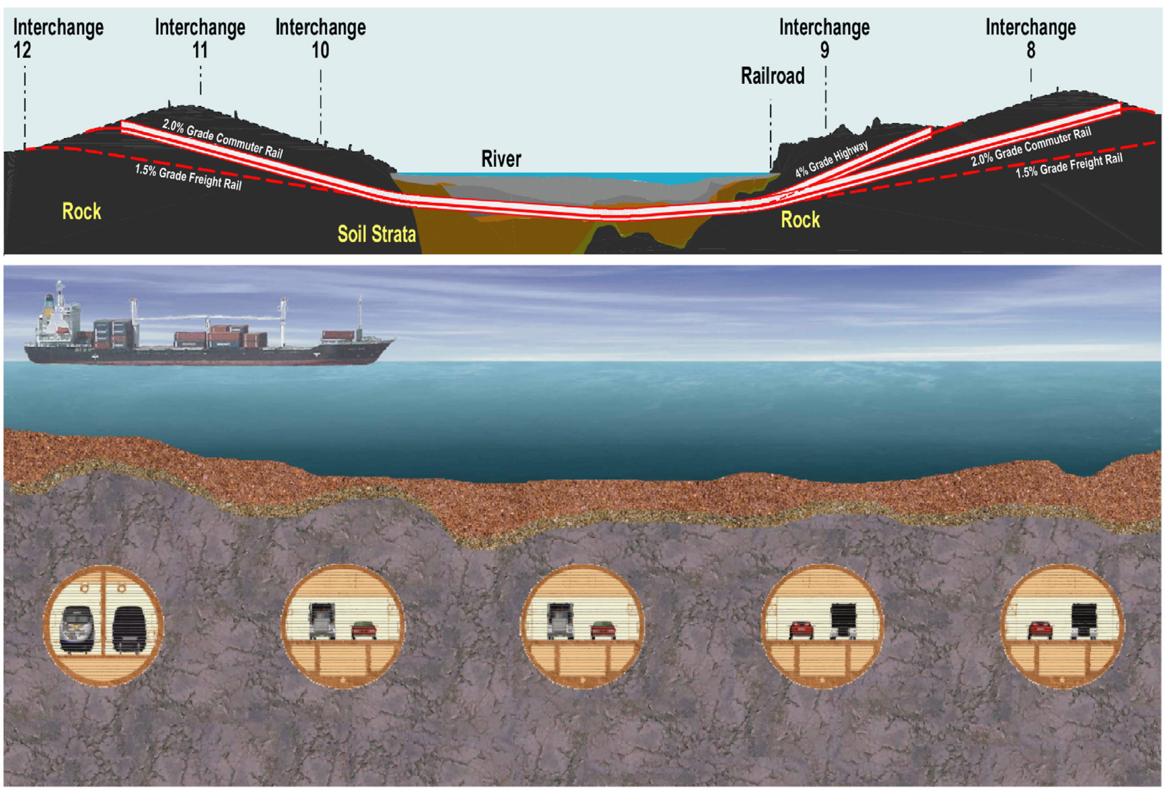
Bored Tunnel

A new bored tunnel would be expected to maintain or enhance the functionality provided by the existing bridge while minimizing intrusion into the community and the Hudson River. By its very nature, a bored tunnel would pass beneath, rather than through, parts of the community and the river. A new bored tunnel could be constructed to carry I-287 only or I-287 together with various combinations of dedicated busway, light rail line, or commuter rail.

Because it is bored through the soil, rather than resting on top of it, a bored tunnel in soil is typically placed deeper below the surface than immersed tunnels or those built from the surface in open cuts. Consequently, their profiles typically have to climb a longer distance to reach daylight. Given that the Hudson Valley rises fairly steeply on both shores, a bored tunnel is likely to emerge a considerable distance from the river shores and could possibly require grades steeper than three percent, as shown on Figure 2-7.



Bored Tunnel - Profile and Section

Figure 2-7

The same profile would work well with an added busway and/or with light rail. However, for commuter rail and freight rail, the desired grades are 2.0 percent and 1.5 percent, respectively. The corresponding profiles would necessarily be longer, which would make it particularly difficult to connect the tunnel to the Hudson Line, which runs along the east shore's edge.

Alignments that include commuter rail pose additional challenges. It is desirable to allow for the service to continue eastward toward White Plains as well as to connect to the Hudson Line towards New York City. It may be necessary to split the alignment within the tunnel near the east shore, and for the southbound tunnel to curve underground to join the Hudson Line north of Irvington.

Immersed Tunnel

A new immersed tunnel would be expected to maintain or enhance the functionality provided by the existing bridge while minimizing intrusion into the community. By its very nature, an immersed tube tunnel would require trenching of the riverbed. A new immersed tunnel would be constructed to carry I-287 only or I-287 together with various combinations of dedicated busway, light rail line, or commuter rail.

A considerable amount of material would have to be dredged from the river bottom along the proposed tunnel crossing to construct the immersed tube tunnel, some of which would be returned as backfill. The remainder would have to be transported off site and disposed of in accordance with applicable environmental regulations. There would be environmental concerns related to resuspension of fine sediments and other deposits, turbidity, and potential water pollution. Care would be needed to minimize disruption to waterborne traffic as the tunnel elements are placed on the riverbed. Large off-site construction sites accessible from the river would be required in order to prefabricate the units and then transfer them, by flotation, to the river crossing site.

The geological and geotechnical issues associated with an immersed tube tunnel differ from those pertaining to a bored tunnel; settlement and buoyancy of the tunnel rather than structural stability would be the main issues for an immersed tunnel. Currently, immersed tube schemes are being considered for a number of high profile port/harbor crossings outside the United States.

