2 Bus Rapid Transit in the Corridor

Bus Rapid Transit (BRT) is a transit technology that has evolved from the application of existing technologies into a new and integrated transit alternative that offers a number of advantages over more traditional transit technologies. Quoting from the *Bus Rapid Transit Practitioner's Guide*:

> *BRT has been defined by the FTA as a "rapid mode of transportation that can provide the quality of rail transit and the flexibility of buses." In TCRP Report 90 (1), the definition of BRT was expanded to "a flexible, rubber-tired form of rapid transit that combines stations, vehicles, services, running ways, and ITS elements into an integrated system with a strong image and identity." BRT is an integrated system of features, services, and amenities that improves the speed, reliability, and identity of bus transit.*[1]

Much of what BRT accomplishes is through intelligent application of pre-existing practices, but what distinguishes it from previous attempts to make buses more attractive is its systems approach and attention to customer service, resulting in a truly new approach to passenger service.

BRT systems offer a number of attractive attributes to users, including:

- Easy and rapid boarding and alighting.
- Greater visibility.
- Understandable route structure.
- Frequent direct service to key destinations.
- Comfortable, modern, and attractive vehicles.
- Clean, affordable service.
- Low-emission and low-noise operations.

2.1 Description of BRT Systems

The elements of a BRT system are running ways, vehicles, stations, a service plan and the use of Intelligent Transportation System (ITS) technologies to create an integrated system. Overall service can vary, as follows:

- **Express BRT Service** - Since speed is a key component of any successful transit technology, the backbone of a BRT system is its express bus component.
- **Urban Shuttle BRT Service** - Another aspect of making travel convenient is linking the system to nearby destinations, for which shuttle bus services are provided.
- **Local Collector/Distributor BRT Service** - The first and last leg of the service is local collector/distributor service, getting the customer to his or her home and ultimate destination.

From top to bottom:
Express BRT Service
Urban Shuttle BRT Service
Local Collector/Distributor BRT Service

One of the things that distinguishes BRT from LRT, Rail Rapid Transit (RRT), and CRT is the extreme range of options for each element of a BRT system. In its least sophisticated form, BRT is little more than enhanced bus service, while in its most complex form it has all the elements of a rail transit alternative. Figure 2-1 conveys the range of available elements in the BRT technology.

Element	Simple ←			→	Complex
Running Ways	Mixed Traffic	Queue Jumpers	Shared Lanes	Exclusive Lanes	Grade Separated Guideway
Stations	Shelters	"Super" Shelters	Shelters with High Level Platforms	Stations with Parking	Stations with Fare Collection
Service Plan	All Stops		Express Service	Feeder and Line Haul Services	
Vehicles	Buses with Unique Route	Unique Buses	Advance Design Buses	Guided Buses	Specialized BRT Vehicles
Systems	Digital Radios, GPS	Electronic Fare Boxes	Smart Cards	Transit Signal Priority	Central Control System

Figure 2-1 BRT Range of Options

The overall systems approach is to carefully and comprehensively integrate all of the elements of the system to maximize customer convenience while achieving cost savings and integration with current and planned development. This differs from typical bus system service planning in the way it approaches the question of designing the system, which typically focuses on routes and schedules with little consideration of ways to improve operations or enhance access through construction of dedicated facilities.

Three things in particular distinguish BRT from traditional bus-service planning:

- Consideration of capital improvements (busways, stations, unique vehicles).
- Integration of the land use/transit considerations into both transit planning and land use planning.
- The planning does not end once a viable BRT service has been identified, and the consideration of how to make the service as customer-friendly as possible, and to maintain that level, should be addressed.

This is not to say that typical bus-service planning efforts are inadequate or inferior, but rather that what is typically considered to be within the realm of the possible is much more modest, so that such efforts do not go to the lengths to which a BRT plan goes.

[1] Transit Cooperative Research Report 118, Transportation Research Board, Washington, D.C. 2007.

To maximize ease of use, BRT systems feature:

- Simple and understandable route layouts.
- Convenient transfers.
- Station locations that are coordinated with land use plans.
- Service to major activity centers.
- Frequent service on the main line.
- Feeder buses routed onto the BRT guideway (dedicated bus lanes or busway).

A central objective of the BRT concept is to eliminate or to reduce transfers and provide direct service to key destinations. In the past, attention to efficient routing has occasionally led to systems that require longer walks than necessary, more transfers than are desirable, and a lack of coordination between route planning and land use planning. BRT is intended to address these shortcomings. Figure 2-2 illustrates an approach in which some of these shortcomings may be alleviated. Local or feeder routes are given access onto the BRT guideway, eliminating the need to transfer to get the speed and reliability benefits of that guideway. Stations are coordinated with surrounding development. Transit centers provide convenient locations to transfer between routes and are integrated into major development projects such as business parks and shopping centers.

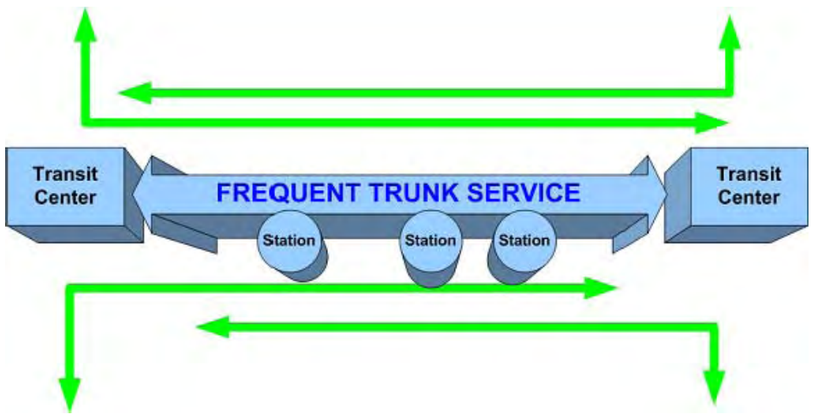


Figure 2-2 BRT Service Concept

BRT planning, therefore, begins from the presumption that there is a significant additional ridership benefit, as well as development benefits comparable to those achievable with rail transit alternatives/options. The question each BRT alternative/option must then address – as must all transit alternatives/options – is whether the potential additional benefits achievable will, in fact, justify the additional costs required to achieve those benefits.

2.1.1 Types of Transitway

Distinctive Pavement Treatment

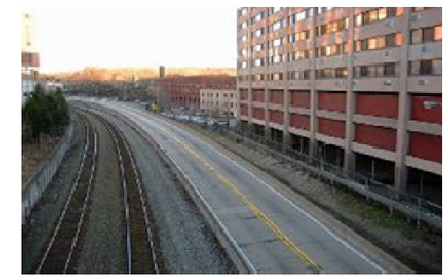
Not only should the guideway operate efficiently, but it should look like a guideway and be clearly distinguishable from lanes intended for mixed traffic.

Where the guideway is dedicated bus lanes, there is no need for special pavement treatments, but where the guideway abuts mixed-traffic lanes it is desirable for the BRT guideway to be visually distinct, not just to lend it identity, but to minimize confusion that could result in drivers illegally entering the guideway.

Busways can be located adjacent to railroads as well as highways. In Pittsburgh, Pennsylvania the M.L. King East Busway was built on what was railroad ROW, with the railroad still occupying one side of the alignment.

In Los Angeles, the Orange Line BRT used a former railroad ROW to create its exclusive guideway.

Orange Line Busway, Los Angeles



Pittsburgh Busway in Railroad Corridor

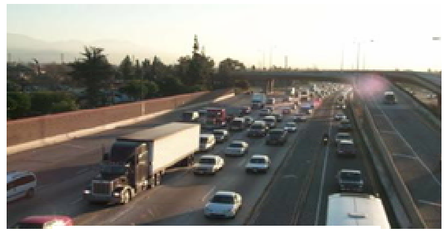
Houston Median Busway/HOV lane Entrance Ramps

In Houston, the busway/High-Occupancy Vehicle (HOV) system occupies freeway medians, among other configurations. The configuration of the Houston Median Busway shows a “T” ramp configuration used to provide access to the busway from frontage roads.

For freeway-median busways, the means of access to the busway is an important consideration. While it is possible to force the BRT vehicles to exit the busway and cross the mixed-traffic lanes, increasingly it is the practice to provide direct-access ramps onto the median guideways.

In addition to the major guideway options, there are design considerations that must be properly addressed in order to deliver on the potential of an exclusive guideway. How the guideway interfaces with local traffic at those points where buses leave that guideway is one such consideration.

Orange Line Intersection with Public Street



Usage with Other Vehicles

Usage by vehicles other than BRT vehicles is also possible, with HOVs the most common sharer of busways. As high-occupancy/toll (HOT) lanes become more common, joint occupancy of BRT lanes with these users will become more common as well. The rationale for such joint occupancy is the availability of unused capacity in the typical busway. Whether this excess capacity can be used without impacting BRT operations should be the key consideration when assessing the feasibility of joint usage. Congestion pricing, ramp monitoring and proactive enforcement can all be used to keep busway joint usage at a level sufficiently low so as to guarantee that the BRT service will not be negatively affected.

Termination Points (Istanbul)

It is important that where vehicles leave the guideway, care be taken to avoid impacting both the busway and local traffic. A comprehensive approach to traffic management is, therefore, integral to BRT system development.

2.1.2 Key Vehicle Concepts

The concept of customer service begins with the vehicle. The following concepts are typical of BRT vehicles:

- Level boarding.
- Multiple doors.
- Distinctive “branded” exteriors consistent with stations.
- High capacity.
- Pleasant interior conveniences.
- Quiet operation.
- Low or zero emissions.

Examples of BRT vehicles follow.

40-Foot Stylized Buses

BRT buses are sized and configured to respond to the needs of the service into which they are placed. The most common size of bus is 40 feet, and for many applications it is the most cost-effective size to meet ridership demand. This does not mean that a standard-issue 40-foot bus is sufficient to meet the customer service objectives of BRT. In particular, increasing the attractiveness of the vehicles is desirable, and modern design concepts have been applied to make them more appealing.

Another important concept is making the vehicles fully accessible, which means ensuring that adequate doorways and ramps are provided to speed up boarding, and removing obstacles to entering the vehicles.

Wheel Chair Ramp Accessibility

A third element of a modern BRT vehicle is GPS (Global Positioning System) and AVL (Automated Vehicle Locator) capability. These technologies help knit each bus into the integrated system, supporting such capabilities as intelligent dynamic signing and passenger information systems.

Low-floor Bus

Among the measures to enhance the process of boarding and alighting from the vehicle is the use of low floors, which also make access within the bus easier and more convenient. This benefits all passengers but is especially helpful to the mobility-impaired and the elderly. The removal of interior steps initially entailed reconfiguring some of the mechanical components of the bus, but that challenge has been successfully met and there are now multiple models of buses that feature low floors.

NABI Articulated Bus

Articulated Buses

Where the ridership demand is high, the option of using articulated buses can be advantageous. In addition to having greater passenger-carrying capacity, these buses can have more side doors.

