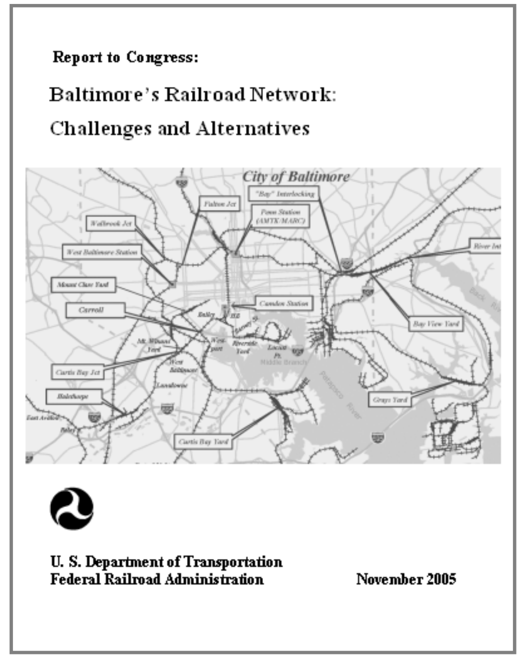
Part II:

Alternatives



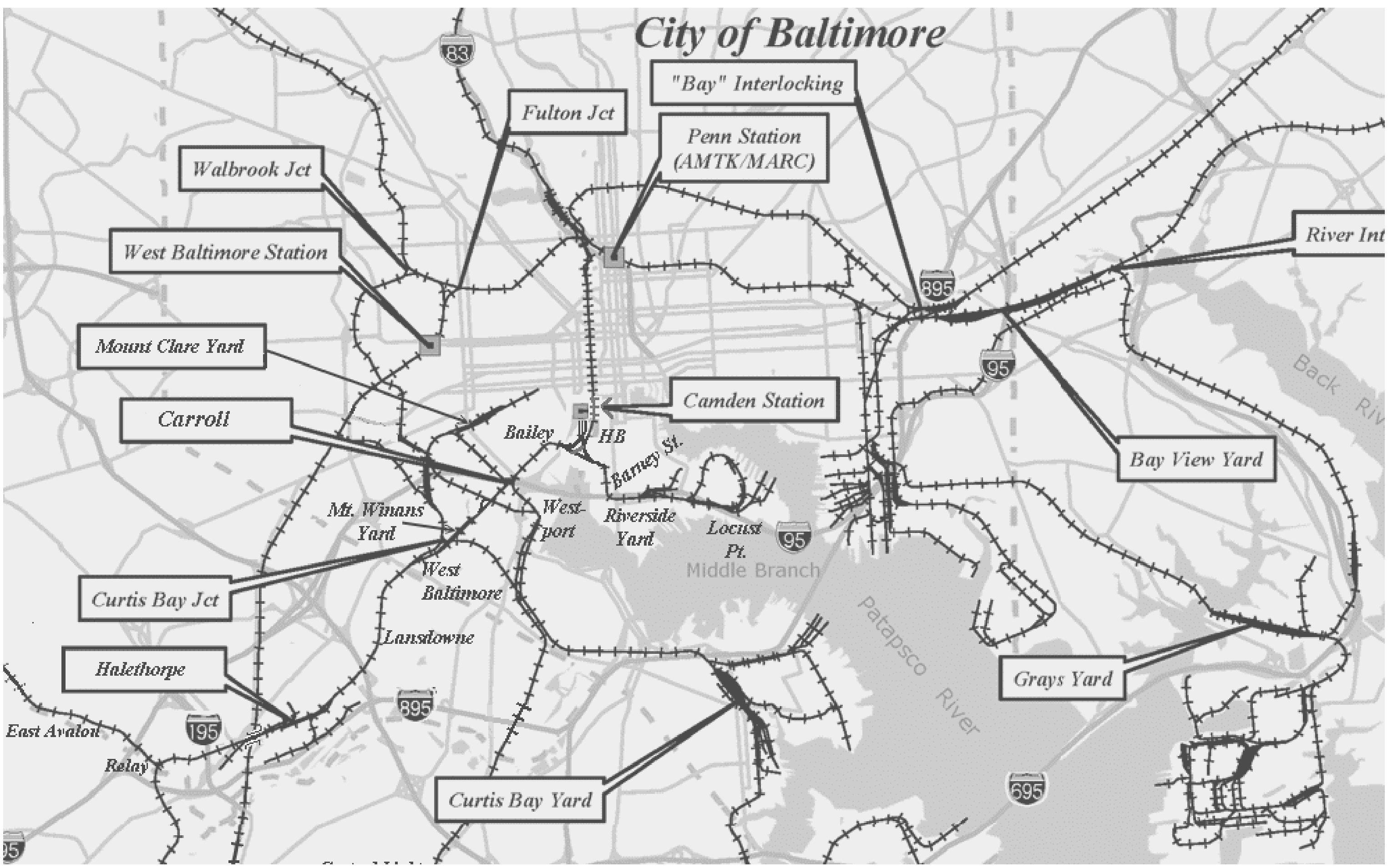
Report to Congress:

Baltimore's Railroad Network:

Challenges and Alternatives

U. S. Department of Transportation
Federal Railroad Administration

November 2005



Chapter Five
STUDY OBJECTIVES, STANDARDS, AND METHODS

Part I of this report describes the challenges facing passenger and freight railroads as they serve their customers over an increasingly congested and antiquated collection of facilities in the Baltimore region. Part II elucidates the principles and techniques that guided, and the results that emerged from, the present effort to develop alternative solutions.

This chapter states the objectives of the planning effort, explains and presents the standards that the study team consistently applied during its investigations, and recounts the methods that the team employed. Subsequent chapters lay out in some detail the alternatives that survived what was essentially a winnowing process.

A. Study Objectives

To turn the built-in drawbacks of Baltimore's railways into inherent advantages, the study team adopted the following objectives:

1. **Make the service quality and capability of the system, both as a whole and in its important parts, no worse than it is today.**

   Beyond doing no harm:

2. **Remove all through freight service from the Howard Street Tunnel.**
3. **Provide high-cube, double-stack clearance routes through Baltimore for both NS and CSXT freight trains.**
4. **Provide grades for freight trains that are less than those now encountered—preferably much less.**
5. **Provide a replacement for the B&P Tunnel.**
6. **Increase speeds for both passenger and freight trains wherever economically feasible.**
7. **Provide capacity to support traffic levels for freight, intercity passenger and commuter services based on reasonable projections for the year 2050, for each existing and projected route—while making every effort to reduce the future cost of providing still more capacity, should traffic grow beyond the design level.**
8. **Maintain access to all freight and passenger yards, port facilities, maintenance facilities, as well as CSXT Camden and Amtrak Pennsylvania Stations.**
9. **Provide for CSXT and NS intra-terminal moves in Baltimore.**
10. **Identify any relatively near-term improvements that could benefit users while long-term projects are progressed.**

Such near-term improvements would, if implemented, foster capital and operating cost-effectiveness; minimize disruptions to the regional transportation system; and maximize use of the region's existing and committed transportation infrastructure.

11. Avoid, minimize, and/or mitigate any significant adverse environmental impacts caused by Corridor improvements.

Any restructuring projects will necessarily—

- Comply with all applicable local, State, and Federal standards and/or procedures such as those for air quality, noise, surface and ground water quality, storm water management, ecosystems, environmental justice, energy consumption, hazardous materials, and river navigation; and

- Minimize community disruption, displacements, and relocations; as well as adverse impacts to public parks, historic resources, and visual resources and aesthetics resulting from mobility improvements in the Corridor.

12. In making changes to accomplish all the above objectives, assure that railway operating expenses in the study area will not increase on a unit basis—and will, preferably, decrease.[1]

B. Standards for the Development and Evaluation of Alternatives

To fulfill the objectives laid out above, each alternative would need to meet or exceed core design and performance standards. While subject to elaboration and revision, these standards allowed the study team to develop the initial set of alternatives for presentation and evaluation.

1. Different Needs for Freight and Passenger Service

Standards for Baltimore alternatives differ for passenger and freight service because the needs of the two types of transportation diverge. The divergence becomes apparent in Table 5 - 1, particularly with respect to gradient, clearances, and the desirability of passing through Pennsylvania Station. While one percent and two percent grade limits may appear very similar (as they are separated by a single percentage point), in railway engineering terms the difference is huge. Similarly, while reliability and uninterrupted train movements are aims common to both freight and passenger service, travel time in the NEC's city- pair markets—for example, through Baltimore itself—is the prime factor for passenger operations. For freight traffic, however, the elimination of circuity and the achievement of consistent, reduced transit times on a national scale (at least, for each carrier involved) constitute the prime ends. While faster freight train transit times within Baltimore would, of course, help the freight carriers, improved clearances and geometric layouts would have an even greater impact on the routing possibilities for modern freight cars and on operating economy. Thus the priorities of freight

[1] This objective is listed here for the sake of completeness and as an expression of the study team's intention. Detailed analysis of operating expenses and the effects thereon of various alternatives, fell outside the scope of this study but would necessarily be part of future development, if any, of the alternatives. By way of example: this study does not address the terms or prices of trackage rights under the various alternatives, which will be subject to negotiation among the project partners.

and passenger service differ markedly—so much so that the creation of separate freight and passenger pathways may well provide the optimal solution to the Baltimore challenge. This is all the more true because the minimal capacity requirement—two freight and two passenger tracks—already implies the installation of between two and four tunnel tubes. If separate tubes are necessary, their designs can vary to follow their divergent functions and purposes.

Although this dichotomy of needs has always prevailed, only since the mid-20th Century—with the replacement of two parallel, competing, all-purpose railroads with an intercity passenger railroad (Amtrak's NEC), a commuter agency (MARC), and two Class I freight railroads (CSXT and NS), the latter of which enters the region over trackage rights—has the institutional structure so changed as to allow comprehensive solutions to emerge, in which separate, dedicated facilities for freight and passenger service may be contemplated.

2. Summary of initial standards

Table 5 - 1 summarizes the initial standards that the study team applied in developing and screening alternative scenarios for resolving the Baltimore challenge. Selected topics of special interest in the table are discussed in the following section.

Table 5 - 1: Initial Standards for Development and Evaluation of Alternatives

Criterion	Freight		Passenger	
	Comments	**Initial Standard**	**Comments**	**Initial Standard**
Main priority	The freight carriers wish to optimize flows on their networks. Efficient routings with unrestricted clearances through Baltimore are key.	Nationwide transit times, elimination of circuity, flexibility of operation. (Local flows within Baltimore region are definitely of concern as well.)	NEC's needs are paramount for Amtrak; efficiency and reliability of commuter operations are critical to MARC.	Transit times internal to the NEC, and to Baltimore in particular.
Grades	CSXT's maximum grade north and south of Baltimore is less than 1.0 percent.	1.0 percent maximum (0.8 percent desirable maximum)	The ruling grade on the NEC is 1.9 percent in the New York tunnels. (Grades are less injurious to relatively light, amply-powered passenger trains than to freights.)	2.0 percent
Curves	Curvature must be considered in conjunction with grades. CSXT's 10-degree curve north of Howard Street Tunnel and the NEC's sharp curves in the B&P Tunnel impact speeds and make train handling difficult.	Reduce curvature, below its present excessive levels, to allow maximum design speeds (below). NOTE: some of the alternatives impose speed restrictions due to curvature that require careful review given the long life of these improvements.	Curvature in B&P Tunnel adversely impacts through train speeds	Reduce curvature and improve geometry of high-speed paths, to allow maximum design speeds (below).

Criterion	Freight		Passenger	
	Comments	**Initial Standard**	**Comments**	**Initial Standard**
Maximum Design Speeds[2] (between Gunpowder River and Halethorpe)		60 mph (intermodal trains) 55 mph (merchandise freight trains) NOTE: some of the alternatives impose speed restrictions due to curvature that require careful review given the long life of these improvements.	Between Bay View Yard and B&P Tunnel area	125 mph
			North of Bay View and south of the B&P Tunnel area (per Amtrak proposal).[3]	150 mph
Clearances	Need to accommodate the largest freight cars, such as high-cube double stack container cars and tri-level auto racks, neither of which can now pass through the Baltimore tunnels.	Establish Plate H in double-track freight service through Baltimore. To benefit most traffic flows, this will require improvement in Washington D.C.'s Virginia Avenue Tunnel, as well as investigation and correction of all undue clearance restrictions (e.g., overhead bridges) in the study area.	Only passenger clearances (equal to or better than those in New York Tunnels) are required, unless interoperability of the freight and passenger services through each other's facility is desired and is feasible and cost-effective.[4]	

[2] The actual design speed contemplated for each location will depend upon the projected speeds resulting from braking or accelerating at stations or other constraining points. For example, a northbound Amtrak intercity train ideally could enter the south end of an alternative alignment to the B&P Tunnel at maximum authorized speed (MAS) but immediately begin to brake for the station stop; the curves in the tunnel would be designed to permit operation at the maximum braking or accelerating speed.

[3] The cost-effectiveness of expanding the NEC mileage subject to a 150 mph top speed limit has yet to be determined. Use of this theoretical 150 mph top speed in this report does not imply FRA endorsement of such an expansion.

[4] The issue of interoperability, its feasibility and its costs, including (among other issues) those of electrification, connectivity with Pennsylvania Station, the range of conditions in which sharing of facilities would occur, and what to do about freight trains negotiating steeper passenger grades, would need to be explored in any follow-up analyses.

Criterion	Freight		Passenger	
	Comments	**Initial Standard**	**Comments**	**Initial Standard**
Capacity	Capacity must be available to reliably accommodate current and future through, terminating, and originating services, in both north-south and east-west traffic lanes,[5] as well as all local services.	Provide a double-track main line freight route allowing for the most demanding clearances, with multiple tracks and other facilities where necessary to accommodate various types of freight service and yard operations.	Capacity must be available to reliably accommodate current and future services on existing routes. (Any potential new routes[6] were not part of this study.)	Provide at least a double-track main line passenger route with multiple tracks where necessary to accommodate various types of passenger service.
Tunnels: Design life of structures	120 years			
Design life of key internal fittings[7]	50 years			
Fire, life safety concerns	See discussion below.			
Bridges	Drawbridges are obstacles to water and rail commerce and centers of excessive cost.	No drawbridges are to be added to Baltimore's rail infrastructure.	There are already too many drawbridges in the NEC.	No drawbridges are to be added to Baltimore's rail infrastructure.
Commuter routings	Does not apply.		No basic restructuring is contemplated. (Any possible future use of the Howard Street Tunnel is beyond the scope of this report.)	CSXT Baltimore-Washington service will continue to serve Camden Station. NEC Perryville–Pennsylvania Station–Washington service will continue to use the through passenger route and station.

[5] The terms "north-south" and "east-west" refer to national traffic patterns, not to the localized movements by means of which the railroads satisfy those national patterns. For example, NS traffic from the West approaches Baltimore from the northeast (compass direction), and a portion of CSXT traffic from western points passes through Washington and approaches Baltimore from the southwest (compass direction).

[6] I.e., any possible future commuter services on certain portions of the Baltimore rail freight network that are currently freight-only. No new routes for intercity passenger service are presently envisioned for the Baltimore region.

[7] I.e., those fittings requiring tunnel closure for renewal.

Criterion	Freight		Passenger	
	Comments	Initial Standard	Comments	Initial Standard
Motive power:	Status quo assumed to be maintained.	All service: Non-electric. (See footnote 4.)	Status quo assumed to be maintained.	All intercity service, and commuter service via "Penn Line": Electrified. (See footnote 4.) Commuter service via Camden line: Non-electric.
Through passenger station[8]	If interoperability is deemed a major requirement,[4] or if the optimal routing for freight makes use of the through passenger station location, then the track configuration at the through passenger station must provide for freight needs. (See discussion below.)		Explorations of realigning to other through passenger station locations revealed fatal flaws, e.g., capital costs many times higher than re-using Pennsylvania Station.	For through service: Serve Pennsylvania Station as a fixed point (see discussion below).
Freight yards–location, design, operating method	Some options may require modification of this standard. (See discussion below.)	Assume existing yards to be fixed in place. Track layouts should allow for through trains to set off or pick up cars without changing direction or backing up for a substantial distance ("progressive moves").	Does not apply	

3. Topics of particular interest

Certain topics in Table 5 - 1 merit expanded discussion, as follows.

a. Capacity

To be worthwhile, alternative scenarios must be capable of handling projected short- and long-term rail freight and passenger volumes from, to, and through the Baltimore region. These alternatives must overcome existing constraints while improving east-west and north-south train routes and simultaneously enhancing the ability of operators to serve local markets efficiently. The improved routes would upgrade clearances to handle oversize rail cars and furnish sufficient capacity to minimize the train delays that inconvenience freight customers, intercity travelers, and commuters.

[8] The use of Camden Station as a terminus for MARC's Baltimore-Washington commuter service via the Camden Line/CSXT is accepted as a given.

The routing solutions developed through the study effort would eliminate, or minimize the effect of bottlenecks on all types of freight and passenger service for all the carriers involved.

b. Facilities assumed immovable

Based largely on considerations of cost, safety, and the urgent need to maintain that continuity in all modes of transportation which is vital to the economic health of the Baltimore region, the study team assumed the following fixed points and constraints, and recognized a number of design challenges:

- Fixed points
  - — The port facilities in East and West Baltimore, either existing or proposed[9];
  - — The Baltimore Metro Subway Tunnel;
  - — The CSXT Capital and Old Main Line Subdivisions west of St. Denis;
  - — The CSXT Philadelphia Subdivision north of Bay View Yard;
  - — The NEC Main Line north of Bay View Yard; and
  - — The NEC Main Line south of West Baltimore Commuter Station.
  - — The location of the Central Light Rail Line main line and shops,[10] and the Jones Falls Expressway northwest of the existing Penn Station, adjacent to the former Northern Central Right-of-way.
- Constraints
  - — Maintain a maximum Fort McHenry channel depth of 50 feet (55 feet with an allowance for maintenance dredging).
  - — Cannot tunnel under the Fort McHenry (I-95) highway tunnel.
- Challenges
  - — The existing navigable streams and channels leading to the Patapsco River.
  - — Maintain an effective grade of one percent or less for tunnel approaches or relocated routes.
  - — Find environmentally acceptable routes through or around the city.

c. Pennsylvania Station

A prior chapter explained the PRR's decision to site its major passenger station north of the central business district (CBD) and adjacent to the Jones Falls and the Northern Central Railway. Although prior planning efforts[11] had viewed this location as immovable a priori,

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[9] This includes the existing railroad yards, branches, and industrial tracks serving the port facilities.
[10] Treating the Central Light Rail Line facilities as immovable adds greatly to the cost of the Belt Freight Alternative. Therefore, further studies may usefully examine the design and <u>total</u> cost implications of allowing changes these facilities.
[11] Specifically, planning for the NEC Improvement Project in the mid-to-late 1970s.

initial scenario development for this report disregarded any such restriction, for two reasons: (a) a station located in the heart of the CBD might theoretically be preferable; and (b) the current station location and orientation (at an approximate 90-degree angle to the desired flow of traffic), and the resultant difficult configuration of the tracks leading to it, result in a significant stretch of passenger train operations at speeds less than 110 mph (see Figure 3-18).[12]

Nevertheless, a review of station relocation options for intercity service concluded that a more central location would be prohibitively expensive. As Baltimore's ridges and valleys run north and south in the CBD area, any direct east-west route would necessarily run at cross purposes to the topography, thus occasioning monumental civil works—as already exemplified by the Orleans Street Viaduct. Such a project would inevitably involve very expensive tunneling under the CBD, its many historical landmarks, and its major commercial buildings. As a truly central station would require at least four tracks and probably more, an enormous and prohibitively expensive cavern would need to be dug out in the heart of Baltimore.[13] Other potential routings for passenger service (for instance, an underwater tunnel or a "beltway"-type route around the north) would entail exorbitant expense and would defeat the prime advantage of intercity rail service—its accessibility at the core of major cities. Finally, although fault can be found in Pennsylvania Station's location, it serves commercial and residential areas alike and affords easy access to major north-south arteries (Charles and St. Paul Streets and the Jones Falls Expressway); furthermore, it is at no greater a distance from its City's business center (about 15 blocks) than is 30th Street Station in Philadelphia or Union Station in Washington, D.C. For all these reasons, and in view of the relatively low cost of passenger alternatives that would preserve service via Pennsylvania Station, the study team by induction found that retention of the present location would make sense in any Baltimore restructuring. In effect, Pennsylvania Station became a fixed point as the study progressed, not beforehand.

For commuter service only, a vacated Howard Street Tunnel could imaginably afford options for some kind of through service with better downtown distribution than presently exists. Such options, their feasibility, and their concomitant requirements—a complex topic—fall outside the scope of this report, although their implementation might be integrated with that of any larger restructuring of Baltimore's railway facilities.

d. Freight train operations in Pennsylvania Station vicinity

The option of creating a freight route through Pennsylvania Station, which would require constructing a new freight tunnel and reconstructing the old Union Tunnel, was evaluated. The location of utilities under the tracks through the station and overhead bridge piers were physical constraints that were identified. Further studies, if any, would appropriately address the advisability of operating freight trains through Pennsylvania Station from all viewpoints—engineering, operational efficiency, and safety.

[12] A series of Trip Time Performance Calculator (TPC) runs would necessarily be performed to document the trip time impact of the slow speed running, should alternatives development be pursued.

[13] An above-ground "central" station in the Jones Falls Valley, oriented in an east-west direction, was also considered.

e. Freight yard locations and train movements

Existing CSXT and NS yards initially were assumed to be fixed locations. However, an initial analysis of Harbor tunnel options, and at least one northern route, revealed that maintaining access to the existing facilities, particularly CSXT's and NS's neighboring Bay View yards, may result in inefficient routing of trains. Further, the analysis of harbor tunnel options indicated that an extension of the Curtis Bay Branch, which presently ends at Curtis Bay Yard, would be required. Such an extension would require reconfiguration of yard tracks and the possible relocation of the Car Repair Shop. To assess the feasibility of providing better train routings in this wide range of options, a certain level of conceptual design of altered yard facilities was necessary.

Maintaining efficient and economical access to, and between, all existing freight yards was one of the primary objectives that ultimately eliminated many potential alternatives. For example, maintaining access for CSXT through freight trains that currently set off or pick up at Bay View also required that, upon completion of any Baltimore restructuring, freight trains should be able to set off or pick up at Bay View in a progressive move as they do today, if possible. The same criterion initially was applied to NS freight trains and the NS Bay View Yard, should NS ever run through freight traffic on the NEC. Ultimately, the criterion was downplayed as other criteria eliminated consideration of numerous alignment alternatives and it became evident that certain alignment alternatives that did not facilitate progressive moves offered other advantages.

f. Fire, life safety concerns

The security systems within all tunnel options would provide full fire and life safety features for the users of the tunnels and emergency crews. Items to be included include:

- Fire detection and alarms;
- Supervisory control and data acquisition for pumps, ventilation fans, lighting and emergency services;
- Security systems, such as CCTV and intrusion alarms;
- Access control; and
- Telephones.

Other systems and design considerations would provide:

- Emergency lighting,
- Pumping,
- Signage throughout the length of the tunnel,
- Walkways throughout the length of the tunnels to allow evacuation in the event of an accident; and
- Cross-passages at regular intervals along the length of the tunnels to connect the adjacent bores.

The ventilation system would:

- Ensure acceptable temperatures throughout the tunnel system to support the normal operations;
- Maintain pollutants to an acceptable level for train crews; and
- Control smoke and temperatures in the event of a fire within the tunnels.

These state-of-the-art standards for security, safety, fire, and ventilation systems would not only benefit all users and operators of the new tunnels but also avoid the heavy expense of post-construction retrofitting.

C. Methodology

The study team began its complex task by gathering and assessing background information on the development, current status, and future prospects of Baltimore's railway infrastructure (Chapters Two, Three, and Four). Based on engineering analyses and contacts with users and government officials, the team derived a set of characteristics that a meaningfully restructured network should possess (Section B of the present Chapter). After identifying and screening the general sectors through which improved passenger and freight routes might pass (Chapter 6), the team developed and evaluated a sufficient number of alternatives to assess the viability of each sector for each type of rail transportation. By an iterative process of elimination reflecting the desired system characteristics and associated engineering requirements, the team arrived at a relatively small number of promising illustrative alternatives, for each of which it prepared initial cost estimates (Chapters Seven, Eight, and Nine). Finally, a review of the work upon which this report is founded suggested some avenues of further study (also Chapter Nine) that would assist planners and policymakers in resolving the Baltimore challenge in a cost-effective manner, should they choose to pursue such a resolution.

The following sections describe these methodological steps in further detail.

1. Gather Fundamental Data

Through personal communications with experts and examination of key documents, the study team reviewed the current status of all rail lines in the study area[14] and their ability to safely and efficiently handle the present and future levels of rail services imposed by passenger and freight railroads. The initial review addressed both facilities and operating patterns. Box 5 - 1 lists the principal elements of the fixed plant that received scrutiny, and the universe of evaluative factors that might apply[15] to each element.

[14] Both existing and relevant abandoned facilities were considered. The degree of attention was roughly proportional to the facilities' proximity to and impact on the core of the study area in Baltimore City. Thus, the Virginia Avenue Tunnel in Washington, D.C., although important to obtaining the full benefit of any Baltimore-specific investment, was not reviewed and would need careful attention in any future investigations.

[15] The list does not claim to be exhaustive; a railway is a complex machine indeed. Also, the scope of the study did not permit all evaluative factors to be applied to all elements. Only the most important topics—those relevant to determining whether meaningful resolutions of the Baltimore challenge were potentially available, and in which general sectors—could qualify for attention in the present analysis.

Specialized documentation—base mapping and geological data—assisted the study team in developing concepts for passenger and freight alternatives in each sector under consideration.

a. Consultations and Documentation

Initial and follow-up consultations took place with appropriate staff members of the passenger and Class I freight railroads[16] and interested public transportation and planning agencies in the region. These contacts helped to identify the freight and passenger railroads' current and projected traffic levels and operations in the region, for traffic lanes through, from, to, and within Baltimore and its port.

The freight railroads provided essential track charts,[17] curve information, and some data on ongoing track maintenance and upgrading efforts. Amtrak, state and local agencies, and freight rail operators made available relevant maps and documents, including Valuation Maps and As-Built NECIP plans for review by the study team. The team also obtained and reviewed current information on use of the lines and pending plans for any betterments to the railroad system in the study region.

Limited on-site inspections occurred. The rail lines, particularly key locations, have been thoroughly documented with digital photographs.