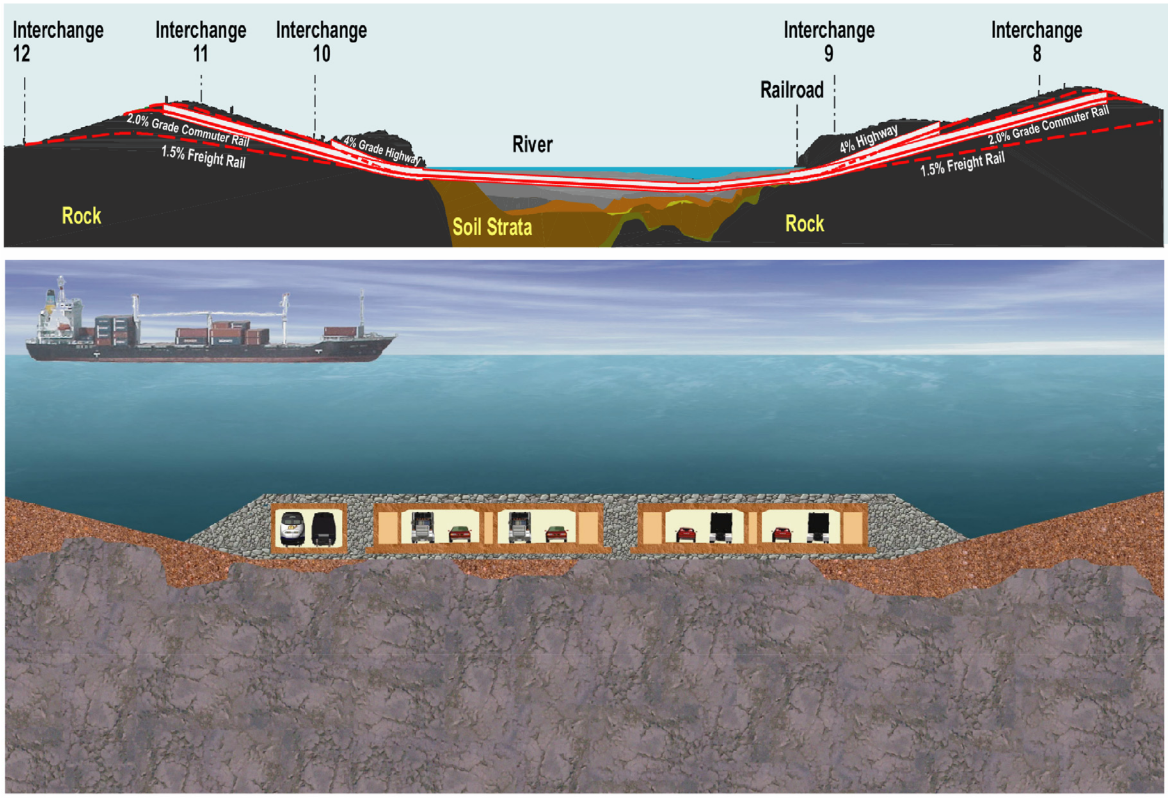
Typically an immersed tube tunnel, although seated below the riverbed, would not be placed as deeply below the surface as a bored tunnel. As such, the overall length would be expected to be shorter than a correspondingly deeper bored tunnel. However, the valley topography largely negates this theoretical advantage and the primary benefit to the highway profile is somewhat flatter grades. Figure 2-8 shows a representative profile for an immersed tube tunnel.

The same immersed tunnel highway profile as that of a bored tunnel would apply to an added busway or light rail system. However, although the profiles for commuter rail and freight rail would be longer because of the desired grades of 2.0 percent and 1.5 percent, respectively, they would not be as long as those required for a bored tunnel.

Alignments that include commuter rail pose similar challenges, if slightly less pronounced, than with bored tunnel construction. The split in tunnels near the east shore may need to veer inland underneath Tarrytown and parts of Irvington to reach the Hudson Line.

Replacement Serial Bridge/Tunnel

With the understanding that tunnel solutions generally extend well past the river shores, while bridge solutions can be accommodated within the limits imposed by the shore, alternative elements can be identified that might draw from positive aspects of both. Sequential combinations, which cross part of the river on a bridge structure and part in a tunnel, could provide the desired results. Sequential combinations have been successfully adopted elsewhere. One prominent example is the Hampton Roads Bridge-Tunnel in Virginia. A more recent example, which carries both highway and rail, is the Oresund Link between Sweden and Denmark.



Immersed Tunnel - Profile and Section

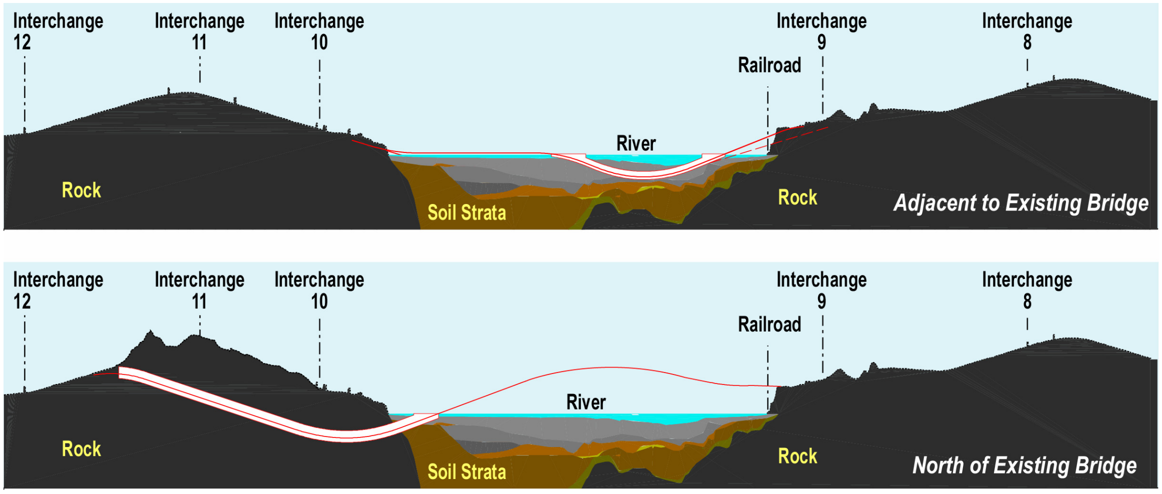
Figure 2-8

The connection between tunnel and bridge often takes place at an artificially constructed island in the river (Figure 2-9). The tunnel spoil material could be used to form the island. The island could, but need not, provide additional land space that could be used for ancillary components such as tunnel vent structures.

Two versions of the serial bridge/tunnel approach have been identified: one along a northerly alignment and another closer to the existing corridor. The northerly alignment would be suitable for any combination of highway and transit modes.

Replacement Bridge and Transit Tunnel

A new bridge plus a new separate tunnel would accommodate all of the various transport modes along alignments most favorable to each. For example, the highway, pedestrian and cyclist pathway, and possibly a light rail line would be placed on the bridge, while commuter and freight rail would go into the tunnel. The combination would enable the criteria for all modes to be grouped and met efficiently, and since the bridge and tunnel alignments would be separate and discrete, each would be oriented to optimize the connections with the existing highway and rail network. A variety of possible options was studied.



Profiles of Serial Bridge plus Tunnel (Immersed)

Figure 2-9

2.1.4.3 Supplemental River Crossings

A supplemental crossing would be a potential means of relieving congestion on the Tappan Zee Bridge and would enhance corridor mobility. Any supplemental crossing could be combined with any of the alternatives that retain the existing Tappan Zee Bridge. New bridges could accommodate a pedestrian/cyclist pathway; new tunnels and serial bridge/tunnels could not.

The Tappan Zee Bridge would continue to carry the bulk of automotive and truck traffic across the Hudson. With the primary east-west highway function served by the existing bridge, a supplemental crossing carrying only highway lanes would be located at a remote location, whereas one that carried exclusive transit facilities could be either near the existing bridge or at a remote location.

Supplemental River Crossings – Highway Only

A substantial portion (30 percent) of the traffic crossing the Tappan Zee Bridge is destined to and from New York City and points south. The supplemental highway crossings would provide an opportunity to explore remote placements for the southbound connections. There are north and south alternative elements that address these possibilities (Figure 2-10):

- **Remote North Crossing Corridor** – a new highway bridge located about 3 miles north of the Tappan Zee Bridge.

- **Remote Southern Crossing Corridor** – a new highway bridge located approximately four miles south of the Tappan Zee Bridge. The concept of diverting traffic from the Tappan Zee Bridge to a remote river crossing would appear to be more effective if the new location were located south of the existing bridge, since the destination of a considerable share of the vehicles crossing the Tappan Zee Bridge from Rockland County is southern Westchester, New York City, or points south. Two alternative element locations were studied, both about four miles south of the Tappan Zee Bridge.