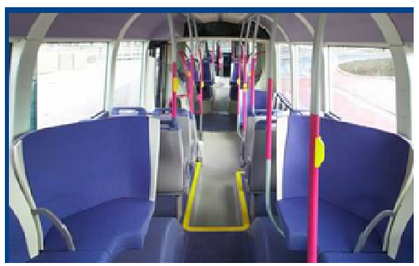
Specialized Vehicles

Specialized vehicles are also available that combine the characteristics of other BRT vehicles with futuristic and innovative styling. This category includes vehicles that can be fully guided as a tram, or operated manually and driven as a bus. Guided-bus technologies have evolved to include electronic guidance systems as well as mechanical systems.

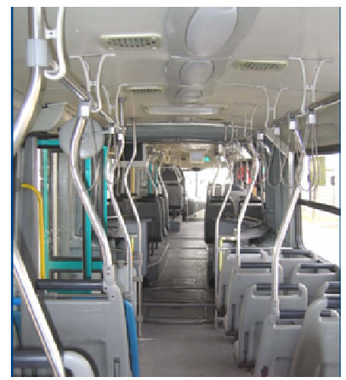
"Phileas" Bus

Attractive Interiors

Customer care extends to the experience of riding in the vehicle, and advances in the design of vehicle interiors have transformed the riders' experience.



Wright Streetcar, Las Vegas



Marco Volvo Leon, France

Advanced Propulsion Systems

As the appearance, size and configurations of vehicles have changed, so too have the choices for propulsion. In fact, as shown in Figure 2-3, BRT systems typically feature ultra-low-emission propulsion systems. These advanced propulsion systems are capable of reducing emissions and improving the energy efficiency of BRT systems, with further improvements expected to continue.

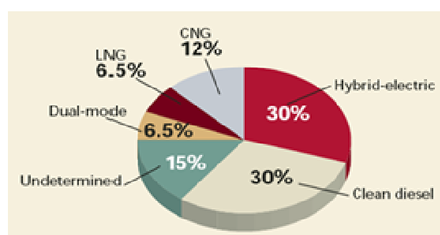


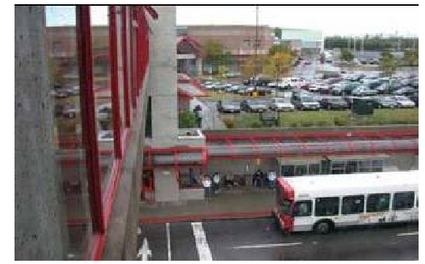
Figure 2-3 BRT Propulsion Systems

2.1.3 Key Station Concepts

The customer care concept is as important in the stations as it is in the vehicles. Among the concepts that make BRT a viable alternative are the creation of distinctive stations that feature level boarding and alighting, are attractive, and are clearly part of a system.

To realize the system concept, it is necessary that all of the components appear to be part of a system. This includes creating a visual signature that reassures users that they are in the BRT system. This is often referred to as "branding," with the color schemes of the buses and stations and all other elements of the system having a coordinated appearance.

Ottawa BRT Station



Ottawa BRT Station and Bus

The attention to details extends to providing high-quality, attractive and functional amenities that one would expect in any other transportation terminal, including water fountains, trash receptacles, benches, wind screens and even restrooms, depending on the size of the station.

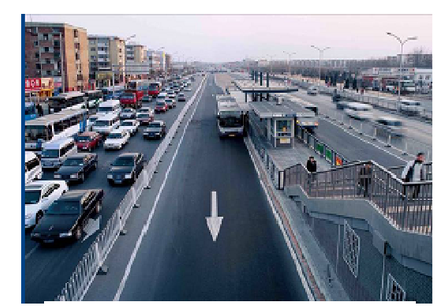
BRT station alternatives are as broad as they are for rail alternatives, and include elevated BRT stations and BRT subway stations. Among the more visually impressive are Seattle's downtown subway stations, which have been in operation for more than a decade.

Seattle Bus Subway Station

Seattle Bus Subway Station

BRT stations are common in roadway medians as well.

Transit stations are natural multimodal transportation centers, with the opportunity to provide a hub for transit service, auto access, bicycle access and pedestrian access. Where the transit mode is a dedicated ROW – such as with CRT, BRT or LRT – providing enhanced access means from surrounding areas is highly desirable to increase ridership and encourage transit use. Where the mix of adjacent land uses is appropriate, the development of TOD projects provides the means of capitalizing on the improved access the multimodal transportation center provides and further encouraging walk access to transit. Multimodal transportation centers can be important development hubs that have the capacity to enhance community transportation, transit usage and harmonious development.



Beijing BRT Station

2.1.4 Intelligent Transportation System (ITS) Components

Part of creating a system is providing a way of coordinating its components, and a state-of-the-art control center is the means to do that.

BRT Operations Control Center

Rail systems have had centralized monitoring and control for decades, and providing this same means of monitoring and controlling performance is essential to achieving the desired levels of service and reliability that BRT promises.

Transit Signal Priority

The control center is used to monitor operations, advise of delays, adjust service to meet demand, and deal with traffic incidents. New York State operates such a Traffic Management Center, which could provide this function.

Ideally, the BRT operation is integrated into the signal system in which the fleet operates. This includes giving BRT vehicles priority at traffic signals. Such priority is referred to as Transit Signal Priority.

Variable Signing and Incident Management

Another aspect of the management of the BRT system is the use of intelligent signage and advanced incident management to allow the system to adapt to changing conditions in time to avoid delays.

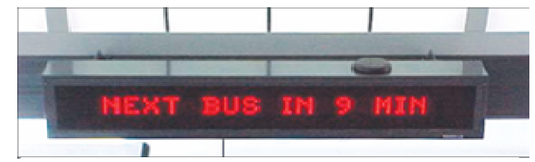
Smart Card Fare Collection System

Fare collection should be as advanced as all the other elements of the system. The technologies available include smart cards and equivalent systems, some of which do not even require the passenger to remove the farecard from his pocket or her purse. Faregates can be simplified or even eliminated entirely with a variety of available enforcement methods. The objective is to make fare collection not only seamless but to eliminate the delays formerly associated with them.

Intelligent Signage

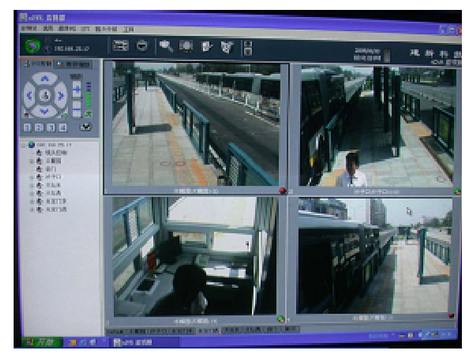
Passenger information systems can include visual and audio announcements of when the next bus will arrive, the location of the vehicle you are traveling on, its next stop, and the time remaining until arrival at the terminal.

Bus Station Next Bus Arrival Time Signage



On Board Information System

System security is another aspect of the control center and systems aspect of BRT systems. Through the use of closed-circuit television (CCTV) cameras and the active monitoring of the conditions throughout the system, the central control facility can deploy security personnel to the right location in a timely manner should the need arise. This includes health incidents as well as other events where specialized personnel are needed.



BRT Control Center Security Screens

CCTV Surveillance Camera in BRT Facility

2.1.5 US Cities with BRT or BRT Projects

BRT services have been implemented in over a dozen US cities (Figure 2-4). Some are relatively modest, but the more ambitious projects have been almost uniformly successful. A selection of those BRT systems follows.

Figure 2-4 US BRT Systems

Figure 2-5 East Bay BRT Berkeley to San Leandro Route

2.1.5.1 Alameda Contra Costa Transit – East Bay BRT

The Alameda Contra Costa East Bay BRT project is programmed to open in 2011. It is more than 15 miles in length and features more than 35 stations (Figure 2-5). It is projected to cost $310 to $400 million when complete.

Projected ridership of this BRT system is from 42,000 to 49,000 weekday riders – over 14,000 more than the same corridor without BRT.

A 25-percent travel-time improvement is projected for users of the East Bay BRT project. As shown in Figure 2-6, this BRT project will convert the inner lanes and median of its route into a median busway.

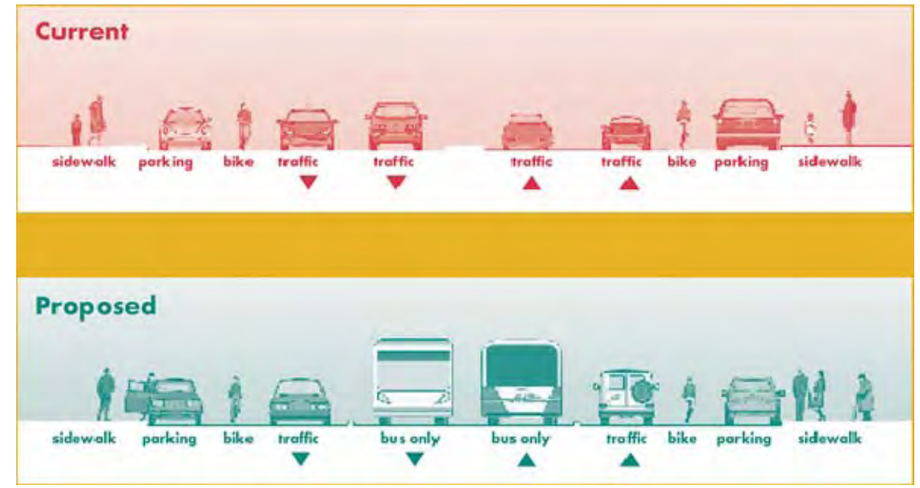


Figure 2-6 East Bay BRT Cross Section

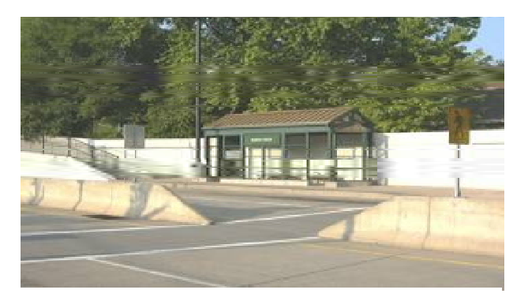
2.1.5.2 Port Authority of Allegheny County

West Busway

The Port Authority of Allegheny County has three busways in addition to its LRT system and its extensive bus system. The West Busway extends from downtown Pittsburgh toward Carnegie and into the airport corridor to Pittsburgh International Airport (Figure 2-7). This corridor utilizes abandoned railroad ROW for much of its length, including a refurbished railroad tunnel.

The West Busway opened in 2000. It is five miles long and has six stations. It cost $258 million to construct and on an average workday carries more than 9,500 passengers on its 11 bus routes in 413 trips.

Figure 2-7 Pittsburgh West Busway



West Busway Station

Pittsburgh M.L. King East Busway Adjacent to Railroad

M.L. King East Busway

The M.L. King East Busway (Figure 2-8) is the longest of Pittsburgh's busways, at 9.1 miles, of which 2.3 miles were added in 2003. It opened in 1983 and has nine stations. The 2.3- mile extension cost $183 million. On an average weekday, 30,000 riders use this busway's 34 routes to access downtown Pittsburgh. This busway accommodates 943 bus trips on an average work day.