Box 5 - 1: Main Components of Data Gathering

Fixed Plant Elements Considered	**Evaluative Factors (Not All Apply to All Elements)**
• Track	• Geometric design configuration
• Roadbed (ballast, subgrade)	◦ Location and accessibility
• Tunnels	◦ Grades
• Undergrade bridges	◦ Curvature
• Overhead bridges	◦ Clearances
• Other railroad structures	• Physical condition
• Signal and traffic control systems	• Speeds
• Electric traction systems	• Capacity
• Vehicle maintenance facilities (passenger and freight)[18]	• Routings
• Yards (passenger and freight) and their access	• Methods and measures of operation
• Passenger stations[18]	• Life-cycle costs (operating, capital)
• Port facilities and their access	
• Grade crossings	
• Maintenance-of-way bases	
• Recently-completed improvements (since 1992)	
• Short-term improvement project proposals	

[16] Any further development of options would require close and continuing coordination with the smaller railroads.
[17] A track chart is a scroll-like line diagram of a particular section of railroad, showing (among other items) each track, the degree of curvature and location of each curve, grades, stations, interlockings (see the Glossary at the end of this volume) and other details of the road's facilities and geometry.
[18] Identified but not inspected.

b. Base Mapping

Base mapping assisted in the delineation and evaluation of alternative routing concepts and the initial projection of their external impacts. The study team gathered geographic information system (GIS) data from sources including (but not limited to) the following:

- Baltimore City;
- U.S. Geological Survey (USGS);
- The FRA Maglev Deployment Program[19]; and
- The U.S. Army Corps of Engineers.

The data gathered have included:

- Maryland County Map information;
- Vector roadway data;
- Environmental resources (Wetlands; Floodplains; etc);
- Census data;
- Historic Resources data;
- USGS 7.5 minute Quadrangles and digital elevation models; and
- Aerial photography.

The base mapping for this study combined all these GIS data elements with the available railway-specific information. For example, railroad elevations, grades, and tunnels were entered into the system from track charts and related sources. The mapping and evaluation process enabled the study team to concentrate its efforts on alternatives that would respond to the project's goals and objectives while avoiding obvious "fatal flaws" in their design and external effects. The mapping effort also enabled team members to prepare detailed graphics of the alternatives.

c. Geological Data

Because any restructuring of the Baltimore rail network would inevitably involve major civil works including tunneling, geological information has assumed a special importance in this study. Accordingly, the following sources provided data for incorporation in the study's database:

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[19] The FRA Maglev Deployment Program, mandated under the TEA-21 transportation authorization, aims to demonstrate magnetic levitation technology in the United States in a relatively short (less that 50-mile) corridor. A number of corridor projects in several States have competed for available planning funds; a corridor between Baltimore (Camden Station vicinity), BWI Airport, and Washington—sponsored by the State of Maryland— has emerged as one of the leading contenders for implementation should Congress elect to provide additional funds. Current plans do not contemplate a direct intermodal connection at Pennsylvania Station, Baltimore, between the Baltimore/Washington Maglev project and the NEC through passenger service. There could, however, be design, construction, and other interactions in a number of locations in the Baltimore region if both the Maglev project and a Baltimore rail restructuring plan are implemented.

- Boring data collected in advance of Northeast Corridor Improvement Program (NECIP) investigations;
- Available borings from earlier NECIP investigations;
- Boring data from nearby Maryland State Highway Administration highway projects;
- Published geologic data for the project area; and
- Project data on file for earlier Baltimore projects.

2. Evaluate the Network's Current Status and Prospects

On the basis of the data thus gathered, the study team assessed the current status and prospects of Baltimore's railway network. The assessment necessarily considered not just historical conditions but also the very limited investments made by Amtrak, Maryland DOT, CSXT, and NS since 1992. Also taken into account were the current and projected service levels for intercity passenger, commuter, and freight operations. In conjunction with the track charts, the GIS data, and other resources, the traffic projections highlighted areas of concern with respect to operational capacity before, during, and after construction of the various alternatives.

With regard to the traffic projections:

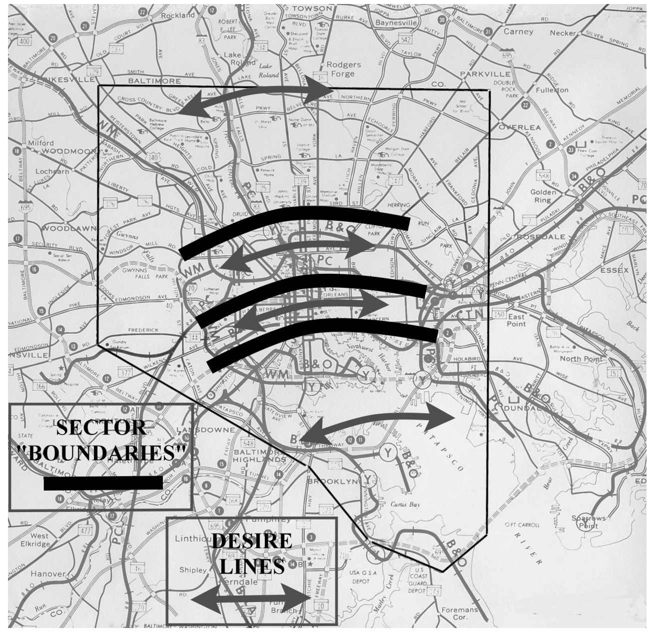
- Forecasts for both intercity and commuter train frequencies relied on schedules prepared in the late 1990s by the operating entities. Amtrak has a timetable for projected service in the year 2015, and MARC has done forecasts for 2020. Extrapolating from those carrier's horizon years, the study team developed train volumes for the year 2050.
- The scope of the study did not include detailed, computerized simulations of the projected operations on potential future infrastructures in the Baltimore region.[20] Accordingly, these forecasts served as inputs to the conceptual development of the alternatives, and for initial screening purposes.

The results of this evaluation appear in Chapters Two and Three above, and contribute to the findings that (a) improvement of the network is highly desirable and (b) meaningful improvements in operations would require separate, though highly coordinated, analysis and treatment of freight and passenger needs.

[20] Such detailed simulations will be essential to any detailed evaluation of alternatives; see Chapter 9.

3. Define "Sectors" for Initial Consideration

Figure 5 - 1: The Sector Concept



The prior chapters demonstrate how complex is the Baltimore challenge, with its many traffic types and service lanes. The freight operation, in particular, serves a host of shippers and commodity types on all sides of one of the East Coast's busiest ports; this intricate freight movement pattern involves short lines as well as the major national carriers. However, in its simplest terms, the main challenge devolves into a single question: how best to get the passenger and freight traffic from one side of Baltimore to the other? Addressing this underlying question, the study team noted that there were four broad, concentric arcs in which improvement alternatives might be sited to satisfy the inherent desire line of traffic (roughly southwest to northeast). These broad arcs are termed "sectors" in this report (Figure 5 - 1).

The study team then subjected the sectors to an initial screen based on common sense, in order to eliminate beforehand alternatives that would be frivolous. For example, the sector at the top of the map—many miles removed from the center of Baltimore—could not house passenger "service" worthy of the name and was eliminated accordingly. Most of the sectors, however, offered some advantage for either passenger or freight operations or both, and underwent further analysis.

4. Develop Potential Alternatives Within Each Sector

Once identified, the likely sectors were examined to develop a broad range of alternative solutions, all of which involved tunnels. This analysis considered all the GIS and geological data amassed earlier in the study, as well as the operational advantages and drawbacks of each alignment with respect to passenger and freight transportation. Also considered were concepts suggested in 20th Century studies of the same challenge.[21] The search for alternatives took into account all relevant prior reports and selective site visits—for example, inspections of alternative passenger station locations.

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[21] Baltimore's railway difficulties emerged almost as soon as the network was completed (before 1900), and studies—never implemented—began forthwith. The effect of subsequent growth in the Baltimore and Washington metropolitan regions militates against the early-20th Century design concepts created by the PRR and the B&O in their desperation to modernize, expedite, and economize on their Baltimore operations. The NECIP in the 1970s and 1980s also devoted planning resources to this issue, but budgetary limitations forbade any but short-term improvements.

5. Screen the Alternatives

The alternatives went through extensive screening both by the study team and by officials of participating organizations. Engineering judgment, railway operating experience, and familiarity with the study region influenced both the initial conceptualization and the ongoing, iterative review of the alternatives. In addition, a formalized screening and comparison of alternatives took place along the following lines:

- Functional/design screening: An evaluation of the railway design features, the operational benefits and liabilities, and potential construction staging problems of each alternative; and
- External impact screening: A preliminary effort to identify potential environmental and societal concerns of each route.

Alternatives passing the functional/design screening were then subjected to the external impact screening, as described below.

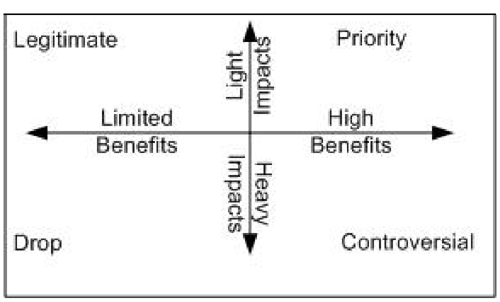
Not all criteria applied to all alternatives; the Harbor Sector options, for instance, faced some different tests than options in other Sectors.

a. Functional/Design Screening Criteria

Functional/design screening was intended to identify and winnow out alternatives that would have very large negative impacts and that would do little to improve passenger and freight transportation through the Baltimore region. Functional design screening also allowed the detailed evaluation and discussion to focus on the most important and controversial remaining alternatives. The process enabled a preliminary analysis of alternatives by characterizing them according to the quadrants illustrated in Figure 5 - 2.

The primary determinants in winnowing the alternatives were:

Figure 5 - 2: Screening Concept



- The availability of land to utilize for the tunnel approaches;
- The requirement to—
  - — Establish and maintain a maximum one percent gradient; and
  - — Safely and economically construct beneath either the Fort McHenry or Baltimore Harbor Tunnel (Harbor Sector tunnels only);
- The length and alignment of a tunnel[22]

[22] The analysis assumed that any tunnel in the Harbor Sector would be constructed employing the immersed-tube technique. The construction of the tunnel would require dredging and deep excavations in soils ranging from very soft organic, clays, and estuarine silts to stiff over-consolidated cretaceous clays of the Potomac Group.
The analysis also assumed that the appropriate technique, whether it be the use of a TBM or mining, would be used to construct any land-based tunnel(s).

to connect the two potential portals,—particularly if the alignment would be constructed for a significant length beneath the Fort McHenry channel;

- The ease of integration of the train operations on the new alignment with:
  - — The existing rail network; and
  - — The existing freight and passenger yards and terminals.

For each alternative, the functional/design screening assumed that any significant adverse environmental impacts could be mitigated and that such implementation issues as legislative needs, jurisdictional questions, and public controversies could be addressed. These criteria properly belong to the next level of screening: for external impacts.

b. External Impact Screening Criteria

After functional/design screening had winnowed out the least productive alternatives, the remaining alternatives were evaluated for their external impacts. The following topics were addressed:

- Potential consistency with existing land uses[23];
- Potential extent of acquisitions, displacements, and relocations;
- Potential to impact resources listed on or eligible for listing on the National or State Register of Historic Places;
- Potential to impact parklands and 4(f)/6(f) resources;
- Construction impact severity and duration;
- Potential impacts to ecosystems and water resources; and
- Any identifiable implementation issues that are likely to inhere in each alternative, based on engineering judgment.[24]

6. Conduct Additional Analyses

Within each Sector and for each type of service, only a limited number of alternatives passed, without any fatal flaws, both the functional/design and external impact screens. The study team subjected an illustrative set of the surviving alternatives to some additional analyses:

- Conceptual engineering at a scale of 1'=400", including plan and profile drawings of the proposed route(s) and connections to existing lines and facilities;
- Initial analyses of critical system components and implementation methods, including—

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[23] Consistency with likely future land uses would need to be researched and estimated in any future studies that might build upon this report.

[24] Any of the Baltimore alternatives would be of such a size as to necessitate a formal public participation process, with intensive involvement of all involved governments. All implementation issues would thus be fully aired; but that is for the future, if any such project is progressed.

- — Turnout sizes to be installed in interlockings and at the intersection of line segments;
- — Signal system requirements;
- — Temporary facilities required during construction (track, station platforms, signals, electric traction systems, etc.); and
- — Construction techniques and any specialized equipment;

- Performance of a minimal number of train performance calculator (TPC) runs to compare the expected train operating characteristics of the restructuring alternatives with the existing routes;
- Identification of any betterments near the outer limits of the study area that would be required to support the contemplated Baltimore improvements and capitalize on the efficient through movement of people and goods; and
- A summary level operational analysis.

The study team then prepared initial cost estimates of a limited number of alternatives on the basis of unit cost methods and appropriate contingencies. Although these cost estimates must be regarded as very preliminary, they provide planners and policymakers with a contemporary overview of the potential cost of meeting the Baltimore challenge. They also provide an order-of-magnitude comparison of the relative costs by sector, and in so doing, suggest priority topics for possible future analysis.[25]

7. Identify Directions for Any Future Work

Finally, whether one year or 100 years from now, the study team believes that policymakers, planners, and transportation operators will wish to revisit the Baltimore challenge—if only because a late-19th Century infrastructure (particularly a substandard one) will not last indefinitely, nor can it possibly keep place forever with the growth of industrial commerce and travel in the busy NEC megalopolis. Whatever the timing or motivation for further analysis, certain predictable topics—left untouched or only partially explored in this study[26]—will require work. To assist future planners, the study team has developed a listing of the most critical areas for further exploration (see Chapter 9).

[25] An example is the large cost differential between the Penn Freight and Belt Freight alternatives; the latter is over $0.4 billion, or 50 percent, higher than the former. The sizes of this differential suggests an eventual rethinking of the assumption that the Central Light Rail Line facilities cannot be moved—an assumption that contributes to the Belt Freight option's relatively high total cost.

[26] See Chapter I for a discussion of the scope and resources of the present study.

Chapter Six
CONCEPTUAL FRAMEWORK FOR THE ALTERNATIVES

This chapter presents a conceptual framework for the development of passenger and freight railway restructuring alternatives for the Baltimore region. Chapters Seven and Eight then go on to describe and evaluate the passenger and freight alternatives, respectively.

In theory, at least, rail passenger and freight traffic can cross the Baltimore region in one of four Sectors, as shown in Figure 6 - 1 and described below.

A. Description

The Sectors run roughly southwest to northeast, which is not only the general tendency of the traffic lanes but also a product of topography. Except within the Jones Falls Valley,[1] a radial climb from the Inner Harbor into the Piedmont produces nearly-impossible grades. (The basic problem with the CSXT's Belt Line is that it attempts such a radial climb across the grain of the Sectors—and pays a price, with its 1.87 percent compensated grade[2] between Mount Royal Station and Huntingdon Avenue.)

In brief, the Sectors are:

- **Far North Sector.** Serving as a kind of railroad "beltway," an alternative using this Sector would avoid the central areas of Baltimore City entirely.
- **Near North Sector.** This Sector lies just north of the CBD and currently houses Amtrak's NEC and the easterly portion of the CSXT's main line.
- **Central Sector.** This Sector would cross the CBD proper. As explained in Chapter Two, the natural route through Baltimore—abutting the Inner Harbor near Pratt and Lombard Streets—lies in this Sector but was never a possibility as development in that precise area antedated the invention of the railroad.
- **Harbor Sector.** Because the Harbor is extensive and complex, with multiple inlets and points on both sides, many alternatives are hypothetically possible in this Sector.

B. Evaluation of the Sectors

Based on all the considerations described in prior chapters, the study team considered the feasibility of using each of the four Sectors to improve the movement of passenger and freight trains, respectively, through Baltimore. Table 6 - 1 summarizes the findings of this initial analysis, which are described below.

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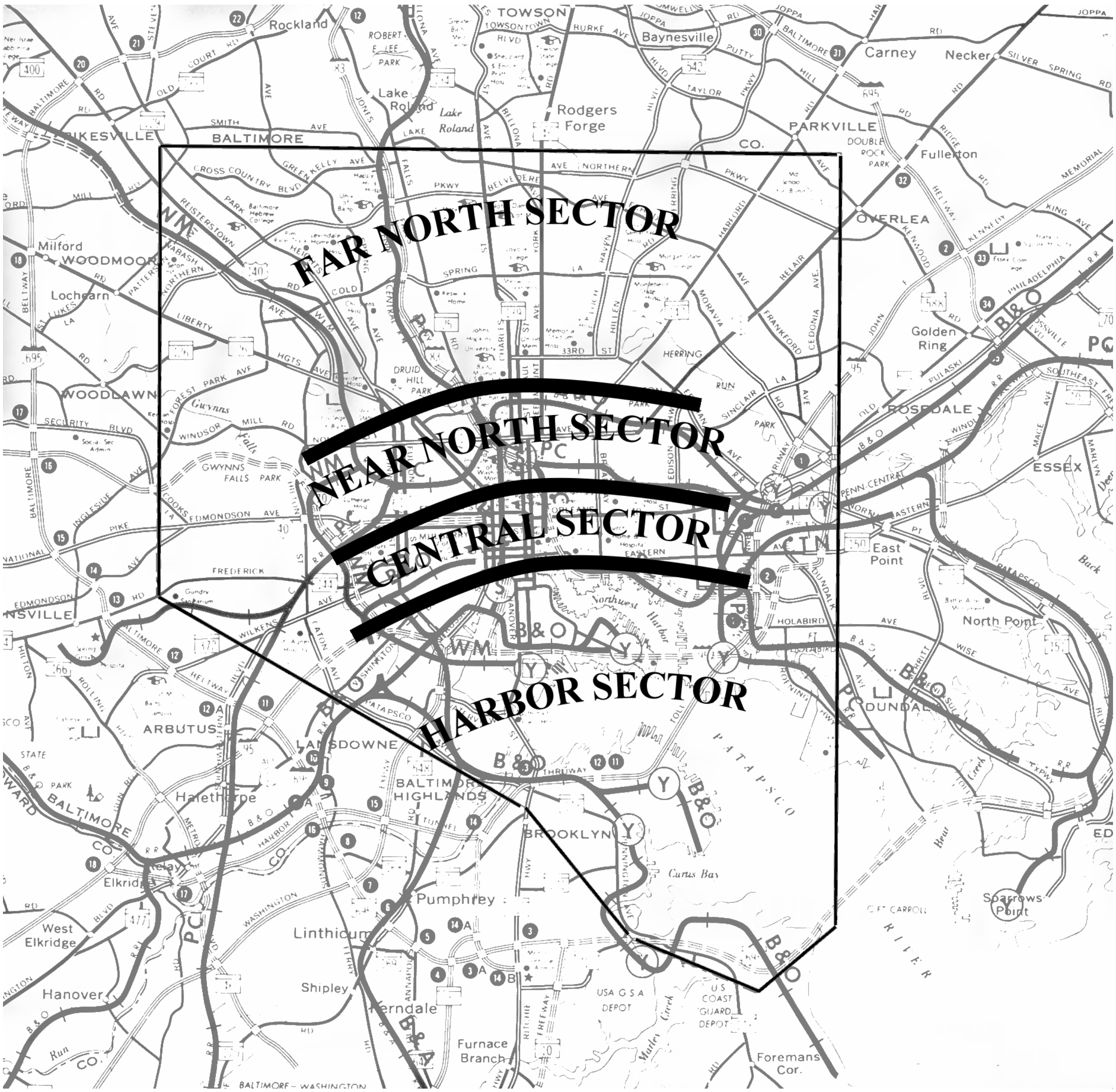
[1] The Valley is at a 90-degree angle to the direction of traffic—not much use for the purposes aimed at in this Report.

[2] 1.55 percent uncompensated grade on an 8 degree curve, 1.55 + (.04 x 8) = 1.87.

Figure 6 - 1: The Sectors[3]



[3] The Sector map is overlaid on the a map prepared in 1974 by the Cartographic Division of the Maryland State Highway Administration (SHA) entitled "State of Maryland Railway Network, 1974," © 1974 SHA. Used by permission.

Table 6 - 1: Initial Evaluation of Sectors for Passenger and Freight Service

Sector	Passenger	Freight
Far North	Does not serve Central Baltimore	Crosses built-up areas, grades likely to be heavy, lacks connectivity with existing network and yards
Near North	Possible	Possible
Central	Likely excessively expensive, but possible; more central station location for businesses	Too expensive, grade problems, and no need for freight to be in CBD
Harbor	Expensive and no closer to CBD than present station	Possible

Legend:	***May meet all initial standards***	***Has obvious difficulties***	***Ruled out at outset***

1. **Far North**

The Far North Sector would not provide a solution for passenger traffic. It would not only add to the NEC's distance but also eliminate center-city service, perhaps the foremost inherent advantage of high-speed rail. For freight service, initial studies suggest that a far northern route would cut a swath through built-up areas (Towson, for example), encounter challenging grades in crossing Piedmont hills and valleys, and be far removed from existing freight facilities and shippers. Although studied seriously by the former PRR and B&O in the early 20th Century, alternatives through the Far North Sector are unrealistic today and merit no further consideration.

2. **Near North**

The nexus of Baltimore's transportation system lies at the intersection of the CSXT, the NEC, the Northern Central Railway (right-of-way, Light Rail Line, and support facilities), the Jones Falls Expressway, North Avenue, and the north-south arterials (Howard Street, Maryland Avenue, Charles Street, and St. Paul Street).[4] Clearly, long experience has shown the Near North Sector to be an attractive site for transportation facilities and flows. Whether, with all these facilities already extant, crammed into close quarters, and occupying horizontal and vertical space, this Sector offers opportunities for meaningful improvement in the rail passenger and freight infrastructure, is examined further below.

[4] Also nearby, about one mile to the west, is Baltimore's Metro subway along Pennsylvania Avenue, which has a bearing on the design of Near North Sector alternatives.

3. Central

Involving tunneling under the very heart of Baltimore's business district, this Sector would inevitably prove to be very expensive and replete with engineering and environmental complexities. Although, as discussed above, passenger service might benefit from a more central location, the requirements for a CBD station—probably involving the digging of a cavern some 125-175 feet wide and 1200-1500 feet long beneath the built-up city core—would entail a very heavy expenditure. Despite the cost and in view of the marketing considerations, passenger alternatives utilizing this sector receive treatment later in this section.

Freight service has no need to be in the heart of the City and incur the associated expense. Therefore, no particular justification exists for considering the Central Sector for freight.

4. Harbor

For passenger service, an underwater tunnel would imply a relocated station south of the CBD. The precise location would depend on tunnel alignment possibilities; in the best case, the new station might lie at roughly the same distance from Charles Center (to the south) as that of Pennsylvania Station (to the north). While many other factors than distance must enter into any comparison of station locations, a Harbor Sector passenger route cannot be ruled out on the issue of station siting alone.

Freight service could potentially benefit from a Harbor Sector location. Indeed, the Study Team analyzed many alternatives to determine their operational implications and an order of magnitude of their costs.

C. Initial Findings

The initial review of passenger and freight improvements in the four identified sectors—

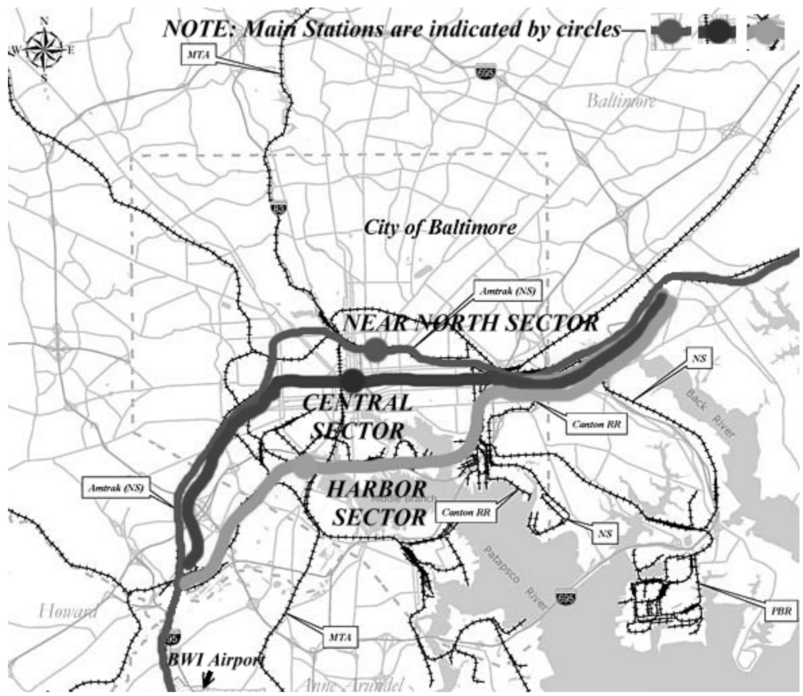
- Eliminated further consideration of passenger service in the Far North Sector and freight service in the Far North and Central Sectors;
- Indicated, pending further engineering work, the potential for meaningful passenger and freight betterments in the Near North Sector, and for meaningful freight betterments in the Harbor Sector; and
- Was inconclusive regarding the feasibility and utility of passenger improvements in the Central and Harbor Sectors, although the analysis did identify special challenges to passenger solutions in those Sectors.

The following Chapters describe the range of passenger and freight alternatives in the combinations of services and Sectors that remained after the initial findings summarized above.

Chapter Seven
PASSENGER ALTERNATIVES

Three of the Sectors could at least theoretically accommodate a restructured passenger route through Baltimore: the Near North, Central, and Harbor. Guiding the creation of alternatives (including the search for potential tunnel portals and approaches to them) was the requirement to access the existing Pennsylvania Station—or another main station location no farther than Pennsylvania Station from the CBD—while efficiently connecting to the NEC south and north of Baltimore. The design of passenger alternatives also took into account the need to minimize conflicts between intercity passenger, commuter, and freight trains, and to provide sufficient capacity for the expected types and volumes of traffic. In this regard, the lack of expansion-room adjacent to certain branch or main lines influenced the design of the alternatives.

Figure 7 - 1:
Generalized Passenger Alignments and Main Stations



The study team found that use of the Near North sector would involve retention of Pennsylvania Station; that the Central Sector would imply a station in or near the Route 40 corridor; and that the Harbor Sector could include a station just southwest of the Inner Harbor. The generalized passenger alignments and station locations in each Sector appear in Figure 7 - 1.

The following sections describe and evaluate the detailed passenger alternatives examined in the course of the study. These are summarized in Table 7 - 1.

