Appendix 9

TECHNICAL REPORT
Task 9: Service Development Plan

November 2014





New Hampshire

Capitol Corridor Rail & Transit Alternatives Analysis (Parts A & B)

State Project Numbers 16317 and 68067-A

New Hampshire DOT
Department of Transportation

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AA	Alternatives Analysis
ACSES	Advanced Civil Speed Enforcement System
ADA	American Disabilities Act
AHWD	Automatic Highway Warning Devices
AIP	Airport Improvement Program
AREMA	American Railway Engineering and Maintenance-of-Way Association
ARRF2	Aggregate Rail Ridership Forecasting Model 2.0
B&M	Boston and Maine Railroad
BX	Boston Express
CAT	Concord Area Transit
CBD	Central Business District
CFR	Code of Federal Regulations
CMAQ	FHWA Congestion Mitigation and Air Quality Improvement Program
CN	Canadian National Railroad
CNHRPC	Central New Hampshire Regional Planning Commission
CPF-NC	Control Point: Freight Main Line – North Chelmsford
CTC	Centralized Traffic Control
CTPP	Census Transportation Planning Package
CTPS	Central Transportation Planning Staff
CWR	Continuous Welded Rail
CY	Cubic Yard
DCS	Data Communication System
EA	Each
ETMS	Enhanced Traffic Management System
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Agency
GHG	Greenhouse Gas
GHGER	Greenhouse Gas Emissions Reduction
GIS	Geographic Information System
GL	Gallon
GP	General Purpose
HOV	High Occupancy Vehicle
HR	Hour

HSIPR	High-Speed and Intercity Passenger Rail
ICE	Iowa, Chicago and Eastern Railroad
ICE-CN	Iowa, Chicago and Eastern Railroad/Canadian National Railroad
LEED	Leadership in Energy and Environmental Design
LF	Linear Foot
LOS	level of service
LRTA	Lowell Regional Transit Authority
LS	Lump Sum
LSP	Licensed Site Professional
MAP-21	Moving Ahead for Progress in the 21st Century Act
MAPC	Metropolitan Area Planning Council
MassDOT	Massachusetts Department of Transportation
MBCR	Massachusetts Bay Commuter Railroad Company
MBTA	Massachusetts Bay Transportation Authority
MCP	Massachusetts Contingency Plan
ML	Main Line
MoE	Maintenance-of-Equipment
MoW	Maintenance-of-Way
MP	Mile Post
mph	miles per hour
MPO	Metropolitan Planning Organization
MTA	Manchester Transit Authority
MUTCD	Manual on Uniform Traffic Control Devices
MVPC	Merrimack Valley Planning Commission
MVRTA	Merrimack Valley Regional Transit Authority
NEGS	New England Southern Railroad
NEPA	National Environmental Policy Act
NHDOT	New Hampshire Department of Transportation
NHML	New Hampshire Main Line
NH OEP	New Hampshire Office of Energy and Planning
NHRTA	New Hampshire Rail Transit Authority
NMCOG	Northern Middlesex Council of Governments
NNEPRA	Northern New England Passenger Rail Authority
NORAC	Northeast Operating Rules Advisory Committee
NOTAX CVA	Non-Taxable Conservation Area
NRPC	Nashua Regional Planning Commission
NTS	Nashua Transit System
O&M	Operations and Maintenance
OCP	Opportunity Corridor Performance District
PAR	Pan Am Railways
pc/mi/ln	passenger-cars-per-mile-per-lane
PFC	Passenger Facility Charge
P&R	Park-and-Ride
PRCIP	Passenger Rail Corridor Investment Plan

PRIIA	Passenger Rail Investment and Improvement Act
PSNH	Public Service of New Hampshire
PTC	Positive Train Control
RCRA	Resource Conservation and Recovery Act
RDC	Rail Diesel Cars
RFP	Request for Proposal
RGGI	Regional Greenhouse Gas Initiative
RIDOT	Rhode Island Department of Transportation
ROW	Right-of-Way
RPC	Regional Planning Commission
RRIF	Railroad Rehabilitation and Improvement Financing
RSIA	Rail Safety Improvement Act
RTC	Rail Traffic Controller
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SDP	Service Development Plan
SNHPC	Southern New Hampshire Planning Commission
SY	Square Yard
TEA-21	Transportation Equity Act for the 21st Century
TIFIA	Transportation Infrastructure Finance and Innovation Act
TIGER	Transportation Investment Generating Economic Recovery
TOD	Transit-Oriented Development
TN	Ton
TSM	Transportation Systems Management
UNH	University of New Hampshire
UP	Union Pacific
USDOT	United States Department of Transportation
v/c	Volume-to-Capacity
VMT	Vehicle Miles Travelled
WIA	Workforce Investment Area

1 Project Purpose and Need Summary

Increasing transportation demand and growing concerns about mobility, economic development, and quality-of-life have led New Hampshire and Massachusetts citizens and officials to explore transit and/or intercity passenger rail service options in the 73-mile corridor (Capitol Corridor) between Boston, Massachusetts and Concord, New Hampshire.[1] The purpose of this Capitol Corridor Rail and Transit Alternatives Analysis (AA) Study is to evaluate a diverse set of rail and bus options to improve connectivity by leveraging existing transportation infrastructure, including Pan Am Railways (PAR), Route 3, and I-93. Investment in an improved transportation strategy is needed for several reasons:

- Projected population growth will result in increased roadway congestion
- New Hampshire's existing transportation network does not effectively connect existing modes
- The regional economy is singularly dependent on roads for movement of goods and passengers
- Improved transportation options will attract employers to New Hampshire and improve employment options for New Hampshire residents
- Young New Hampshire professionals are leaving the area to be closer to employment and cultural/social opportunities associated with larger urban centers
- New Hampshire's growing senior population needs more "car-light" mobility options
- Residential development patterns resulting from population growth may negatively impact the region's existing quality-of-life
- The existing transportation network cannot accommodate increased levels of demand without negative environmental consequences

2 Task Objectives

Service development planning is the technical analysis of new passenger rail (and related public transportation) services by progressively narrowing the set of reasonable alternatives that can best meet corridor needs. The Service Development Plan (SDP) lays out the overall scope and approach for the proposed service alternative as selected through the National Environmental Protection Act (NEPA) screening process. Primary SDP objectives include the following:

- Clearly demonstrate the Rationale for new or improved passenger rail service
- Summarize analysis of the proposed new or improved passenger rail service and describe the alternative that would best address the Rationale and Purpose and Need as identified through the NEPA process

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[1] The report "Task 2: Project Purpose and Need" (Appendix 2 to the AA Final Report) provides an in-depth evaluation of the Capitol Corridor's historical, current, and future state, and how Massachusetts and New Hampshire citizens would benefit from a transit investment strategy responsive to transportation needs and the region's economic, social, and environmental climate

- Demonstrate the operational and financial feasibility of the new service
- As applicable, describe how SDP implementation may be divided into discrete phases

This Capitol Corridor AA Study was jointly funded by the Federal Transportation Agency (FTA) and Federal Railroad Administration (FRA) to ensure the broadest possible universe of alternatives was considered to address the corridor's transportation issues. While these two funding streams supported one Study, each agency designated use of their funds for specific tasks and geographies. This SDP responds to the FRA's desire to identify and implement corridor projects and programs that will achieve four results:

1. Serve as a catalyst for growth in regional economic productivity and expansion by stimulating domestic manufacturing, promoting local tourism, and driving commercial and residential development
2. Increase mobility by creating new choices for travelers in addition to flying or driving
3. Reduce national dependence on oil
4. Foster livable urban and rural communities

This project also lays the groundwork for developing future intercity rail services north – from Boston into New Hampshire and beyond. A Passenger Rail Corridor Investment Plan (PRCIP), including preparation of a NEPA environmental review, will become the foundation for potential future efforts (i.e., engineering design, environmental reviews, permitting, and construction).

3 SDP Report Organization

This SDP is composed of 10 sections:

- Rationale, Goals, and Objectives
- Existing Corridor Conditions
- Service Alternatives
- Market Analysis
- Preferred Intercity Rail Service Design and Operations
- Preferred Intercity Rail Stations and Layover Facilities
- Preferred Intercity Rail Required Capital Improvements and Capital Costs
- Forecast Operating Costs and Revenues
- Preferred Intercity Rail Public Benefits
- Preferred Intercity Rail Implementation and Finance

4 Rationale, Goals, and Objectives

The fundamental starting point of any transportation planning effort is to identify the Rationale for improving transportation system service. To meet federal standards, this Rationale conforms to and supports the Purpose and Need Statement as mandated by the NEPA.[2] This Statement defines the public concern that provoked the need to study infrastructure investment in the environmental review process. The definition of the transportation problem considers current and forecasted travel demand and capacity conditions, describes transportation challenges and opportunities faced in markets to be served by the proposed service, and defines the Study's goals and objectives.

4.1 Public Concern/Project Need

The New Hampshire Capitol Corridor AA Study, jointly funded by FRA and FTA, was initiated by the New Hampshire Department of Transportation (NHDOT) in cooperation with the Massachusetts Department of Transportation (MassDOT) to explore and evaluate opportunities to improve public transportation service (intercity rail, commuter rail, express bus) along the 73-mile corridor between Boston, Massachusetts and Concord, New Hampshire (Figure 4.1). The corridor is currently served by express and intercity bus service between New Hampshire and Boston and by commuter rail and express bus service within Massachusetts.

Figure 4.1: New Hampshire Capital Corridor Study Area

The most heavily used transit service in the corridor is the Massachusetts Bay Transportation Authority's (MBTA) commuter rail service, which runs 25 miles between Lowell and Boston and carries more than 17,000 passenger trips each weekday. Permanent passenger rail service has not operated north of Lowell since 1967. A Public Private Partnership, supported by the State of New Hampshire, operates 80 weekday bus trips within the corridor between Manchester, Nashua, and Boston. This service typically carries 1,800 passengers per day. A related private enterprise uses a state-

[2] See Appendix 2 to the Capitol Corridor AA Final Report (Task 2: Project Purpose and Need)

owned terminal to operate intercity bus service between Concord and Boston that carries 150 passengers on typical day. Further south, several publicly operated express bus services link communities up and down the I-93 corridor in Massachusetts with downtown Boston. All together, the Massachusetts bus services carry 2,200 passengers on a typical day.

For purposes of the AA Study, the Capitol Corridor is defined as the area included in the Central New Hampshire Regional Planning Commission (CNHRPC), the Nashua Regional Planning Commission (NRPC), Rockingham Planning Commission, the Southern New Hampshire Planning Commission (SNHPC), the Merrimack Valley Planning Commission (MVPC), the Northern Middlesex Council of Governments (NMCOG), and the Boston Region Metropolitan Planning Organization (MPO).

4.1.1 Study Corridor Dynamics

Metropolitan Boston, like most large American cities, has been continuously extending its reach and geographic scope for decades. With a 20th century highway network and 21st century communication links, the economies of Boston, Nashua, Manchester, and Concord have never been more closely intertwined. Boston's zone of influence first moved beyond I-95/Route 128, then I-495 in Massachusetts, and now clearly extends into southern New Hampshire. It can be expected to continue expanding northward, in addition to westward and southward.

Expansion of the metropolitan area and the Boston commuter-shed has contributed to congestion in the Capitol Corridor, especially near Boston and particularly on I-93. This congestion results partly from the fact that Route 3 loses its freeway functionality south of I-95/Route 128, which negatively impacts traffic flow on the Lowell-Nashua-Manchester side of the corridor.

The congestion resulting from heavy north-south travel along corridor is exacerbated by sprawl-type suburban residential development patterns throughout parts of southern New Hampshire. Sprawl-type development contributes to increased vehicle miles travelled (VMT) throughout the corridor. Denser development patterns do exist within the corridor, particularly in Nashua, Manchester, and Concord.

Business development and job creation in the northern two thirds of the corridor have not kept pace with residential growth, especially in the high-technology sectors that are flourishing in the southern third. This residential/employment disconnect exacerbates transportation issues driving the Capitol Corridor AA Study.

Existing express and intercity bus services are not attractive to an especially broad market and employ a park-and-ride strategy with a focus (mainly) on park-and-ride facilities located at or very near freeway interchanges. This strategy does not promote the dense, sustainable development that leads to reduced VMT.

4.1.2 Project History and Planning Context

Passenger rail service in the corridor started 175 years ago when a train from Boston first pulled into Nashua. Freight service on the line has run continuously since that time. Regular passenger rail service between Concord and Boston ended in 1967, with the exception of a brief restoration of service during a

1980-81 demonstration project. As the region has grown, traffic congestion on the main highway arteries has increased with adverse impacts on travel time and reliability for automobile and bus travel. Consequently, public interest in passenger rail service has grown (as trains are insulated from highway congestion and less likely to impact air quality).

Since the 1980s, numerous studies and plans have supported the return of passenger rail service and expanded transit options in this corridor:

- In 1984, the MBTA and the Boston and Maine Railroad (B&M) studied an extension of commuter rail service to Nashua's newly opened Pheasant Lane Mall. In the early 1990s, NHDOT Commissioner Charles O'Leary and Congressman Dick Swett asked MBTA to consider extending its commuter rail service into Nashua.
- In 2006, the Community Advisory Committee to the NHDOT Commissioner recommended expanded passenger rail as one of the five "initial action items" in its final report, a component of the state's long-range transportation plan.
- In 2007, New Hampshire invested $35 million in new express bus services for travel from greater Manchester and Nashua to Boston. NHDOT has also supported private bus service from Concord to Boston with the purchase of buses and construction of a new bus terminal in Concord.
- In 2007, the New Hampshire legislature created the New Hampshire Rail Transit Authority (NHRTA) with a charge to establish passenger rail service in New Hampshire.
- In 2009, the *New Hampshire Climate Action Plan*, prepared by the New Hampshire Climate Change Policy Task Force, recommended expanded passenger service as part of a balanced transportation system.
- In 2003, the state departments of transportation from New Hampshire, Vermont, and Massachusetts commissioned a feasibility study for the Boston to Montreal rail corridor: *Boston to Montreal High-Speed Rail Planning and Feasibility Study Phase I: Final Report.* The study describes existing conditions, including within the Boston to Concord portion of the Study corridor, and presents a ridership analysis of stations in the corridor. The study found that "further study of associated operational, engineering and cost/revenue factors is warranted."
- In 2004, NHDOT developed a *Lowell, MA to Nashua, NH Commuter Rail Extension Project Environmental Assessment* in anticipation of extending MBTA commuter rail service to New Hampshire.
- The 2010 *New Hampshire Capitol Corridor Project Overview,* a white paper prepared for Amtrak, detailed the corridor's state-of-readiness to function as part of the federal High Speed Intercity Passenger Rail (HSIPR) program.
- Also in 2010, NHRTA commissioned the report *Economic Impact of Passenger Rail Expansion along the New Hampshire Capitol Corridor*. The report assessed the economic impacts of restoring intercity passenger rail service between Boston and Concord. The study supports the case that the implementation of passenger rail along this corridor is a net economic benefit for New Hampshire.

- In 2011, the University of New Hampshire (UNH) Survey Center conducted a poll of New Hampshire residents' attitudes regarding the extension of commuter rail service on the Capital Corridor. It suggested that a majority of residents strongly favored extending commuter service into New Hampshire and a plurality that supported using federal funding to study the issue.
- In 2014, a second poll was conducted that found 68 percent of New Hampshire residents favor the Capitol Corridor project to extend passenger rail service up the Merrimack River valley into New Hampshire. Only seven percent of the statewide sample opposed the service expansion, while 25 percent were undecided or had no opinion.

4.1.3 Population and Employment

While both the New Hampshire and the Massachusetts portions of the corridor are projected to grow over the next two decades (Table 4.1), the Massachusetts portion is projected to grow at a slightly faster pace. It can be anticipated that this population growth will increase demand on the transportation network, which may result in increased levels of congestion and travel times, particularly in corridor's southern portion, which already experiences intense peak-hour highway congestion.

Table 4.1: Historical, Existing, and Forecast Population in the Capitol Corridor Study Area

Geography	1990	2000	2010	2020	2030	2035	Total Change 2010-2035	Percent Change 2010-2035
MA Study Area	3,474,873	3,666,175	3,782,361	3,942,000	4,093,000	4,182,000	399,639	10.6%
NH Study Area	647,011	733,134	775,520	801,029	832,598	840,034	64,514	8.3%
Total	**4,121,884**	**4,399,309**	**4,557,881**	**4,743,029**	**4,925,598**	**5,022,034**	**464,153**	**10.2%**

Source: Metropolitan Area Planning Council (MAPC), NMCOG, MVPC, New Hampshire Office of Energy and Planning (NH OEP)/ CNHRPC. Note: areas include Boston Region MPO, NMCOG, MVPC, CNHRPC, SNHPC, NRPC, and Rockingham Planning Commission

The nation's largest population group falls between the ages 35 and 64. The fraction of New Hampshire's total population that falls within that age group is higher than Massachusetts, New England, or the nation. The growth of New Hampshire's population over age 65 increased at a significantly faster rate between 2000 and 2011 than in Massachusetts, New England, or U.S.

The median age has increased within the Study corridor, New Hampshire, Massachusetts, New England, and the U.S. The increase in median age has been greatest within the Study corridor (four years), which is more than twice the nationwide increase in median age during the same time period (1.7 years).

Residents of New Hampshire and the Study corridor are older and aging at a faster pace than the surrounding states and the nation. As New Hampshire's residents age, a robust multi-modal transportation network that reduces reliance on single-car ownership will be necessary to support continued mobility and maintain their quality-of-life.

In addition to understanding existing and projected population growth, it is important to ensure that the specific needs of mobility-challenged populations are considered when developing and evaluating transport investment strategies. These households rely on public transportation for local and regional travel (Table 4.2). Maximizing project benefits to these populations while minimizing adverse impacts is important to the success of expanded public transportation services (rail or bus) in the Capitol Corridor.

Table 4.2: Zero Car Households in the Study Corridor

Geography	Zero Car Households	Total Households	Percent of Households with Zero Cars
Boston Region MPO	193,254	1,263,402	15.3%
Merrimack Valley Planning Commission	13,644	143,769	9.5%
Northern Middlesex Council of Governments	9,099	129,979	7.0%
Massachusetts Total	**215,997**	**1,537,150**	**14.0%**
Central New Hampshire RPC	2,958	54,519	5.4%
Nashua RPC	3,533	87,570	4.0%
Rockingham Planning Commission	2,798	80,423	3.4%
Southern New Hampshire Planning Commission	5,937	124,784	4.8%
New Hampshire Total	**15,226**	**347,296**	**4.4%**
STUDY CORRIDOR TOTAL	**231,223**	**1,884,446**	**12.3%**

Source: American Community Survey 2010 Five-Year Data

Employment

Employment levels within the five Study corridor counties are shown in Table 4.3. Employment has generally been growing at one to two percent per year over the last five years.

Table 4.3: Number of Jobs in the Five Counties that the Study Corridor Passes Through (2013 Q2)

Geography	2013 Q2	2012-2013 Change
New Hampshire	602,462	1.1%
Hillsborough County, NH	193,248	1.2%
Merrimack County, NH	75,768	1.0%
Rockingham County, NH	139,900	1.6%
Massachusetts	3,352,700	1.3%
Middlesex County, MA	847,700	1.9%
Suffolk County, MA	608,100	1.7%

New Hampshire Source: Longitudinal Employer-Household Dynamics; http://ledextract.ces.census.gov/
Massachusetts Source: Bureau of Labor Statistics, County Employment and Wages in Massachusetts – Second Quarter 2013; http://www.bls.gov/ro1/maqcew.htm

Massachusetts and New Hampshire each forecast industry growth (by the North American Industry Classification System) to 2020. Massachusetts organizes the projections by Workforce Investment Areas (WIAs), while New Hampshire uses the RPC jurisdictions. While the WIA boundaries do not exactly conform to the Capitol Corridor Study area, the Study area generally falls within four WIAs.
Table 4.4 highlights the fastest-growing industries through 2020. The fastest-growing industry in each geography is highlighted in bold font. The fastest growing industries in Massachusetts are – with the exception of construction – service-oriented industries: finance and insurance, professional, scientific and technical services, and other services. New Hampshire's fastest-growing industry – with the exception of professional, scientific, and technical services in NRPC – is health care and social assistance.

These findings reflect New Hampshire's comparatively higher older population and the role of Boston as a regional finance, technology, and business service hub.

Table 4.4: Projected Change in Industry Employment 2010-2020

	Massachusetts					New Hampshire			
NAICS Industry	**Boston WIA**	**Greater Lowell WIA**	**Lower Merrimack Valley WIA**	**Metro North WIA**	**North Shore WIA**	**Rockingham RPC**	**Central NH RPC**	**Southern NH RPC**	**Nashua RPC**
Construction		**50%**			**41%**				
Wholesale Trade		49%			33%				
Retail Trade									
Transportation and Warehousing		34%							
Finance and Insurance				**60%**					20%
Professional, Scientific and Technical Services	36%		**44%**	27%		22%	17%	23%	**26%**
Administrative/Support/Waste Mgmt./Remediation				24%	26%	19%	20%	19%	
Health Care and Social Assistance						**24%**	**25%**	**25%**	24%
Arts, Entertainment and Recreation	33%		35%						
Other Services	**43%**		37%						

Source: Massachusetts Executive Office of Labor and Workforce Development, the Bureau of New Hampshire Employment Security

Households within the Study corridor have a median income over $80,000 per year – greater than median incomes of New Hampshire, Massachusetts, New England, and the nation. This may reflect the fact that the Study corridor includes the most densely developed areas of Massachusetts and New Hampshire (where residents tend to have higher incomes) and excludes the majority of the lower density, rural areas (where residents tend to have lower incomes). Median household income within the Study corridor has risen by two percent (in 2011 constant dollars) between 2000 and 2011, which outperformed New Hampshire, Massachusetts, New England, and the nation.

While the Study corridor fraction of the population living below the poverty line is lower than for all of New Hampshire, all of Massachusetts, or the entire nation, it increased 18 percent increase between 2000 and 2011. As the population living in poverty grows, it will be increasingly important to provide these residents with lower-cost mobility options that reduce the need to own a car.

4.1.4 Existing and Future Land Use

A legacy of New Hampshire's and Massachusetts' colonial and 19th century industrial past is the prevalence of the traditional town-center pattern of development, which was designed to support pedestrian rather than vehicular traffic. This style of development has a comparatively high-density mix of uses in the "downtown" that is easily accessed on foot from the surrounding residential areas. While some infrastructure elements have been retrofitted to facilitate driving, the historic downtown development patterns of Boston, Lowell, Nashua, Manchester, and Concord (and other smaller towns within the Study corridor) reduce the prioritization of cars and elevate the role of pedestrian and non-motorized modes of transportation.

Another traditional land use pattern, particularly within the New Hampshire portion of the corridor, includes rural, farmland, and open spaces. These land uses, and the environmental assets they preserve, are a critical element of New Hampshire's identity and a major factor in the continued high quality-of-life for New Hampshire residents.

As the population has grown over the decades and development has spread outside of these traditional town-centers, auto-oriented, lower-density residential, and commercial development patterns have emerged. These patterns, which can be found throughout the Study corridor, are typically dominated by the segregation of land uses (as opposed to the mixed use patterns that can be found in the town-center style of development). These separated land uses are connected by comparatively few limited access roadways, which can result in increased levels of traffic congestion during peak travel times.

Both Massachusetts' and New Hampshire's population is projected to grow over the next two decades: According to recent research one-quarter of New Hampshire residents were born in Massachusetts and the population of Massachusetts-born residents is growing faster than the population born in the state.[3] Regardless of the source of the population growth, it will continue to exert increased development pressure on New Hampshire's communities. In the absence of a strategic land use framework, this pressure could result in increased levels of congestion, encroachment into open spaces, and a reduced quality-of-life.

Communities throughout New Hampshire and Massachusetts, including those within the Study corridor, have recognized the potential costs associated with policy and regulatory inaction, and have undertaken numerous land use and development planning activities designed to encourage more sustainable land use patterns.

4.1.5 Economic Development and Land Use

Access to Boston-based Employment

Public transportation investment along the Capitol Corridor will improve multi-modal connectivity between New Hampshire's residents and Boston, the region's major employment center. Expanded access to Massachusetts' diversified employment base will benefit existing New Hampshire residents, and may encourage them to stay in their current communities rather than move closer to Boston.

[3] Kenneth M. Johnson; Many New Voters Make the Granite State One to Watch in November; Carsey Institute; http://cola.unh.edu/sites/cola.unh.edu/files/research_publications/IB-NHVoter08.pdf

Business Attraction in New Hampshire

In addition to improved access to Boston's employment market, public transport investment in the corridor may be leveraged to lure businesses into New Hampshire. Millennials – the 18- to 34-year-olds that rival the Baby Boomers in size and cultural influence – have repeatedly stated a preference for built environments that support a car-light or car-free urban-style existence. These Millennials are the rising "creative class" – workers whose career orientation is towards ideas and innovation rather than heavy manufacturing and assembly lines. As businesses – particularly technology-oriented businesses – look for lower-cost alternatives to downtown Boston and more Millennial-friendly environments than the Route 128 corridor, Capitol Corridor communities can increase their attractiveness by investing in non-automotive transport. Improved connectivity will not only improve access to Boston-based employment, but can draw these "creative class" workers (and the companies that want to hire them) into the New Hampshire portion of the Capitol Corridor.

More Strategic and Sustainable Land Use Patterns

Access to the Boston employment market and the attraction of businesses into New Hampshire both rely on the efficient flow of people between their homes and places of employment. Regardless of any transport investment, travel in the corridor is anticipated to increase. In the absence of transportation network investment, this growth in travel will lead to increased levels of congestion and decreased levels of mobility. Simply expanding the roadway network is not a solution to this problem as it would likely induce additional demand that, in turn, would further exacerbate congestion.

While mobility problems are most directly solved by transportation investment, land use patterns play a critical role in supporting the efficient movement of people and goods. In addition to using public transportation investment to expand transportation network capacity, strategic land use planning that focuses higher-density, mixed use development near public transportation stations can reduce demand on the transportation network by supporting trip efficiencies. This land use pattern would reflect a return to the traditional New England "town-center" development style.

More efficient land use patterns can also encourage the expansion of employment opportunities closer to home, resulting in shorter travel distances. This would reduce demand on the transportation network, which would reduce overall travel times and congestion.

Sustainability and Quality-of-Life

A sustainable transportation system is one that meets and balances existing community environmental, social, and economic needs without compromising resources for future generations.

Environmental

A portion of the New Hampshire character is rooted in the state's natural beauty, including its mountain ranges, chains of lakes, sea coast, and protected forest land. The environmental impacts of increased levels of development and corresponding growth in transportation network demand may negatively impact these environmental assets unless proactive investments in sustainable infrastructure are pursued.

New Hampshire's Energy, Environmental, and Economic Development Benchmark Report,[4] released by the New Hampshire Energy and Climate Collaborative in 2012, reports that transportation accounts for 35 percent of the New Hampshire's energy use and 46 percent of the its greenhouse gas (GHG) emissions. Total transportation-related energy consumed and GHG emission rates have remained flat in recent years, even though VMT and per capita VMT have decreased approximately five percent between the peak in 2006 and the most recent data in 2009. At the same time, public transport use has increased 25 percent between 2000 and 2010.

Because the Capitol Corridor is home to the three largest cities in the state (Concord, Manchester, and Nashua) as well as two major north-south arteries (Route 3 and I-93), transportation network investments that support mode shift away from automobiles are likely to support a decrease in per capita VMT and may support reductions in GHG emissions.

Economic

The New Hampshire Center for Public Policy Studies' *From Tailwind to Headwind: New Hampshire's Shifting Economic Trends,*[5] published in 2012, found that state demographic trends are related to economic trends. The state's economic advantage has traditionally been rooted in three areas: consistent population growth, increased productivity, and a more resilient economy than its competitors. However, data shows that population growth is slowing, labor force participation is declining (due to an aging population), and the rate of growth in educational attainment is slowing.

Like the Baby Boomer generation before them, the sheer size of the Millennial generation, those born between approximately 1982 and 2003, means their preferences will shape every aspect of the country's economy and culture in the coming decades. Communities that invest in infrastructure and make policy decisions attractive to this generation will be successful in creating an economic framework for sustainable growth. This is particularly important for New Hampshire, which is aging at a higher-than-average rate. A 2013 report by U.S. Public Interest Research Group, *A New Direction: Our Changing Relationship with Driving and the Implications for America's Future,*[6] came to three conclusions:

- Young people aged 16 to 34 drove 23 percent fewer miles on average in 2009 than they did in 2001 – a greater decline in driving than any other age group. The severe economic recession was likely responsible for some of the decline, but not all.
- Millennials are more likely to want to live in urban and walkable neighborhoods and are more open to non-driving forms of transportation than older Americans.

[4] http://www.unh.edu/news/releases/2012/jun/ds28climate.cfm
[5] http://www.nhpolicy.org/UploadedFiles/Reports/New_Hampshire_New_Reality_2012_final1.pdf
[6] http://www.uspirg.org/sites/pirg/files/reports/ANewDirectionvUS.pdf

- If the Millennial-led decline in per capita driving continues for another dozen years, even at half the annual rate of the 2001-2009 period, total vehicle travel in the U.S. could remain well below its 2007 peak through at least 2040 – despite a 21 percent increase in population.

The Capitol Corridor is home to one of the largest private employers in the state (BAE Systems) and the state's largest labor pool. Public transport investment within this corridor will provide a lower-cost commuting alternative that links New Hampshire residents with employment opportunities while increasing New Hampshire's attractiveness as a place to do business.

Social

In his 2012 report *New Hampshire Demographic Trends in the Twenty-First Century,*[7] Kenneth Johnson of the Carsey Institute at the UNH documents several trends that can be extracted from the most recent census data:

- New Hampshire's population increase is slowing, New Hampshire's population is aging, the pace of demographic change is uneven in the state, and the state is becoming more diverse.
- Young adults are migrating to metropolitan cores, family age residents are migrating to suburbs, major metropolitan cores are losing older residents, and rural counties are losing young adults.
- Many towns in the Capitol Corridor, including Manchester and Nashua, have the largest concentrations for young persons (less than 18) in the state.

Quality-of-Life

Granite State Future is a statewide project coordinating development of regional plans in each of the RPC's jurisdictions. It recognizes the interconnection between development patterns, availability of housing choices, and diversity of transportation choices as a means to preserve natural resources and community vitality and promote energy efficiency. Public transportation investment within the Capitol Corridor would be a powerful investment that can be leveraged to implement this regional, multi-discipline vision to maintain New Hampshire's high quality-of-life.

4.1.6 Project Need Summary

Capitol Corridor dynamics (i.e., population expansion, employment conditions, existing/future land use, and economic development and land use) have contributed to the need for improved public transportation service, as summed below.

[7] http://gencourt.state.nh.us/house/committees/committee_websites/waysmeans/DOI2013/Report-Johnson-Demographic-Trends-NH-21st-Century.pdf

Projected population growth will result in increased roadway congestion. As population density increases over the coming years, an increased number of multi-modal transportation options to Boston, the region's largest employment center, will be critical to mitigate corresponding increases in roadway congestion, particularly along I-93 and Route 3.

New Hampshire's existing transportation network does not effectively connect existing modes. Increased levels of corridor transit investment will improve local and regional mobility by linking travelers to the network of existing transportation modes: roadway, buses, commuter rail, heavy rail, light rail, bicycles, ferries, and airplanes. These increased linkages will improve ridership and usage across all modes, while promoting sustainable mobility.

The regional economy suffers from singular dependency on roads for movement of goods and passengers. Investing in transportation infrastructure that provides an alternative to roadway transport will link New Hampshire's businesses, industries, and residents to the national and New England transportation network.

Improved transportation options will attract employers to New Hampshire and improve employment options for New Hampshire residents. A mismatch between locations of residence and employment forces many in New Hampshire to spend comparatively long periods of time commuting to work. Investing in more efficient transportation modes will not only improve connectivity between existing centers of residence and employment, but increased levels of multi-modal access may also catalyze additional business investment within New Hampshire.

New Hampshire is experiencing a young professional "brain drain." While the region's overall population is projected to grow in the coming decades, young professionals are choosing to leave southern New Hampshire to be closer to the employment and cultural and social opportunities associated with larger urban centers. Improved transit connectivity will support the attraction and retention of young professionals within the Capitol Corridor Study area.

New Hampshire is getting older. New Hampshire's senior population continues to grow. Additional shared transportation accommodations that support "car-light" mobility will be required to accommodate these emerging demographic and lifestyle trends, and will continue to make New Hampshire attractive to residents from childhood through retirement.

Residential development patterns resulting from population growth may negatively impact the region's existing quality-of-life. Population growth, if not guided through strategic infrastructure investments that promote efficiency, will result in uncoordinated development patterns and sprawl, diminishing the region's high quality-of-life and negatively impacting its unique character.

The existing transportation network cannot accommodate increased levels of demand without negative environmental consequences. Expanding existing roadways and constructing new roadways will not be sufficient to sustainably accommodate the projected growth in travel demand, causing negative environmental consequences associated with an increased number of VMT and corresponding congestion.

4.2 Defining the Transportation Problem

4.2.1 Transportation Facilities and Services – Travel Demand and Capacity

The Capitol Corridor's robust transportation network includes roadways, highways, transit services, intercity passenger rail service, freight railroads, airport, and pedestrian and cyclist facilities. Despite the dense, multi-modal nature of this transportation network, peak highway demand outweighs available capacity and opportunities exist to improve connectivity between the current modes.

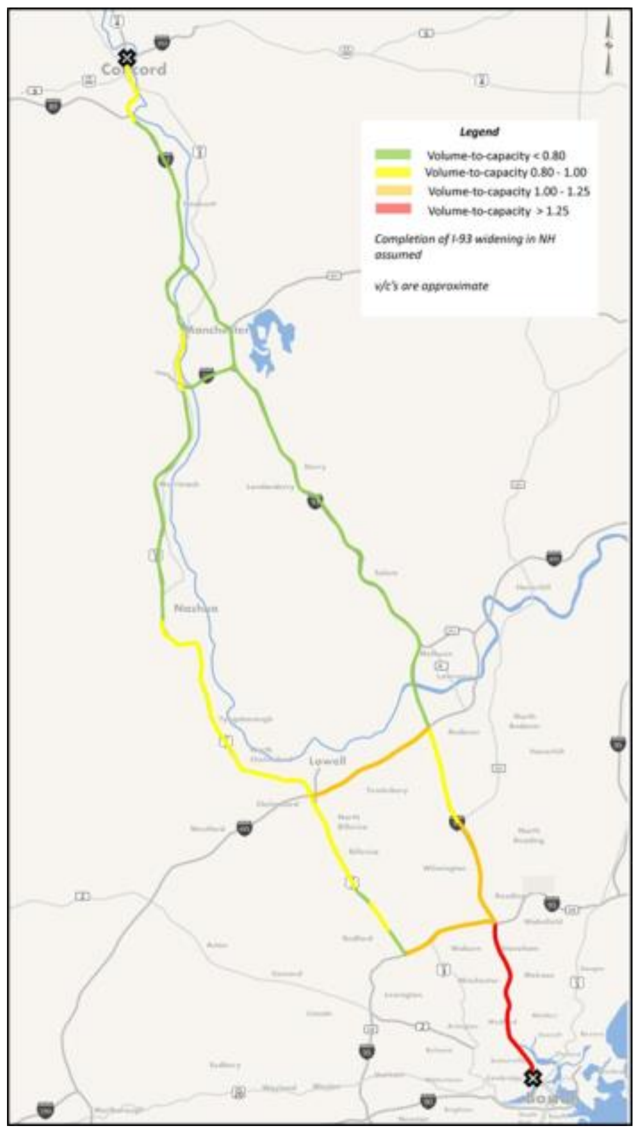
Highway Facilities

The limited access highways that connect New Hampshire's major population centers to metropolitan Boston – I-93, US Route 3/Everett Turnpike, I-95/Route 128, I-293, and, I-495 – cover 134 miles of limited access freeway facilities and interchanges, shared between the States of New Hampshire and Massachusetts. The breakdown on the corridor mileage is as follows:

- I-93: 65 miles
- US Route 3: 49 miles
- I-95/Route 128: 11 miles
- I-293: 11 miles
- I-495: 9 miles

The corridor has experienced rapid population growth, and many of the new residents commute to jobs in greater Boston. New Hampshire and Massachusetts expanded the highway system to accommodate increasing traffic, but the prospects for additional expansion are unlikely due to financial and environmental constraints. At a minimum, the advent of passenger rail service may delay the need for further highway widening. Traffic volume at the state line on US Route 3/Everett Turnpike in Nashua grew by nearly 26 percent from 2002 to 2009, to 88,200 (average daily traffic), and projections are for continued traffic growth in the corridor in both states. More detail on existing highway conditions is provided in *Section 5: Existing Corridor Conditions*; Figure 4.2 shows current morning peak highway volume-to-capacity ratios (more detailed information is provided in *Section 5: Existing Corridor Conditions*, *Highway Level of Service*).

Figure 4.2: Current Morning Peak Highway Volume-to-Capacity Ratios



Public Transportation Services and Facilities

The Capitol Corridor has a variety of commuter and local bus operators, as well as MBTA commuter rail service and Amtrak intercity passenger rail service on the *Downeaster* line.

Regional and Local Bus Service

Seven regional and four local bus operators provide service within New Hampshire and intercity service to Boston and beyond. Boston Express (BX) provides the primary commuter service within the Study area along the heavily congested Massachusetts segments of I-93. Existing traffic congestion along I-93 and Route 3 significantly impact scheduled travel times for express and intercity bus services. For instance, BX's 6:30am southbound departure from Londonderry (Exit 4) on the I-93 service is scheduled for a one-hour trip to Boston South Station. Meanwhile, the 9:50am southbound departure is scheduled for a two-hour and 20 minute trip, which is a built-in or induced delay of one hour, 20 minutes. More detail on existing bus services (Base) is provided in *Section 5: Existing Corridor Conditions*.

MBTA Commuter Rail Service

On a typical weekday in 2014, Lowell was served by 44 MBTA revenue trains to and from Boston's North Station. The 25-mile trip serving up to seven intermediate station stops takes 44 to 49 minutes. Six weekday non-revenue "deadhead" trains run between Lowell and Boston to stage the service because there is no facility for the overnight storage or maintenance of the trains in Lowell. Typical weekday MBTA ridership on the entire line is 17,500 passenger trips, including both northbound and southbound travel. Lowell is the busiest station on the line with 4,280 weekday boardings and alightings. The running time between Lowell and Boston ranges between 45 and 49 minutes with a maximum allowable speed of 70 mph. The daily schedule includes approximately 150 daily deadhead train miles. More detail on existing commuter rail service is provided in *Chapter 5: Existing Corridor Conditions*.

Amtrak *Downeaster* Service

Intercity passenger rail service between Boston and Portland was restored in 2001 after an absence of more than 35 years. The *Downeaster* service features five daily round trips between Portland and Boston North Station, with eight intermediate stops – Woburn, Haverhill, Exeter, Durham-UNH, Dover, Wells, Saco, and, in season, Old Orchard Beach. On November 1, 2012, two daily *Downeaster* trains were extended to Freeport and Brunswick, Maine. Ridership on the *Downeaster* service in FY2013 was nearly 560,000 passengers, up 3.4 percent from the year before. Most trains make the Boston-Portland trip in two hours, 30 minutes.[8] More detail on existing intercity passenger rail service is provided in *Section 5: Existing Corridor Conditions*.

[8] Amtrak Fact Sheet, Fiscal Year 2013, State of New Hampshire

Freight Railroad Service and Facilities

The New Hampshire Main Line (NHML) was, and remains, a principal artery of the B&M network and a key economic link between the Granite State and the national economy. Since the 1980s, the B&M has belonged to a regional amalgam of railroads initially called the Guilford Rail System, later changing its name to PAR. Headquartered in Billerica, Massachusetts, PAR owns and operates the former B&M and Maine Central Railroads as an integrated system, roughly running from Bangor to Albany with numerous branches in New Hampshire and other New England states. North of Chelmsford, PAR refers to the route as its "Northern Branch." More detail on existing rail freight rail service is provided in *Section 5: Existing Corridor Conditions*.

Air Travel

Expanded public transportation in the corridor could create an additional connection between the Manchester-Boston Regional Airport (Manchester Airport or MHT) and Boston – a system in which the three principal Boston-area airports are connected by rail (with the MBTA Blue Line connection at Boston-Logan Airport and the MBTA commuter rail connection to Providence's TF Green Airport). Manchester Airport is an important economic engine for New Hampshire and the region, creating jobs, facilitating commerce, and providing access to the global marketplace. Manchester Airport contributes over $1 billion annually to the region's economy and accounts for more than 3,500 jobs in the three-county region contiguous to the airport. A connection to the airport through an intermodal station adjacent to the airport access highway would create new rail-air connectivity.