Figure 2-8 Pittsburgh M.L. King East Busway

South Busway

The South Busway is Pittsburgh's oldest, having opened in 1977. It has nine stops along its 4.3-mile length (Figure 2-9) and cost $27 million to construct. Sixteen bus routes use this busway to carry about 11,000 riders on an average weekday in 552 bus trips.

Figure 2-9 Pittsburgh South Busway

2.1.5.3 Greater Cleveland Regional Transit Authority

The Dual Hub Corridor project is a median busway along Euclid Avenue, as shown in Figure 2-10. It will connect downtown Cleveland and the University Circle area, a 10-mile-long corridor over which four bus routes will operate.

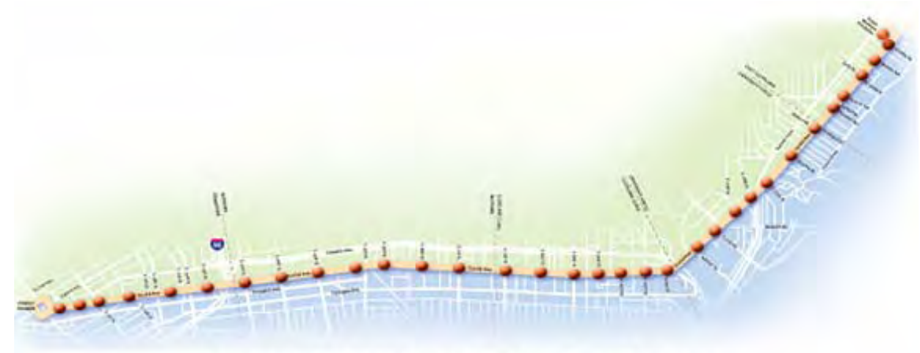


Figure 2-10 Dual Hub (Euclid) Corridor BRT Route

An integral part of the project is the planning for redevelopment and revitalization of the Euclid Corridor. The photo below conveys how this BRT project will fit into its urban setting.

Cleveland Dual Hub Corridor

Figure 2-11 Houston Busway/HOV Network

2.1.5.4 Houston Bus/HOV System

Houston, Texas has an extensive busway/HOV system of 112.9 miles, extending in six corridors (Figure 2-11). This system features an extensive park-and-ride lot strategy that is used both for HOVs and bus passengers (Figure 2-12).

Because the system allows HOVs as well as buses on the guideway, the signage delineating where commuters are and are not allowed must be very clear; examples of such signage are shown below.

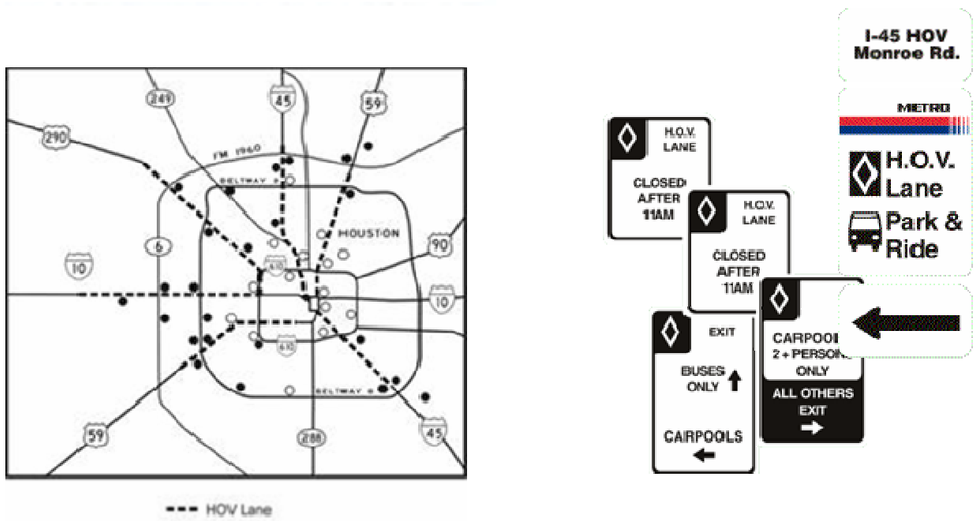


Figure 2-12 Houston Remote Park-and-Ride Lots

Houston Busway/HOV Guideway

2.1.5.5 Non-US BRT Examples

As discussed, there are many examples of successful BRT projects in the United States -- projects that have been developed in communities with similar economics, availability of automobiles, and commuting needs as exist in the Tappan Zee Bridge/I-287 Corridor. In addition, there are many notable examples of successful BRT systems in foreign cities, including:

- Ottawa, Canada
- Brisbane, Australia
- Curitaba, Brazil
- Bogota, Colombia
- Leon, France
- Mexico City, Mexico

BRT is a proven technology that can offer a viable alternative to other fixed-guideway transit modes.

2.2 Application of BRT Technology to the Tappan Zee Bridge/I-287 Corridor

The technology related to BRT that can be incorporated in this corridor includes the ITS technologies that are an integral part of all alternatives/options, and specific ITS applications that are particularly appropriate to BRT, including, but not limited to, vehicle-tracking and passenger-information technology. The HOT lanes would be fully monitored as part of the dynamic-tolling and volume-control technology, ramp metering with bus and HOV bypass are already included in the planning, and bus priority signals are being considered for all in-street operations of the BRT.

A BRT system has the flexibility to serve door-to-door journeys, eliminating transfers in many cases. This characteristic of BRT makes it attractive, especially for shorter journeys. This mode, with its inherent ability to deviate from a fixed path, also serves a greater number of markets. For example, in the Tappan Zee Bridge/I-287 Corridor, the Yonkers-to-White Plains or Spring Valley-to-Nanuet moves can be served by a one-seat ride on a BRT system.

A workshop was held on September 10 and 11, 2007 with panelists experienced in the planning and operation of BRT systems in Canada and Latin America, as well as the United States. At that workshop, the BRT alternative now described as Alternative 3 was explained to the panelists, who then developed a series of suggestions. Options 3A and 3B were developed in response to those suggestions, and are intended as enhancements to Alternative 3. The specific changes are:

- A trunk route was developed, serving all stations along the corridor, with frequent service using buses easily identified as “the BRT” throughout the day. The trunk route appears in the Service Plans for Options 3A and 3B as Route T, has five-minute peak-hour headways and 10-minute off-peak headways. The extensive network of routes developed in Alternative 3 was maintained, except that the routes would be feeders, terminating at the busway during off-peak periods with a transfer to Route T. During peak periods, they would join the busway and provide one-seat rides to most passengers.

- Additional stations were added, to provide a closer station spacing and easier access to the system. Stations were added at:

- Monsey, where Route 59 crosses I-287.
- Nyack, at Interchange 11.
- Broadway and Route 119 in Tarrytown (allowing a Tarrytown stop without diverting all buses to the Tarrytown Metro-North Station).
- White Plains Avenue east of the White Plains Central Business District.
- South Ridge Street in Rye Brook.
- Boston Post Road in Port Chester.

- Fewer routes were diverted to the Tarrytown Metro-North Station.

- The busway was extended all the way to the Port Chester Metro-North Station to provide convenient access to the New Haven Line, permitting a dependable trip to Connecticut destinations.

In Option 3B, the changes indicated above were incorporated into a full busway option, with exclusive grade-separated ROWs crossing Westchester County and serving the White Plains Transportation Center (WPTC).

2.3 Description of BRT Alternatives/Options

2.3.1 Alternative 3 – Full-Corridor BRT

Alternative 3 provides cross-corridor BRT service from Suffern to Port Chester, with a transfer to Tarrytown (Figures 2-13 and 2-14). It is described here because it was one of the preliminary DEIS alternatives identified in the *AA Report* and is the basis for Option 3A. However, it is not further analyzed in the report, as Option 3A is an enhanced version of Alternative 3.

2.3.1.1 Rockland County

Alternative 3 in Rockland County primarily uses the HOV/HOT lanes as a busway sharing the lanes with high-occupancy vehicles-3 (HOV+3) and single-occupant vehicles (SOVs) willing to pay a toll. From the west, the HOV/HOT lanes would begin west of Interchange 14B (Airmont Road) in a reconstructed and widened Thruway and continue uninterrupted across Rockland County, onto and across a rehabilitated or replacement Tappan Zee Bridge, through the toll plaza and ending just east of Interchange 9 (Tarrytown). The HOV/HOT lane toll would be adjusted to maintain uncongested flow, thereby ensuring that BRT travel times would be consistent with the service plans. Possible station locations along the BRT alignment are as follows:

Rockland County:	Downtown Suffern	Interchange 14A (Garden State Parkway)
	Airmont Road	Palisades Mall
Westchester County:	Tarrytown Metro-North Hudson Line Station	White Plains Transportation Center
	Meadow Street	Galleria Mall
	Benedict Avenue	Westchester Mall
	Elmsford West - Rte 9A	Corporate Park Drive–Platinum Mile
	Elmsford East - Knollwood Road	Westchester Avenue
	Westchester County Center	Port Chester Metro-North New Haven Line

Since downtown Suffern has no direct access to the Thruway, it could be served by converting a portion of the existing Piermont Line ROW into a dedicated busway from Route 202, Orange Avenue to Airmont Road, where buses could enter the HOV/HOT lane. The existing weekly freight service would continue on the Piermont Line ROW with no direct impact from the busway.

BRT stations in Rockland County are spaced approximately four miles apart and would generally be located near interchanges, in close proximity to major arterials, and where existing and/or proposed park-and-ride lots could allow commuters to easily transfer to buses. The proposed BRT stations would be located off the alignment, except for the downtown Suffern Station. Buses would access the stations by either bus-only dedicated flyover structures from the HOV/HOT lanes, or through drop ramps that exit into mixed traffic onto local arterials for short distances to and from the BRT stations.

Suffern Terminus and East of Suffern

A possible downtown Suffern BRT Station could be located on Route 202 at the New Jersey Transit Suffern Station. Bus access to this station would be via a one-way loop on local streets, with a connection to the Piermont Line busway at Chestnut Street. BRT would run in a dedicated busway constructed in the Piermont Line ROW for approximately 2 miles to Airmont Road, where a possible BRT station would be located and would have access to/from the HOV/HOT lanes. The proposed station would include a park-and-ride facility south of the Thruway eastbound on-ramp, possibly at a site currently occupied by a commercial facility. Buses from the station heading east would exit the station onto Airmont Road, turn north to the center of the overpass, then turn east onto the drop ramp to enter the HOV/HOT lane. Buses from the Piermont Line would turn north onto Airmont Road and access the HOV/HOT lane using drop ramps. Since the service plan does not include buses from Orange County stopping at an Airmont Road Station, the proposed drop ramps would only provide HOV/HOT lane access to and from the east. Buses from the west would not have direct access to the station from the HOV/HOT lane.

