4 Commuter Rail Transit in the Corridor

Commuter rail transit (CRT) provides suburb-to-central city commuter service as well as suburb-to-suburb service. Commuter rail was the original engine for many of the older suburbs and "bedroom" communities surrounding major American cities, predating the rise of the automobile for commuting. The service is typically heavily weighted to serve the commuting needs of workers, with a concentration of service during rush hours and reduced service at other times.

Commuter Rail Transit

Nowhere else is this better demonstrated in the US than in the NYC Metropolitan Area. The Metro-North Railroad, a subsidiary agency of the Metropolitan Transportation Authority (MTA), is the second-largest commuter railroad system in the US. The Metro-North system covers a vast area, connecting New York City (Manhattan and the Bronx) with Westchester, Putnam, Dutchess, Rockland, and Orange Counties, as well as Fairfield and New Haven Counties in Connecticut. Metro-North captures a dominant market share of total peak-hour trips to the Manhattan central business district (CBD) from the suburbs north of New York City and Connecticut. In 2007, it moved 80.7 million passengers on its entire network.

The railroad is organized around five lines, with two discrete networks: East-of-Hudson and West-of-Hudson. The East-of-Hudson network consists of the Hudson, Harlem, and New Haven Lines. The West-of-Hudson network consists of the Port Jervis and Pascack Valley Lines. Metro-North carries its weekday ridership on over 600 daily scheduled trains on the East-of-Hudson network and over 60 trains on the West-of-Hudson network.

Each of Metro-North's five major lines crosses the I-287 Corridor in a north-south direction (Figure 4-1). There are no Metro-North facilities that run in an east-west direction, either parallel to the corridor, or across the Hudson River. One of the objectives of the current study is to establish the feasibility of instituting new commuter rail service across the corridor and the Hudson River.

East-of-Hudson Commuter Rail Service

The East-of-Hudson network is mostly electrified. Rolling stock on the majority of services on the Hudson and Harlem Lines are provided by electrical multiple units (EMUs) of the M7 class, drawing power from a third-rail system with an under-running current pickup. Metro-North also operates dual-mode (third-rail and diesel) locomotives and coaches in push-pull mode on the East-of-Hudson lines into GCT.

The Hudson Line extends to Dutchess County, and runs along the eastern bank of the Hudson River through Putnam and Westchester Counties, into the Bronx and Manhattan – a distance of 76 miles from Poughkeepsie to GCT. The Hudson Line is shared with Amtrak services (in the Empire Corridor to and from Penn Station New York) and with CSX and CP Rail (north of Highbridge).

Figure 4-1 MTA Metro-North Railroad Map

The Harlem Line begins in Wassaic, also in Dutchess County, and continues south through the heart of Putnam and Westchester Counties into the Bronx, where it joins the Hudson Line at Mott Haven junction – a distance of 77 miles.

From their junction at Woodlawn, the New Haven and Harlem lines continue south and merge with the Hudson Line at Mott Haven, from which point they continue over the Harlem River into Manhattan and onto the Park Avenue Viaduct, with a station at 125th Street in Harlem. The Viaduct continues to 97th Street, where the line goes into the Park Avenue Tunnel, feeding into GCT.

The New Haven Line begins in New Haven, Connecticut, and continues into Fairfield County, in between and paralleling Interstate 95 and the Long Island Sound shore, the area commonly referred to as the Gold Coast. The line enters New York State in Westchester County and then continues into the Bronx, joining the Harlem Line at a point just north of Woodlawn Station. The length of the New Haven Line from New Haven to the junction with the Harlem Line is 61 miles. In addition, the New Haven Line has three branches: the New Canaan Branch, at nearly 8 miles in length, the Danbury Branch, at 24 miles in length, and the Waterbury Branch, at 27 miles in length. The New Haven Line is operated under a joint agreement with the Connecticut Department of Transportation (ConnDOT), which provides funding to Metro-North for both operating and capital expenses, and maintains all of the stations in Connecticut.

The New Haven Line is also mostly electrified. The line is equipped with under-running third rail to a point just south (west) of Pelham Station. The remainder of the line to New Haven is equipped with an overhead catenary. Three unique classes of EMUs, known as the M-2, M-4, and M-6 cars, provide service on the New Haven Line. These cars are equipped with both third-rail shoes and pantographs for current pickup from the overhead catenary.

West-of-Hudson Commuter Rail Service

The West-of-Hudson network consists of two lines: the Port Jervis Line and the Pascack Valley Line. These two lines are operated under an agreement with New Jersey Transit (NJT), utilizing a common equipment pool manned by NJT personnel. The West-of-Hudson network is not electrified; diesel locomotives and coaches in push-pull mode provide services on those lines.

The Port Jervis Line originates at Port Jervis near the Pennsylvania, New Jersey, and New York border. It initially loops north through Orange County before turning south again at Salisbury-Mills Cornwall, from which it heads to Suffern. South of Suffern, express rail service continues along NJT's Main/Bergen Line to Hoboken, New Jersey via Secaucus.

The Secaucus Transfer is a hub for 10 of New Jersey's 11 rail lines. It allows passengers traveling on the Main/Bergen and Port Jervis lines to transfer to NJT trains directly into New York's Penn Station on Manhattan's west side. The Secaucus Transfer provides a more direct trip to Penn Station, New York, cutting travel time by about 15 minutes. Transfer is also available at Secaucus to trains to Newark, Trenton, Long Branch, and Morristown. At Hoboken, passengers have the option of transferring to a PATH train to Midtown or the World Trade Center site, or to a commuter ferry for service to lower or Midtown Manhattan. The total length from Port Jervis to Hoboken is over 95 miles.

The Pascack Valley Line originates in Spring Valley, Rockland County, serving Nanuet and Pearl River before crossing into New Jersey. It merges with the Main/Bergen Line just north of Secaucus. It is nearly 31 miles from Spring Valley to Hoboken. Metro-North in conjunction with the Village of Spring Valley and the NYSDOT constructed a new bus intermodal area at the Spring Valley Station and rehabilitated the station building, platform, and parking facilities.

4.1 Description of CRT Systems

CRT systems are primarily designed for longer-distance trips than the other transit modes, and feature fewer stations per mile than RRT or LRT. They are also designed to operate on exclusive guideways at high speeds. CRT systems typically have few stations in the downtowns they serve, most often having a single central terminal where all or most of the lines converge. Key aspects of typical CRT systems are:

- Long station spacing (usually over two miles).
- Guideway types largely limited to exclusive ROWs.
- Long trains (four to 10 cars).
- Typically high top speeds (90 mph or more).
- Coordination with local bus services.
- On-board fare collection.
- High passenger capacity.

CRT systems operate as integrated services, with central controls that monitor system operations. Because CRT systems operate in exclusive guideways, they are able to operate at high speeds, with long trains that give them very high passenger capacities. New commuter rail systems are usually designed with few grade crossings. Commuter services often have both local and express services, which is less common with other types of rail transit service. They are high-capacity systems operating trains of 10 or even more cars generally on less-frequent headways than LRT or RRT. Typical peak-hour headways of 30 minutes are common, although some lines operate on headways as short as 15 minutes. Where CRT systems have tighter headways, it is not uncommon for them to vary their station stop pattern so that not all trains stop at each station.

CRT systems tend to be more dependent on automobile access to their stations than other rail transit systems are. This is at least partly due to their being typically designed to serve longer-distance commuters located in suburban areas, where automobiles predominate over public transit services. Consequently, it is common for commuter rail stations to have large parking areas. Despite the prevalence of auto access, CRT systems also need good feeder-bus access. This includes provision of locations for passengers to transfer between the rail and bus systems, addition or modification of bus service to allow passengers to make transfers, and may also include close coordination of bus and rail operations.

Unlike the other rail-transit technologies, to operate within railroad ROWs commuter rail trains must comply with Federal Rail Administration (FRA) regulations. The FRA has broad powers to regulate such commuter-rail systems, including the establishment of:

- Track safety standards.
- Workplace safety standards.
- Operating rules.
- Communications.
- Employee hours of service.
- Safety appliance standards.
- Signal systems, including grade-crossing warning devices.
- Passenger equipment safety standards.
- Passenger train emergency preparedness.

The FRA can also set vehicle requirements to ensure the ability to interoperate with freight rail systems. The net result of these restrictions is that CRT systems generally abide by the same constraints as the freight railroads in terms of track design, including maximum gradients of two percent and minimum curves of over 2,000 feet radius.

4.1.1 Types of Guideway, Grades, and Geometry

For reasons of safety and to permit higher-speed operations, commuter rail guideways are confined to exclusive ROWs. The desirable space to accommodate a set of two commuter rail tracks at grade is about 54 feet (without parapets or barriers) or 57 feet (with parapets or barriers); the minimum distances would be 34 and 37 feet, respectively. Greater width would be required at stations where platforms of 15-foot width add a total of 30 feet of additional width. Figure 4-2 provides a cross-section showing the space needed for a typical guideway segment.