Supplemental River Crossings with Exclusive Transit Facilities

A supplemental crossing presents an opportunity to explore the merits of a smaller supplemental bridge or tunnel to carry exclusive transit facilities in close proximity to the existing crossing or at a remote location. The placement and alignment would be optimized for each specific transit mode along several of the potential alignments.

A substantial potion of the transit market west of the Hudson is also destined for New York City. A series of alternative elements was developed to explore the potential for serving this market more directly through an exclusive commuter rail connection to the Hudson Line, either within the corridor or south of the existing bridge.

Hybrid Replacement Bridge with Highway and Commuter Rail

During the public scoping process, a new highway bridge was proposed with an alignment that would cross the existing bridge alignment west of the channel. This alternative element would also include a commuter rail component that would pass under Blauvelt Park in Rockland County through a tunnel, then proceed onto a new separate bridge over the western part of the river, and join the new highway bridge to pass over the channel. The commuter rail would continue into Westchester County through a tunnel and connect to the reinstated Putnam Line. This alternative element also would consider incorporating segments of the existing causeway trestle into the new alignment.

2.2 Level 1 Screening Criteria

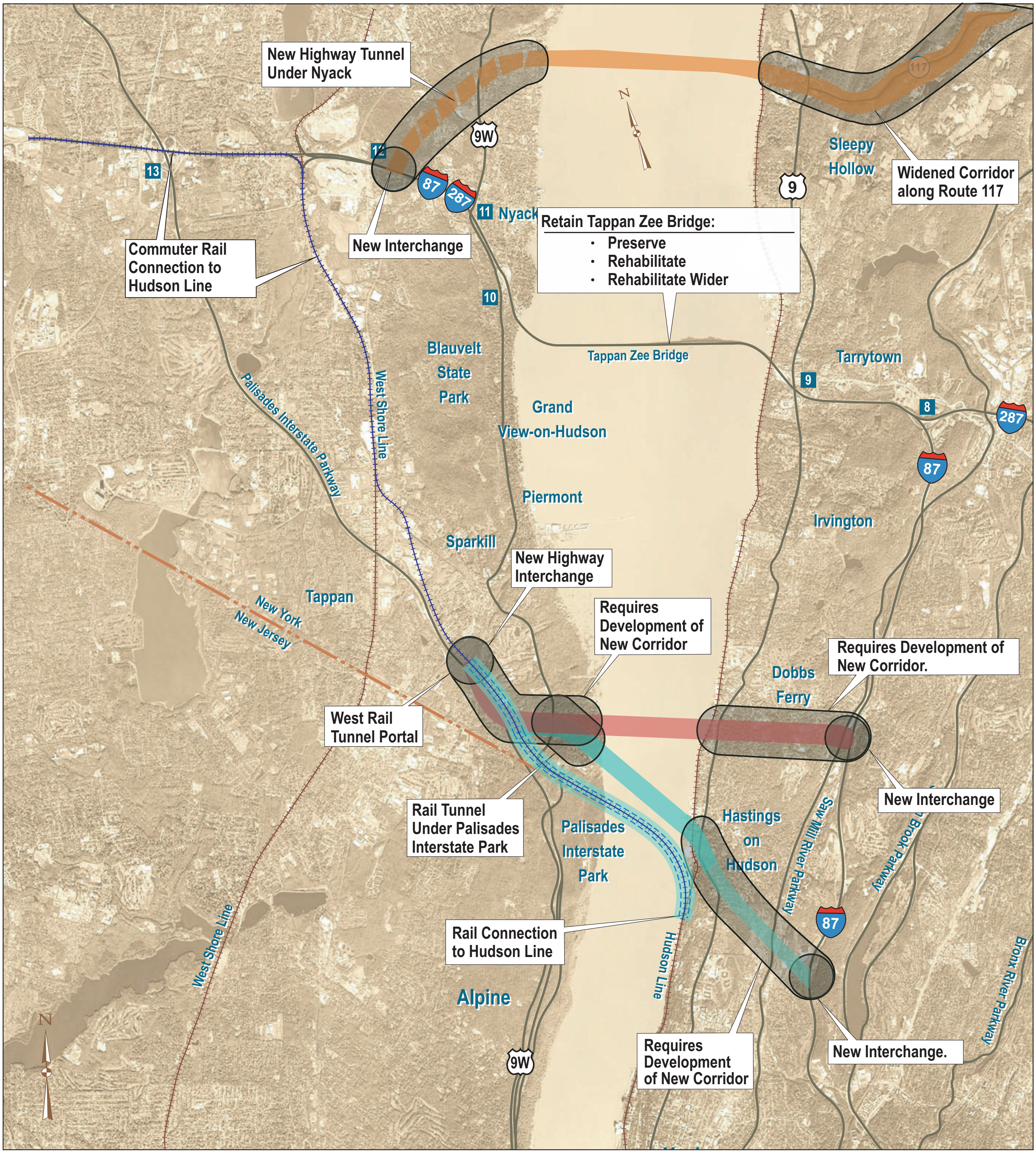
To evaluate the effectiveness of the alternative elements and their ability to meet the goals and objectives identified for the corridor, screening criteria or performance measures were developed. At this level of analysis, the alternative elements were developed only to a conceptual definition and most measures were qualitative.

The intent of this initial screening was to highlight the key differences in performance among the alternative elements within each category (i.e., TDM/TSM measures, transit service improvements, corridor-wide improvements, and river crossings) based on social, environmental, engineering, economic, and transportation factors. Not all of the initial criteria were relevant to all alternatives and for some there were no distinctions among alternatives. Therefore only those criteria that were relevant and/or permitted such distinctions were applied.

Separate screening procedures were developed for individual improvement categories whenever the criteria used to evaluate alternatives in one category were not relevant to those in other categories. Criteria for the river crossing alternatives, for example, included an assessment of structural integrity, ability to withstand seismic events, and vulnerability to natural or manmade incidents, which are not relevant for use in evaluating the alternatives in other categories.

For Level 1 screening, detailed design, cost, ridership, and impact information were not available; thus, many of the Level 1 criteria were surrogate measures or qualitative, professional judgments. The information was presented in several ways, depending on the measurement method, as follows:

- Some assessments provided numerical results. For example, travel time was summarized by the number of minutes for typical trips.



Supplemental River Crossings

Figure 2-10

- Some assessments resulted in a "pass/fail." For example, the river crossing alternatives either do or do not include a pedestrian/bicycle facility.

- Many assessments resulted in a "level of impact/effectiveness" rating. For example, level of parklands and 4(f) resource impacts were presented using a simple, qualitative statement as to the judged degree of potential impacts.

The letter codes for "type" of rating in the tables refer to the following:

- **Q** = Qualitative rating based on judgment (for example, the severity of construction impacts);

- **M** = Direct Measurement (for example, auto speed on selected roadway links which is a direct output of the traffic model).