Manchester Airport strongly supports the development of passenger rail service in New Hampshire as part of a multi-modal solution to meet the growing and changing transportation needs of the region. The airport incorporated a review of passenger rail service (and an anticipated airport rail station) as a focus of its 2011 *Master Plan Update* and determined that there are important synergies between passenger rail and air passenger transportation systems. Manchester Airport will benefit from both rail ridership by enplaning passengers (air travelers originating from the area and using passenger rail service to travel to the airport from their home or business) and deplaning passengers (air travelers accessing New England through Manchester Airport and using passenger rail service to travel from the airport to their final destination).

4.2.2 Travel Patterns and Market Analysis

Market analysis provides a critical first step to estimate travel demand in the Capitol Corridor. The market analysis provides "big-picture" travel flows in the Study area and identifies their relationship to the corridor by quantifying the total size of the travel market and key origin-destination travel patterns.

The geographic area of the Capitol Corridor travel market is defined by the existing track alignment along the banks of the Merrimack River extending north from Lowell through the proposed station locations of Nashua and Manchester, and ending in Concord. This corresponds roughly with the US Route 3 corridor in New Hampshire. The full length of the corridor varies by alternative, but, at its maximum, generally runs from Concord's intercity bus terminal adjacent to the rail corridor in the north, to Boston's North Station in the south. This section focuses on the New Hampshire market[9] in the proposed Study area, considering three main work and business travel markets:

- New Hampshire to Massachusetts
- New Hampshire to New Hampshire
- Massachusetts to New Hampshire

Mobility of individuals and their ability to reach places of employment, particularly to locations outside their areas of residence, is highly dependent on the availability of an automobile. Workers without an automobile, or access to one, are transit-dependent if they live outside walking or biking distance of their jobs.

Corridor population[10] within the proposed service catchment area is an important indicator of the potential use of transportation infrastructure and services. The corridor connects the three largest cities in New Hampshire: Concord, Manchester, and Nashua. These cities, as well as the other communities on the corridor, represent nearly 39 percent of the population and just over 41 percent of employment in the entire State of New Hampshire. Concord, Manchester, and Nashua alone account for 24 percent of the population and just over 27 percent of the employment in the state.

- **New Hampshire-to-Massachusetts Work-Trip Market:** The New Hampshire communities within the corridor generate approximately 200,000 work trips, of which over 28,000 (14 percent) are destined for locations in eastern Massachusetts. Of these 28,000 trips, approximately 10,000 (35 percent) are destined to locations along the existing MBTA Lowell commuter rail line. These trips are the main component of the New Hampshire-to-Massachusetts work-trip market that would be served by the Capitol Corridor.
- The main destinations of the New Hampshire work trips are Lowell and Boston/Cambridge. Lowell attracts just over 2,000 work trips from the corridor communities and Boston/Cambridge attracts just over 4,000. The Boston/Cambridge trips face severe congestion during work commuting times and are considered a very strong market for the Capitol Corridor service.
- **New Hampshire-to-New Hampshire Work-Trip Market:** Of the approximately 200,000 work trips generated by the New Hampshire corridor communities, just over 170,000 remain in New Hampshire and a large majority of these nearly 148,000 stay within the corridor itself. Not all of these trips are part of the market that the Capitol Corridor project would serve, but they do show the relatively large number of work trips within New Hampshire.

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[9] The New Hampshire market is considered to be communities along the corridor and consists of Concord, Manchester, Nashua, as well as Bow, Pembroke, Hooksett, Goffstown, Bedford, Londonderry, Merrimack, Litchfield, and Hudson

[10] Population, employment, and commuting to work numbers are from the U.S. Census Bureau, 2006-2010 American Community Survey five-year estimates

The intra-New Hampshire market consists primarily of the work trips among the major cities of Concord, Manchester, and Nashua. Excluding intracity trips, the work-trip market between these cities approaches 10,000 trips each weekday.

- **Massachusetts-to-New Hampshire Work-Trip Market:** This market is the smallest of the three major work-trip markets, with a total of 1,370 work trips from the Massachusetts communities in the corridor to the cities of Concord, Manchester, or Nashua. The majority of these trips are from the cities of Lowell (773) and Boston (300). Similar to the trips from New Hampshire to Boston, the trips from Boston face the severe congestion during peak commuting hours.

4.3 Goals and Objectives

A set of goals and objectives (Table 4.5) were developed to determine how well a public transportation (intercity rail, commuter rail, or express bus) investment along the Capitol Corridor will address regional and corridor needs and build on current and recent planning. Research and analysis to date demonstrates that integrated transportation and land use planning can play a positive role in supporting an economically, environmentally, and socially sustainable community. A major public transportation investment would be a significant step in implementing this integrated planning approach within the Capitol Corridor.

Table 4.5: Capitol Corridor AA Study Goals and Objectives

Goals	Objectives
Transportation and Mobility Leverage the existing transportation network to improve access and mobility within the corridor and throughout the region	▪ Provide alternatives to address congestion within the Study corridor ▪ Expand the transit network capacity ▪ Increase transit ridership and mode share by expanding the existing rider base and attracting choice riders ▪ Provide travel time savings ▪ Improve the efficiency, convenience, and reliability of transit service
System Integration Invest in transportation improvements that complement the existing multi-modal transportation network	▪ Increase corridor modal connectivity ▪ Provide connections to other corridors within the region ▪ Increase access to the Manchester Airport through additional transit service ▪ Balance system capacity (MBTA, BX, Concord Coach) ▪ Ensure operating efficiency
Economic Development and Land Use Support the vision for growth laid out in local/regional development plans	▪ Improve access to higher-paying jobs in greater Boston ▪ Support development patterns/lifestyle choices that attract younger, highly educated professionals to New Hampshire ▪ Leverage younger, highly educated employee base to attract new businesses/grow existing ones ▪ Promote Transit-Oriented Development (TOD) to mitigate sprawl development patterns ▪ Improve the potential for additional freight rail business through infrastructure upgrades
Sustainability Support transportation investments that contribute to an environmentally, economically, and socially sustainable community	▪ Leverage existing transportation infrastructure to qualify for federal transportation investment dollars ▪ Mitigate potential adverse environmental impacts resulting from anticipated development ▪ Support growth patterns that attract and retain residents from childhood through retirement ▪ Improve access to other tourism, recreation, and cultural attractions in greater Boston and New Hampshire

5 Existing Corridor Conditions

5.1 Railway Facilities and Services

The first passenger train in New Hampshire arrived in Nashua from Lowell, Massachusetts in October 1838.[11] Passenger rail service along this alignment was soon extended to Manchester and Concord with further extensions into the White Mountains and westerly to Hanover and White River Junction. The NHML was, and remains, a principal artery of the B&M network. Consequently, the line functions as a key economic link between the Granite State and the national economy. NHML passenger service ran for almost 130 years until it was abandoned in 1967. Passenger service was briefly restored in 1980, but abandoned again when federal funding expired. Freight service has been operated continuously for 175 years.

Based on a review of 20th century passenger timetables, the fastest trips between Boston and Concord were offered in the 1950s when the new light and self-propelled Budd RDC (Rail Diesel Cars) made the 73-mile trip in as little as 82 minutes. During the steam age, in the first half of the century, the shortest travel times were 120 minutes for the same destination pair.

In the first quarter of the 20th century, 29 passenger stations existed between Boston and Concord (see Table 5.1). With the rise of the highway network, that number was gradually reduced to 16 in 1945.

Table 5.1: Passenger Service Summary 1910-1954

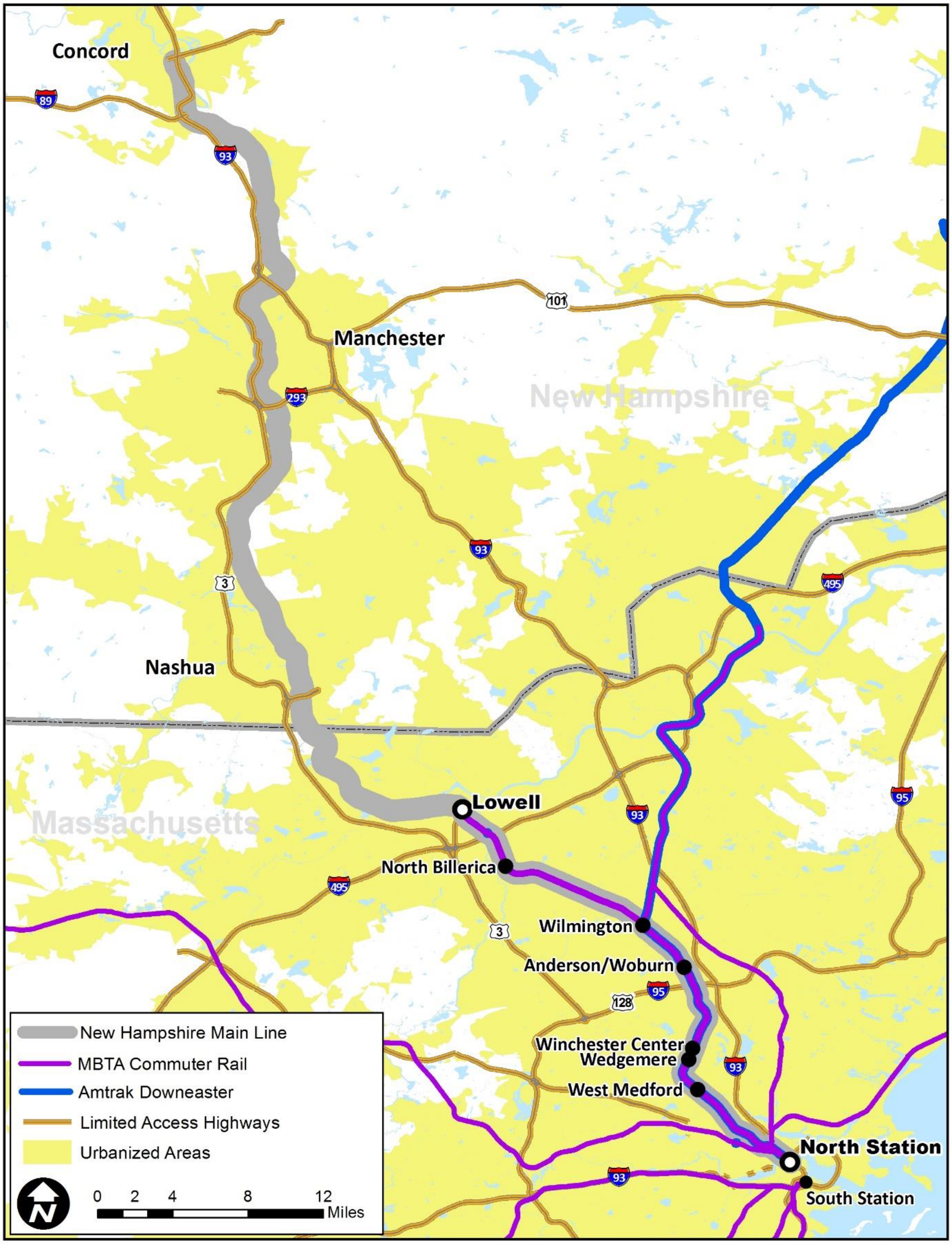
Year	Number of Stations	Nashua Trains	Manchester Trains	Concord Trains
1910	29	30	28	28
1926	29	26	24	24
1945	16	18	17	17
1954	16	19	22	21

Source: Jacobs' analysis of historic public timetables

The numbers of weekday passenger trains serving the line also declined from a high of 30 in 1910 to a low of 18 in 1945. In 1954, with the introduction of new Budd RDC cars and post-war prosperity, the B&M slightly expanded the frequency of passenger trains along the line. However, by the late 1960s, the passenger service was no longer profitable and was discontinued due to the growth of the interstate highway system. Existing passenger rail service is shown in Figure 5.1.

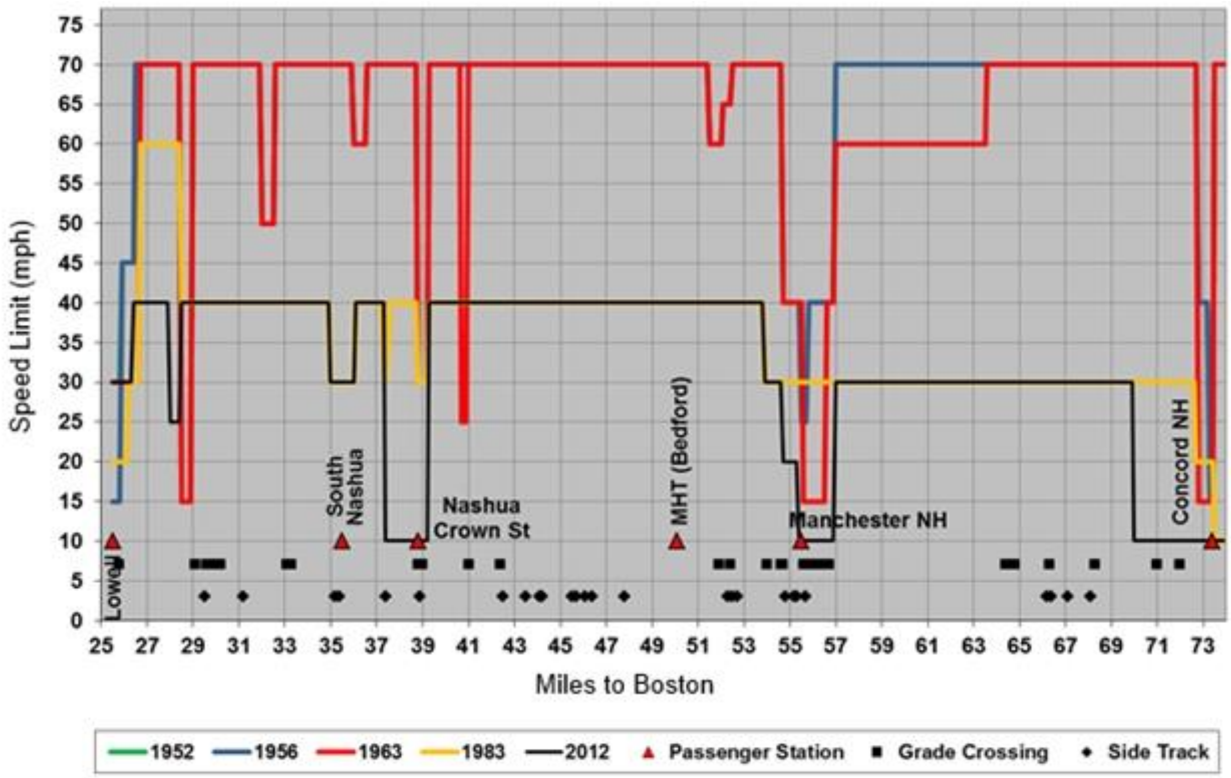
[11] New Hampshire Department of Transportation, *New Hampshire State Rail Plan 2012*, p. 21

Figure 5.1: Existing Passenger Rail Services



A review of B&M employee timetables showing speed limits for the line during the 1950s and 1960s indicated that the maximum allowable speed along most of the line between Lowell and Concord was 70 miles per hour (mph) with numerous speed restrictions for curves, densely settled urban areas with a high-density of grade crossings and railway yards (see Figure 5.2).

Figure 5.2: Historic and Existing Speed Profiles for NHML from Lowell, MA to Concord, NH



When passenger service was abandoned due to declining ridership in the late 1960s, the B&M stopped maintaining the line for passenger speeds and lowered the maximum allowable speeds to 40 mph south of Manchester and 30 mph north to Concord. Currently, the short segment between Lowell and Chelmsford is part of the B&M's existing freight main line and is still operated and maintained at a 60 mph freight standard. The maximum allowable passenger speeds between Lowell and Boston are between 60 and 70 mph.

5.1.1 *Track Configuration*

Once a busy main line railway, the NHML was double tracked to Concord and beyond. However, today the railway is largely single tracked north of Chelmsford with some passing sidings, yards in Nashua and Manchester, and numerous turnouts to customer sidings.[12] A track configuration chart for the segment north of Lowell can be found in Figure 10.1. The 48-mile segment between Lowell and Concord has 26 switches off the main line to yards, customers, sidings, and branches. The most notable freight customers along the line are Public Service of New Hampshire (PSNH), Quebec Cement, Anheuser Busch, and Nashua Corporation. The PSNH power plant in Bow regularly receives unit trains of coal (approximately 100 annually) and is by far the state's largest volume receiver of rail freight. This may change in the future as PSNH considers a potential future conversion to natural gas turbines.

The NHML has two active branches:

- The Hillsboro Branch leads west from Nashua approximately 30 miles to Bennington, New Hampshire. The eastern most 12 miles to Wilton are owned and operated by PAR. The 18 miles between Wilton and Bennington are owned by the State of New Hampshire and operated by the Milford-Bennington Railroad.
- New England Southern Railroad (NEGS) operates north from Concord using 18 miles of the state-owned line that runs north from Concord toward Lincoln.

5.1.2 *Ownership*

In Massachusetts, the southernmost 34.5 miles of the line were acquired by MBTA in the 1960s. At that time MBTA acquired most of the main line assets of B&M and the New Haven Railroads in eastern Massachusetts. Today, the southernmost 25.4 miles of the route between Boston and Lowell are busy with passenger traffic operated by the MBTA and Amtrak, and some local freight services operated by PAR.

In New Hampshire, the NHML is property of PAR. In 2011, PAR conveyed trackage rights to MBTA to operate passenger trains on the NHML northward into New Hampshire between the state line and Concord.

5.1.3 *Railway Signal System and Traffic Regulation*

The train control signal system for the route supports Northeast Operating Rules Advisory Committee (NORAC) Rule 261 between North Station and Manchester. Rule 261 allows for bi-directional operation with automatic wayside block signals on all main line tracks. North of Manchester, there are no wayside signals and operations are governed by Data Communication System (DCS) rules, wherein a Form D train order issued over the radio by the railroad dispatcher in Billerica, Massachusetts is necessary to move a train.

[12] The line is double-tracked for the 25 miles between Boston's North Station and the Gallagher Intermodal Terminal in Lowell

5.1.4 Track Conditions and Potential for Upgrades

Inspection of MBTA and PAR timetables and track charts coupled with a hi-rail inspection trips in April and June 2014 between Lowell, Massachusetts and Concord, New Hampshire provided the following information concerning track conditions.

Railway track is the structure consisting of rails, fasteners, tie plates, ties, and stone ballast that guides and supports the train as it moves down the railroad. More than 150 years of development has led to near universal standards for track design, but marginal innovations are made every few years. The predominant track form worldwide consists of flat-bottom steel rails that support and guide rail vehicle wheels. The rails are seated on steel plates fastened to and supported by timber ties. The ties are laid in a bed of crushed stone, also known as ballast.

For generations, rails were laid in 39-foot sections tied together with joint bars and bolts. The joints in the rail are a weak point in the track structure, subject to substantial maintenance to provide a smooth route for the vehicle wheels. Loose and damaged joints diminish ride quality, tie life, and maximum allowable speeds. Beginning in the 1950s, U.S. railroads started welding their rails into long continuous ribbons that significantly improved ride quality and eliminated most maintenance associated with joints. The conversion to welded rail has been a long process. Today, most heavily trafficked and higher-speed railways use track constructed with continuously welded rails fastened to the ties with an array of resilient, elastic steel fasteners that further reduce maintenance and improve ride quality. Routes with less traffic have generally not been updated with welded rail or the newer fastening devices.

In recent decades, the U.S. rail industry has been using heavier rail for main line track construction. Heavier rail can support greater axle loads and higher train speeds with less stress, damage, and resulting maintenance compared to lighter rail. Rail weight is graded in pounds per yard. For most new construction, MBTA and Amtrak use rail in the range of 132 to 136 pounds/yard, but substantial portions of both networks use rail in range of 112 to 115 pounds/yard. For instance, most of Amtrak's *Downeaster* route between Boston and Brunswick runs on 115-pound rail. PAR's main line is built with 100, 112, and 115 pounds rail.

The traditional rule of thumb for track life has been that timber ties should be replaced after 20 years and rail should be expected to last 50 years. MBTA has had several bad experiences with concrete ties and is not installing them on their commuter rail road. With the materials technology and manufacturing advances of the second half of the 20th century, both rail and ties are showing longer lifecycles, but there is considerable variability in longevity. Depending on a variety of circumstances, some timber ties last as long as 40 years, while other ties fail in as little as four years after installation. Heavier traffic tends to reduce track life. Moisture from poor drainage and weak ballast support also tends to hasten wooden ties' deterioration.

- **Inspections**: U.S. railway track used for passenger operations is subject to two inspections per week that visually check for track defects and obstructions. The most common defects are loose or missing fasteners that are fixed by the inspection patrol, as discovered. In addition to frequent inspections, a program of renewal and replacement is required to keep the track up to the desired FRA standard.

- **Ballast**: Once installed, operating track is maintained by periodically renewing (supplementing) the ballast while refining any deviation in the grade and cross level of track.
- **Ties**: There are typically 24 ties per 39-foot section of rail. Only eight to 10 of those ties need to be in good condition to support 60 mph passenger trains. The remainder can be allowed to deteriorate. To maintain a constant distribution of good ties in the track structure, the ties are periodically renewed to replace the worst with new ties.
- **Rail**: Rail is regularly ground to keep the surface smooth and in good condition. The rail is also subject to regular ultrasonic inspection to find hidden defects in the steel. Where the rail is jointed, defective rails are cutout and replaced. The mechanism for replacing a bad spot in a string of welded rail requires cutting to remove the bad spot and welding in a plug rail to replace it. Wholesale rail replacement programs are infrequent, unless anticipated changes to traffic on the line require greater strength or higher allowable speeds.

5.1.5 Track Class and Maximum Speeds

Standards for track maintenance and maximum speeds are set by FRA. Tracks maintained to a higher standard are allowed to operate at a higher speed. Passenger train speeds generally range between 60 mph for FRA Track Class 3 up to the Class 7 maximum speed of 125 mph (see Table 5.2). Currently, the Northeast Corridor between Boston and Washington is the only route in the U.S. that permits speeds in excess of 125 mph.[13,14] Most passenger routes and main line freight routes are maintained to FRA Class 3 or 4. Branch lines and other lightly used routes are maintained to FRA Class 2 or 1.

Table 5.2: FRA Track Class and Maximum Allowable Speeds (mph)

Track Class	Freight Trains	Passenger Trains
Excepted	10	N/A
1	10	15
2	25	30
3	40	60
4	60	80
5	80	90
6	110	
7	125	
8	160	
9	200	

49 Code of Federal Regulations (CFR) 213.9 - CLASSES OF TRACK: OPERATING SPEED LIMITS (Classes 1-5), and 49 CFR 213.307 - CLASS OF TRACK: OPERATING SPEED LIMITS (Classes 6-9)

[13] U.S. Department of Transportation (USDOT), FRA, Code of Federal Regulations (CFR), Title 49, Track Safety Standards Part 213, Subpart A to F, Class of Track 1-5, July 11, 2013

[14] U.S. Department of Transportation (USDOT), FRA, Code of Federal Regulations (CFR), Title 49, Track Safety Standards Part 213, Subpart G, Class of Track 6 and Higher, July 11, 2013

5.1.6 Current Track Class and Speeds

Within the southern 25 miles of the NHML between Boston and Lowell, MBTA currently operates daily commuter rail service, independent of most freight operations, with some segments maintained to a 70 mph speed standard. Most trackage is rated for 60 mph passenger operations. It is presumed that any future passenger rail trains operating within this section of commuter rail territory would use existing track and be restricted to the current timetable speeds.

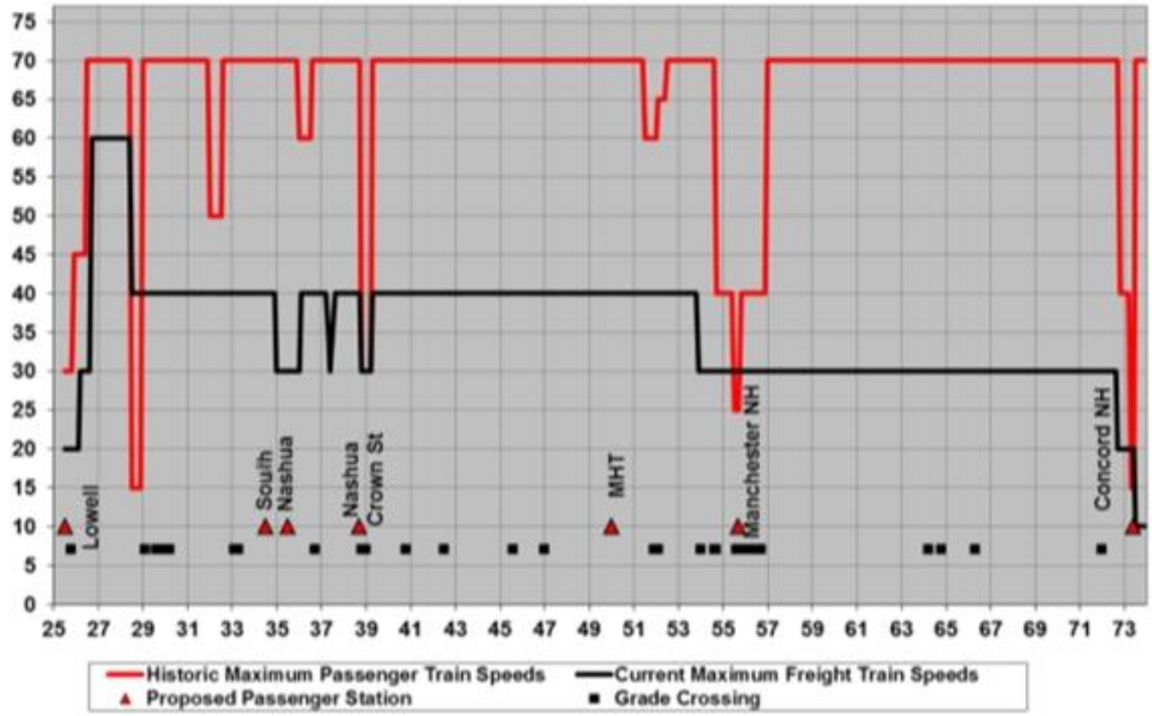
Existing rail traffic north of Lowell consists solely of freight movements with varying levels of train volume depending on the location. The greatest traffic is on the southern portion of the route between Lowell and North Chelmsford, Massachusetts. Traffic density between North Chelmsford and Concord, New Hampshire decreases as the route extends north of the New Hampshire state line into Nashua, Manchester, Bow, and Concord with typically no more than two train movements per day north of Bow.

North from Lowell is a three-mile section of track to North Chelmsford that experiences heavy freight traffic. This segment of PAR's east-west main line is maintained for a maximum freight speed of 40 mph (Class 3).

At North Chelmsford the line splits at a wye. The western leg is PAR's east-west main line and the northern leg is the lesser-traveled NHML. The NHML line runs northerly another seven miles to the New Hampshire state line where right-of-way and track ownership changes from MBTA to PAR.

PAR's ownership continues 39 miles to the north through the cities of Nashua, Manchester, and Concord with mostly 40 and 30 mph freight speeds on predominately Class 3 track north to Bow with Class 2 track north to Concord. Figure 5.3 shows the historic passenger train speeds and the current freight train speeds between Lowell and Concord.

Figure 5.3: Historic Passenger Speeds and Current Freight Speed for NHML from Lowell, MA to Concord, NH



5.1.7 Track Conditions

The track conditions along the route are consistent with the assigned FRA Track Class and maximum speeds. Over the 25 miles where MBTA operates its Lowell commuter rail service, all rail is welded with the latest major tie renewal completed in 1992. The oldest rail on this segment was manufactured in 1980. Much of the track uses 132-pound rail, but approximately 20 of the 51 track miles between Boston and Lowell uses 115-pound rail.

The character of the PAR main line between mile post (MP) 25.5 and MP 28.5 varies radically from the MBTA service segment. The track is jointed here, and the northbound track is primarily constructed with 100 pound rail manufactured in 1927. The southbound track is mostly constructed with 112-pound relay rail from 1965. Relay rail is rail that had been previously used at a different location where it was removed and reinstalled at its present location. Field inspection indicates that tie conditions along this segment are commensurate with the track class (e.g., at least 10 out of every 24 ties are in good condition).

Traffic density and composition on the line changes north of the wye at North Chelmsford. Fewer trains are operated, but one of the regular trains is a long (approximately 90 car), heavy (over 10,000 tons) coal train bound for the power plant in Bow at MP 68, approximately 40 miles north of the wye. Similar to the PAR main line, the rail is almost all jointed. There are approximately two miles of welded rail just north of downtown Manchester. Nearly all of the rail is 112 pounds manufactured during the first half of the 1940s. Records supplied by PAR indicate that the last major tie renewals took place in the 1990s, but field inspections indicate that the line seems to be in a near constant state of spot tie renewal to maintain sufficient track structure to safely support the coal train. North to Manchester the line is rated as FRA

Class 3. North to Bow, the nominal track condition is FRA Class 2. Informal inspection of the line indicates that the coal train's requirements force PAR to keep approximately half of the ties in good condition to support and guide the heavy train. Where the vertical profile of the railroad is not restricted by grade crossings, the bed of ballast supporting the coal train tends to be deep with full ballast shoulders.

5.1.8 Railway Bridges

A review of PAR track charts and inspection and rating reports indicate 25 bridges exist along the NHML between Lowell's Gallagher Terminal and Concord. The FRA requires all rail carriers to implement bridge management programs that include annual inspections of railroad bridges and determination of the structure's safe load capacity. PAR reports rate the 25 structures along the route subject to passenger rail restoration generally fair to good, with one bridge noted in poor condition.

The locomotive is the heaviest vehicle in a passenger train with a typical weight of 250,000 pounds. All of the rated bridges along the route are qualified to carry this load. Most of the bridges are rated to safely carry cars with a gross weight of 286,000 pounds or more. The bridge classified as being in the poorest condition is rated to carry a capacity of 263,000 pounds. *The two longest bridges crossing the Merrimack River are not rated and should be inspected before passenger service is restored.*

5.1.9 Highway Grade Crossings

There are 35 locations identified between Lowell's Gallagher Terminal and Stickney Avenue in Concord where roadways or pedestrian paths cross the railway at grade. Grade crossings are of particular concern as they present the greatest accident hazard on the railway due to the potential for vehicle/pedestrian conflicts with trains. Grade crossings will require sensitive treatment should substantially greater volumes of trains be reintroduced along the route. Federal safety regulations require trains to sound their horns at all grade crossings. A federally sanctioned "quiet zone" may be established cooperatively with the local community working with the railroad to make substantial investments that reduce the likelihood of accidents.

The density of 35 crossings along the 48-mile route is relatively low for a suburban railway. The railway generally hugs the bank of the Merrimack River and only several of the streets are heavily travelled. Most of the grade crossings lead to relatively small riverfront residential enclaves or industrial sites. Of the 35 grade crossings, 21 are public roads, 13 are private driveways, and one is an informal community crossing.

Public grade crossings are roadways under the jurisdiction of, and maintained by, a public authority. Private grade crossings are on privately-owned roadways, such as those leading into an apartment complex, housing estate, or commercial/industrial development. A private crossing is not intended for public use and is not maintained by a public road authority. Nationwide, there are approximately 148,000 public crossings and 95,000 private crossings.

- **Lowell**: No grade crossings on the Study corridor in the City of Lowell
- **Chelmsford**: Three private crossings in the Town of Chelmsford; one of these actually functions as a public crossing since it leads into a substantial new residential development on the riverfront

- **Tyngsborough**: Two private crossings in the Town of Tyngsborough; one leads to an older established residential enclave, the other to several commercial buildings and a boat launching ramp
- **Nashua**: Four public crossings in the City of Nashua, three of which are heavily travelled; there is also one private unprotected crossing and one informal crossing used by local residents to recreationally access undeveloped land along the riverfront
- **Merrimack**: Four private crossings in the Town of Merrimack, all of which are lightly travelled
- **Bedford**: No public or private grade crossings in the Town of Bedford
- **Manchester**: Thirteen public and one private crossing in the City of Manchester; seven crossings are located along a single mile of the route adjacent to Manchester's Mill District; Granite Street is undoubtedly the most heavily trafficked crossing along the Study corridor
- **Hooksett**: Two public crossings in the Town of Hooksett; neither grade crossing is heavily travelled
- **Bow**: Two public and two private grade crossings in the Town of Bow; three lead into a single farm or industrial plant and one is a busy local street
- **Concord**: No roadway grade crossings along the Study corridor in the City of Concord

5.1.10 Current Rail Passenger Services

On a typical weekday in the spring of 2013, Lowell was served by 44 MBTA revenue trains to and from Boston's North Station. The 25-mile trip serves up to seven intermediate station stops. The running time between Lowell and Boston ranges between 45 and 49 minutes with a maximum allowable speed of 70 mph. Six weekday non-revenue deadhead trains run between Lowell and Boston to stage the service because there is no facility for the overnight storage or maintenance of the trains in Lowell. Typical weekday MBTA ridership on the entire line is 17,500 passenger trips, including both northbound and southbound travel. Lowell is the busiest passenger station on the line with 4,280 weekday boardings and alightings.

The current NHML MBTA service provides 64 weekday passenger trains to and from North Station (see Table 5.3). Of those trains, 44 are revenue trains running between Boston and Lowell and six are the aforementioned non-revenue deadhead trips. The remaining 14 trains are a mix of peak-period, short-turn trains between Woburn and Boston and a variety of express and reverse-peak trains running between Boston and Haverhill via the Wildcat Route.[15] The line also serves 10 Amtrak *Downeaster* trains from Portland to Boston North Station via Woburn and the Wildcat Route.

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[15] The Wildcat Route is a single-track, 2.88 mile railroad branch line that connects the MBTA Lowell Line in Wilmington, Massachusetts to the MBTA Haverhill Line at Wilmington Junction.

Table 5.3: MBTA Service, Ridership and Revenue Statistics (2012$)

Station	MP	Amtrak Weekday Revenue Trains	MBTA Weekday Revenue Trains	MBTA Typical Weekday Southbound Boardings	MBTA Cash Fare	MBTA Average Revenue per Passenger Boarding	MBTA Typical Total Weekday Passenger Revenue
Lowell	25.5	-	44	2,141	$6.75	$6.67	$28,566
North Billerica	21.8	-	44	1,427	$6.25	$6.38	$18,195
Wilmington	15.2	-	47	758	$5.25	$5.09	$7,711
Woburn	12.6	10	57	1,743	$4.75	$4.77	$16,640
Mishawum	11.9	-	6	50	$4.75	$4.95	$495
Winchester	7.8	-	49	1,002	$4.25	$4.34	$8,701
Wedgemere	7.3	-	48	740	$4.25	$4.36	$6,459
West Medford	5.5	-	49	884	$1.70	$1.83	$3,244
North Station	0.0	10	58	n/a	n/a	n/a	n/a
Totals	-	10	58	8,745	-	$5.15	$90,011

Source: MBTA Conductor's Audit Reports Thursday - February 9, 2012 and Jacobs Analysis

The Lowell service requires four train sets in the morning and five train sets in the afternoon. As shown in Table 5.4, the peak five trains are required to be six, five, six, seven, and five cars long. The seven-car train regularly carries 652 passengers. All but one car assigned to the Lowell service is a single-level coach. The maximum length of any train berthing at North Station is eight cars. As ridership on the NHML grows, the number of higher capacity bi-level coaches on the route will need to be increased.

Table 5.4: MBTA NHML Peak Train Lineup

Set	Peak Train	Single-Level Coaches	Bi-Level Coaches	Seats	Peak Riders
N	310	6	-	684	579
O	304	4	1	636	493
P	306	6	-	684	600
Q	308	7	-	798	652
R	327	5	-	570	480

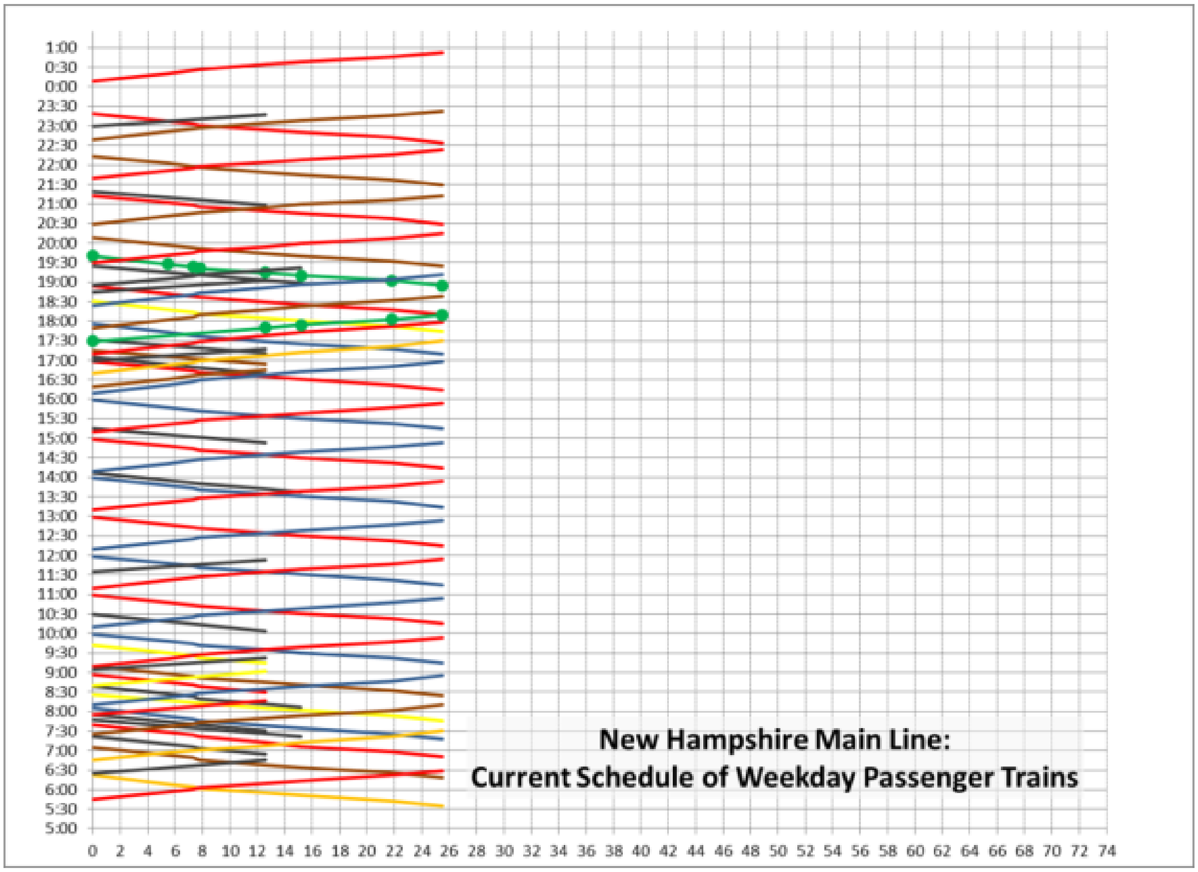
Source: North Side Equipment Cycle Seating Requirements for 198 Scheduled Weekday Trains, MBTA, February 29, 2012

A stringline diagram, also referred to as a time-distance diagram, is helpful for planning the flow of railroad traffic. These diagrams are a graphical depiction of the timetable and provide a visual representation of trains scheduled to operate on a corridor. The diagrams show distance and station locations along the x-axis and time along the y-axis. The stringlines show the time and location of each scheduled trip. The slope of line indicates direction and relative speed with upward lines representing northbound trips and downward lines representing southbound trips. Intersecting lines show when and where trains will meet and identify where passing sidings or double tracking will be required.

A stringline diagram illustrating current weekday passenger operations on the line is shown in Figure 5.4. For reference, North Station is located at MP 0 and Lowell is at MP 25. Nashua, Manchester, and

Concord are located at MPs 39, 55, and 73, respectively. The timetable of services can be found in *Section 6: Service Alternatives*.

Figure 5.4: Existing NHML MBTA Passenger Rail Services



Stringline diagrams are used to identify potential schedule conflicts (meets/passes), potential open slots for new service, and resource planning (crews, locomotives, etc.). The schedule is also impacted by certain track restrictions that determine line capacity such as physical track layout, number of tracks, and the number and spacing of sidings. If a stringline becomes vertical, it means that the train must stop at that location for the duration of the vertical line. Required changes in scheduled departures and arrivals, station dwell times, and train meets can be identified and adjusted in the stringline diagram and then used to update the timetables.