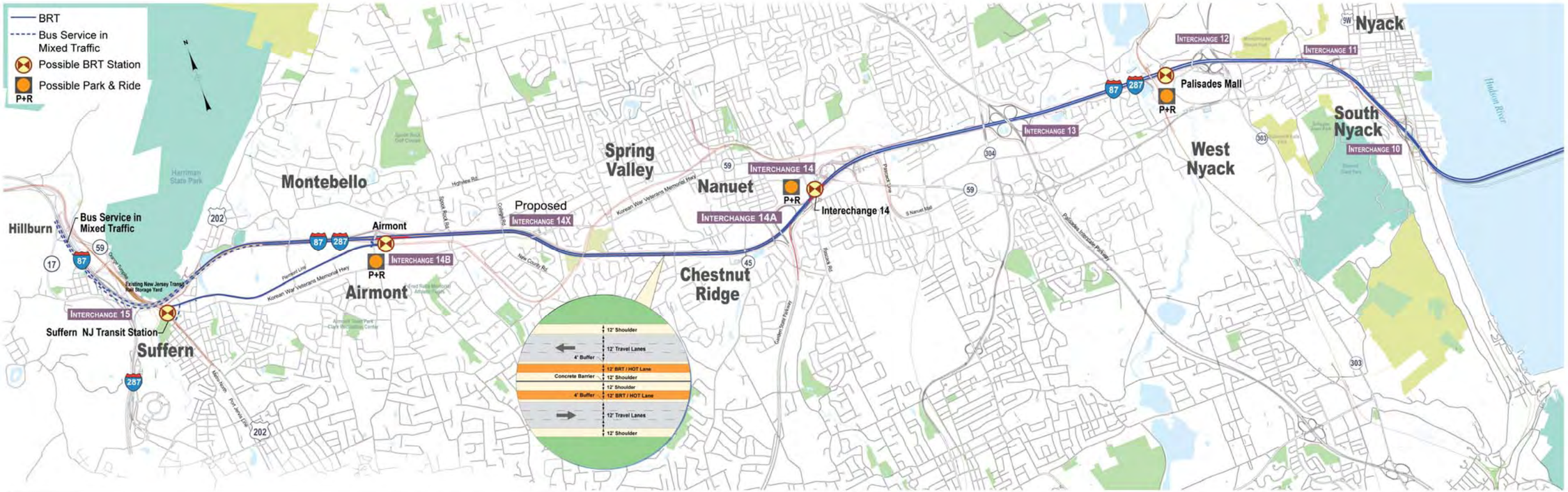
Spring Valley

East of Interchange 14B (Airmont Road), the BRT alignment would continue in the HOV/HOT lanes. A station that would serve Spring Valley would be located approximately 4.5 miles east of Airmont Road in the vicinity of Interchange 14A (Garden State Parkway). An existing park-and-ride facility on the north side of the Thruway, bordered by Route 59, Pascack Road and Forman Drive, could be expanded for additional parking, as required. Buses leaving a station at this location to access the HOV/HOT lane would proceed south on Pascack Road in mixed traffic to the HOV/HOT lane eastbound entrance ramp situated beneath the I-87/I-287 median. In an arrangement similar to that at Airmont Road, the HOV/HOT lane drop ramps would only service buses headed to or from the east. Station access to and from I-87 west would not be required based on the proposed service plan.

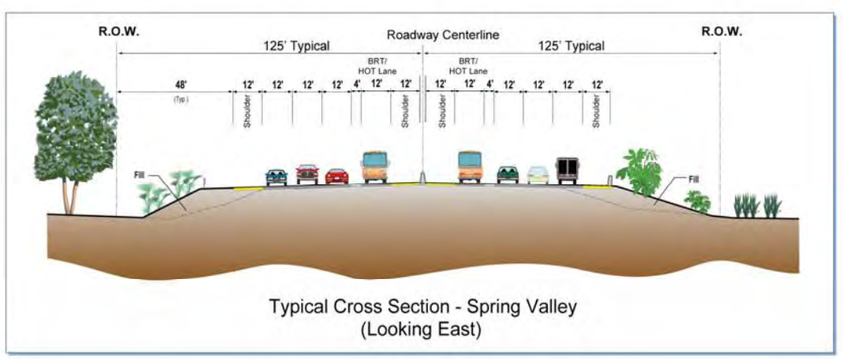
West Nyack and Nyack

The easternmost station in Rockland County would possibly be located at the existing park-and-ride lot at the Palisades Mall – commonly called Parking Lot J – which is located at the west end of the Mall. Access to this facility for commuters and potential feeder buses is through the perimeter “ring road” which circles the Mall. For buses in the HOV/HOT lanes, access to the facility would be from a “Texas T”, which is an elevated intersection with a direct ramp over the highway into the station. Unlike the other Rockland County stations, the service plan would require bus access to this station from the west and would be provided with this ramp configuration.

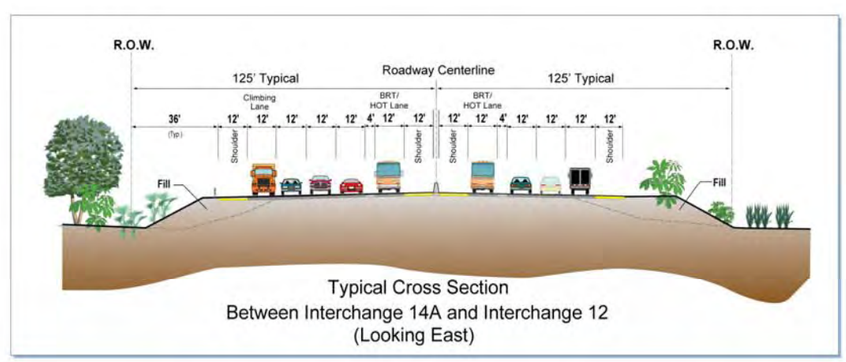
Other than from the three stations with their associated direct-access ramps, feeder-bus connectivity to the HOV/HOT lanes would be from two proposed “slip ramps” on I-87/I-287. These are located east of Interchange 13 (Palisades Interstate Parkway) and east of Interchange 11 (Nyack). Slip ramps would give buses in mixed traffic on the Thruway the opportunity to enter the eastbound HOV/HOT lane or exit the westbound HOV/HOT lane and follow their designated routes on local roads.



Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 3 - Rockland	0	0	71,300 ft	71,300 ft (13.5 Miles)

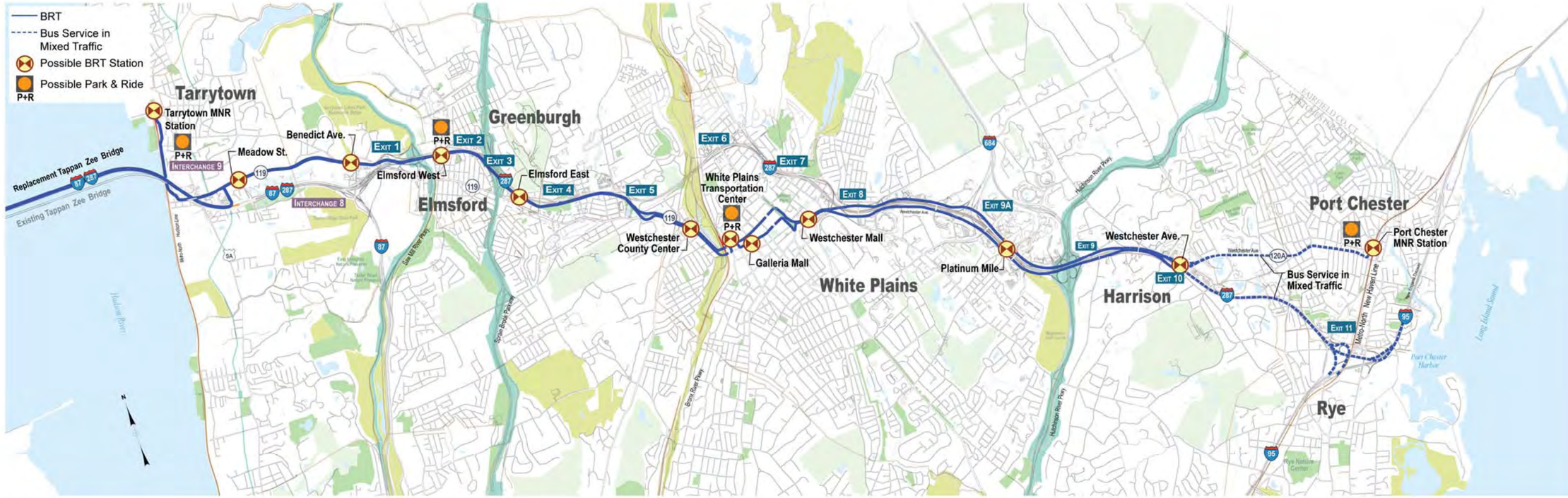


Typical Cross Section - Spring Valley
(Looking East)

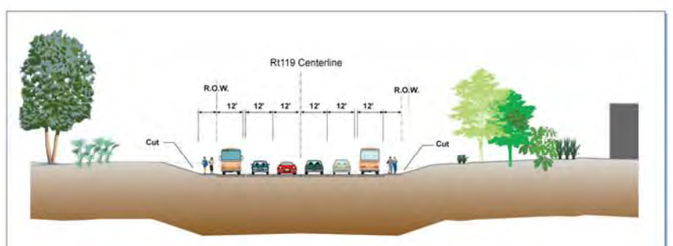


Typical Cross Section
Between Interchange 14A and Interchange 12
(Looking East)

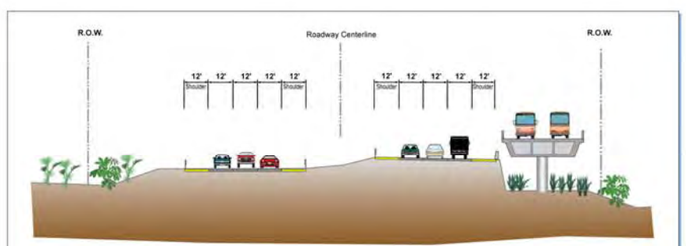
Figure 2-13 Alternative 3 – Full-Corridor Bus Rapid Transit in Rockland County



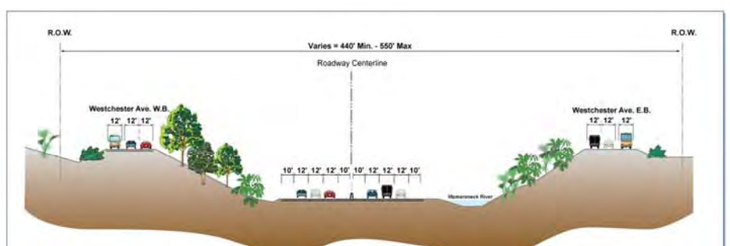
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 3 - Westchester	0	6,500 ft	43,500 ft	50,000 ft (9.5 Miles)



Typical Cross Section - Along Route 119 in Tarrytown
(Looking East)



Typical Cross Section in Elmsford
(Looking East)



Typical Cross Section - East of Exit 8
(Looking East)

Figure 2-14 Alternative 3 – Full-Corridor Bus Rapid Transit in Westchester County

2.3.1.2 Westchester County

Unlike the proposed highway improvements in Rockland County, which will feature the construction of new HOV/HOT lanes for BRT service, I-87/I-287 in Westchester County has been precluded from additional highway improvements, such as the addition of HOV/HOT lanes, based on the FHWA April 1998 ROD that provided selective safety and operational improvements along the highway. As a result, the BRT alignments in Westchester County are limited to the use of exclusive bus lanes on local roads, dedicated busways adjacent to I-287, and buses in mixed traffic where projected congestion levels determined in the AA process are considered light enough to allow buses to travel at speeds that would maintain their schedules. Providing BRT on local arterials has the advantage of providing more stations to serve local destinations, but overall travel times would be longer.