For the corridor-wide alternatives, preliminary travel demand estimates were used including forecast travel times, travel speeds, use of transit and highway modes, and vehicle miles traveled[1]. "Reserve Capacity" or the estimated person-moving capacity of the transportation corridor beyond the time horizon of this study was calculated on the basis of the four-hour peak period (6:00 AM to 10:00 AM) for the corridor-wide alternatives for the year 2020. (In the Level 2 screening process, the year 2025 was used when additional forecasts became available.) In addition to using the quantified information, assumptions on transportation performance were made based on judgment and interpolation, guided by the results of the model runs and an understanding of future corridor travel conditions.

The corridor-wide and river crossing improvements were evaluated based on their potential to interconnect components of existing and proposed highway and transit systems within the corridor, as applicable. Environmental screening focused on direct impacts to the natural and manmade environment. A number of Section 4(f) resources are found in the study area. Section 4(f) of the US Department of Transportation Act of 1966 applies to publicly-owned parklands and historic sites. Pursuant to Section 4(f), alternatives that could result in direct impacts to, or changes in the aesthetic setting and character of, historic properties, districts, or publicly owned parklands would require a demonstration that there is no feasible and prudent alternative to that use, and that all possible planning was undertaken to minimize harm to the affected property from that use. Section 6(f) of the US Land and Water Conservation Fund Act provides similar protections to recreational facilities and parklands as does Section 4(f). However, the resources protected under Section 6(f) are those specifically funded pursuant to the Act. Section 6(f) also provides an opportunity to off set project impacts by providing an opportunity to replace 6(f) facilities if no practicable non-impacting alternative exists.

The Level 1 screening criteria used to evaluate the long list of alternative elements are presented in Tables 2-1 to 2-5. These criteria tables also indicate the relationship of each of the screening criteria to the previously discussed goals and objectives.

[1] Preliminary travel demand forecasts were developed using the Best Practice Model (BPM), which is a regional model developed by the New York Metropolitan Transportation Council (NYMTC). See Chapter 4 for details.

Table 2-1

TDM/TSM and Improvements to Existing Transit Services
Level 1 Screening Criteria

Criterion	Measurement Method	Type	Units/Rating System	Related Goal(s)
1.Traffic Operations	Potential to reduce congestion and/or incrementally increase vehicular capacity	Q	Poor/Neutral/ Fair/Good	1
2. Transit Ridership	Potential to increase transit ridership	Q	Poor/Neutral/ Fair/Good	1
3.Auto Occupancy	Potential to increase ridesharing	Q	Poor/Neutral/ Fair/Good	1
4. Peak Period Vehicle Trip Reduction	Potential to reduce peak period vehicle trips	Q	Poor/Neutral/ Fair/Good	1
5. Socioeconomic Impacts	Potential for disproportionate impacts to low income and/or minority populations	Q	Yes/No	5
6. Air Quality Impacts	Potential change in air quality as a result of changes in travel conditions	Q	Deterioration/ Neutral/ Improvement	5
7. Other Significant Adverse Impacts	Significant adverse impacts to other environmental resources, as appropriate given the characteristic of the improvement	Q	Nature and Degree of Impact	5
8. Implementation Issues	Judgment based on legislative needs, jurisdictional issues, and public controversy with action	Q	Poor/Neutral/ Fair/Good	6
9. Cost Effectiveness	Rating on anticipated benefits in relation to costs	Q	Poor/Neutral/ Fair/Good	6

Table 2-2

Corridor-Wide Improvements
Level 1 Transportation Performance Screening Criteria

Criterion	Measurement Method	Type	Units/Rating System	Related Goal(s)
10. Travel Time	Highway: AM peak period/peak direction travel times for selected pairs of origin and destinations	M	Average travel time in minutes	1
	Transit: AM peak period/peak direction travel times for selected pairs of origins and destinations	M	Average travel time in minutes	1
11. AM Peak Period/Peak Direction Mode Split	Reduction in SOV crossing Hudson River screenline	M	Number of vehicles	1
	Increase in transit share for selected travel markets	M	Percentage	1
12. Transit Ridership	Increase in transit ridership crossing the Hudson River	M	Number of passengers	1
	Increase in regional transit ridership	M	Number of passengers	1
13. AM Peak Period Reserve Capacity	Year 2020 reserve peak period/peak direction highway person-capacity at selected screenlines	M	People/hour	1, 2
	Year 2020 reserve peak period/peak direction transit person-capacity at selected screenlines	M	People/hour	1, 2
14. Transportation System Integration	Ease of integration with existing roadway network	Q	Poor/ Fair/Good	2, 6
	Ease of integration with existing transit infrastructure	Q	Poor/ Fair/Good	2, 6
15. Freight	Potential to accommodate rail freight	Q	Low/Medium/ High	1, 2, 6
16. Alternative Mode(s) not in Mixed Traffic	Inclusion of alternative mode(s) operating on roadway/guideway not subject to highway congestion	Q	Yes/No	1, 2, 6

Table 2-3

Corridor-Wide Improvements
Level 1 Environmental Screening Criteria

Criterion	Measurement Method	Type	Units/Rating System	Related Goal(s)
17. Potential for Existing Land Use Impacts	Potential consistency with existing land use	Q	Low/Medium/ High	5
18. Potential for Future Land Use Impacts	Potential consistency with adopted land use plans and policies	Q	Low/Medium/ High/Variable	5
19. Potential Change in Air Quality	Year 2020 potential change in air quality	Q	Slight Deterioration/ None/Slight Improvement	5
20. Acquisitions, Displacements, and Relocations	Potential extent of acquisitions, displacements, and relocations	Q	Low/Medium/ High	5
21. Historic and Archaeological Resources	Potential to impact resources listed on, or eligible for listing on, the National or State Register of Historic Places	Q	Low/Medium/ High	5
22. Parklands and Section 4(f)/6(f)	Potential to impact parklands and 4(f)/6(f) resources	Q	Low/Medium/ High	5
23. Potential Impacts on Upland Ecosystems and Water Resources	Potential impacts to ecosystems and water resources	Q	Low/Medium/ High/Severe	5
24. Construction Impacts	Construction impact severity	Q	Low/Medium/ High	5, 6
	Construction impact duration	Q	Short/Medium/ Long	5, 6

Table 2-4

River Crossings
Level 1 Transportation Performance Screening Criteria

Criterion	Measurement Method	Type	Units/Rating System	Related Goal(s)
25. Travel Time	AM peak period/peak direction travel time change by mode	M	Average travel time in minutes	1
26. Traffic Operations and Safety	Potential changes in traffic operations and overall traffic safety based on roadway configuration and geometrics	Q	Negative/ Neutral/Low/ Medium/ High	1, 4
27. AM Peak Period Reserve Capacity	Year 2020 reserve peak period/peak direction highway person-capacity	M	People/hour	1, 2
	Year 2020 reserve peak period/peak direction transit person-capacity	M	People/hour	1, 2
28. Transportation System Integration	Ease of integration with existing roadway network	Q	Poor/ Fair/Good	2, 6
	Ease of integration with existing transit infrastructure	Q	Poor/ Fair/Good	2, 6
29. Freight	Potential to accommodate rail freight	Q	Low/Medium/ High	1, 2, 6
30. Structural Integrity	Structural sufficiency rating, based on degree to which river crossing is brought into compliance with current structural standards	Q	Poor/Fair/ Good	3
31. Seismic Standards	Seismic sufficiency rating, based on degree to which river crossing is brought into compliance with current seismic standards	Q	Poor/Fair/ Good	3
32. Vulnerability	Assessment based on type and characteristics of structure(s)	Q	Poor/Fair/ Good	4
33. Alternative Mode(s) not in Mixed Traffic	Inclusion of alternative mode(s) operating on roadway/guideway not subject to highway congestion	Q	Yes/No	1, 2, 6
34. Non-Vehicular Travel	Inclusion of pedestrian and bicycle facilities	Q	Yes/No	1, 2