Figure 5.5: Amtrak *Downeaster* Service

Amtrak *Downeaster* service between North Station and Brunswick, Maine also operates on the NHML line as far north as Woburn (Figure 5.5). It then uses the "Wildcat Route" to travel northeasterly Haverhill, Massachusetts and on to Maine. Each *Downeaster* train serves passengers to and from the north at North Station and

Woburn. No southbound Amtrak passengers are allowed to board at Woburn and no northbound tickets to Woburn are sold from North Station. The *Downeaster* averages 1,400 passengers per day at all stations. The typical daily passenger traffic at Woburn is 30 boardings and alightings.

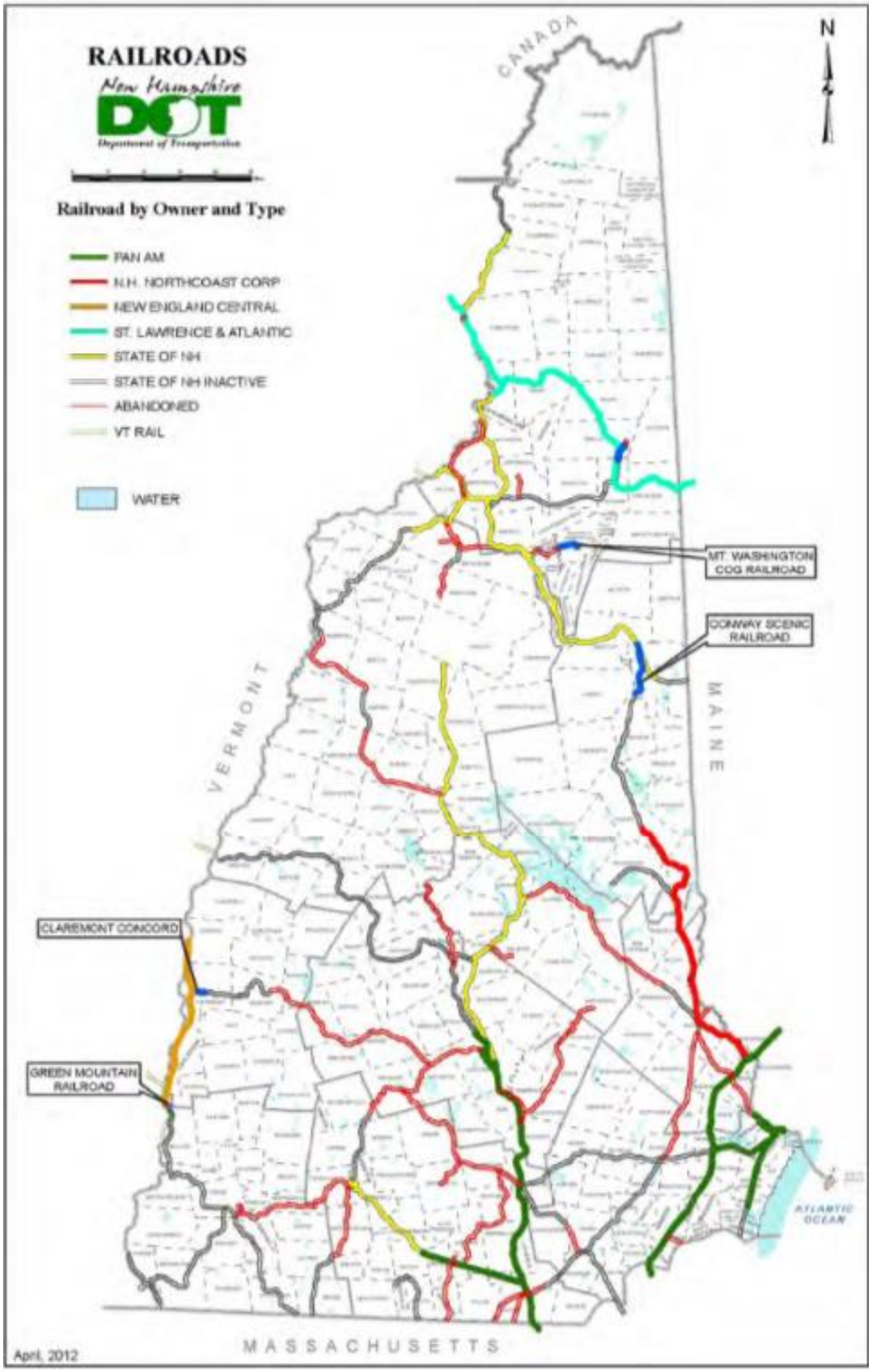
5.1.11 Rail Freight Service

The New Hampshire rail system is composed of five primary owners of the railroad lines: PAR, New Hampshire Northcoast Corporation, New England Central Railroad, St. Lawrence & Atlantic Railroad, and the State of New Hampshire (see Figure 5.6). In addition to these five primary owners, four of which are also railroad operators, six additional freight railroads either operate on small segments of track in New Hampshire or over track owned by others, such as the state-owned lines Claremont-Concord Railroad, Green Mountain Railroad, Milford-Bennington Railroad, New Hampshire Central Railroad, New England Southern, and Twin State Railroad.

New Hampshire's population and industry are well served by three intermodal terminals located near the state's borders in Worcester, Massachusetts; Ayer, Massachusetts; and Auburn, Maine. New Hampshire and the rest of New England is often referred to as a cul-de-sac in the national rail network, since the area is primarily a freight destination, and no major rail routes traverse the region. Rail volumes in New England tend to be considerably lower than other parts of the nation, with only a single Class I rail connection between Boston and Albany, New York.

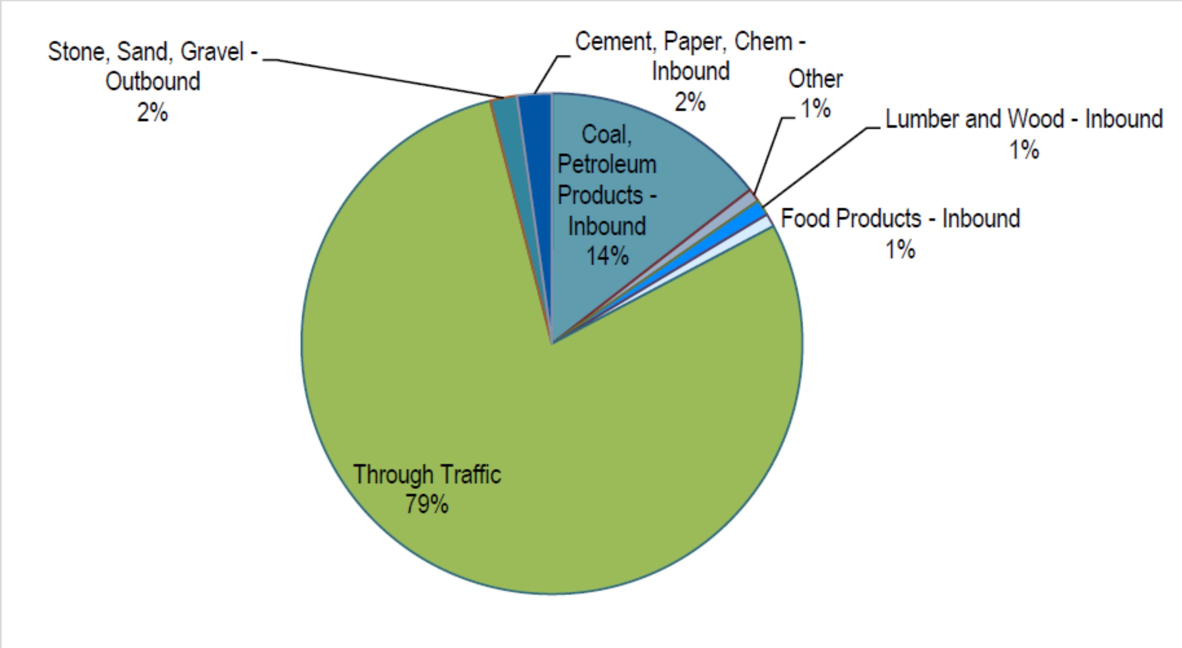
Approximately 85 percent of national rail freight tonnage is bulk commodities, such as agriculture and energy products, automobiles and components, construction materials, chemicals, equipment, food, metals, minerals, and pulp and paper. Figure 5.7 illustrates that the commodities most commonly shipped to New Hampshire are coal and petroleum products bound for local consumption.

Figure 5.6: New Hampshire Railroads by Owner and Type



Source: New Hampshire State Rail Plan, 2012

Figure 5.7: New Hampshire Freight Rail Traffic by Commodity/Direction (% of carloads)



Source: New Hampshire State Rail Plan, 2012

The commodity most commonly shipped from New Hampshire is sand and gravel bound for cement and asphalt plants in Massachusetts. Almost 80 percent of the rail cars moving through the state are through movements between Maine, Eastern Canada, and the balance of the U.S.

The NHML connects to the national freight network only at Lowell, Massachusetts. This corridor currently receives three quarters of all rail freight tonnage shipped into New Hampshire. While the freight received is quite diverse, traffic flow is dominated by coal for electric generation shipped to Bow, New Hampshire. Clay, concrete, glass, and stone also comprise much of the remaining rail freight tonnage moving on the corridor. Other products shipped along the corridor include farm products, lumber and wood products, food, chemicals, and some nonmetallic minerals. Significantly more freight rail traffic is shipped into southern New Hampshire than is shipped out. Shippers categorize the small amount of outbound freight rail traffic as miscellaneous freight.

Most rail traffic currently shipped to New Hampshire is for local consumption and the volume of outbound rail traffic other than building materials is quite minor. Unless there is a major shift in New Hampshire's economy to produce, process, or consume large volumes of bulk commodities, it is unlikely that the total volume of rail traffic to or from the Granite State will grow at a rate that varies significantly from expected population growth. That is not to say that rail freight in the state would not benefit from improvements to a key rail line serving the state's major population centers, but the magnitude of benefit for long journeys on the national network will likely be relatively small.

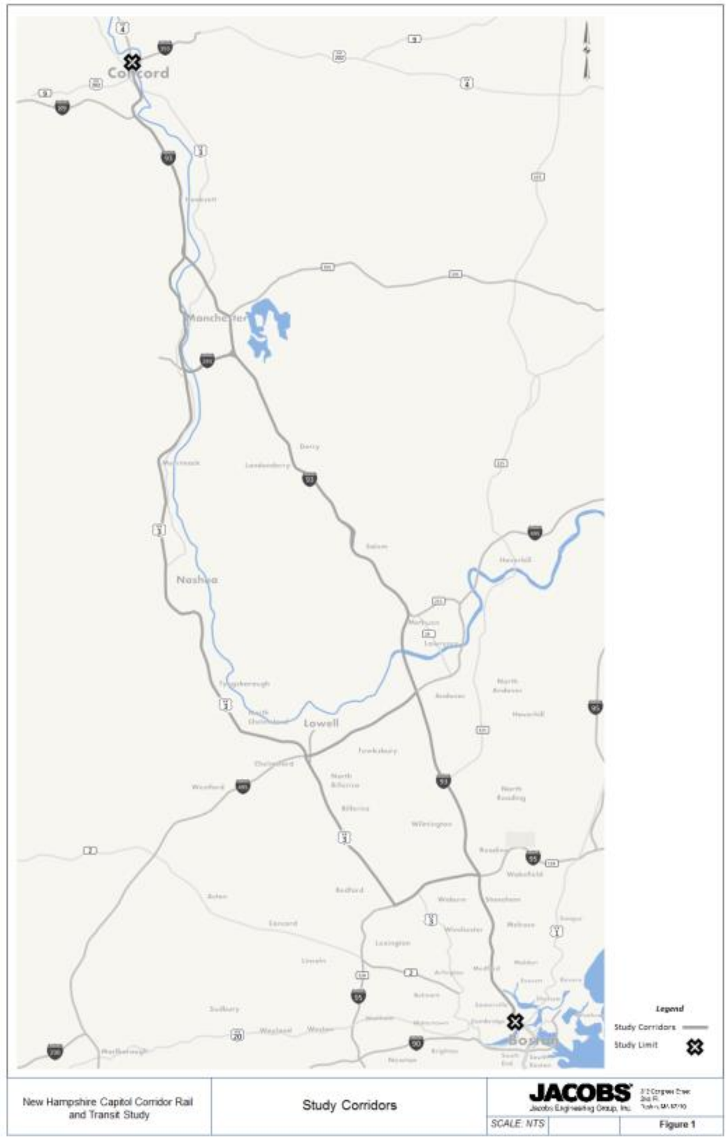
5.2 Highway Facilities and Level of Service

The Capital Corridor's limited access highways that connect New Hampshire's major population centers to metropolitan Boston are I-93, US Route 3/Everett Turnpike, I-95/Route 128, I-293, and, I-495. An overall corridor Study map showing the subject corridors is shown in Figure 5.8. These highways cover 268 round trip miles of limited access freeway facilities and interchanges, shared between the States of New Hampshire and Massachusetts. The breakdown on the corridor mileage is as follows:

- 130 round trip miles on I-93
- 22 round trip miles on I-293
- 98 round trip miles on US Route 3
- 22 round trip miles on Route 128/I-95
- 18 round trip miles on I-495

Most analysis focuses on I-93 since it is the only direct link into Boston from the Study corridor. US Route 3, I-293, I-95/Route 128, and I-495 all feed into I-93 for the purposes of travel along the Capitol Corridor to and from the regional core.

Figure 5.8: Study Corridor Highways



5.2.1 Highway Geometrics

I-93 southbound offers three lanes for travel between Hooksett and I-293 where it drops a lane until it reaches the state line in Massachusetts. A fourth general purpose (GP) lane is added in the vicinity of Wilmington near the Route 125 interchange.

Near Medford and Somerville, Massachusetts, south of Exit 30, I-93 southbound splits into one high occupancy vehicle (HOV) lane and three GP lanes. After Exit 28, the three GP lanes on I-93 southbound drop to two GP lanes for approximately 1,360 feet before regaining the third GP lane at Exit 29.

I-93 is currently being widened to four GP travel lanes in each direction in New Hampshire between Exits 1 and 5 from the Massachusetts state line to Manchester, New Hampshire for a distance of approximately 19.8 miles. The project is expected to be completed in 2018. For the purposes of this Study, the widening project is presumed to be complete.

US Route 3/The Frederick Everett Turnpike southbound generally carries two GP travel lanes from Concord to I-89 where it adds a third lane. US Route 3 carries three GP lanes from I-89 to the I-93 split.

After the I-93 split, US Route 3 generally carries two GP lanes from Manchester to New Hampshire Route 101, where US Route 3 widens and fluctuates between three and four lanes. It narrows and fluctuates between two and three GP lanes from Exit 13 in Merrimack, New Hampshire to Exit 8 in Nashua, New Hampshire. From Exit 8 and to the Massachusetts state line, US Route 3 fluctuates between four and three GP lanes. In Massachusetts, US Route 3 generally carries three GP lanes from the state line to Route I-95/128 in Burlington, Massachusetts.

I-95/Route 128 northbound generally carries four GP lanes between US Route 3 and I-93. North of I-93, I-95 has a lane drop from four to three GP travel lanes.

I-495 northbound generally carries three GP lanes between US Route 3 and I-93.

I-93 northbound generally carries four GP travel lanes from Exit 29 in Somerville, Massachusetts to Exit 41 in Wilmington, Massachusetts. After Exit 41, a lane is dropped and there are three GP lanes up to the state line. In New Hampshire, I-93 northbound carries two GP lanes from the state line to Exit 5 in Manchester, New Hampshire. After Exit 5, I-93 northbound fluctuates between two and four lanes up to Exit 7 where it generally settles to three GP lanes up until the US Route 3/Frederick Everett Turnpike merge. As noted above, I-93 is currently being widened to four GP travel lanes in each direction in New Hampshire from the state line to Manchester, New Hampshire for a distance of approximately 19.8 miles.

US Route 3 northbound generally carries three GP travel lanes from Burlington, Massachusetts though the state line to Merrimack, New Hampshire. Starting before Exit 10, US Route 3 northbound fluctuates between three and two lanes up to the I-93 merge. North of the I-93 merge, US Route 3 northbound fluctuates between three and four GP lanes. After the I-89 interchange, US Route 3 northbound carries two GP lanes up to Concord, New Hampshire.

I-95/Route 128 southbound carries three GP travel lanes into the I-93 interchange and adds a fourth lane south of the interchange, which carries through to and beyond US Route 3.

I-495 southbound carries three GP travel between I-93 and US Route 3.

5.2.2 Breakdown Lanes and Managed Lanes

Peak period breakdown travel lanes on I-93 northbound and southbound between Exits 45 and 47 exist at this time, but will be permanently removed with the reconstruction of the Methuen interchange at Route 110/113 and I-93.

An existing managed lane on I-93 southbound begins in Medford, Massachusetts. After Exit 30 and before Exit 28, I-93 southbound splits into one HOV lane and three GP lanes. There is a four-foot painted buffer separation between the HOV lane and the adjacent GP lanes. The HOV lane ends at the Leonard P. Zakim Bunker Hill Bridge at the I-93/Route 1 merge. There are no other entrances or exits for the southbound HOV lane between the Mystic Avenue on-ramp entrance and the Zakim Bridge. Buses, carpools (defined as two or more occupants), motorcycles, and vanpools using the HOV lane can save up to 10 minutes during the morning peak-period commute. The HOV restrictions apply between 6:00am and 10:00am, Monday through Friday.

5.2.3 Highway Level of Service

Level of service (LOS) is commonly used to describe the operating conditions for ground transportation facilities. LOS for freeway facilities is calculated from vehicular speed, volume, and density. LOS ranges from LOS A to F, where LOS A describes free-flow operations, LOS E describes operations at capacity, and LOS F describes breakdown conditions and unstable traffic flow.

LOS analysis for freeway sections is based upon density of vehicles. Density is measured in passenger-cars-per-mile-per-lane (pc/mi/ln). LOS is a term used to denote different operating conditions that occur at a given roadway segment under various traffic volume loads. It is a qualitative measure of the effect of a number of factors including roadway geometrics, speed, travel delay, freedom to maneuver, and safety.

The LOS for ramp merge and diverge points are based upon the density of vehicles upstream of the merge and downstream of the diverge points. Weave sections are defined as the roadway segment bounded by an on-ramp followed with an off-ramp, creating a potential conflict for vehicles trying to enter the roadway and vehicles trying to exit the roadway within the same stretch of pavement.

Given the regional scale of this Study, LOS and volume-to-capacity (v/c) were identified as appropriate performance measures to evaluate the limited access freeway conditions during the weekday peak hours. The LOS criteria for freeway sections, ramp junctions, and weaving segments are shown in Table 5.5.

Table 5.5: Highway LOS Thresholds

LOS	Freeway	Ramps	Weaving
	Density (cars/mile/lane)	Density (cars/mile/lane)	Density (cars/mile/lane)
A	0 – 11	0-10	0-10
B	> 11 – 18	> 10-20	>10-20
C	> 18 – 25	>20-28	>20-28
D	> 25 – 35	>28-35	>28-35
E	> 35 – 45	>35	>35-43
F	Overcapacity	Overcapacity	>43

Source: 2000 Highway Capacity Manual

Year 2013 existing weekday morning peak-hour LOS and v/c ratios for inbound traffic towards metropolitan Boston are shown in Figure 5.9. Under current conditions, there is severe traffic congestion inbound towards Boston during the weekday morning peak hour. The vehicular demand exceeds capacity with a v/c ratio greater than 1.25 from Exits 36 to 27. Various sections between Exits 36 and 27 have LOS E conditions. I-93 between I-95/Route 128 and I-495 is generally over-capacity with LOS E and F conditions. I-95/Route 128 between US Route 3 and I-93 is generally over-capacity with traffic congestion.

The existing weekday evening peak-hour LOS and v/c ratios for outbound traffic from metropolitan Boston are shown in Figure 5.10. Under current conditions, there is severe traffic congestion outbound from Boston during the weekday afternoon peak hour. Vehicular demand exceeds capacity with a v/c ratio greater than 1.25 for various segments between Exits 27 to 39. Various sections between Exits 27 and 39 have LOS E and F conditions. North of Exit 39 and up to I-495, I-93 is generally at or over capacity. I-95/Route 128 between US Route 3 and I-93 is generally over-capacity with traffic congestion, and predominately at or near capacity closer to US Route 3.

Figure 5.9: Year 2013 Morning Peak-Hour Highway LOS

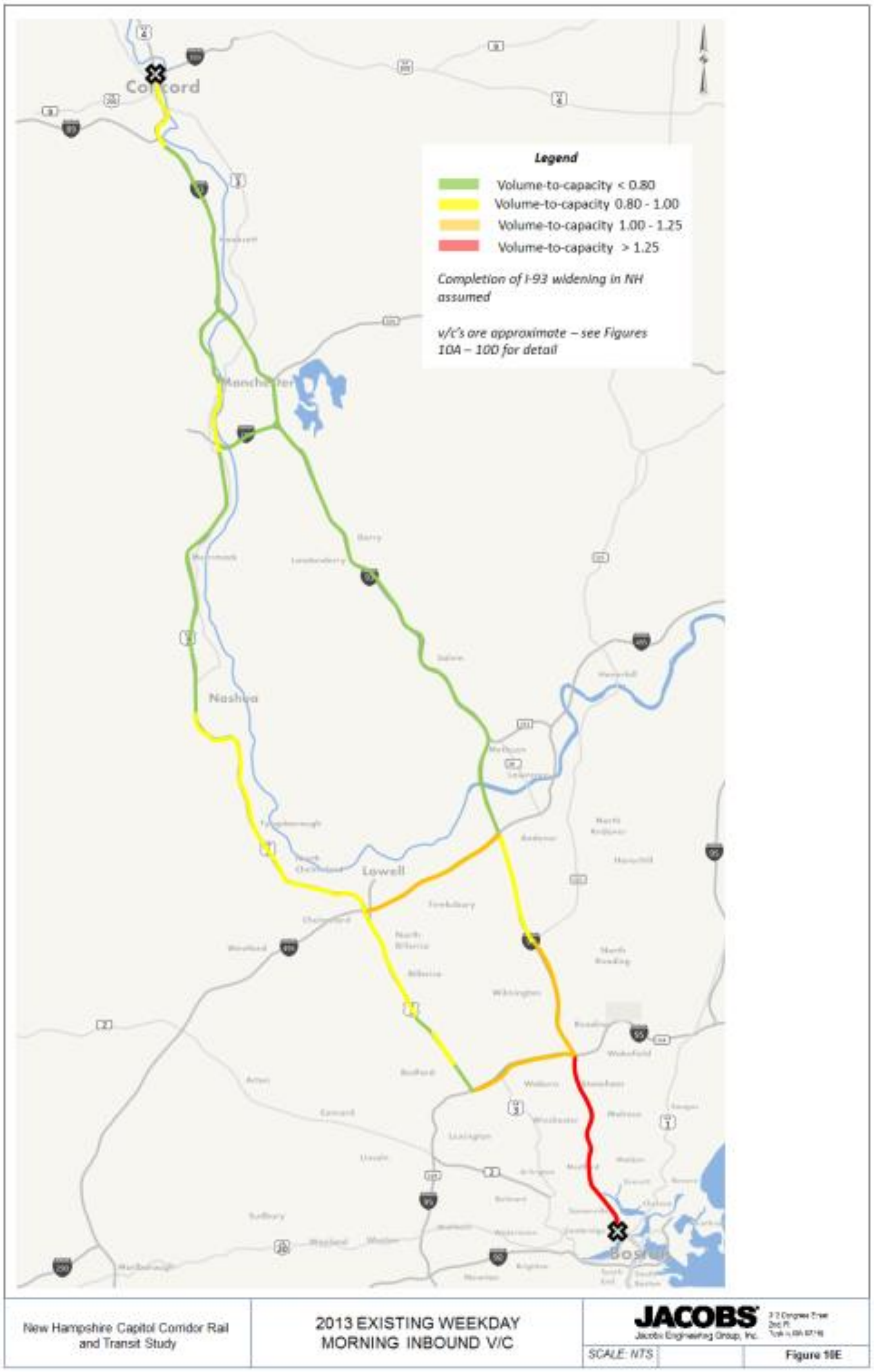
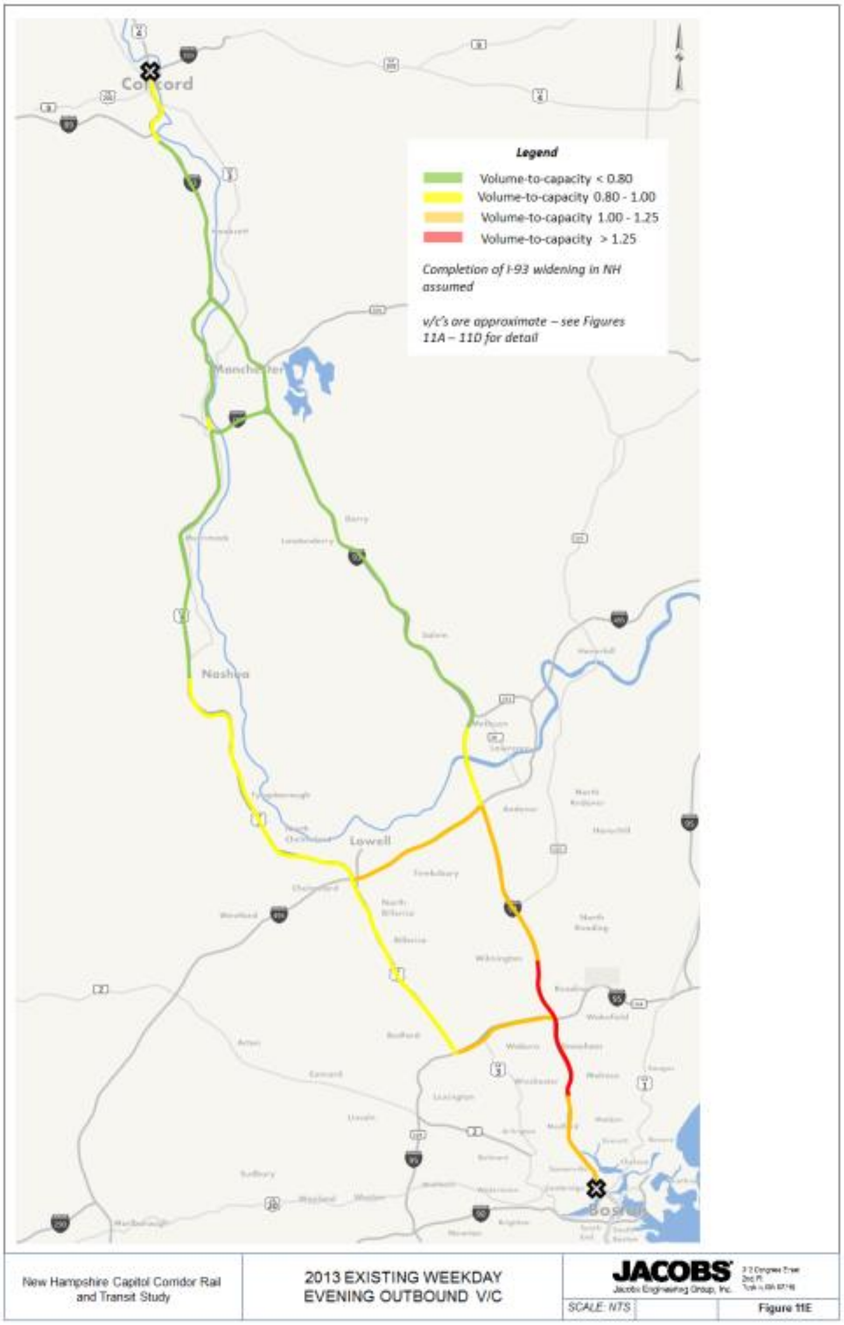


Figure 5.10: Year 2013 Peak-Hour LOS



5.2.4 Peak Travel Speeds

Travel speed and time data for the network was collected via real-time, GPS-equipped, anonymous cell phone technology – through two internet mapping sources (www.google.com/maps and www.bing.com/maps). The internet data established current travel speeds and hot spot locations for congestion between the major population centers in New Hampshire and Boston. The data collection was undertaken in June 2013 during the weekdays – excluding Mondays and Fridays.

Year 2013 existing weekday morning peak-period travel speeds for inbound traffic towards Boston are shown in Figure 5.11. The existing weekday evening peak-period travel speeds for outbound traffic from metropolitan Boston are in Figure 5.12.

Figure 5.11: Year 2013 Weekday Morning Inbound Speeds

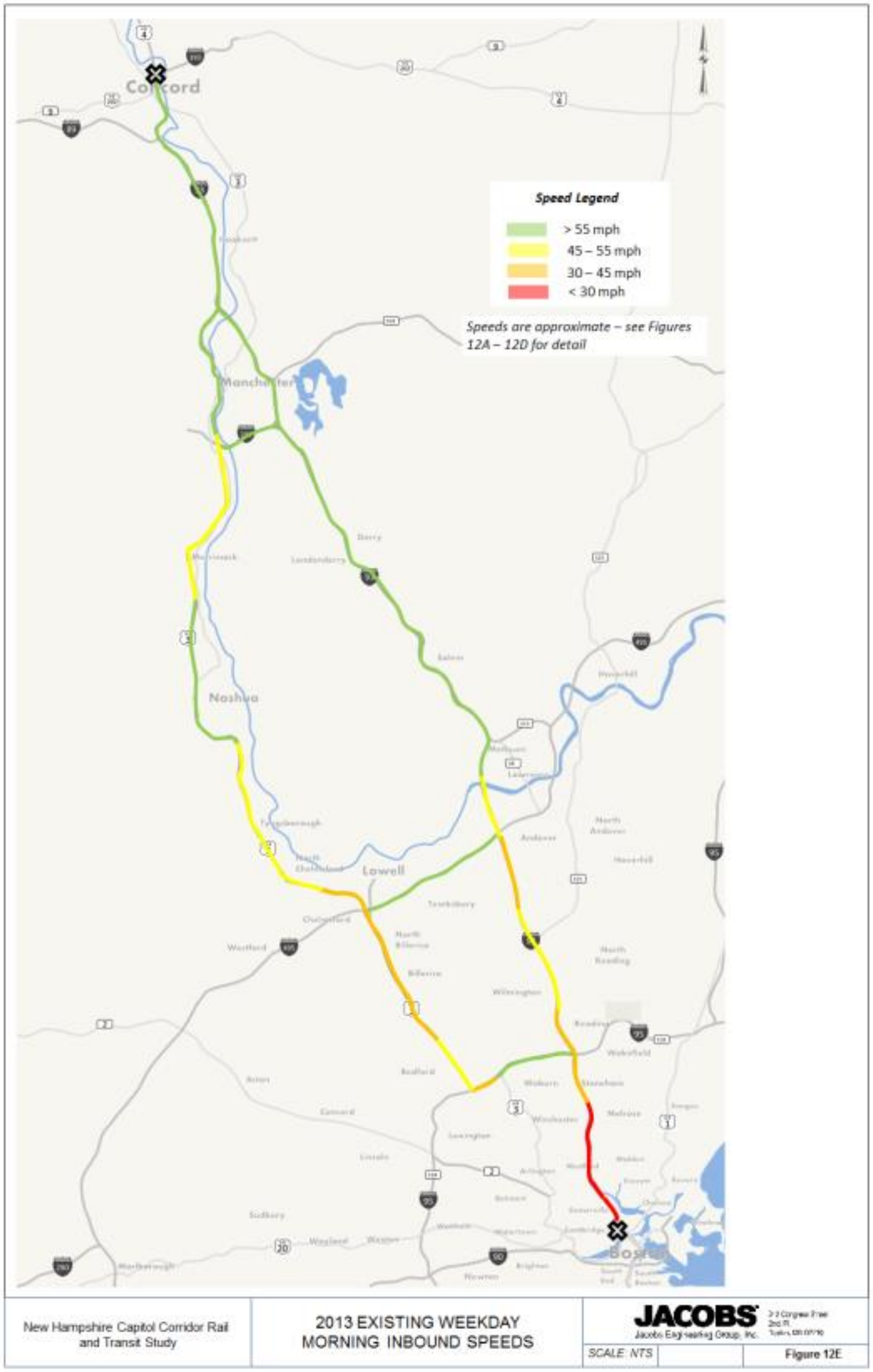
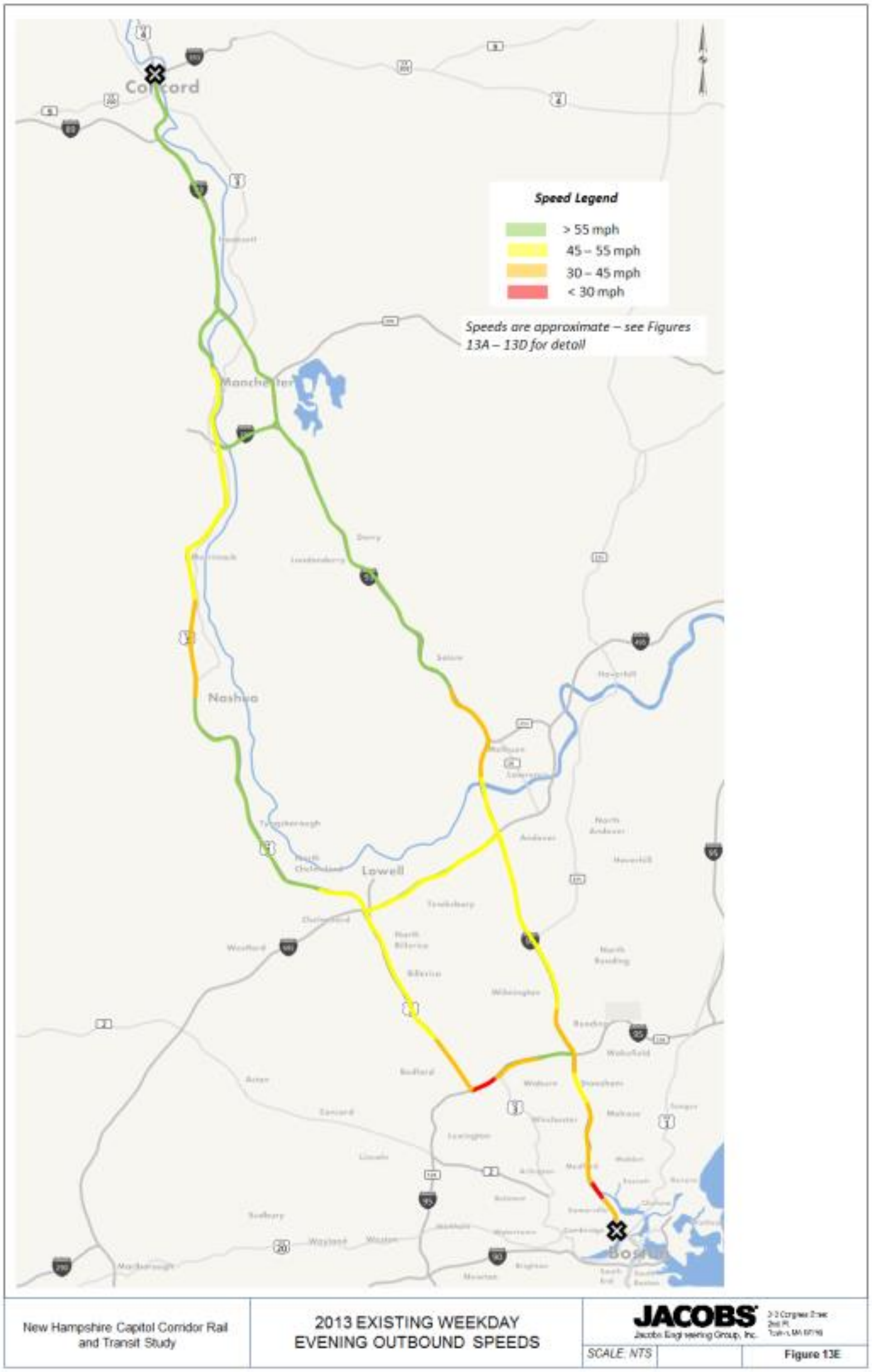


Figure 5.12: Year 2013 Weekday Evening Outbound Speeds



5.2.5 Travel Time Contours

Year 2013 existing weekday morning peak-hour travel time contours for inbound traffic towards Boston are shown in Figure 5.13. The existing weekday evening peak-hour travel time contours for outbound traffic from Boston are shown in Figure 5.14.

Figure 5.13: Year 2013 Evening Inbound Peak-Period Travel Time Contours

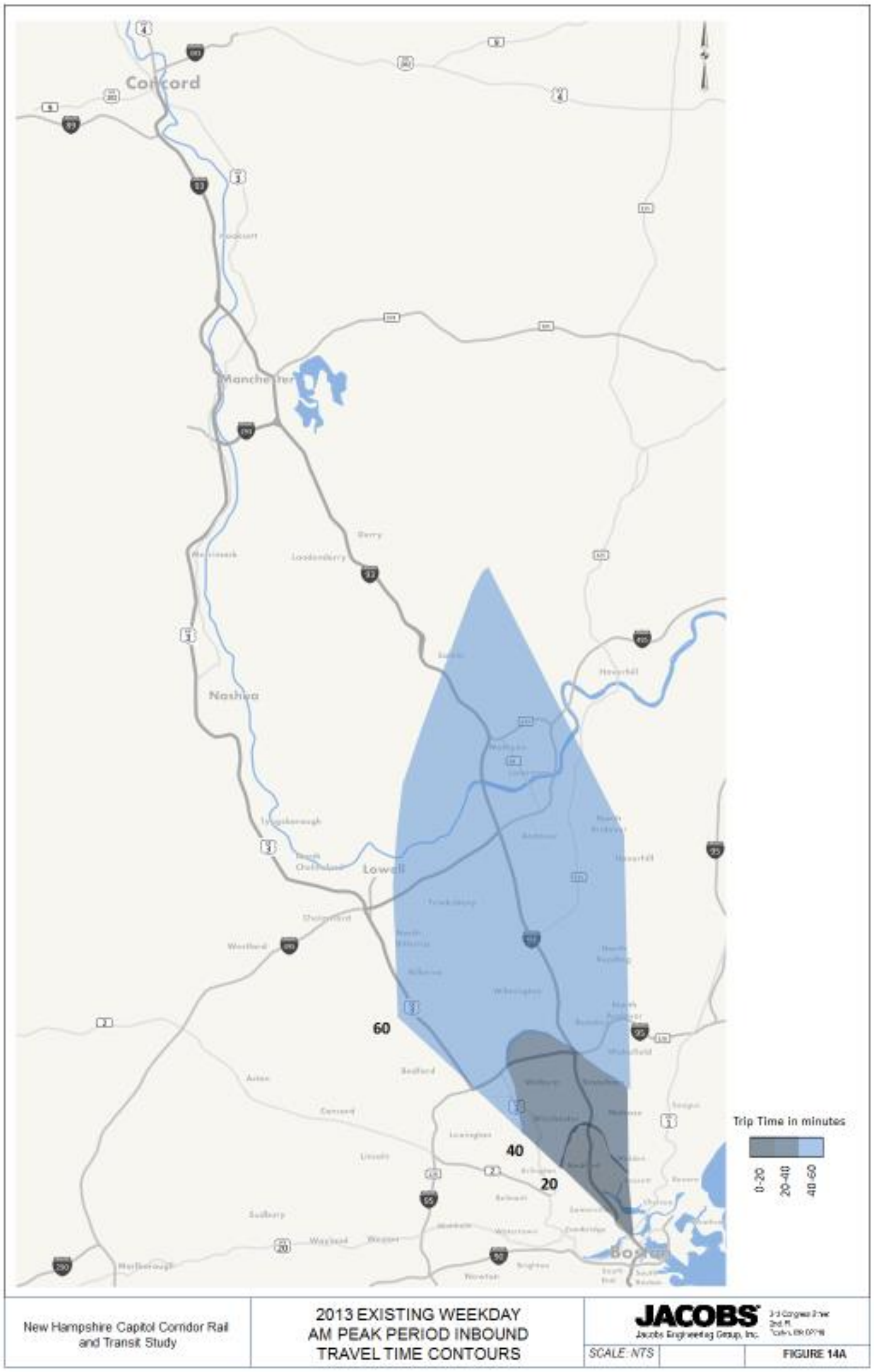
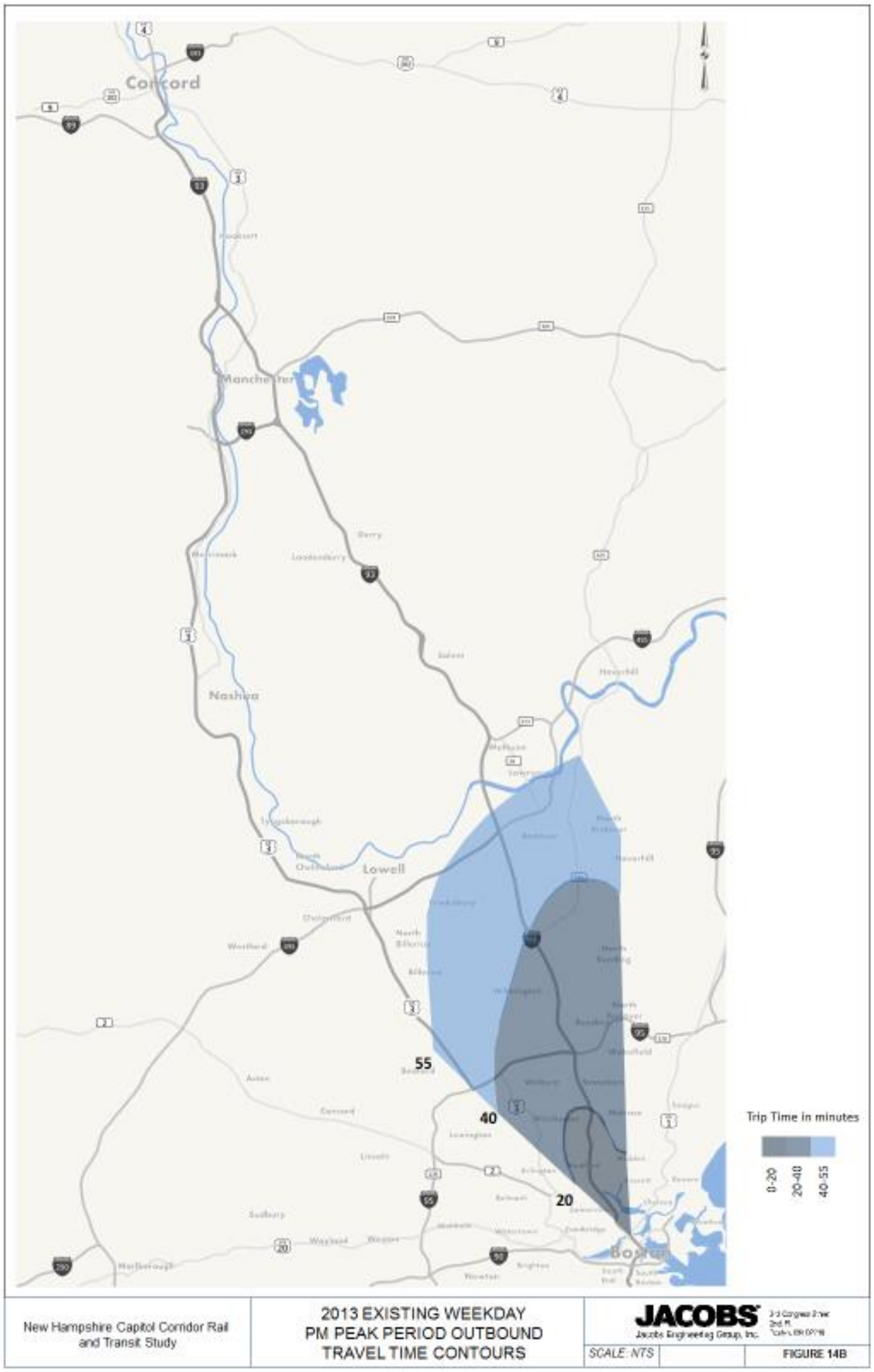


Figure 5.14: Year 2013 Evening Outbound Peak-Period Travel Time Contours



Travel times from Concord to Boston during the inbound morning commute are bottom-heavy due to the gradual increase in congestion approaching Boston. Nearing Boston, congestion is severe with speeds less than 30 mph. Travel times inbound currently take up to 20 minutes from Medford, Malden, and Everett – areas only four miles from Boston – with an average speed of 12 mph. Expanding radially by another four miles, the travel times into Boston double to 40 minutes – still with an average speed of 12 mph. Between I-95 and I-495, travel times into Boston can take up to 60 minutes by vehicle.