After crossing a rehabilitated or replaced Tappan Zee Bridge, the HOV/HOT lanes would terminate at Interchange 9 (Tarrytown), where a direct ramp connection would be provided from the HOV/HOT lanes to Route 119, White Plains Road in Tarrytown. Buses in the HOV/HOT lane would exit the highway and turn onto dedicated bus lanes with transit-signal priority along Route 119. Buses headed for the Tarrytown Metro-North Hudson Line Station would turn west onto Route 119, cross Broadway and continue on a new bridge spanning over the toll plaza, then turn north under the Tappan Zee Bridge approach and use a dedicated busway along the east side of the Hudson Line tracks that would run north into the Tarrytown Station.

BRT service not stopping at the Tarrytown Metro-North station would turn east onto Route 119 at Interchange 9 (Tarrytown) and stop at stations possibly located at Meadow Street and Benedict Avenue. To provide dedicated bus lanes on Route 119, the roadway would be widened from Broadway to the vicinity of White Plains Road (a distance of approximately one mile) to maintain the existing five-lane roadway configuration. East of Old White Plains Road, Route 119 widens, creating additional lanes, which allows taking the curb lanes for BRT without creating significant traffic impacts.

Continuing the use of dedicated bus lanes on Route 119 through Elmsford was considered, but rejected because of the heavily congested nature of the arterial and the negative impacts that would result from taking away the curb lanes for buses. Alternatively, an exclusive barrier-separated busway alignment adjacent to I-287 was developed. From Benedict Avenue this alignment would rise up on a viaduct and cross over I-287 at Exit 1 and continue east on the south side of the highway on a separate structure. A possible elevated station with parking – Elmsford West – would be located at Route 9A, Central Avenue (Exit 2). The exclusive busway would continue east on the south side adjacent to I-287 and drop down beneath the Sprain Brook Parkway (Exit 3) to an at-grade station – Elmsford East – possibly at the *Bed Bath and Beyond/Syms* shopping center just west of Knollwood Road (Exit 4). East of Knollwood Road the alignment adjacent to I-287 continues to Exit 5 (Hillside Avenue). Directly east of Hillside Avenue the busway would join the Exit 5 ramps and transition onto exclusive curbside bus lanes on Route 119 – Tarrytown Road for access into downtown White Plains. Transit-signal priority for buses would be provided at Route 119 intersections. A possible BRT station would be located near the Westchester County Center across from Central Avenue. The BRT dedicated lanes would cross over the Bronx River and under the Harlem Line as a one-way pair using Hamilton Avenue and Main Street, respectively, for access to and from the WPTC and for transfer to the Metro-North Harlem Line.

Several possibilities exist for BRT routes through downtown White Plains (see Subchapter 2.3.1.3 for more details). As yet there has been no consensus on the optimal BRT route through downtown. Discussions with the City and other stakeholders are expected to continue into the DEIS, and ultimately a final alignment will be established. Among those options under consideration, the option that has been exhibited at public open-house presentations has eastbound buses on Main Street and westbound buses on Hamilton Avenue, with transit-signal priority at all bus intersections. At Broadway both alignments would circle Tibbits Park and rejoin on Westchester Avenue. Two bus stations are proposed in downtown White Plains, with possible locations at the Galleria Mall and the Westchester Mall.

East of downtown White Plains, the alignment splits around Exit 8E and buses use dedicated lanes on Westchester Avenue. A possible Platinum Mile Station is proposed at Corporate Park Drive, and could include jitney service to the Platinum Mile and other corporate parks. Continuing east, a proposed station is possible at Exit 10, Westchester Avenue in Purchase. East of Purchase, the dedicated lanes would end and buses would either use Route 120A, Westchester Avenue for local service to downtown Port Chester and the Metro-North New Haven Line Station, or enter I-287 general-purpose lanes at Exit 10 and proceed to the I-95 interchange in mixed traffic for continued service north to Connecticut or south to New York City.

2.3.1.3 White Plains

A separate study (NYSDOT et al, August 2008) was conducted to compare alignment options for BRT routes in White Plains. As White Plains is the central hub of the corridor and traffic in White Plains is the most congested urban traffic in the corridor, special consideration was given to the routing through White Plains. Crossing White Plains from west to east, connecting to the WPTC and Metro-North Station and serving the other activity centers is not easily accomplished. Key destinations (Figure 2-15) include the Galleria Mall, White Plains Mall, and Westchester Mall, the complex of county buildings along Martine, and the White Plains City Hall.

The following criteria were developed and used to compare alignment options for BRT in downtown White Plains:

- **Minutes Run Time**: Walk time between Metro-North White Plains Station and Westchester Mall is about 22 minutes. Therefore, transit run times should be less than half walk times if they are to offer a serious advantage to travelers.

- **Split Service over One Block Apart**: Options that would run buses in different streets more than a block apart depending on the direction of operation (referred to in the table as split service) would have two undesirable traits, because split service would require use of different boarding and alighting locations for a given station. This would mean any destinations at the fringe of one route would be outside the limit of convenient walk distance from the other – meaning split stations would offer less coverage when convenience of the riders is considered. Furthermore, having to go to different streets to find a given station depending on the direction of travel can confuse users, particularly visitors.

- **180° Turns**: Sharp turns reduce speeds significantly. Depending on turn geometry and gradients, some tight turns could require use of wider turns, potentially impacting traffic in both directions. Doubling back on a route is inherently inefficient.

- **Length in Miles**: The shorter a route that provides equivalent coverage, the less costly and more efficient that route will be both to build and operate. Because BRT systems involve signal-system modifications, street modifications for paving, curb and gutter changes and drainage inlet redesign/replacement, the longer a route the more costly it will be to construct. Similarly, the longer the route, the more bus miles and time will be required to provide the same level of service, requiring more operating dollars as well. Therefore, length of route was used as a measure of higher costs – both operating and construction.

- **Walk Distances to Key Destinations**: Walk distances of ½ mile to transit are observed, but most transit users walk ¼ mile or less to their destinations/stations. Therefore, walk distance is a surrogate for ridership potential. The options that required walk distances substantially greater than ¼ mile were judged to offer less access than the others.

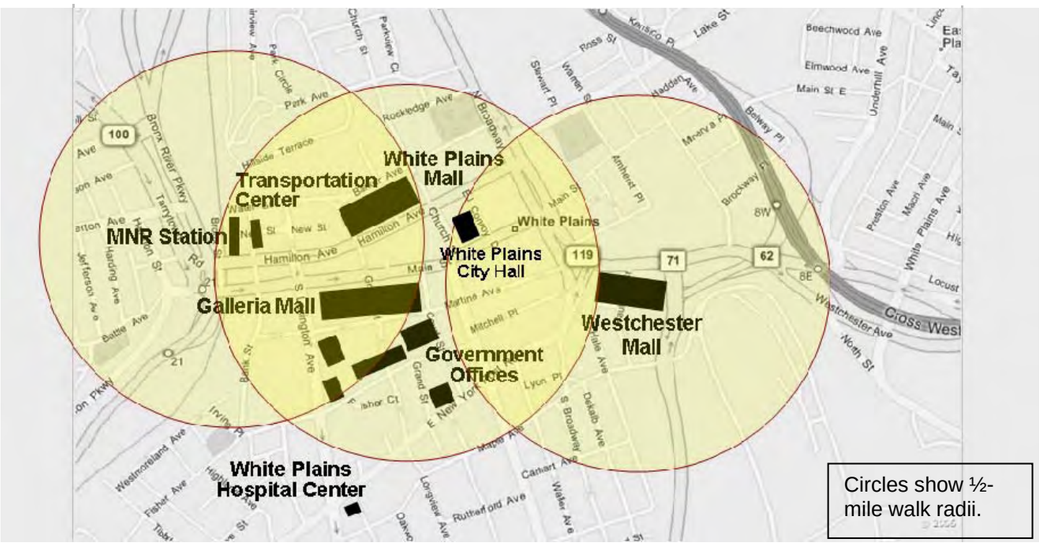


Figure 2-15 Key Destinations and Walk Distances in White Plains

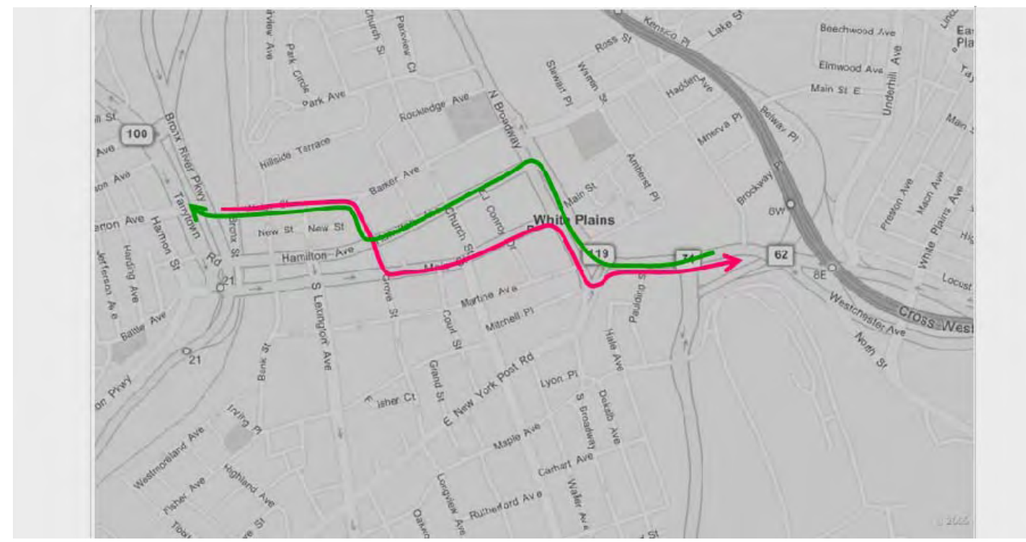


Figure 2-16 BRT White Plains Alignment Option 1

The alignment options considered use dedicated lanes on existing streets for the BRT operation, crossing streets at grade, and priority traffic signals. They were evaluated and compared, as shown in Table 2-1. Two of these alignment options – Options 1 and 3 – are being considered for further analysis (Figures 2-16 and 2-17). Variations of these alignment options may result from the detailed traffic analysis being performed in the DEIS. The alignment options not shown, each of which had significant operational, access, or service issues, generally followed these routes:

- **Option 2** – Main and Martine.
- **Option 4** – Main, Martine, and Grove.
- **Option 5** – Lexington, Maple, Church, and Barker.