Table 2-5

River Crossings
Level 1 Environmental Screening Criteria

Criterion	Measurement Method	Type	Units/Rating System	Related Goal(s)
35. Potential for Existing Land Use Impacts	Potential consistency with existing land use	Q	Low/Medium/ High	5
36. Potential for Future Land Use Impacts	Potential consistency with adopted land use plans and policies	Q	Low/Medium/ High/Variable	5
37. Potential Change in Air Quality	Year 2020 potential change in air quality	Q	Slight Deterioration/ None/ Slight Improvement	5
38. Acquisitions, Displacements, and Relocations	Potential extent of acquisitions, displacements, and relocations	Q	Low/Medium/ High	5
39. Historic and Archaeological Resources	Potential to impact resources listed on or eligible for listing on the National or State Register of Historic Places	Q	Low/Medium/ High	5
40. Parklands and Section 4(f)/6(f)	Potential to impact parklands and 4(f)/6(f) resources	Q	Low/Medium/ High	5
41. Potential Impacts on Hudson River Ecosystems and Water Resources	Potential impacts to ecosystems and water resources	Q	Low/Medium/ High/Severe	5
42. Construction Impacts	Construction impact severity	Q	Low/Medium/ High	5, 6
	Construction impact duration	Q	Short/Medium/ Long	5, 6

2.3 Summary of Level 1 Screening Results

The screening process narrowed down the long list of alternative elements by eliminating those that would not meet the study's goals and objectives, i.e., they would:

- Offer little or no benefit compared to a No Build condition.
- Perform poorly in meeting the study's goals and objectives with no apparent benefit compared to other alternative elements.
- Result in significant impacts that could not likely be mitigated.

The disposition of each alternative element is presented in Table A-1 (Appendix A), which indicates those elements that were eliminated from further consideration and those that are retained, in original or modified form, for further detailing and analysis in the Level 2 screening process. The rationale for this screening follows. Chapter 3 contains a description of the Level 2 scenarios.

2.3.1 TDM/TSM Measures

Many of the TDM/TSM measures in the long list were determined to be potentially effective ways to improve travel conditions in the corridor. The following measures are those that are not recommended to proceed to Level 2 screening, and the rationale for eliminating these measures:

- Mandating participation in the presently voluntary MetroPool ETR Program would require a significant coordination effort with employers throughout the corridor, new state legislation, and a cumbersome and potentially costly monitoring program to ensure and enforce compliance. The limited expected transportation benefit from a mandatory MetroPool Program, together with the added difficulties and expense of enforcing compliance, make this an ineffective way to address mobility in the corridor.

- Currently, most suburban employee parking is provided by the employer at no cost to the employee. While managing the supply and demand of employee parking has the potential to change travel behavior in the corridor, such policies could unfairly penalize non-corridor users and would be difficult to implement, requiring new legislation and the cooperation and coordination of multiple jurisdictions and/or private partners.

- The measures that would limit use of a presently general-purpose lane (either on the Tappan Zee Bridge or I-87/I-287) to buses or other HOVs would have an overall detrimental impact on traffic operations and would be inconsistent with the study goal of increasing mobility in the corridor.

- A reduction in general-purpose lane capacity would result in deteriorated levels of service under existing conditions, with significant impacts expected in future years. The number of vehicles that would be removed from the general-purpose lanes by adding an HOV lane would not compensate for the reduction in highway capacity. Travel times would increase for the majority of commuters traveling in the corridor, and more bottlenecks throughout the corridor and longer delays at the toll plaza would occur. The conversion of the reversible lane on the bridge alone, for example, would increase travel time for the general-purpose lane users by more than three minutes.

Today, the bridge can process only about 2,050 vehicles per hour per lane due to the lack of shoulders, constrained lane width, and number of truck trips crossing the Hudson. The capacity of the bridge today, therefore, is 8,200 vehicles per hour in the peak direction of travel and 6,150 in the reverse peak direction. Traffic volumes on the bridge are expected to continue to grow at a rate of more than 1 percent per year. As a result, peak hour traffic is expected to exceed 9,000 vehicles per hour by 2020 in the peak direction of travel. Traffic traveling in the reverse peak direction is expected to grow at a faster rate than the peak direction.

- The introduction of corridor-wide distance-based tolls would result in traffic diversion to parallel arterials as drivers try to avoid/minimize their toll charges. These traffic diversions would simply displace congestion problems in the corridor without improving overall mobility.

2.3.2 Transit Service Improvements

Bus, park-and-ride, and Hudson Line commuter rail service improvements have been retained for further analysis in Level 2 screening. Several transit service improvements performed poorly with little or no apparent benefit compared to those retained for further analysis. These were:

- **Service improvements on the New Haven and Harlem Lines** – such improvements, while potentially worthwhile, would not measurably improve transportation performance in the corridor and rated poorly due to their very limited benefit as stand-alone options. However, these service improvements are considered below in conjunction with corridor-wide improvements.

- **Ferry service expansions and new routes** – while several of these alternatives may be pursued by others in the future where it makes economic sense, ferries would not offer a significant transportation performance benefit in relation to corridor traffic. This conclusion was based on the very limited opportunities for development of needed shoreline support facilities (access roads, parking, and docking facilities); the impacts that these facilities and operations would have on river communities; and the limited markets and capacity. As a result, a major new ferry component was not carried forward into Level 2 analysis.

A number of transit service improvements were already committed and scheduled to be completed and were carried forward in the No Build scenario. These include Metro-North and NJTransit projects on the Port Jervis and Pascack Valley Lines. Concurrent with the opening of Secaucus Junction during weekdays, Metro-North has been increasing train service on the Port Jervis and Pascack Valley Lines. To support this increased service, new coaches and locomotives have been purchased, train storage yards and parking at stations on both lines are being expanded, and signal system improvements and new passing sidings are planned for the Main/Bergen and Pascack Valley Lines to increase capacity.

2.3.3 Corridor Improvements

A full array of multi-modal solutions was carried forward into the Level 2 screening process, including scenarios that involve highway alone, highway and bus rapid transit (including a dedicated busway across Rockland and Westchester counties), highway and commuter rail, and highway and commuter rail with a light rail or bus rapid transit component. Alternative elements that were eliminated as a result of Level 1 screening are described below.

2.3.3.1 Bus Rapid Transit

Construction of a continuous bus rapid transit facility on parallel arterials in the corridor (NY 59 in Rockland County and NY 120 in Westchester County) was considered and eliminated because it performed poorly in meeting the study's goals and objectives with no apparent benefit compared to the BRT scenarios that were retained for further analysis. These arterials do not have adequate right-of-way width to add a continuous exclusive lane without substantial property acquisition.

