET. It is optimistically assumed that this construction would take approximately one year, though it is likely to take longer. While many of this demolition and construction activities can happen concurrently with the overall Green Line Extension construction, the support facility would be the last element of the project completed and service could not begin, nor could new vehicles be accepted by the MBTA, until the new facility was substantially complete.

Since no specific location for a relocated BET has been identified, it is difficult if not impossible to estimate the incremental costs of such a move. The costs are certain, however, to be substantial. The original construction cost of the BET was $285 million when it opened in 1997. Assuming construction of a relocated facility could begin in 2015, this same cost would be $450 million adjusted for inflation. Since the MBTA owned the property at the time the BET was built, there were no substantial real estate and relocation costs associated with the project. Since there is not an obvious MBTA-owned location for a relocated facility, it is safe to assume that one would need to be purchased and that existing activity on that site would need to be relocated. Those costs would need to be added to the project. Additionally, since approval for federal funds as well as NEPA approval would need to wait until the planning of a new commuter rail facility, an additional three years of inflation would need to be added to the entire project.

All of these costs – largely unknown at this point – would be borne by the Green Line Extension project and would therefore factored into the MBTA's costs and cost-effectiveness calculations. Since there are no additional travel time savings or operating cost savings associated with the relocation and construction of a new commuter rail facility, these costs would increase, perhaps substantially, the MBTA's cost-effectiveness quotient, which is a critical factor with which the FTA makes decisions on New Starts funding. Measures of cost-effectiveness quantify the costs of an investment in relation to anticipated benefits resulting from the investment. Any major changes to the project that result in significant capital and/or operating costs, without a corresponding increase in travel time savings would increase the cost effectiveness factor for the GLX and thereby make it less competitive in the New Starts process and therefore less likely to be funded.