A. Near North Sector—Passenger Alternatives

All passenger alternatives in the Near North Sector would make use of the existing trackage from Bay Interlocking (at the NS Bay View Yard), through the Union Tunnels and Pennsylvania Station, to a new tunnel with a northeastern[1] portal in the Jones Falls Valley and a

[1] Directions in this chapter follow the compass direction of the traffic lanes, which generally run southwest to northeast through the Baltimore region. Because the network is convoluted and circuitous, neither the railroad

Table 7 - 1: Passenger Alternatives by Sector								
Sector	**Alternatives Considered**	**Station Location**		**Location of Tunnel and Approaches by Alternative**				
		Pennsylvania	**Other**	**Southwestern Approach**	**Southwest Portal**	**Northeast Portal**	**Northeastern Approach**	
Far North								
Near North	**Existing B&P Tunnel**	•		BWI to Bolton Hill/ Druid Hill Park area	Gilmor Street	Jones Falls	From NEC via Union Tunnels and Pennsylvania Station	
	Presstman Street —PRR Alignment	•		BWI to Bolton Hill/ Druid Hill Park area	Presstman Street	Jones Falls just northwest of existing B&P portal	From NEC via Union Tunnels and Pennsylvania Station	
	Presstman Street —Modified Alignment	•		BWI to Bolton Hill/ Druid Hill Park area	Presstman Street	Jones Falls just northwest of existing B&P portal	From NEC via Union Tunnels and Pennsylvania Station	
	Great Circle Passenger Tunnel	•		BWI to Bolton Hill/ Druid Hill Park area	A location just north of existing B&P portal	Jones Falls just northwest of existing B&P portal	From NEC via Union Tunnels and Pennsylvania Station	
Central	**Route 40 Alternative (Franklin/Mulberry/ Orleans Streets)**		•	BWI to West Baltimore	West end of the CBD, just west of IRS Building and Martin Luther King, Jr., Boulevard	Kresson Street south of Route 40, west of NEC Main Line near NS Bay View Yard	From NEC to Kresson Street	
Harbor	**Locust Point Passenger Alternative (Locust Point–Canton)**		•	BWI to Herbert Run to Locust Point (generally following CSXT)	Locust Point	Canton	NEC to Canton via old PRR alignment	

southwestern portal in the vicinity of Bolton Hill, south of Druid Hill Park. Most options (of course, excepting reuse of the double-track B&P Tunnel) would utilize two single-track passenger tunnels, an assumption that could change as and if design work progresses.

The Near North passenger alternatives are as follows:

- Employ the existing or parallel alignments:
  - — Enhance the existing B&P Tunnel; or
  - — Utilize the Presstman Street tunnel design and right-of-way inherited from the PRR (Presstman Street—PRR Alignment); or

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direction nor the compass direction at precise points adequately takes into account the underlying desire lines of the passenger traffic and freight shipments.

— Modify the Presstman Street alignment (Presstman Street—Modified Alignment); or

- Employ a "Great Circle" alignment north of Presstman Street ("Great Circle Passenger Tunnel")[2]

Each of these choices is discussed below in turn.

1. Existing and parallel alignments

In the late 1970s, the Northeast Corridor Improvement Project (NECIP) intended to make major B&P Tunnel improvements that would include decreasing tunnel leakage, rebuilding the drainage system, lowering the concrete invert of the tunnel to provide clearance for freight cars, and installing a new track system. Early in the NECIP planning effort it became evident that delays in service might be necessary during renovation and that an improved B&P Tunnel would not provide sufficient capacity for projected traffic. Therefore, the studies were expanded to include evaluation of a possible new Presstman Street tunnel to be used, in various configurations along with the existing tunnel, to provide capacity for reliable movement of future passenger and freight train volumes.[3] The new tunnel would have followed an alignment along the west side of Presstman Street about 1,200 feet northwest of and parallel to the existing Wilson Street tunnel. (The Presstman Street right-of-way was obtained by the Pennsylvania Railroad in 1931 for a new tunnel planned at that time.) The NECIP studies yielded a number of alternatives that proved useful in the present analysis and are described below.

a. Existing B&P Tunnel, Upgraded

All analyses of the B&P Tunnel, from the NECIP to the present, indicate that its betterment would not be an effective, much less cost-effective, approach to the Baltimore challenge.

(1) NECIP analyses

The NECIP team evaluated construction alternatives that would enable the existing tunnel invert to be lowered one track at a time, with the second track remaining in service during construction. Existing subsurface data, supplanted by additional borings and the installation of piezometers, were utilized.

The tunnel was inspected and evaluated between 1976 and 1978 by Amtrak and NECIP personnel. In summary, the tunnel arch was found to contain many areas of seepage, particularly between John Street and Pennsylvania Avenue. Water also was discharging from weep holes in the tunnel sides although many of the weep holes appeared to have become clogged. Seepage near the crown of the tunnel was often above the adjacent ground water level and appeared to be from other sources. Brick courses were found to have been removed at a few locations and anchor bolts added to permit clearance for freight cars.

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[2] All these alignments were treated in the NECIP. The "Great Circle" route was conceived under the NECIP but extensively elaborated for this study.

[3] At the time of the NECIP studies in the late 1970s, there still remained an important freight service on the NEC and the concept of tunnels segregated by function rather than by corporate ownership had not yet crystallized.

Drainage through the tunnel consisted of pipe drains below the center of each track. The pipes were clogged in some areas resulting in standing water or flow above the pipe to the next inlet. In other areas, the pipe was broken out leaving a trench. At that time, Amtrak's crews were in the process of performing temporary track repair to correct an uneven track condition that was very evident in some areas as trains passed through the tunnel.

The geotechnical investigations defined subsurface conditions generally surrounding the existing Wilson Street tunnel and determined the thickness and strength of the concrete invert and sidewalls of the tunnel at several locations. Some of the more pertinent conclusions reached by the NECIP team included the following:

1. The existing ground water table dropped 10 to 20 feet near this tunnel from its general surrounding levels, reflecting drainage through the tunnel walls. Sealing of the tunnel walls would raise water levels and increase tunnel loading. This was considered undesirable as the original tunnel was designed with a ballast invert and was not intended to be waterproof.
2. Leakage above the springline originated above the ground water table and very likely was coming from leaking utility lines.
3. Drainage along the invert was very poor. An improved drainage system design was needed.
4. The practical limit for lowering top of rail in the B&P as the method for obtaining additional clearance [would be] approximately 44". If a section requires greater interior dimensions, beyond that obtained by maximum rail lowering, the walls should be widened *by open cut methods.* [Emphasis added to underline environmental challenges].
5. Lowering of the tunnel invert by about three feet *would probably require blasting of rock for a length equivalent to four or five city blocks* in the northern portion of the tunnel. Alternative construction methods were evaluated and it was concluded that lowering of the invert three feet, while maintaining train traffic on one track, would be very expensive.[4] [Emphasis added to underline environmental challenges.]

Ultimately, the NECIP—short of funds but long on mandates for speedy service improvement—concentrated its resources on other system components and locations, and limited its work in the B&P Tunnel to minor repair of the tunnel lining, drainage improvements, and installation of a new improved track system after tunnel invert was replaced.[5] While benefiting

[4] A June 1977 NECIP report concluded that the “practical limit for lowering top of rail in the B&P as the method for obtaining additional clearance was approximately 44". If a section requires greater interior dimensions, beyond that obtained by maximum rail lowering, the walls should be widened by open cut methods”.

[5] The contract to rehabilitate the tunnel invert and install a new track structure, one track at a time, was completed in 1982 and was deemed one of the NECIP’s successes. See U.S. Department of Transportation, *Northeast Corridor: Achievement and Potential,* January 1986, pp. 2-19 and 2-20.

passenger safety, ride quality, and reliability in the short term, these improvements did nothing to effect a permanent improvement in passenger service capacity, travel times, or viability.[6]

(2) Recent B&P Evaluations

Since the NECIP B&P Tunnel Rehabilitation Project was completed, Amtrak has continued to have the responsibility for upkeep of the tunnel. Recent evaluations have concluded that the B&P tunnel should be replaced within 20 years as the existing tunnel is increasingly difficult and expensive to maintain.

For example, a recently completed Mid-Atlantic Rail Operations Study report[7] had the following summary; although emphasizing freight movement, it is relevant to this section:

"The Baltimore passenger station has the Union Tunnels to the north and the B&P Tunnel to the south. The Union Tunnels (actually two tunnels side by side) are approximately ¾-mile long, and consist of three tracks. Clearances through them are restricted to a maximum height of 17 feet 9 inches. The B&P Tunnel is nearly two miles long, was constructed in the 1870s. The B&P Tunnel consists of a two-track brick arch design built in three separate sections. In the [early 1980s], the invert (floor) was lowered and stabilized after structural problems nearly shut down the bore. Despite this work, the B&P Tunnel does not have clearance for cars greater than Plate E (15 feet 9 inches). The tunnel has [severe] curves, heavy grades and a constant water problem. The repairs [completed in 1982] were intended only as an interim design (30 to 50 years) and ultimately, this tunnel will need to be replaced. The present clearance through the entire route is restricted by the smaller B&P clearance, and the clearances through both tunnels preclude freight railroads from operating excess dimension car designs, including double-stack cars (maximum 20 feet 2 ins.) through the tunnels. This project consists of re-boring and rehabilitation of the tunnels to eliminate their continuing deterioration of the tunnels and increase their ability to handle modern railcar equipment. The order of magnitude of the cost of this project is estimated to be *$100 million in near term for design, with an additional $900 million in medium term for construction*. Benefit to be derived from this project is the elimination of deteriorating conditions and restrictions on the size of railcar traffic over the NEC through Baltimore."[8] [Emphasis added, regarding costs to rebuild the B&P Tunnel in place.]

(3) Observations Based on the Present Study

Upgrading the B&P Tunnel would contradict the fundamentals of engineering economy. As prior chapters amply demonstrate, the tunnel's basic geometry was substandard when it was

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[6] The tunnel invert, in addition, was not materially lowered and through freight services (then under Conrail's direction, and in the process of disappearing from the NEC) derived no clearance benefit.

[7] According to the Executive Summary of the *Interim Benefits Assessment* (I-95 Corridor Coalition, February 2004): "The Mid-Atlantic Rail Operations Study (MAROps) is a joint initiative of the I-95 Corridor Coalition, five member states (New Jersey, Pennsylvania, Delaware, Maryland and Virginia), and three railroads (Amtrak, CSX, and Norfolk Southern). The Federal Railroad Administration (FRA) and Federal Highway Administration (FHWA) participate as advisors. Over a two-year period, the MAROps participants crafted a 20-year, $6.2 billion program of rail improvements aimed at improving north-south rail transportation for both passengers and freight in the Mid-Atlantic region and helping reduce truck traffic on the region's overburdened highway system."

[8] I-95 Coalition, *MAROps Final Report*, 2002, Appendix I.

completed, and is irremediable by any reasonable amount of rehabilitation—whether for passenger or freight service. What's more, the B&P upgrading cost suggested by the MAROps study ($1 billion) would likely exceed that of a brand-new, much improved facility achieved by deep-bore tunneling. Neither expediting passenger nor enhancing freight service, the B&P Tunnel alternative deserves no further consideration in this study.

b. Presstman Street—PRR Alignment

The PRR in the early 1930s selected Presstman Street as a possible location for a new tunnel roughly parallel to the B&P (Figure 7 - 2). Twenty-seven borings were drilled then, of which the records included only generalized soil and rock types. Therefore, the NECIP study made six additional borings in 1977. The geotechnical investigations defined subsurface conditions for the completion of a preliminary study of the alignment.

Based on the geological sections thus developed, the study concluded that the original PRR proposal for the new tunnel along Presstman Street had the following advantages:

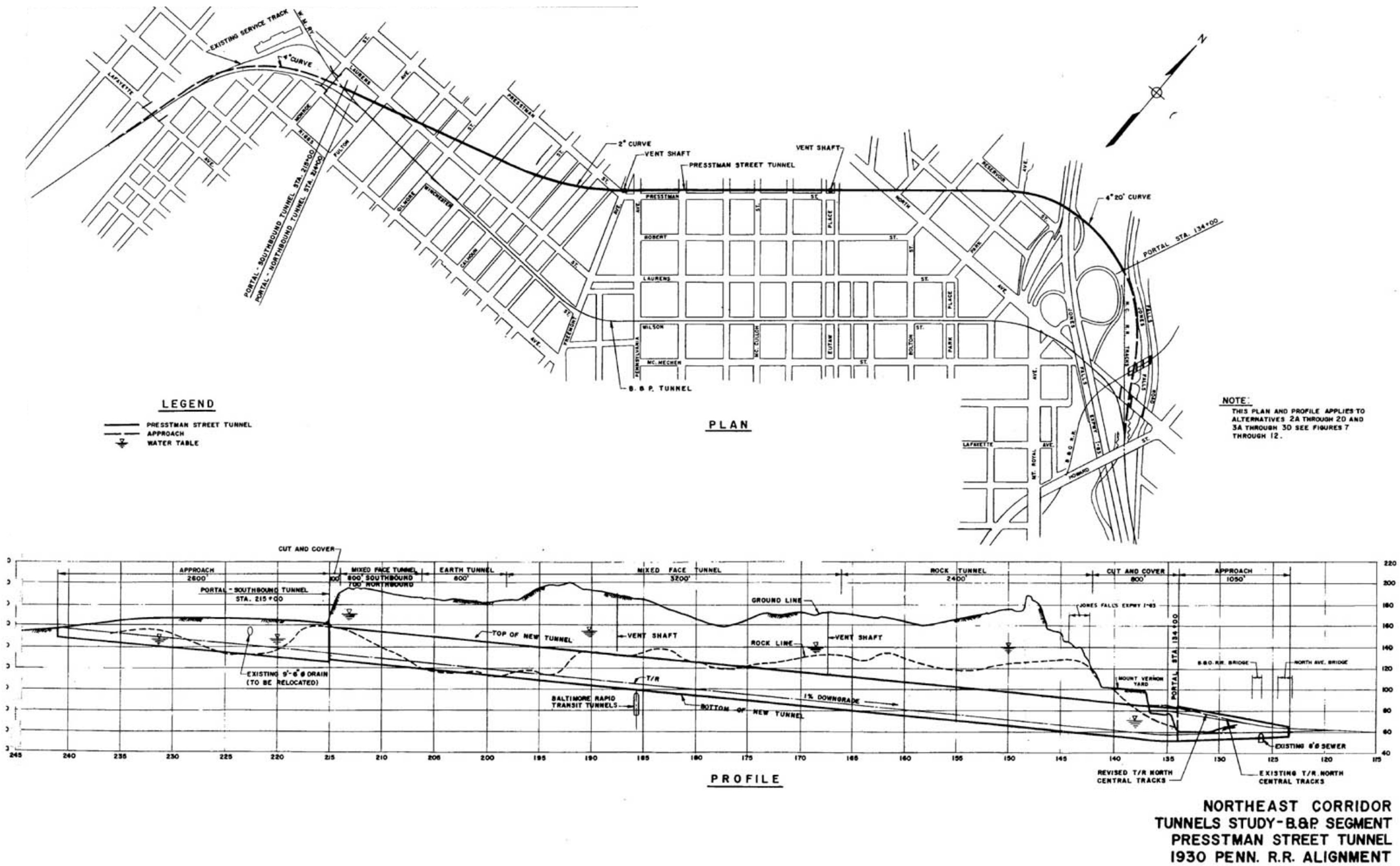
- The tunnel would have a uniform vertical compensated grade of 1 percent, which was a significant improvement over the existing B&P Tunnel (1.5 percent compensated[9]);
- The tunnel would be relatively short; and
- Most of the tunneling right-of-way along this alignment already had been acquired and had passed to Amtrak with its acquisition of the NEC.

The original PRR Presstman Street proposal was determined to have the following disadvantages:

- Construction of the Baltimore Rapid Transit Tunnels (since completed) immediately below this alignment could open joints in the rock above, increasing the tendency for costly overbreak when the railroad tunnels are excavated. Even though the transit tunnels were reportedly being designed to take into account this future tunnel loading, special precautions would be necessary during construction to—
  - — Limit blasting;
  - — Avoid concentrated temporary supports above the transit tunnels; and
  - — Maintain and possibly reinforce the rock on either side and between the underlying tunnels.
- Due to the position of the top of the rock along this alignment, a mixed face (soil and rock) tunneling procedure would be involved, and therefore result in a high cost of excavation.
- Dewatering would be difficult, and expensive, due to the location of the proposed tunnel mostly beneath existing buildings and the presence of porous soils close to and above the crown of the tunnel.
- Due to the shallow depth of the proposed tunnel, most of the buildings may have to be evacuated during construction, as a precautionary measure.

[9]Maximum grade of 1.34 percent uncompensated, with a four-degree curve; 1.34 + (4 x 0.04) = 1.5 percent.

Figure 7 - 2: Presstman Street —PRR Alignment



- Possible costly damage to some of the buildings along tunnel alignment.
- Extra cost of noise and vibration attenuation from trains at this shallow depth below buildings.

c. Presstman Street—Modified Alignment

In an effort to eliminate most of the disadvantages encountered by the PRR's Presstman Street Alternative, three additional alternatives—located below the Baltimore Rapid Transit Tunnels on Pennsylvania Avenue—underwent scrutiny. These alternatives consisted of varying tunnel slopes and tunnel lengths and included the flattening of horizontal curves as necessary.

Advantages of these alternatives included:

- A considerable increase in the length of rock tunnel with a resulting decrease in mixed face tunnel and a significant decrease in the tunneling cost.
- The possible use of a Tunnel Boring Machine (TBM), which would have reduced the construction time and construction costs.
- A substantial reduction of the environmental impact of the tunnel and tunnel construction.
- The work would have been accomplished in an area where, with some exceptions, the tunneling right-of-way was generally already acquired.

Disadvantages of these alternatives were:

- The first alternative required steep grades west of Pennsylvania Avenue.
- The second and third alternatives required longer tunnels and the lowering of the western approach to the tunnel on the NEC main line, which might have affected crossing roadways.
- A new tunnel may disturb the Baltimore Metro tunnels above.

From the geotechnical point of view, these alternatives appeared to be more desirable than the PRR Presstman Street Alternative. However, from a passenger service viewpoint, the four-degree curves in any of the Presstman Street alternatives—although much gentler than the 7-degree, 30-minute curve in today's B&P—would still hamper the speed of trains through Baltimore. At the high price entailed by any of these parallel B&P/Presstman Street tunnels,—all of which would require conventional instead of the cheaper deep-bore construction methods, and all of which would heavily impact the affected neighborhoods at least during the construction process,—a more satisfactory travel time payoff should be expected.

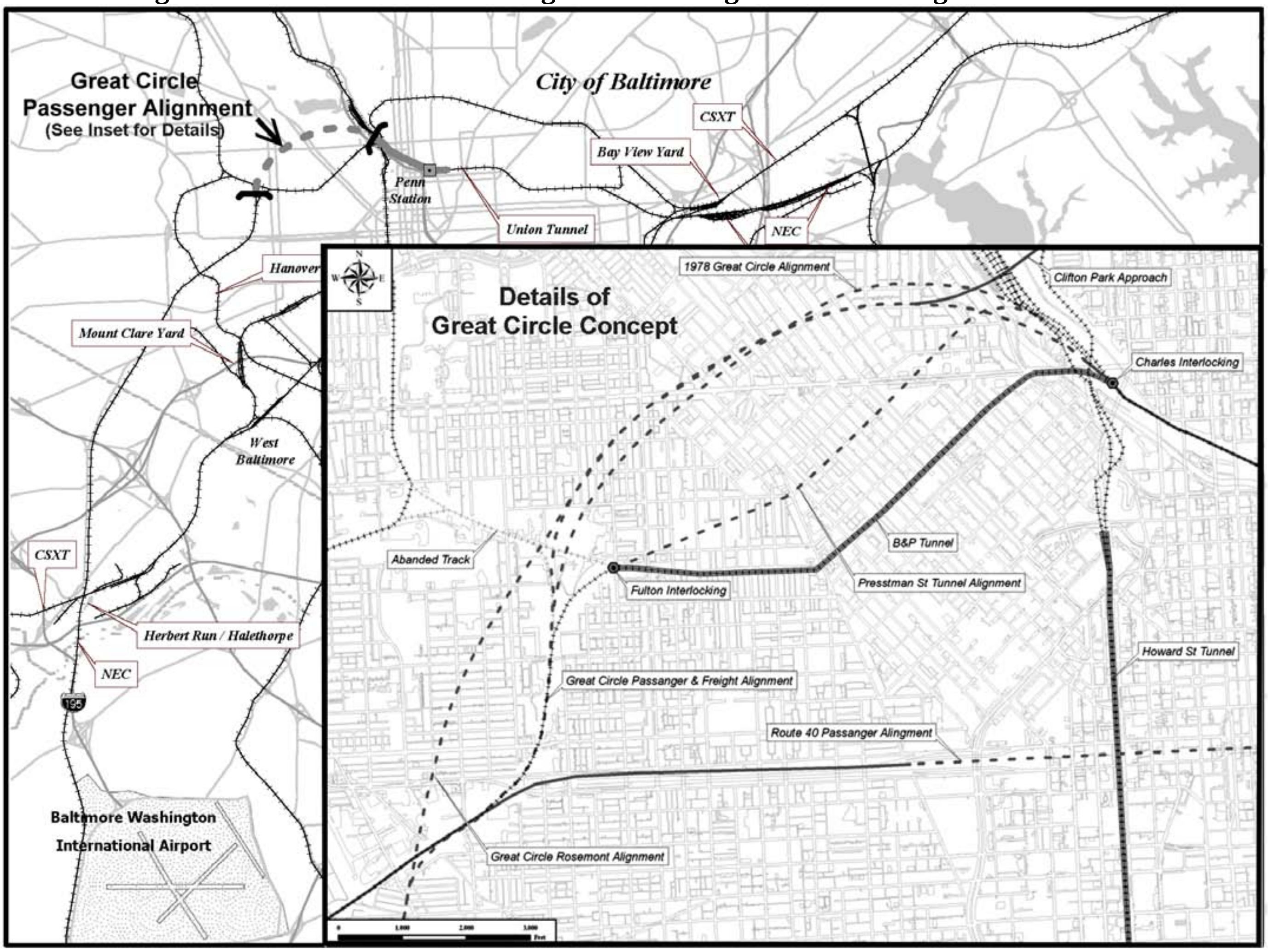
2. Great Circle Passenger Tunnel[10]

The Great Circle Passenger Tunnel (GCPT) alternative would replace the existing B&P Tunnel on an alignment ranging up to some 3,600 feet north of the present tunnel. This

[10] The Great Circle alignment was originally proposed by Mueser Rutledge Consulting Engineers (then known as Mueser, Rutledge, Johnston & DeSimone), working for the NEC Improvement Program, in March 1977.

alignment would have improved geometry for passenger service, would reduce trip times entering and leaving Baltimore Pennsylvania Station, and would retain the existing Union Tunnels and the alignment northward from the Union Tunnels to Bay Interlocking.

Figure 7 - 3: Great Circle Passenger Tunnel Alignment in Its Regional Context



a. General Description

With portals not far removed from those of the B&P Tunnel, the GCPT would follow a large arc north of the existing and Presstman alignments (Figure 7 - 3). By providing a gradual curvature permitting higher train speeds, the alignment would have a continually changing direction, which would minimize the possibility of encountering a weak shear zone.

The route retains the present NEC alignment south of Fulton (MP 97.7) through the West Baltimore MARC station. The route at the northeast end of the GCPT reconnects to the NEC at Charles (MP 95.9). The platforms at Pennsylvania Station would not be modified; however, the track alignment between Charles and Paul (MP 95.2) could optionally be reconfigured to enable train speeds to be increased on the approaches to the platforms.[11] Reconfiguration of the Pennsylvania Station tracks and platforms, especially if the Penn Freight alternative[12] is selected, would likely reduce the storage space available to MARC trains in the station, for which substitute facilities would be needed.[13]

The present NEC alignment between Paul and Bay (MP 91.9) would or would not be modified, depending upon the determination of the location of the freight alternative. The selection, side by side with the GCPT, of the Penn Freight alternative, would require a modification of the NEC between Broadway and Edison Highway to accommodate two freight tracks and two passenger tracks. The selection of any of the other freight alternatives would not modify the NEC between Paul and Bay.

b. Advantages of the GCPT

The Great Circle alignment would have a number of advantages. First, trains would be operated at much greater speeds than through the other two alignments. Initial train performance analyses have concluded that the Great Circle alternative, albeit longer than the extant route, would save about two minutes in comparison with the B&P alignment.[14] Second, and much more importantly, the Great Circle route follows the ridgeline so the tunnel can be deeper below the surface, in rock strata that would reduce construction costs by enabling a tunnel-boring machine (TBM) to be used.

c. Challenges Inherent in the GCPT

Unfortunately, a uniform grade cannot be obtained between the north and south GCPT portals because the profile must go under the Metro Subway near the intersection of Pennsylvania and North Avenues. The elevation of the bottom of the Metro subway at that important intersection is about 120 feet. Therefore, to pass under the subway, the elevation of the tracks of the Great Circle tunnel must be less than 85 feet. The highest elevation on Amtrak south of the B&P tunnel is about 168 feet near La Fayette Street, which is near the location of the current Bridge Interlocking (MP 98.2). The preliminary conceptual design indicates that the elevation could be lowered to elevation 162 feet at the La Fayette Street Bridge. The distance between La Fayette Street and the subway is about 5,250 feet and the conceptual design indicates that a descending grade of 1.75 percent would achieve a top of rail of about 78 feet beneath the tunnel.

The selection of the 1.75 percent, rather than the minimum 1.48-percent grade,[15] is the result of the initial design of the passenger tunnel to be constructible with the Great Circle Freight Tunnel (GCFT), discussed below. This design requires the passenger tunnel to pass over

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[11] This option is not reflected in any trip time estimates reported in this section for the GCPT.

[12] Chapter 8 defines the "Penn Freight" and "Belt Freight" alternatives.

[13] The location of any alternate MARC storage was beyond the cope of present analysis. See Chapter 9, "Analytical Paths."

[14] It would thus reduce Amtrak's Washington–New York travel time by about one percent, and the Baltimore-Washington travel time by about six percent. (Times are for Acela Express.)

[15] The minimum grade is that which could be achieved by a passenger train tunnel alignment if there were no requirement to interface with a freight train tunnel.

the freight tunnel at a location approximately 1,350 feet north of the Metro Subway. The elevation of the roof of the tunnel at that location (essentially under McCulloh Street) is about elevation 56. The other option is to pass over the subway at a top of rail elevation of 155 to 160 feet, then descend to a top of rail elevation of about 55 feet beneath the access ramp to the North Avenue light rail station. The distance is about 5,950 feet. Going under the subway is preferable because it would be a deeper tunnel, constructed in better quality rock.

A schematic of the GCPT in conjunction with the GCFT appears in the section treating the latter.

3. Evaluation of Near North Passenger Alternatives

A major restoration of the existing B&P Tunnel, carried on under traffic, would entail a huge expense—about $1 billion according to the MAROps study—merely to preserve the existing capabilities of the NEC. No geometric characteristics of the tunnel would be altered—its seven degree, 30 minute and four degree curves would remain in place. As this option, studied in depth during the NECIP, would lead to no improvement beyond the safety benefit of restoring the tunnel, it constitutes a kind of "status quo" alternative that does not respond to the goals and objectives of the study. If, however, a more comprehensive restructuring is not initiated, then the B&P alternative will ultimately be necessary—at a potentially higher cost than the Great Circle route.