Table 2-1

BRT Alignment Options In White Plains - Performance Summary

Alignment Option	Minutes Run Time	Split Service Over 1 Block Apart	180° Turns	Length in Miles	Walk Distances to Key Destinations
BRT 1					
BRT 2			●		
BRT 3					
BRT 4		●	●		
BRT 5	●	●		●	●
Note: ● Does not meet criterion.					

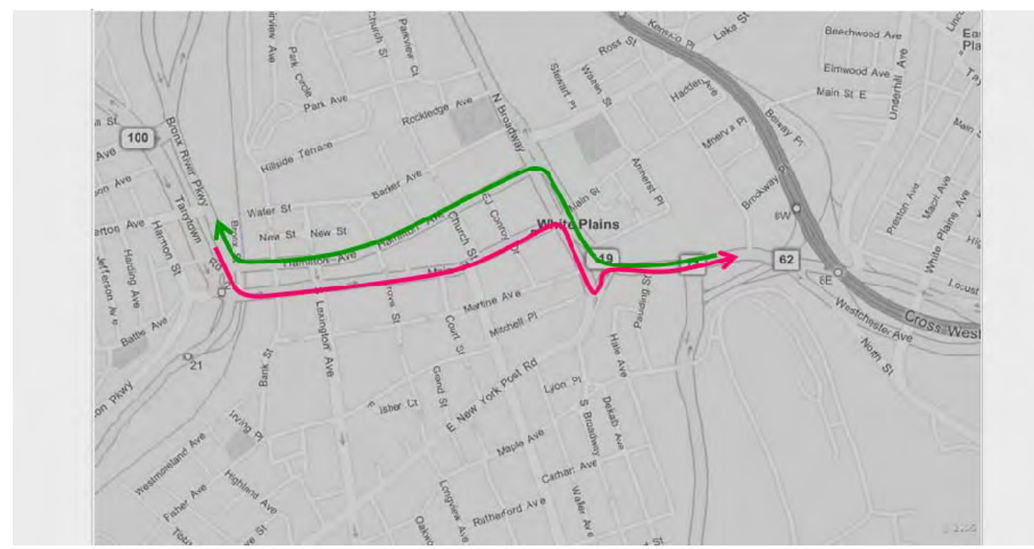


Figure 2-17 BRT White Plains Alignment Option 3

2.3.2 Description of Option 3A

Option 3A improves the BRT service provided in Alternative 3 (Figures 2-18 and 2-19). This is accomplished by a number of methods, including more frequent headways, more bus stations, and improved running ways.

In Rockland County, the Option 3A improvements include enhanced service plans and two new stations: Route 59 in Monsey and Interchange 11 (Nyack). The Monsey Station would be an offline station, with parking possibly located just east of the Route 59 overpass and on the north side of the highway. Access from the HOV/HOT lanes to the station would likely be by direct flyover ("Texas T") similar to that proposed for access to Parking Lot J.

Establishing a possible Nyack Station at Interchange 11 would be challenging due to the combination of the highway geometry, the angle at which Route 59 passes under the Thruway, the Mountainview and Highland Avenue overpasses, and the interchange ramps. A possible layout would locate the station beneath the highway where it crosses Route 59 - Main Street. The Thruway would be widened an additional 30 feet approximately, to provide drop ramps from both directions to meet Route 59 at grade. Bus platforms and amenities would be provided on both sides of Main Street and transit-signal priority would be provided to allow buses to cross Route 59 without delay. An advantage of this layout is the ability of feeder buses to access the station and easily connect to the HOV/HOT lanes via the drop ramps.

In Westchester County, Option 3A would provide additional stations and a dedicated busway alignment east of White Plains that includes a direct connection to the Metro-North Port Chester Station. The proposed new stations could be provided at these possible locations:

- Broadway in Tarrytown.
- Hillside Avenue.
- White Plains Avenue at I-287.
- South Ridge Street in Rye Brook.
- Boston Post Road at the I-95 Interchange.

The Westchester County BRT alignment for Option 3A would remain basically unchanged through Tarrytown, except that a possible BRT station would be provided at Broadway and Route 119. In Elmsford directly after Knollwood Road, the Option 3A alignment on the south side of I-287 would cross over to the north side to create a possible station with parking located west of Hillside Avenue.

Directly east of Hillside Avenue, the busway would cross over I-287 and join the Exit 5 ramps to connect to exclusive bus lanes on Route 119 – Tarrytown Road, as proposed in Alternative 3. Although optional exclusive bus routes to the WPTC and through downtown White Plains will be investigated, the possible station locations would not appreciably change and the running times would be consistent with the service plans.

East of White Plains the exclusive bus lane arrangement on Westchester Avenue, as provided in Alternative 3, would continue to Exit 10, but a transition to a barrier-separated busway would begin at Exit 10 and continue to a direct connection to the Metro-North Port Chester Station. The exclusive busway would be located along the north side of I-287, with new on-line stations at South Ridge Street and east of Boston Post Road adjacent to the shopping center. East of this station the exclusive busway would turn north and parallel the west side of the Metro-North New Haven line and terminate at the Port Chester Station. Buses continuing north or south on I-95 would enter general-purpose lanes on I-287 at Exit 10.

2.3.3 Description of Option 3B

Option 3B in Westchester County would provide a dedicated busway with an independent alignment from the Hudson River crossing to Port Chester. Some essential elements of a BRT system that have been added include trunk line stations and feeder-bus connectivity. The infrastructure necessary to maintain a high-speed trunk line with minimal interference from general-purpose traffic on I-287 and local arterials has been provided. In Rockland County, Option 3B would be the same as Option 3A. The dedicated busway is described in segments across Westchester County (Figures 2-20 and 2-21) below.

2.3.3.1 Tarrytown to Interchange 8

Upon entering Westchester County in a HOV/HOT lane across a replacement or rehabilitated Tappan Zee Bridge, the first important destination is the Metro-North Hudson Line Tarrytown Station. The Option 3A plan to access the Tarrytown Station would have buses exit at Interchange 9 (Tarrytown) in the HOV/HOT lanes, then turn west onto dedicated lanes on Route 119, and cross Broadway to enter a dedicated busway that would extend to the Tarrytown Station. The concept developed for Option 3B would drop the BRT lanes just below a widened toll plaza to a lower-level, open-cut roundabout with a short tunnel link to a busway on the north side of the toll plaza. The busway would follow the same alignment proposed in Option 3A along the east side of the Hudson Line to the Tarrytown Station. The HOV/HOT lanes would remain at the toll plaza grade and bypass the lower level busway. Impacts of this concept include a wider toll plaza to allow for the drop ramps and retaining walls. Advantages of this concept include faster access to the Tarrytown Station and elimination of the need for dedicated lanes on Route 119 from the exit ramp to Broadway.

A possible trunk line station is proposed at Broadway, located just west of the Broadway overpass, and at the same lower level as the roundabout. Passenger access to the station would be from the west side of a widened Broadway Bridge down to the bus platforms.

East of the Broadway Station buses would join the HOV/HOT lane and exit ramp at Interchange 9 (Tarrytown), but just after the exit ramp passes over the I-287 westbound lanes, buses would traverse an elevated roundabout on the north side of I-87/I-287. From the roundabout, buses could continue north and exit onto Route 119 and become feeder buses, or head east from the roundabout and enter a dedicated busway on a viaduct adjacent to the north side of I-87/I-287. The viaduct would be within the I-87/I-287 ROW as it passed the Talleyrand Swamp toward Interchange 8.

Approaching Interchange 8, the busway alignment would have two options. The alignment option that would provide a preferred station location would curve to the north out of the I-87/I-287 ROW and transition to grade for a possible Benedict Avenue Station just south of Route 119. Buses could bypass the Benedict Avenue Station if it is not on their service plan. This alignment and station location would require property acquisition and/or easements between I-287 and Route 119. The second option would maintain the alignment along the north side of Interchange 8 on a viaduct, with a possible station located on the alignment at the rear of the commercial properties abutting the interchange.

It is important to note that the Option 3B alignment adjacent to I-287 would preclude a possible station at Meadow Street and Route 119, but this station could still be served by feeder buses that would have access to the exclusive busway at Broadway/Route 119 or further east, at Route 9A.

2.3.3.2 Interchange 8 to Route 9A

Heading east from the Benedict Avenue Station, the busway would transition onto a viaduct and cross over Route 119 and then continue on the north side of I-287 to cross the Saw Mill River valley. A possible Elmsford West Station would be located at Route 9A, Central Avenue. The busway would drop down beneath the westbound I-287 Exit 2 ramps through cut-and-cover bridge sections to bring the BRT to an at-grade crossing with Route 9A just north of I-287. Transit-signal priority would allow buses to cross Route 9A without delay.

The Elmsford West Station here would be an on-line, at-grade station, thus allowing feeder buses that currently operate on Central Avenue direct access to the busway. The BRT station would be located with platforms on both sides of Route 9A to provide pedestrian access to the eastbound and westbound buses prior to the bus crossing Route 9A. Park-and-ride lots could be constructed on either side of I-287 in this area. If the service plan modifications were to dictate that some BRT routes would bypass this station, the station could include pull-out bays for buses that would be stopping, and center bypass lanes for through buses.

2.3.3.3 Route 9A to White Plains

Proceeding east through Greenburgh, possible stations are proposed in the vicinity of Knollwood Road (Elmsford East), and Hillside Avenue, in addition to a direct connection to the WPTC.

Between Route 9A and the Sprain Brook Parkway, the busway would be on the north side of I-287 in a retained-cut and then in cut-and-cover bridge section beneath the Sprain Brook Parkway (Exit 3). Between the Sprain Brook Parkway and Knollwood Road the busway would be at grade and through cut-and-cover bridge sections under the westbound I-287 Exit 4 ramps at Knollwood Road. A possible Elmsford East Station would be at grade adjacent to I-287 and below the elevation of Knollwood Road. Pedestrian access to the station would be provided from the bus platforms up to a station facility constructed on the west side of the Knollwood Road overpass.

East of Knollwood Road, the busway would climb on a viaduct to the elevation of I-287 and then rise again as it approached a possible elevated Hillside Avenue Station on the north side of I-287. A proposed park-and-ride facility could be located on the north side of I-287 adjacent to the station; pedestrian access would be provided from Hillside Avenue up to the elevated bus platforms.

Continuing east of the station, the elevated busway would cross over Hillside Avenue and I-287, then follow alongside I-287 on the south side, at the same elevation as the existing I-287 viaduct over the Bronx River Parkway. In Alternative 3 and Option 3A, the BRT alignment transitions onto Route 119 at Exit 5 to access the WPTC and downtown destinations. In Option 3B, a busway from I-287 would be provided for direct access to the WPTC and thereby eliminate possible traffic impacts to Route 119. In this option, an elevated busway “T” intersection would be provided just west of where I-287 passes over the Metro-North Hudson Line, to allow buses to turn south on a viaduct then down to grade along the west side of the Metro-North Hudson Line. A short tunnel under the Harlem Line embankment would be provided for the buses to drive onto Water Street to access the WPTC. Depending on the service plan, buses would either return to the I-287 busway on the viaduct, bypassing downtown, or continue through downtown White Plains in dedicated bus lanes, as provided in Alternative 3 and Option 3A.