2.3.3.2 Commuter Rail

Several commuter rail alternatives were eliminated from further consideration either because they would not perform as well as those retained for analysis in Level 2 screening or because they had potentially serious impacts that would be difficult to mitigate. Eliminated alternatives include the following:

- **Harlem Line Connection.** Connecting the Port Jervis Line to the Harlem Line was eliminated because it would perform less effectively than connecting to the Hudson Line for a number of reasons. The Harlem Line currently operates at capacity during peak hours and would require construction of significant additional trackage to accommodate increased service levels, whereas sufficient capacity exists on the Hudson Line. Travel time from/to Manhattan via the Harlem Line would be significantly longer (approximately 10 to 15 minutes, depending on intermediate stops in Tarrytown or Greenburgh) compared to the Hudson Line due to its more indirect route, slower speeds, and heavier traffic density. In addition, direct connection of the rail lines would result in direct impacts to Section 4(f) parkland associated with the Bronx River Parkway Reservation. Residential property takings north of White Plains would potentially be required.

- **Reinstitute Putnam Line Service.** The commuter rail alternative that would reinstitute commuter rail on the Putnam Line would not perform as well as those alternatives that make better use of the existing rail infrastructure, such as connecting the Port Jervis and Hudson lines, which have considerably fewer environmental impacts and property acquisition requirements. Use of the Putnam Line for commuter rail operations would duplicate existing north-south commuter rail services and reestablish rail in a location currently unaccustomed to such activity. Most of the Putnam Line between the Bronx and Putnam Counties has been converted into a trailway for recreational use.

2.3.3.3 West Shore Line Passenger Service

The possibility of implementing commuter rail service on the West Shore Line from the study area south along the west side of the Hudson River through New Jersey was raised at several public meetings. A major freight line, CSX, operates over the West Shore Line and has jurisdiction over operations and maintenance of the line. NJTransit is preparing an environmental impact statement that evaluates implementing West Shore passenger service to serve Rockland County between West Nyack and Hoboken. An extension to West Haverstraw is also being considered. This AA process will, therefore, not separately consider this same West Shore line commuter rail alternative. However, the progress of the NJTransit studies will be monitored and findings of analyses performed by the project teams will be shared to facilitate effective decision-making.

2.3.3.4 Cross Westchester Tunnels

In keeping with comments received at the January 14, 2003, scoping meeting, consideration of a tunnel that would relocate all or portions of I-287 underground between the Hudson River and its terminus at I-95 in Rye was examined in Level 1 screening. In addition, a Cross Westchester subway between Suffern and Rye for rail transit service was considered. These tunnel alternatives would generally not meet the goals and objectives of the study.

I-287 is an integral part of the interstate highway system, an east-west roadway that connects important north-south highways and major arterials that radiate from the core of the New York metropolitan area. These include the New York State Thruway (I-87), the Saw Mill River Parkway, the Sprain Brook Parkway, Interstate 684/Hutchinson River Parkway, the New England Thruway (I-95), Route 9, Route 9A, Route 100A, Route 100, Route 22, Westchester Parkway/Westchester Avenue, and Route 120. In essence, I-287 weaves the regional highway network together. If relocated into a tunnel, this segment of I-287 would still have to perform this essential function of interconnecting the regional network of roadways through a series of surface to underground ramp connections.

Three conceptual tunnel profiles were considered and are discussed below: (1) a shallow tunnel that rises to the surface to meet the existing roadway network at critical interchanges; (2) a shallow tunnel with new underground interchanges; and (3) a deep tunnel with equally deep underground interchanges:

- **A shallow cut-and-cover tunnel with above ground interchanges** would require major utility relocations and an extended and highly disruptive construction period. A number of interchanges are so closely spaced along this segment of I-287 that a tunnel could not be constructed between them and rise to meet the ramps at the surface. Hence, a shallow tunnel in these locations would require the permanent closure of certain interchanges. This alternative would not meet the study's primary goal and objective of improving mobility within the corridor.

- **A shallow cut-and-cover tunnel with underground interchanges** would permit a continuous tunnel with connections to the north-south highways and arterials; however, it would require substantial dismantling and reconstruction of interchanges. Ramps that rise from crossing roads to meet I-287 would have to be replaced with ramps that drop onto I-287, and ramps that drop onto I-287 would have to be significantly lengthened to reach the underground roadway. Because most interchange ramps are intricately linked to one another from both a functional and spatial standpoint, this would result in extensive reconstruction at most of the 12 interchanges. Where interchanges are very closely spaced, the longer ramps would likely conflict, necessitating compromises in design or elimination of conflicting movements.

  The connections to I-287 would occur at new underground interchanges. The roadway box would have to be widened to accommodate the ramps and acceleration/deceleration lanes. This widening would require a corresponding expansion of the areas of open excavation during construction that would extend beyond the footprint of the current interchanges.

- **A deep tunnel,** while avoiding the need to open a large trench for the full length of the corridor, would have many of the same problems just identified. Large open cut sections and new rights-of-way would be required for reconstructed interchanges. Each ramp would constitute a separate tunnel that would have to be built from the surface, largely in open cuts, down to the underground interchange.

Connectivity of an underground subway system with existing and proposed at-grade transit services would also be difficult. Given the preliminary ridership estimates for the Cross Westchester transit line, a tunnel would not be cost-effective and did not perform as well as did the primarily at-grade (with aerial or tunnel sections where topography would dictate) commuter rail and LRT alignments that were retained for analysis in Level 2 screening.

2.3.4 River Crossings

The concepts of preservation, rehabilitation without widening, rehabilitation with widening, replacement bridge, replacement bored tunnel, combination of a new bridge and a transit tunnel, and a rehabilitated bridge and new transit tunnel were all advanced into Level 2 screening. Rehabilitating the existing bridge without widening was retained for further analysis as part of the No Build scenario, and used as the environmental baseline for comparison to the other scenarios. Rehabilitating the bridge without widening (but with major seismic upgrade) was retained for incorporation into a TDM/TSM scenario. These rehabilitation bridge alternatives have fewer environmental issues but perform less well with respect to traffic operations and safety, structural integrity, and vulnerability than the replacement bridge and tunnel alternatives. Alternative elements that were eliminated from further consideration are reviewed below.

2.3.4.1 Alternative Elements with Six General-Purpose Lanes

The alternative elements with only six general-purpose lanes on the bridge would not meet the study’s goal of improving mobility in the corridor, as they would be expected to cause unacceptable levels of congestion and increase travel time for the vast majority of commuters and weekend travelers in the corridor, creating more bottlenecks and worsening delay at the toll plaza. As previously discussed, lane capacity on the existing bridge is only about 2,050 vehicles per hour due to lateral clearance, percentage of trucks, and other factors. Thus, the effective capacity of three lanes is only 6,150 vehicles per hour.