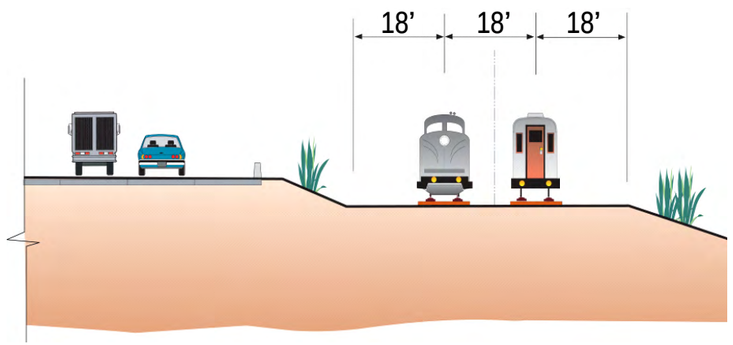


Figure 4-2 Typical Guideway Segment

Where a surface alignment is not possible, the guideway may need to be placed in an open cut or on an elevated structure. CRT systems must be designed to avoid gradients of greater than two percent. Since this is not always possible without raising or lowering the guideway relative to the natural grade of a potential alignment, this requirement can lead to the need for open cuts, tunnels, embankments, and viaducts. Each of these structures requires more space than does an at-grade guideway, and each costs substantially more to construct and maintain than does an at-grade guideway.

For this reason, the process of route selection for a commuter rail system must carefully consider the potential structures a route could entail. This does not mean routes that require structures cannot be selected, but rather only that such routes require careful consideration of their operational consequences.

Sixth Street Embankment

Elevated guideway alternatives generally take three forms: 1): embankments, 2) bridges, and 3) trestles (aka viaducts). Embankments are used where the height of the guideway over grade is sufficiently small (usually less than 30 feet) to accommodate the width required. Embankments may be retained by walls or simply have steep unretained side slopes. They are earthen structures that may have portals under them to accommodate crossing streets. Retained-fill segments are generally preferred where possible because of their lower cost compared to bridges and viaducts. If the width of structure is an issue, concrete or stone retaining walls are commonly used. The photo shows an abandoned embankment called the Harsimus Stem Embankment, an elevated stone structure that once carried seven tracks of the Pennsylvania Railroad to the Hudson River Waterfront for a half mile along 6th Street in downtown Jersey City, New Jersey.

Embankments are not always possible or desirable, in which case a trestle may be appropriate. Unlike embankments, trestles can be quite tall, as evidenced by the Metro-North Railway's Moodna Viaduct. A trestle is essentially a bridge with a continuous support structure holding it up. Unlike an embankment, the supporting structure does not form a continuous wall at grade level, enabling movement under the trestle without the need for portals or tunnels.

Commuter Rail Viaduct (Moodna Viaduct – Metro-North)

Where it is not possible to have a continuous support structure, bridges are used to span gaps, often in combination with trestles and embankments for their approach sections. The size and complexity of the necessary bridge structure varies with the site conditions, projected usage, and the span of bridge required. The forms of bridge structures available are quite broad, but except for the Tappan Zee Bridge itself, it is unlikely any bridges in the corridor would be large structures. In the past, railroad bridges were often large and not necessarily attractive structures typical of the era in which they were built. There are now numerous bridge forms available that blend well in urban environments. As the photo of the Dallas Area Rapid Transit bridge shows, they can be harmoniously integrated into an urban environment.

Dallas Area Rapid Transit Bridge and Embankment

There are also two basic methods of putting guideways below grade, tunnels and open cuts. Open-cut structures, sometimes called ditches, can be created with earthen sides or retaining walls. The deeper the open cut, the more likely retaining walls will be needed. Open-cut segments are commonly used for the transition sections from at-grade to tunnel sections called portals. Like embankments, open-cut sections form a barrier to crossing traffic that requires a structural solution, in this case overpasses. Open cuts are generally less than 30 feet deep.

Open Cut Section

Tunnels are underground structures that do not restrict access on the ground surface, but are very expensive to construct. Tunnels can be built by two basic methods – cut-and-cover construction or driven-tunnel construction. Without exploring the many variants of these techniques, it is sufficient to say cut-and-cover construction consists of digging a ditch, creating the tunnel structure and filling the ditch back to the previous natural grade. It entails significant surface disruption during construction. Driven tunnels typically use boring machines, and are usually less disruptive during construction.

While structures can overcome natural topography, there are limited solutions to curvature constraints. Here again, walls and fill may be required to provide adequate length to accommodate the gentle curves needed for commuter rail systems. A consequence of curves is that the tighter the curve, the more slowly trains must travel to traverse it, and tight curves can cause wheel squeal, an

undesirable quality. In addition, curved track causes accelerated wear of wheels, the rail itself wears out more quickly, and for passengers on trains negotiating tight curves the imbalance felt in the vehicles can be uncomfortable. Track can be superelevated to alleviate some of the impact of curves on speed and passenger comfort, but that introduces additional maintenance costs. Therefore, curves can reduce speeds, lower service levels, cause undesirable noise levels, require more maintenance, and reduce ride quality – all things to be minimized or avoided completely.

Commuter Rail Curved Segment

The guideway geometric constraints described above give rise to several guideway considerations:

- Alignments that are perpendicular to rather than parallel with the natural fall of streams and other topographical features can necessitate significant amounts of cut and fill and even open cuts and viaducts.
- Operational and geometric constraints generally limit the location of curves to relatively flat areas with space for wide turns.
- Existing freight rail routes are prime candidates for new commuter rail service, since suitable ROW exists.

4.1.2 Key Vehicle Concepts

There are two basic varieties of commuter rail trains. One has passenger coaches pulled or pushed by a locomotive. The second integrates the motive power into the passenger car, so the passenger cars are themselves powered. The power systems available for either configuration are diesel or electric power. In addition, whatever the power system configuration, single- and bi-level versions are available. Thus there are three distinct types of commuter rail vehicles:

- Push-pull locomotive/passenger car systems.
- Electric multiple unit (EMU) systems.
- Diesel multiple unit (DMU) systems.

Metro-North Diesel Electric Locomotive

Although wide ranges of both vehicle types and configurations are available, each has unique characteristics that make it more or less suited to particular applications. For example, double-stack freight rail cannot operate with EMUs because clearance is not feasible under the catenary. DMUs are most appropriate to routes where ridership is light, and tend to be used where there are not subway stations or long tunnels, since ventilating of diesel fumes complicates construction and increases costs.

Acela Train

Locomotives

Locomotives include diesel/electric dual-mode locomotives, in which the electric mode is typically used in tunnels and subway segments, with diesel power used elsewhere. The electric power could be provided by either a powered third rail or an overhead catenary, although the combination of diesel with overhead catenary is not proven technology at this time.

The most common locomotives are referred to as “diesels.” They are not dual-mode, as just described, but do use a diesel engine to power an electric generator, which drives electric traction motors.

The third type of locomotive is the electric locomotive, which requires a catenary or, less commonly, a powered third rail. These locomotives can only be used where the entire route has electric power, and they are not mixed with freight rail because the catenary wire would interfere with double-stack freight cars (not a problem with third rail). These locomotives are further divided into those designed for typical commuter rail operations and those designed for high-speed rail operations. The electric locomotives designed for high-speed rail operations operate at speeds higher than 100 mph, often substantially higher. An example of such a locomotive would be the Acela locomotive used by Amtrak. These vehicles usually have a distinctive look, with front ends approximating those of aircraft.

Passenger Cars

Passenger coaches come in two major types, single-level and bi-level. Single-level passenger cars can carry between 80 and 120 passengers each, with the exact number of seats determined by the length of the car and any space needed for other purposes.

Metro-North Passenger Car – Single Level

The bi-level versions provide greater capacity per car, although not double that of single-level cars, as they must accommodate stairs providing access to the second level.

In addition, some railroads elect to use gallery cars, which have the second level open to the first down the center aisle of the car, which allows ticket agents to collect tickets from both levels at the same time while walking down the aisle on the first level. Such cars have lower seating capacity than standard bi-level passenger cars.

Gallery Car

Regardless of the configuration of commuter rail passenger cars, none are designed to provide for numerous standees. This includes provision of narrower aisles than on LRT or CRT cars, since the aisles are not intended to accommodate standees.

Metro-North Electric Multiple Unit

EMU cars are self-propelled, eliminating the need for a locomotive. These vehicles require the entire alignment to have electric power, which is usually provided via a powered third rail. In addition, there are also DMUs that provide many of the benefits of EMU commuter-rail vehicles but are diesel-powered.

DMU

As of this writing, there is only one manufacturer of such vehicles whose product meets FTA requirements, and that is the Colorado Car. It is a self-propelled passenger vehicle with seating for up to 188 passengers in the bi-level version and 92 in the single-level version. These cars have been used in revenue service in Florida on the TriRail system.

These vehicles are potentially more cost-effective for low-volume operations where trains of fewer than four cars are required. However, where passenger demand is expected to exceed the capacity of a four-car train, analysis has shown EMU and push-pull commuter trains to be more economical.

4.1.3 Key Station Concepts

CRT stations have the same elements as other guided transit technologies:

- Platforms and platform enclosures.
- Waiting and ticketing areas.
- Parking.
- Bus transfer areas.
- Pedestrian access.

Tarrytown Commuter Rail Station

Commuter rail stations are typically larger than LRT or RRT stations because they often provide waiting areas, as the frequency of service is usually lower than it is for the other rail modes. As an example, the Tarrytown Station is a free-standing commuter rail station, including the building, parking, and transfer areas where buses and cars can pick up and drop off passengers.

Station Platform with Overpass

The platforms of CRT stations are typically high-level platforms, to provide level boarding to the trains, although low-level platforms are not uncommon. High-level platforms offer the advantage of both faster boarding and alighting, resulting in reduced dwell time, and the elimination of stairs in passenger cars. Some lines have a mixture of high- and low-level platforms, in which case the passenger cars must have interior stairs as well as plates to overlay those stairs to access high-level platforms. The CRT station shows a high-level platform accessed via a pedestrian overpass. Typical attributes of the platforms include canopies for weather protection, lighting, benches for waiting passengers, and signage to direct passengers.