A Presstman Street tunnel, whether on the PRR or a modified alignment, would almost exactly parallel the existing B&P, would echo its debilities in attenuated form, and would do little to expedite passenger service. On the other hand, as a soft-earth tunnel close to the surface, a Presstman Street project would have heavy neighborhood impacts and excessive costs in comparison with deep-rock tunneling by means of a TBM. Thus, there is no apparent advantage to a Presstman Street routing in 2005, much as it may have appealed to the PRR's world-class engineers in 1931 with the technology, cost structure, and environmental laxness then prevailing.

Finally, a Great Circle Passenger Tunnel would significantly ease the curvature and raise the speed limits on the NEC's approach to Baltimore from the south.[16] Utilizing TBM technology in the deep rock, it could be constructed (as will be shown in Chapter 9) at relatively reasonable cost and, because of its depth, with much less risk of impact to the fully built-up neighborhoods above.

Therefore, from among the Near North Sector passenger alternatives, this study chose only the GCPT alignment for further analysis and screening, of which Table 7 - 2 summarizes the results.

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[16] For reasons described elsewhere in this report, a GCPT alignment would involve a continued routing of passenger trains through the existing Pennsylvania Station

Table 7 - 2: Application of Screening Criteria to Illustrative Near North Passenger Alternative

Functional/Design Screening Criteria	Great Circle Passenger Tunnel
Availability of Land	Likely
Less than One Percent Grade Freight; Two Percent Passenger	Likely
Beneath Harbor Highway Tunnel	No
Tunnel Length > 4 miles	Unlikely
Ease of Integration with Network	Good
Ease of Integration with Yards	Good
Pass/Fail	***Pass***
Adverse Environmental Impact	
Implementation Issues	

External Impact Screening Criteria	Great Circle Passenger Tunnel
Consistent with Existing Land Use	Likely
Extent of Acquisitions, Displacements, and Relocations	Low
Impact Listed or Eligible National or State Historic Place	No
Impact Parklands, 4(f)/6(f) Resources	No
Construction Impact Severity	Pass
Impact Ecosystems, water resources	Low
Implementation Issues	
Pass/Fail	***Pass***
Issues to be Addressed Next Phase / Comment (in ())	

B. Central Sector—Passenger Alternatives

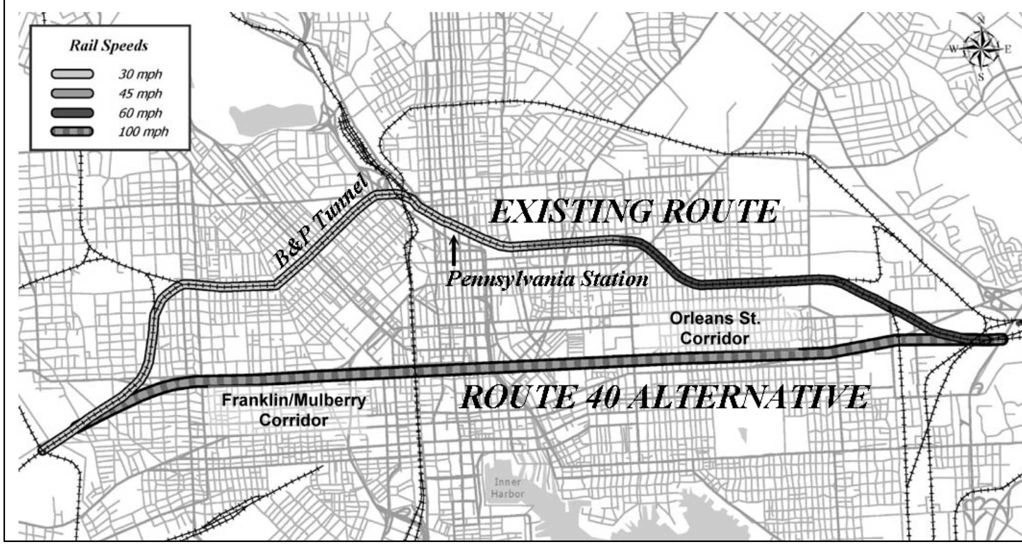
Hypothetically, the most obvious and direct route for a passenger alternative in the Central Sector would make use of a broad public right-of-way in the U.S. Route 40 corridor from the NEC at West Baltimore station, to the vicinity of Martin Luther King Boulevard, thence due east in a tunnel under the CBD to a connection with the NEC near Bay Interlocking. Termed in this report the “Route 40 Alternative,” this route illustrates the challenges and costs of a Central Sector passenger solution. Other CBD-based passenger alternatives, posited further below, might ultimately merit closer examination should a Central Sector passenger solution be deemed advisable and affordable.

1. Overview and Performance Effects of a Route 40 Alternative

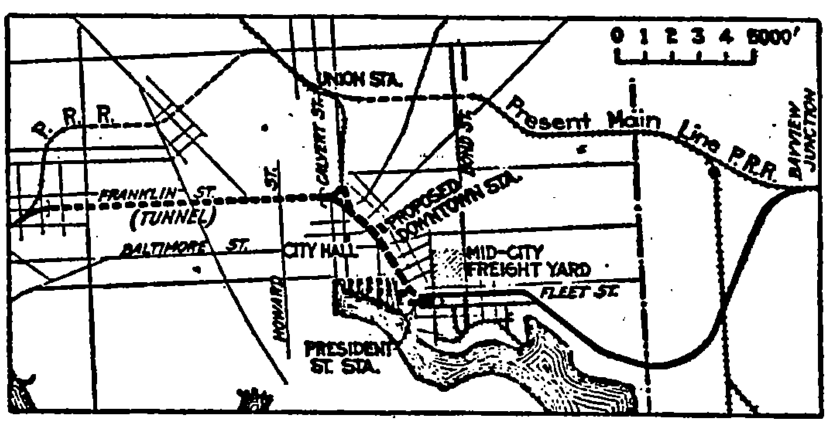
Figure 7 - 4 compares the location and speeds of the present B&P route with an illustrative alignment for a Route 40 alternative. By replacing tortuous curves with a nearly straight line, such a Central Sector solution would markedly outperform the existing route,

without a doubt.[17] The potential reduction in running time for express intercity passenger service remains to be calculated as it would depend on the station location, the alignment of its approaches, its track layout, and the resultant train braking and acceleration patterns; at a minimum, the alignment would allow the relatively high speeds northeast of Bay to be extended southwestwardly into the tunnel. If significant time savings are found, they might impact demand and revenue levels for Amtrak's high-speed services between Washington, Baltimore, Philadelphia, and New York, and perhaps affect the economics of the Route 40 alternative vis-à-vis those in the Near North and Harbor sectors. Whether those economic effects would appreciably counterbalance the higher cost of the Route 40 alternative is unknown.

Figure 7 - 4:
Central Sector, Route 40 Alternative and Existing Route Compared



[17] Interestingly, recent research indicates that PRR and city officials in 1917 were discussing a route (at that time proposed for freight service only) that would have used the west end of the present-day Route 40 corridor to City Hall and thence to President Street. "Pennsylvania Changes at Baltimore Under Discussion Again," *Engineering News Record,* Vol. 78, No. 5, May 3, 1917, pp. 252 ff. The route is shown below:



CITY OFFICIAL PROPOSES SEPARATE FREIGHT TUNNEL

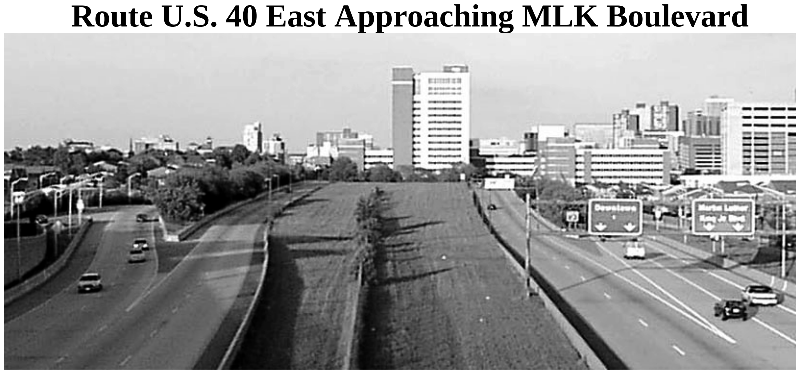
2. Detailed Description of a Route 40 Alternative

This alternative would consist of three main segments (proceeding in a northeastwardly direction): the NEC to Martin Luther King, Jr. (MLK) Boulevard; MLK Boulevard to the Jones Falls Valley; and the Valley to the NEC near Bay Interlocking. These segments are addressed sequentially.

a. NEC to MLK Boulevard

Figure 7 - 5: U.S. 40 East of NEC in West Baltimore

Figure 7 - 6: Route U.S. 40 East Approaching MLK Boulevard



An initial analysis of the Central Sector indicated that there was an isolated segment of the former I-70 corridor, now Route U.S. 40 (Figure 22), between the current MARC West Baltimore Station and MLK Boulevard, approximately 7,000 feet long. (Figure 7 - 5.) The corridor is located between Mulberry Street, on the south, and Franklin Street, on the north. All of the property between Mulberry and Franklin Streets was taken for what had been intended to be a portion of I-70, but after considerable controversy and public participation, the Franklin-Mulberry segment was never connected to Exit 94 of I-70 on the west side of Leakin Park, at the city line.[18] The possibility of placing the rail alignment in this broad corridor was evaluated from an engineering viewpoint; the rail right-of-way potentially would

[18] According to one source, "I-70 was supposed to end at I-95 just east of Caton Ave. (Exit 50). I-70 through Baltimore City was killed due to community concern about its course through Leakin Park and along the Gwynns Falls… The section completed along the Franklin-Mulberry corridor…was redesignated US 40 in 1989. I-70 now ends at a park and ride at the city line."(http://www.mdroads.com/routes/ is070.html.) The project, and the community impacts that actually occurred before it was stopped (demolishments included a school, 971 houses and 62 businesses), raised such intense and lasting feelings in the community that as late as 1997, the Mayor of Baltimore was proposing to restore the neighborhood by eliminating the orphaned freeway section that was actually constructed. (*Baltimore Sun,* April 23, 1997.)

replace one of the two-lane roadways, since space was provided in the median for a future light rail line.

Near the West Baltimore Station, Franklin and Mulberry Streets descend westward to pass under the NEC. To the east, the “orphaned” freeway right-of-way ends at MLK Boulevard (Figure 7 - 6), an urban arterial ring road that connects I-395 and the Baltimore-Washington Parkway, on the south side, with I-83, the Jones Falls Expressway (JFX), on the north, channeling north/south traffic around the CBD.

b. MLK Boulevard to the Jones Falls Valley

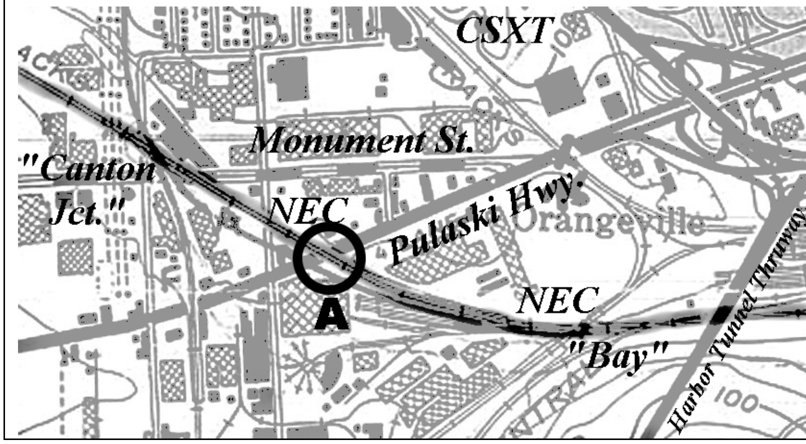
The CBD is at a higher elevation than the alignment of Route 40 to the eastward towards Orleans Street and westward towards the NEC. Approaching downtown from the west, the alignment would go into a tunnel that would have to pass under the central Enoch Pratt Free Library; the Basilica of the Assumption (the oldest Roman Catholic Cathedral in the United States); the Metro Tunnel; and the Howard Street Tunnel. The latter two are at a relatively high elevation, and initially it appears that the alignment would be well below them. Most of the tunnel alignment would be in mixed ground (soils and rock). Due to the sensitivity of the historic structures above, expensive low impact tunneling techniques would have to be implemented. Potentially, the alignment could be diverted to one side or the other, running under either Franklin or Mulberry Streets; this would lengthen the tunnel and might require an unacceptable gradient leaving/accessing the NEC.

The relatively deep Jones Falls Valley is located east of St. Paul Street, where Franklin and Mulberry Streets merge to become Orleans Street, which crosses the valley on a viaduct. The railroad alignment would emerge at, or above ground level in the valley. This would be a potential station site. Such a station would be located about four blocks north of City Hall and about six blocks north of the financial district. At this point there is good access to the JFX, which runs north to the Baltimore Beltway (I-695), allowing easy access to all points on the north side of the city. I-83 continues northward to York and Harrisburg, Pennsylvania, where it merges with I-81. I-83 also runs southward for a short distance, where it then connects with several major east-west arterials, some of which lead to I-395. The Jones Falls Valley in this location, which was a rail yard for both the Western Maryland (WM) and Northern Central (NC) railways, contains a significant amount of vacant land. A large portion of the land currently is used for surface parking. Some marginal industrial activity would need to be relocated; the effects on the street grid would need to be addressed in any further design work for this alternative.

c. From the Jones Falls Valley to a Junction with NEC near Bay

For illustrative purposes, the alignment was assumed to run northeastward under Orleans Street and Pulaski Highway to Point A in Figure 7 - 7**,** where Pulaski passes beneath the NEC, midway between Canton Junction and Bay. East of the viaduct over the JFX, Orleans Street is 10+ lanes wide as far as Broadway, where it narrows to 4 to 6. This would be the most difficult part to plan, design, and construct, in terms of community issues, due to the proximity of residences.

Figure 7 - 7:
Site of Potential Junction, Route 40 Alternative with NEC



A connection to the NEC between Bay and Canton Junction might prove suitable. The NEC descends on a 0.5-percent grade while turning its compass direction from southeast to east at MP 92.42, where Pulaski Highway passes under it while veering slightly toward the northeast as it heads away from downtown Baltimore. Conceptual engineering would be needed to determine whether the Route 40 Alternative would ramp directly up from under Pulaski into the NEC, or whether some other junction design would be optimal.

3. Other Central Sector Alternatives

To relocate the NEC main line to the Central Sector would mean choosing a new main passenger station location. Any decision to abandon the present station and move rail passenger service closer to the CBD would require not just an engineering investigation of potential sites, but—even more to the point—a careful marketing and demand analysis of the workplaces, residences, and travel habits of actual and prospective station users, both commuter and intercity. The dynamics of and factors in their modal choice decisions must come under careful scrutiny. It is by no means certain, for example, that the origins and destinations of a majority of present and likely future users of Pennsylvania Station (in both intercity and commuter service) would be closer and more accessible to a downtown station than to the current one. On the other hand, a more central station might induce completely new travel demands and create perceptible shifts in modal shares that might outweigh any losses of current Pennsylvania Station users. Other important issues include the rail service goals and objectives of the various Metropolitan Planning Organizations, transportation agencies, and rail operators in the Baltimore and Washington metropolitan areas, as well as the economic and development impacts on the neighborhoods affected by such a change of venue.

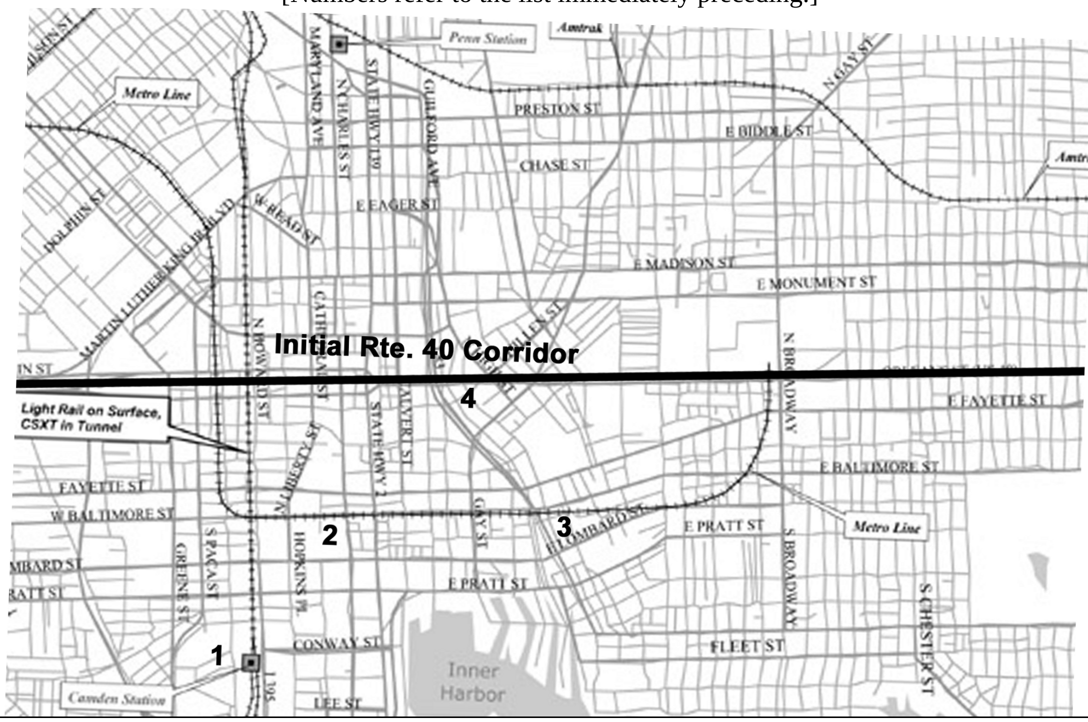
All these complexities—while essential to the station location issue—fall outside the scope of this engineering report. In evaluating the Central Sector for passenger service, the study team satisfied itself with identifying a number of potential station sites, the existence of which would be the most critical element to be considered in the evaluation of potential alternative alignments. As shown in Figure 7 - 8 (in which the numbers are cross-referenced to the following list), the envisioned sites were:

1. Near the original CSXT Camden Station;

2. Adjacent to Charles Center Metro Station;
3. Adjacent to, or near, the Market Place Subway Station; and
4. The Jones Falls Valley station site, described earlier.

Figure 7 - 8: Alternate Station Sites, Central Sector

[Numbers refer to the list immediately preceding.]



Identification of possible alignments to serve the first three sites, and of concepts for the layout of all four stations, fell outside the scope of this report (see Chapter 9). Still, certain probabilities and issues came to light as the array of sites was scrutinized:

- The downtown station most likely would be underground, beneath the most densely developed part of Baltimore City, thus making it more expensive to construct. One preliminary reckoning is that such a station would need to be 125 to 175 feet wide and 1200 to 1500 feet long—a veritable cavern. Such a project would raise both environmental and cost concerns.
- The potential site mentioned in the discussion of the Jones Falls Valley Alternative (number 4 on the sketch), although above ground, would have no existing rail transit access and would be in a warehouse-type area north and slightly east of the financial district. While precise distances and accessibility issues cannot be known unless and until the station concept were to be better developed, a careful comparison of access, egress, and marketability would need to be made with the existing Pennsylvania Station.
- The new site would require commuters, living in the northern neighborhoods of Baltimore but working in Washington, to access a station deeper into the city than is presently the case. Transit availability, traffic conditions, and parking adequacy and prices would likely become important concerns to that group of system users. If Penn

Station and the B&P tunnel are retained for commuter service, then, effectively, two passenger tunnels would have to be constructed (or rehabilitated), maintained, and operated.

- The Charles Center and Market Place Station locations would imply a Baltimore Street alignment. The Metro Subway is located under Baltimore Street between Howard Street and Central Avenue. The potential for utilization of this street for a rail passenger tunnel would be limited.
- Inspection of aerial photos of the Central Sector indicates that access to the alternative station sites (number 1, 2, and 3 on the map) from West Baltimore and at Bay would necessarily use more southerly, and more difficult, alignments than that conceived for the Route 40 Alternative.

4. Initial Overview Assessment of the Illustrative Central Sector Alternative

An initial overview assessment based on detailed local knowledge of the area and a review of available mapping and photography (including aerial photos) indicated that many stretches of the illustrative Route 40 alternative would not pass under or through adjoining residential neighborhoods. For example, there is nothing residential between MLK and Asquith, and very little residential development between Asquith and Rutland Avenue (east of Broadway). East of Highland Avenue, too, the development is industrial.

On the other hand, the Franklin/Mulberry Corridor in West Baltimore is populated, as is Orleans Street between Rutland and Highland Avenues. While these neighborhoods have always experienced a high level of traffic on Route 40, public reaction to adding railway construction and operation to the ambient noise and activity levels is unknowable at this time. However, the intense (and ultimately effective) public response to the I-70 project decades ago testifies to the sensitivity of the affected communities to issues of transportation encroachment on their environment. Therefore, even beyond the customary and required environmental processes, early and well-heeded public participation would be of critical importance in any further consideration and development of the Central Sector.

Table 7 - 3 summarizes the performance of the Route 40 Alternative, illustrative of the use of the Central Sector for passenger service, on the screening criteria developed for this study. It passes “with comment” due to the environmental implications and likely public controversy. Also of great concern to the study team is the likely cost of any downtown station that directly serves the heart of the CBD, which would need to be underground, large, and in close proximity to the Baltimore Metro.

Table 7 - 3: Application of Screening Criteria
to Illustrative Central Sector Passenger Alternative

Functional/Design Screening Criteria	Route 40 Alternative
Availability of Land	Probable
Less than One Percent Grade Freight; Two Percent Passenger	Likely
Beneath Harbor Highway Tunnel	No
Tunnel Length > 4 miles	Unlikely
Ease of Integration with Network	Good
Ease of Integration with Yards	Good
Pass/Fail	***Pass***
Adverse Environmental Impact	Potential for Parklands/4(f); Ecosystems; Construction impact
Implementation Issues	Public Controversy Likely

External Impact Screening Criteria	Route 40 Alternative
Consistent with Existing Land Use	Probable
Extent of Acquisitions, Displacements, and Relocations	Low
Impact Listed or Eligible National or State Historic Place	No
Impact Parklands, 4(f)/6(f) Resources	No
Construction Impact Severity	Pass
Impact Ecosystems, water resources	Low
Implementation Issues	Public Controversy Likely
Pass/Fail	**Pass with Comment**
Comment	Impact of construction: in Route 40, beneath center city, beneath Metro and Howard Street Tunnels

C. Harbor Sector—Passenger Alternatives

In order to test the feasibility of a Harbor Sector passenger route providing a main station reasonably close[19] to the CBD, the study team laid out a "Locust Point Passenger Alternative" crossing the Northwest Harbor to the north of the Fort McHenry Tunnel. The tunnel route from the southwest to the northeast connects Herbert Run (where the CSXT crosses the NEC) and Bay Interlocking in East Baltimore. Sited south of the CBD, this alternative would link Locust Point with Canton.

1. Description of the Locust Point Passenger Alternative

The basic concept for this alternative may be described as follows, proceeding from the southwest to the northeast (numbers refer to points on Figure 7 - 9):

1. At Halethorpe/Herbert Run, northeast-bound passenger trains would divert from the existing NEC to the CSXT main line via a connection that is yet to be configured. (Its configuration would depend on the operating patterns for other types of traffic through Baltimore.) For example, the junction might resemble Union Interlocking in Rahway, NJ, which connects the six-track NEC main line with the double track branch to Perth Amboy. The junction uses duckunders[20] constructed in the middle and side of the NEC to facilitate the movement of New Jersey Transit branch line trains to and from the NEC.
2. Between Halethorpe and Mt. Winans, the alternative could potentially have Amtrak, CSXT, NS, and MARC all operating in the already overburdened CSXT corridor. (Which carrier operates where for what type of traffic would depend on the resolution, if any, of the freight challenge in the region.) Development of a track configuration sufficiently capacious to accommodate up to the entire trans-Baltimore traffic, while minimizing conflicts, lay outside the scope of this study; six tracks might be necessary, with several complex interlockings and track connections and all the associated signaling and programming.
3. At a location east of Mt. Winans, the passenger alignment would diverge to the northeast from the CSXT right-of-way. It would continue to the northeast, crossing over local roads and streets, to Westport, where it would have an intermodal station stop as it bridges over Baltimore's light rail line (4). Trains would then cross the Middle Branch of the Harbor on an elevated structure located basically above the former WM moveable bridge (5).
6. Neither an advantageous station location in, nor a consequent route through, the Locust Point area could be identified within the scope of this study. (Hence the dotted lines in the Locust Point area in Figure 7 - 9.)

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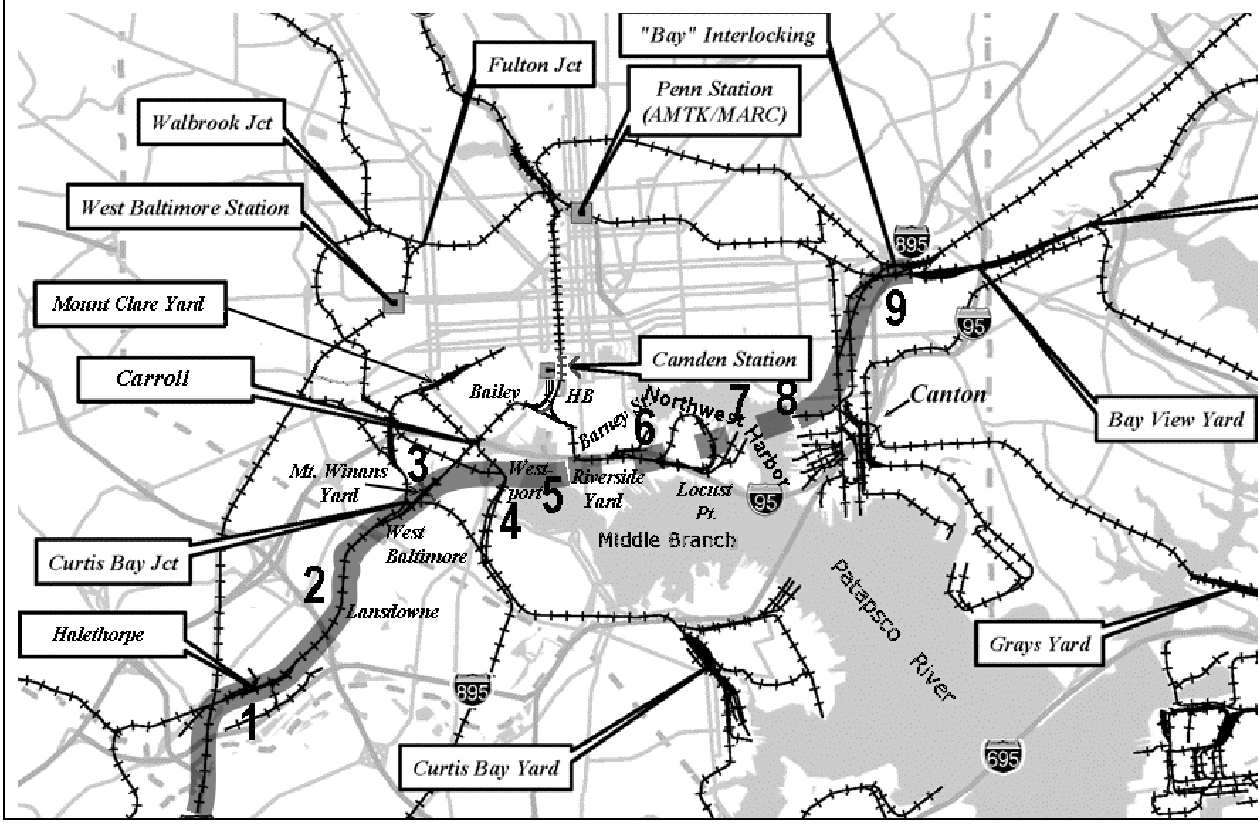
[19] "Reasonably close" in this context means "no farther from the CBD than the current Pennsylvania Station."
[20] A duckunder is a railway structure in which the branch line, separating from the main, gradually ramps down and, on attaining sufficient vertical distance from the main line grade, smoothly bears away from the principal right- of-way beneath a bridge carrying the main line tracks.