Travel times outbound from Boston during the afternoon commute are top-heavy due to the severe congestion experienced exiting Boston northbound – but not as severe as the morning peak hour. Travel times outbound currently take up to 20 minutes to Medford, Malden, and Winchester – areas only seven miles from Boston – averaging just over 20 mph. Expanding radially by another seven miles, the travel times exiting Boston double to 40 minutes – still averaging just over 20 mph. Travel times to Lawrence currently take less than 60 minutes, and commutes to beyond Salem, New Hampshire take less than 70 minutes. Travel times from Boston to Concord take less than 90 minutes in weekday afternoon peak-hour traffic.

5.2.6 Highway Conditions Summary

Severe traffic congestion is evident entering and exiting Boston via I-93 North during the weekday peak periods. When travel speeds drop below 30 mph, traffic volumes are generally understood to exceed road capacity by over 25 percent. Average peak-period speeds on I-93 have been shown to drop to as low as 12 mph for the last eight miles inward to Boston.

The current freeway infrastructure on I-93 North is a contributing factor to the severe traffic congestion experienced entering and departing Boston. After Exit 28 in Somerville, the three GP lanes on I-93 southbound drops to two GP lanes for over 1,000 feet before regaining the third lane at Exit 29. This lane drop, less than four miles away from Boston, is currently a choke point causing severe congestion on I-93 on typical weekday morning conditions.

In New Hampshire, I-93 North is currently being widened to four GP travel lanes in each direction between Exits 1 and 5 from the Massachusetts state line to Manchester, New Hampshire for a distance of approximately 19.8 miles. This will add tremendous peak-hour vehicular capacity and facilitate more efficient traffic operations in New Hampshire.

However, the future lane imbalance with the I-93 SB lane drop from four lanes to three lanes between the New Hampshire state line and Exit 41 in Wilmington, Massachusetts for approximately 11.5 miles is expected to be a key choke point and source of congestion in the future morning peak period.

In the northbound direction during the afternoon peak period, after Exit 41 and the Route 125 interchange, I-93 northbound drops a lane and consist of three GP lanes to the New Hampshire state line. In the future, this reduction from four to three lanes at Exit 41, and back to four lanes in New Hampshire is expected to be choke point and a source of peak-hour congestion in the weekday afternoon.

Additionally, the peak-period breakdown travel lanes on I-93 northbound and southbound between Exits 45 and 47 will permanently be eliminated with the reconstruction of the Methuen interchange at Route 110/113 and I-93.

With regards to managed lanes and the benefits of higher travel speeds and higher person throughputs, an existing managed lane on I-93 southbound begins in Medford, Massachusetts. After Exit 30 and before Exit 28, I-93 southbound splits into one HOV lane and three GP lanes. There is a four-foot painted buffer between the HOV lane and the adjacent GP lanes. The HOV lane ends at the Bunker Hill Bridge at the I-93/Route 1 merge. There are no other entrances or exits for the southbound HOV lane between the Mystic Avenue on ramp entrance and the Zakim Bridge.

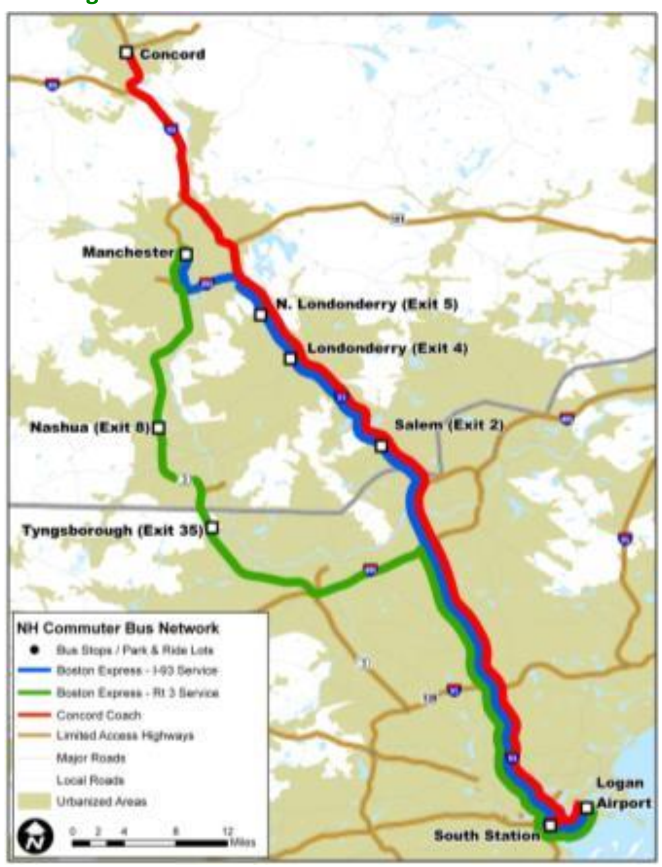
While there is a managed lane for I-93 southbound that spans approximately two miles, it does not span the nine mile breadth of inbound congestion during the morning peak period, which begins just south of I-95/Route 128. There are no managed lanes northbound on I-93 to improve travel speeds or user throughput during the weekday afternoon peak period.

5.3 Corridor Bus Services

In total, seven regional and four local bus transit operators provide service within New Hampshire and intercity service to Boston and beyond. All of these services are subject to the same highway congestion that affects automobile traffic on I-93 and other elements of the corridor highway network. Each of these services has access to the HOV lane on I-93 that travels 2.5 miles between the Shore Drive overpass in Somerville and the Zakim-Bunker Hill Bridge, potentially saving up to 10 minutes compared with morning peak travel in the GP lanes.

BX provides the primary commuter service from the Study area to Boston along the heavily congested Massachusetts segments of Interstate 93. The service was initially introduced by NHDOT as a mitigation measure during highway construction along I-93. Concord Coach also provides intercity service to Boston along the central spine of New Hampshire as far north as Berlin, New Hampshire. Figure 5.15 shows BX and Concord Coach bus routes. In Massachusetts, the MBTA and Merrimack Valley Regional Transit Authority (MVRTA) also provide commuter service to Boston along I-93 from communities to the north of the city.

Figure 5.15: BX and Concord Coach Bus Routes



Additional New Hampshire regional bus service between communities outside of the Study area and to Boston operates through the Study area or along Study corridor segments. Dartmouth Coach provides service from Dartmouth University in Hanover, New Hampshire and White River Junction, Vermont to Boston and travels non-stop through the Study area along I-89 and I-93.

Service to and from the New Hampshire Seacoast is operated by C&J from Dover, Durham; Portsmouth, New Hampshire and Newburyport, Massachusetts to Boston and New York City. Finally, Greyhound provides intercity service from Boston to Manchester, Concord, and points north and west and from Boston to Nashua via Worcester and Leominster, Massachusetts.

Local bus service within the New Hampshire Study area portion is provided by Concord Area Transit (CAT), Manchester Transit Authority (MTA), and Nashua Transit System (NTS). Local bus service in Massachusetts is also provided within the Study area by the Lowell Regional Transit Authority. Interconnections between these local providers are limited.

5.3.1 Boston Express (BX)

BX is a privately operated network of commuter buses that were originally procured by the State of New Hampshire as a mitigation measure for the expansion project on I-93. NHDOT allocated capital investment to acquire the buses and construct a number of park-and-ride facilities.

Two routes provide service to Boston South Station from the downtown Manchester bus terminal on Canal Street at Granite Street and via park-and-ride facilities on Route 3 or I-93. The Route 3 service makes stops at Exit 8 in Nashua and Exit 35 in Tyngsborough, Massachusetts, while the I-93 service makes stops at Exit 5 in North Londonderry, Exit 4 in Londonderry, and Exit 2 in Salem.

The I-93 service operates 24 peak period trips per day at 15-30 minute headways and 31 off-peak trips 30-60 minute headways. The Route 3 service operates 14 peak-period trips per day at 20-30 minute headways and 32 off-peak trips per day at 45-120 minutes headways.

Most BX trips follow I-93 directly to Boston South Station, but many of the southbound peak period trips on the I-93 service travel through downtown Boston to serve commuters on the way to or from South Station. Northbound trips to New Hampshire do not circulate through downtown, but depart directly from South Station and travel north on I-93.

Existing traffic congestion along I-93 significantly impacts BX's scheduled travel times. For instance, the 6:30am southbound departure from Londonderry (Exit 4) on the I-93 service is scheduled for a one-hour trip to South Station. Meanwhile, the 9:50am southbound departure is scheduled for a two-hour and 20 minute trip, which is a built-in or induced delay of one hour and 20 minutes.

Average daily ridership on the I-93 service is approximately 1,200 boardings and on the Route 3 service, approximately 600 daily boardings (Tables 5.6 and 5.7).

Table 5.6: BX I-93 Service

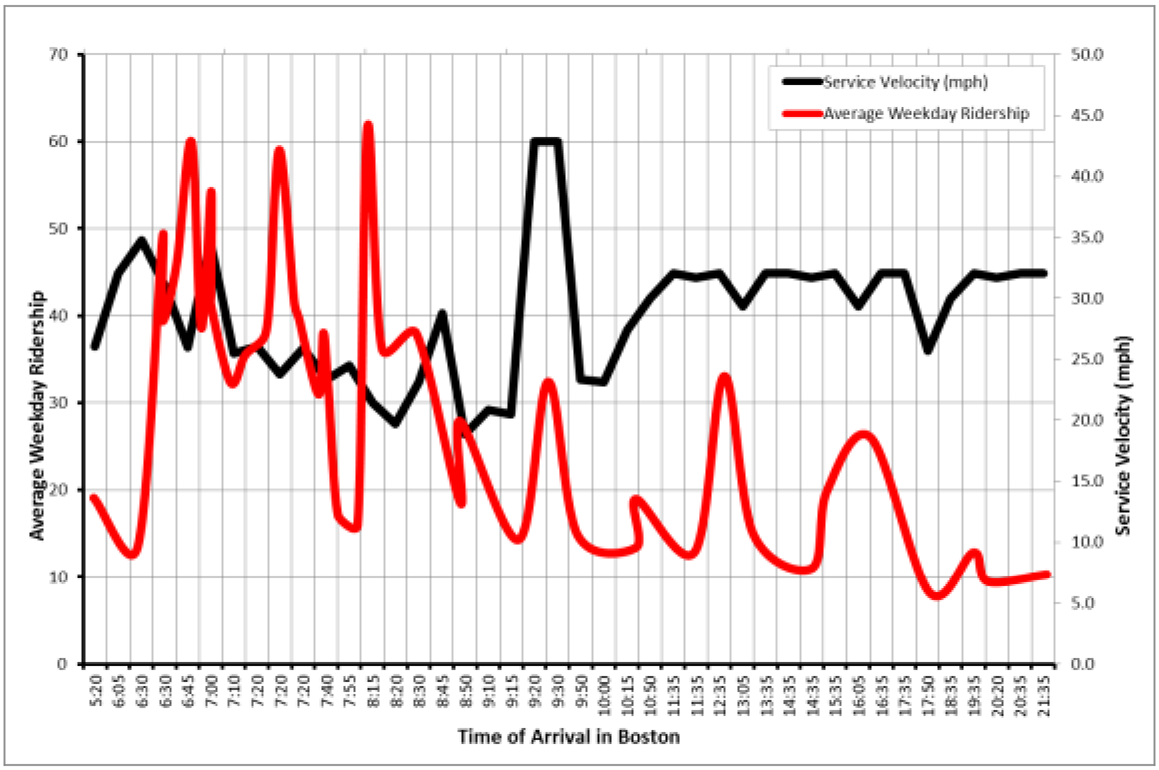
	I-93 Southbound Service	I-93 Northbound Service
Average Weekday Ridership (March 2013)	613	602
Peak Trips	12	12
Off-Peak Trips	17	14
Span of Service	4:00am-9:50pm	7:15am-11:55pm
Peak Headways	20-30 min	15 min
Off-Peak Headways	30-60 min	60 min

Table 5.7: BX Route 3 Service

	Route 3 Southbound Service	Route 3 Northbound Service
Average Weekday Ridership (March 2013)	298	306
Peak Trips	7	7
Off-Peak Trips	16	16
Span of Service	5:30am-8:35pm	7:15am-11:00pm
Peak Headways	30 min	20-30 min
Off-Peak Headways	90-120 min	45-90 min

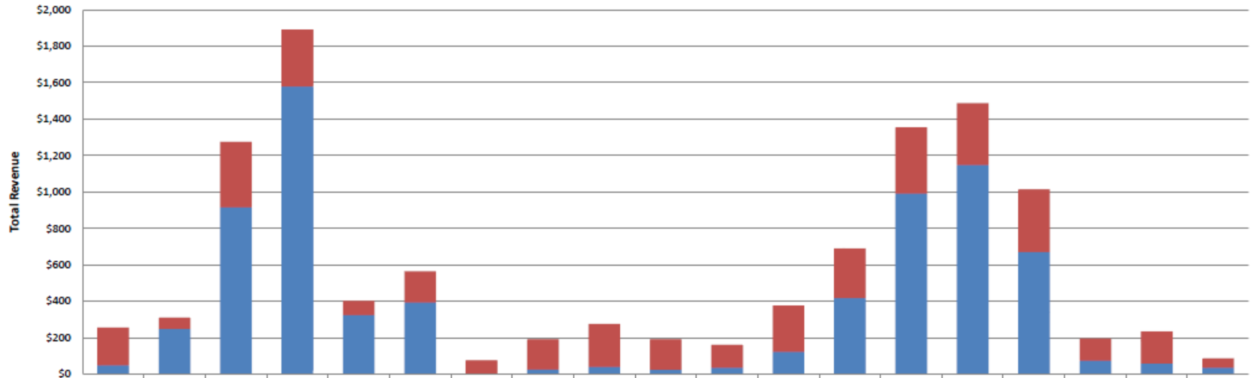
Figure 5.16 shows the average weekday ridership and service velocity by the southbound time of arrival in Boston for March 2013. The black line shows scheduled service velocity in miles per hour by time of day. As would be expected, service velocity is substantially higher for midday and evening trips. The red line shows average daily ridership for each scheduled trip. BX suffers due to traffic congestion on I-93 because its service velocity is lowest when demand for its service is highest.

Figure 5.16: Average Weekday Ridership and Service Velocity by Southbound Time of Arrival in Boston (March 2013)



Most peak users of the BX service are regular commuters as evidenced by their use of the discounted multi-ride commuter tickets. The off-peak riders are much more likely to travel using a full-fare, one-way ticket. Figure 5.17 shows the number of passengers per hour who use a multi-ride commuter ticket (blue) and the number who purchase full-fare, single-ride tickets.

Figure 5.17: Hourly BX Total Revenue Collected by Fare Type and Departure Time of Day



	03:01 - 04:00	04:01 - 05:00	05:01 - 06:00	06:01 - 07:00	07:01 - 08:00	08:01 - 09:00	09:01 - 10:00	10:01 - 11:00	11:01 - 12:00	12:01 - 13:00	13:01 - 14:00	14:01 - 15:00	15:01 - 16:00	16:01 - 17:00	17:01 - 18:00	18:01 - 19:00	19:01 - 20:00	20:01 - 21:00	22:01 - 23:00
Full Fare	206.5	60.5	357.5	311	77	170.5	75	166	234.5	166.5	126	253.4	271	362.5	339	343	121	174.88	51.5
Commuter	49.119091	248.92	916.44	1578.78	324.6	393.2		25.1	40.56	24.16	35	122.48	418.44	991.22	1147.56	670.2	73.82	58.16	35

BX operates commuter service on a franchise from the State of New Hampshire and receives an annual subsidy. The subsidy is assessed each year based on operating revenue shortfalls. Its sister operation, Concord Coach, operates as an entirely private entity and does not receive operating support for its intercity service. Both services use buses purchased with financial assistance from the State of New Hampshire. All the park-and-ride lots in the corridor used by BX and Concord Coach were constructed and are owned by state or local governments.

5.3.2 Concord Coach

Formerly known as Concord Trailways, Concord Coach Lines, Inc., is an intercity bus company originally founded in 1967, and expanded in 1988 with the purchase of the Trailways franchise. Concord Coach Lines operates along the I-93 corridor with service from Berlin and Littleton, New Hampshire through Concord to Boston South Station and Logan Airport (see Table 5.8 for a summary of service). It also operates service in the I-95 corridor between Bangor, Maine and Boston. NHDOT tracks Concord Coach boardings at the Concord, New Hampshire bus station on Stickney Avenue. In 2012, ridership averaged approximately 150 passenger boardings per day.

Concord Coach operates a total of 13 northbound and 12 southbound trips per day between Concord, South Station, and Logan Airport in Boston. Two round trips per day operate between Concord and Littleton. One round trip per day operates between Concord and Berlin and a truncated weekend-only service operates between Concord and as far north as North Conway. BX tickets are cross-honored on all trips between Manchester, North Londonderry, Salem, and Boston.

Table 5.8: Concord Coach I-93 Bus Service

	Southbound Service	Northbound Service
Ridership	Not available	Not available
Peak Trips	4	5
Off-Peak Trips	8	8
Span of Service	5:00am-8:50pm	7:15am-11:20pm
Peak Headways	60 min	60 min
Off-Peak Headways	60-120 min	60-120 min

5.3.3 Massachusetts Bay Transportation Authority (MBTA)

MBTA operates four peak-period, weekday-only express bus services within the Study corridor along I-93 from Woburn, Burlington, and West Medford to Haymarket and State Street in downtown Boston. Together these four routes carry almost 2,000 weekday passenger trips (Table 5.9). These routes are subject to the same peak-period traffic congestion on I-93 that adversely impacts motorists and other express bus services.

Table 5.9: MBTA I-93 Bus Service

Route	Garage	Terminals	Weekday Boardings		
			Inbound	Outbound	Total
325	Charlestown	Elm St. – Haymarket Station	171	149	320
326	Charlestown	West Medford – Haymarket Station	227	207	434
352	Charlestown	Burlington – State Street	180	197	377
354	Fellsway	Woburn Line – State Street	365	427	792
Total			**943**	**980**	**1,923**

5.3.4 Merrimack Valley Regional Transit Authority (MVRTA)

The MVRTA Boston Commuter Bus provides four inbound trips in the morning and four outbound trips in the evening via I-93. These buses carry 257 passenger trips on a typical weekday and are subject to the same peak congestion that impacts other users of I-93.

5.3.5 Greyhound

Greyhound provides intercity service from Boston to Manchester, Concord, and points north and west. Four daily Montreal-bound trips depart from Boston, three of which stop at Manchester Airport, two in Manchester, and one in Concord. Of the four daily southbound trips from Montreal to Boston, one stops in Concord and Manchester, while all four stop at Manchester Airport. Greyhound also provides one trip per day between Boston, Nashua, Manchester, and Concord via Worcester and Leominster, Massachusetts.

5.3.6 Dartmouth Coach

Dartmouth Coach provides intercity service from New Hampshire's Upper Valley to Boston and New York City. It does not make any stops or provide any service to communities within the Study area.

5.3.7 Manchester Transit Authority (MTA)

The MTA provides bus service throughout Manchester and operates express service to Nashua and Concord. Thirteen routes provide scheduled service to Manchester and surrounding destinations. Two express routes provide service from downtown Manchester to Concord and from downtown Manchester to the Nashua Mall. Concord Express originally served the Manchester Airport, but that service was eliminated to low ridership.

5.3.8 Nashua Transit System (NTS)

The NTS comprises nine local routes that begin and end their trips at the downtown Transit Center behind City Hall. Each route operates 12-13 round trips per day on hourly headways.

5.3.9 Concord Area Transit (CAT)

The CAT operates three weekday routes serving the City of Concord and surrounding communities. Each route operates 12-13 hours per day.

5.3.10 Lowell Regional Transit Authority (LRTA)

The LRTA operates 12 local routes and one downtown shuttle serving the City of Lowell and the towns of Billerica, Burlington, Dracut, Chelmsford, Tewksbury, Tyngsborough, Westford, and Wilmington, Massachusetts. All 12 routes now operate on hourly headways. The downtown shuttle operates on 30-minute headways from 7:30am - 7:00pm.

6 Service Alternatives

The Study team held numerous meetings with a wide variety of stakeholders, including public officials from New Hampshire and Massachusetts, all regional public transportation providers, Amtrak, PAR, and the general public. The project Rationale derived from the process of assembling and evaluating information concerning existing and likely future travel conditions in the corridor. This research and consultation led the team to understand the opportunities and constraints it faced in framing alternatives for improved corridor public transport service. As the Study was jointly funded by the FRA and FTA, the range of alternatives considered and developed covered both bus and rail service options. Bus service options included modifications to the frequency and operating conditions of the existing BX commuter bus system. Rail service options included extensions of MBTA's Lowell Line service and options for intercity rail services that would overlay on the existing mix of passenger and freight rail services.

The most salient transport problem addressed in developing the alternatives was improving connections between southern New Hampshire and the regional core in downtown Boston. The principal travel obstacle in the corridor is the extreme peak-period highway congestion that slows Boston-bound travel to a 12 mph crawl for the final eight miles of a typical morning peak trip into the city.

The Study team consulted with MBTA, PAR, NHDOT, MassDOT, BX, and others to develop a set of two base, nine rail, and three bus service options for preliminary screening (Tables 6.1 and 6.2). Using preliminary estimates of cost, demand, and revenue, the Study team consulted with project stakeholders and the general public to screen the 12 initial build options down to seven intermediate options and then five final options (three rail, one bus, one no build) for refinement and more detailed analysis. This section introduces the 12 preliminary build options then reviews the intermediate and final options in more detail.

Table 6.1: Preliminary Rail Service Options

Options	Weekday Revenue Trains			Route Miles	Stations Served
	Nashua	Manchester	Concord		
No Build	0	0	0	26	8
Intercity Passenger Rail Options					
Intercity 8	8	8	8	73	6
Intercity 12	12	12	12	73	6
Intercity 18	18	18	18	73	6
Commuter and Regional Rail Options					
Concord Regional	30	8	8	73	13
Concord Commuter	26	22	18	73	13
Manchester Regional	34	16	0	56	12
Manchester Commuter	30	20	0	56	12
Nashua Commuter	34	0	0	39	10
Nashua Minimum	16	0	0	35	9

Table 6.2: Preliminary Bus Service Options

Options	Weekday Revenue Trips								Weekday Vehicle Miles	%& Increase in Weekday Vehicle Miles
	Manchester	N. Londonderry	Londonderry	Salem	Nashua	Tyngsborough	South Station	Logan Airport		
No Build	18	46	17	39	24	23	80	58	3,932	0%
Expanded Base	32	40	39	40	38	38	120	120	5,850	49%
Bus on Shoulder	18	46	17	39	24	23	80	58	3,932	0%
Expanded Bus on Shoulder	32	40	39	40	38	38	120	120	5,850	49%

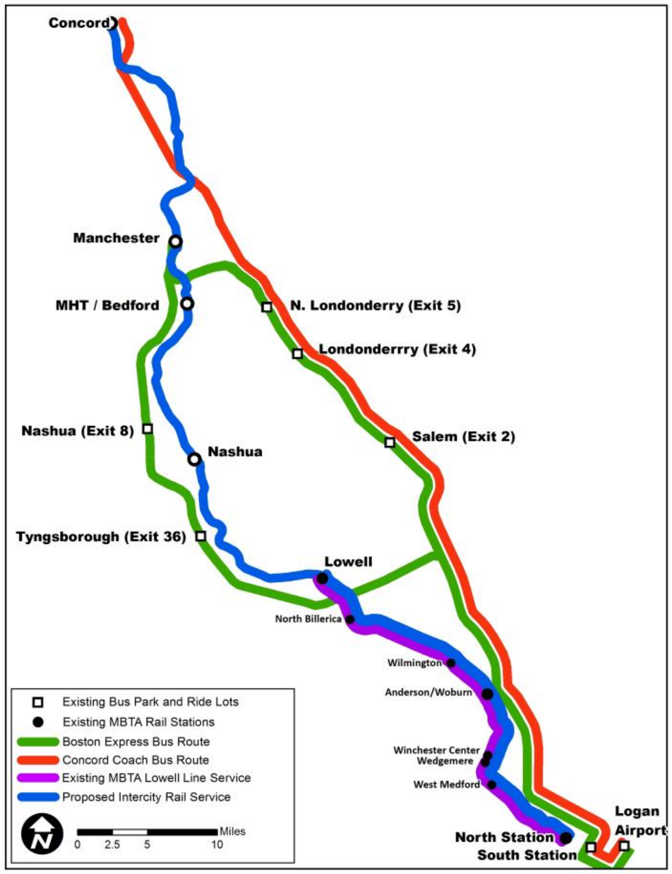
6.1 Preliminary Intercity Rail Service Options

The Study team devised a hierarchy of three conceptual options that could be operated as an independent intercity rail service that would extend 73 miles northward from North Station to Concord (Figure 6.1). These options are based on NHML historic and current physical attributes, the schedule of passenger services on the line, and general service parameters for Amtrak services in corridors of less than 150 miles. Each service would have the following characteristics:

- Operate independently of MBTA and Amtrak *Downeaster* passenger services already serving the route's southernmost 25 miles
- Require no upgrades to infrastructure south of Lowell
- Require upgrades to rail infrastructure north of Lowell

- Upgrade 48 miles of existing track to FRA Class 4 providing for maximum passenger train speeds of 70 mph, since no historic records show higher speeds along the route since its opening in the 1800s
- Establish Crown Street in Nashua as a passing point for northbound and southbound passenger trains (Intercity 12 and 18)
- Install one or more industrial sidings between Nashua and Concord allowing passenger trains to pass or meet freight trains
- Install a passing siding on the PAR main line west of North Chelmsford to reduce the need for trains to stand east of North Chelmsford on the route between Lowell and Nashua
- Install NORAC Rule 261 signals between Manchester and Concord (approximately 18 miles)
- Install MBTA Positive Train Control (PTC) protection

Figure 6.1: Intercity Rail Service Options



Services would stop at six passenger stations north of Boston. The distance and travel time to Boston for each station are listed in Table 6.3.

Table 6.3: Initial Preliminary Design Miles and Travel Time to Boston

Station	Miles to Boston	Time to Boston
Concord	73.3	1:36
Manchester	55.5	1:22
Bedford/MHT	50.1	1:09
Nashua	38.8	0:56
Lowell	25.5	0:38
Woburn	12.6	0:23

The projected travel times compare favorably with historic minimum travel times between Concord and Boston (see Table 6.4).

Table 6.4: Historic Minimum Concord-Boston Travel Times

	1910	1926	1945	1954
Travel Time	2:00	2:05	1:35	1:22
Average Speed (mph)	37	35	46	54

Source: Jacobs analysis of archived public timetables

6.1.1 Intercity 8

The eight-train-per-day Intercity 8 option would provide four daily round trips over the 73-mile route, stopping at five intermediate stations including the Manchester Airport (see the preliminary timetable in Table 6.5). The end-to-end trip time would be approximately 96 minutes. The service would entail 586 daily train miles. Presuming an average cost of $36 per train mile, Intercity 8 would cost approximately $7.7 million per year to operate.

Table 6.5: Intercity 8 Preliminary Timetable

380	382	384	386		Station	MP		381	383	385	387
6:38	10:38	14:53	19:53	Read Down	Concord, NH	73.3	Read Up	10:07	14:22	18:57	23:37
6:52	10:52	15:07	20:07		Manchester, NH	55.5		9:41	13:56	18:31	23:11
7:05	11:05	15:20	20:20		Bedford/MHT	50.1		9:33	13:48	18:23	23:03
7:18	11:18	15:33	20:33		Nashua	38.8		9:20	13:35	18:10	22:50
7:36	11:36	15:51	20:51		Lowell	25.5		9:02	13:17	17:52	22:32
7:52	11:52	16:07	21:07		Anderson/Woburn	12.6		8:46	13:01	17:36	22:16
8:15	12:15	16:30	21:30		North Station	0.0		8:30	12:45	17:20	22:00

The service could be extended with possible connections to private bus services for North Country destinations. No substantial changes in express bus service for commuting to Boston via US Route 3/Everett Turnpike or I-93 would be expected. Local bus service to the intercity rail stations could be offered, but would not be integral to the service design. The service would use a single four-car train set stored in Concord. A spare locomotive and a spare coach would also be required.

6.1.2 Intercity 12

The 12-train-per-day Intercity 12 option would operate six daily round trips (see the preliminary timetable in Table 6.6). The service would provide travelers in both New Hampshire and Massachusetts with more convenient morning northbound trips and evening southbound trips that would not be available with Intercity 8. The service would entail 880 daily train miles. Presuming an average cost of $36 per train mile, Intercity 12 would cost approximately $12 million per year to operate.

As with Intercity 8, the service could be extended with possible connections to private bus services for North Country destinations. No substantial changes in express bus service for commuting to Boston via US Route 3/Everett Turnpike or I-93 would be expected. Local bus service to the rail stations could be offered, but would not be integral to the service design. The service would use two four-car train sets. One would be stored in Concord and the other in Boston. A spare locomotive and one spare coach would also be required.

Table 6.6: Intercity 12 Preliminary Timetable

Southbound						
Train	**380**	**382**	**384**	**386**	**388**	**390**
Concord, NH	6:33	8:33	10:33	16:33	18:33	22:33
Manchester	6:47	8:47	10:47	16:47	18:47	22:47
Bedford/MHT	7:00	9:00	11:00	17:00	19:00	23:00
Nashua	7:13	9:13	11:13	17:13	19:13	23:13
Lowell	7:31	9:31	11:31	17:31	19:31	23:31
Woburn	7:47	9:47	11:47	17:47	19:47	23:47
North Station	8:10	10:10	12:10	18:10	20:10	0:10
Northbound						
Train	**381**	**383**	**385**	**387**	**389**	**391**
North Station	6:20	8:23	10:23	16:23	18:23	22:23
Woburn	6:36	8:39	10:39	16:39	18:39	22:39
Lowell	6:52	8:55	10:55	16:55	18:55	22:55
Nashua	7:13	9:13	11:13	17:13	19:13	23:13
Bedford/MHT	7:26	9:26	11:26	17:26	19:26	23:26
Manchester	7:34	9:34	11:34	17:34	19:34	23:34
Concord, NH	8:00	10:00	12:00	18:00	20:00	0:00

6.1.3 Intercity 18

The 18-train-per-day Intercity 18 option would provide nine daily round trips (see the preliminary timetable in Table 6.7). This would constitute bi-hourly, bi-directional service 18 hours per day between Concord and Boston. It represents an upper limit on the density of intercity service that could be considered between Central New Hampshire and Downtown Boston. The service would entail 1,319 daily train miles. Presuming an average cost of $36 per train mile, Intercity 18 would cost approximately $17 million per year to operate. As with the other options, Intercity 18 could be extended with possible connections to private bus services for North Country destinations. No substantial changes in express bus service for commuting to Boston via US Route 3/Everett Turnpike or I-93 would be expected. Local bus service to the intercity rail stations could be offered, but would not be integral to the service design. Like Intercity 12, the service would use two four-car train sets. One would be stored in Concord and the other in Boston. A spare locomotive and one spare coach would also be required.

Table 6.7: Intercity 18 Preliminary Timetable

Southbound									
Train	**380**	**382**	**384**	**386**	**388**	**390**	**392**	**394**	**396**
Concord, NH	6:33	8:33	10:33	12:33	14:33	16:33	18:33	20:33	22:33
Manchester	6:47	8:47	10:47	12:47	14:47	16:47	18:47	20:47	22:47
Bedford/MHT	7:00	9:00	11:00	13:00	15:00	17:00	19:00	21:00	23:00
Nashua	7:13	9:13	11:13	13:13	15:13	17:13	19:13	21:13	23:13
Lowell	7:31	9:31	11:31	13:31	15:31	17:31	19:31	21:31	23:31
Woburn	7:47	9:47	11:47	13:47	15:47	17:47	19:47	21:47	23:47
North Station	8:10	10:10	12:10	14:10	16:10	18:10	20:10	22:10	0:10
Northbound									
Train	**381**	**383**	**385**	**387**	**389**	**391**	**393**	**395**	**397**
North Station	6:20	8:23	10:23	12:23	14:23	16:23	18:23	20:23	22:23
Woburn	6:36	8:39	10:39	12:39	14:39	16:39	18:39	20:39	22:39
Lowell	6:52	8:55	10:55	12:55	14:55	16:55	18:55	20:55	22:55
Nashua	7:13	9:13	11:13	13:13	15:13	17:13	19:13	21:13	23:13
Bedford/MHT	7:26	9:26	11:26	13:26	15:26	17:26	19:26	21:26	23:26
Manchester	7:34	9:34	11:34	13:34	15:34	17:34	19:34	21:34	23:34
Concord, NH	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00	0:00

6.2 Preliminary Commuter Rail Options

Meetings with MassDOT and MBTA in the Spring of 2013 indicated a willingness to work with NHDOT on the provision of passenger service along the NHML from New Hampshire to North Station. This cooperation could come in the form of MBTA operation of trains into New Hampshire or the operation of intercity trains along the same route. It was stated that with the imminent relocation of the Spaulding Hospital immediately west of North Station that two new station tracks at the terminal would be opened providing capacity for one additional peak Amtrak train in each direction. MBTA would also be willing to extend its service into New Hampshire provided that the service extension was essentially transparent to existing MBTA passengers using services offered between Lowell and Boston and that the net cost of the service extension to Massachusetts taxpayers would be zero.

The “net cost of zero” would be achieved via a “Pilgrim Partnership” arrangement with NHDOT that would mimic successful rail service funding and operational arrangements between Rhode Island and Massachusetts that allow MBTA to offer passenger rail service into Rhode Island. The broad outline of the “Pilgrim Partnership” calls for the host state to provide MBTA with an ongoing flow of capital funds. The funds, much of which would be federal formula grants, would be spent at the MBTA’s prerogative on rolling stock and facilities necessary for its overall commuter rail operation. Some of the funded assets may be used for the interstate service, but none of the assets are dedicated or obligated to that service. With that capital funding in-place, MBTA would agree to operate trains into the neighboring state in exchange for the passenger revenue collected from out-of-state passengers. The funding host state would be responsible for upkeep of the fixed infrastructure in its state and any fees charged by the host railway. The MBTA would then pay for management, training of crews, fuel, and maintenance of rolling stock.

The Study team devised a hierarchy of six conceptual rail services that could be operated as an extension of MBTA Lowell service northward into New Hampshire. These options were based on NHML historic and current physical attributes, the schedule of passenger services on the line, and parameters of MBTA's offer to operate the service as integral portion of its other services to and from North Station. Each service would have the following characteristics:

- Extend existing MBTA service into New Hampshire
- Be generally transparent to existing MBTA customers
- Have no impacts on existing Amtrak service between North Station and Maine
- Require no upgrades to infrastructure south of Lowell
- Require upgrades to rail infrastructure north of Lowell
    - Upgrades to existing track (up to 48 miles) to FRA Class 3 providing for maximum passenger train speeds of 60 mph
    - Installation of second main line track between North Chelmsford and downtown Nashua
    - Installation of at least one siding between Nashua and Bow allowing passenger trains to pass or meet freight trains serving this segment
    - Installation of NORAC Rule 261 signals between Manchester and Concord (approximately 18 miles)
    - Installation of MBTA PTC protection

Class 3 track was selected for the preliminary options to reduce costs. An upgrade to Class 4 would cost more for track upgrades and maintenance. The estimated difference in running times between Nashua and Lowell with an upgrade to Class 4 would be one minute. Class 4 track would cut approximately six minutes on the running time between Concord and Lowell. For one commuter rail option (Concord Commuter), the team used Class 4 speeds (up to 70 mph) to establish an economic harmony between the existing MBTA schedules and rolling stock and crew requirements.

The six conceptual commuter rail services are described below. The services would stop at up to five passenger stations north of Lowell. Table 6.8 lists the five stations with their distance to Boston and projected maximum and minimum travel times.