Beacon Station

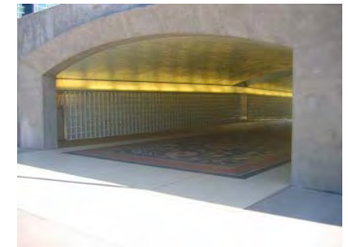
The appearance of CRT stations tends to display greater variety than is the case with other rail-transit technologies. The Beacon Station shows a very open style of station. This station was upgraded with the active participation of the City of Beacon, and includes an expanded parking area, a modern canopy, and extensive landscaping.

Yonkers Station

The Yonkers Station is an example of an historic restoration that won the 2006 Excellence in Historic Preservation Award. The photo shows the front of the station.

Pedestrian Access

Enhancing pedestrian access to stations is as important as providing good access for vehicles, since for every person walking to a station, the need to provide space to store a car (and perhaps the auto trip itself) is eliminated. The methods used to enhance station access for CRT stations are equally applicable to other transit modes.



Pedestrian Underpass

Pedestrian underpasses need to be as open as possible for security and the appearance of security for walkers. The use of materials appropriate to the area is important to visually integrate underpasses or overpasses into the surrounding community.

Pedestrian Overpass

Overpasses may be needed to span roadways, waterways or similar obstacles. When properly sited and designed, they can make the difference between passengers walking to the station or choosing to drive. Protection for those below an overpass is as important as providing a sense of safety for those using the overpass.

Where station sites are below or above local grades, or where a station site itself has more than one level, it is necessary to provide stairs and ramps to facilitate access. Elevators could also be provided. Finally, cross-walks need to be clearly delineated and have curb cuts to facilitate access for the mobility-impaired. Such delineation may be achieved by means as simple as painted treatments, though it may also take other forms, including the use of embedded paving materials that offer a distinctive appearance.

Station Parking

Parking areas are important because adequate parking eliminates the tendency of commuters to search for on-street spaces in surrounding neighborhoods or to simply give up and drive to work. While surface lots are entirely appropriate where space permits, parking structures may be needed where the footprint of the site is inadequate to accommodate all the parking needed.

Poughkeepsie Station with Parking

Structured Parking at Poughkeepsie Rail Station

Where space is limited and demand warrants the investment, parking structures may be needed. As with surface lots, the design of such

structures should complement the architecture of the area. An alternative to unavailable station parking is use of connecting services (e.g., Metro-North's Hudson Rail Link or Transit of Rockland to Tarrytown).

The surface parking area with landscaping treatments can provide a visual separation of the lot from the surrounding area. Parking lots also require adequate lighting, but it must be provided in such a manner as to avoid spillover of light into the surrounding area. In addition, spaces and movement lanes need to be clearly delineated, and parking near the station entrance should be reserved for the mobility-impaired. Internal walkways are needed for large lots in order to separate walkers from cars circulating through the lot.

Landscaped Commuter Rail Station Parking Area

Surface parking adjacent to such structures is usually reserved for short-term parking, and in cases in which the structure can be integrated into the station itself, riders can benefit from the weather protection the structure provides when moving from their cars to the station.

As with BRT and LRT, CRT stations may offer an excellent opportunity to create multimodal transportation centers where pedestrians, bicycles, cars, and transit vehicles converge. They may also foster TOD.

4.1.4 ITS Components

Commuter rail systems require integrated control and communications systems to manage train movements, monitor performance and adjust for changed operating conditions. A central control facility is the hub of CRT operations, with the capacity to monitor and control the entire rail system. Among the functions of the central control facility are management of the traction power system, control of all train movements, monitoring of operations, monitoring of stations, communications between stations and central control, communications between trains and central control, and monitoring of safety. These systems enable commuter rail systems to adapt to changing conditions and coordinate and adjust operations as necessary to maintain service.

Also commonly implemented in CRT systems are passenger information systems designed to provide projected arrival times, incident reporting, and rider alerts in stations and aboard vehicles. Fare collection in CRT systems is usually managed on-board the vehicles, with the conductors validating all tickets. Coordination with feeder-bus services is usually through schedules, as commuter trains arrive on fixed schedules.

4.2 Application of CRT Technology to the Tappan Zee Bridge/I-287 Corridor

4.2.1 Technology

CRT service already reaches into this corridor, although perpendicular to the east-west direction of travel, so a new technology is not being introduced. Any new equipment or trackage would be 'state-of-the-art' technology to permit smoother operations and enhance passenger ride experience, but would be incorporated with a view toward the continued utilization of existing equipment as well. There is a possibility that bi-level passenger cars can be developed that are compatible with the Park Avenue tunnel; if this possibility is realized, such cars would then be usable in this corridor as well. Any new stations would be equipped with passenger information technology that would display the timing and destination of the next arriving train on each platform. This equipment can also be provided at existing stations beyond the corridor as system upgrades. As the equipment would also operate on existing rail lines, no automation of operation is anticipated.

4.2.2 System Connectivity

Because the CRT improvements are additions to the existing infrastructure, connectivity is an important concern. As currently planned, connectivity is provided to the Port Jervis Line from the north in Alternatives 4A, 4B, and 4C and Option 4D, to the Hudson Line to the south in the same alternatives, and to the New Haven Line to the north in Alternative 4A. Consideration was also given to connectivity with other rail lines that cross the corridor, with the following conclusions:

- Connectivity could be provided to the West Shore CSX freight line, but no passenger service is anticipated on that line, either to the north or south, as it is a heavily used single-track freight line.
- Connectivity could be provided from the Hudson Line to the eastbound cross-corridor line in Alternative 4A, permitting service down the Hudson Line and east to White Plains, but it was eliminated in the Alternatives Analysis as too expensive and serving only limited markets.
- Connectivity could be provided to the Harlem Line at White Plains in Alternative 4A, but the Harlem Line is already at capacity south of White Plains, so there would not be available capacity for additional trains from either the east or west. With a direct connection to the Hudson Line in 4A, there is no need for a direct connection to the Harlem Line (however, a transfer would be provided).

The direct connection to the Hudson Line southbound is complicated by grade changes, and results in a tunnel from the bridge down to the river shore. Transfer to the Hudson Line was considered in the Alternatives Analysis as an alternative, and was re-studied in Option 4A-X. The loss in ridership caused by that transfer (whether the connection is to the existing Tarrytown Station or a new Tappan Zee Station) was sufficient to justify the expense of the connection.

4.3 Description of CRT Alternatives/Options

4.3.1 Alternative 4A

Alternative 4A provides full-corridor CRT, which includes both cross-corridor service and Manhattan-bound service to GCT via a direct connection to the Hudson Line (Figures 4-3 and 4-4). At the river crossing, the commuter rail alignment for Alternative 4A could be constructed on either a rehabilitated or replacement Tappan Zee Bridge that would carry both the highway and the commuter rail. The rehabilitated bridge would include a supplemental structure parallel to the existing bridge to accommodate the commuter rail.

The commuter rail alignments were developed using design criteria and guidelines based on Metro-North practices prepared for this project. Generally, track centers would be spaced between 14 feet (minimum) and 18 feet (desirable), centered within a ROW width of between 37 feet (minimum) and 57 feet (desirable) that would include parapets or barriers. The absolute maximum grade that would be allowed on the line would be 2.0 percent, at covered locations and for short distances at uncovered locations; otherwise, the maximum grade would be 1.5 percent. Within the I-87/I-287 ROW, the CRT alignment would generally be parallel/concentric to the highway alignment. Where the desirable design speed (110 mph) would cause the CRT alignment to drift outside the ROW, design speed would be reduced

appropriately and would generally be maintained at between 90 and 95 mph at these locations. The minimum design speed would be 45 mph. Given the highly variable terrain in both counties, a significant part of the alignment would be in tunnel or on viaduct. The track would be electrified from Suffern to Port Chester and to the Hudson Line via third rail.

Alternative 4A would link four of the five existing north-south rail lines in the corridor by providing direct connections to the Port Jervis, Hudson, and New Haven Lines, and a transfer facility to the Harlem Line. Alternative 4A also includes 11 proposed stations with 860-foot minimum length platforms, and most would include park-and-ride facilities:

- **Rockland County** – Hillburn, Airmont, Garden State Parkway/Interchange 14A, and Palisades Mall. Each of these stations would include new or expanded park-and-ride facilities.
- **Westchester County** – Tappan Zee, Elmsford, White Plains Transportation Center, Westchester Mall, Platinum Mile, and Purchase. All of these, except Platinum Mile, would include new or expanded park-and-ride facilities.

4.3.1.1 Rockland County

The CRT alignments in Rockland County for Alternatives 4A, 4B, 4C and Option 4D are fundamentally identical, However, they each would have two alignment options from downtown Suffern to Airmont Road (Interchange 14B) – Piermont ROW or I-87/I-287 south side. In addition, there are two alignment options east of Interchange 14B – CRT in the I-87/I287 highway median or along the highway's south side. The highway median option would divert from the south side option about a mile and a half east of Interchange 14B and continue in the median for approximately 8 miles to the tunnel that extends under Nyack to the rehabilitated or replacement Tappan Zee Bridge.

The Piermont ROW in Suffern and the south side alignment east of Interchange 14B are used in this study as a basis of comparison for each of the CRT alternatives/options and they are described in detail in the following paragraphs. These pairs of alignment options will be analyzed in the DEIS to determine the optimal solution based on the established evaluation criteria and the project's goals and objectives.