7. The option would utilize two single-track passenger tunnels that would pass under a portion of Locust Point before rising to ground level north of I-95 in Canton.
8. Northeast of the tunnel, the alignment—threading its way through freight trackage and other obstacles in the Canton port area (see evaluation below)—would necessarily be slow and circuitous and would not significantly contribute to reducing travel times through Baltimore.[21] Curves immediately east of Northwest Harbor and the curve connecting into the NEC at Bay (9)—both exceeding two degrees, 50 minutes—would restrict speed.

Figure 7 - 9: Schematic of Harbor Sector—Locust Point Passenger Alternative



2. Evaluation of the Harbor Sector—Locust Point Passenger Alternative

From both engineering and passenger traffic viewpoints, the Locust Point passenger alternative evinces obvious drawbacks:

[21] One of the Harbor Sector freight alternatives involves a Locust Point-Canton freight alignment that might be constructed above the Locust Point Passenger Alternative. However, due to grade problems that have not yet been resolved, this particular freight alternative did not survive the screening imposed on it (see further below).

- West of the Harbor, the passenger-only line would have to pass beneath I-95. Access beneath the interstate highway to create a relatively direct and fast route would require considerable reconstruction of the piers and abutments supporting the highway on its approach to the Fort McHenry Tunnel.
- The alignment would be made more difficult by the requirement to construct a grade-separated alignment, i.e., without a moveable bridge, over the Middle Branch, in the vicinity of the former Western Maryland swing bridge that once provided access to Port Covington.
- The Westport intermodal station would be farther from downtown Baltimore than the existing Pennsylvania Station, and would pose difficult barriers to pedestrian access. In Locust Point, a feasible location for a main station was not identified during the study. Within the alignment constraints already perceived by the study team, it would be almost impossible to site a Locust Point station within an equivalent walkable distance to downtown as that of the existing Pennsylvania Station.
- East of the Harbor, the access of Amtrak intercity trains between the NEC at Bay and the eastern portal at Canton would be constrained by:
  - — At-grade railroad-highway crossings;
  - — Overhead and undergrade bridges that presently separate the existing freight-only tracks from the city streets; and
  - — The need to maintain local freight connections and operations between the CSXT and NS yards and local industries and facilities in Canton and Dundalk.
- Finally, if intercity rail passenger service is diverted to the south, a vicinity already served by MARC's Camden Line, then the Penn Line—providing access to the vast residential areas north of the CBD—may well remain in place. Retention of commuter service to Pennsylvania Station would necessitate —alongside the Harbor Sector passenger tunnel—either permanent maintenance and rehabilitation of the B&P tunnel for commuters, a new tunnel for commuter service alone, or an arrangement for commuter service to share trackage with a Great Circle Freight Tunnel. In the context of this comprehensive study, none of these outcomes accords with the economic theory of railway location.

The foregoing engineering and traffic considerations eliminated the Harbor Sector passenger alternative from further consideration. (See Table 7 - 4.) As there is no chance of designing any other Harbor Sector alternative that would both provide a main station 15 walkable blocks or less from the CBD and speed trains through Baltimore more quickly than via the present route, no need arose to develop additional passenger options in this Sector.

Table 7 - 4: Application of Screening Criteria to Illustrative Harbor Sector Passenger Alternative

Functional/Design Screening Criteria	Locust Point Passenger Alternative
Availability of Land	Probable
Less than One Percent Grade Freight; Two Percent Passenger	Likely
Beneath Harbor Highway Tunnel	No
Tunnel Length > 4 miles	Unlikely
Ease of Integration with Network	Poor; may increase congestion on upgraded CSXT Capital Subdivision
Ease of Integration with Yards	Good
Pass/Fail	***Fail***
Adverse Environmental Impact	Potential for Acquisitions, displacements, Relocations; Construction Impact
Implementation Issues	Would likely require reconstruction of I-95; would require approval of Coast Guard.

External Impact Screening Criteria	Locust Point Passenger Alternative
Consistent with Existing Land Use	Low
Extent of Acquisitions, Displacements, and Relocations	Medium
Impact Listed or Eligible National or State Historic Place	No
Impact Parklands, 4(f)/6(f) Resources	Yes, Parkland in Herbert Run
Construction Impact Severity	High (both on rail traffic and adjacent land)
Impact Ecosystems, water resources	Low
Implementation Issues	Would likely require reconstruction of I-95; would require approval of Coast Guard; Would increase congestion on upgraded CSXT Capital Subdivision.
Pass/Fail	**Fail**
Comment	

Chapter Eight
FREIGHT ALTERNATIVES

The study team identified two sectors in which viable freight alternatives might, at least theoretically, be found:

- **Near North**—roughly analogous to the existing PRR alignment and the eastern portion of the B&O Belt Line, but refined due to state-of-the-art engineering and construction techniques; and
- **Harbor**—an underwater solution that would be complex because of the number of potential portal sites, and the multiplicity of port, land transportation, and industrial facilities on either side of Baltimore Harbor.

As explained above, a Far North Sector freight alternative was ruled out because it would pose severe gradient challenges, bypass important freight yards, and disrupt much parkland and intense suburban development. Likewise, an inevitably costly freight solution in the Central Sector was not pursued as the associated expenditure would far outweigh any foreseeable benefit of such a location at the heart of Baltimore's CBD.

A. Freight Alternatives in the Near North Sector

The two Near North freight alternatives would involve the construction of tunnels of varying lengths on different alignments. The freight alignments would replace both the existing CSXT route using the Howard Street Tunnel and the NEC route currently available to the NS via the B&P and Union tunnels. Concentrating all the cross-Baltimore freight traffic on a single, much-improved route, the Near North alternatives would relieve most of the constraints to commerce that the extant alignments interpose. Both of the Near North freight alternatives would involve a Great Circle Freight Tunnel (GCFT), similar in concept to the Great Circle Passenger Tunnel (GCPT) broached earlier. By following a gentle, long arc bored deeply underground, instead of a cut-and-cover excavation hewing to the vagaries of the City's street layout, a GCFT would help to attenuate the ill effects of Baltimore's challenging topography.

As depicted in Figure 8 - 1, all the Near North Freight alternatives would begin at Herbert Run (near Halethorpe), where northeast-bound NEC freight traffic would join through CSXT traffic on the CSXT main line.[1] Following the CSXT Mount Clare Branch to the Mount Winans Yard, the entire through freight traffic would divert briefly (using a new connection) toward compass northwest via the Hanover Branch (the former Western Maryland Railway). In West Baltimore, the route would bear compass northeast from the Hanover Branch to a tunnel portal leading to Presstman Street, where the GCFT's characteristic alignment begins. Emerging

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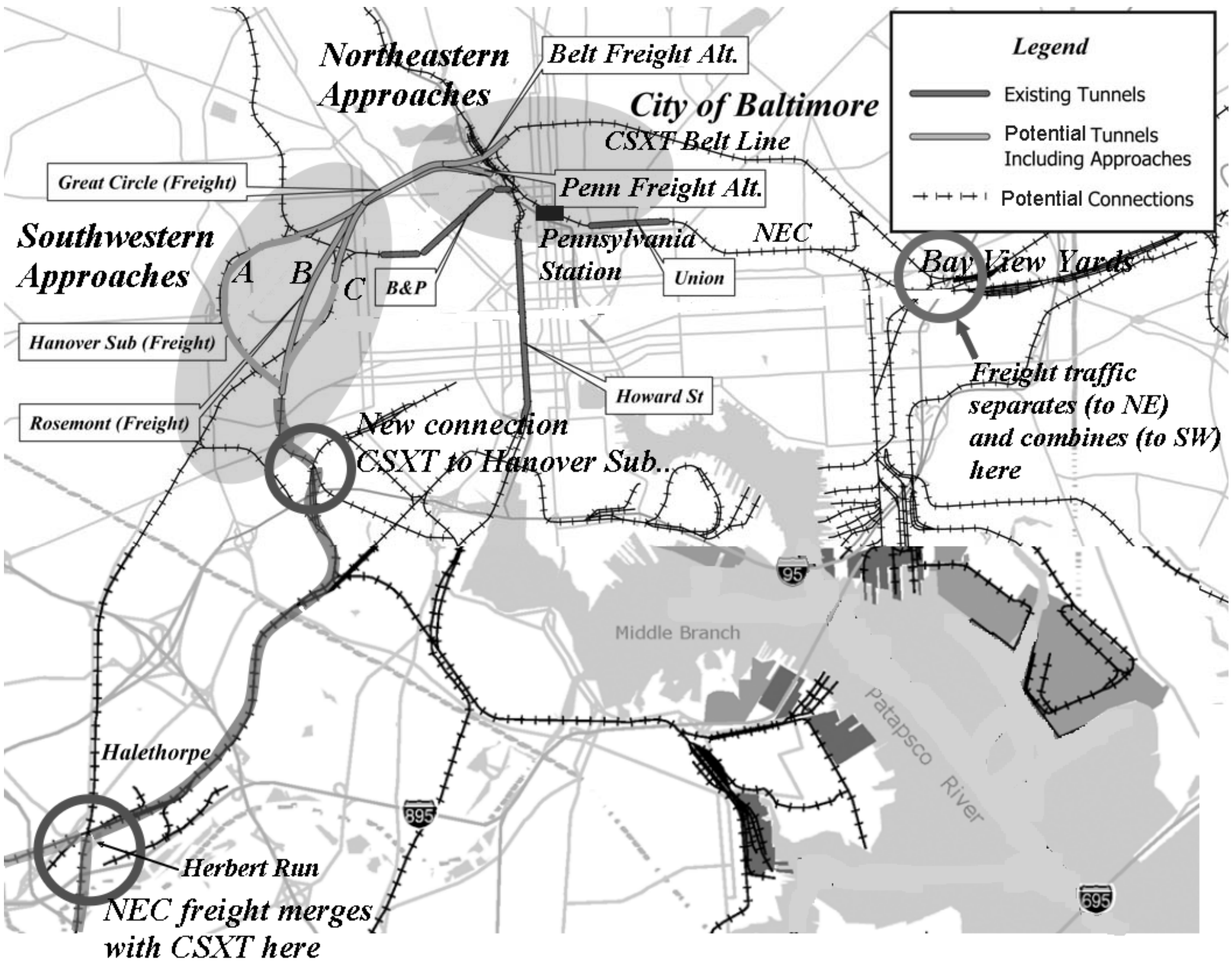
[1] Only early conceptual engineering has taken place with regard to the connection at Herbert Run and the joint freight route from that point to the Hanover Subdivision to the contemplated tunnel portals. To handle the complex freight moves to, from, within, and through the Baltimore Terminal, connections would be required in addition to those described here.

through a portal west of the Jones Falls Valley, both alternatives would cross the Falls to rejoin existing but upgraded freight trackage. Near Bay View, the CSXT- and NS-based traffic would split, each company's trains going their separate ways. The shared operation, therefore, would occur between the Herbert Run (Halethorpe) and Bay View vicinities.

Figure 8 - 1: Near North Freight Alternatives: "Belt Freight" and "Penn Freight"[2]



Within this common Near North concept, there are two alternatives, differentiated by their routes and elevations across the Jones Falls Valley. In the **Belt Freight Alternative**, the through freight route would cross the Valley at a relatively high elevation toward compass northeast to a connection with the CSXT's Belt Line through Clifton Park to Bay View. By contrast, in the **Penn Freight Alternative,** the through freight route would bridge the valley at a lower elevation toward compass southeast and would make use of the NEC right-of-way through

[2] Note: Highlighted route in this schematic is for southwest-northeast through freight only. Additional connections would be needed to improve service to other flows, including those to and from Locust Point and internal moves within the region.

a refurbished “Old” Union Tunnel to Bay View. While the basic concept of the GCFT would remain constant, its design would vary significantly to meet the particular elevation requirements of the Belt Freight and Penn Freight Alternatives while also avoiding the Metro tunnel at Pennsylvania Avenue in West Baltimore.

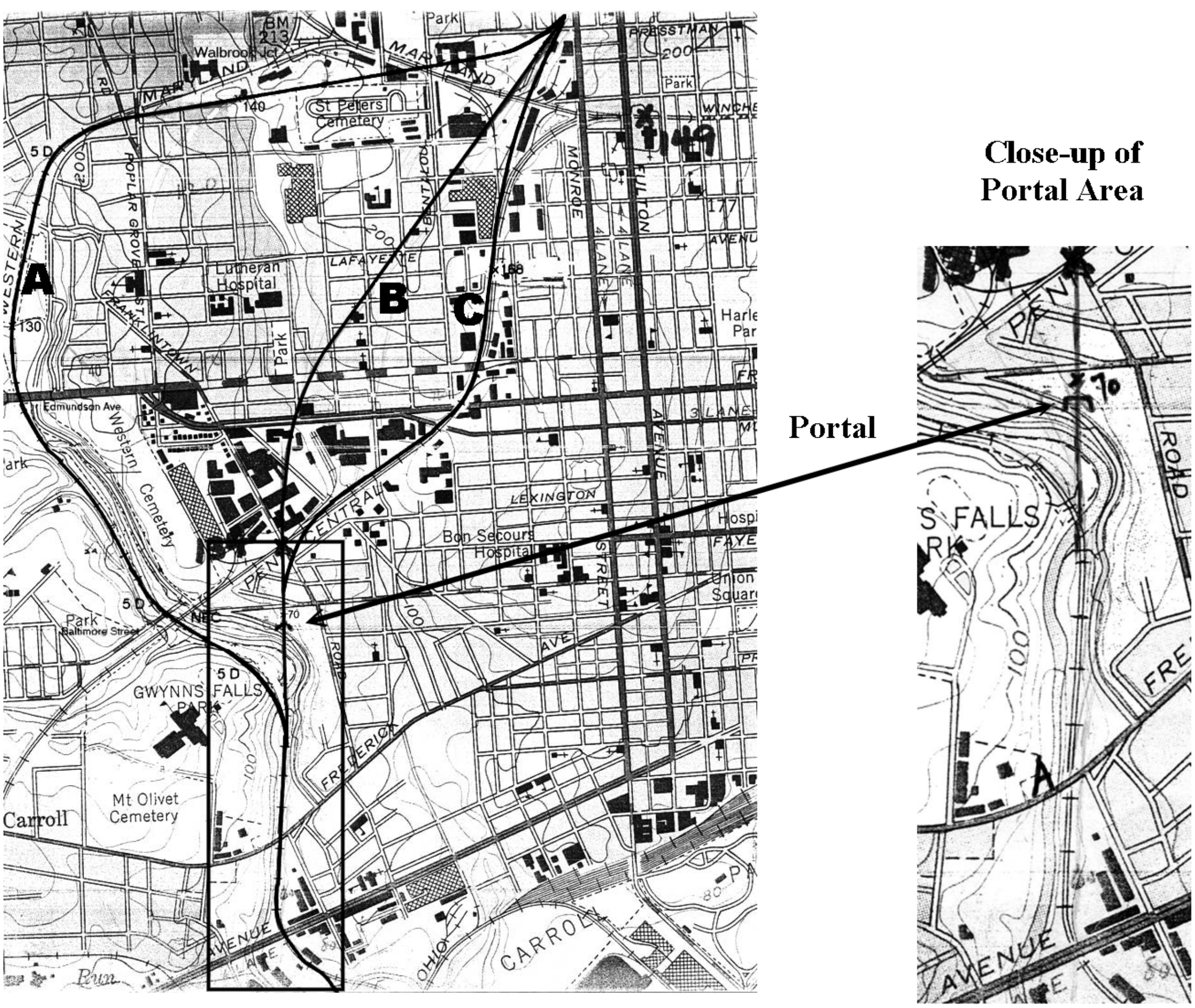
In the conceptualization of both Near North alternatives, the study team assumed that the GCPT must be provided for.

The following discussion first deals with the suboptions that may be available at the southwestern approaches to either alternative. Then follows a discussion and evaluation of the Belt Freight and Penn Freight Alternatives.

1. Southwestern Approach Options (Potentially Available in Either Alternative)

As noted above, the approach to the Great Circle Freight Tunnel from the southwest would make use of the CSXT Baltimore Terminal Subdivision between Halethorpe/Herbert Run

Figure 8 - 2:
Three Southwestern Approach Options to Great Circle Freight Tunnel



and Mt. Clare Yard to access the CSXT Hanover Subdivision (the former WM main line to/from Port Covington). Three alternative route approaches from the Hanover Division to the southwest tunnel portal were evaluated, are shown in Figure 8 - 2**,** and are discussed below. Of these options, two would utilize a common western portal located north of Gwynns Falls; the third would have its portal at Walbrook.

a. Gwynns Falls–NEC Option

Predicated on the assumption that minimal right-of-way acquisition would be required, the Gwynns Falls–NEC tunnel option ("C" on Figure 8 - 2) would be constructed underneath the NEC as far northeast as Fulton.[3]

From its portal just north of Gwynns Falls (see close-up in Figure 8 - 2), the tunnel alignment would curve to the northeast from the southwest portal to reach its position underneath the NEC right-of-way. The length and degree of curvature would vary depending on whether it was desirable to minimize the length of alignment rights that would have to be acquired. The longest, least sharp curve would be approximately two degrees 30 minutes and approximately 2,000 feet long; while a 1,215-foot long, three-degree 20-minute curve would result in a maximum speed of 50 mph.[4]

The NEC, just east of Franklintown Road (UG Bridge 98.95), is approximately 1,300 feet north of the contemplated south portal. The elevation of the NEC at Franklintown Road is approximately 134 feet. The roof of the freight tunnel would be approximately 35 to 40 feet beneath the NEC. Warwick Avenue[5] and Franklin Street pass under the NEC; however, the freight tunnel would have to be designed to pass beneath both streets. This requirement would apply for both the Belt Freight and the Penn Freight alternatives. Further investigations would be required to determine whether this vertical distance would be adequate to enable the tunnel to be constructed without disturbing the NEC roadbed and structures.

The alignment would proceed underneath the NEC to Lafayette Avenue, where the NEC is approximately at elevation 168 feet and the roof of the freight tunnel would be at approximately either elevation 135 or 75, depending upon the choice of either the Belt Freight or Penn Freight alternative. The Penn Freight Alternative would be located beneath the Great Circle Passenger Tunnel at Presstman Street, while the Belt Freight Alternative would be parallel to the Great Circle Passenger Tunnel.

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[3] The feasibility of tunneling underneath the NEC was not evaluated as part of this study, and would need careful and early analysis should work on this option be considered.

[4] While such speed restrictions would probably be "good enough" for most freight operations, they would hamper the railroads' operating (hence marketing) potential to expand their high-value freight business for all time and should be reviewed very carefully. The 50 mph mentioned here is **below the design speed** specified in the study's goals and objectives.

[5] It was assumed that the tunnel should be located at least 15 feet beneath the road surface of a street.

b. Rosemont Option

Alternatively, the shorter route between Gwynns Falls and Presstman Street (labeled "B" on Figure 8 - 2) would pass under the Rosemont section of Baltimore.

The alignment would extend northward from the Gwynns Portal until it passes under the NEC right-of-way. The alignment would curve to the northeast on a 2,831-foot long one-degree curve. The subsequent 3,980-foot long tangent would pass under the former WM Wye Tracks at Fulton on the NEC. The freight tunnel alignment becomes parallel to the Great Circle Passenger Tunnel, but approximately 90 feet lower, near Presstman Street.

c. Walbrook Option

The third option for accessing a Great Circle Freight Tunnel (labeled "A" in Figure 8 - 2) would continue following the CSXT Hanover Division to the vicinity of Bloomingdale Road, where it would bear to the right (going northeast) to converge with the other options under Presstman Street. Unfortunately, no portal and tunnel configuration using the Walbrook option could be found that would meet the grade or clearance requirements of this study. Accordingly, this option was dropped.

2. Belt Freight Alternative

Ascending to a top-of-rail elevation of at least 150 feet to enable the tunnel to pass over the Metro Subway at Pennsylvania Avenue, the Belt Freight Alternative would directly access the CSXT Belt Line (the Clifton Park Freight Alignment) east of Jones Falls, by means of a bridge spanning the valley. The Belt Freight Alternative option would parallel the Great Circle Passenger Tunnel between Baker Street and Newington Avenue. The option of constructing the Great Circle Freight tunnel beneath the Great Circle Passenger tunnel was evaluated; however, sufficient clearance between the tunnels could not be established to enable the alignment of the freight tunnel to cross over the top of the passenger tunnel between Presstman and Monroe Streets.

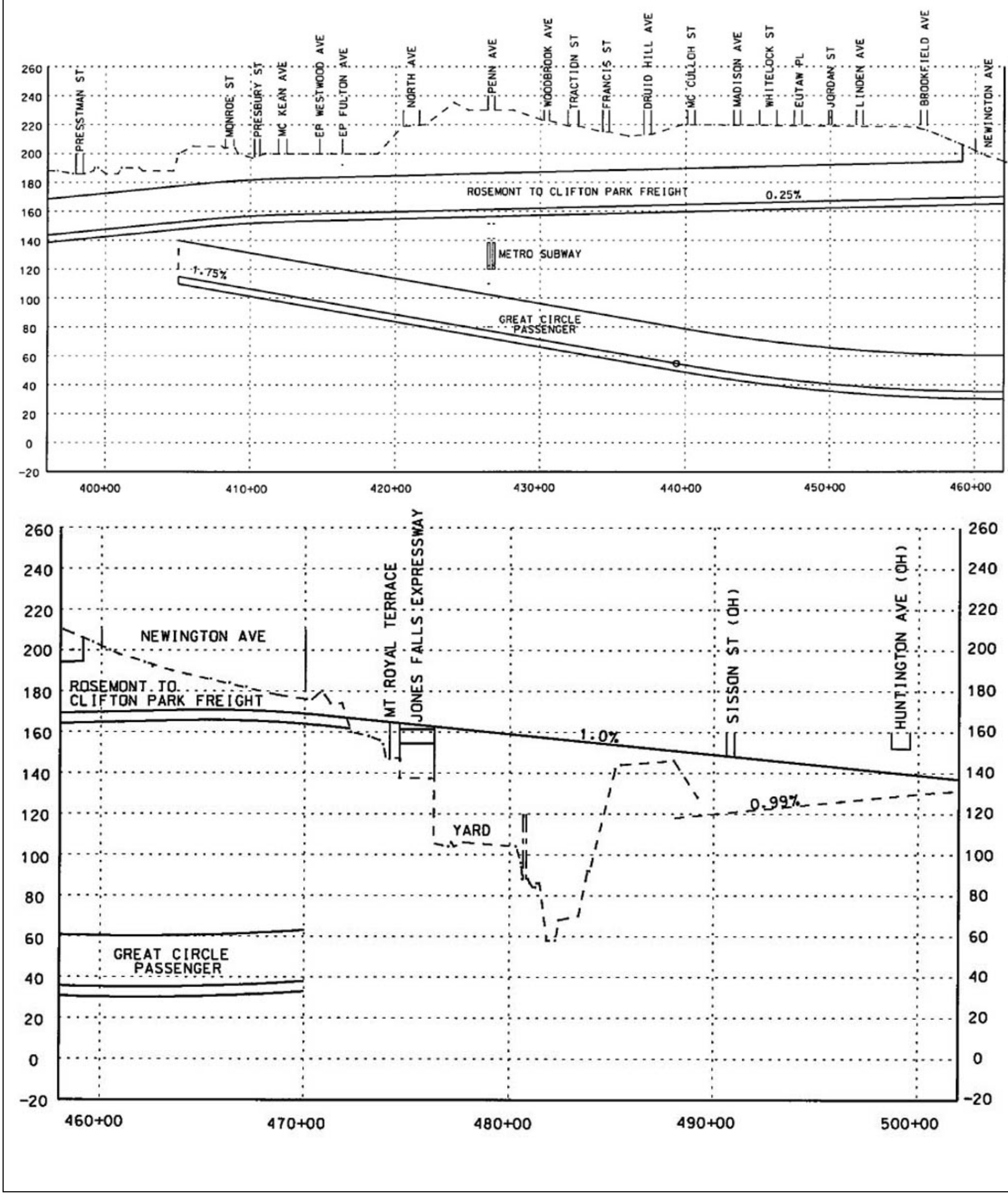
The profile of the Belt Freight Alternative from Presstman Street to Huntingdon Avenue on the CSXT Belt Line is shown in Figure 8 - 3. The alignment would ascend from less than 70 feet at the Gwynns Falls portal to pass over the subway at an elevation of 150 feet, on a one percent grade. The gradient would be controlled by the need to cross over the top of the Great Circle Passenger Tunnel near Baker Street. Some parts of the Belt Freight Alternative between the south portal and Pennsylvania Avenue would have less than 20 feet of ground cover. However, it does not appear upon first inspection that an open trough, rather than a tunnel, would be an option in these locations.

Selecting a Belt Freight alignment to cross the valley from the north portal of the Great Circle Freight Tunnel required careful analysis of the location of all important intervening structures. Vertical, as well as horizontal, alignment considerations were critical in the finalization of the analysis. The main elevations are shown in Figure 8 - 3.