Table 6.8: Initial Preliminary Commuter Rail Designs: Miles and Minutes to Boston

Station	Miles to Boston	Maximum Travel Time to Boston	Minimum Travel Time to Boston
Concord	73.3	1:54	1:46
Manchester	55.5	1:32	1:25
Bedford/MHT	50.1	1:24	1:17
Downtown Nashua	38.8	1:14	1:02
Nashua South	35.5	1:08	0:54

6.2.1 *Concord Regional Rail Service*

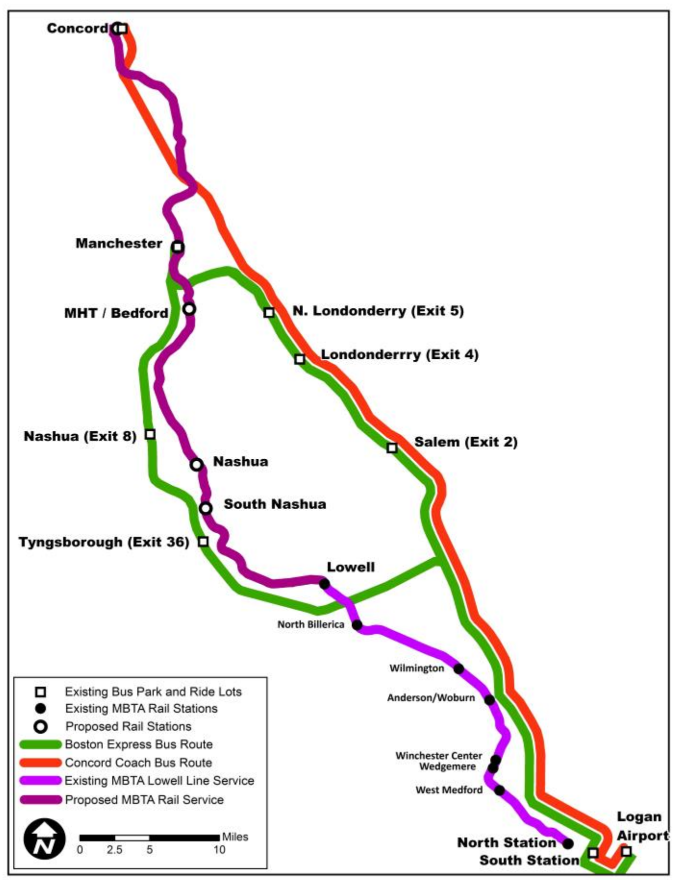
Concord Regional Rail provides a mix of commuter train service for Nashua with a lower frequency regional service provided for Manchester and Concord. The service adds six new stations to the line with eight weekday trains for Concord and Manchester and 30 weekday trains for Nashua. All MBTA deadhead trains are eliminated. A layover facility for one train set would be required in Concord and for three trains in the vicinity of Nashua. The service would require an additional train set conservatively estimated at seven coaches. Additional coaches on the other five train sets assigned to the service would be required to carry the new passengers onto the NHML services. Up to 12 coaches and one locomotive would be added to the MBTA's weekday line-up of equipment for one new seven-car train and five additional coaches on existing consists assigned to the service.

6.2.2 *Concord Commuter Rail Service*

Compared with Concord Regional, Concord Commuter provides a more ambitious LOS for Concord (and Manchester). It is the only commuter rail option that would require Class 4 track and would necessitate extensive track upgrades, with maximum speeds between Lowell and Concord restored to their historic maximum of 70 mph where possible. Like Concord Regional, it adds six new stations to the line, but provides 18 trains to Concord, 22 to Manchester and Bedford/Manchester Airport, and 26 trains to Nashua. Four MBTA train sets assigned to the line are stored overnight in the vicinity Concord.

Owing to the higher maximum speeds, the travel times from Concord, Manchester and Nashua would be somewhat shorter, approximately 105 minutes, 90 minutes, and 66 minutes respectively. The largest time savings resulting from the higher speeds is for

Figure 6.2: Concord Rail Service Options



the 73-mile trip to Concord. Like Concord Regional, the service would require an additional train set conservatively estimated at seven coaches. Up to 12 coaches and one locomotive would be added to the MBTA's weekday line up as in Concord Regional. Concord Regional and Concord Commuter Rail Service options are shown in Figure 6.2 above.

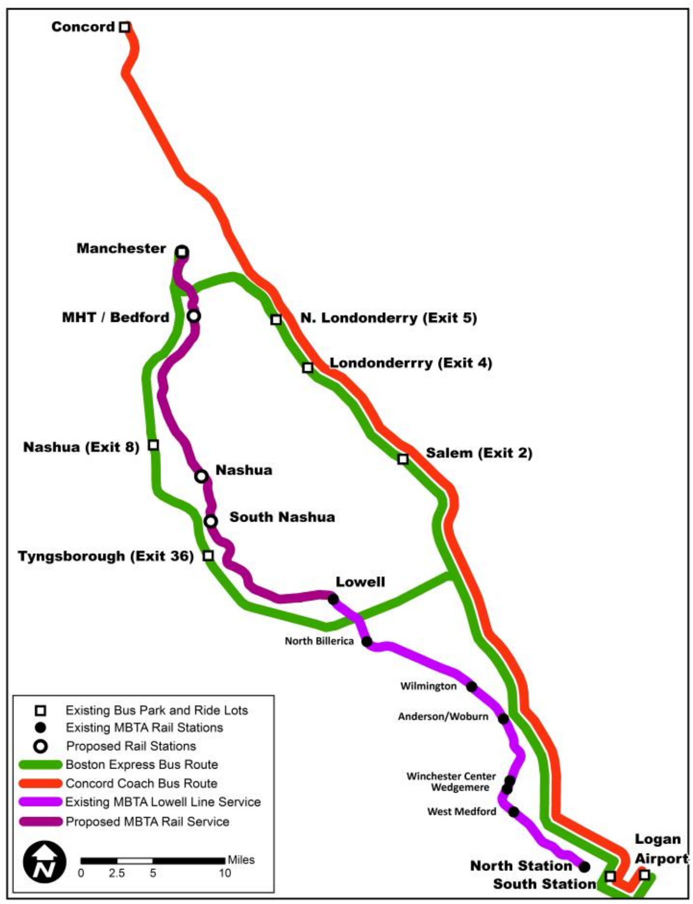
6.2.3 Manchester Regional Commuter Rail Service

Manchester Regional provides a mix of commuter train service for Nashua with a lower frequency regional service provided north to Manchester. MBTA service would be extended 30 miles to downtown Manchester. The service adds five new stations to the line with 16 weekday trains for Manchester and 34 for Nashua. As with Concord Regional and Concord Commuter, all MBTA deadhead trains are eliminated. A layover facility for four train sets would be constructed in the vicinity of Manchester. Up to 12 coaches and one locomotive would be added to the MBTA's weekday line-up of equipment.

6.2.4 Manchester Commuter Rail Service

Manchester Commuter provides more extensive service for Manchester compared with the Concord Regional, Concord Commuter, and Manchester Regional. As with Manchester Regional, MBTA service would be extended 30 miles to downtown Manchester. The service adds five new stations to the line with 20 weekday trains for Manchester and 30 for Nashua. As with the previous options, all MBTA deadhead trains are eliminated. As with Manchester Regional, a layover facility for four train sets would be constructed in the vicinity of Manchester. Also as with the previous options, up to 12 coaches and one locomotive would be added to the MBTA's weekday line-up. Manchester Commuter and Manchester Regional are shown in Figure 6.3.

Figure 6.3: Manchester Rail Service Options



6.2.5 Nashua Commuter Rail Service

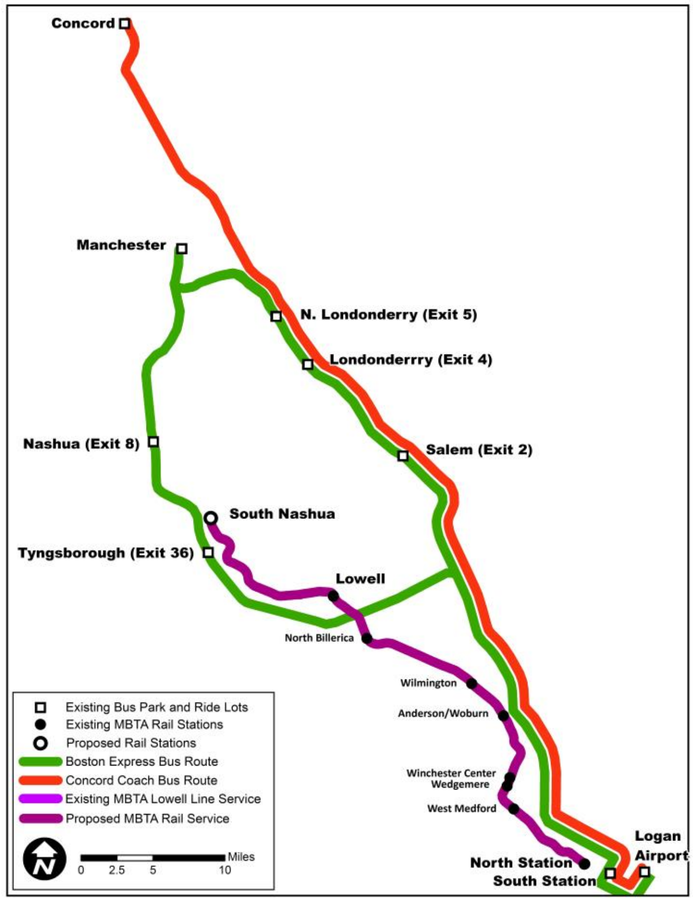
Nashua Commuter provides commuter train service to and from downtown Nashua with no rail service beyond to Manchester or Concord. It could be developed and operated as an interim service coordinated with bus service for Manchester and Concord until service is implemented further north. MBTA service would be extended 13 miles from Lowell to downtown Nashua. The service adds two new stations to the line with 34 weekday trains for Nashua. A layover facility for four train sets would be constructed in the vicinity of

Nashua. As with the other options, up to 12 coaches and one locomotive would be added to the MBTA's weekday line up.

6.2.6 Nashua Minimum Commuter Rail Service

Nashua Minimum provides a minimal peak-only commuter rail service to and from South Nashua with no rail service beyond Nashua to Manchester or Concord. It is specifically designed to minimize MBTA's operating cost of extending service to Nashua. Like Nashua Commuter, it could be developed and operated as an interim service coordinated with bus service while markets and finances for more New Hampshire options were given time to develop.

Figure 6.4: Nashua Rail Service Options



MBTA service would be extended 9.7 miles to the South Nashua station located at or immediately across the New Hampshire state line. The service adds one new station to the line with 16 weekday trains for Nashua. As with Nashua Commuter, a layover facility for four train sets would be constructed in the vicinity of South Nashua. Similar to the previous options, up to 13 coaches and one locomotive would be added to MBTA's weekday line-up of equipment. The South Nashua station would be located approximately at MP 35.2 in the vicinity of Pheasant Lane Mall or Spit Brook Road.

Nashua Minimum is proposed to provide service from Boston North Station to South Nashua during peak periods only and would travel only as far north as Lowell, Massachusetts during off-peak periods. The rail service could potentially be supplemented by a schedule of feeder buses that would extend the reach of off-peak trains north to South Nashua to ensure adequate mid-day mobility and travel options are available to daily commuters. Six inbound and six outbound buses could be provided throughout the day and could be operated with a single vehicle.

To schedule the feeder service with a single bus, the Study team decided to prioritize travel time for southbound passengers. Timetables developed by the team show that southbound trips are scheduled to provide five minutes for transfer from bus to rail. This will require that the bus portion of the trip is operated reliably to ensure that the connection to the train is made on time. Northbound trips will depart using the same bus and passengers will therefore wait approximately 15 minutes for the transfer from rail to bus. This is due to the time required for crews to turn the train in Lowell. This longer transfer time built-in to the schedules will allow for any delays on outbound rail trips from Boston and ensure that transferring passengers are not left at the station in Lowell. Nashua Rail Service options are shown in Figure 6.4 above.

6.3 Preliminary Bus Service Options

Recognizing that any rail service would require a substantial investment in upgrading track and constructing support facilities, the Study team also developed options that could improve the frequency and/or travel time of corridor express and intercity bus service. Recognizing that peak-period bus service from New Hampshire to Boston is mired in the same crawling automobile traffic that slows travel for motorists, the Study team spent considerable time researching the potential benefits of offering Bus on Shoulder service along I-93 in Massachusetts. The team also developed options that would expand the frequency and directness of bus service between downtown Boston and southern New Hampshire. The mix of more and frequent service resulted in three bus service options for consideration plus the base (existing) service option, as summarized in Table 6.9.

Table 6.9: Preliminary Bus Service Options

Options	Weekday Revenue Trips								Weekday Vehicle Miles	%& Increase in Weekday Vehicle Miles
	Manchester	N. Londonderry	Londonderry	Salem	Nashua	Tyngsborough	South Station	Logan Airport		
Base	18	40	19	32	37	21	80	58	3,932	0%
Expanded Base	32	39	38	39	37	37	120	120	5,850	49%
Bus on Shoulder	18	40	19	32	37	21	80	58	3,932	0%
Expanded Bus on Shoulder	38	39	38	39	37	37	120	120	5,850	49%

This portion of the SDP describes how Bus on Shoulder could be developed to offer some peak travel time savings. It then goes on to summarize the three bus service investment options. Additional details on the preliminary bus options can be found in Appendix 4 to the AA Final Report (Task 4 Initial Conceptual Transit Alternatives).

6.3.1 Base Service (Existing Bus Service)

Base service currently offered in the corridor is used as a baseline to compare the performance of any proposed transit service expansion to existing conditions. It is assumed to include any planned improvements to the highway network that would be in-place by 2030, such as the NHDOT I-93 improvement project and various interchange and lane improvements within Massachusetts. This option also includes the existing park-and-ride lots throughout the corridor. It maintains the current express and intercity bus service between New Hampshire, South Station, and Logan Airport along I-93. It does not incorporate any expansion of corridor rail service, but includes the proposed commuter rail extension to Plaistow, New Hampshire. Tables 6.10 and 6.11 list the number of weekday trips and scheduled travel times between the park-and-ride lots and the South Station bus terminal.

Table 6.10: Base Service Bus Trips

	Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsborough (Exit 35)	South Station	Logan Airport
SB Trips	8	21	7	20	12	11	42	31
NB Trips	10	25	10	19	12	12	38	27
Total	18	46	17	39	24	23	80	58

Table 6.11: Base Service Travel Times to/from South Station

		Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsborough (Exit 35)
Max	Off-Peak	2:15	1:40	1:50	1:20	1:45	1:30
	Peak	2:20	1:30	1:45	1:25	1:50	1:35
Min	Off-Peak	1:05	1:05	1:15	0:45	1:04	0:50
	Peak	1:40	1:05	1:00	0:45	1:00	1:05

6.3.2 Expanded Base

The Expanded Base option increases the frequency of bus service along the corridor by providing additional peak-period, point-to-point, non-stop trips from each New Hampshire park-and-ride lot to Boston's South Station. The service would add approximately 40 trips to the daily schedule, and would provide more frequent service to and from each existing park-and-ride lot. The additional service would require approximately 10 more vehicles and drivers. There are no transit priority measures proposed in this option that would aim to increase service velocities or decrease travel times.

Peak-period, point-to-point service would be provided between each park-and-ride lot and South Station at 30 minute headways, except for the Manchester service, which would be operated at 60 minute headways throughout the day. Hourly off-peak service would provide service to each park-and-ride lot within the I-93 or Route 3 corridors. Tables 6.12 and 6.13 list the number of weekday trips and scheduled travel times between the park-and-ride lots and the South Station bus terminal.

Table 6.12: Expanded Base Trips

	Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsborough (Exit 35)	South Station
SB Trips	16	20	19	20	18	18	60
NB Trips	16	20	20	20	20	20	60
Total	32	40	39	40	38	38	120

Table 6.13: Expanded Base Travel Times

		Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsborough (Exit 35)
Max	Off-Peak	2:15	1:40	1:50	1:20	1:45	1:30
	Peak	2:20	1:30	1:45	1:25	1:50	1:35
Min	Off-Peak	1:05	1:05	1:15	0:45	1:04	0:50
	Peak	1:40	1:05	1:00	0:45	1:00	1:05

6.3.3 Bus on Shoulder

Bus on Shoulder would not add any additional trips, but would provide faster, more reliable travel times between New Hampshire and South Station. The proposed timetables maintain the existing arrival and departure times at South Station and modify the departure and arrival times at New Hampshire park-and-ride lots based on possible estimated travel time savings. The service would not require any additional vehicles to operate the proposed schedule. It could potentially reduce vehicle requirements by allowing vehicles to operate more reliably so that they could provide multiple peak-period round trips. Tables 6.14 and 6.15 list the number of weekday trips and scheduled travel times between park-and-ride lots and the South Station bus terminal.

This option could potentially be combined with a viable passenger rail option or advanced as a Transportation Systems Management (TSM) approach or be implemented as a companion to a potential rail service improvement. A TSM is an FTA designation for an option that would contain a collection of low-cost transportation improvements that seek to mitigate congestion or enhance operational capacity of the existing transportation network.

Table 6.14: Bus on Shoulder Trips

	Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsborough (Exit 35)	South Station
SB Trips	8	21	7	20	12	11	42
NB Trips	10	25	10	19	12	12	38
Total	18	46	17	39	24	23	80

Table 6.15: Bus on Shoulder Travel Times

		Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsborough (Exit 35)
Max	Off-Peak	1:35	1:20	0:00	1:00	1:20	1:05
	Peak	2:10	1:27	1:37	1:15	1:40	1:25
Min	Off-Peak	1:25	1:05	0:00	0:45	1:04	0:50
	Peak	0:53	0:52	0:57	0:37	0:51	0:51

Bus on Shoulder Service

Bus use of highway shoulders has been an operational practice in North America for over 20 years. This growing practice allows professional bus drivers the discretionary authority to drive within highway shoulders to reduce travel times and increase the reliability of transit service. The long-standing history of Bus on Shoulder operations and the increasing number of communities pursuing such projects point to this practice's success in terms of both passenger and institutional benefits, and automobile driver acceptance. Many agencies have demonstrated that Bus on Shoulder can safely and cost-effectively improve transit service on congested roadways.

Highway shoulders, generally used as an emergency breakdown lane and for emergency response vehicles, can be easily adapted for bus use. The key design requirements are a minimum lane width of 10 feet (12 feet preferred), adequate shoulder pavement strength, drainage inlets level with roadway, and signage. Conflicts with pavement edge rumble strips and lateral obstructions adjacent to shoulders sometimes need to be addressed. The costs for these upgrades vary widely, but are modest compared with most highway widening and interchange reconstruction costs.[16]

Figure 6.5: Bus on Shoulder in Minneapolis

Two of the earliest and most extensive Bus on Shoulder networks are operated in Minneapolis (Figure 6.5) and Ottawa. Both systems have been in safe operation for more than 20 years. In Ottawa, buses can use the shoulders of limited access highways at any time with maximum allowable speeds of 62 mph (100 kmh). The more conservative Minneapolis system allows buses to use highway shoulders when the speed of general traffic drops below 35 mph. Buses on the shoulder may operate at speeds 15 mph faster than travel in other lanes, up to a maximum speed of 35 mph. The more liberal Ottawa approach is consistent with current general purpose vehicle use of highway shoulders on I-93 and I-95 in greater Boston where automobiles are allowed to travel at 65 mph in the shoulder during peak periods.

With more than 300 miles of Bus on Shoulder operations, the Twin Cities and Ottawa examples are the most extensive North American Bus on Shoulder networks. Many other communities have found this practice to be advantageous. As of 2012, transit buses were also operating on shoulders in Virginia, Maryland, Illinois, Washington, New Jersey, Georgia, Delaware, California, Florida, Kansas, North Carolina, Ohio, and Ontario.

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[16] Martin, Peter C. (2006). *TCRP Synthesis 64*: *Bus Use of Shoulders, A Synthesis of Transit Practice*, Transportation Research Board, National Research Council, Washington D.C. 2006, 100 pp.

Locally, the MVPC and MassDOT are evaluating Bus on Shoulder operations for I-93 in Massachusetts. That study assumes that Bus on Shoulder service along I-93 would follow the Minnesota operating model of 35 mph maximum speeds between I-495 and the Leonard P. Zakim-Bunker Hill Bridge in Boston.

Benefits of Bus on Shoulder

The direct benefits of Bus on Shoulder include reduced travel times and increased service reliability. Bus on Shoulder allows bus operators to maintain travel speeds, even in the case of unexpected traffic conditions, in turn increasing transit service reliability. Not only are actual travel times reduced once buses are allowed to bypass congestion, but customers perceive even greater reductions in travel time. Since perceptions are a key determinant in travel-mode decisions, perceived travel time savings are a real catalyst for increased transit market share.

Safety

Despite the long history of Bus on Shoulder, communities considering new Bus on Shoulder systems are often concerned with potential safety impacts. These concerns often focus on the ability of buses to merge in and out of GP lanes around highway entrances and exits or vehicles stopped on the shoulder (disabled vehicles, tow trucks, emergency responders, etc.). Bus on Shoulder networks in operation, however, have proven that thoughtfully designed Bus on Shoulder operations are inherently safe.

In the Twin Cities area, approximately half of all bus routes operated by the region's two largest transit providers operate on corridors that have the option to use Bus on Shoulder at some point along the route. The number of accidents involving these buses is low considering the scope of Bus on Shoulder operations. During the initial 10 years, between 1991 and 2001, there were 200 Bus on Shoulder accidents. Since the Twin Cities Bus on Shoulder system averaged 90 miles over this period, the number of accidents can be expressed as 0.2 accidents per mile per year. Most accidents were minor scrapes or mirror clips. No injuries were reported. Since 2001, there has been one injury:[17] An automobile struck a Bus on Shoulder bus from the rear killing the automobile driver. After 15 years of operations, Minneapolis Metro Transit reserves only $7,000 per year for damages resulting from Bus on Shoulder-related accidents. In other words, Metro Transit currently budgets approximately $26 per mile, annually, for Bus on Shoulder-related damages and contingencies.

Travel on the shoulder is advantageous only under congested conditions when buses have an opportunity to bypass slow moving traffic. Because buses only operate on shoulders when traffic in GP lanes is slow, the potential for accidents, especially those causing injury, are low. Whether operating a bus or private automobile, drivers' ability to react to changing conditions is much greater at low speeds.

[17] State and Local Policy Program, Hubert H. Humphrey Institute of Public Affairs, University of Minnesota (June 2007). Bus-only Shoulders in the Twin Cities. Prepared for the FTA. Retrieved from http://www.hhh.umn.edu/img/assets/11475/Bus/Only/Shoulders/Report/FINAL.pdf

For example, merging around obstructions is relatively easy for both buses and slow-moving traffic on congested roadways.

Existing Conditions

I-93 in New Hampshire is currently undergoing reconstruction to add two GP lanes in each direction as a congestion mitigation measure. Travel is not currently permitted on the shoulders. I-93 in Massachusetts is three lanes in either direction between the state line and Exit 41 (Route 125) in Andover. South of Exit 41, an additional general travel lane is added in each direction.

Peak vehicles in Massachusetts have been allowed to travel at speeds for up to 65 mph along the shoulders of I-93 north of Exit 41 since 1999.[18] Traffic flow in the peak periods is facilitated by the use of the shoulder in the peak direction between 6:00am and 10:00am in the morning, and between 3:00pm and 7:00pm in the afternoon. Shoulder use is not currently permitted for use by transit vehicles or commercial buses. Permission to use the breakdown lane for full speed GP traffic operations was extended by the Federal Highway Administration (FHWA) as an interim measure until a fourth lane is added north of Exit 41.

Bus on Shoulder operations would preclude shoulder use for private automobiles so that some mitigating measure may be necessary if Bus on Shoulder were implemented on this portion of I-93 before it is widened in Massachusetts' Essex County. There are currently no funded Massachusetts plans to widen I-93 between the state line and Exit 41.

MassDOT is planning to reconstruct Exit 46 in Methuen. When complete, a short portion of the highway between the state line and Exit 41 will not have a breakdown lane creating a potential choke point for any Bus on Shoulder implementation north of the Merrimack River. Typical peak traffic operates at free flow conditions along this segment so the impact on Bus on Shoulder benefits at this location would be minimal.

As noted in earlier, BX scheduled morning peak travel times are as much as 45 minutes longer than off-peak travel times due to congestion along their route (see Table 6.16). Bus on Shoulder operations could reduce some, but not all, of this congestion-related delay from the bus schedules. The Study team estimated that travel time savings from a Minnesota-Style Bus on Shoulder operation would save as much as 12 minutes on typical day. On days where the impacts of traffic congestion are compounded by accidents or incidents, the savings would escalate to as much as 37 minutes based on estimates derived from the Study sample data.

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[18] Use of the breakdown lane for travel in the peak periods was instituted in 1999 after Andover State Representative Barry Finegold brought legislators and officials from Massachusetts and New Hampshire together to discuss options to reduce congestion on I-93

Table 6.16: Estimated Bus on Shoulder Bus Travel Time Savings by Time of Day and Direction

	Arrival Time at Boston South Station	Morning Peak Southbound							
		6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00
Typical Day	From NH State Line	0:07	0:08	0:08	0:09	0:08	0:08	0:12	0:13
	From I-495	0:07	0:08	0:08	0:09	0:08	0:08	0:12	0:13
	From I-95	0:07	0:08	0:08	0:09	0:08	0:07	0:08	0:08
Bad Traffic Day	From NH State Line	0:12	0:23	0:26	0:37	0:24	0:27	0:02	0:00
	From I-495	0:12	0:23	0:26	0:33	0:23	0:27	0:02	0:00
	From I-95	0:10	0:21	0:13	0:16	0:15	0:27	0:02	0:00
	Departure Time from Boston South Station	**Afternoon Peak Northbound**							
		4:00	**4:30**	**5:00**	**5:30**	**6:00**	**6:30**	**7:00**	
Typical Day	To I-95	0:00	0:01	0:02	0:02	0:02	0:00	0:00	
	To I-495	0:00	0:01	0:02	0:02	0:02	0:00	0:00	
	To NH State Line	0:00	0:01	0:02	0:05	0:03	0:00	0:00	
Bad Traffic Day	To I-95	0:06	0:07	0:09	0:12	0:08	0:07	0:01	
	To I-495	0:09	0:12	0:13	0:15	0:16	0:11	0:09	
	To NH State Line	0:10	0:19	0:18	0:29	0:25	0:20	0:13	

6.3.4 *Expanded Bus on Shoulder*

The Expanded Bus on Shoulder service option provides faster and more frequent service by combining the increased service of Expanded Base with Bus on Shoulder operations to improve reliability and service velocity. Like the Expanded Base option, the service would add approximately 40 trips to the schedule, but would provide more frequent service to and from each of the existing park-and-ride lots than the Bus on Shoulder option. The additional service would require approximately 10 more vehicles and drivers.

Peak-period, point-to-point service would be provided between each park-and-ride lot and Boston's South Station at 30-minute headways, except for Manchester service, which would be operated at 60-minute headways throughout the day. Hourly off-peak service would provide service to each park-and-ride lot within the I-93 or Route 3 corridors. Tables 6.17 and 6.18 list the number of weekday trips and scheduled travel times between the park-and-ride lots and the South Station bus terminal.

Table 6.17: Expanded Bus on Shoulder Trips

	Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsborough (Exit 35)	South Station
SB Trips	16	20	19	20	18	18	60
NB Trips	16	20	20	20	20	20	60
Total	32	40	39	40	38	38	120

Table 6.18: Expanded Bus on Shoulder Travel Times

		Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsborough (Exit 35)
Max	Off-Peak	1:35	1:20	0:00	1:00	1:20	1:05
	Peak	2:10	1:27	1:37	1:15	1:40	1:25
Min	Off-Peak	1:25	1:05	0:00	0:45	1:04	0:50
	Peak	0:53	0:52	0:57	0:37	0:51	0:51

6.4 Multi-Modal Options

Throughout the Study process, representatives of New Hampshire's intercity bus operators (BX, Concord Coach, C&J, and Dartmouth Coach) have indicated a willingness to work with NHDOT on the continued provision of commuter bus service along the I-93 corridor from New Hampshire to South Station. The continuation or expansion of the existing BX bus service does not preclude the opportunity for a combined bus and rail option in a later Study phase. Here are three multi-modal alternatives suggested by stakeholders:

1. Rail in the Route 3 corridor with Bus on Shoulder in the I-93 corridor
2. Rail serving the North Station market with bus serving the South Station market
3. Rail service during peak commute hours and bus service during off-peak hours

The intercity bus operators are very supportive of implementing a Bus on Shoulder strategy on I-93, and the co-location or sharing of station and park-and-ride facilities between the various modes.

6.5 Screening Preliminary Alternatives[19]

The Study team developed preliminary estimates of ridership, operating costs, capital costs along with land use, economic development, and environmental impacts of the nine rail and three bus alternatives to screen the alternatives down to a more manageable number for final evaluation. The team's recommendations were reviewed with all stakeholders, including the FRA and FTA as well as the general public, before being finalized. Table 6.19 shows the basic performance metrics calculated for each alternative.

[19] For more information on preliminary screening, see Appendix 5 to the Capitol Corridor AA Final Report (Task 5 Preliminary Evaluation of Conceptual Alternatives and Recommended Alternatives for Detailed Evaluation)

Table 6.19: Preliminary Estimates of Basic Economic Performance Metrics for Preliminary Alternatives

	Typical Weekday NH Passengers	Required Capital Expenditure (In Millions, 2014$)	Annual Operating Cost (In Millions, 2009$ for commuter rail, 2012$ for intercity rail and bus)	Annual Incremental Passenger Revenue (In Millions, 2014$)	Net Operating Cost (In Millions, 2012$)
Intercity 8	1,460	$162	$7.7	$3.5	$4.2
Intercity 12	1,720	$174	$11.6	$4.1	$7.45
Intercity 18	2,040	$174	$17.3	$4.9	$12.4
Concord Regional	2,700	$226	$11.1	$6.1	$5.0
Concord Commuter	3,020	$206	$13.3	$7.1	$6.1
Manchester Regional	3,120	$164	$9.7	$7.2	$2.5
Manchester Commuter	3,060	$164	$9.9	$7.1	$2.8
Nashua Commuter	2,040	$124	$6.8	$4.2	$2.6
Nashua Minimum	1,480	$124	$5.2	$2.7	$2.4
Expanded Base	346	$6	$3.0	$0.8	$2.2
Bus on Shoulder	692	$7	$0.0	$1.7	$0.0
Expanded Bus on Shoulder	1,038	$14	$3.0	$2.5	$0.5

After extensive consultation primarily focusing on the fiscal constraints faced by the State of New Hampshire, seven intermediate alternatives (three rail, three bus, and a No Build option) were selected for more detailed evaluation (see Table 6.20). The two commuter rail options with the lowest potential net operating cost, the one intercity rail option with the lowest preliminary net operating cost, and the three low-cost bus alternatives were recommended for refinement and detailed evaluation, as was the No Build Option.

Table 6.20: Intermediate Service Options Selected for Detailed Evaluation

Service Option	Required Capital Expenditure (In Millions, 2014$)	Net Operating Cost (In Millions, 2012$)
Intercity 8	$162	$3.6
Manchester Regional Commuter Rail	$164	$2.5
Nashua Minimum Commuter Rail	$124	$2.4
Expanded Base	$6	$2.2
Bus on Shoulder	$7	$0.0
Expanded Bus on Shoulder	$14	$0.5

The Intercity 8 alternative was selected from the three intercity rail service options because of its low net operating cost and reasonable mobility benefit perspectives. As shown in Table 6.21, the number of additional riders attracted by more frequent service with Intercity 12 and 18 did not keep pace with the additional forecasted capital and operations costs.

Table 6.21: Intercity Service Riders versus Cost

	Typical Weekday NH Passengers	Net Operating Cost (In Millions, 2012$)
Intercity 8	1,460	$3.6
Intercity 12	1,720	$6.9
Intercity 18	2,040	$11.8

6.6 Screening Intermediate Alternatives[20]

This section describes screening of the seven Intermediate alternatives (including No Build) with special emphasis on the preferred intercity and commuter rail alternatives (Table 6.22). Among the most salient of the refinements was resolution concerning disposition of express bus services should any of the rail service options be implemented. The seven intermediate alternatives are discussed in detail below.

Table 6.22: Intermediate Service Alternatives

Intercity 8	▪ Four daily intercity passenger rail round trips between Concord, NH and Boston, MA making intermediate stops at Manchester, Bedford/Manchester Airport, Nashua Crown Street, and Lowell and Woburn, MA ▪ Base BX service is retained
Manchester Regional Commuter Rail	▪ Extends MBTA commuter rail service north from Lowell, MA to Manchester, NH with intermediate stops at South Nashua, Nashua Crown Street, and Bedford/Manchester Airport ▪ BX I-93 service to Manchester, North Londonderry, Londonderry, and Salem is retained ▪ BX Route 3 service to Manchester, Nashua, Tyngsborough is retained
Nashua Minimum Commuter Rail	▪ Extends MBTA commuter service north from Lowell, MA to Manchester, NH with an intermediate stop at South Nashua, NH ▪ BX I-93 service to Manchester, North Londonderry, Londonderry, and Salem is retained ▪ BX Route 3 service to Manchester, Nashua, and Tyngsborough is retained
Expanded Base	▪ New Hampshire's BX bus service is increased from current 80 buses per day to 120 buses per day ▪ All peak buses run direct and non-stop between each New Hampshire park-and-ride lot and Boston South Station with service every 30 minutes ▪ Each park-and-ride lot sees hourly off-peak service making intermediate stops at each New Hampshire park-and-ride lot ▪ No changes to existing passenger rail services
Bus on Shoulder	▪ Existing BX bus service of 80 daily trips is permitted to operate within the I-93 shoulder south of I-495 to bypass congestion in general travel lanes ▪ Savings of 8 to 12 minutes predicted during the morning peak period ▪ No significant travel time savings predicted during the afternoon peak period
Expanded Bus on Shoulder	▪ Expanded Bus service of 120 daily trips is permitted to operate within the I-93 shoulder south of I-495 to bypass congestion in general travel lanes ▪ Savings of 8 to 12 minutes predicted during the morning peak period ▪ No significant travel time savings predicted during the afternoon peak period

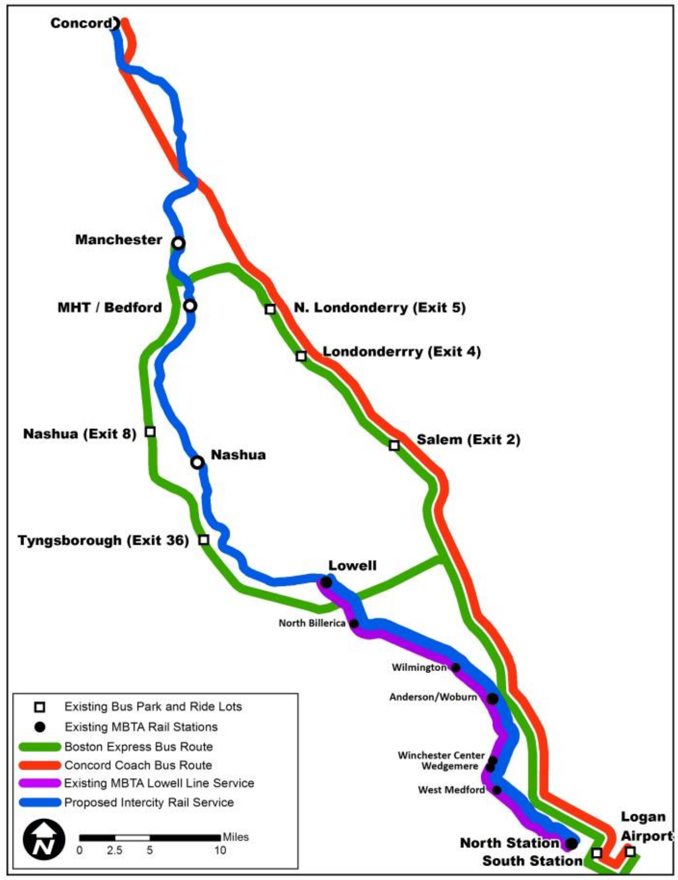
[20] For more information on the intermediate rail and bus alternatives, see Appendix 7 of the Capitol Corridor AA Final Report

6.6.1 *Intercity 8*

- Four daily intercity passenger rail round trips between Concord, New Hampshire and Boston, Massachusetts making intermediate stops at Manchester, Bedford/Manchester Airport, Nashua Crown Street, and Lowell and Woburn, Massachusetts
- BX Route 3 service to Nashua and Tyngsborough and BX I-93 service to Manchester, North Londonderry, Londonderry, and Salem is retained

The eight-train-per-day Intercity 8 rail option would provide four daily round trips over the 73-mile route stopping at five intermediate stations (see Figure 6.6). Intercity rail service would operate much like Amtrak's *Downeaster* service between Boston and Brunswick, Maine. The Intercity 8 option could be operated by Amtrak or the MBTA or contracted to a third-party service provider.

Figure 6.6: Intercity 8 Rail Service



The end-to-end trip time would be approximately 96 minutes and the service would operate 586 daily train miles. A timetable for the proposed service is shown in Table 6.23. Presuming an average cost of $36 per train mile, the Intercity 8 option would cost approximately $7.7 million per year to operate.

The service would provide connections in Concord to private bus services for North Country destinations. No changes are proposed to express bus service for commuting to Boston via I-93 or Route 3. Local bus service to the intercity rail stations could be offered, but would not be integral to the service design. A BX/Concord Coach/intercity rail fare integration scheme similar to that used by the *Downeaster* at Portland, Maine could be employed at the Concord and Manchester stations that would be shared by both intercity rail and coach bus services.

Anticipated ridership responses to the service initiative would include new riders attracted to the intercity rail service. It is anticipated that few current MBTA passengers living in New Hampshire would shift from using MBTA Lowell and North Billerica Stations to the new intercity rail service. Some BX and Concord Coach customers may shift to intercity rail service from Nashua, Manchester, and Concord. The overall increase in the quality and frequency of transit options to Manchester and Concord may stimulate bus ridership as has been observed at the shared terminal in Portland, Maine.

Table 6.23: Proposed Intercity 8 Timetable

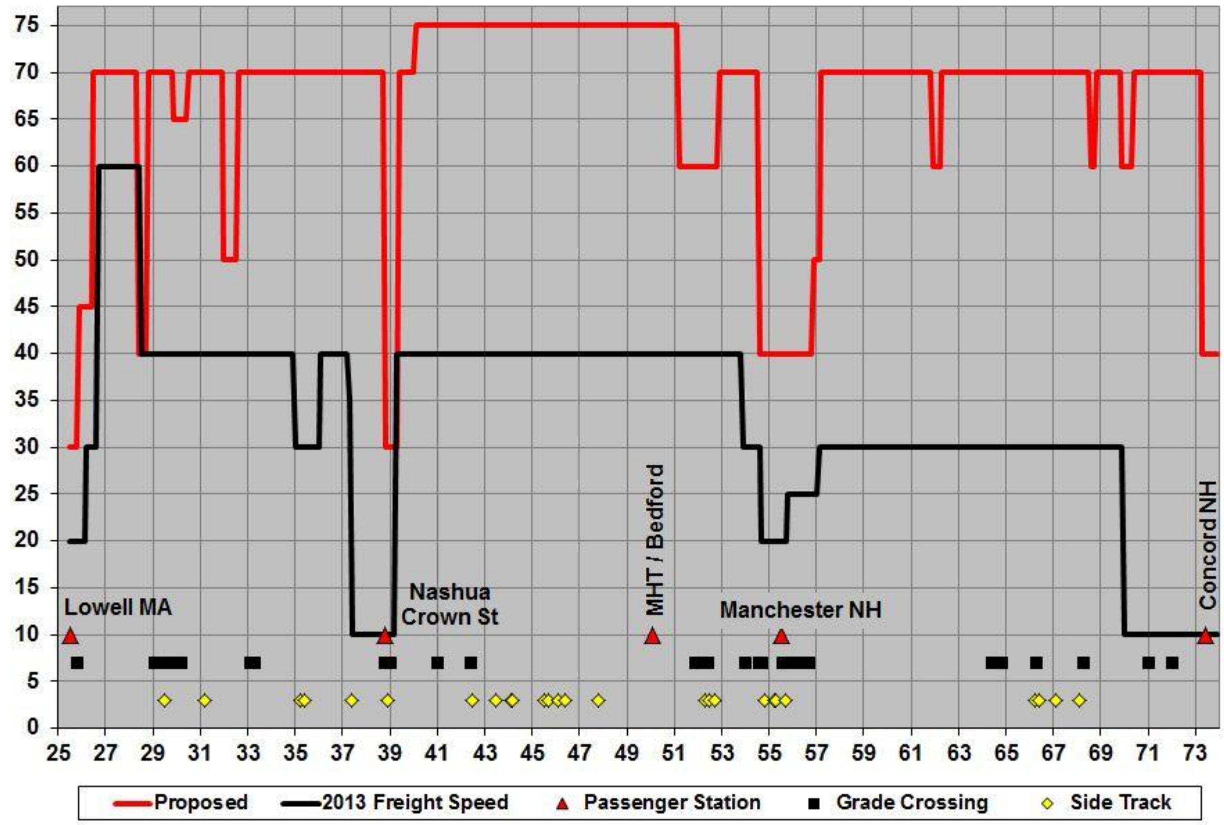
380	382	384	386		Station	MP		381	383	385	387
6:41	10:41	14:56	19:56	Read Down	**Concord NH**	73.3	Read Up	10:05	14:20	18:55	23:35
6:54	10:54	15:09	20:09		**Manchester NH**	55.5		9:39	13:54	18:29	23:09
7:07	11:07	15:22	20:22		**Bedford/MHT**	50.1		9:31	13:46	18:21	23:01
7:20	11:20	15:35	20:35		**Nashua**	38.8		9:18	13:33	18:08	22:48
7:36	11:36	15:51	20:51		**Lowell**	25.5		9:02	13:17	17:52	22:32
7:52	11:52	16:07	21:07		**Anderson/ Woburn**	12.6		8:46	13:01	17:36	22:16
8:15	12:15	16:30	21:30		**North Station**	0.0		8:30	12:45	17:20	22:00

No improvements would be required south of MBTA's Lowell Gallagher Terminal. North of Lowell the railroad would be upgraded to permit safe, reliable operation of eight daily passenger trains at speeds of up to 75 mph. Recommended upgrades to track, bridges, crossings, and signals are summarized below.