Hillburn/Suffern

The alignment developed to connect the new service from the Port Jervis Line would take the commuter rail from the proposed Hillburn Station just south of 4th Street onto a curved alignment that would descend under Route 59 and continue east either hugging the south side of I-287 (Option 1) or onto the Piermont ROW in a cut-and-cover tunnel under Route 59 and open-cut configuration until it passes over the Mahwah River (Option 2).

A possible Hillburn Station could be located south of the 4th Street Bridge between Route 59 and the railroad tracks in a space that is currently a commercial facility. A proposed storage yard could be located where a commercial area exists north of 4th Street between Route 59 and the tracks. The Hillburn Station would serve downtown Suffern and provide transfers from the NJT Bergen/Main Line that would extend service to the proposed Hillburn Station. The location of the existing NJT Suffern Station is too far south to accommodate direct rail connections from the Port Jervis Line to the I-287 Corridor.

East of Suffern

Alignment Option 1 would bring the CRT over Route 59 where it crosses under Interchange 15 (Suffern) and curve east and climb to the south side of I-87/I-287 parallel to Wayne Avenue. In this option the CRT would continue adjacent to the south side of the highway within the I-87/I-287 ROW. The CRT would rise up to a viaduct over Airmont Road as would the CRT in the Piermont alignment.

In Option 2, the CRT alignment would continue in a cut-and-cover tunnel along the Piermont ROW east of Route 59 to Chestnut Street and transition to a retained open cut. East of Washington Avenue the CRT would remain in an open cut and ascend to cross over the Mahwah River. The CRT would share the Piermont ROW with an existing single-track freight line that operates on an infrequent schedule. East of the river the alignment for the most part would follow the elevation of the existing freight line tracks until it approaches Airmont Road, where the CRT would ascend onto a viaduct to avoid conflict with the existing Interchange 14B ramps and Airmont Road.

Just east of Airmont Road, a CRT station is proposed between I-87/I-287 and the Piermont Line ROW, and could be located at the site of an existing commercial facility. East of the Airmont Station, the alignment would join the I-87/I-287 ROW and proceed along the south side of the highway. The alignment would cross above Spook Rock Road, under College Road, and below Route 59 (Nyack Turnpike), which is essentially at the highest elevation of I-87/I-287 within Rockland County. East of the Route 59 crossing near Monsey, the CRT would cross above the Piermont Line on structure, then continue at grade and transition onto a viaduct to cross over Saddle River Road and then, in a retained cut, cross beneath Hungry Hollow Road. Approaching Route 45, the alignment would enter a 900-foot-long tunnel, then remain in a retained cut and enter a 2,000-foot-long tunnel that would extend under Scotland Hill Road and the Garden State Parkway (GSP), then daylight in a retained cut, with two GSP ramps (Interchange 14A) carried on structure above.

Spring Valley/Nanuet

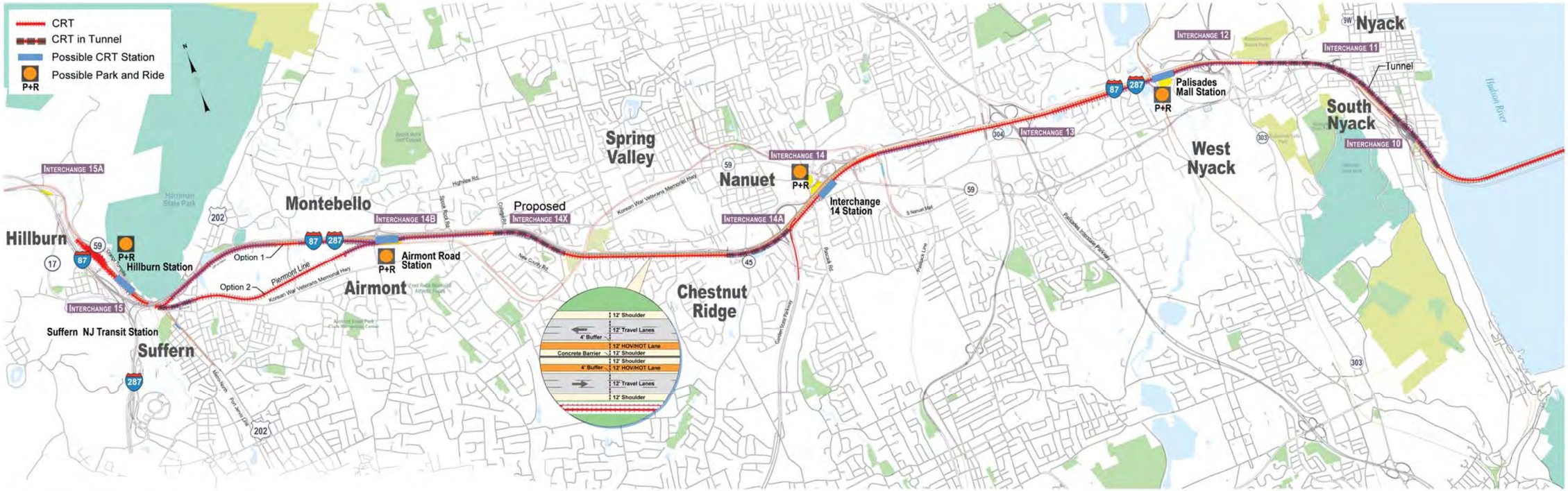
East of the GSP, the CRT would be carried on a viaduct over Pascack Road and the Pascack Brook, then return to retained cut and pass beneath Route 59 and the ramps of Interchange 14 (Spring Valley). A proposed GSP/Interchange 14 Station could be located between Pascack Road and Route 59, with the platform on the south side, near Old Nyack Turnpike. This possible station could utilize the existing park-and-ride facilities on the north side of the Thruway at Pascack Road and Forman Drive, which could be expanded as necessary. A pedestrian bridge over the highway would be built to provide patron access from the parking lots to the station platforms.

After passing beneath the Pascack Valley Line rail bridge, the alignment would extend on a viaduct over the Nauraushaun Brook, and on retained fill and structure over North Middletown Road, and on retained cut and a short tunnel beneath Route 304 and the Palisades Interstate Parkway (Interchange 13).

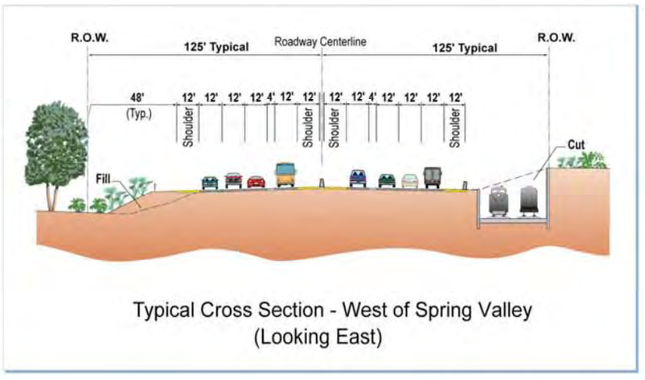
West Nyack

As the CRT alignment descends toward the Hackensack River valley, the retained-cut section would transition onto a long viaduct. This viaduct, more than a mile and a half long, extends from west of Strawtown Road to east of Route 303, crossing above Strawtown Road, the Hackensack River, the CSX West Shore Line, Palisades Center Drive, Interchange 12 ramps, and Route 303.

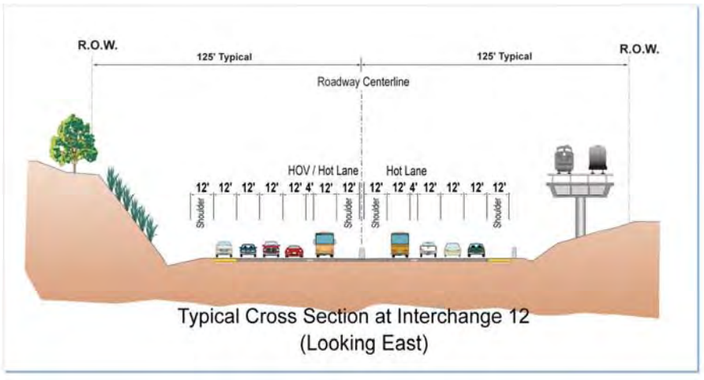
Just east of the CSX West Shore Line, a proposed commuter rail station could be located at the existing park-and-ride facility referred to as Parking Lot J, which is adjacent to the Palisades Mall. The commuter rail alignment on viaduct at this location would require station platforms approximately 45 feet above the I-87/I-287 roadway and approximately 25 feet above the existing park-and-ride surface. East of Route 303, the viaduct section would transition into a retained cut before entering the portal for a tunnel section for the approach to the Hudson River. The western portal would be located on the hillside, east of Route 303.