The engineering analysis of the Belt Freight Alternative and its connection across the Jones Falls Valley to the northeastern portions of the CSXT Belt Line through Clifton Park led to the following conclusions, which take into account all the conflicting determinants:

- Exacting geometry restrictions are imposed by factors including but not limited to the following:
  - — The Metro tunnel at Pennsylvania Avenue;
  - — The proximity of a possible Great Circle Passenger Tunnel, which would need to be planned for (as long as it is a viable option);
  - — The need to pass over or under the JFX with ample clearances;
  - — The existence, on the direct path between any likely GCFT portal and the CSXT Belt Line, of the Central Light Rail Line yards, shops, and main trackage;
  - — The need to maintain grade separations at Sisson Street and Huntingdon Avenue on the east side of the valley; and
  - — The need to adhere to the one percent grade limitation (better if possible).
- The location of the Central Light Rail Line (CLRL) facilities, coupled with the assumption that they cannot be moved, prevents the Belt Freight Alternative from passing under the JFX and instead requires a high bridge across the freeway. This in turn—
  - — Raises the necessary elevation of the northeast tunnel portal, necessitates cut-and-cover construction through the local area, and forces the bridge over the valley to begin approximately 200 feet west of Mount Royal Terrace, thus markedly affecting the neighborhood between Druid Hill Park and North Avenue. In fact, preliminary estimates indicate that an 1800-foot strip of Mount Royal Terrace would have to be removed under the Belt Freight Alternative; and
  - — Results in a difficult aerial alignment through the CLRL, with freight train speed limits of 40 mph; this is inconsistent with the goals and objectives of the project.
- The establishment of a one percent grade east of the Great Circle Freight Tunnel eastern portal, connecting the new freight alignment with the CSXT Belt Line, would result in significantly raising the roadway surface of both Sisson Street and Huntingdon Avenue, or the closing of both streets. As a result of these neighborhood impacts, this option may not be viable. The only other choice (holding constant the horizontal alignment) would be to keep the elevation of the Belt Line constant and adjust the gradient of the connection from the northeastern tunnel portal to the east side of the Valley. The resultant gradient becomes 1.6 percent descending to the Belt Line—far beyond that allowable to meet the study objectives.
- Construction of the Belt Freight Alternative would encounter poor-grade rock and soil.

Figure 8 - 3: Profile of Belt Freight Alternative



- To meet study specifications, Belt Line improvements would require double-tracking and seven bridge replacements to provide double-stack clearances.
- Based on operational, neighborhood impact, and cost[6] considerations, the Belt Freight Alternative emerges from *this* study as inferior to the Penn Freight Alternative. However, changes in assumption and additional engineering investigations might improve the characteristics, feasibility, and relative position of the Belt Freight Alternative among potential approaches to railway restructuring in Baltimore.

3. Penn Freight Alternative

The Penn Freight Alternative would descend on a 0.60 percent grade from Franklintown Road (approximately 700 feet north of the Gwynns Falls portal) to pass under the Metro Subway at a top of rail elevation of approximately 15 feet. At this location the freight tunnel alignment would be north of the GCPT alignment. The freight tunnel would then descend for another 1,400 feet prior to ascending on a one-percent grade to the Jones Falls portal. The freight and passenger tunnels would have the same gradient and top of rail elevation for the nearly the last 2,100 feet of their respective tunnels. This is natural, as they would debouch onto the same NEC right-of-way.

The twin freight tunnels would remain parallel to each other until they were under the JFX. At this location the outside tunnel would diverge to the north to an alignment that would enable it to pass under the CSXT railroad bridge at North Avenue. The Penn Freight alignment would emerge from the GCFT at two portals[7] in the wall supporting the Light Rail line and would curve toward compass southeast towards Penn Station. (Figure 8 - 4.) The portal of the outside freight track would be located approximately 400 feet compass northwest of the portal of the inside freight track. At the CSXT railroad bridge:

- A bridge pier of the railroad bridge would separate the two freight tracks; and
- The inside freight track would be located adjacent to, and parallel with, the two passenger tracks.

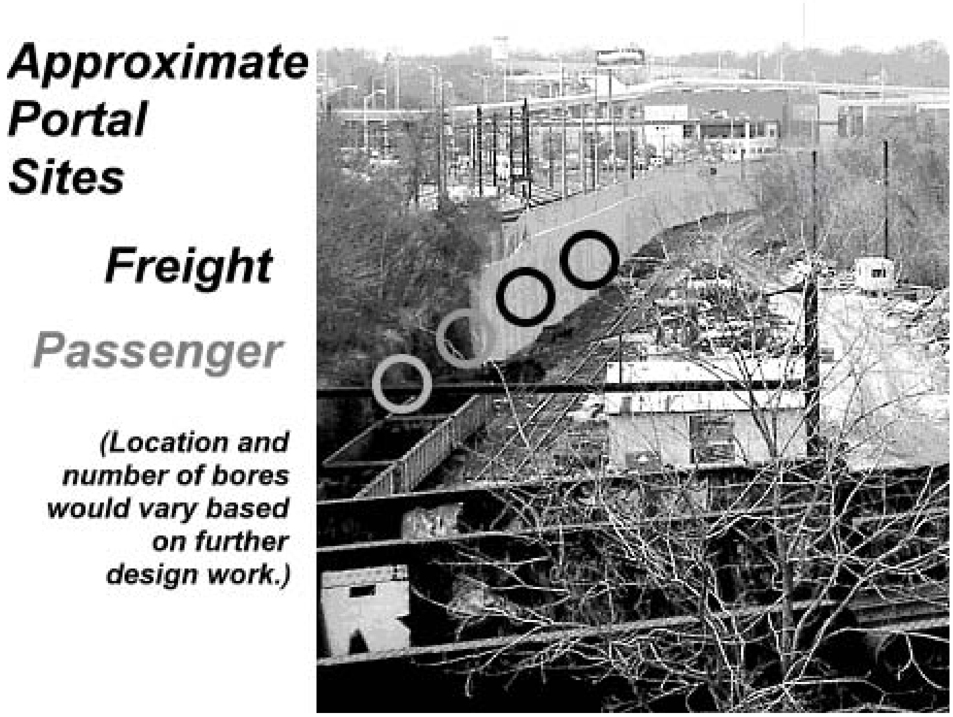
The vertical curve connecting the tunnel alignments with the NEC would end east of the Howard Street Bridge.

Connecting to the existing NEC near the north portal of the B&P Tunnel, the double-track Penn Freight alignment would be located compass northeast of the double-track passenger alignment. The combination passenger and freight alignment between the northeast portals of the Great Circle Tunnels and the station would require a reconfiguration of Charles Interlocking,

[6] Costs are reported in Chapter 9.
[7] The portal of the outside, northern, tunnel is located approximately 350 feet north of the inside tunnel. The locations of the piers for the CSXT Bridge and Howard Street require that the outside track cannot be located parallel, and 14 feet apart, from the inside track. The two tracks (or the tunnels they are located in) are not parallel for approximately the easternmost 3,000 feet of the Penn Station Freight Tunnel alignment. This assumes two bores for freight and two for passenger; the precise tunnel configurations and locations would be determined in further stages of design.

located compass northwest[8] of the station platforms. The track alignments would pass beneath the existing North Avenue Bridge and the CSXT Bridge.

Figure 8 - 4
View of Potential Portal Sites
for GCFT (Penn Freight) and GCPT
(View from CSXT Bridge over Northern Central Railway, Looking Northwest)



The freight alignment would pass to the north of the Penn Station platform tracks and utilize a rebuilt Old Union Tunnel to reach East Baltimore, where access to the CSXT main line and the NS Bay View Yard and the NEC would be provided.

As part of a Penn Freight Alternative, the Old (northernmost) Union Tunnel would have to be double tracked and clearances increased. The current grade through the Union Tunnel is 1.17 percent, eastward, which is greater than the specified maximum 1.0 percent grade. [9] The

[8] In discussing Pennsylvania Station, oriented at cross purposes to the direction of traffic, it is important to reiterate for the reader that—except where noted— all directions having to do with the railroad are expressed as southwest/northeast, which is the major traffic lane.

[9] Train Performance simulations show that three Dash 8 diesel units cannot start a 4,000-foot train consisting of loaded 315,000-pound capacity cars when the locomotive is stopped at the apex of the grade at Broadway (MP 94.50). Additionally, the same trains, if stopped at the south end of the Union Tunnel can barely make the grade. The train at the south end makes the grade because, when the locomotive is at the base of the grade, the entire train behind it is on a downgrade. This allows the locomotives to start the train and gain some momentum before the entire train is on the grade. If it were not for the momentum, the train would stall. Needing to depend upon momentum for normal operations is not preferred.

elevation at the south end of the Union Tunnel is 51 feet and the elevation of the apex at Broadway is 95 feet, a climb of 44 feet in 3,900 feet. The elevation cannot be lowered at Broadway. Therefore, the only way to make the grade through the Old Union Tunnel to meet the one percent requirement would be to raise the elevation at the south end of the tunnel by five feet. This would reduce the rise to 39 feet in 3,900 feet, or one percent. The overhead clearance under Guilford Avenue, the first overhead bridge south of the tunnel portal, would not be adversely impacted.

Although the Penn Freight Alternative has survived this preliminary analysis without the discovery of fatal flaws, questions remain to be answered about its feasibility, cost, and consequences. For example:

- The alignment requires clearance improvements through Pennsylvania Station, which would require careful investigation. For instance, initial indications are that five bridges do not meet minimum requirements;
- Connections to CSXT and NS yards in Orangeville are necessary; and
- The track configuration from the Union Tunnels to Bay View was not evaluated within the scope of this study.

4. Summary and Evaluation of Near North Freight Alternatives

Two alternative Near North Sector alignments to enhance CSXT and NS freight operations into and through Baltimore were evaluated. After careful investigation of the engineering possibilities, the study team carried both the Belt Freight and Penn Freight alternatives through to initial cost projections. The Penn Freight Alternative—deemed preferable under the study's assumptions—would require the construction of a Great Circle Freight Tunnel between Gwynns Falls and Pennsylvania Station's approaches and the rebuilding of the Old Union Tunnel. The Penn Freight alignment would replace the existing CSXT route using the Howard Street Tunnel and the NS freight route via the Union and B&P Tunnels. (The built-in limitations of these existing routes were explored in Chapter Two.)

Table 8 - 1 provides a formal comparison of the two major alternatives according to the screening criteria of this study.

Table 8 - 1:
Application of Screening Criteria
to Near North Freight Alternatives

Functional/Design Screening Criteria	Belt Freight Alternative	Penn Freight Alternative
Availability of Land	Likely	Likely
Less than One Percent Grade Freight; Two Percent Passenger	Likely	Likely
Beneath Harbor Highway Tunnel	No	No
Tunnel Length > 4 miles	Unlikely	Unlikely
Ease of Integration with Network	Good	Good
Ease of Integration with Yards	Good	Good
Pass/Fail	***Pass***	***Pass***
Adverse Environmental Impact	Potential for: Acquisitions, Displacements, Relocations	Potential for: Conflict with land use; Acquisitions, Displacements, Relocations; Parklands/4(f); Impact National Historic Place
Implementation Issues	Public controversy likely	Public controversy likely

External Impact Screening Criteria	Belt Freight Alternative	Penn Freight Alternative
Consistent with Existing Land Use	Likely	Low
Extent of Acquisitions, Displacements, and Relocations	High	High
Impact Listed or Eligible National or State Historic Place	No	Yes, Greenmount Cemetery
Impact Parklands, 4(f)/6(f) Resources	Yes, Parkland in Herbert Run	Yes, Greenmount Cemetery, Parkland in Herbert Run
Construction Impact Severity	High	High
Impact Ecosystems, water resources	***Low***	Low
Implementation Issues	Public controversy likely	Public controversy likely
Pass/Fail	**Pass; but inferior to Penn alternative under prevailing assumptions.**[10]	**Pass with comment. Superior to Belt alternative under prevailing assumptions.**[10]
Comment	As configured, 1800' of local neighborhood removed.[10]	Impact of rehab of Old Union Tunnel

[10] In the event that additional analyses are deemed appropriate, it is recommended that a Belt Freight Alternative option be evaluated under the assumption that the Light Rail Line and shops are relocated. This reconfiguration could conceivably alter the comparison between the Belt and Penn freight alternatives, when all relevant benefits and costs are weighed.

B. Freight Alternatives—Harbor Sector

Baltimore Harbor, with its lengthy coastline, is complex and—at least in theory—affords a host of opportunities for underwater railway crossings. Progressively eliminating the impractical while focusing on the feasible concepts, the study team identified the most likely portals, their plausible approaches and connections on each side of the harbor, and the tunnel alignments that would logically connect each pair of portals. While resources did not allow for full-scale investigations of all the theoretical approach-portal-tunnel-portal-approach combinations, sufficient data emerged to provide useful indications regarding the practicability, desirability, and cost of a harbor-based freight solution to the Baltimore challenge.

1. Assumptions and concerns common to all alternatives

The following factors guided the conceptual design and winnowing process:

a. Design concept

Based on standard engineering practice for situations analogous to that of Baltimore Harbor, the analysis assumed that a double-tube Harbor Tunnel (with a total of two tracks) would be constructed employing the immersed-tube technique. The construction of the tunnel would require dredging and deep excavations in soils ranging from very soft organic, clays, and estuarine silts to stiff over-consolidated cretaceous clays of the Potomac Group.

b. Importance of connections

Because a Harbor Sector tunnel would be located well to the south and east of the present CSXT and NEC alignments through Baltimore, the analysis focused heavily on the means of connecting the CSXT and NEC/NS freight facilities south and west of the harbor with the respective infrastructures of the CSXT, NEC/NS, Canton, and Patapsco & Back Rivers railroads north and east of the harbor. With so many freight movements to be handled reliably in this major logistical hub, the efficacy of connections among the various roads' facilities could make or break any Baltimore rail restructuring project—just as much as such a project's impacts on through moves, clearances, and capacity.

c. Availability of land

The availability of land for the two Harbor Sector tunnel approaches influenced the selection of alternative approach alignments and of potential locations for the tunnel portals. This is so because the expansion of railroad capacity through the construction of additional main line tracks and yard leads would generally require the acquisition of adjoining industrial real estate. In limited instances—for example, near necessary rail-highway grade separations— the need may also arise to obtain residential real estate.

A review of prior reports and an inspection of land uses bordering the existing railroad rights-of-way indicated that the level of residential and industrial development in the sections of Baltimore City and County adjacent to the Patapsco River would, in effect, require the use of existing railroad main lines, branch lines, and industrial tracks to access the proposed tunnel portals.

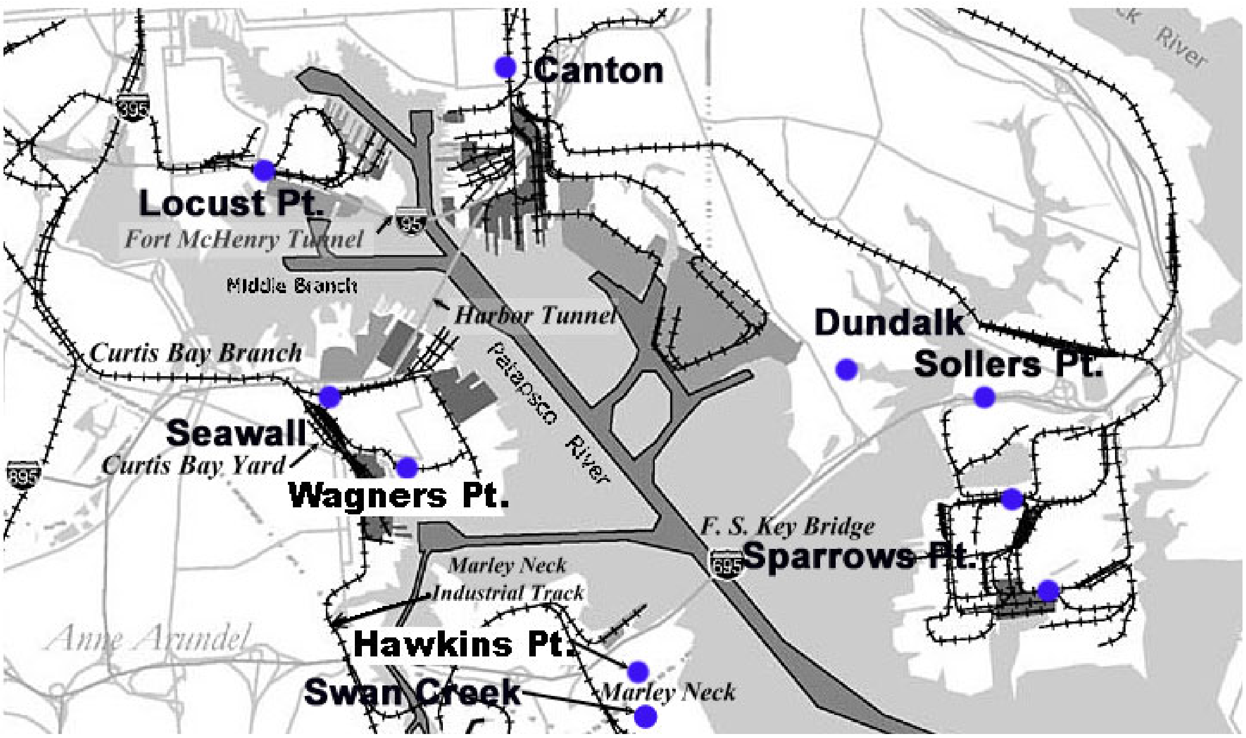
2. Southwestern Approaches

The harbor tunnel alternatives evaluated share a common southwestern approach between CSXT Halethorpe (BAA 5.8) and CSXT West Baltimore (BAA 3.2). Existing CSXT branch lines and secondary tracks were then used to access the southwestern tunnel portals. A brief overview of the approaches is provided below; a more detailed analysis appears in a subsequent section.

The secondary and branch lines used to access various possible southwestern tunnel portals were:

- The CSXT Locust Point Branch; and
- The CSXT Curtis Bay Branch in west Baltimore, including the Marley Neck Industrial Track that extends southeastward from Curtis Bay Yard. (See Figure 8 - 5**.)**

Figure 8 - 5: Potential Portals and Approaches—Harbor Sector Freight Tunnels
(Note: For design reasons, portal locations will sometimes differ from the locations of the features after which they are named.)

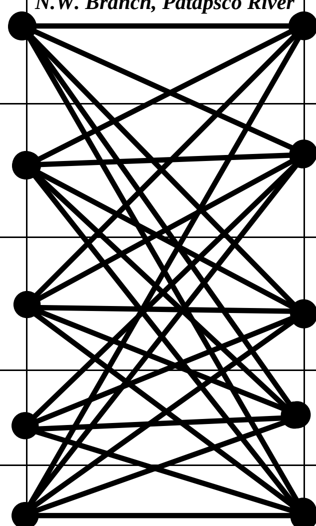


3. Portals—Summary Listing

As shown in Figure 8 - 5 and listed in Table 8 - 2, the portals were located either on or near an existing branch line and/or industrial track.

The analysis addressed, at least initially, potential tunnel alignments linking each of the southwestern with each of the northeastern portals shown in the table. As is evident from both Figure 8 - 5 and Table 8 - 2, linking portals closest with portals farthest from the Inner Harbor would require the longest tunnels. Also, as the portal locations become more and more distant from the Northwest Branch of the Patapsco River, both the length and circuity of the resultant through routes increase. The added length of the more distant[11] options, however, gives them more space to overcome—with a gradient under one percent—the significant differences in elevation between the low point in any tunnel (beneath the dredged Harbor channel) and the NEC and CSXT main lines to the southwest and northeast of the portals. On the other hand, the more distant Harbor crossings could add to the time and train-mileage required for through and local moves. For this reason, a painstaking examination of the operational and economic costs and benefits of the various alternatives would necessarily come at an early stage of any further work on rail restructuring in Baltimore.[12]

Table 8 - 2: Portal Options and Hypothetical Tunnel Connections

***Portal Options*— Southwest Side of Baltimore Harbor**	**Tunnel Alignments Hypothetically Possible**	***Portal Options*— Northeast Side of Baltimore Harbor**
• East end of the Locust Point Branch	***N.W. Branch, Patapsco River*** 	• Canton, on the CSXT Sparrows Point Industrial Track, near MP 1
• East end of the Seawall Industrial Track, northeast of Curtis Bay Yard,		• Dundalk, on the PRR Bear Creek Track
• Wagners Point, southeast of Curtis Bay Yard		• Sollers Point, at the east end of I-695's Key Bridge over the harbor
• Hawkins Point, east of the Marley Neck Industrial Track		• North Sparrows Point, at the north end of the ISG steel plant
• Swan Creek, east of the Marley Neck Industrial Track	***Mouth of Patapsco River***	• South Sparrows Point, at the south end of the ISG steel plant

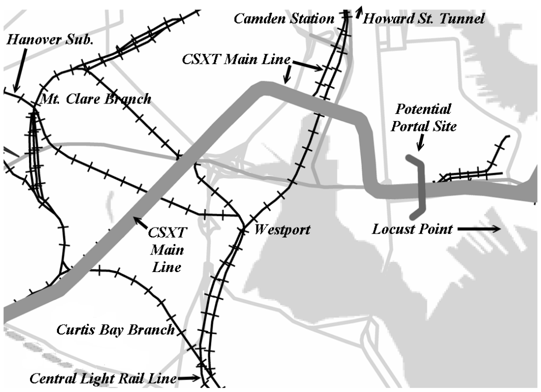
[11] I.e., more distant from downtown Baltimore, the Inner Harbor, the Northwest Branch, and Canton.
[12] See Chapter VII. In concept, such an examination would (a) identify and rank the most important local and through movements (e.g., CSXT moves from Curtis Bay to Bay View), (b) evaluate the operating, service quality, and cost effects on each movement of each tunnel alternative, and (c) develop a methodology for synthesizing the results into conclusions useful for planners and decision-makers.

4. **Southwestern Portals and Associated Tunnel Connections**

a. Locust Point – East End of CSXT Locust Point Branch

(1) The Portal

Figure 8 - 6: Possible Locust Point Portal Location



Note: See Figure 8 - 7 for possible tunnel alignments east of this potential portal site.

A potential Locust Point portal (Figure 8 - 6) would be located northwest of Fort McHenry and the Fort McHenry Tunnel, and would be west of Locust Point Yard. Motivating such a location would be the need to maintain a maximum one percent gradient on tunnel approaches and within the tunnels themselves. A maximum top-of-rail depth of minus 90 feet has been assumed for each alternative; this depth would provide clearance to a maintained depth of minus 50 feet in the harbor channel. Depending upon the location of the tunnel alternative alignment evaluated, the portal itself could shift a few hundred feet east or west of the location shown. The portal would be east of Bailey (BAA 0.7), and generally east of Russell Street and I-395, which pass over the Locust Point Branch. Each of the contemplated tunnels would pass beneath Locust Point Yard.

(2) Potential Tunnel Connections

Locust Point–Canton. Two alternative tunnel alignments between Locust Point and Canton were evaluated; they are shown in Figure 8 - 7. However, the northernmost alignment would lie almost directly beneath Tide Point, a $63 million conversion of the former Procter & Gamble soap factory into a 15-acre, 400,000 square foot corporate office complex. Since this premier waterfront property in Locust Point would sustain impacts from a northern tunnel and its approaches, the southernmost alignment was assumed to be more appropriate.

Conceptual engineering indicated that the gradient of the northeastern approach, on the right side of Figure 8 - 7, would have the most significant effects on the tunnel's vertical alignment. The connection between a Canton portal and the freight railroads on the northeastern side of the Harbor is discussed under "Northeastern Portals and Associated Approaches," on Page 8-21.

Locust Point to other eastern portal locations. Any freight tunnel to Dundalk, Sollers Point, or Sparrows Point from Locust Point would pass beneath the two existing highway tunnels shown in Figure 8 - 7. The proximity of the Fort McHenry Tunnel alignment to the west portal location in Locust Point would cause railway tunnel vertical alignments to exceed the specified limit of one percent. Moreover, due to concerns about the integrity of the existing structures and the consequent risk to the constant flow of vehicular traffic within them, State and Federal agencies most likely would not permit the construction of *any* new harbor tunnel beneath the

Fort McHenry and Baltimore Harbor Tunnels.[13] All options requiring construction of railway tunnels beneath highway tunnels were therefore dropped from further consideration. Thus, all hypothetical tunnel alternatives linking Canton with points south of Locust Point were also excluded.