East of the elevated “T”-intersection, the busway would drop down beneath the two eastbound I-287 Exit 6 ramps at North Broadway (Route 22) through cut-and-cover bridge sections to bring the BRT down to the elevation of I-287 and pass beneath North Broadway. The busway would rise onto a viaduct between the North Broadway eastbound I-287 entrance ramp and Grant Avenue, along the south side of I-287, and continue over all crossing streets. East of Brockway Place, the alignment drops down beneath the four existing eastbound and westbound Exits 8W & 8E Interchange ramps, and then rises again onto a viaduct just west of White Plains Avenue.

2.3.3.4 East of White Plains to Port Chester

East of downtown White Plains, the elevated busway would pass over White Plains Avenue to enter a proposed White Plains Avenue Station, which would be on a retained fill and possibly located between the south side of I-287 and Westchester Avenue. This station would have central bypass lanes.

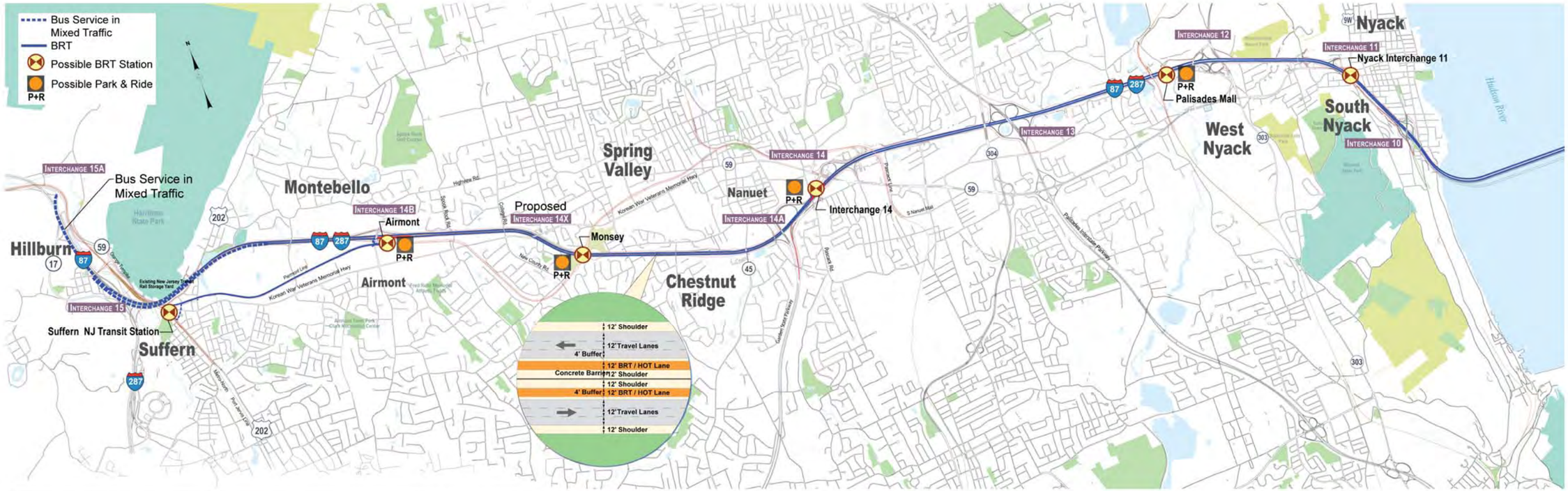
The busway would continue east on elevated viaduct located along the south side of I-287, cross over Bryant Avenue, and then drop down to a possible at-grade Platinum Mile Station. The station could have curb frontage along Westchester Avenue to facilitate connection to jitney service to the Platinum Mile and other corporate parks. Beyond the station, the busway would rise back onto elevated viaduct and follow along the south side of I-287, except where it would swing south along the outside of the eastbound I-287 ramps of the Hutchinson River Parkway (Exit 9) Interchange. The busway would remain elevated on the south side of I-287 and cross over to the north side of I-287 just west of Exit 10, where Westchester Avenue (Route 120A) turns north to Port Chester. A connection to grade would be provided to Westchester Avenue at this location to provide access for feeder buses on Westchester Avenue to the busway.

The busway would continue along the north side of I-287 on viaduct, with a possible elevated station just east of Westchester Avenue. The station would provide for pedestrian access to the elevated bus platforms from a possible park-and-ride site within the parking lot of a commercial property on Webb Avenue. This station would include central bypass lanes for through buses and pull-out bays for buses that would be stopping.

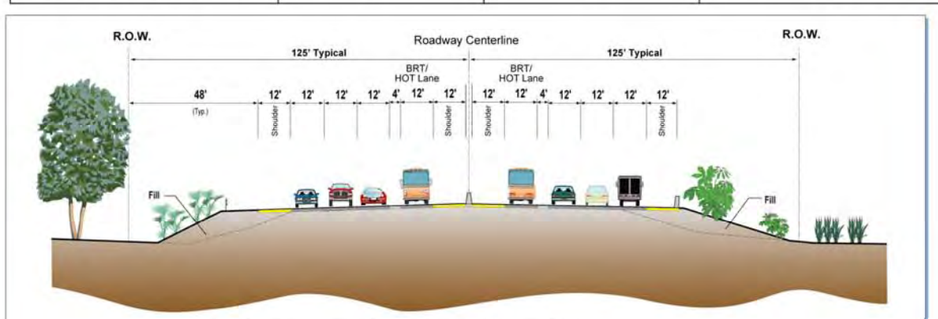
Between Bowman Avenue and South Ridge Street, a connection to the I-287 eastbound and westbound general-purpose lanes is provided for buses leaving the busway and continuing on I-287 to the I-95 Interchange. The I-287 roadway would require approximately 30 feet of widening in this area to provide for the connection.

Just west of South Ridge Street, the elevated busway would continue to a possible South Ridge Street Station, which would be on a retained fill north of I-287. This station would have central bypass lanes. The elevated busway would pass over South Ridge Street, High Street, and Boston Post Road, and drop down to a possible Boston Post Road Station, which could be located north of I-287 along the south side of the shopping center, and could include provision for parking.

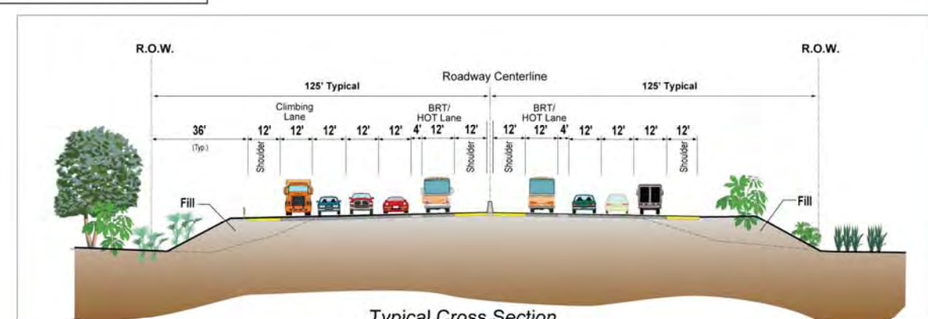
From the Boston Post Road station, the busway, in a dedicated alignment, would turn north and parallel the west side of the Metro-North New Haven Line, mostly at grade, and cross over Westchester Avenue and terminate at the Port Chester Metro-North Station.



Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Option 3A - Rockland	0	0	71,300 ft	71,300 ft (13.5 Miles)

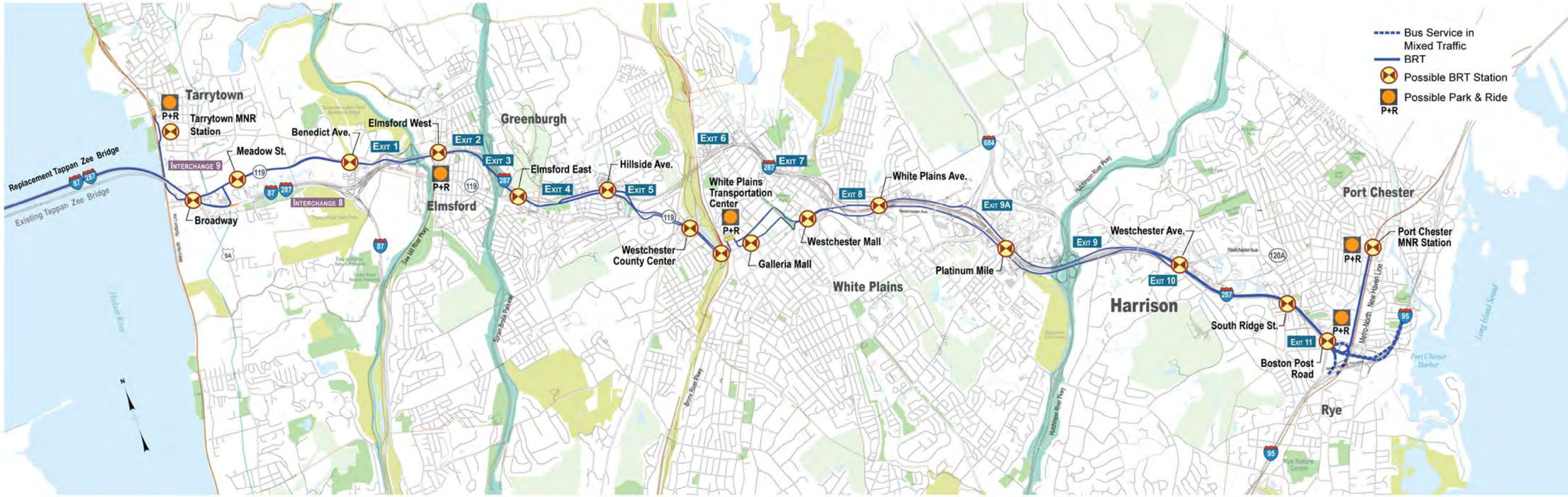


Typical Cross Section - West of Spring Valley
(Looking East)

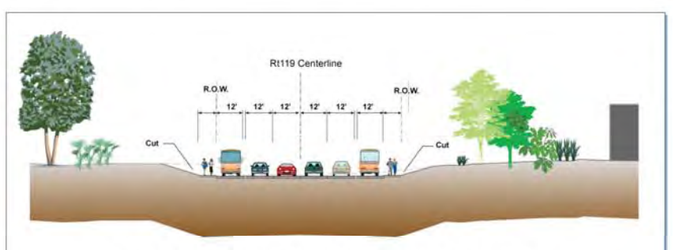


Typical Cross Section
Between Interchange 14A and Interchange 12
(Looking East)

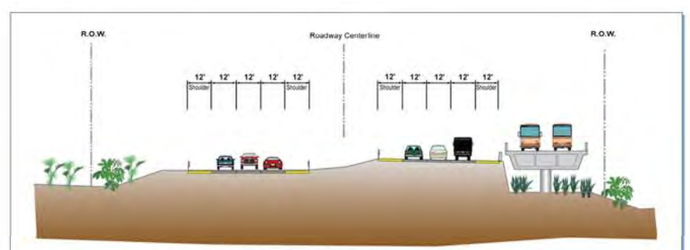
Figure 2-18 Option 3A - Full-Corridor Bus Rapid Transit in Rockland County