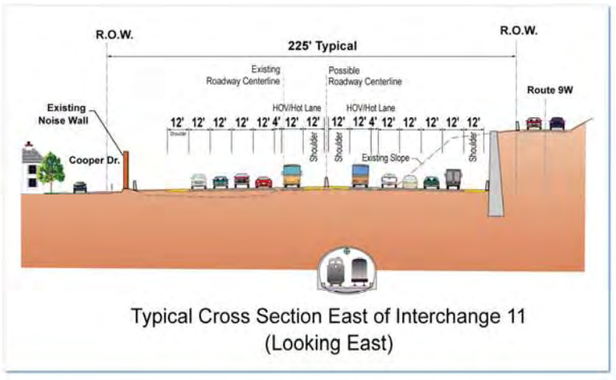
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 4A, 4B, 4C - Rockland	14,850 ft.	13,250 ft.	52,400 ft	80,500 ft (15.2 Miles)



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

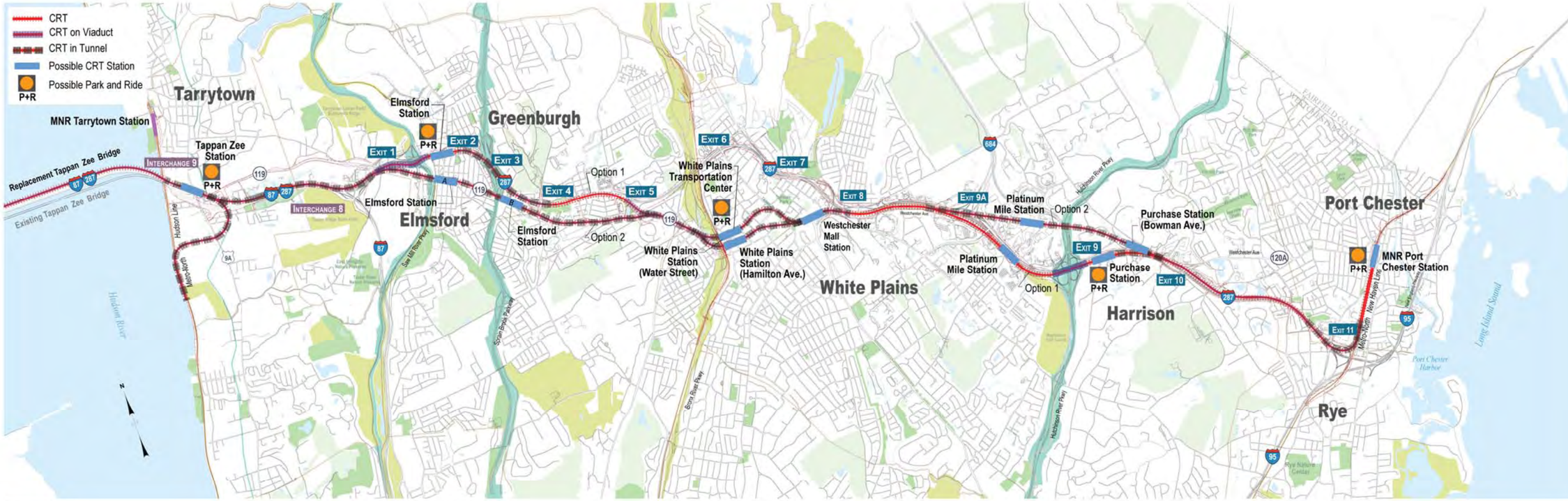


Typical Cross Section at Interchange 12 (Looking East)

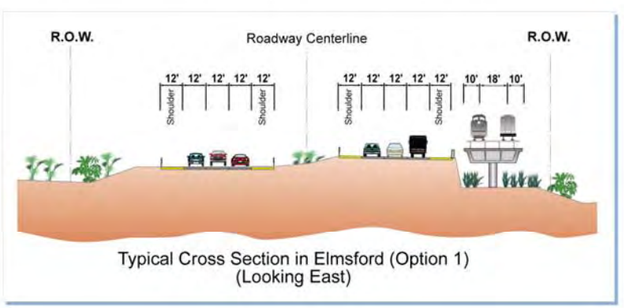


Typical Cross Section East of Interchange 11 (Looking East)

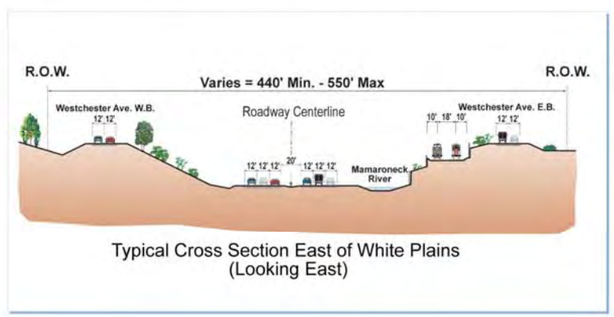
Figure 4-3 Alternative 4A-4B-4C Full-Corridor Commuter Rail Transit in Rockland County



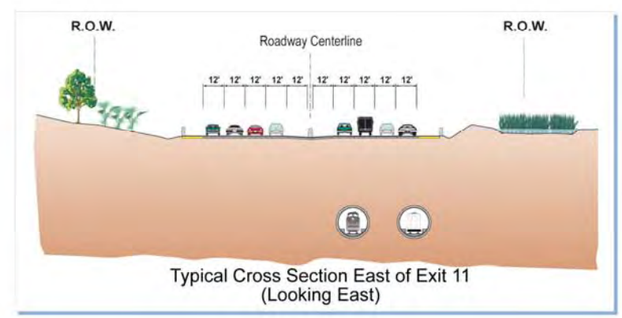
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 4A - Westchester	42,400 ft	3,900 ft	41,700 ft	88,000 ft (16.7 Miles)



Typical Cross Section in Elmsford (Option 1)
(Looking East)



Typical Cross Section East of White Plains
(Looking East)



Typical Cross Section East of Exit 11
(Looking East)

Figure 4-4 Alternative 4A Full-Corridor Commuter Rail Transit in Westchester County

Nyack

The combination of a steep I-87/I-287 profile in South Nyack and the grade constraints for commuter rail would require that the rail line be in tunnel passing below the Nyack Palisades. The rail tunnel would daylight and transition onto the proposed replacement or rehabilitated bridge. The rail tunnel from east of Route 303 to the portal near the Hudson River shoreline would be approximately 2 miles long.

4.3.1.2 Westchester County

Tarrytown

A rehabilitated or replacement river-crossing structure that would accommodate CRT at the Westchester County shoreline would carry the commuter rail from the bridge into a proposed Tappan Zee Station and then diverge for the cross-Westchester CRT alignment and the Hudson Line Connector tunnel. The descending Hudson Line Connector tunnel would essentially follow an 'S' configuration to the east and south, with a design speed of 45 mph. It would ultimately lead under, and then up to the Hudson Line, to meet existing top-of-rail elevation between the express tracks before the Irvington Station.

The Hudson Line Connector tunnel described above would begin as a diverge from the through tracks extending eastward for the cross-corridor commuter rail alignment. East of the diverge, the profile would transition from the 2.0 percent downgrade, allowing the cross-corridor track tunnel to rise and ultimately daylight east of Interchange 8.

Prior to the track diverge an underground Tappan Zee Station would be located on the north side of the toll plaza and extend east under Broadway into the existing shopping center. The existing Tarrytown Station would remain, and a shuttle bus service would be provided for transfers to the cross-corridor service at the Tappan Zee Station.

East of Broadway, the CRT tunnel would the follow the I-87/I-287 alignment and be deep enough to avoid potential conflict with the Talleyrand Swamp and Interchange 8 (Cross Westchester Expressway). Overall, the rail tunnel extending from the Hudson River shoreline to Interchange 8 would be approximately 2 miles long.

Greenburgh/Elmsford

East of the tunnel beneath Interchange 8, the CRT could run along the south side of I-287, proceeding for about one-half mile in retained cut/retained fill sections before rising onto a viaduct that would carry the CRT alignment over the Saw Mill River Parkway, the Saw Mill River, and North Central Avenue (Route 9A). A proposed elevated CRT Elmsford Station could be centered between Nepperhan Road and North Central Avenue. A parking structure with a vertical connection to the platforms would be provided as part of this facility.

East of the Elmsford Station viaduct, a 4,000-foot-long tunnel would carry the alignment beneath the Sprain Brook Parkway and the Catskill Aqueduct. The tunnel would daylight west of Knollwood Road, and would rise over Manhattan Avenue and then descend in retained cut beneath Hillside Avenue before entering the west portal of the proposed rail tunnel that would be constructed beneath White Plains to avoid land use and traffic impacts in the densely developed city.

An alternative to the I-287 alignment is an option to continue the tunnel that runs beneath Interchange 8 (Cross Westchester Expressway) along Route 119 through Elmsford (labeled Option 2 on Fig. 4-4). A possible underground Elmsford Station could be located at the intersection of Route 9A and Route 119, (A), or possibly further east near Knollwood Road, (B). The tunnel in this option would continue under Route 119 into downtown White Plains.

White Plains

The rail tunnel alignment would depart from the I-287 ROW at Exit 5, Hillside Avenue, and proceed to the southeast beneath Route 119 en route to the WPTC and the existing Metro-North Harlem Line station. The CRT tunnel would cross beneath the Bronx River Parkway and the Harlem Line tracks for the proposed underground White Plains Station with provision for vertical transfer to the Harlem Line and the WPTC. Depending on the tunnel alignment chosen, the proposed White Plains Station would be located immediately east of the Harlem Line and either under Water Street or Hamilton Avenue. Beyond the White Plains Station, the CRT would proceed to the east, following either Hamilton Avenue or Main Street (depending upon the results of further subsurface investigations).

To the east, after passing beneath Broadway and Tibbits Park, an additional underground station – East White Plains – could be located at the Westchester Mall. After this station, the CRT tunnel would daylight north of Westchester Avenue at Exit 8 and re-enter the I-287 ROW. The alignment would be along the south side of I-287, predominantly at-grade and in retained cut to the east of the I-684 Interchange (Exit 9A). Between I-684 and the Hutchinson River Parkway, a possible station is proposed at Corporate Park Drive that could include jitney service to the Platinum Mile and other office parks accessible from Westchester Avenue.