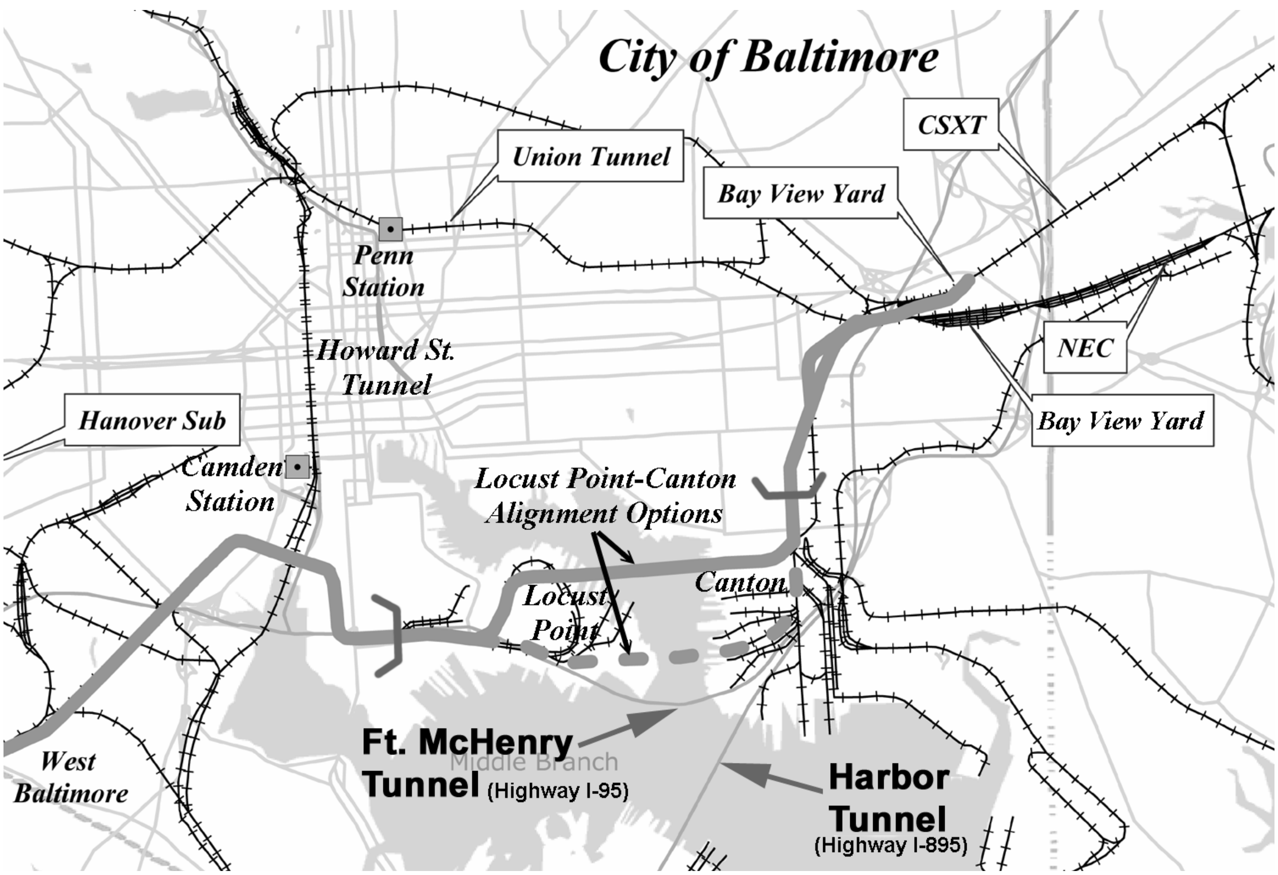
Even if crossing under the highways were feasible, any tunnel from Locust Point to Sollers or Sparrows Point would necessarily exceed five miles in length, much of which would underlie the dredged harbor channel. This length would make for a costly tunnel indeed, in comparison with shorter, more direct options. As a result of all these factors, the team did not develop alignments for tunnels from Locust Point to Dundalk, Sollers Point, and Sparrows Point.

b. The Seawall Portal – 7,000 Feet East of Curtis Bay Yard

(1) The Portal

The Seawall Portal would lie southeast of the Baltimore Harbor Tunnel (I-895). The

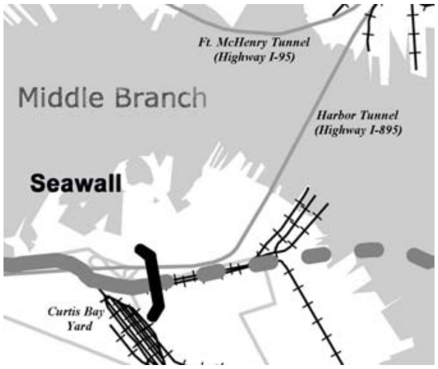
Figure 8 - 7: Locust Point–Canton Tunnel Options



[13] It is assumed that lengthy stoppages of cross-harbor vehicular traffic on account of railroad construction would not be permitted by State authorities.

location illustrated in Figure 8 - 8 is east of Curtis Bay Yard; any actual portal site, however, would vary with the location of the low-point of its associated tunnel concept.

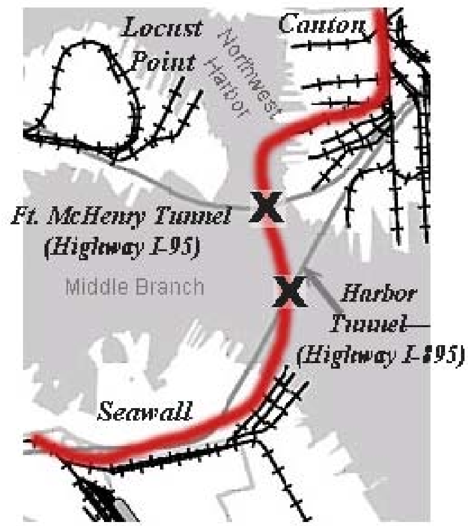
Figure 8 - 8: Seawall Portal
(showing potential tunnel alignment toward Dundalk)



(2) Potential Tunnel Connections

Seawall–Canton. Since a tunnel from a Seawall Portal to Canton would pass beneath the existing highway tunnels (see points marked "X" in Figure 8 - 9), it would not be allowable under the premises of this study.

Figure 8 - 9: Seawall–Canton: Excluded



Seawall–Dundalk. If feasible, a Seawall-Dundalk alignment concept would look something like that drawn in Figure 8 - 10. As the Seawall Branch is a primary, highly congested access route to numerous port facilities, however, providing capacity for through freight trains while facilitating local freight service would be impractical. The study team, in fact, was unable to develop a satisfactory southwestern approach to a Seawall portal. Since an acceptable northeastern approach to a Dundalk portal was not found either (see "Dundalk" under "Northeastern Portals and Associated Approaches" at Page 8-22), the Seawall–Dundalk alternative was dropped from further consideration.

Seawall to Sollers Point and North Sparrows Point. The same issues of tunnel length and pathway through the dredged harbor channel that would affect the alignments from Locust Point to Sollers Point or Sparrows Point also ruled out those starting at Seawall. Even though the latter options would be nearly 8,000 feet shorter than the former, the Seawall–Sollers or –Sparrows Point options would still rank among the longer, more expensive harbor tunnel possibilities.

As a result of the numerous, obvious difficulties attached to all the options using Seawall as the southwestern portal, the study team did not further refine these alignments.

c. The Wagners Point Portal

(1) The Portal

The Wagners Point portal would be located at the point indicated at the center of Figure 8 - 11), approximately 8,000 feet east of the east end of Curtis Bay Yard.[14]

[14] As indicated in the discussion of other portals, more definitive locations would depend on specific tunnel designs—in particular, the low point.

Figure 8 - 10: Schematic of Seawall–Dundalk Concept (Excluded)

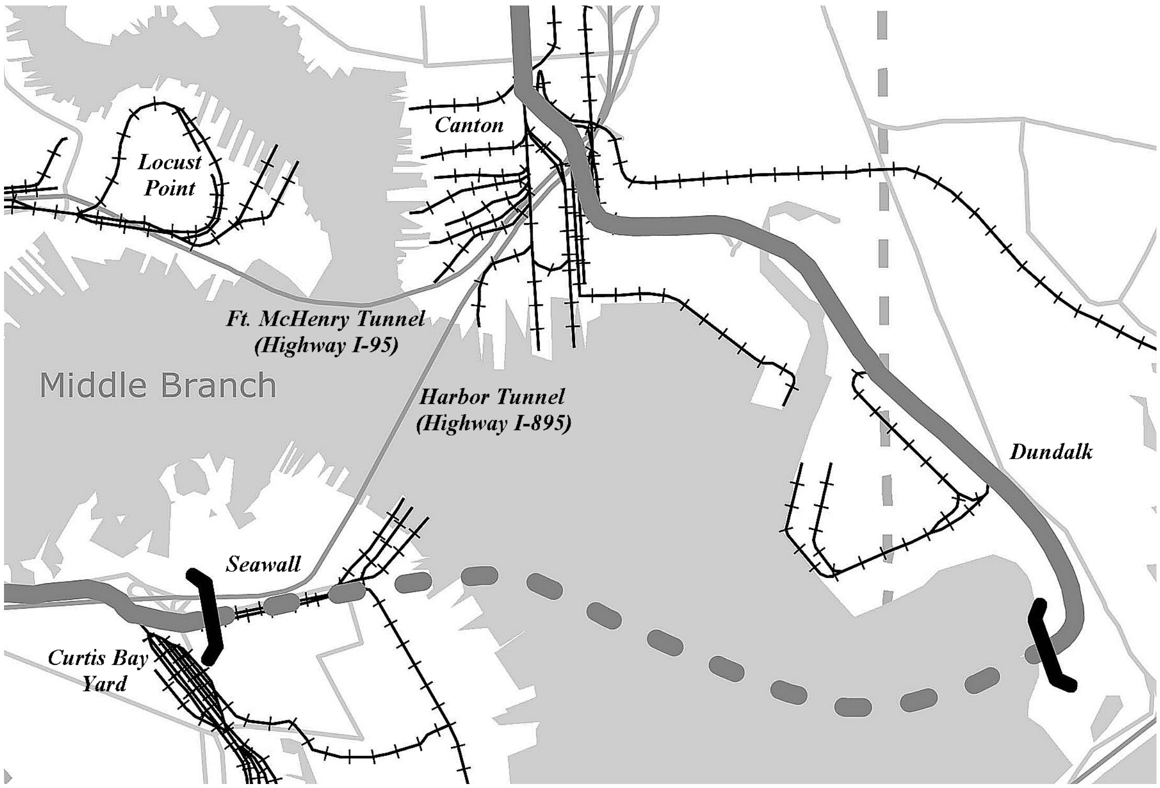
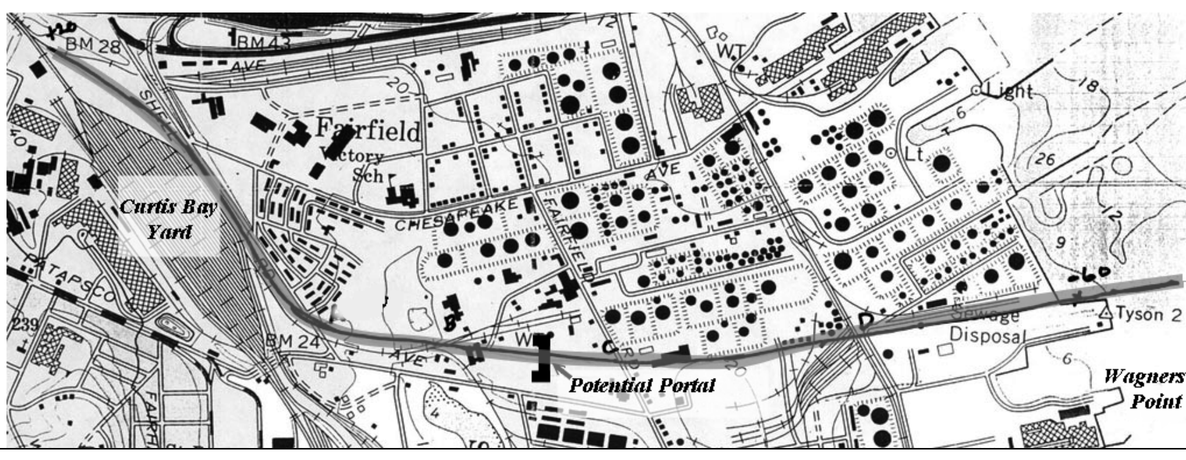


Figure 8 - 11: Wagners Point Portal and Approaches



The study team regards this portal site as less than optimal because of the potential for conflict with Curtis Bay Yard operations.

(2) Potential Tunnel Connections

A northeastern portal in Canton is ruled out because of the intervening highway tunnels; Dundalk fails the gradient test. Thus, a Wagners Point portal might be suitably paired only with

Soller's Point (which suffers from inherent disadvantages discussed below at Page 8-23) or the two Sparrows Point alternatives. While these last portal options appear to allow for proper approaches, they are much more distant from Wagners Point than from the Marley Neck portals described in the next section. For these reasons, there was no reason to pursue the Wagners Point options any further.

d. The Marley Neck Portals

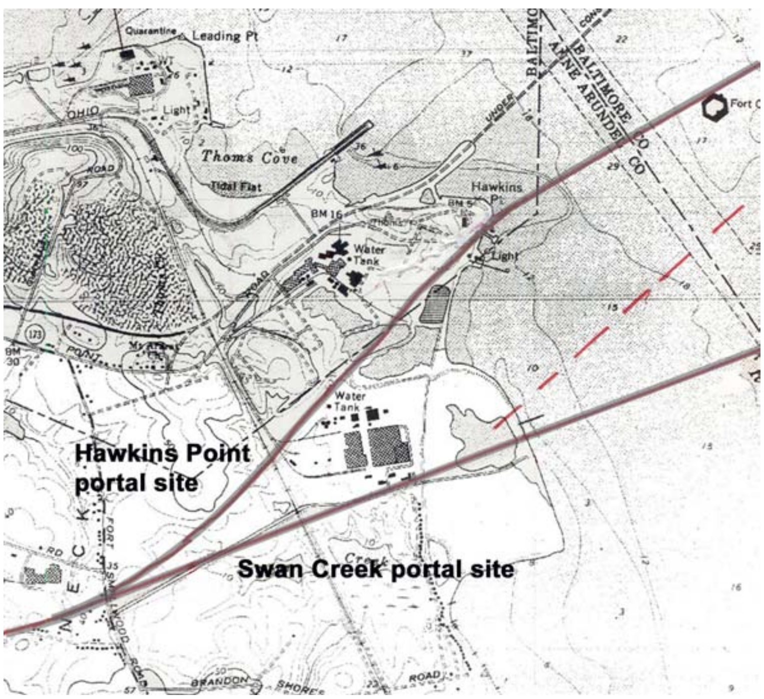
(1) The Portals

The study team evaluated two portal sites to which the CSXT Marley Neck Industrial Track would provide access:

- Hawkins Point, shown in the center of Figure 8 - 12; and
- Swan Creek, shown toward the bottom of Figure 8 - 12.

As is the case elsewhere in this report, the precise site of these portals within the indicated locales would depend on more detailed design.

Figure 8 - 12: Marley Neck Portal Options

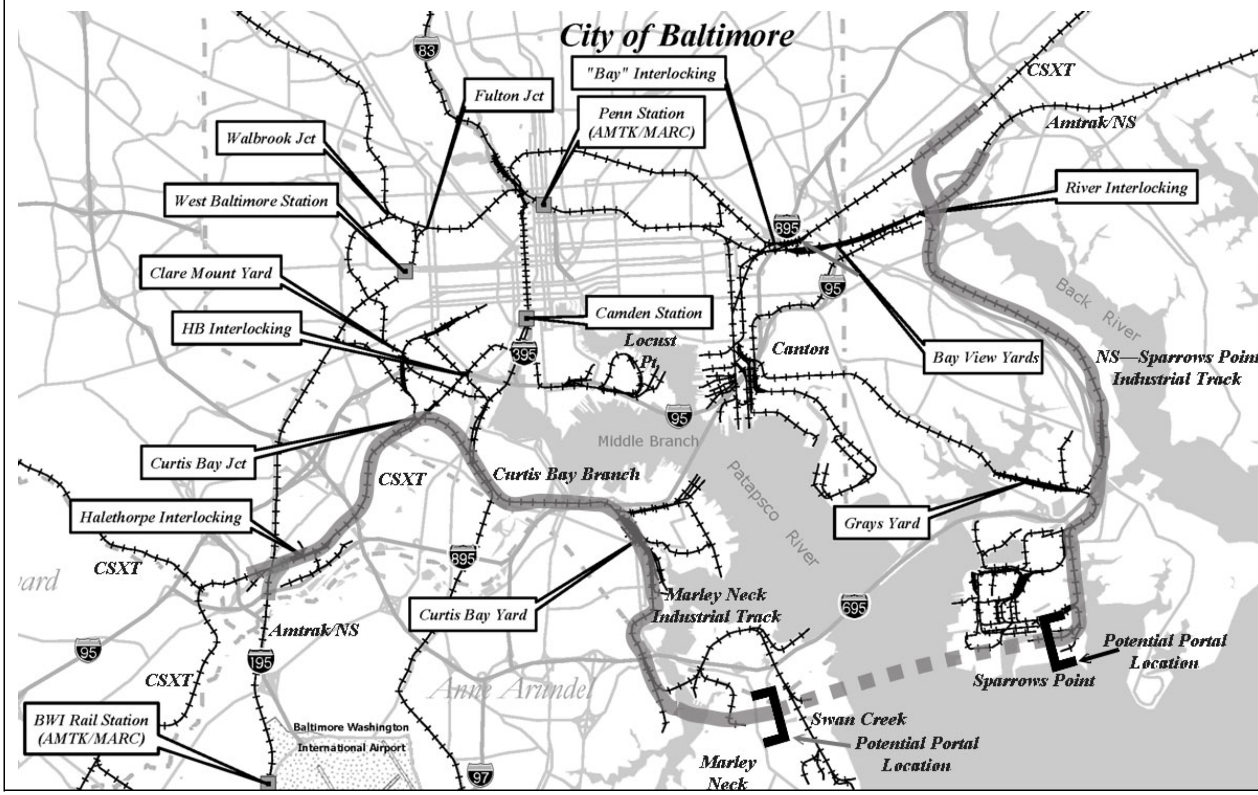


(2) Tunnel Connections

Since the northeastern portals at Canton, Dundalk, and Sollers Point are eliminated from consideration (as described below under "Northeastern Portals and Associated Approaches"), any Marley Neck tunnel alignments would cross the harbor south of the Francis Scott Key Bridge (I-695) to a northeastern portal in the vicinity of Sparrows Point (see Figure 8 - 17 on page 8-24). Several options exist for designing such a crossing; for purposes of this report, these options are designated collectively as the Marley Neck–Sparrows Point alternative.

Three options for crossing under the harbor and connecting into the Sparrows Point complex were evaluated: Hawkins Point to North Sparrows Point, Swan Creek to North Sparrows Point, and Swan Creek to Sparrows Point. The northerly route between Hawkins Point and North Sparrows Point would be the shortest route between Curtis Creek and the NS Sparrows Point Industrial Track; however, the southerly route, between Swan Creek and Sparrows Point, would have the shortest tunnel. (The Patapsco River is about 880 feet across between the point marked -60 in Figure 8 - 12 and the point marked -70[15] in Figure 8 - 17.) Employing the Swan Creek–Sparrows Point as an illustrative option, Figure 8 - 13 places the Marley Neck–Sparrows Point concept in context.

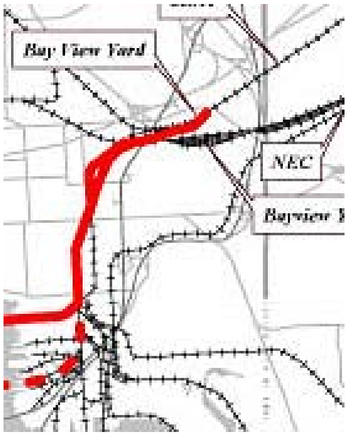
Figure 8 - 13: Marley Neck–Sparrows Point Tunnel: Initial Concept in its Regional Context
(Swan Creek–Sparrows Point Option for Example)



As further described in the next section, the eastern portals in Sparrows Point and North Sparrows Point would be located within the steel mill facility, about 3,000 feet inland from the northeastern shoreline.

[15] As conceptually designed, the top of rail elevation rose to elevation -60.

Figure 8 - 14: Northeastern Approach, Canton—Bay View



5. Northeastern Portals and Associated Approaches

Treating the potential railway tunnel portals on the northeastern side of Baltimore Harbor, the following sections describe the connections and difficulties attendant on each.

a. Canton

Because of the assumption excluding a rail crossing beneath existing highway tunnels, the Canton portal would be available only to a tunnel extending from Locust Point (as described on Page 8- 15).

In theory, a Locust Point–Canton rail freight tunnel would present obvious advantages. It would be the least circuitous Harbor Sector option, and would preserve direct access to and through the Bay View freight yards from the southwest.

Thus, as shown in Figure 8 - 14, the study team evaluated an alignment that would access the respective Bay View Yards of CSXT and NS, as well as the CSXT and NEC main lines to the northeast, from a tunnel portal in Canton. To restrain costs and to maintain the existing NEC geometry, so vital to passenger service, this alternative assumed no major changes in the railway infrastructure in the Bay View area. For instance, the freight connector from Canton to Bay View would bridge the NEC at Bay (MP 91.9), as the CSXT Sparrows Point Industrial Track presently does.

Under this assumption, gradients would be a prohibitive problem for a Canton–Locust Point alignment. Indeed, the initial analysis concluded that after climbing upgrade from the tunnel mouth, the alignment would require an unacceptable gradient of 1.5 percent or greater. The reasons for this adverse geometry are as follows:

- The top of rail in a tunnel connecting Locust Point and Canton, at its maximum depth beneath the channel, would be approximately (-) 85 feet;
- The top of rail of the existing CSXT bridge over the NEC is +85 feet; and
- The distance between the two locations is approximately 13,000 feet.[16]

This geometry would result in an uncompensated grade[17] of 1.59 percent—worse than those in the Howard Street and B&P Tunnels, and far greater than the project's limit of one percent for freight grades. Even the connection between the critical low point in the rail tunnel,

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[16] The distance between these same two points on the hypothetical alignment (the CSXT over the NEC and the critical low point under the dredged channel) would need to be an unattainable 17,000 feet or more to satisfy the project's one percent freight gradient standard.

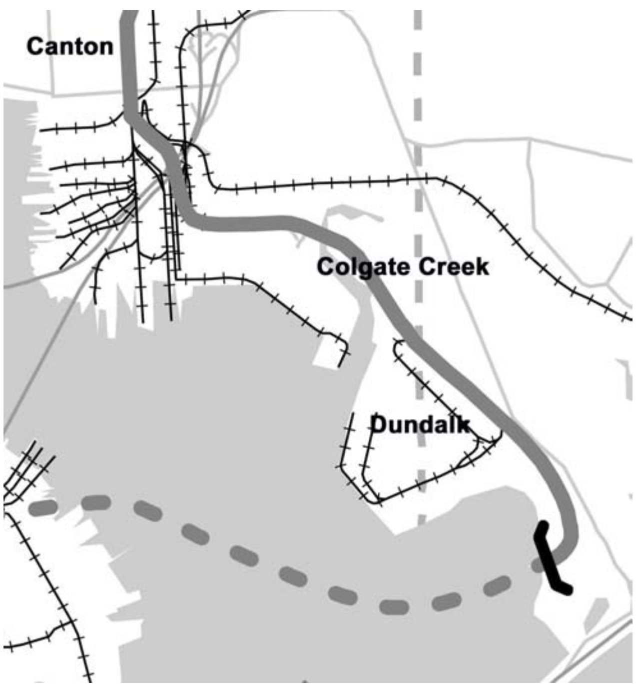
[17] For a discussion of the relationship of grades to curvature, see the extensive discussion of grades and curves in Chapter 2.

beneath the dredged channel, and the top of rail of the NEC *beneath* the CSXT bridge would not meet the one percent standard.[18]

As the unacceptable gradient northeastward to Bay View from Canton would be a fatal flaw, the Locust Point–Canton tunnel alignment was therefore dropped from further consideration in the present study.

It is worthy of emphasis that the decision to eliminate a Locust Point–Canton alignment rests on the assumption of no major redesign of the CSXT or NEC/NS facilities at Bay View. If a cost-effective, environmentally and operationally advantageous solution at Bay View can be devised that lowers the total cost of a Harbor Sector freight tunnel while fully meeting the standards for freight restructuring in Baltimore and having no adverse impact on passenger service quality, reliability, and capacity, then the viability of a Locust Point–Canton rail tunnel might eventually merit further scrutiny.

Figure 8 - 15: Northeastern Approach, Dundalk to Canton



Note: The highway tunnels, their approaches, and other highways are shown above in light gray.

b. Dundalk

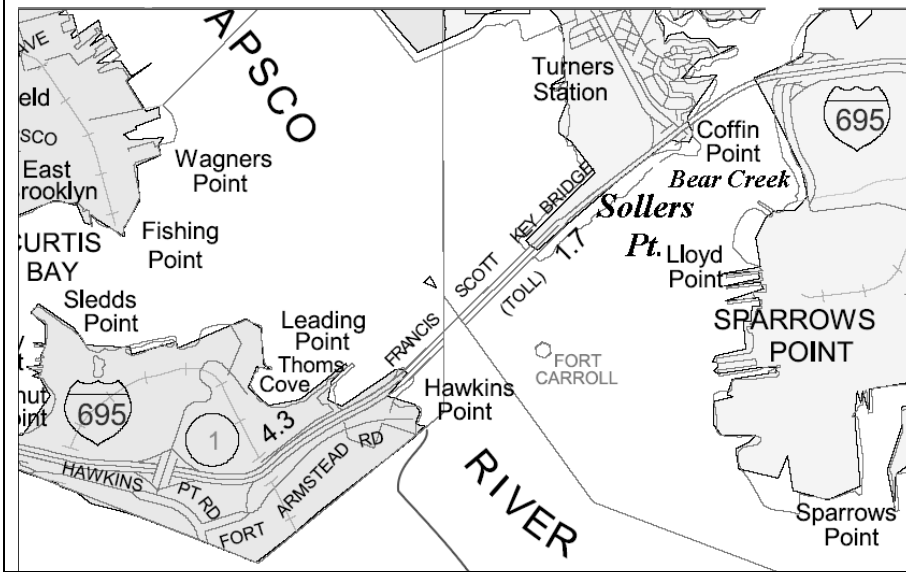
For many of the same reasons applicable to the Canton portal, a Dundalk portal would not satisfy the vertical gradient standards of this study. The rail alignment would have to pass beneath the complex skein of interstate and local highways (Figure 8 - 15) between Canton and Dundalk before beginning to ascend either to the +60 elevation of the NEC or to the +85 elevation of the CSXT bridge over the NEC. This cannot be done within the one percent freight gradient limit of this study.

Furthermore, an alignment northward from a portal in Dundalk would not only pass through the complex network of general cargo facilities of the 570-acre Dundalk Marine Terminal but also conflict with the NS rail network, also utilized by CSXT, that accesses the marine terminal and general cargo facilities.

[18] The top of rail of the NEC beneath the CSXT bridge is about (+) 60 feet; the distance between the NEC under the CSXT would need to be no less than 14,500 feet to provide an effective grade of one percent or less. This distance would be greater depending upon the degree of curvature that would be required to connect the alignment under the channel with the alignment between Canton and the NEC at Bay.

For all these reasons, a Dundalk portal, with its critical connection to the Bay View area, would be fatally flawed. The Dundalk alternatives were therefore dropped from further consideration.

Figure 8 - 16: Location of Sollers Point



c. Soller's Point

Located at the eastern end of the Francis Scott Key Bridge, where Bear Creek joins the Patapsco River, Sollers Point would not serve as an adequate tunnel portal site.

In view of the difficulties already noted in Dundalk and Canton, the most efficient, low-grade access from a Sollers Point portal to the NEC and CSXT main lines would be via Sparrows Point. In any tunnel leading to Sollers Point, a one percent grade from the critical low point beneath the dredged channel of the Patapsco River would not allow the alignment to rise enough in the available distance to enable the railroad to cross Bear Creek (a navigable waterway) on a fixed-span bridge.[19] Thus, any Harbor Sector crossing via Sollers Point would need to be extended in a continuous tunnel beneath an I-695 interchange as well as the Bear Creek channel. This necessity would lengthen a Sollers Point tunnel by minimum of 2,000 feet.

Accordingly, the study team dropped all Sollers Point options from further consideration.

d. Sparrows Point.

The study team investigated the concept of linking portals in the Sparrows Point area with the NEC and the CSXT Main Line east of their respective Bay View Yards. Such a concept would rely on the NS Sparrows Point Industrial Track, a 5.6-mile line that which presently links the northeast end of the NS Bay View Yard with the P&BR's Grays Yard serving the former Bethlehem Steel—now International Steel Group, Inc. (ISG)—mill at Sparrows Point. (See Figure 8 - 17 and Figure 8 - 18.) The NS Sparrows Point Industrial Track is advantageous in that its right-of-way permits expansion and it has a favorable geometry, with the exception of a five-degree curve at Eastern Avenue and a three-degree curve north of North Point Boulevard.