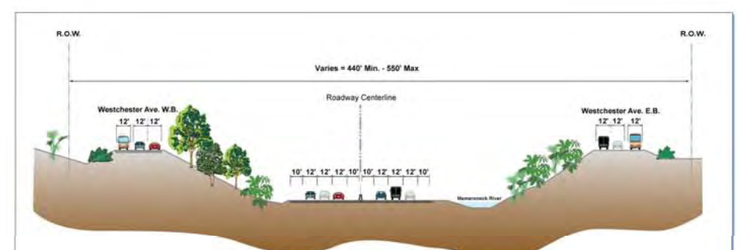
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Option 3A - Westchester	0	9,200 ft	65,700 ft	74,900 ft (14.2 Miles)



Typical Cross Section - Along White Plains Rd. (Route 119)
(Looking East)

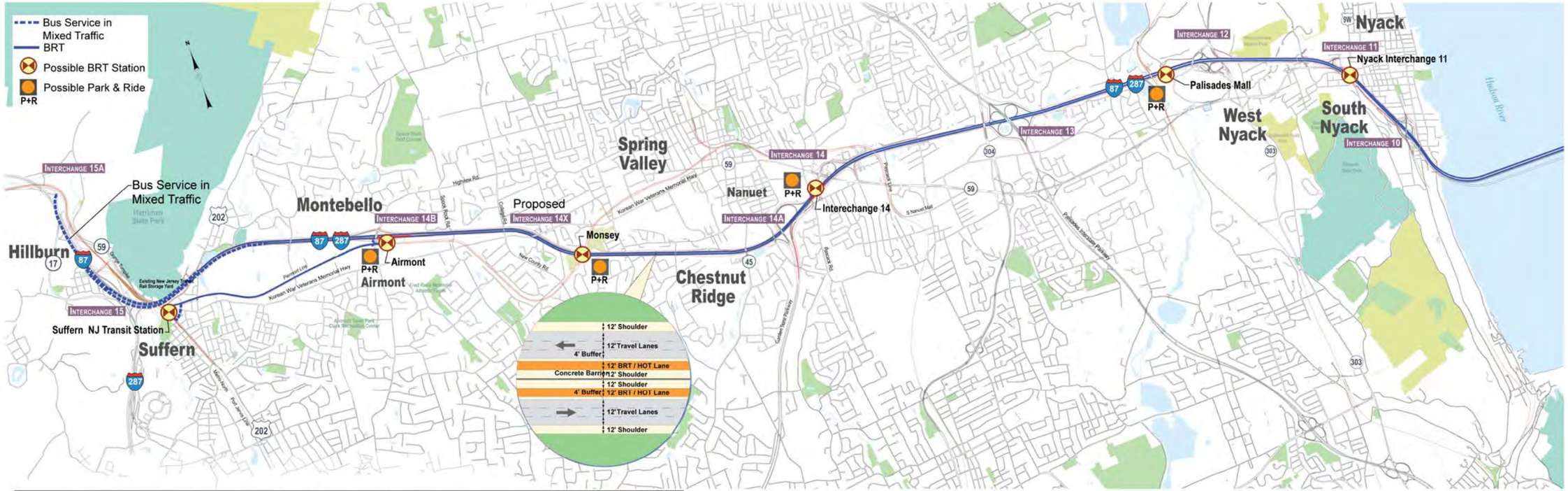


Typical Cross Section in Elmsford
(Looking East)

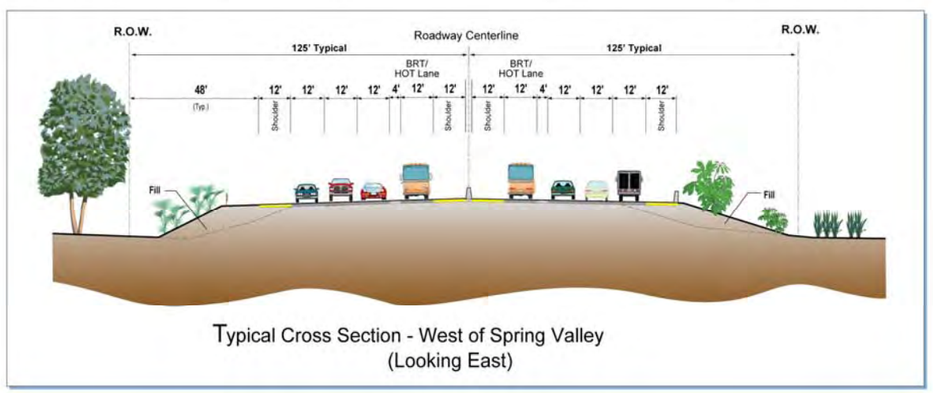


Typical Cross Section - East of Exit 8
(Looking East)

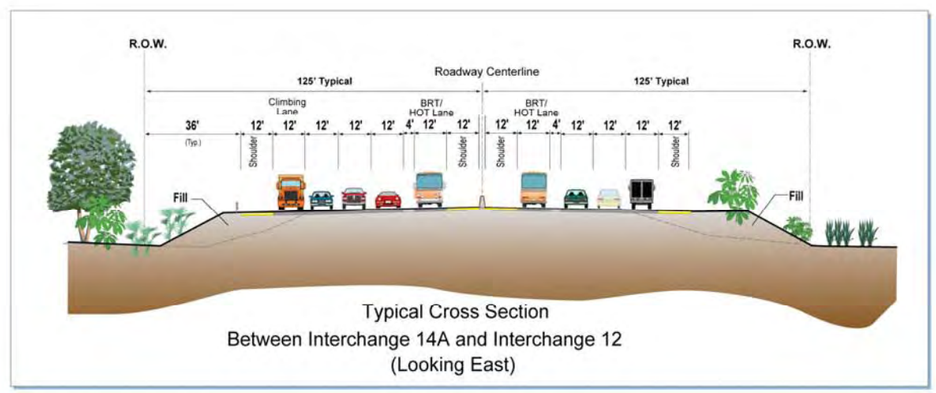
Figure 2-19 Option 3A – Full-Corridor Bus Rapid Transit in Westchester County



Alignment Quantities				
	Tunnel	Viaduct/Major Bridge	At Grade, Cut, or Fill	Total
Option 3B - Rockland	0	0	71,300 ft.	71,300 ft. (13.5 Miles)



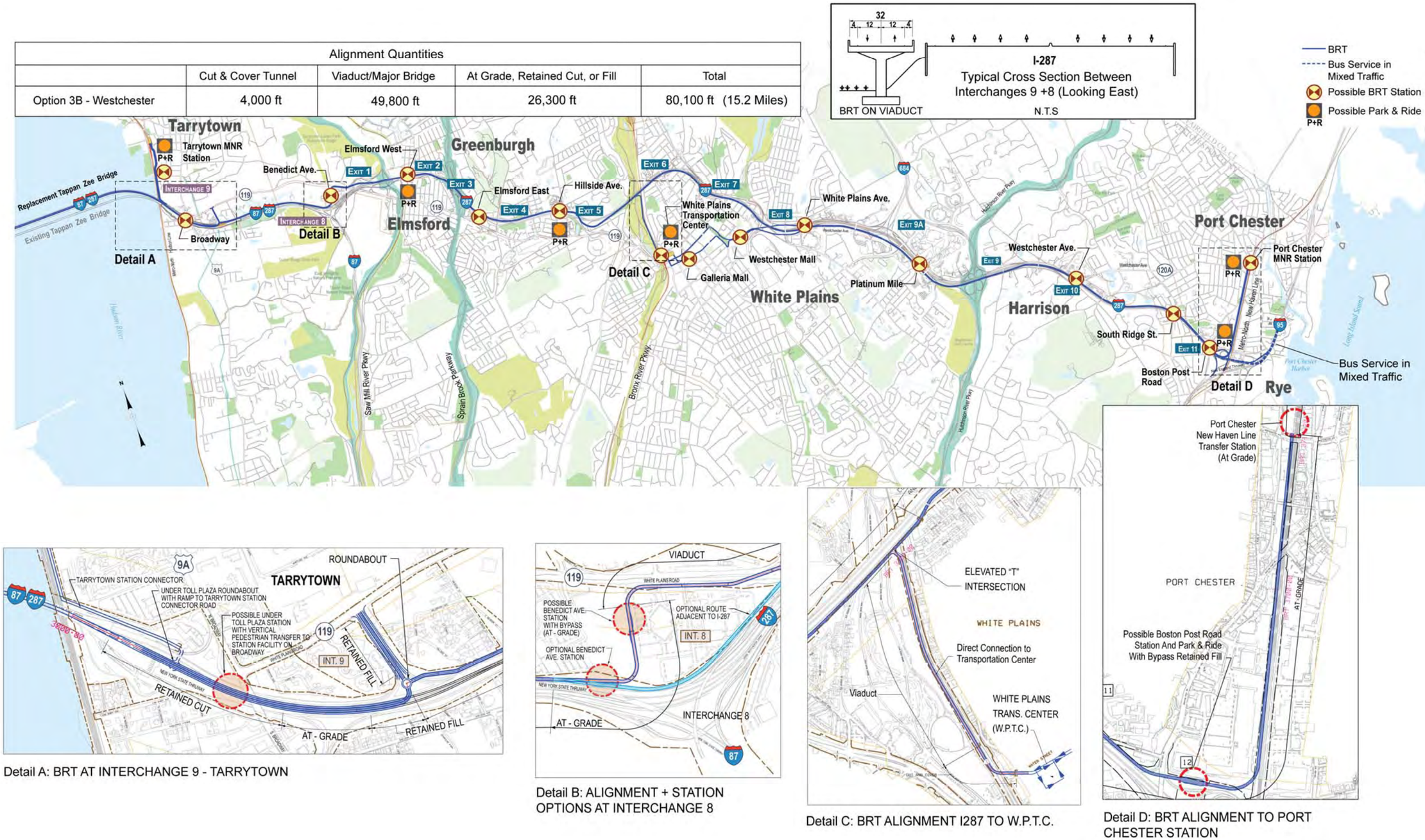
Typical Cross Section - West of Spring Valley
(Looking East)



Typical Cross Section
Between Interchange 14A and Interchange 12
(Looking East)

Figure 2-20 Option 3B – Full-Corridor Bus Rapid Transit in Rockland County

Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Option 3B - Westchester	4,000 ft	49,800 ft	26,300 ft	80,100 ft (15.2 Miles)



Detail A: BRT AT INTERCHANGE 9 - TARRYTOWN

Detail B: ALIGNMENT + STATION OPTIONS AT INTERCHANGE 8

Detail C: BRT ALIGNMENT I287 TO W.P.T.C.

Detail D: BRT ALIGNMENT TO PORT CHESTER STATION

Figure 2-21 Option 3B – Full-Corridor Bus Rapid Transit in Westchester County

BRT

LRT

CRT