An optional alignment to the I-287 alignment being considered would put the CRT in a tunnel under the Platinum Mile office parks (Option 2 on Figure 4-3) and then re-enter the I-287 corridor east of Bowman Avenue, where a possible Purchase Station could be located adjacent to the north side of I-287.

Harrison

The I-287 CRT alignment would continue eastward in retained cut/retained fill, and be located between I-287 and eastbound Westchester Avenue. East of the Hutchinson River Parkway crossing, a partially below-ground Purchase Station could be located in the vicinity of Kenilworth Road. To the east of the station, the alignment would enter a 3,600-foot tunnel passing under Purchase Street and daylight where Westchester Avenue departs from the I-287 ROW. The CRT alignment would continue east into Rye along the south side of I-287 in retained cut/retained fill sections.

Rye/Port Chester

Just west of South Ridge Street, the alignment would enter a tunnel beneath Boston Post Road (Route 1) and the I-95 Interchange. The mile-long tunnel carrying the westbound CRT track would daylight at the north side of the I-95 Interchange at the southeast corner of the large shopping center east of Boston Post Road. Beyond the tunnel, direct connection at-grade would be achieved with the New Haven Line southbound local track. For connection to the New Haven Line northbound local track, the eastbound CRT would be carried in a tunnel extended beneath all four tracks of the New Haven Line, and then ascend along the east side to meet existing grade for connection to the northbound local track. To the north, the CRT would platform at Port Chester Station from the local tracks.

4.3.2 Option 4A-X

An option to Alternative 4A that does not include the direct connection to the Hudson Line has been modeled in the transit mode analysis as Option 4A-X. With this option, Manhattan-bound CRT riders who had a one-seat ride to GCT in Alternatives 4A, 4B, and 4C would be required to exit the train at the proposed Tappan Zee Station and board a shuttle bus to the Metro-North Tarrytown Station for service on the Hudson Line. Alternatively these Manhattan-bound riders could transfer to the Harlem Line at the White Plains Station.

Apart from the elimination of the Hudson Line connection, the proposed number and possible station locations, and the basic CRT alignment of Option 4A-X would be identical to that of Alternative 4A.

4.3.3 Alternative 4B

Alternative 4B would provide Orange and Rockland County commuters a one-seat CRT ride to Manhattan and transfer capability to LRT serving employment centers in Westchester County and Connecticut (Figures 4-4 and 4-5). Alternative 4B would provide increased mobility within Westchester County and between Westchester and Connecticut, as well as increased access to Metro-North rail lines serving Manhattan. This alternative also provides a transfer from the Metro-North upper Hudson Line service territory at Tarrytown to LRT serving Westchester County and Connecticut.

Alternative 4B provides a two-track CRT alignment from the Port Jervis Line in Suffern to the Hudson Line at Tarrytown (as in Alternative 4A), and LRT service from the existing Tarrytown Hudson Line station to the Port Chester New Haven Line Station. The Manhattan-bound CRT alignment would connect to the Hudson Line through the Hudson Line Connector tunnel, as in Alternative 4A. There would be a new Tappan Zee Station at the existing bridge toll plaza for transfers between CRT and LRT. At the river crossing, the commuter rail alignment could be constructed on either a rehabilitated or replacement Tappan Zee Bridge.

The LRT service in Alternative 4B would start at the Hudson Line Tarrytown Station, allowing a transfer to/from the existing Hudson Line. A proposed LRT rail alignment from the Tarrytown station along the east side of the Hudson Line would connect to the proposed Tappan Zee Station. The LRT alignment through Westchester County would follow a hybrid, high-speed/in-street LRT alignment, as proposed in the Full-Corridor LRT alternative. The in-street alignment would be used on Route 119 in Tarrytown to I-287 and through downtown White Plains. The high-speed alignment, constructed adjacent to I-287, would be used in Elmsford and Greenburgh, as well as east of White Plains to the direct connection to Port Chester Station.

Alternative 4B would link four of the five existing north-south rail lines in the corridor by providing direct connections to the Port Jervis and Hudson lines, and transfer facilities at the Harlem and New Haven Lines. Alternative 4B would provide four possible CRT stations in Rockland County, in addition to the proposed Tappan Zee Station, and 14 possible LRT stations in Westchester County, as follows:

- **Rockland County** – Hillburn, Airmont, GSP/ Interchange 14, and Palisades Mall.
- **Westchester County** – Meadow Street, Benedict Avenue, Elmsford, Greenburgh, Hillside Avenue, County Center, WPTC, Galleria Mall, Westchester Mall, White Plains Avenue, Corporate Park Drive, Purchase, South Ridge Street and Boston Post Road.

4.3.4 Alternative 4C

Alternative 4C (Figures 4-3 and 4-6) would provide Orange and Rockland County commuters a one-seat ride CRT to Manhattan and transfer capability to BRT serving employment centers in Westchester County and Connecticut. It would provide increased mobility within Westchester County and between Westchester and Connecticut, as well as increased access to Metro-North rail lines serving Manhattan. This alternative also provides a transfer from the Metro-North upper Hudson Line service territory at Tarrytown to BRT serving Westchester County and Connecticut.

Alternative 4C provides a two-track CRT alignment from the Port Jervis Line in Suffern to the Hudson Line at Tarrytown (as in Alternative 4A), and BRT service from the existing Tarrytown Hudson Line station to the Port Chester New Haven Line station. The Manhattan-bound CRT alignment would connect to the Hudson Line through the Hudson Line Connector tunnel as in Alternative 4A. There would be a new Tappan Zee Station north of the new toll plaza for cross-platform or vertical-transfer transfers between CRT and BRT depending on the station configuration. Buses in Rockland County would use the HOT lanes for faster service and access them through slip ramps. At the river crossing the commuter rail alignment could be constructed on either a rehabilitated or a replacement Tappan Zee Bridge.

The BRT service in Alternative 4C would begin at the Hudson Line Tarrytown Station, providing for a transfer to/from the existing Hudson Line. A proposed dedicated busway from the Tarrytown station along the east side of the Hudson Line would connect to the proposed Tappan Zee Station. The BRT alignment through Westchester County would follow the Alternative 3 alignment consisting of dedicated lanes with transit-signal priority on Route 119 in Tarrytown and through downtown White Plains, on an exclusive busway adjacent to the south side of I-287 through Elmsford and Greenburgh, and on dedicated lanes along Westchester Avenue east of White Plains to Exit 10. East of Exit 10 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.

Alternative 4C would link four of the five existing north-south rail lines in the corridor by providing direct connections to the Port Jervis and Hudson lines, and transfer facilities at the Harlem and New Haven Lines. Alternative 4B would consider providing four CRT stations in Rockland County, in addition to the proposed Tappan Zee Station in Tarrytown, and 10 proposed BRT stations in Westchester County at the same possible locations proposed in Alternative 3.

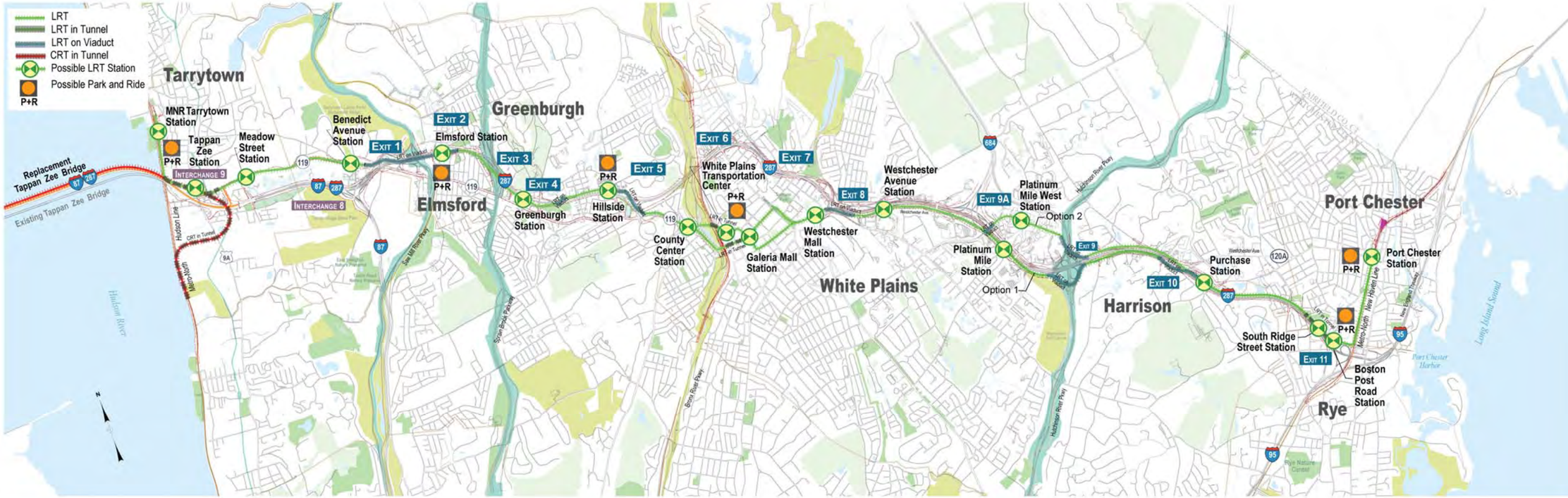
4.3.5 Option 4D

Option 4D (Figures 4-7 and 4-8) was developed in response to comments from the general public, stakeholders, and sponsoring agencies at various times during the study, including the open-house presentations in February 2007 of the proposed alignments of the six build alternatives developed in the Alternatives Analysis Report, and on the basis of the results of the two-day BRT workshop in September 2007. In addition, the project team continued its analyses of the alternatives with the goals of improving the BRT cross-corridor service proposed in Alternative 3 and providing more cost-effective CRT service to GCT in Manhattan.