Volumes on the bridge today routinely exceed that capacity in the peak direction of travel during peak periods both on weekdays and on the weekends. Weekend travelers, in particular, experience significant delays in the southbound direction on Sunday afternoons as a result of 10- to 15-mile queues at the toll plaza. Thus, those alternatives that would convert the existing reversible (“zipper lane”) to HOV or HOT lane use were eliminated from further study.

2.3.4.2 Rehabilitation with Widening

A rehabilitated and widened bridge was retained as an option to accommodate an LRT system only. A rehabilitated and widened bridge with commuter rail would present a number of serious problems when compared to a replacement bridge due to the need to meet commuter rail live loads and operational requirements. The weight of commuter rail cars and locomotives and their vibration effects differ from that of vehicular traffic. As a result, rail load requirements and current standards would require the modification of almost all components in all segments of the existing crossing.

The deck of the bridge is divided into 197 separate spans that are connected by joints. Poor interaction between the joints and the tracks would be detrimental to the stability of tracks as well as the quality of the train ride. Conversely, the frequent train movements would be detrimental to the joints. Together, the relatively steep grade of the bridge and the frequency of joints would limit the train’s speed and degrade its effectiveness to undesirable levels. Maintenance requirements, metal fatigue, and safety would also be of concern.

A bridge widened to accommodate general-purpose or bus lanes was eliminated from consideration primarily because of concern for traffic safety. The desirable arrangement for eight lanes would place three lanes on each side of a fixed median barrier at the center of the roadway, and one additional lane on new steel members connected to the existing structure on the outside of the existing truss (i.e., the long span steel structure that supports the roadway over the navigational channel). The consequent separation of traffic at the main spans would result in unsafe conditions because it would require additional driver decisions at unexpected locations.

2.3.4.3 Immersed Tube Tunnels

Bored tunnels fared much better in the analysis than immersed tube tunnels based on engineering and environmental considerations. Minimal cost and performance differences were identified between the two types of tunneling. However, construction of the immersed tube tunnel in the Hudson River would entail a major dredging effort that would generate significant sediment disturbance and resuspension over an extended construction interval.

The resuspended sediment plume would directly impact water quality and influence the passage of important commercial and threatened fish species. Dredging would physically disturb a large area and result in a significant loss of bottom habitat. As a result of these considerations, immersed tube tunneling was eliminated from consideration.

2.3.4.4 Supplemental River Crossings

A number of northern and southern supplemental crossings that would be constructed outside the corridor were examined. These alignments would require the development of new travel corridors and would not make good use of the existing transportation infrastructure. A number of significant environmental and community issues were identified for these remote crossings:

- **A remote northern crossing**, approximately three miles north of the bridge, would require a new two-mile corridor in Rockland County diverging from I-87/I-287 near Interchange 12 and extending to the west shoreline in Upper Nyack. A crossing in this location was chosen for its ability to connect to Route 117 in Westchester County, the nearest east-west roadway located outside of the corridor to the north. A tunnel would be required under Nyack to avoid the impacts and displacements associated with a new highway through the center of Nyack.

  On the east shoreline, the river crossing would require a new one-half-mile long roadway corridor from the river to a direct connection with Route 117 at its interchange with Route 9. The supplemental corridor would continue on an upgraded Route 117 for nearly four miles to a proposed new interchange with Route 9A (Saw Mill River Road) and the Taconic State Parkway. This remote crossing would pass directly through the Rockefeller State Park Preserve, with direct impacts to this Section 4(f) resource.

- **A remote southern crossing** would appear to be more effective from a regional travel perspective since a considerable share of vehicles crossing the bridge is destined for southern Westchester, New York City, and points south. One southern crossing that was considered would be in the vicinity of Sneden's Landing, about four miles south of the existing bridge. This location was chosen to avoid the hilly topography of the Palisades that would be encountered farther to the south.

In Rockland County, the Palisades Interstate Parkway, a four-lane parkway that connects to I-87/I-287 at Interchange 13, would be used to link I-87/I-287 with the river crossing for a length of about six miles. From the Westchester shore, a four- or six-lane, east-west roadway corridor would be required through Dobbs Ferry to meet the New York State Thruway near Exit 7.

Significant environmental and community impacts associated with this alternative include direct impacts to Section 4(f) parkland (part of the Palisades Interstate Parkway) and Hudson River ecosystem impacts because of the proximity of the alignment to the Piermont Marsh, a New York State Significant Coastal Habitat.

- **Other southern crossing locations** were examined; however, each had significant direct impacts that eliminated them from further consideration.

2.3.4.5 Serial Bridge/Tunnel

The concept of a serial bridge (a crossing partly on a bridge and partly in a tunnel) was explored. The connection between the tunnel and bridge segments would occur in the river, requiring construction of an "island" or peninsula extensions from the shore to accommodate the section where the highway transitions from a tunnel to a bridge. This island would be quite large, approximately 3,100 feet long by 500 feet wide. The adverse ecological impacts of filling in a portion of the Hudson River, in addition to the aforementioned negative impacts of immersed tube tunneling (which would also be required) rendered this concept unacceptable for environmental reasons.

2.3.4.6 Channel Relocation

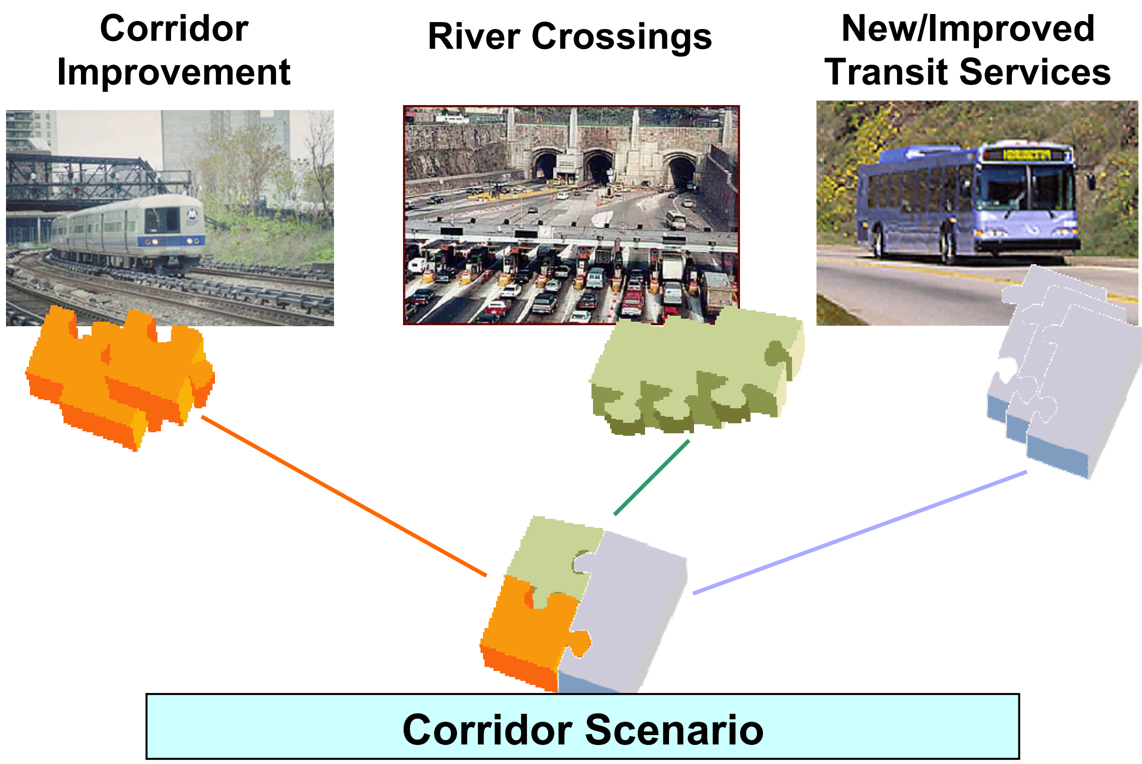
Relocating the navigational channel was considered as a way to improve the commuter rail connection to the Hudson Line from a new bridge. Shifting the navigational channel westward would allow for a more gradual descent at the river's eastern shoreline. However, based on a review of historic maps, the channel in this reach has naturally sought the easterly shoreline and has not markedly changed its configuration in more than 100 years.