Intercity 8 would require more extensive infrastructure upgrades than the commuter rail options as it is approximately 18 miles longer than the Manchester Regional Commuter Rail service. The service would also operate at higher maximum speeds; up to 75 mph between Manchester Airport and Nashua and 70 mph at many other locations (see Figure 6.7).

Unlike the Manchester Regional and Nashua Minimum Commuter Rail options, no double track would be required between North Chelmsford (MP 28.5) and the southern end of the Tyngsborough Curve (MP 32). Industrial sidings would be created at three key areas of freight activity in Nashua and Merrimack to eliminate conflicts between local freight deliveries and through passenger trains. At these locations the existing main line track would be retained as an industrial siding with an entirely new parallel main line track constructed in the same alignment for use by through trains. Adding a second track would be straightforward as the railway was once entirely double tracked with the double-track bed still largely intact.

Figure 6.7: Proposed Maximum Passenger Speeds



Four new passenger stations would be constructed (see Table 6.24). They would be a mix of high-level platforms and low-level platforms with "mini-high" platforms for handicapped accessibility. The platforms at Nashua and Manchester would be less complex than for the commuter rail options because no intercity trains would turn from northbound to southbound at these stations.

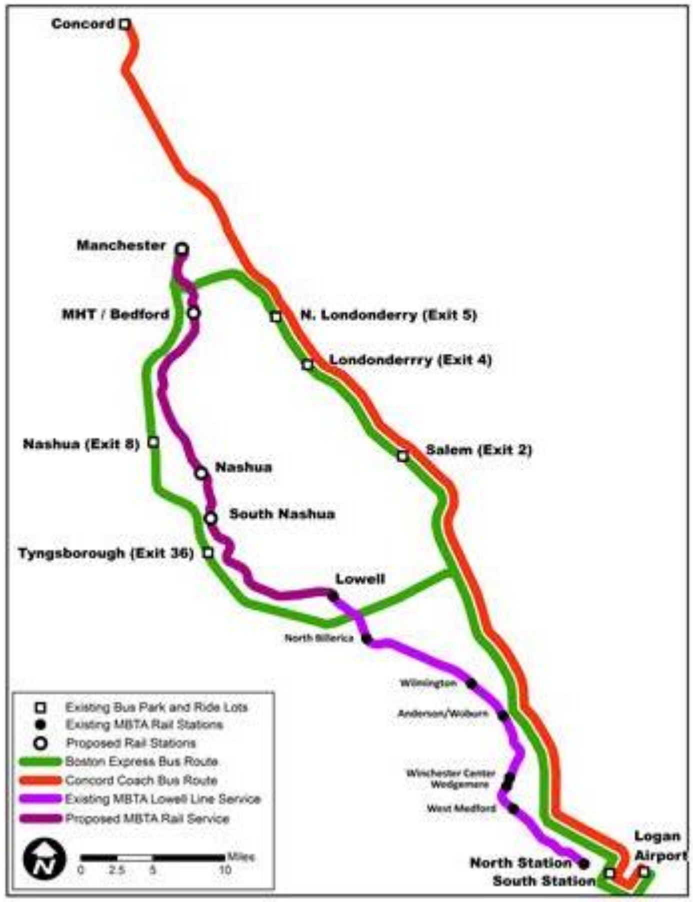
Table 6.24: Intercity 8 Passenger Station Development Plan

Station	MP	Comments
Concord	73.3	Single high-level platform on the stub end terminal track east of the main line
Manchester	55.5	Single low-level platform with mini-high to the east of the single main line track
Bedford/MHT	50.1	Single low-level platform with mini-high to the west of the single main line track
Nashua	38.8	Single low-level platform with mini-high to the west of the single main line track

6.6.2 Manchester Regional Commuter Rail

- Extends MBTA commuter rail service north from Lowell, Massachusetts to Manchester, New Hampshire with intermediate stops at South Nashua, Nashua Crown Street, and Bedford/Manchester Airport
- BX I-93 service to Manchester, North Londonderry, Londonderry, and Salem is retained
- BX Route 3 service to Manchester, Nashua, and Tyngsborough is retained

Figure 6.8: Proposed Manchester Regional Commuter Rail and Bus Service Configuration



The Manchester Regional Commuter Rail option would extend MBTA service 30 miles north from Lowell to downtown Manchester. The service initiative would provide all day commuter rail service between Boston and Nashua with a lower frequency regional service provided north to Manchester (see Figure 6.8). The service adds four new stations to the line with 16 weekday trains for Manchester and 34 weekday trains for Nashua. All existing MBTA deadhead trains on the Lowell Line would be eliminated.

No improvements would be required south of Lowell's Gallagher MBTA Terminal. North of Lowell the railroad would be upgraded to permit safe, reliable operation of passenger trains at speeds of up to 60 mph. A layover facility for four train sets would be constructed in the vicinity of Manchester. Up to six coaches and one locomotive would be added to the MBTA's weekday equipment line-up. The number of weekday MBTA train miles operated on the line would increase 42 percent to 2,068. Six MBTA trains would be marginally adjusted with most changes required on light ridership reverse peak trains. The number of affected passengers would be 520 (3.9 percent) of 13,382 weekday riders. The total effect would be 10,202 passenger minutes of change (2.4 percent) out of 430,954 total daily passenger minutes of travel.

Ridership response to this service initiative is anticipated to include new riders attracted to rail service provided to the proposed New Hampshire stations. It is assumed that some current MBTA rail passengers living in New Hampshire would shift to these new stations from the existing MBTA Lowell and North Billerica Stations. Ridership impacts on the BX I-93 main line services to Londonderry and North Londonderry and Salem would be likely negligible.

Five new passenger stations – a mix of high-level and low-level platforms with MBTA mini-high platforms for handicapped accessibility – would be would be constructed (see Table 6.25). High-level platforms would be preferred at all locations. A low-level with mini-high platform approach would be employed where no path was available for PAR freight trains to avoid using the platform track to ensure a clear route for wide freight loads.

Table 6.25: Manchester Regional Commuter Rail Passenger Station Development Plan

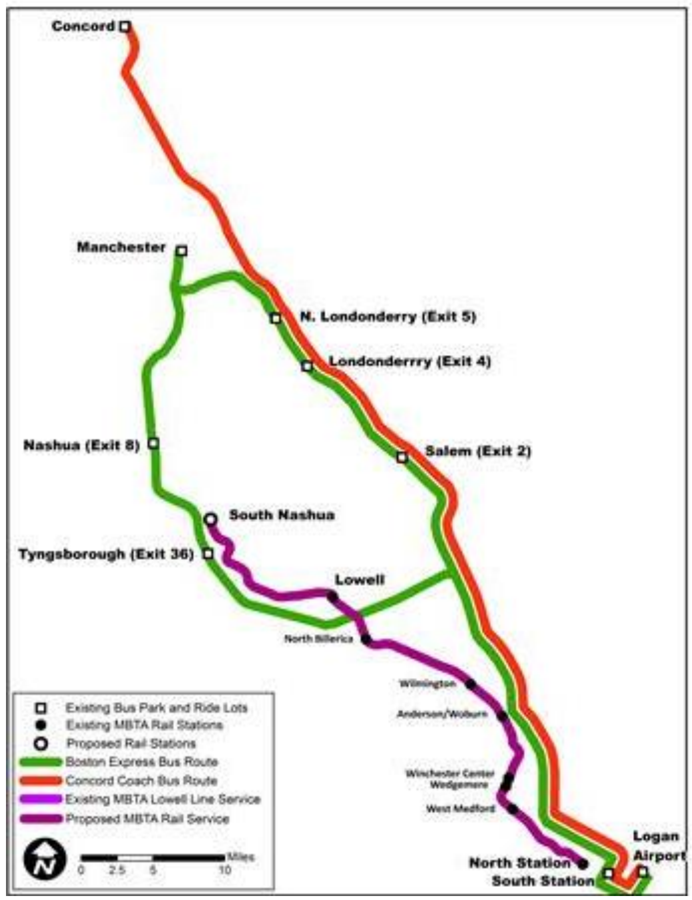
Station	MP	Type	Comments
Manchester	55.5	High-Level	Single high-level platform to the east of the eastern main line track
Bedford/MHT	50.1	Low-Level	Single low-level platform with mini-high to the west of the single main line track
Nashua	38.8	High-Level	Single island high-level platform between two main line tracks; oversize freight would run around platform using yard tracks
South Nashua	35.5	Low-Level	Single low-level platform with mini-high to the west of the single main line track

6.6.3 Nashua Minimum Commuter Rail

- Extends MBTA commuter service north from Lowell, Massachusetts to South Nashua, New Hampshire BX Route 3 service to Nashua and Tyngsborough is retained
- BX I-93 service to Manchester, North Londonderry, Londonderry, and Salem is retained

The Nashua Minimum Commuter Rail service option provides a minimal peak-period-only commuter rail service to and from South Nashua with no rail service further north to Manchester or Concord (Figure 6.9). It is specifically designed to minimize the MBTA operating cost of extending service to Nashua. It could be developed and operated as an interim service coordinated with bus service while markets and finances for further New Hampshire service were given time to develop.

Figure 6.9: Proposed Nashua Minimum Commuter Rail and Bus Service Configuration



MBTA service would be extended 13.5 miles north from Lowell to the South Nashua Station. The service adds one new station to the line with 20 weekday trains for South Nashua. A layover facility for four train sets would be constructed in the vicinity of South Nashua. No additional coaches or locomotives would need to be added to the MBTA's weekday line up of equipment.

The number of weekday MBTA train miles operated on the line would increase only three percent to 1,496. Schedules for several MBTA trains would be marginally adjusted with most changes required on light ridership reverse peak trains. The number of affected passengers would be 876 (6.5 percent) of 13,382 weekday riders. The total effect would be 9,846 passenger minutes of change (2.3 percent) out of 430,954 total daily passenger minutes of travel.

Optional midday and early evening feeder bus service would provide connecting service to fill out a complete schedule of services. Three midday and two early evening bus round trips linking South Nashua with the Lowell MBTA train station could supplement the peak-only rail service. BX I-93 service to Manchester, North Londonderry, Londonderry, and Salem would be retained, as would Route 3 service to Nashua and Tyngsborough. Ridership response to this service initiative is anticipated to include new riders attracted to rail service provided to the proposed new station. It is assumed that some current MBTA rail passengers living in New Hampshire would shift to this new station from the existing MBTA Lowell and North Billerica Stations. It is also anticipated that many or most passengers from BX Route 3 service would shift to the commuter railroad potentially allowing for the elimination of that service. Ridership impacts on the BX I-93 main line services to Londonderry and North Londonderry and Salem would be likely negligible.

One new passenger station with a low-level platform would be constructed for the Nashua Minimum Commuter Rail option (see Table 6.26).

MBTA mini-high platform would be located at the north end of the station for handicapped accessibility.

Table 6.26: Nashua Minimum Commuter Rail Passenger Station Development Plan

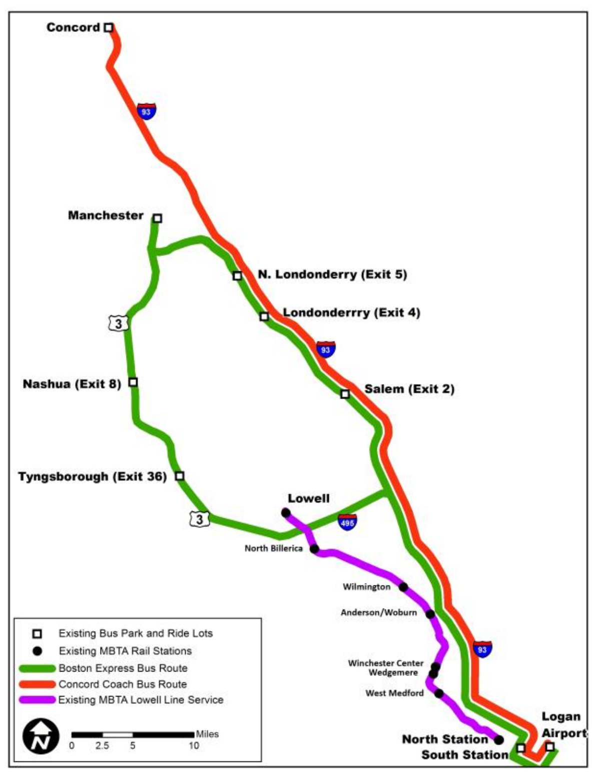
Station	MP	Comments
South Nashua	35.5	Single low-level platform with mini-high platform to the west of the single main line track

6.6.4 Expanded Base

- New Hampshire's BX bus service is increased from current 80 buses per day to 120 buses per day
- All peak buses run direct and non-stop between each New Hampshire park-and-ride lot and Boston South Station with service every 30 minutes
- Each park-and-ride lot sees hourly off-peak (but not direct) service
- No changes to existing passenger rail services

The Expanded Base option (Figure 6.10) increases transit service frequency and directness within the Study Corridor by providing peak-period, point-to-point, non-stop trips from each of the New Hampshire park-and-ride lots to points within downtown Boston (southbound trips only), South Station, and Logan Airport. The service would add

Figure 6.10: Existing Study Corridor Bus and Rail Services



approximately 40 trips to the schedule and would require approximately 16 additional vehicles. There are no transit priority measures proposed in this option that would result in increased service velocities or decreased travel times.

Peak-period, point-to-point service would be provided at 30-minute headways, except for the Manchester service, which operates at 60-minute headways throughout the day. Hourly off-peak service would provide non-point-to-point service between each park-and-ride lot within the I-93 or Route 3 corridors and Boston South Station and Logan Airport without circulating through downtown Boston. A timetable for the proposed service is included in Index A at the end of this Section 1. Anticipated ridership response to this service initiative would include increased ridership at all BX park-and-ride lots and some possible reduction of ridership on MBTA commuter rail service from Lowell and, perhaps, North Billerica, Massachusetts.

6.6.5 Bus on Shoulder

- Existing BX bus service of 80 daily trips is permitted to operate within the I-93 shoulder south of I-495 to bypass congestion in general travel lanes
- Savings of eight to 12 minutes predicted during the morning peak period
- Savings of up to five minutes predicted during the afternoon peak period

The Bus on Shoulder option provides faster peak-period service by permitting buses to operate within the I-93 shoulder south of I-495 to bypass peak congestion in Massachusetts. Typical southbound morning peak-period savings would be eight to 12 minutes depending upon arrival time. Typical northbound afternoon peak-period savings would be approximately five minutes. The option would not add any additional trips or operate in a point-to-point manner, but would provide faster, more reliable peak travel times. The proposed schedules maintain the existing arrival and departure times at South Station and modify the departure and arrival times at New Hampshire park-and-ride lots based on the estimated travel time savings resulting from Bus on Shoulder operation. The service would not require any additional vehicles to operate the proposed schedule. The timetable (see Index A at the end of this Section 1) prepared for this analysis reflects time savings estimated using a variety of sources. Ridership response to the service initiative is anticipated to include increased ridership at all BX park-and-ride lots and some possible reduction of ridership on MBTA commuter rail service from Lowell and perhaps North Billerica.

6.6.6 Expanded Bus on Shoulder

- 120 daily trips permitted to operate within the I-93 shoulder south of I-495 to bypass congestion in general travel lanes
- Savings of eight to 12 minutes predicted during the morning peak period
- Savings of up to five minutes predicted during the afternoon peak period

The Expanded Bus on Shoulder option merges the increased frequency and directness of the Expanded Base option with the peak-period congestion bypass feature of the Bus on Shoulder option. It would offer faster and more direct peak service with more frequent off-peak service to all New Hampshire park-and-ride lots. The timetable prepared for this analysis merges the Bus on Shoulder and Expanded Base service concepts and can be found in Index A at the end of this Section 1. Ridership response to this service initiative is anticipated to include increased ridership at all park-and-ride lots and some possible reduction of ridership on MBTA commuter rail service from Lowell and, perhaps, North Billerica.

6.7 Screening Intermediate Alternatives[21]

In refining and then screening the various service options, the Study team coordinated extensively with the FRA, FTA, MBTA, MVRTA, PAR, and BX regarding the alternatives' design and necessary infrastructure and rolling stock investments. Schedules, stringline diagrams, and corresponding track configuration diagrams were prepared for each rail option. Schedules and equipment rosters were prepared for the bus options.

Each of the rail options that were evaluated during the screening of intermediate alternatives exhibited a range of costs and benefits that were further refined for consideration by stakeholders and decision-makers. The Expanded Base and Expanded Bus on Shoulder options were eliminated from further evaluation. The Expanded Base option would result in the highest net operating cost and would attract the fewest new passengers of the three bus options. The Expanded Bus on Shoulder options would generate the greatest mobility benefits of the three bus options, but would do so at more than twice the capital cost of the Bus on Shoulder option.

From this information the Study team was able to make more detailed and accurate estimates of costs for each rail and bus service option. Another round of ridership forecasts was prepared using more sophisticated forecasting techniques. Separate models were used for the intercity rail, commuter rail, and express bus options. Amtrak's ridership forecasting team prepared the patronage forecasts for the Intercity 8 option. Each key economic performance metrics and assumptions are described in Table 6.27 and final estimates of cost and demand are summarized in 6.28.

[21] For more information on the intermediate alternatives, see Appendix 7 to the AA Final Report

Table 6.27: Key Economic Performance Metrics and Assumptions

Economic Performance Metric	Evaluation Assumptions
New NH Transit Passenger Trips	Includes all new transit trips originating in New Hampshire including rail trips diverted from Lowell to Nashua and any changes in BX ridership
New Corridor Transit Passenger Miles	Includes all transit trip miles made by passenger rail and BX; reflects downward adjustments in BX passenger miles for options where BX service is reduced or eliminated
Total Project Value (In Millions, 2014$)	Includes cost of all necessary infrastructure investment (e.g., railroad improvements, stations, rail yards, and bus shoulder lanes), the value of any necessary rolling stock (buses or trains), and the prorated value of MBTA's 37-mile Nashua to Concord trackage rights based on the option's length in New Hampshire; Intercity 8 would use Amtrak's statutory trackage right, not rights acquired by MBTA
NH Costs after Federal Grants and MA Contributions (Conservative Case)	Assumes that MBTA contributes rolling stock and trackage rights to the project, but does not contribute to the cost of infrastructure improvements north of Lowell; also assumes FTA does not consider MBTA contribution of rolling stock or trackage rights as contributing to eligible project value; consequently, the 50% FTA grant would cover half of the infrastructure investment; also assumes that FRA would fund half of the overall project value for Intercity 8 and that no federal capital funding would be available for the bus options
Annual Operating Cost (In Millions, 2012$)	Updated preliminary cost estimates for commuter rail options; final estimates for intercity and bus options; assumes weekday-only operation for commuter rail and bus services; intercity service would operate 365 days per year
Net Operating Cost (In Millions, 2012$)	Annual operating costs minus forecast passenger revenue and federal formula funds; FTA fixed-guideway formula funding is distributed for commuter rail service, but not for bus or intercity rail programs
Annual NH Debt Service	Assumes that NH share of project cost would be retired with 20-year bonds at 5% annual interest
NH Annual Total Cost	Sum of Net Operating Cost and Annual Debt service
NH Annual Cost Per New Passenger Mile	Shows NH annual cost divided by new annual transit passenger miles
NH Annual Cost per New NH Rider	Shows NH annual cost divided by new annual NH transit passengers

Table 6.28: Forecasts for Passenger Demand, Capital Cost, Operating Cost (In Millions), and Economic Metrics

Metrics	Intercity 8	Manchester Regional Commuter Rail	Nashua Minimum Commuter Rail	Bus on Shoulder
New NH Transit Passenger Trips	946	2,568	670	48
New Corridor Transit Passenger Miles	48,853	90,506	5,542	2,112
Forecast Capital Cost (In Millions, 2014$)	$256	$246	$120	$7
NH Costs after Federal Grants and MA Contributions (Pessimistic Case)	$128	$97	$49	$1
Annual Operating Cost (In Millions, 2012$)	$7.7	$11	$4	$0
Net Operating Cost (In Millions, 2012$)	$5	$2	$2	$0
Annual NH Debt Service (In Millions, 2012$)	$10	$8	$4	$1
NH Annual Total Cost (Debt Service and Operating Deficit) (In Millions, 2012$)	$15	$9	$6	$1
NH Annual Cost Per New Passenger Mile	$1.19	$0.41	$3.89	$1.11
NH Annual Cost per New NH Rider	$61	$14	$32	$49

Review of the forecast performance indicates that the Manchester Regional Commuter Rail, while expensive from a capital and operating cost perspective, would generate the greatest mobility benefits and the lowest unit costs per passenger mile and per passenger. The Bus on Shoulder option would be relatively inexpensive, but would generate limited mobility benefits with resulting medium-to-high unit costs per passenger and per passenger mile. Intercity 8 would be slight more expensive to construct than the Manchester Regional Commuter Rail; it would also attract fewer passengers and fewer passenger miles, resulting in a reduced operating efficiency. Nashua Minimum Commuter Rail would be half as expensive as the other rail options, but would attract many fewer passengers, resulting in relatively unattractive measures of efficiency.

7 Market Analysis

This section describes the methods and findings of the project's market analyses and patronage forecasts for the intercity rail options. Two sets of forecasts were prepared. The first set, prepared in 2013, supported preliminary analyses and screening. A second, more detailed set of forecasts was prepared for each of the final options, including the Intercity 8 option.

7.1 Ridership Forecasting[22]

Preliminary forecasts for Capitol Corridor rail service options were prepared using FTA's Aggregate Rail Ridership Forecasting Model 2.0 (ARRF2). Since the proposed service was only 73 miles long (shorter than some commuter rail lines in New York, Florida, and California), it was decided that the ARRF2 model would provide reasonable first estimates of potential ridership for both the commuter and intercity rail options. These first forecasts were for initial screening purposes. After initial screening, more robust forecasts were developed in consultation with FRA and FTA.

7.1.1 ARRF2 Model Limitations

The ARRF2 model is intended to develop order-of-magnitude estimates of rail ridership. The results presented in the preliminary estimates are considered to have "sketch planning" levels of accuracy sufficient for preliminary screening purposes.

- The ARRF2 model produces daily ridership estimates for new proposed rail services
- As an "order-of-magnitude model," the total ridership forecast provides a rough estimate of ridership
- The model does not produce boarding or alighting data by station. The boardings per station include riders that may have previously boarded at the Lowell station or any other station, but now choose to board at a new station. The Central Transportation Planning Staff (CTPS) on-board survey completed in 2008-2009 indicates that for the existing Lowell line, Boston's North Station accounts for 85 percent of all inbound alightings. It is reasonable to expect local or regional passenger service on this line would have a similarly high percentage of inbound alightings at North Station.

7.1.2 Aggregate Rail Ridership Forecasting Model 2.0 Overview

The model, as described in the ARRF2 Model Application Guide, is as follows:

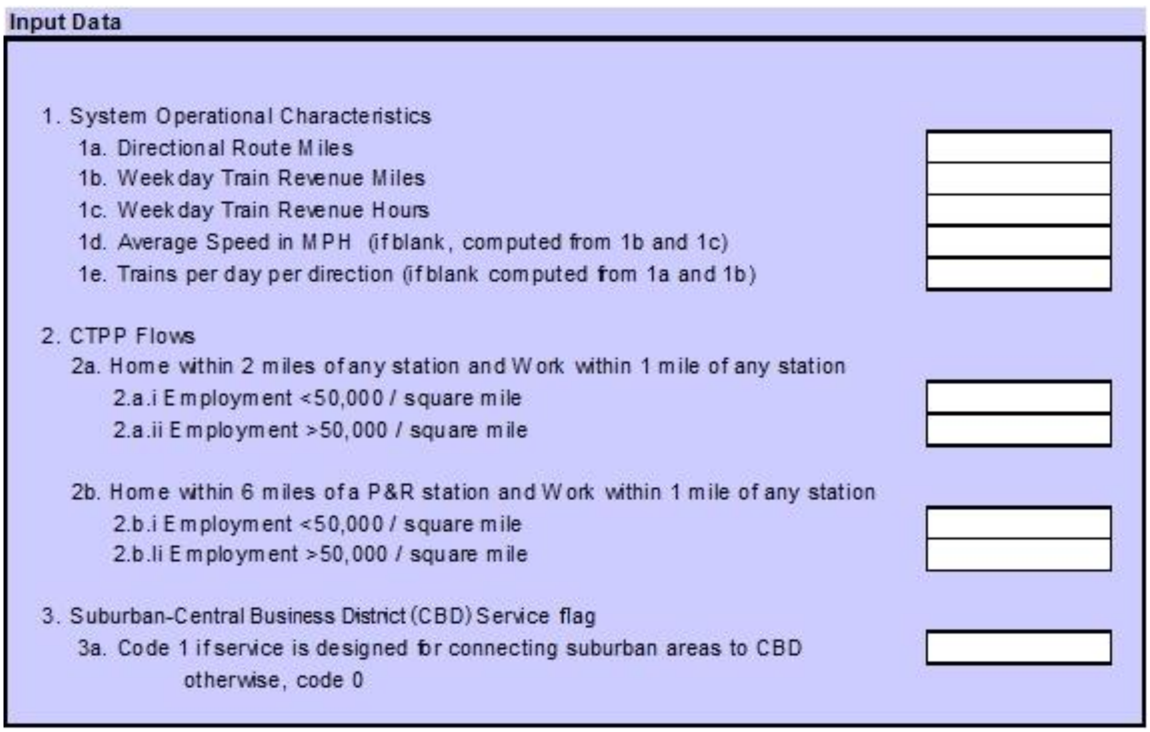
> *This model estimates total unlinked rail transit trips for light rail and commuter rail systems by applying a series of expected rail shares to the amount of total (all mode) travel to work occurring*

[22] For more detail on rail ridership forecasts, see Appendix 6 to the Capitol Corridor AA Final Report (Task 6 Evaluation Criteria and Methodology)

within the rail corridor as recorded in the Year 2000 Census Transportation Planning Package (CTPP). Ridership is adjusted up or down to account for the level-of-service (speed and frequency) of the modeled rail line as compared to the baseline values for the rail lines used to calibrate the model. This model is intended to develop order-of-magnitude estimates of ridership for new rail lines in metropolitan areas.

The model uses the CTPP worker flows, station locations, and service operational characteristics to estimate ridership. The service operational characteristics are based on the proposed service, the rail station locations with distance-buffers using Geographic Information System (GIS) software, and the CTPP data to estimate the worker flows within the service area. Figure 7.1 shows the input data setup required to run the ARRF2 model.

Figure 7.1: ARRF2 Inputs



Input Data

1. System Operational Characteristics
   1a. Directional Route Miles
   1b. Weekday Train Revenue Miles
   1c. Weekday Train Revenue Hours
   1d. Average Speed in MPH (if blank, computed from 1b and 1c)
   1e. Trains per day per direction (if blank computed from 1a and 1b)

2. CTPP Flows
   2a. Home within 2 miles of any station and Work within 1 mile of any station
      2.a.i Employment <50,000 / square mile
      2.a.ii Employment >50,000 / square mile

   2b. Home within 6 miles of a P&R station and Work within 1 mile of any station
      2.b.i Employment <50,000 / square mile
      2.b.Ii Employment >50,000 / square mile

3. Suburban-Central Business District (CBD) Service flag
   3a. Code 1 if service is designed for connecting suburban areas to CBD
   otherwise, code 0

7.1.3 Project Use of ARRF2

For the Capitol Corridor preliminary forecast, ARRF2 was applied to the existing MBTA Lowell Commuter Rail line to determine a baseline value. Each alternative was analyzed as in incremental addition to the service corridor.

7.1.4 ARRF2 Base Case Lowell Line Forecast

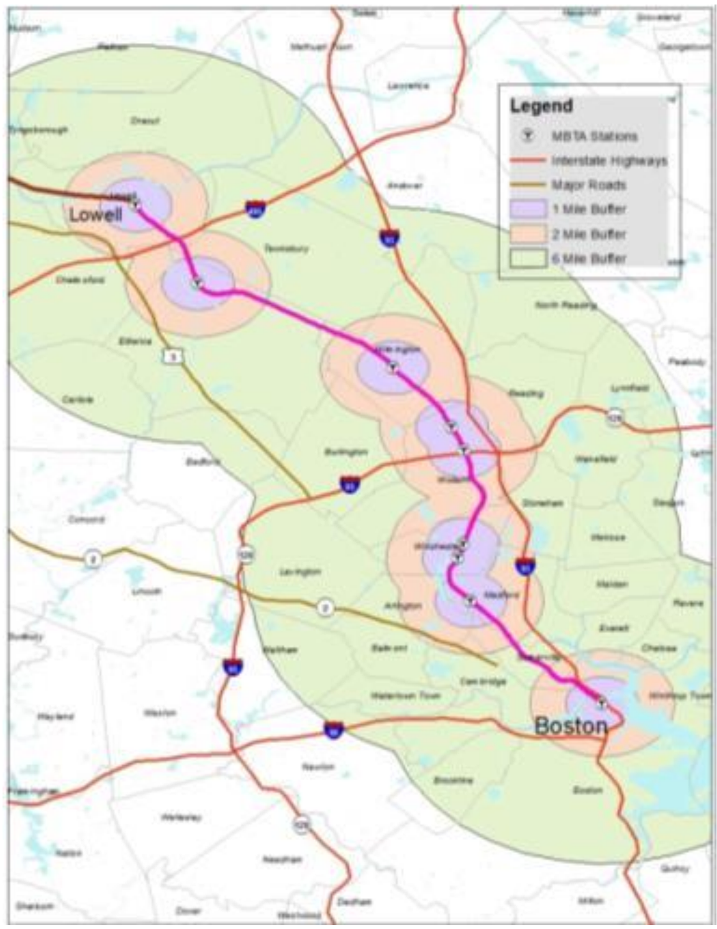
The ARRF2 model was used to produce daily ridership forecasts for the commuter and intercity rail service options. Prior to analyzing the alternatives, the existing MBTA Lowell commuter rail line was tested using the ARRF2 model to establish a benchmark for the ARRF2 model to use as an adjustment to the alternative forecasts.

The ARRF2 model uses buffers around the rail stations to determine the catchment area for work flows. Figure 7.2 shows the one-, two-, and six-mile buffers around the existing MBTA Lowell commuter line. The ARRF2 model produced a forecast of ***9,096 riders*** using the Lowell line's operational characteristics and CTPP worker flows.

7.1.5 System Operational Characteristics

ARRF2 uses several system characteristics that describe the rail service's operational parameters as inputs to the forecasts. Specific characteristics used by the model include round trip route miles, average train speed, and the number of trains per day. The round trip route miles are used to provide the model with information regarding the extent of the system. The figures for average train speed and number of trains inform the model concerning the quality of service being provided. The weekday train revenue miles and weekday revenue hours are used to calculate the average train speed. The weekday revenue miles and the round trip route miles are used to calculate the number of trains per day.

Figure 7.2: Existing Lowell Line Station Buffers



7.1.6 CTPP Flows

CTPP data was used to approximate the market of trips that travel within the corridor. These worker flows were split into various submarkets that were used to estimate the magnitude of "walk-to" and "drive-to" markets for each train station. The "walk-to" flows are estimated using the number of households within a two-mile radius of any train station on the line. These flows are further segmented by the number of households that have travel flows to areas within a one-mile radius of any station, by employment densities less than 50,000 employees per square mile and by work flows to areas with more than 50,000 employees per square mile.

Park-and-ride flows are estimated using the number of households within a six-mile radius of any train station on the line. These flows are further segmented by the number of households that have workflows to areas within a one-mile radius of any station, by areas with employment densities less than 50,000 employees per square mile, and by those with work flows to areas with greater than 50,000 employees per square mile.

7.1.7 ARRF2 Lowell Line Forecast: System Operational Characteristics

The Lowell station is 25.5 rail miles from North Station in Boston, which gives the base service a total of 51 direction route miles of service. Based on the current train schedules, the service offers 1,299 weekday train revenue miles and 38.52 weekday train revenue hours.

7.1.8 Base CTPP Travel Flows

Using the two-mile station buffering procedure for the existing Lowell line, the total number of households within two miles of a station that had employment within one mile of a station was 16,111 households (see Table 7.1). Of these households, 8,231 are employed in areas with less than 50,000 employees per square mile and 7,880 are in areas with more than 50,000 employees per square mile.

The six-mile buffer for park-and-ride trip estimation, results in 49,909 households within six miles of a particular station and employed within one mile of a different station. A total of 22,770 and 27,139 households are employed in areas with less than, and greater than, 50,000 employees per square mile, respectively.

Table 7.1: Lowell Line Base CTPP Flows

CTPP Flows	Base
Home within two miles of any station and Work within one mile of any station	
Employment <50,000/square mile	8,231
Employment >50,000/square mile	7,880
Home within six miles of a Park-and-Ride (P&R) station and Work within one mile of any station	
Employment <50,000/square mile	22,770
Employment >50,000/square mile	27,139

7.2 Preliminary Intercity Rail Forecasts

The operational characteristics of the proposed intercity regional services are based on the number of daily trains and the average speed. These values are shown in Table 7.2.

Table 7.2: Intercity Service Statistics

	Intercity 8	Intercity 12	Intercity 18
Route Miles (Round Trip)	146.8	146.8	146.8
Weekday Train Revenue Miles	586	880	1,319
Weekday Train Revenue Hours	12:40	19:00	28:30

The buffers used for the alternative analysis are presented in Figure 7.3. Depending on the stations included in each intercity and commuter rail alternative, some or all of these buffers were used.

7.2.1 New Hampshire CTPP Worker Flows

The worker flows can be broken down into three groupings for the alternatives, including the existing Lowell line worker flows plus each incremental extension: the Nashua flows, the Nashua/Manchester flows, and the Nashua/Manchester/Concord flows.

ARRF2 evaluated the incremental differences in service to analyze the alternatives. The CTPP flows shown in Table 7.3 are for the entire corridor and include those for the existing Lowell line. It shows that the incremental difference in flows for each of the alternatives is simply the difference between the alternative flow and the base flows for the MBTA Lowell line.

Figure 7.3: NHML Proposed Station Buffers

Table 7.3: Lowell Line Base and Intercity CTPP Flows

CTPP Flows	Base (A)	Intercity Rail Markets (Concord, Manchester, Nashua) (B)	Incremental Intercity Flows (B-A)
Home within two miles of any station and Work within one mile of any station			
Employment <50,000/square mile	8,231	11,046	2,815
Employment >50,000/square mile	7,880	8,147	267
Home within six miles of a P&R station and Work within one mile of any station			
Employment <50,000/square mile	22,770	30,951	8,181
Employment >50,000/square mile	27,139	27,818	679

7.2.2 Comparison of Observed and Forecasted Ridership

The MBTA Lowell line sees approximately 8,745 daily boardings, whereas the base forecast was for 9,096 boardings. Using this actual and alternative forecast ridership and a boarding factor of 1.9, a combined scaling and rider-to-board conversion factor was developed to adjust the alternative forecasts. The scaling factor corrects for error in the base condition (existing) forecast, and the boarding factor converts boardings to riders. Table 7.4 lists the unadjusted and adjusted forecast for each alternative.

Table 7.4: Adjusted and Unadjusted Alternative New Riders Forecasts

Alternative	Unadjusted Forecast	Adjusted Forecast
Base	9,096	8,745
Intercity 8	659	633
Intercity 12	769	740
Intercity 18	913	878

7.2.3 City Boarding Distribution

The gross forecasts of ridership were allocated to three origin regions as a first step toward deriving station-level forecasts. The CTPP flow data and service information for each city were combined to allocate boardings at the city level. Since these market shares were based on the magnitude of worker flows within the corridor, it is understandable that Nashua was shown to have the largest market share (see Table 7.5). This means that while Manchester is the larger city, more Nashua residents work in the Boston area than residents of Manchester. These market shares were then weighted by the number of trains that would stop in each city for the various alternatives.

Table 7.5: City Market/Level of Service Weighted Distribution Factors

Alternative	Market Distribution		
	Nashua	Manchester	Concord
Intercity 8	0.51	0.39	0.10
Intercity 12	0.51	0.39	0.10
Intercity 18	0.51	0.39	0.10

7.2.4 Station Boarding Distribution

The second step in deriving station-level forecasts was to distribute the city-level forecasts to the proposed stations. To allocate the boardings in cities with two or more stations, the Study team used the population within the six-mile catchment area and an accessibility factor. For the intercity services, the only necessary station allocation involved Bedford/Manchester Airport and the downtown Manchester Station, which were allocated at 53 percent to downtown Manchester and 47 percent for Bedford/Manchester Airport.

7.2.5 Preliminary Ridership and Boarding Estimates

Table 7.6 presents the preliminary total ridership and southbound boarding estimates for the three intercity rail service options as determined using the ARRF2 forecasting model.

Table 7.6: Preliminary Total Ridership and Southbound Boarding Forecasts

	Total Ridership	Southbound Boardings
Intercity 8	1,260	630
Intercity 12	1,480	740
Intercity 18	1,760	880

7.2.6 *Station Southbound Boarding Distribution*

Preliminary station-level southbound boarding and total ridership estimates are presented in Table 7.7.

Table 7.7: Rounded Total Ridership and Station-Level Boarding Estimates

		Northbound Boardings	Southbound Passenger Boardings			
Alternative	Total Ridership	Boston	Nashua	Bedford/MHT	Manchester	Concord
Intercity 8	1,260	600	320	120	130	60
Intercity 12	1,480	700	370	140	160	70
Intercity 18	1,760	840	440	160	190	90

7.2.7 *Preliminary Estimates of Passenger Miles*

Estimates of the passenger miles that would be expected from each service option were developed for the purposes of comparing alternatives on their mobility benefits and to facilitate derivation of revenue forecasts (see Table 7.8). Weekday passenger mile estimates were derived by multiplying the forecast southbound boardings at each station by the distance from each station to Boston North Station. This product was then doubled to reflect the mileage resulting from returning northbound trips.

Table 7.8: Forecast Southbound Boardings and Weekday Passenger Miles

		Forecast Boardings			Weekday Passenger Miles		
Intercity Rail Station	Miles to Boston	Intercity 8	Intercity 12	Intercity 18	Intercity 8	Intercity 12	Intercity 18
Concord	73.3	60	70	90	8,796	10,262	13,194
Manchester	55.5	130	160	190	14,482	17,824	21,166
Bedford/MHT	50.1	120	140	160	12,024	14,028	16,032
Nashua	39	320	370	440	24,960	28,860	34,320
Totals		**630**	**740**	**880**	**60,262**	**70,974**	**84,712**

7.2.8 *Intercity 8 Forecasts*

A separate more refined forecast for the selected Intercity 8 option was prepared in collaboration with Amtrak and its ridership forecasting consultant, which has been supporting Amtrak's Market Research and Analysis Department with ridership and ticket revenue forecasts for all of Amtrak's services across the U.S.[23] For Study purposes, Amtrak estimated ridership on the 73-mile, eight-train-per-day Concord

[23] For more detail on final forecasts for all final options, see Appendix 6 to the Capitol Corridor AA Final Report (Task 6 Evaluation Criteria and Methodology)

service by analogy to the nearby 114-mile, 10-train-per-day *Downeaster* service. Each station on the proposed Intercity 8 service was associated with a *Downeaster* "surrogate" station with similar travel time, station demographics, and train service characteristics. The model was then factored for differences between the surrogate *Downeaster* station and the proposed Capitol Corridor station. The Capitol Corridor stations and their *Downeaster* surrogate stations are shown in Table 7.9.