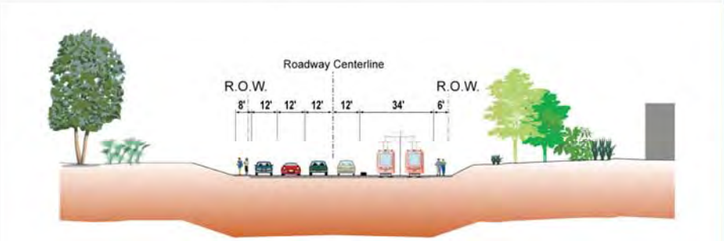
To meet these objectives, Option 4D combines the two transit modes (BRT and CRT) and focuses on the two key markets to be served by the project by providing commuter rail service from Suffern to GCT in Manhattan, and enhanced trunk-line BRT cross-corridor service from Suffern to Port Chester.

Option 4D - CRT

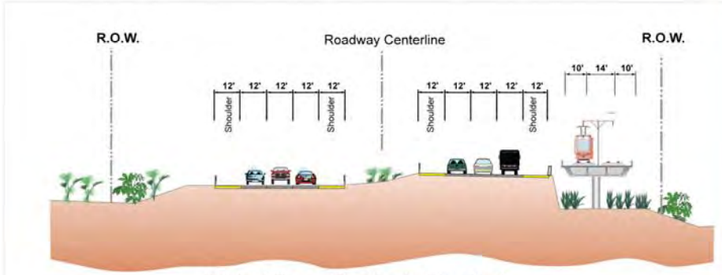
The Option 4D CRT component in Rockland County would have the same alignment options as Alternative 4A. The only significant difference would be the elimination of the proposed Airmont Road Station for cost- and travel-time savings considerations. In addition to a Hillburn Station at the connection to the Port Jervis line, CRT stations could be located at GSP/Interchange 14A and Palisades Mall/Parking Lot J, as in Alternatives 4A, 4B, and 4C, but, as an additional cost-saving consideration in Option 4D, the Tappan Zee Station in Westchester County would not be included. The CRT would use the replacement or rehabilitated bridge and descend into the Hudson Line Connector tunnel for its connection to the Hudson Line for the Manhattan-bound service.



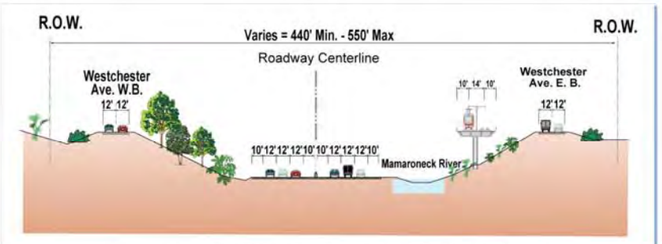
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 4B - Westchester	5,500 ft.	40,000 ft.	34,900 ft	80,400 ft (15.2 Miles)



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

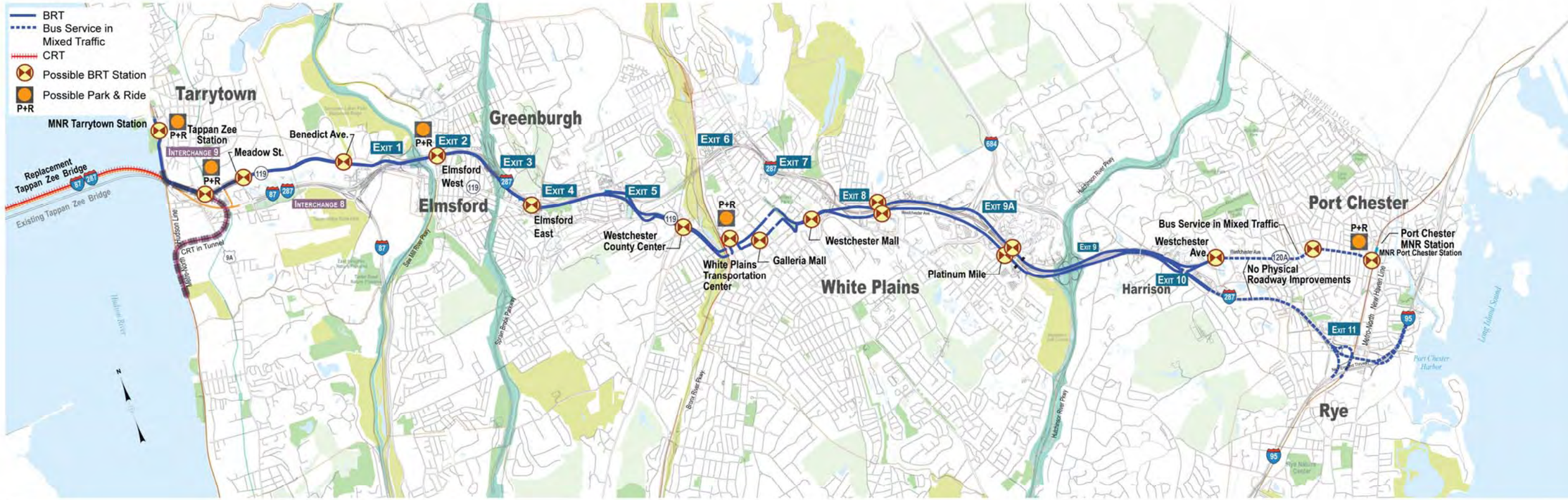


Typical Cross Section in Elmsford
(Looking East)

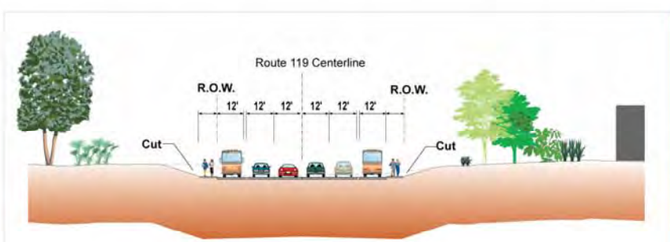


Typical Cross Section - East of White Plains
(Looking East)

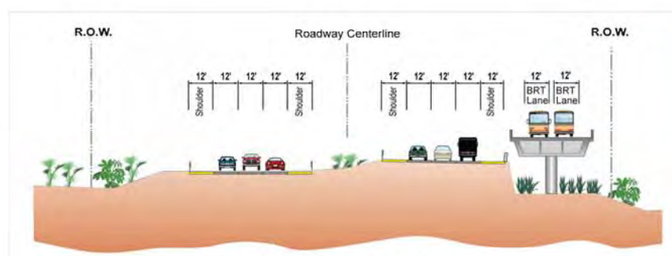
Figure 4-5 Alternative 4B Manhattan-Bound Commuter Rail Transit with Light Rail Transit in Westchester County



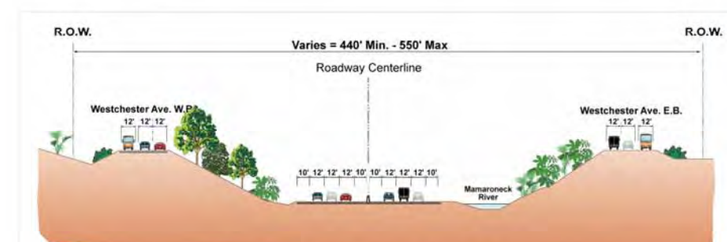
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 4C - Westchester	5,500 ft	6,500 ft	43,500 ft	55,500 ft (10.5 Miles)



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

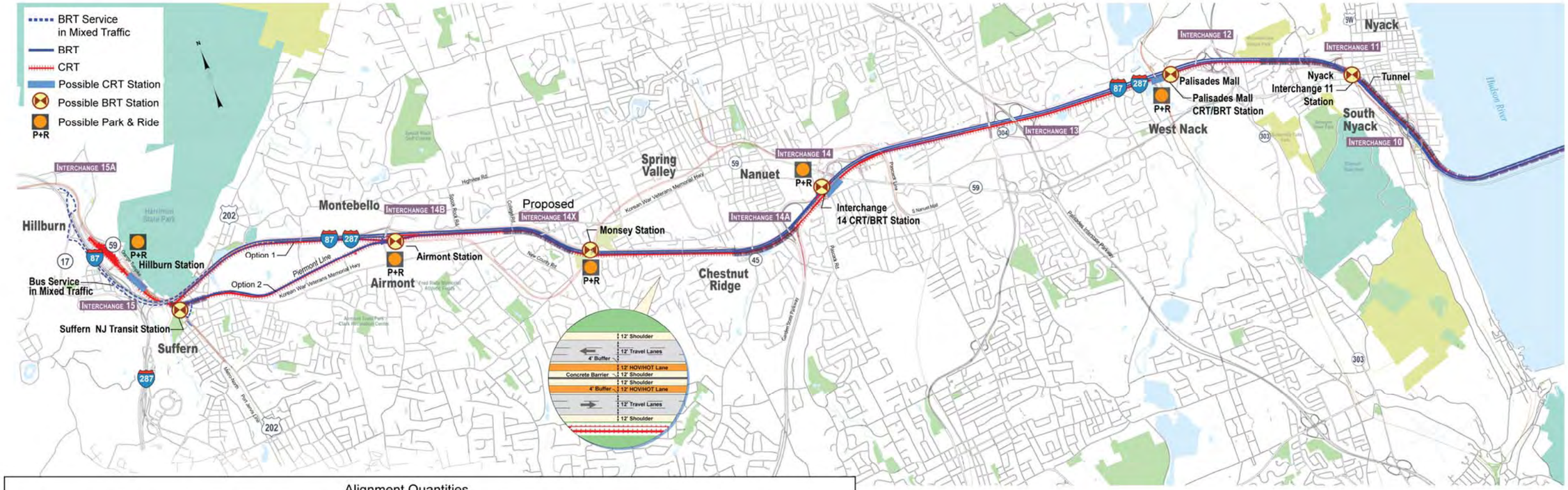


Typical Cross Section in Elmsford
(Looking East)