[19] A new drawbridge—representing a step backward and a permanent impediment to commerce—would be impermissible under the standards of the study. See Chapter 5.

Figure 8 - 17: Concepts for East Side of Marley Neck —Sparrows Point Tunnel

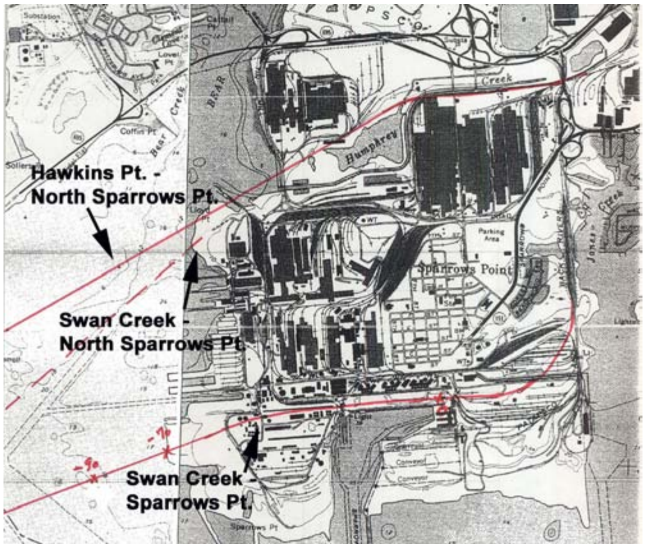
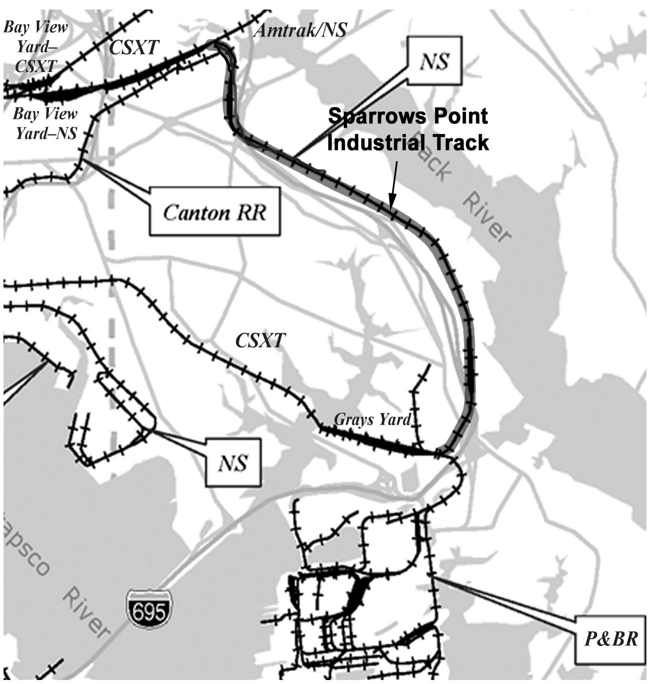


Figure 8 - 18: NS Sparrows Point Industrial Track



The resources available to this study permitted only a conceptual overview and initial exploration of these highly complex Sparrows Point alternatives, with respect to which selected issues are broached in this section.

(1) The Portals

As suggested in the concepts shown in Figure 8 - 17, both the North Sparrows Point and Sparrows Point portal sites would make use of property pertaining to ISG. According to ISG's corporate website: "…about 4,000 people produce four million tons of cast steel slabs for hot-rolled and cold-rolled sheets, tin mill products, galvanized products, galvanized sheet and Galvalume sheet" at the company's facility at Sparrows Point. Employment at the facility has decreased in recent years and the output of the facility has been reduced.

Potential tunnel alignments have not been discussed with ISG. Such discussions would be premature in view of the early stage of planning, the availability in the Near North Sector of a land-based—and perhaps preferable—alternative, and the uncertainties affecting the future of rail restructuring in the Baltimore region. However, for the sake of the region's economy, it will be important in any future planning effort to do nothing which might adversely affect the future of the plant, its owners, and its employees. Should a Sparrows Point alternative be selected at the end of a multi-year planning and environmental process, the closest public/private cooperation would be necessary, both before and after the selection is made, to assure that no economic harm is done.

(2) Connection to Railroad Main Lines

From a North Sparrows Point Portal. Initial perceptions by the study team suggested that a connector linking a North Sparrows Point portal with freight railroad main lines to the northeast might be somewhat shorter than the alignment from Sparrows Point described below. The need to set study priorities, however, precluded development of a conceptual alignment passing to the north of the steel plant but still located on ISG property. The determination that a Harbor tunnel between Marley Neck/Swan Creek and North Sparrows Point would be longer than a tunnel between Marley Neck/Swan Creek and Sparrows Point would offset the reduction in approach length imputed to a North Sparrows Point portal.

The concern that the eastern portion of the approach alignment would require a speed-restricted curve to connect to North Point Boulevard would need attention in any follow-on evaluations of a North Sparrows Point portal concept.

From a Sparrows Point portal. The study team developed a concept for a connection between a Sparrows Point portal and the NS Sparrows Point Industrial Track. Inevitably, such a connection would make use of the ISG property and would need to thread its way through many existing highway and other facilities.

At Sparrows Point, a theoretical alignment was found that would neither interfere unduly with existing traffic, nor violate the one percent gradient limit for freight, nor prevent trains from maintaining their intended speed maxima. Of all the Harbor Sector tunnel concepts described in this report, the Marley Neck–Sparrows Point alignment is the only one to survive, thus far, the many tests described in earlier chapters.

While hopeful, this finding must be regarded as extremely tentative, for the following reasons:

- It has not yet been proven that the freight route concept can be built through Sparrows Point without adversely affecting the operations and viability of the ISG steel mill, which is so vital to the economy of the Baltimore region.
- It would be very difficult, if not impossible, to adjust this concept to allow through trains to stop at Bay View to drop off or pick up cars as a through, single-direction move. Instead, through trains from the southwest would proceed directly through the tunnel, circle back toward Bay View, accomplish their business, and then reverse direction to head northeast from Bay View. This facet is not an improvement over the present operation, with all its many disadvantages.
- A Marley Neck–Sparrows Point route would be relatively distant from the central parts of the region. Detailed operational analysis would be necessary to assure that the added circuity implied by this distant location would be recompensed by higher overall speeds and the advantages of a virtually unrestricted-clearance route. In such analyses, the characteristics and requirements of both through and local movements, of both Class I and smaller railroads, and of both shippers and carriers would require careful and evenhanded attention.

- The specifics of the connections and approaches at both the northeastern and southwestern ends of this route would require significant development to confirm that a Marley Neck–Sparrows Point alignment would fulfill the promise of its concept in an environmentally, economically, and operationally advantageous way.
- Finally, the cost of this Harbor Sector tunnel concept (see Chapter 9) would require careful comparison with the benefits to be obtained to the carriers, to the Baltimore port and economy, to shippers, and—especially if public financing is involved—to the general public.

Chapter Nine
CONCLUSIONS AND PATHS FOR ANALYSIS

This study of the railway network in the Baltimore region has—

- Developed a conceptual framework and methodology for analyzing the complex and longstanding challenges presented by the subject matter;
- Winnowed through the available sectors through which practicable solutions might be designed;
- Screened and further eliminated a large number of alternatives;
- Performed initial conceptual design for a few illustrative alternatives; and
- For those alternatives, prepared preliminary estimates of investment costs.

This Chapter presents preliminary costs for the few alternatives that survived the triage process so well as to merit focused attention. It then goes on to recapitulate the study's analytical conclusions. Recognizing that this report could represent but the beginning of a planning process that—even if recommenced immediately on a priority basis—would require many years to yield tangible results, the study team concludes the report with a number of technical avenues that would inevitably need attention, whether next year or 100 years from now.

A. Illustrative alternatives

The following alternatives survived the screening described in the preceding chapters:

- **Passenger—Near North Sector: Great Circle Passenger Tunnel**
- **Freight:**
  - **Near North Sector: Great Circle Freight Tunnel (Penn Freight alternative)**
  - **Near North Sector: Great Circle Freight Tunnel (Belt Freight alternative)**
  - **Harbor Sector: Marley Neck–Sparrows Point alternative**

B. Preliminary cost measures

Figure 9 - 1 summarizes the preliminary cost estimates for the illustrative alternatives. The underlying numbers appear in Table 9 - 1.

Figure 9 - 1: Preliminary Costs for Illustrative Alternatives
(Billions of 2003 Dollars)

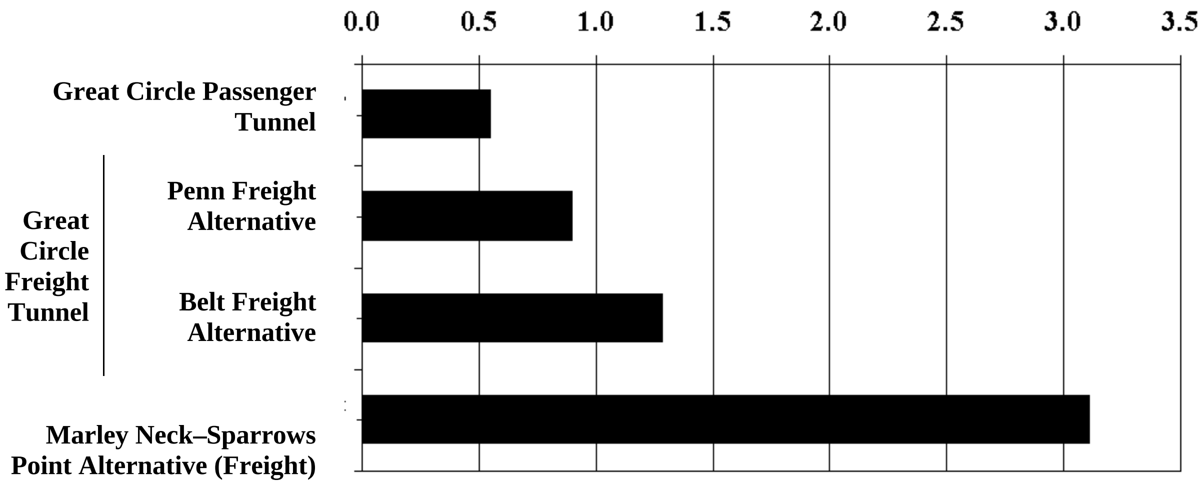


Table 9 - 1: Major Components of Preliminary Cost Estimates

Alternative		Western Approach	Tunnel	Eastern Approach	Total Estimated Cost
Great Circle Passenger Tunnel		$11,100,000	$529,200,000	$6,000,000	$546,300,000
Great Circle Freight Tunnel	Penn Freight Alternative	$103,400,000	$472,200,000	$289,400,000	$865,000,000
	Belt Freight Alternative	$103,400,000	$850,800,000	$304,900,000	$1,259,100,000
Marley Neck–Sparrows Point Alternative (Freight)		$300,200,000	$2,536,200,000	$271,200,000	$3,107,600,000

These preliminary estimates include contingencies of between 30 and 40 percent (with the higher figure applied to tunneling costs), and add-on fees of 18 percent to cover design, construction management, and project management.

The significant difference in cost between the land- and water-based tunnels largely reflects, first, recent advances in the cost-effectiveness of deep boring techniques to which the geology of the Great Circle alternatives is projected to be conducive and, second, the need for elaborate new approaches to the Harbor Sector tunnel alternatives.

C. Conclusions

The study team arrived at the following principal conclusions as a result of its investigations:

1. Baltimore's railway network is so antiquated and underdeveloped, and so important to the Nation's transportation system, as to fully justify the Congressional request for this analysis. For example, the B&P Tunnel was completed eight years after the Civil War ended.
2. In the environment of Baltimore's topography and development patterns, the needs of freight and passenger service differ so greatly as to mandate separate freight and passenger facilities.[1] To attempt to meet the challenge with a single facility would likely result in compromises that would undermine the justification for any restructuring plan so designed. Indeed, analogous compromises made in the nineteenth century by two separate railroads, each developing a multipurpose facility on limited funds, produced the two inadequate facilities inherited by the railways of today.
3. Further incremental repairs to existing facilities, other than for purposes of safety and operational continuity, will not address any of the inherent geometric problems that plague the transit of Baltimore by rail.
4. Baltimore City, with its heavy existing development, pre-existing facilities, and difficult topography, presents severe engineering challenges to the design of new tunnel crossings, whether for freight or passenger service.
5. Dividing the region into four sectors—Far North, Near North, Central, and Harbor—provides a useful conceptual framework for the derivation of passenger and freight alternatives, respectively.
6. With respect to passenger alternatives:
    a. The Far North Sector does not allow for a central station, and no reasonably close-in, accessible station site for a Harbor Sector tunnel was found.
    b. The Central Sector offers the prospect of a station in or near the heart of the CBD, but at such prohibitive cost in excavation and disruption to the downtown area as to raise questions about the practicability of this class of alternatives.
    c. By a process of elimination, only a Near North alternative utilizing the existing Pennsylvania Station appears to provide a cost-effective long-term solution to the challenges posed by the existing B&P Tunnel.[2]
7. With respect to freight alternatives:
    a. Neither the Far North Sector nor the Central Sector merits further study—the former because of its circuity, cost, and distance from freight facilities and shippers, and the latter because there is no purpose to be served in bringing freight, at enormous expense, closer to the downtown district.

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[1] While separate, such facilities would require a high level of coordination to avoid inefficiencies in design and construction.

[2] Regarding cost effectiveness: analyses by others imply that the cost of a Great Circle Passenger Tunnel could conceivably be less than that of rebuilding of the existing B&P Tunnel. See Chapter Seven, section entitled "Upgrade the B&P Tunnel." Any such inference would, of course, require detailed substantiation in the course of additional investigations.

b. Both the Near North Sector and Harbor Sector appear, on the basis of this study's analyses, to provide alternative freight routes. Confirmation of the utility and efficacy of these alternatives—particularly in view of the many complex and vital freight movements that must be handled—would be needed as part of any further development.

c. Of the Harbor Sector freight alternatives, it appears that those farthest from the Inner Harbor have the best chance of meeting the objectives of this study.

d. The cost of a land-based Great Circle Freight Tunnel appears to be one-third that of a Harbor Tunnel. However, the full range of life-cycle benefits and costs—especially, the place of both possible tunnels in the goods movement within, through, to, and from the Baltimore region—would need to be considered in any such choice.

8. If and when the concerned parties wish to progress a restructuring of the railway network in the Baltimore region, significant further analytical work will be unavoidable—and essential to assure that any possible future investment is wisely and optimally spent.

The following section outlines the areas of analysis that the study team deems important to test, confirm, and deepen the results of this study, should the interested polities and companies ever wish to do so.

D. Analytical paths

Topics worthy of further attention would include, but would not be limited to, the following:

1. Further refinement of alternatives

The present study does not claim to be the final word on the desirability of the alternatives it considered, or on the feasibility of other possible approaches. Additional conceptual design work might therefore be devoted to such options as the following:

- **Refinement of existing illustrative alternatives**, already discussed at length in this report. For example, the relative advantages and disadvantages of the Penn Freight and Belt Freight alternatives merit further analysis based on changes in such assumptions as the immovability of the Central Light Rail Line and its support facilities.

- **Other passenger alternatives:**

  — Additional investigation of Central Sector alternative with various station sites, including a station in the Jones Falls Valley, which might avoid the huge cost of a subterranean station under the heart of downtown, but which would not avoid the cost of a tunneled right-of-way in that area.

  — Additional investigation of a Harbor Sector alternative, particularly with respect to finding any suitable station site that is as close and as accessible to Charles Center as the present Pennsylvania Station.

- **Other freight alternatives:**
  - — Additional investigation of the Harbor Sector Locust Point–Canton alternative, particularly regarding alleviation of the grade differential between the low point in the tunnel and the junctions with the freight railroads near Bay View. The effects on passenger infrastructure and operations (and the attendant costs) would figure heavily in any such analysis.
- **Coordination of passenger and freight alternatives:** While the needs of passenger and freight fundamentally differ, it would be prudent to consider two areas of possible coordination:
  - — Optimization of the design of parallel alternatives, to reduce points of conflict and lower the total cost of the two projects where possible. This concept has already been applied in the case of the Great Circle tunnels (see Chapters Seven and Eight).
  - — Exploration of the requirements, costs, and benefits of cross-operability, wherein the passenger route could serve as a bypass route for freight, and/or vice versa, in the event of an emergency or some extended maintenance operation in or near one or other of the facilities. Such cross-operability would need to overcome the inherent differences in design standards and in motive power, and might entail changes in the track layout at critical junctions. It may well be found that the expected benefits of designing for cross-operability of some kind would be outweighed by the costs.

2. Analysis of Washington alternatives

The full benefits of a Baltimore restructuring, at least for freight traffic up down the East Coast, can only materialize if the clearances in Washington's Virginia Avenue Tunnel are relieved simultaneously with those in Baltimore. Accordingly, an analysis of the Virginia Avenue Tunnel—and of any other clearance constraints in the affected traffic lanes—would appropriately take place concurrently with further examinations of the challenges in Baltimore.

3. Operations analysis

For each alternative under consideration, operational studies would be necessary to verify the degree of improvement they promise, with respect to both the present situation and each other. The techniques employed would be as follows:

a. Train Performance Calculator runs

Train performance calculators (TPCs) model the acceleration, speed, running time, and fuel consumption of an individual train over a predefined segment of railroad. For each alternative, detailed TPC runs would need to be performed—not just for main line traffic over the contemplated alignment, but also for the important and typical local movements within the Baltimore region. An alternative that expedites through service but harms the quality of most local operations is not likely to meet the objectives for a Baltimore restructuring. This is particularly true of freight traffic, with its complex set of origins and destinations in the region.

b. Modeling of train movements for capacity review

In a complex situation like that of Baltimore, a TPC run—modeling a single train—serves only as a preliminary screening device. To verify the practicality of a particular alternative requires a simulation of *all* train movements and interactions within a given operating region over an extended period of time—for example, a week. Such a simulation, dealing with both scheduled and unscheduled trains, would offer the best available analytical proof of an alternative's capacity and its built-in bottlenecks. Knowledge of the latter can be fed back into the design process in an iterative manner.

The simulations, whether for passenger or freight alternatives, would have to cover not just the tunnels and approaches, but also the junctions between freight and passenger routes, and any other links and nodes of the network where capacity is at issue. To do less would be to ignore potentially serious operating conflicts, which must be avoided if a given alternative is to fulfill the first objective of any restructuring—to make the situation no worse than it is today (see Chapter Five).

c. Signal layout

The placement of signals, at yards and interlockings and on main line tracks, has a significant impact on operations and would be reflected in simulation results. Therefore, a signal layout would need to be designed to accompany any alternative, prior to the simulation of train interactions.

d. Support facilities

Both passenger and freight support facilities would require careful attention.

(1) Passenger

For passenger service, significant issues remain unresolved and would need study if any alternatives are to be progressed:

- Station configurations for all affected stations would require thoroughgoing attention, with respect to platform locations and lengths, track layouts, connections to the approach tracks, pedestrian flows within the station complex, and passenger access/egress. In some cases the choice of a freight alternative would affect the passenger station configurations.
- The station configurations could affect the ability to store commuter trains during the day and overnight. Thus, the location, size, cost, and operational characteristics of MARC storage and support facilities within each of the passenger and freight alternatives would require scrutiny.

(2) Freight

As discussed in Chapter 8, some of the alternatives could affect the design, or operation, or both, of certain freight yard facilities. All such affects would be identified and analyzed.

4. **Geology/underground utilities**

With tunneling so integral to any railroad restructuring in Baltimore, development of any alternatives would necessitate a comprehensive search for past boring information, new borings along potential routes, and the assembly and analysis of all utility maps of the affected areas. This intensive effort would supplement the initial searches undertaken within the scope of this work.

5. **Confirm right-of-way/property lines**

Studies of the affected rights-of-way would be needed to refine the cost of land takings and review options for not taking land, wherever possible.

6. **Construction staging**

For each alternative under continued scrutiny, a preliminary staging sequence would be developed and any required temporary facilities would be identified.

7. **Refine construction cost estimates**

On the basis of all the foregoing analytical work, it would be possible and necessary to develop updated estimates of the capital investment required for each alternative.

8. **Prepare comprehensive benefit/cost analyses for the alternatives**

Drawing on the operational and other investigations, total life-cycle benefits and costs would appropriately be calculated for each of the rail restructuring alternatives; furthermore, the incidence of those benefits and costs (i.e., the share to be borne by the general public, by the railways, and by other entities) could be estimated. The results of these analyses would provide much fuller information to decision-makers and the public at large than estimates of construction costs alone, and would better prepare the way for the environmental documentation.

9. **Review regional alternatives for freight movement**

Future analysis would appropriately place the Baltimore restructuring options in their larger context by examining other possibilities for handling the projected increases in passenger and freight traffic. Under this category, analyses of the following would appropriately occur:

- Likely performance of the Baltimore network if no improvements are made and the traffic increases are retained in the rail mode[3];
- Implications, on other modes' congestion and facility requirements, of handling future traffic increases by other modes, especially highway (and air to the extent of available capacity and likely demand);
- Alternatives for upgrading or devising other rail freight routes[4] that would bypass the Baltimore region for through traffic in various national traffic lanes; their costs,

[3] Of course, certain of the increases projected in Chapter 4 cannot occur in the "no-improvement" case.
[4] There are no such conceivable options for passenger traffic.

benefits, and effects upon traffic to, from, and within the study region; their consequences for the various carriers that would be involved.

These "what-if" scenarios could provide a useful contribution to the environmental documentation, by broadening the range of alternatives covered in the background studies.

10. Institutional arrangements

As indicated in Chapter 2, the Achilles heel of Baltimore's railway network at the time of its construction was its fragmented ownership rife with intramodal rivalries. This condition precluded any concerted effort to overcome the challenges of topography and development; hence the network of today.

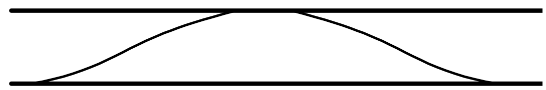
Much has changed since the 19^{th} Century, within the railroad industry and in the industry's place in American transportation. It is therefore conceivable that someday, given a plan that draws on all the analytical processes envisioned in this chapter, the private and public sectors may be able to succeed where the magnates of the 19^{th} century failed, in providing a railway infrastructure in Baltimore that meets contemporary standards for both engineering and service. To effect such an accomplishment, and to derive all its promised benefits in a cost-effective manner that responds to the public convenience and necessity, would require well-designed institutional structures and relationships. Cost sharing would be an issue of profound importance, for example. The creation or adaptation of such institutions, and the resolution of cost and operational issues before any construction begins, would be an analytical task in itself of very high importance.

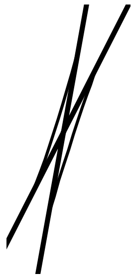
11. Environmental documentation

The analyses described above would help to support the indispensable task of preparing the necessary environmental documentation for a restructuring of Baltimore's railway network.

GLOSSARY AND LIST OF ACRONYMS

Acronym/ Term	Meaning
ADA	Americans With Disabilities Act
AAR	Association of American Railroads (headquartered in Washington, D.C.; represents the Class I railroads)
AREMA	American Railway Engineering and Maintenance-of-Way Association
CFS	FRA's Commercial Feasibility Study of high-speed ground transportation, summarized in the 1997 report *High-Speed Ground Transportation for America*, available on-line at: http://www.fra.dot.gov/us/content/515
C&O	Chesapeake & Ohio Railway
CP	Control point—a term designating an interlocking, where trains can switch tracks. CP-Virginia is the current designation for the former "Virginia Interlocking."
CSXT or CSX	CSX Transportation, Inc., one of the Nation's largest freight railroads. CSXT comprises, among many other predecessor railroads, the former Baltimore & Ohio Railroad and Western Maryland Railway, and is thus a major owner and operator of Baltimore's railway infrastructure.
CTP	Corridor Transportation Plan
duckunder	A railway structure in which the branch line, separating from the main, gradually ramps down and, on attaining sufficient vertical distance from the main line grade, smoothly bears away from the principal right- of-way beneath a bridge carrying the main line tracks.
FRA	Federal Railroad Administration
GCFT	Great Circle Freight Tunnel—the main component (with variations possible) in a freight solution in the "Near North Sector" as defined in the report.
GCPT	Great Circle Passenger Tunnel—the main component in a passenger solution in the "Near North Sector" as defined in the report.
GIS	Geographical Information System
HP	High-level platform (at passenger stations)

Acronym/ Term	**Meaning**
interlocking	 Schematic of a universal, two-track interlocking (each track is represented by a single line). A location where carefully laid-out turnouts ("switches") allow trains to move from one track to another. The trackwork and accompanying signals are all controlled by a mechanical apparatus and/or electric circuitry that is "interlocked" to prevent conflicting paths from being established for simultaneously passing trains. A **universal interlocking** on a multiple-track railroad allows trains to move from any track to any other track.
JFX	Jones Falls Expressway, Baltimore City's north/south freeway.
LP	Low-level platform (at passenger stations)
MP	Milepost
MARC	The commuter rail operation of the State of Maryland, managed by the State's Mass Transit Administration.
MAS	Maximum Authorized Speed
NC	Northern Central Railway, ultimately a component of the Pennsylvania Railroad. A north/south route that followed the Jones Falls Valley to Harrisburg, thence up the Susquehanna Valley to central Pennsylvania and western New York State.
NEC	Northeast Corridor
NECIP	Northeast Corridor Improvement Project (sometimes: Program), a large Federal investment in the NEC main line, most of which occurred between 1976 and 1984.
NEC South	The portion of the NEC main line between New York, Philadelphia (30^{th} Street), Baltimore, and Washington.
NS	Norfolk Southern Corporation
P&BR	Patapsco & Back Rivers Railroad
PRR	Pennsylvania Railroad

Acronym/ Term	Meaning
slip switch	 Where two tracks cross at grade at an acute angle, a special piece of trackwork that allows for trains to either go straight or diverge to the other track. A very simple schematic of a slip switch appears to the left. Because slip switches are complex and labor-intensive to maintain, modern railway engineering practice is to avoid them where possible.
STB	Surface Transportation Board, successor to the Interstate Commerce Commission
TEA-21	Transportation Equity Act for the 21st Century, enacted June 9, 1998 as Public Law 105-178
TPC	Train Performance Calculator
track chart	A scroll-like line diagram of a particular section of railroad, showing (among other items) each track, the degree of curvature and location of each curve, grades, stations, interlockings ("control points"—places where trains can switch from one track to another) and other details of the road's facilities and geometry.
Washington	All references to "Washington" are to "Washington, D.C."
WM	Western Maryland Railway, now a component of CSX.