Since 1902, the earliest year for which the available maps use the current system of depicting river conditions, water depths in the Hudson River appear to be comparable to those shown on the current navigation chart. As a result, shifting the channel westward would potentially create a sediment trap since the river is likely to rework any new channel alignment to restore the stable historic condition. Should this occur, the maintenance-free situation that now exists within this reach of the river would be replaced with the need for routine dredging operations.

Finally, the Piermont peninsula located to the south of the bridge on the western shore would prohibit the development of a straight navigation channel, which would not meet Coast Guard requirements. As a result, the concept of relocating the navigational channel was eliminated from further consideration.

2.4 Conclusions Regarding Level 1 Screening Process

The first part of the two-part screening process was successful in eliminating those alternative elements that would not meet the goals and objectives established for the corridor. The most promising alternative elements from the Level 1 screening process form the components of 15 scenarios that are described in the next chapter. The scenarios were formed by matching the corridor-wide improvements with river crossings, and then adding transit service improvements to complement the match (Figure 2-11). Of the 150 alternative elements in the long list, about 70 are represented in the 15 scenarios carried forward into the Level 2 screening process (a 16th scenario was added later in the process).



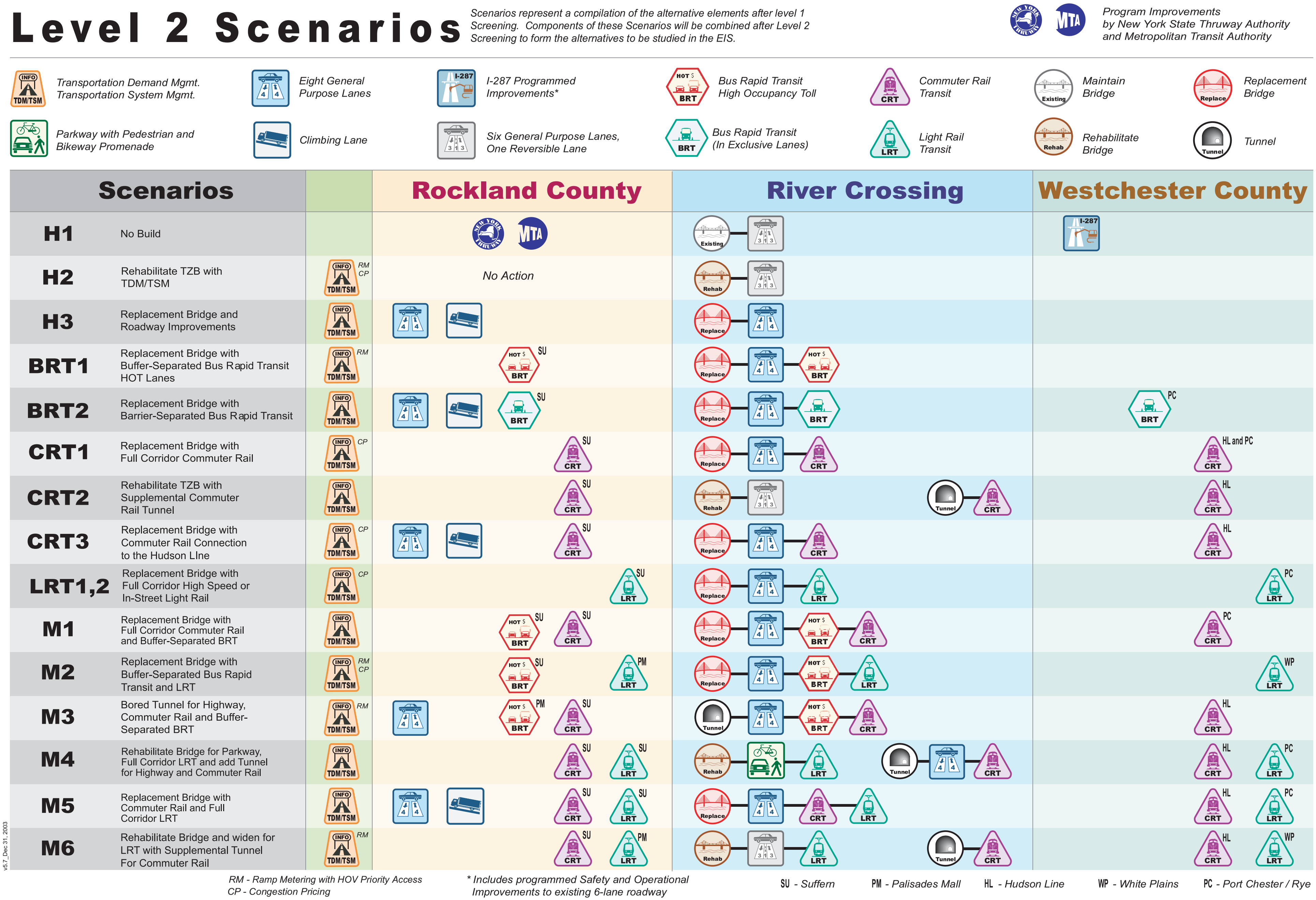
Development of Level 2 Scenarios

Figure 2-11

The scenarios reflect the results of the public review process and include those that evolved to their present form as a result of public comment and review. No Build and TDM/TSM scenarios were defined as stand-alone scenarios to be used as baselines for comparison to the other higher-cost options. It is important to note that the scenarios are not project alternatives; they represent an analytical framework of potential combinations of highway, bridge, and transit elements (including different physical alignments) that were to be analyzed in order to determine the best set of elements that would be combined into EIS alternatives for more detailed analyses in Stages 2 and 3 of the project.

Scenarios that involve highway alone, highway and BRT, highway and commuter rail, and highway and commuter rail with a light rail or BRT component were combined with the river crossing concepts of preservation, rehabilitation without widening, rehabilitation with widening, replacement bridge, replacement bored tunnel, combination of a new bridge and a transit tunnel, and a rehabilitated bridge and new transit tunnel.

To simplify and help understand the complex variety of the alternative elements, a series of graphical symbols ("Zikons") was developed to represent the various TDM/TSM, highway, transit, and river crossing options that were considered for Level 2 screening. Figure 2-12 illustrates the scenarios using these Zikons.



Level 2 Scenarios

Figure 2-12