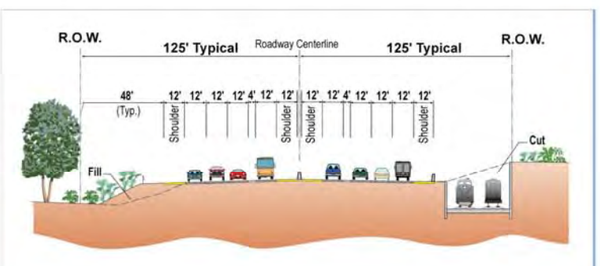


Typical Cross Section - East of Exit 8
(Looking East)

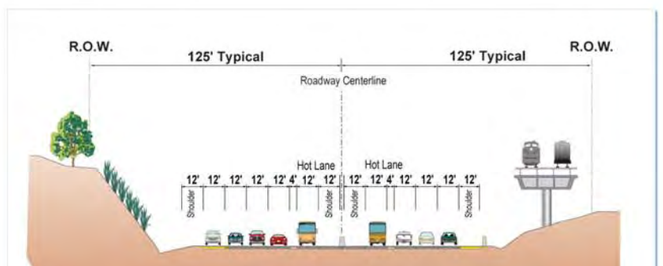
Figure 4-6 Alternative 4C - Manhattan-Bound Commuter Rail Transit with Bus Rapid Transit in Westchester County



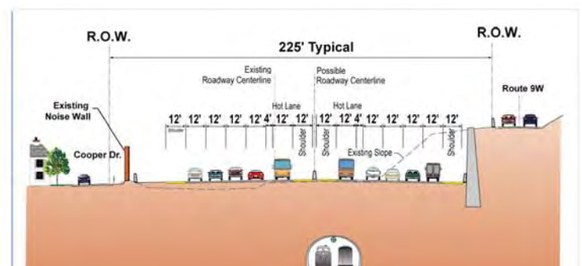
Alignment Quantities				
Option 4D - Rockland	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
CRT	14,850 ft.	13,250 ft.	52,400 ft.	80,500 ft.
BRT	0	0	71,300 ft.	71,300 ft.
Total	14,850 ft.	13,250 ft.	123,700 ft	151,800 ft (28.8 Miles)



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

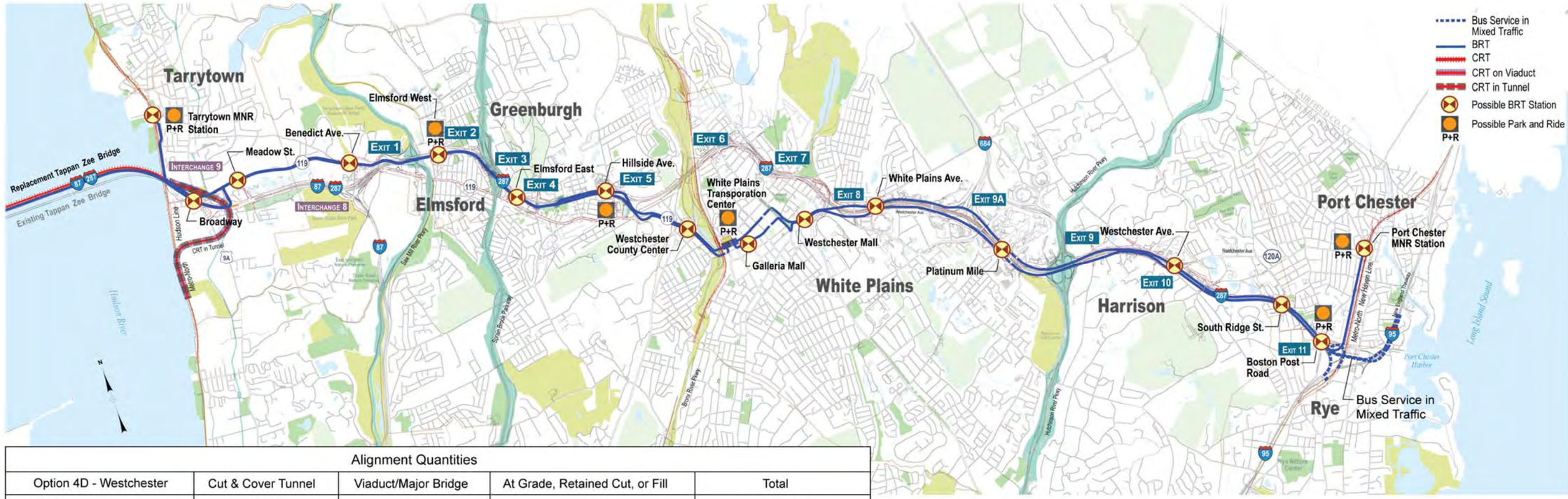


Typical Cross Section West of Interchange 12 (Looking East)

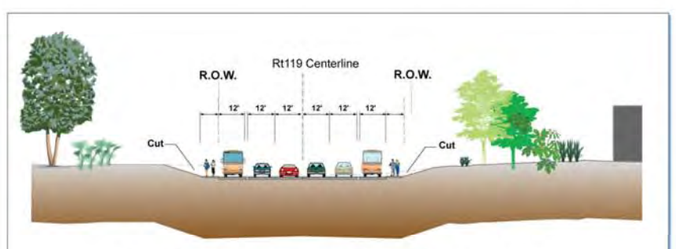


Typical Cross Section East of Interchange 11 (Looking East)

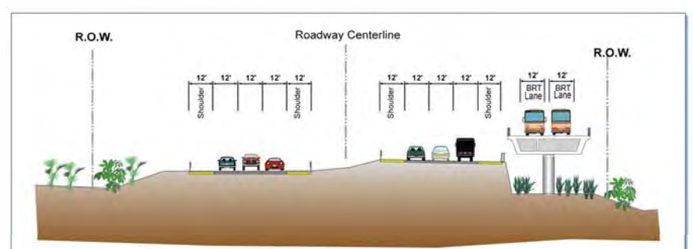
Figure 4-7 Option 4D - Manhattan-Bound Commuter Rail Transit with Cross Corridor Bus Rapid Transit in Rockland County



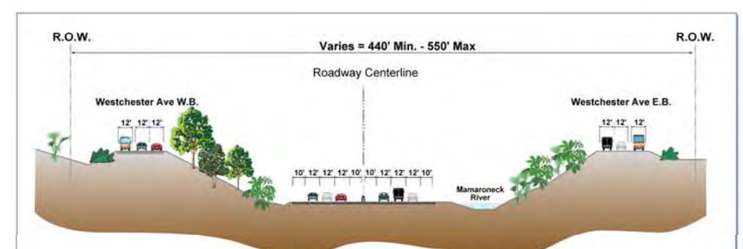
Alignment Quantities				
Option 4D - Westchester	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
CRT	5,550 ft	0	0	5,500 ft
BRT	0	9,200 ft	65,700 ft	74,900 ft
Total	5,500 ft	9,200 ft	65,700 ft	80,400 ft (15.2 Miles)



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



Typical Cross Section in Elmsford
(Looking East)



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

Figure 4-8 Option 4D - Manhattan-Bound Commuter Rail Transit with Cross Corridor Bus Rapid Transit in Westchester County

Option 4D - BRT

The BRT component of Option 4D is the same as in Option 3A, with service from Suffern to Port Chester, which improves on the BRT service provided in Alternative 3. This is accomplished by several means, including the addition of a single "trunk-line" route running the full length of the BRT alignment, with five-minute headways in both directions during peak periods, more bus stations, and improved running ways that would allow feeder buses to access the exclusive busways.

In Rockland, Option 4D would provide enhanced service plans and two new stations, with preliminary locations at Route 59 in Monsey and Interchange 11 (US 9W/NY 59) in Nyack. One of the key planning issues that would be studied in the DEIS is the proposed shared usage of the Piermont ROW for CRT and BRT between Suffern and Interchange 14B (Airmont Road), and consideration of alternative alignments for each of the modes at this location in the corridor. The other key planning issue is the proposed CRT and BRT coincident stations at GSP/Interchange 14 and Palisades Mall/Parking Lot J that could become Intermodal Centers with potential highway-design impacts and unique access issues for buses to/from the HOT lanes and passengers to/from parking areas.

In Westchester County, Option 4D would provide the identical proposed BRT stations and exclusive busway alignment east of White Plains (including a direct connection to the Metro-North Port Chester Station on the New Haven Line) that are provided in Option 3A.