Table 7.9: Intercity 8 Station Associations (June 26, 2014)

NHML Existing and Proposed Stations			Surrogate *Downeaster* Stations		
Station Name	**Miles to Boston**	**Population**	**Station Name**	**Miles to Boston**	**Population**
Boston North Station	0.0	2,667,000	Boston North Station	0.0	2,667,000
Woburn, MA	12.6	1,087,000	Woburn, MA	12.6	1,087,000
Lowell, MA	25.2	746,000	Haverhill, MA	32.1	662,000
Nashua, NH	38.8	340,000	Exeter, NH	51	187,000
Bedford/MHT, NH	50.1	120,000	Durham, NH	62	83,000
Manchester, NH	55.5	266,000	Exeter, NH	51	187,000
Concord, NH	73.3	166,000	Dover, NH	68	162,000
Station Name	**Employment**	**Income**	**Station Name**	**Employment**	**Income**
Boston North Station	1,705,000	146,275,000	Boston North Station	1,705,000	146,275,000
Woburn, MA	574,000	60,660,000	Woburn, MA	574,000	60,660,000
Lowell, MA	370,000	40,388,000	Haverhill, MA	287,000	32,237,000
Nashua, NH	169,000	16,025,000	Exeter, NH	90,000	9,128,000
Bedford/MHT, NH	59,000	5,332,000	Durham, NH	36,000	3,297,000
Manchester, NH	134,000	12,112,000	Exeter, NH	90,000	9,128,000
Concord, NH	88,000	6,740,000	Dover, NH	64,000	5,921,000

Notes: 1) Based on county-level demographic data from Moody's Economy.com
2) Demographics calculated as follows: Determine the population, employment, and income within a 10, 15, 20, and 25-mile radius around the stations (as the crow flies), then multiply by factors of 1.4, 0.9, 0.5, and 0.2 respectively; the sum of these four numbers is the assumed station catchment area
3) Demographic differences between the primary and surrogate stations are adjusted for in the model

The model used Fiscal Year 2013 Amtrak *Downeaster* ridership/revenue data. In the Amtrak model for the *Downeaster*, Boston-Woburn (13 miles) had a higher observed yield than Boston-Haverhill (34 miles) in FY13. This Boston-Woburn/Boston-Lowell assumption has been maintained for the Capitol Corridor ridership estimates. Fares used in the ridership estimates are listed in Table 7.10.

Table 7.10: Intercity 8 Station Fares

Capitol Corridor Station	Surrogate Station	Weekday Fares	Weekend Fares
Boston North Station	Boston North Station	-	-
Woburn	Woburn	$12	$12
Lowell	Lowell	$6	$9
Nashua	Haverhill, MA	$7	$11
Bedford/MHT	Durham, NH	$10	$14
Manchester	Exeter, NH	$9	$14
Concord	Dover, NH	$13	$15

This intercity rail forecasting model, like most intercity rail forecasting models, predicts annual riders for station pairs along the line. Projected ridership by station pair is listed in Table 7.11. Total ridership along the line is projected to be 354,100 passengers per year.

Table 7.11: Annual Intercity 8 Ridership Estimates

	Concord	Manchester	Bedford/MHT	Nashua	Lowell
Concord					
Manchester	900				
Bedford/MHT	200	1,000			
Nashua	600	1,400	1,600		
Lowell	1,300	900	4,200	700	
Woburn	900	500	5,700	800	100
Boston	52,800	130,900	43,600	91,600	14,400

The station pair ridership data is condensed to the New Hampshire station-level annual ridership by summing the station trip origins and destinations at each station. The station-level ridership forecasts are converted to annual boardings by dividing the ridership by two, and annual boardings are converted to daily boardings by dividing by 365 days. These data are shown in Table 7.12.

Table 7.12: Intercity 8 Boarding Estimates

	Annual		Daily
Station	**Ridership**	**Boardings**	**Boardings**
Concord	56,700	28,350	78
Manchester	135,600	67,800	186
Bedford/MHT	56,300	28,150	77
Nashua	96,700	48,350	132
Total	345,300	172,650	473

7.3 Final Estimates of Passenger Miles

An estimate of the passenger miles that would be expected from Intercity 8 service option was developed to facilitate derivation of revenue forecasts and for the purposes of comparing with other non-intercity rail alternatives on their mobility impacts. Weekday passenger mile estimates were derived by multiplying the annual station pair forecasts by the station pair distance and dividing by 365 (see Table 7.13).

Table 7.13: Passenger Miles

<table>
<tr><th rowspan="2">Station</th><th colspan="3">Passenger Miles</th></tr>
<tr><th>Annual</th><th colspan="2">Daily</th></tr>
<tr><td>Concord</td><td>2,014,305</td><td>5,519</td><td rowspan="4">24,762</td></tr>
<tr><td>Manchester</td><td>3,725,930</td><td>10,208</td></tr>
<tr><td>Bedford/MHT</td><td>1,408,625</td><td>3,859</td></tr>
<tr><td>Nashua</td><td>1,889,190</td><td>5,176</td></tr>
<tr><td>Lowell</td><td>353,965</td><td>970</td><td rowspan="3">25,314</td></tr>
<tr><td>Woburn</td><td>242,810</td><td>665</td></tr>
<tr><td>Boston</td><td>8,642,665</td><td>23,679</td></tr>
<tr><td>Total</td><td>18,277,490</td><td>50,075</td><td>50,075</td></tr>
</table>

7.3.1 Forecast Reductions in Automobile VMT

The preferred Intercity 8 option would provide new service in the corridor, but unlike the existing commuter bus and proposed commuter rail services, it was not designed for the work-trip market in the corridor. It is assumed that the Intercity 8 riders will all be new transit riders that have diverted trips from automobiles. To convert passenger miles to vehicle miles, an average vehicle occupancy of 1.67 [24] persons per vehicle was used. The VMT reduction shown in Table 7.14 from the Intercity 8 service is not concentrated in the morning and afternoon peak periods as it is with the commuter bus and commuter rail options.

Table 7.14: Intercity 8 Change in VMT

<table>
<tr><th>Station</th><th colspan="2">VMT Reduction</th></tr>
<tr><td>Concord</td><td>3,305</td><td rowspan="4">14,827</td></tr>
<tr><td>Manchester</td><td>6,113</td></tr>
<tr><td>Bedford/MHT</td><td>2,311</td></tr>
<tr><td>Nashua</td><td>3,099</td></tr>
<tr><td>Lowell</td><td>581</td><td rowspan="3">15,158</td></tr>
<tr><td>Woburn</td><td>398</td></tr>
<tr><td>Boston</td><td>14,179</td></tr>
<tr><td>Total</td><td>29,985</td><td>29,98</td></tr>
</table>

[24] 2009 National Household Survey Data, http://nhts.ornl.gov/tables09/fatcat/2009/avo_TRPTRANS_WHYTRP1S.html

8 Preferred Intercity Rail Service Design and Operations

This section describes the service design and provides an operations overview for the preferred Intercity 8 service option. Intercity 8 was selected from the three intercity rail service options because of its low net operating costs and reasonable level-of-mobility benefit. The number of additional riders attracted by more the frequent service that would be offered by Intercity 12 and 18 did not keep pace with the forecasted cost of the additional service. In preliminary estimates, Intercity 8 was projected to carry 946 daily passengers at a net operating cost of $3.6 million. By comparison, Intercity 12 and 18 would carry 1,104 and 1,308 daily passengers, respectively, at net operating costs of $6.9 and $11.8, respectively.

8.1 Design Objectives

In designing the Intercity 8 option, the Study team worked to maximize the service frequency that could be effectively offered with a single set of equipment and limited crews serving the five major population centers along the corridor: Concord, Manchester, and Nashua in New Hampshire and Lowell and Boston in Massachusetts. The design also would provide service to the suburban Massachusetts intermodal hub in Woburn served by intercity passenger rail service between Portland, Maine and Boston (Amtrak *Downeaster*). The operating characteristics of the successful *Downeaster* service were influential to the Intercity 8 design. Both services (the *Downeaster* and potential Intercity 8) would offer arrivals and departures at North Station at similar times of day.

8.2 Design Constraints, Assumptions, and Paradigms

In designing the service, the Study team was guided by the following constraints, assumptions, and paradigms:

- The new service must overlay onto the existing schedule and mix of passenger trains currently using North Station, including all of MBTA's north side commuter rail service and Amtrak's *Downeaster* service. The design needed to be particularly cognizant of the 68 weekday MBTA and Amtrak passenger trains that use portions of the route between Lowell and Boston.
- To gain acceptance from the host railway, the service needs to be completely transparent to existing MBTA customers.
- To minimize required capital investment and maximize benefits from a limited capital budget, it was assumed there would be no upgrades to infrastructure south of Lowell where successful passenger services are already offered. Instead, investments would be focused along the portions of the route that are currently "freight-only."
- Also to minimize required capital investment, the service was designed to respect limited capacity at North Station. MBTA has allowed that one new peak period arrival/departure by an intercity train could be accommodated at North Station once the currently inoperable Tracks 11 and 12 are put into service.

- Also to minimize capital expenditure, any track improvements would need to stay within the existing rail right-of-way. The line follows the banks of the Merrimack River for most of its route between Lowell and Concord. Since the frequency of curves and degree of curvature associated with the line is quite high due to its riverine routing, this constraint had a significant impact on maximum allowable speeds north of Lowell.
- To provide for harmonious operations with PAR (the freight carrier and owner of the route in New Hampshire), the Study team focused on providing industrial siding tracks at key locations along the line to avoid conflicts between intercity passenger trains and local freight train pick-ups and deliveries at customer locations.

8.2.1 Intercity 8 Design Overview

Meetings with Amtrak, MassDOT, and MBTA in the Spring of 2013 indicated a willingness to work with NHDOT on the provision of passenger service along the NHML from New Hampshire to North Station. This cooperation would take the form of Amtrak operation of intercity trains into New Hampshire or MBTA operation of commuter trains along the same route. The MBTA felt that two new station tracks would be opened at North Station with the imminent relocation of the Spaulding Hospital immediately to the west, providing capacity for one additional peak Amtrak train in each direction. MBTA would also be willing to extend its service into New Hampshire provided that the service extension was essentially transparent to existing MBTA passengers using the services offered between Lowell and Boston.

The Study team devised a hierarchy of three conceptual services that could be operated as an independent Amtrak service 73 miles northward from North Station to Concord, New Hampshire. The options were based on NHML historic and current physical attributes, the schedule of passenger services on the line, and general service parameters for Amtrak services in corridors of less than 150 miles. Each service would have the following characteristics:

- Operate independently of the MBTA and Amtrak *Downeaster* passenger services already serving the southernmost 25 miles of the route
- Require no upgrades to infrastructure south of Lowell
- Require upgrades to rail infrastructure north of Lowell:
    - Upgrades to 48 miles of existing track to FRA Class 4 providing for maximum passenger train speeds of at least 70 mph[25]
    - Installation of two or more industrial sidings between Nashua and Concord allowing passenger trains to pass or meet freight trains serving these segments

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[25] Initially 70 mph was initially selected as no historic records showed higher speeds along the route since its opening in the 1800s; further later analysis indicated that 75 mph maximum allowable speeds could be supported for a relatively short segment between Nashua and Manchester

- Installation of a passing siding on the PAR freight main line west of North Chelmsford to reduce the need for trains to stand east of North Chelmsford on the route between Lowell and Nashua; MassDOT and MBTA have since committed to providing this passing siding independent of this planning initiative to solve capacity problems on the adjacent Fitchburg route also shared by MBTA and PAR trains
- Installation of NORAC Rule 261 signals between Manchester and Concord (approximately 18 miles)
- Installation of PTC protection

The proposed services would call at six passenger stations north of Boston (see Table 8.1).

Table 8.1: Proposed Stations with Distance and Travel Time to Boston

Station	Miles to Boston	Approximate Travel Time to Boston
Concord	73.3	1:29
Manchester	55.5	1:09
Bedford/MHT	50.1	1:01
Nashua	38.8	0:48
Lowell	25.5	0:32
Woburn	12.6	0:16

The projected travel times compare favorably with historic minimum travel times between Concord and Boston (see Table 8.2). The presumed maximum allowable speeds between Lowell and Concord and the proposed NHML maximum allowable speeds are shown Figure 8.1.

Table 8.2: Historic Minimum Concord-Boston Travel Times

	1910	1926	1945	1954
Travel Time	2:00	2:05	1:35	1:22
Commercial Velocity (mph)	37	35	46	54

Source: Jacobs' analysis of archived public timetables

Figure 8.1: Proposed NHML Maximum Allowable Speeds

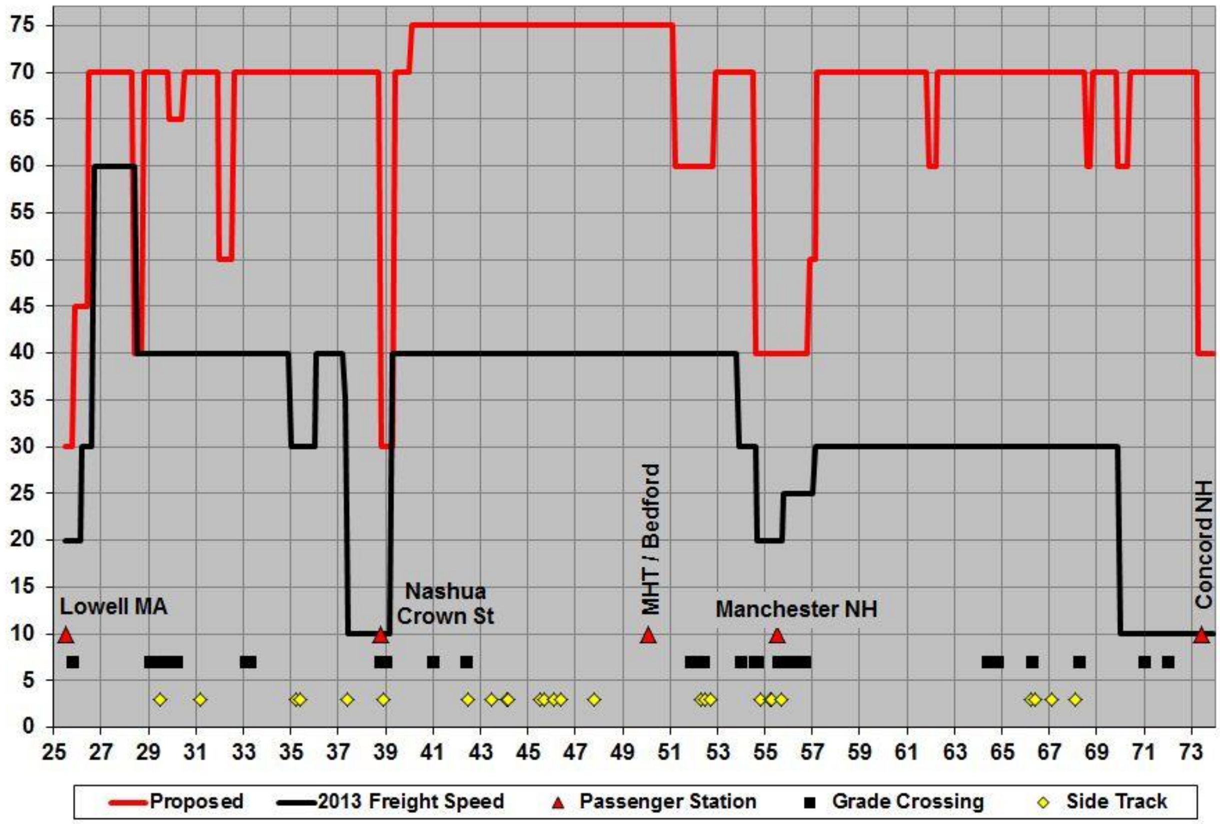


Table 8.3 summarizes the three conceptual Amtrak services that were considered for restoration of passenger service on the line. The Intercity 12 and Intercity 18 options were ultimately screened out from further consideration.

Table 8.3: Operating Characteristics of Proposed Intercity Rail Service Options

Options	Weekday Revenue Trains			Route Miles	Stations	Weekday Train Miles
	Nashua	Manchester	Concord			
Intercity 8	8	8	8	73	6	586
Intercity 12	12	12	12	73	6	880
Intercity 18	18	18	18	73	6	1,319

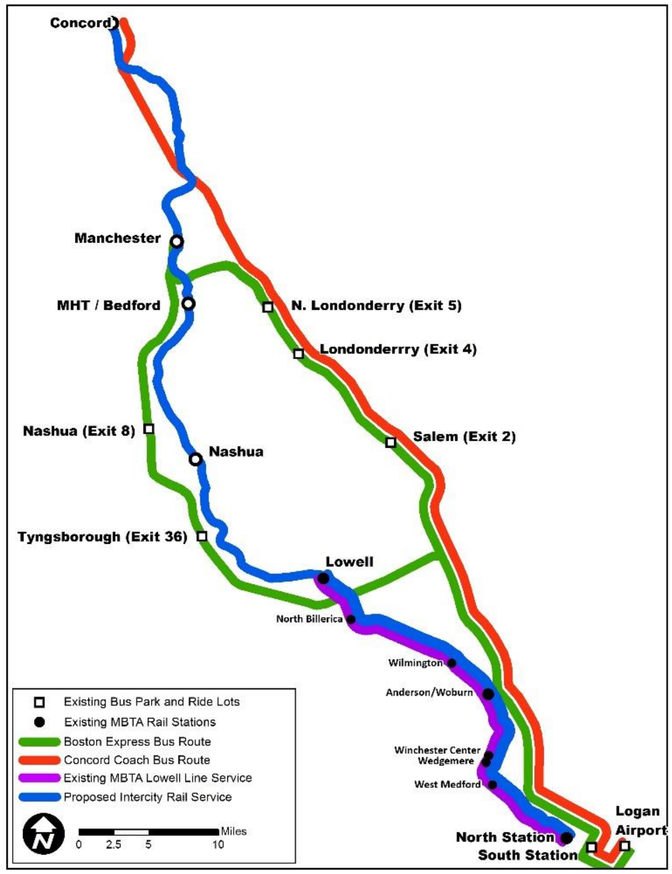
Each intercity rail and commuter rail service was designed using custom train scheduling and stringline diagraming tools used for many rail scheduling and planning assignments at MBTA and other passenger railroads. Given the relatively low density of freight traffic on the NHML, it was decided in consultation with the FRA that full Rail Traffic Controller (RTC) simulation models of the route would not be necessary for this particular Study.

8.2.2 *Intercity 8 Rail Service*

- Four daily intercity passenger rail round trips between Concord, New Hampshire and Boston, Massachusetts making intermediate stops at Manchester, Bedford/Manchester Airport, Nashua Crown Street, Lowell and Woburn, Massachusetts
- Base BX bus service is retained

The eight-train-per-day Intercity 8 rail option would provide four daily round trips over the 73-mile route, stopping at five intermediate stations (see Figure 8.2). The end-to-end trip time would be approximately 96 minutes and the service would operate 586 daily train miles.

Figure 8.2: Intercity 8 Rail Service



A proposed timetable for the service is shown in Table 8.4. A full NHML schedule is found in Figure A.1 in Appendix A and a stringline time-distance diagram showing the proposed service integrated with the existing MBTA service on the line is found in Figure 8.3.

Presuming an average cost of $36 per train mile based on recent experience of the nearby Amtrak *Downeaster* service, Intercity 8 would cost approximately $7.7 million per year to operate.

The service could be extended with possible connections to private bus services for North Country destinations. No changes are proposed to express bus service for commuting to Boston via I-93 or Route 3. Local bus service to the intercity rail stations could be offered but would not be integral to the service design. A BX/Concord Coach/intercity rail fare integration scheme similar to that employed by the *Downeaster* at Portland, Maine could be employed at the Concord and Manchester stations that would be shared by both intercity rail and coach bus services.

Table 8.4: Proposed Intercity 8 Timetable

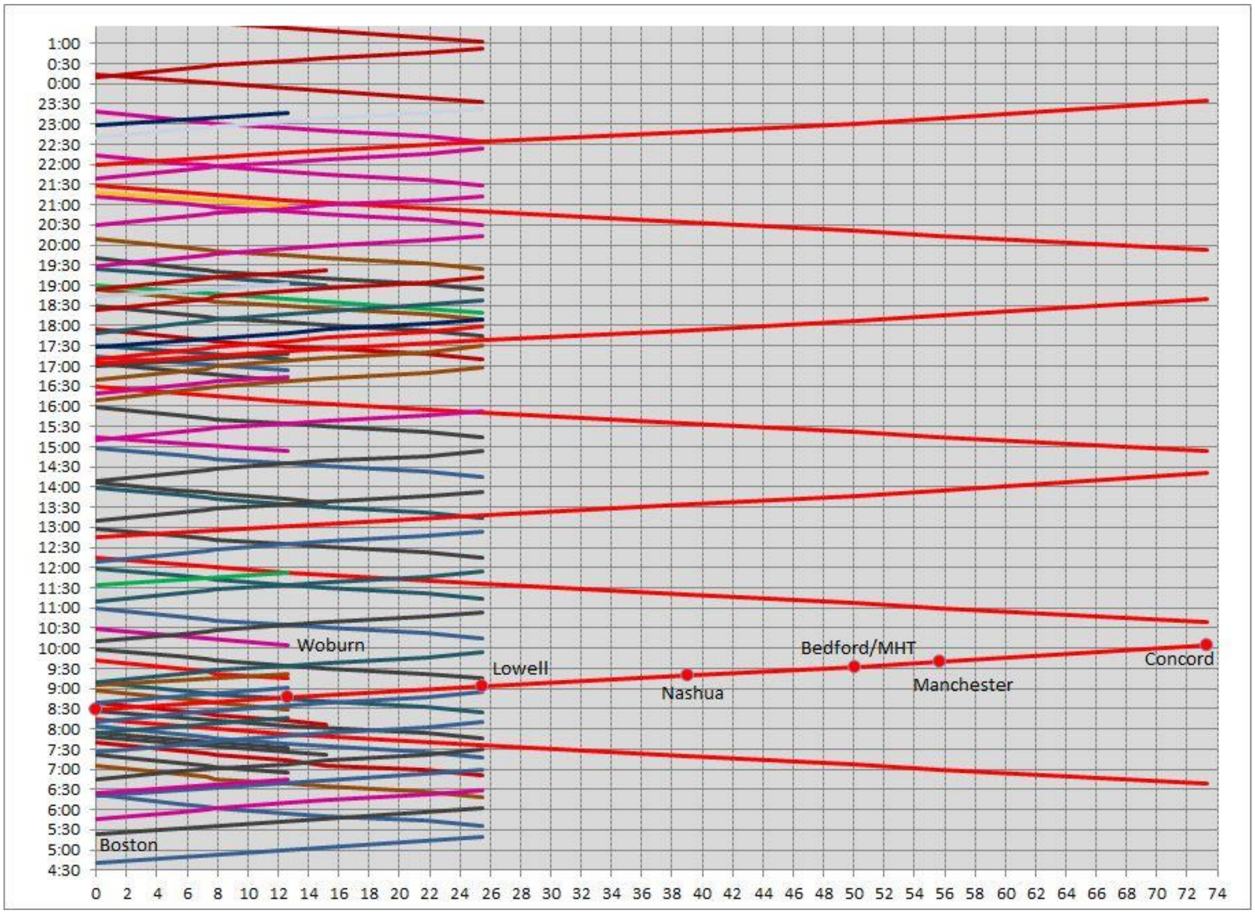
380	382	384	386		Station	MP		381	383	385	387
6:39	10:39	14:54	19:54	Read Down	Concord, NH	73.3	Read Up	9:59	14:14	18:49	23:39
6:58	10:58	15:13	20:13		Manchester, NH	55.5		9:38	13:53	18:28	23:08
7:07	11:07	15:22	20:22		Bedford/MHT	50.1		9:30	13:45	18:20	23:00
7:20	11:20	15:35	20:35		Nashua	38.8		9:17	13:32	18:07	22:47
7:36	11:36	15:51	20:51		Lowell	25.5		9:02	13:17	17:52	22:32
7:52	11:52	16:07	21:07		Anderson/Woburn	12.6		8:46	13:01	17:36	22:16
8:15	12:15	16:30	21:30		North Station	0.0		8:30	12:45	17:20	22:00

It is presumed that service would be offered with a single push-pull locomotive hauled train set with four coaches. The rolling stock would be similar in configuration and performance to the equipment used for the *Downeaster* and MBTA commuter rail service. The train set would be stored and serviced overnight at the Concord Station where a plug-in and basic cleaning and servicing facilities would be provided. It is assumed that the intercity service would be operated from the same pool of equipment used to provide *Downeaster* service with an extra locomotive and control coach added to that pool to offset the additional burden this service would create. Amtrak would provide heavy maintenance at its facilities in Boston's Southampton Street Yard or further south on the Northeast Corridor as is the practice with the *Downeaster* equipment.

Two crews would be required to provide service each day. One crew would handle Trains 380 to 383; while the other crew would handle Trains 384 to 387. A full roster of three crews plus a spare would be necessary to handle routine service requirements. The minimum required crew would be an engineer and conductor, although it is likely that Amtrak would operate the service with a third crew member to assist with operation of doors and management of passengers.

For Study purposes, it was presumed that the service would be operated by Amtrak. Certain economies in crewing, equipment maintenance, and administrative overhead might be available if the service were operated by MBTA and its passenger rail contractor in a manner similar to the operation of their new 78-mile Cape Flyer service. The Cape Flyer started in the summer of 2013 as a seasonal weekend-only experiment. After two seasons of operation, it appears that it may become permanent and a model for the operation of other short distance intercity rail services into Boston.

Figure 8.3: Intercity 8 Stringline/Time-Distance Diagram



9 Preferred Intercity Rail Station and Layover Facilities

This section describes the design requirements and evaluation criteria used to identify and assess potential sites for passenger rail stations and layover facilities proposed to support the Intercity 8 option It then describes the recommended sites, evaluates their performance, and provides preliminary designs, where appropriate. A total of eight intercity passenger rail stations and three layover site options were identified through a combination of stakeholder meetings and public outreach, review of existing and historical conditions, previous studies, and field inspections. Following assessment, four stations and one layover facility were recommended for the Intercity 8 service.

9.1 Design Requirements

Each of the rail stations would require American Disabilities Act (ADA) compliant platforms for passengers to board and alight the trains, provide a canopy for shelter, have provisions for buses and automobiles to pick-up and drop-off passengers, and provide direct access to and from major highways and nearby land uses. All but one station would require parking designated for rail passengers. Sites located in downtown Manchester are too constrained to provide dedicated commuter parking, but ample public parking capacity is located within short walking distance of the identified sites.

Where possible, the Study team designed platforms that were "high-level" for their full length. High-level platforms ease boarding for all passengers by eliminating the need for stairways to climb into and out of the passenger coaches. High-level platforms may conflict with freight train movements; therefore, a short 85-foot-long section of high-level platform, commonly referred to as a "mini-high," might be substituted for a full-length, high platform at some stations. Platform specifications are listed below:

- Low-level platforms must be eight inches above the top of rail
- High-level platforms must be 48 inches above the top of rail
- The preferred side platform width is 12 feet; 10 feet is acceptable and eight feet is the absolute minimum width
- Long side-platforms may taper to a minimum width of eight feet at the ends
- The preferred center-island platform width is 22 feet for a minimum of half the platform length
- Long center-island platforms may taper to a minimum width of 12 feet at the ends
- Outbound platforms should be 765 feet long (shorter platform lengths could be accommodated for the initial service, but longer platforms would provide more room for growth and flexibility in service design and operations)
- Inbound platforms of a minimum 710 feet would be permissible

Table 9.1 identifies the eight potential Intercity 8 station site locations and preliminary site requirements.

Table 9.1: Potential Intercity 8 Station Sites

Station	Requirements	Potential Sites
Nashua	▪ Downtown station to anchor future Nashua TOD ▪ P&R availability ▪ Integrate with local NTS bus service	▪ Crown Street ▪ Beazer East
Bedford/MHT	▪ P&R station for commuter rail and intercity rail options ▪ Shuttle Bus to Manchester Airport ▪ Direct Access to Route 3 and I-293	▪ NHDOT parcel below the Ray Wieczorek Drive/Pearl Harbor Memorial Bridge
Manchester	▪ Downtown anchor to support existing development and Manchester TOD ▪ Integrate with local MTA bus service and downtown intercity bus terminal	▪ Queen City Avenue ▪ Granite Street ▪ Spring Street/Bridge Street
Concord	▪ Downtown station to anchor Concord TOD ▪ Integrate with existing intercity bus terminal and local CATs bus service ▪ P&R availability	▪ Depot Street ▪ Stickney Avenue

Table 9.2 lists the number of station tracks required for Intercity 8. This was determined by evaluating the need for trains to turn or meet in stations, as indicated by the preliminary service schedules.

Table 9.2: Number of Required Intercity 8 Station Tracks

Station	Tracks
Nashua	1
Bedford/MHT	1
Manchester	1
Concord	1

The number of parking spaces proposed for each station was based on two factors: 1) forecast ridership and 2) functional station type (see Table 9.3). Downtown stations would provide parking only where available at the rate of one parking space for every two forecast riders. The regional P&R station at Bedford/Manchester Airport would provide one space for each forecast rider. The Nashua Crown Street station site is currently owned by the City of Nashua and has been proposed to accommodate up to 255 parking spaces. Only accessible parking spaces are proposed for downtown Manchester, since there are many pay-for-parking lots within close proximity of each proposed station site. Finally, there is an existing, heavily-utilized P&R lot at Stickney Avenue in Concord. Due to the nature of intercity travel, at least 100 additional spaces are proposed at this location even though this would exceed the one-space-per-forecasted-rider standard.

Table 9.3: Intercity 8 Preliminary Ridership Forecasts and Parking Space Requirements

	Total	Nashua	Bedford/MHT	Manchester	Concord
Ridership Forecasts	730	200	210	240	80
Parking Space Requirements	545	255	210	0-	100

9.1.1 Site Evaluation Criteria

The following list of evaluation criteria was developed to guide the station site selection process. The evaluation criteria measures were given a rating of one for poorly performing sites to five for highly performing sites. Environmental criteria was designated as Yes or No, while ownership criteria was designated G for government-owned or P for privately-owned.

1. Market
   - Does the site adequately serve the travel market of Boston-bound travel for residents of Nashua, Manchester, Concord, and surrounding towns?
2. Access
   - Is the site adequately served by major roads with connections to the regional highway network?
   - Is there existing parking available at the site?
3. Track Operational Characteristics
   - Is the track straight and free of existing sidings?
   - Are there any grade crossings adjacent to the site?
   - What are train deadhead cost savings and travel time efficiencies?
   - Requirement for new traffic/train signals?
   - Are bridge structures required for roadway access or yard leads?
   - Are freight rail movements/clearances maintained?
4. Parcel Size/Configuration/Ownership
   - Is there adequate land available for station platforms and facilities?
   - Is there sufficient land for parking lots sized to meet ridership forecasts?
   - What is the assessed value per acre?
   - Would displacement of residents/businesses be required?
5. Land Use
   - What are the predominant surrounding land uses?
   - What are municipal and community aspirations/priorities?
   - Consideration of environmental justice, including accessibility by minority populations and low-income households
6. Sensitive Receptors
   - Are there any residential buildings or educational, medical, or religious facilities near the site that would have a heightened sensitivity to noise or vibration impacts?

7. Environmental

    - Is the site adjacent to a river or within a flood zone?
    - Is the site in or adjacent to jurisdictional wetlands?
    - Does the site have a history of contamination?
    - Has the site been designated as a threatened or endangered species habitat?
    - Does the site have nearby sensitive receptors for noise/air quality impacts?

8. Ownership

    - Is the property owned by state or local government or is it privately held?
    - Is the property for sale or held by single or multiple owners?

9.1.2 Preliminary Station Sites

Multiple locations were identified for each of the five proposed stations based on field inspections, interviews with local officials, and a review of previous studies. Each of the evaluated sites and their MP distance from Boston are listed in Table 9.4 and discussed in detail below. Several sites were eliminated during the preliminary assessment, while eight locations were advanced for further evaluation.

Table 9.4: Intercity 8 Preliminary Station Sites

Station	Sites Evaluated	MP
Nashua	25 Crown Street	38.8
	Beazer East	41.0
Bedford/MHT	NHDOT parcel below Ray Wieczorek Drive	50.1
Manchester	Queen City Avenue/Jac-Pac	54.9
	Granite Street	55.5
	Spring Street/Bridge Street	56.4
Concord	Depot Street	72.6
	Stickney Avenue	73.3

Once the station sites were identified, schematic designs were overlaid on annotated aerial imagery prepared by Jacobs Engineering in September 2013. These schematic designs included tracks, switches, platforms, roadways, pathways, parking, circulation, buildings, and other related features. Parcel mapping information provided by municipalities and NHDOT was also incorporated as part of the schematic designs. It will be necessary for the schematic designs to be reviewed by Amtrak, MBTA, PAR, NHDOT, and other stakeholders prior to being finalized. The following sections describe and document each station site with findings from the initial site review. Parcel mapping, site photos, previous station site plans, preliminary schematics, and the proposed conceptual station plan are presented for preliminary environmental and financial review.

9.2 Nashua Station Options

Figure 9.1 illustrates the location of the two potential station locations that could be developed as a Nashua Station: Crown Street and the Beazer-East site.

Figure 9.1: Potential Nashua Station Locations

9.2.1 Nashua – Crown Street

This city-owned and locally preferred site for a downtown Nashua station is located south of Crown Street site and north and west of the PAR rail yard. It is the approximate location of Nashua's historic main line train station. Another station was located on the Hillsboro Branch at Railroad Square on Main Street.

Potential station locations were also evaluated at Bridge Street and East Hollis Street with regard to how a full-length (765-foot) passenger rail station platform could be configured on the site. The Bridge Street site was eliminated because only 520 feet would be available for a platform between the Nashua River railroad bridge on the north and the Bridge Street crossing on the south. The East Hollis Street site located between Bridge Street and East Hollis Street was also eliminated as the platform length would be limited to approximately 400 feet. Site features and challenges follow; see Figures 9.2 and 9.3 for photos and a parcel map, respectively, and Table 9.5 for summary evaluation ratings.

- The station platform would be located adjacent to the Triangle Pacific building, which could potentially be redeveloped
- It is the only viable site near downtown that can accommodate platform requirements
- City plans call for 255 parking spaces and reuse of existing industrial buildings
- Additional parking supply would be constrained by the size of the parcel

Figure 9.2: Nashua – Crown Street Site Photography

Facing southeast towards the PAR Rail Yard

Facing south towards the vegetated area west of the PAR Rail Yard where the proposed platforms would be located

Facing northwest as the NHML continues north, the Hillsboro Branch turns off towards the west

Facing west towards downtown Nashua

Figure 9.3: Nashua – Crown Street Parcel Map

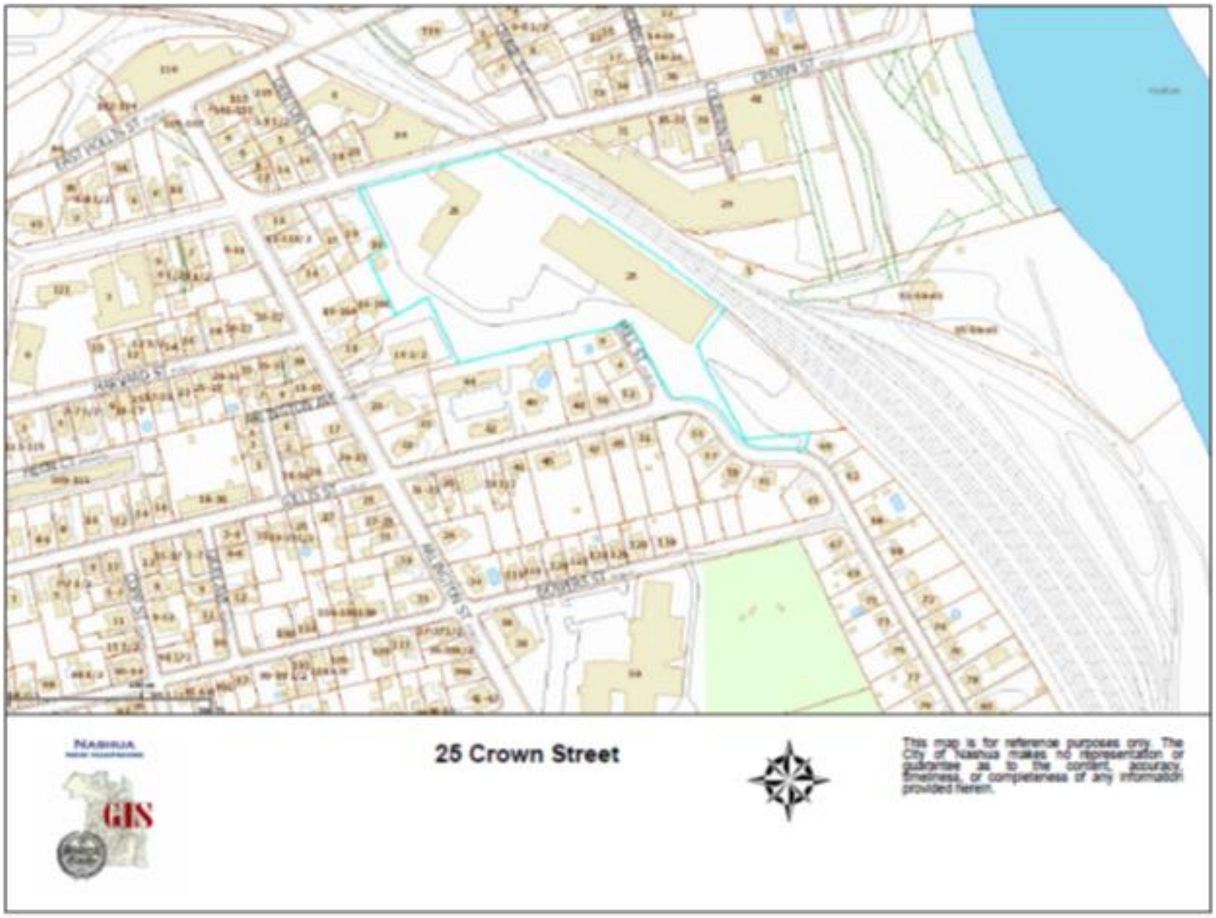


Table 9.5: Nashua – Crown Street Station Area Evaluation

Category	Rating	Notes
Market	4	Close (0.8 miles) to Main Street in downtown Nashua
Access	4	Multiple local road access points
Track	5	Only viable stretch of track in the downtown area
Land use	4	Future P&R site for the city, mixed industrial/residential
Parcel	5	Seven acre site owned by the city, designated for transit
Environmental	Y	Potential soil remediation, unknown; most likely urban fill. Possible complications from site demolition
Owner	G	Government-owned (City of Nashua)
Noise	Y	Mixed residential neighborhoods near site
Miscellaneous	Y	City would like to utilize this site as a park-and-ride location

Assessment: Advanced

This site is recommended as a downtown station for the City of Nashua. Local officials have been contemplating a station at Crown Street for several years with well-developed plans shown in Figure 9.4. The city and state recently cooperated to acquire the site with the intention of developing a P&R lot independent of the proposed rail service, as shown in Figures 9.5 and 9.6; a preliminary station design is shown in Figure 9.7.

Since this location would rely on pedestrian and bicycle accessibility, a new sidewalk would be necessary on the south side of Crown Street and east of Arlington Street to ensure safe site access. A pedestrian/bicycle connection off Harvard Street would provide improved accessibility from the surrounding neighborhoods.

Figure 9.4: City of Nashua Excerpt from East Hollis Street Master Plan

Figure 9.5: City of Nashua P&R Site Plan

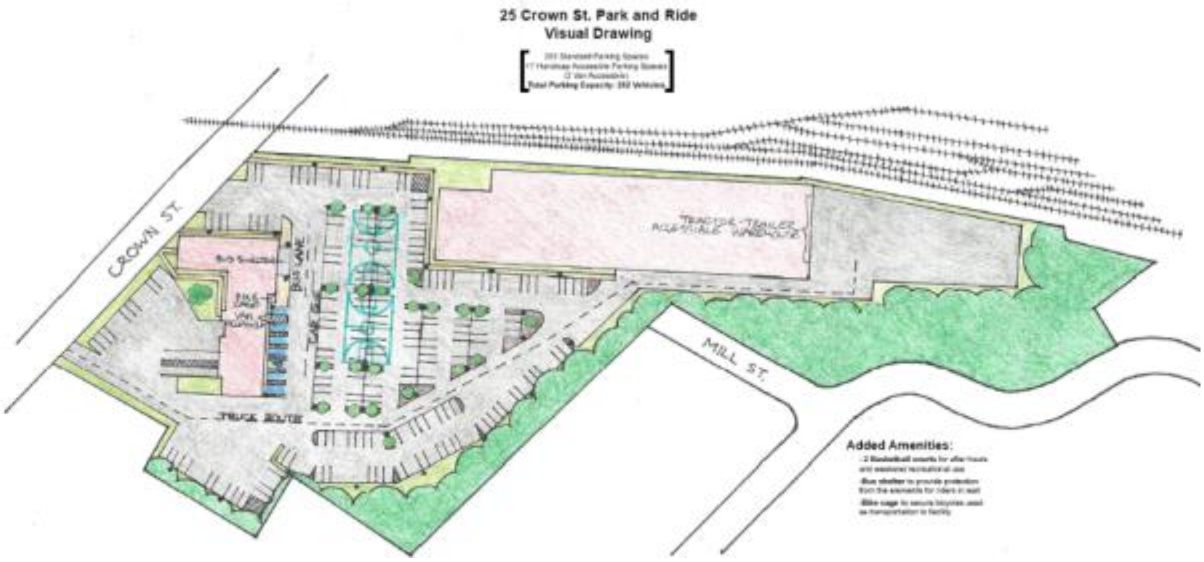


Figure 9.6: City of Nashua P&R Site Plan

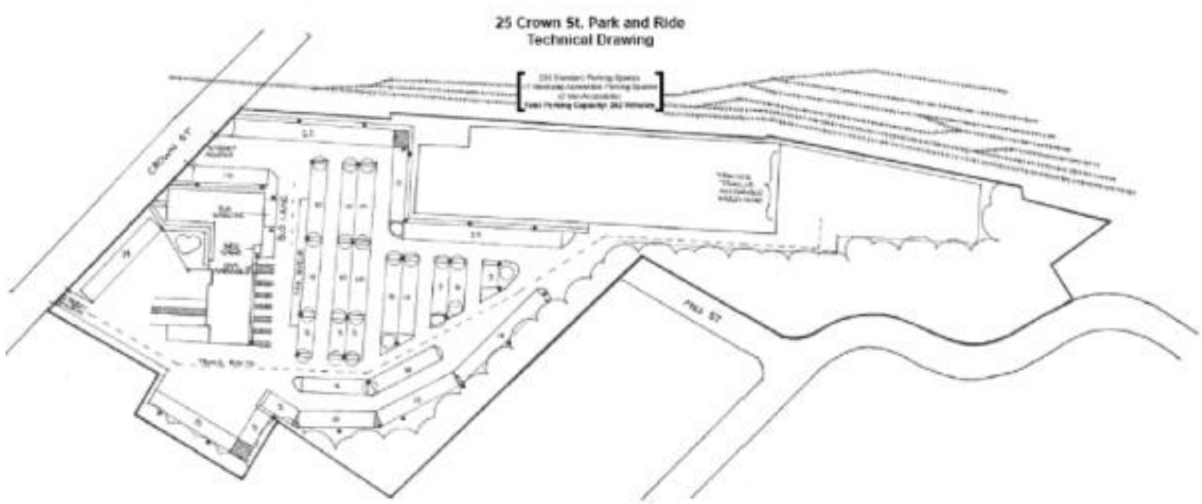
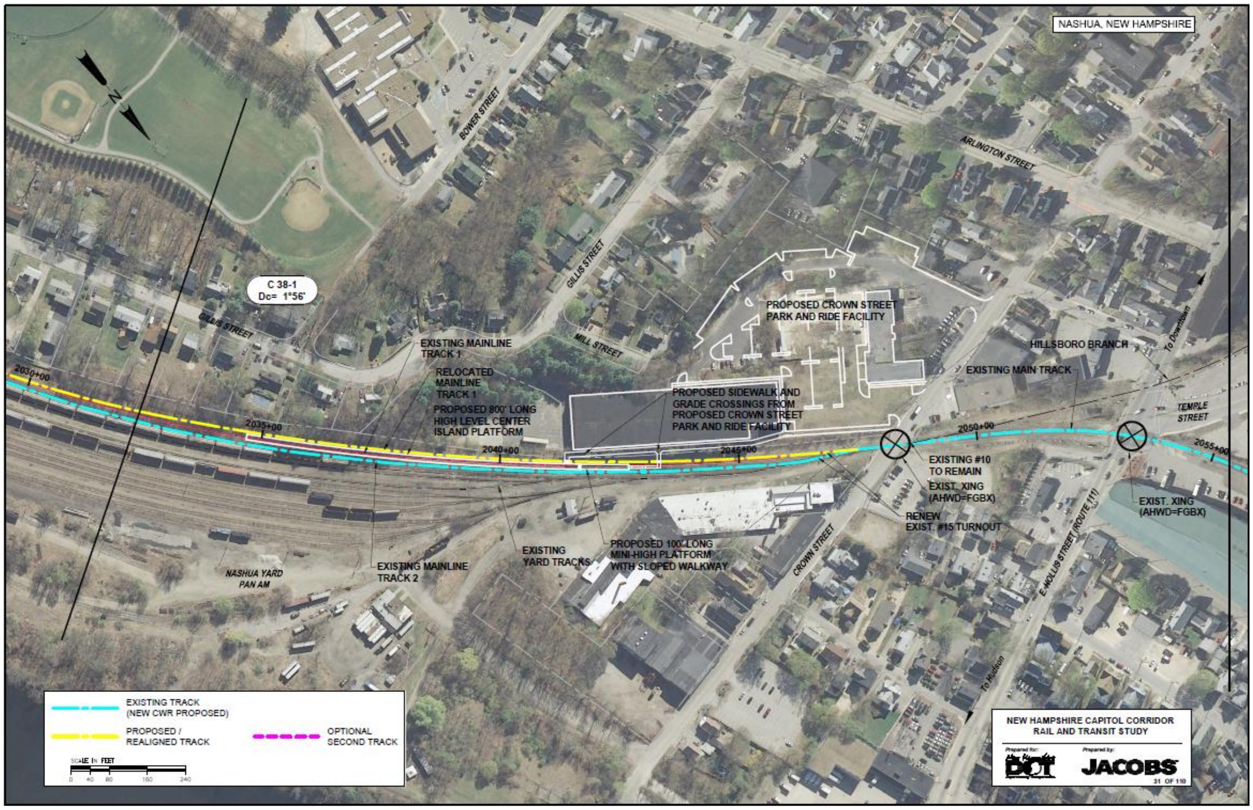


Figure 9.7: North Nashua – Crown Street Station Preliminary Station Design



9.2.2 *North Nashua – Beazer-East*

The Nashua Beazer-East site is located in the southwest corner of a large industrial parcel owned by Beazer-East, Inc. The site was formerly owned by Koppers Company, a manufacturer of railroad ties. Their manufacturing operations included treating ties with creosote. The site was found to be contaminated with creosote and is currently in the process of being cleaned up. It is contemplated that the site will be developed once the remediation effort is completed. Land is principally residential immediately west of the site. Greeley Park, located to the south is owned by the City of Nashua, and is primarily used as a site for launching boats on the Merrimack River. Hills Ferry Road is currently the only access roadway across the railroad tracks into the site. The existing 36.5 kw power line right-of-way was proposed to allow the extension of Henry Burke Highway into the site with an overpass over the tracks, although this option was eliminated from further consideration in 2011. Two small industrial buildings are the only buildings currently on the parcel. The Brownfields site is north of downtown Nashua and does not relate well to current or future rail service or City of Nashua redevelopment plans. However, it does present a large undeveloped parcel along the railway. Site features and challenges include the following (see Figures 9.8 and 9.9 for photos and a parcel map, respectively, and Table 9.6 for summary evaluation ratings):

- 96 acres available, providing multiple options
- Access issues include the need to navigate through a residential neighborhood
- It may be possible to extend Hills Ferry Road into Greeley Park
- Further north, Pennichuk Street is another potential access path with local access options from Route 3 via Daniel Webster Highway and Concord Street
- Planned site development is mixed use retail and residential
- The site is free of wetlands, but adjacent to Merrimack River
- The site is contaminated with creosote and currently undergoing remediation

Figure 9.8: North Nashua – Beazer-East Station Site Photography

Monitoring wells

Remediation building

Hills Ferry Road at-grade crossing

Existing signal

Figure 9.9: North Nashua – Beazer-East Station Parcel Map

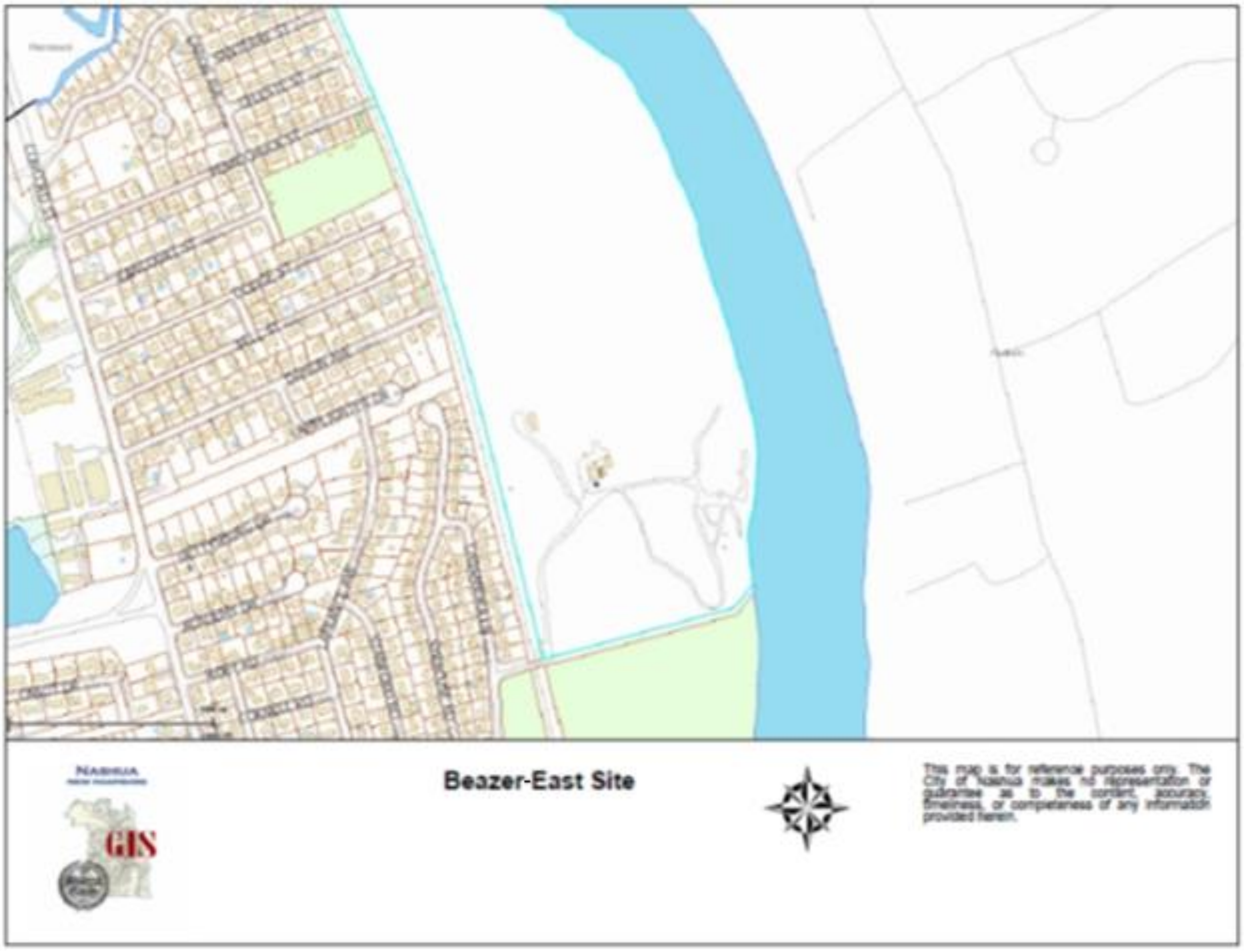


Table 9.6: North Nashua – Beazer-East Station Area Evaluation

Category	Rating	Notes
Market	2	Closer to Merrimack; City of Nashua residents would need to drive north to go south
Access	2	Indirect from Route 3, with access through a residential neighborhood
Track	5	Straight track, no issue
Land use	3	Vacant parcel, but adjacent to existing neighborhood
Parcel	5	Large vacant parcel, plenty of land
Environmental	Y	Site has existing soil contamination; would not interfere with proposed use
Owner	P	Privately-owned, available for development; a station here could help spur redevelopment
Noise	Y	Vacant lot with adjacent neighborhood
Miscellaneous	Y	Need to create new access

Assessment: Eliminated

This site was eliminated from further consideration due to the nature of its poor relation to potential rail service, site access constraints, and existing soil contamination.

9.2.3 Bedford/Manchester Airport

The proposed Manchester Airport station in Bedford would provide a location for air-rail passenger interchange and also serve as a regional P&R for northern Hillsborough and southern Merrimack counties. The site is located under the Ray Wieczorek Drive/Pearl Harbor Memorial Bridge that provides a direct connection between Route 3 and Manchester Airport. This site has also been proposed as a development node within the Town of Bedford. A proposed shuttle bus would meet all trains and provide connecting service along the 2.8 mile (six-minute) route between Manchester Airport's passenger terminal and the proposed station. Similar air-rail shuttle connections are used at airports in Baltimore, Boston, and Milwaukee. The station parking lot would be managed to avoid use by air passengers and keep spaces available for rail passengers. The Town of Bedford supports this station location and has developed plans for mixed use redevelopment in the vicinity of the station. Site features and challenges include the following (see Figures 9.10 and 9.11 for photos and a parcel map, respectively, and Table 9.7 for summary evaluation ratings):

- NHDOT owns the property on the south side of the bridge, some of which was set aside as mitigation as part of the bridge construction
- Property on the north side of bridge is privately held
- Sebbens Brook is a valuable environmental resource located on the south side of the bridge
- Access is difficult to the south of the bridge, although there may be the potential to develop site access through the existing parcel south of the brook
- A small brook and wetland areas also exist on the north side of the bridge
- A propane gas service yard on the north side of the bridge may need to be relocated
- A power line bisects the site north of the bridge

Figure 9.10: Bedford/Manchester Airport Station Site Photography

Railroad right-of-way facing south

Overhead power lines

Railroad right-of-way facing north

Wetlands adjacent to the proposed station

Figure 9.11: Bedford/Manchester Airport Station Parcel Map

Table 9.7: Bedford/Manchester Airport Station Area Evaluation

Category	Rating	Notes
Market	5	Only direct access point to the airport
Access	5	Direct access to the site from Ray Wieczorek Drive
Track	5	Straight unencumbered track
Parcel	4	Potential need to utilize multiple parcels
Land use	5	Mostly vacant, surrounding transportation uses
Sensitive Receptors	5	No sensitive receptors
Environmental	Y	Wetlands – values need to be assessed
Ownership	G/P	State owns some of the parcels, some are privately held

Assessment: Advanced

The proposed Manchester Airport station has been previously identified as a potential passenger rail station by state and local officials. Local plans, published in 2010, embrace the concept of a rail station along the river near the bridge linking Route 3 with the Manchester Airport (Figure 9.12). The station would be a focal point for regional travel and local development as well as for air-rail intermodal passenger transfers. An 800-foot long platform is proposed to be located on the west side of the tracks. The site also has ample room to accommodate the necessary parking without the need for additional land acquisition. Figure 9.13 shows the preliminary station design.

Figure 9.12: Town of Bedford Concept Plans for Manchester Airport Station Area (2010)

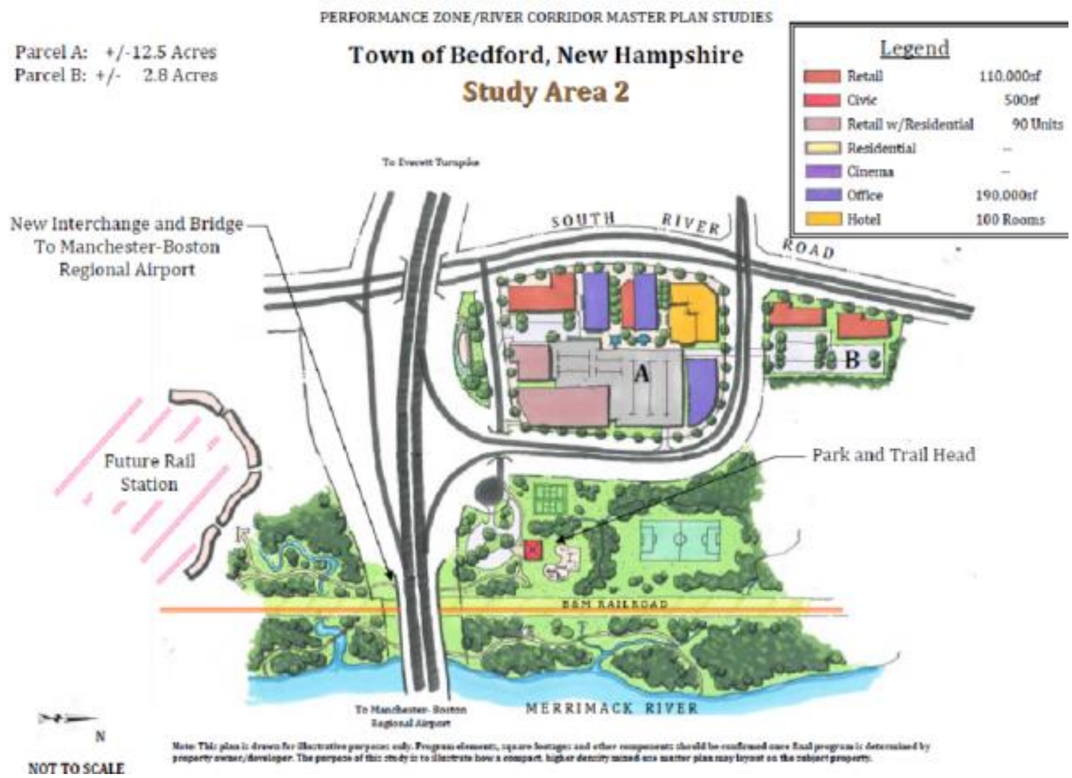


Figure 9.13: Bedford/Manchester Airport Preliminary Station Design

9.3 Manchester Station Options

Three station sites for downtown Manchester were identified and evaluated. Key roles to be fulfilled by the downtown Manchester station include serving as a downtown anchor to support existing development, support future Manchester TOD, integrate the passenger rail service with the local MTA bus hub, and provide multi-modal connections with Manchester's downtown intercity bus terminal.

9.3.1 Manchester: Queen City Avenue

The station proposed at the former "Jac-Pac" site is located under the Queen City Avenue Bridge where it crosses the railway. This location is situated approximately 7,500 feet (30-minute walk) from the downtown bus terminal and the southern end of Manchester's most intense urban development.

Figure 9.14: Historic Manchester Rail Station

Assessment: Eliminated

The Queen City Avenue site was suggested by local officials, but eliminated early in the site selection process due to its weak relationship to the existing downtown and distance from other transit services.

9.3.2 Manchester – Granite Street

Manchester's main passenger rail station stood for many decades on the south side of Granite Street before the building was demolished and the site redeveloped (Figure 9.14 on previous page). The site is proximate to the center of Manchester's densest urban development, across the street from the intercity bus terminal and a short walk to the MTA's downtown hub at Veteran's Park. Site features and challenges include the following (see Figures 9.15 and 9.16 for photos and a parcel map, respectively, and Table 9.8 for summary evaluation ratings):

- Close to downtown, ample private pay-parking available in nearby garages and surface lots
- Across Granite Street from the existing intercity bus terminal
- City of Manchester owns parcel 930-6, which is presently used for public parking
- 1,500 feet (five-minute walk) to MTA's local bus hub at Veteran's Park
- Direct access to I-293 (Exit 5)
- Existing development adjacent to the site and along the rail right-of-way

Figure 9.15: Manchester – Granite Street Site Photography

Facing south towards the location of proposed station platforms from the Granite Street at-grade crossing

Facing north towards the Millyard from the Granite Street at-grade crossing

Facing northeast towards the intercity bus terminal from the Granite Street at-grade crossing

Facing west towards I-293

Figure 9.16: Manchester – Granite Street Parcel Map

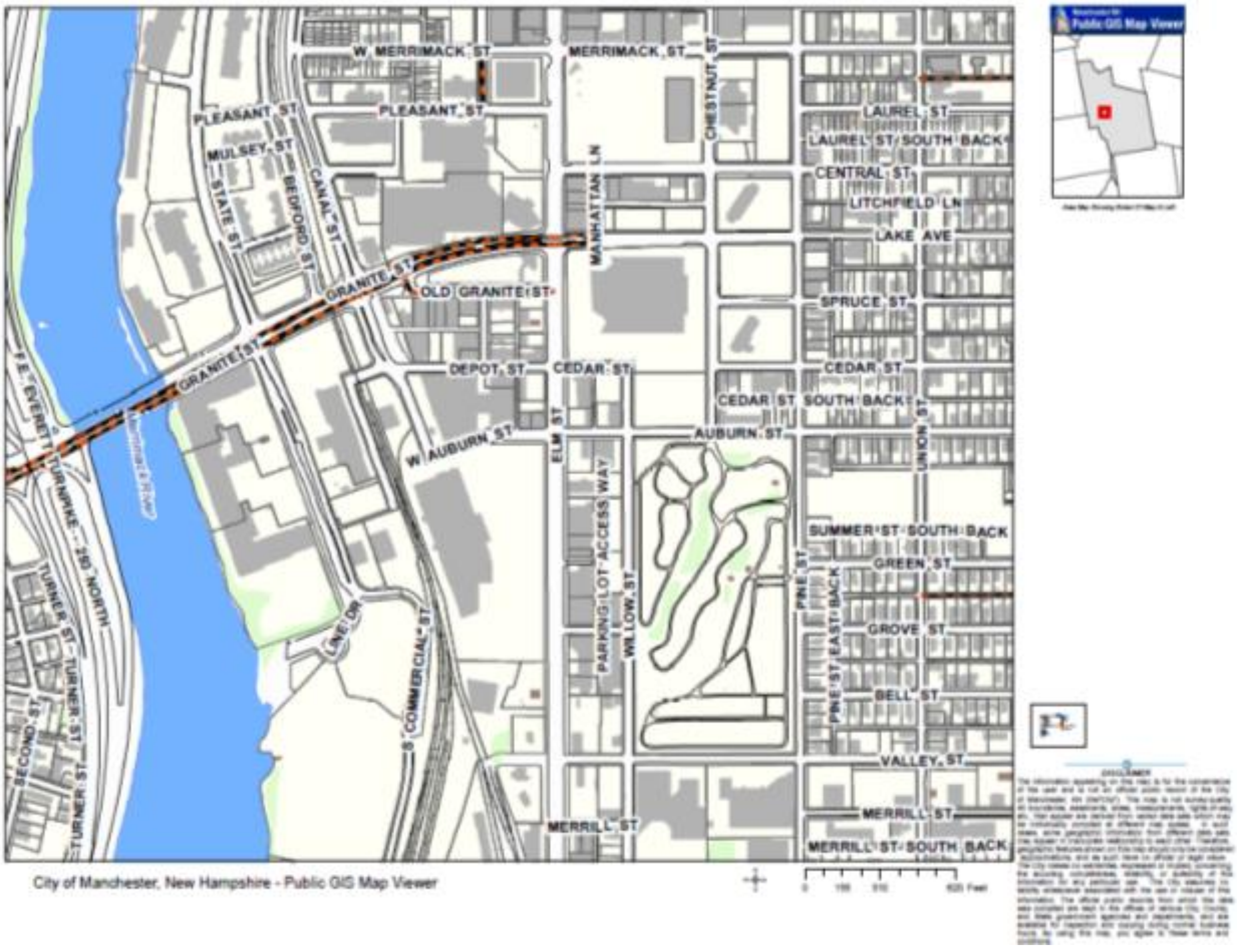


Table 9.8: Manchester – Granite Street Station Area Evaluation

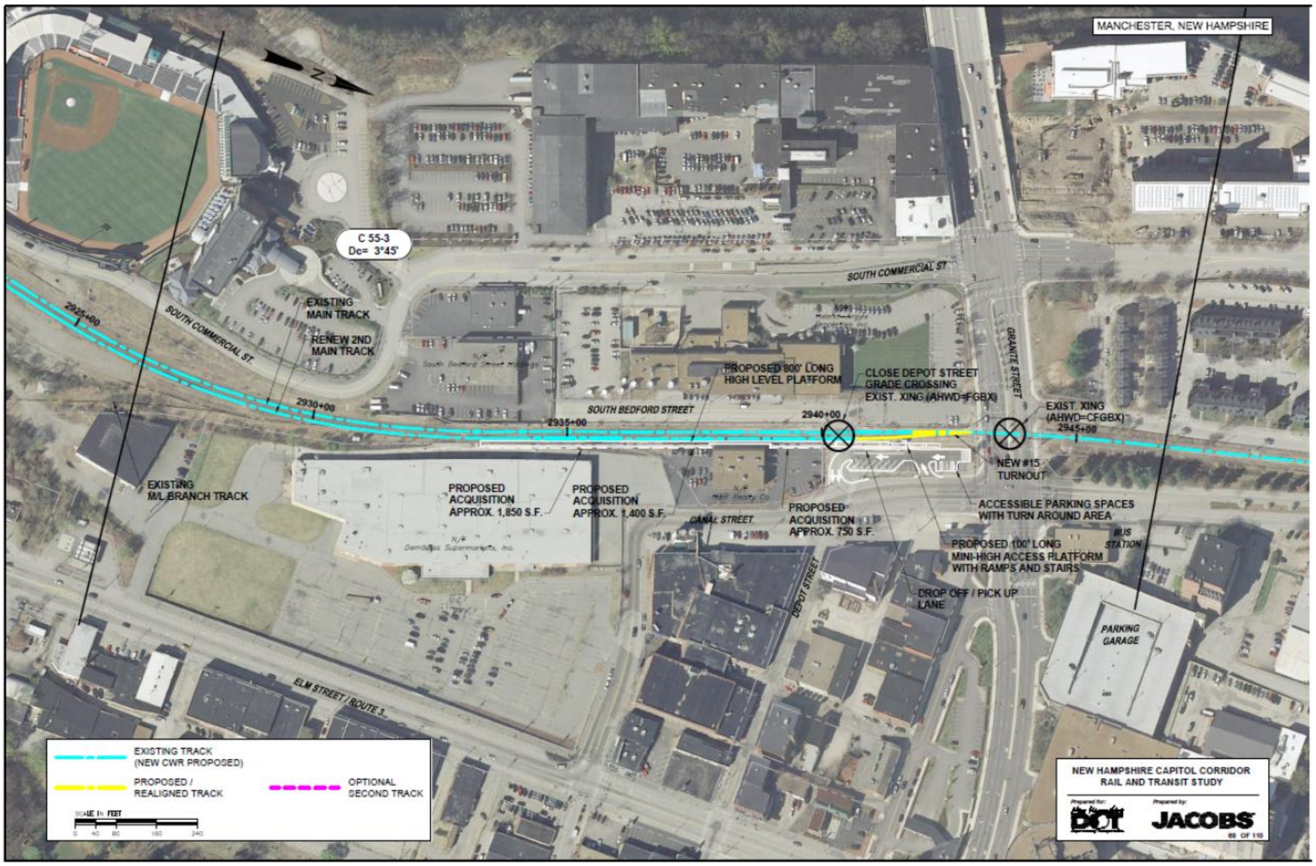
Category	Rating	Notes
Market	5	Located within downtown Manchester
Access	5	Direct access from I-293 with public parking lots and garages nearby
Track	5	Straight track, with no issues
Parcel	5	Tight space, may need surrounding properties for station facilities and parking would need to be located off-site
Land use	4	Existing commercial uses
Sensitive Receptors	4	Surrounding commercial buildings
Environmental	N	Nothing obvious
Ownership	P	Privately-owned railroad right-of-way

Assessment: Advanced

This site is recommended as the downtown station for the City of Manchester. The recommended station design would close the Depot Street crossing and develop the city-owned parcel on the corner of

Granite and Canal Streets that is presently used for public parking. A two-track station option has been developed with a high-level platform serving the east track. This would enable the efficient operation of a terminal station and allow for unimpeded freight traffic to and from the north. Figure 9.17 shows the preliminary station design.

Figure 9.17: Manchester – Granite Street Preliminary Station Design



9.3.3 *Manchester – Spring Street/Bridge Street*

The Manchester Spring Street/Bridge Street site is located on the north end of the Millyard District near the Spring Street grade crossing and under the Bridge Street overpass. The property is owned by the City of Manchester. There are a large number of jobs and existing surface and structured parking lots proximate to the site. Site features and challenges include the following (see Figures 9.18 and 9.19 for photos and a parcel map, respectively, and Table 9.9 for summary evaluation ratings):

- City of Manchester-owned parcel
- Indirect access to I-293 (Exit 6)
- Ample private parking available in adjacent surface and structured parking lots
- 2,500 feet (10-minute walk) from the intercity bus terminal at corner of Canal and Granite
- 2,900 feet (12-minute walk) to MTA the local bus hub at Veteran's Park

Figure 9.18: Manchester – Spring Street Site Photography

Facing north the location of proposed station platforms from the Spring Street at-grade crossing

Facing south from the Spring Street at-grade crossing

Facing southeast towards existing parking structure from the Spring Street at-grade crossing

Facing west towards the Millyard from the Spring Street at-grade crossing

Figure 9.19: Manchester – Spring Street Parcel Map

Table 9.9: Manchester – Spring Street Station Area Evaluation

Category	Rating	Notes
Market	5	Located within downtown Manchester
Access	4	Indirect access from I-293, public parking garage nearby
Track	3	Curve in track, may require eliminating one or more grade crossings
Parcel	4	Tight space, may need surrounding properties for station
Land use	5	Existing commercial uses
Sensitive Receptors	4	Surrounding commercial buildings
Environmental	N	Nothing obvious
Ownership	P	Privately-owned railroad right-of-way

Assessment: Advanced

This site has the potential to operate as the downtown station for the City of Manchester. The recommended station design would construct an 800-foot long station platform on the east side of the tracks (see Figure 9.20 for the preliminary station design).

Figure 9.20: Manchester – Spring Street Preliminary Station Design

9.4 Concord Station Options

Figure 9.21 shows two potential station locations that could be implemented to serve the Intercity 8 option: Depot Street and Stickney Avenue.

Figure 9.21: Potential Concord Station Locations

9.4.1 Concord – Depot Street

The Depot Street location is the site of Concord's historic passenger rail depot that was demolished in 1960 (Figure 9.22). The site is a block from Main Street and a short walk to the State Capital. The former railway yard at this location, however, has been redeveloped as a strip mall with a large parking lot. Site features and challenges include the following (see Figure 9.23 for a parcel map, and Table 9.10 for summary evaluation ratings):

Figure 9.22: Historic Concord Rail Station

- Privately-owned site with active retail uses and proposed for redevelopment
- City of Concord officials are less interested in this site as a railway depot
- Nearby Liquor Commission Warehouse is being sold
- Land adjacent to I-93 has been identified by NHDOT for proposed highway widening and realignment

Figure 9.23: Concord – Depot Street Parcel Map

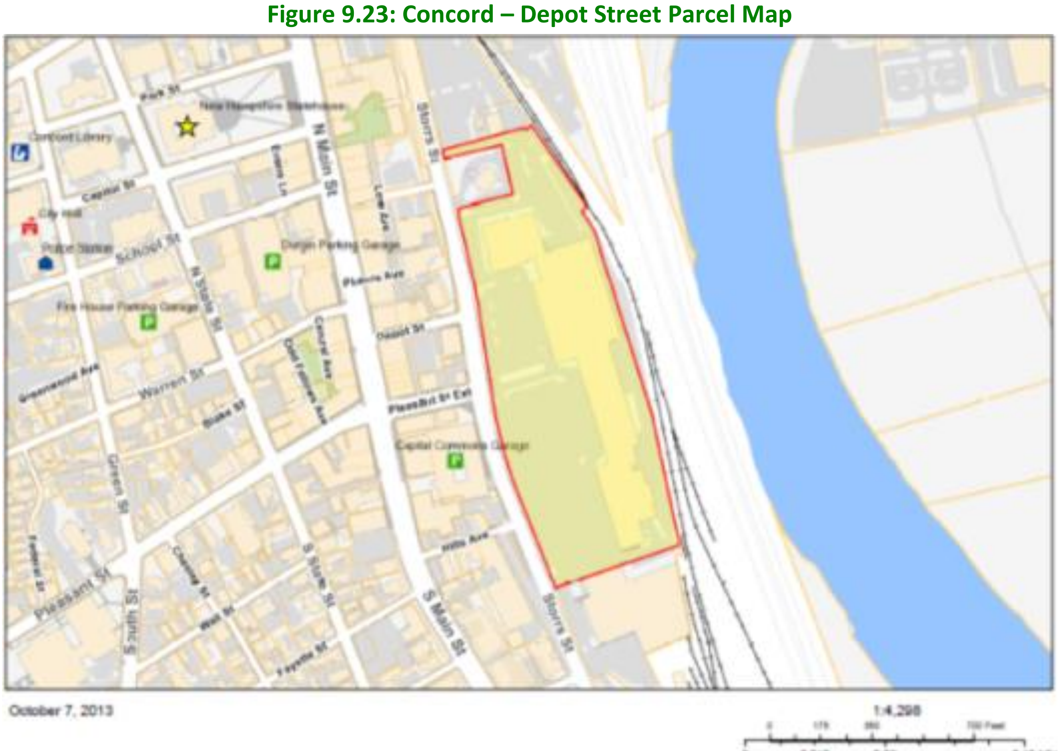


Table 9.10: Concord – Depot Street Station Area Evaluation

Category	Rating	Notes
Market	5	Close to downtown Concord
Access	5	Access from Main Street, could have access from I-93
Track	4	Slight curve in the track at this location, but enough straight tracks for platform
Parcel	5	Large enough to be suitable for redevelopment
Land use	4	Existing commercial development
Noise	5	Located between I-93 and commercial development
Environmental	N	Nothing obvious
Ownership	P	Privately-owned

Assessment: Eliminated

Local officials are more supportive of the nearby Stickney Avenue site where the railway station could be built on public land and would be much closer to the existing intercity bus terminal. Consequently, preliminary plans for the Depot Street site were not prepared.

9.4.2 Concord – Stickney Avenue

Stickney Avenue extends approximately 2,000 feet between I-393 and Loudon Road and runs parallel to I-93 and the PAR NHML. The railroad forks at this location several blocks north of the Depot Street site. NHML heads northwest toward Lebanon, White River Junction, Montpelier, and Montreal. The New England Southern Railroad (NEGS) branch diverges northerly towards the Lakes Region and the White Mountains. The NHML line is the former B&M line, now owned by the State of New Hampshire, and is the anticipated route of a restored passenger rail service between Boston and Montreal. The station design at this site should not preclude any future extension of passenger rail service along either branch.

Concord's state-owned intercity bus terminal is also located on Stickney Avenue. The City of Concord is interested in developing its passenger rail terminal on state-owned land immediately west of the bus terminal. The city is also planning to extend Storrs Street northward on the site's west side to connect with South Commercial Street and encourage site redevelopment. Plans for the terminal area need to reserve space to restore a run around track used by the NEGS that was removed but not replaced in the course of an abandoned project to build a hotel on the site. Site features and challenges include the following (see Figure 9.24 for a parcel map, Figure 9.25 for site photographs, and Table 9.11 for summary evaluation ratings):

- NHDOT planning to demolish former highway garage buildings on the site's east side
- Existing track spur creates constraints
- Ample vacant land for parking
- Direct access to I-93 (Exit 4)
- Intercity bus terminal is located at the furthest point from the existing rail line; it would be difficult to combine the two facilities

- Large U-Haul rental and self-storage facility located adjacent to the site and across from existing intercity bus terminal
- The Friendly Kitchen soup kitchen opened in a new purpose-built structure on the site's north end in late 2012
- Existing neighborhood:
  - Five houses on Herbert Street
  - One duplex on 6 Higgins Street
  - Homeless encampments and squatting in vacant buildings

Figure 9.24: Concord – Stickney Avenue Parcel Map

Figure 9.25: Concord – Stickney Avenue Site Photography

Tracks behind abandoned NHDOT buildings

Railroad right-of-way under I-393 overpass

Houses on Herbert Street

U-Haul rental and self-storage facility

Friendly Kitchen

Railroad right-of-way behind Friendly Kitchen

Table 9.11: Concord – Stickney Avenue Station Area Evaluation

Category	Rating	Notes
Market	5	Close to existing intercity bus terminal and P&R lot
Access	4	Close to I-393, but needs a more direct access point from I-393 and I-93; this would be solved with proposed reconstruction of I-93 and extension of Storrs Street
Track	3	Track realignment necessary due to proposed Storrs Street extension and to maintain freight access north of Concord
Parcel	5	Large site with flexibility and potential for redevelopment
Land use	5	Former NHDOT buildings
Sensitive Receptors	4	Adjacent to I-93, but proximate to commercial and residential uses
Environmental	Y	Potential remediation
Ownership	G	Government ownership

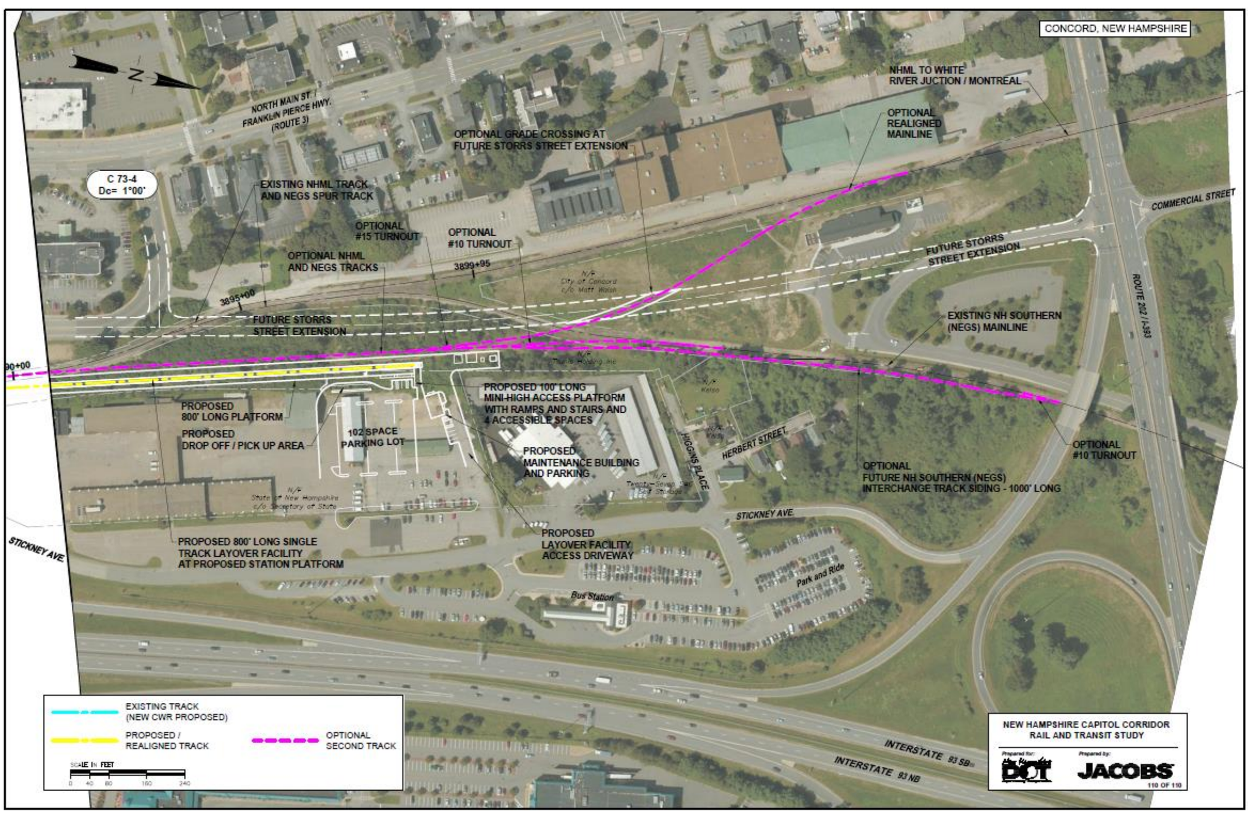
Assessment: Advanced

This Stickney Avenue site is highly rated as it could hold both a station and layover yard. The station would have one platform serving one or two tracks and the joint station/layover facility. Current requirements call for only one track, but with future expansion of intercity service, two storage tracks may eventually be required. A layover yard would be required at or near the terminus of the proposed Intercity 8 service option. The preliminary station design shows ample land within the larger site for construction of a railway station with parking, train layover on the station tracks or on an adjacent track, and an NEGS run around track while still allowing the City of Concord's redevelopment plans to proceed (see Figures 9.26 and 9.27 for extension plans, and Figure 9.28 for preliminary station and layover design).

Figure 9.26: City of Concord Storrs Street Extension Plans

Figure 9.27: Alternative City Plan for Storrs Street Extension

Figure 9.28: Concord – Stickney Avenue Preliminary Station and Layover Design



9.5 Evaluation of Station Sites

Table 9.12 summarizes evaluation criteria described earlier in this report that were used to guide the layover site selection process (the light gray shaded rows represent stations that were advanced for consideration). Criteria were given a rating of one for poorly performing sites to five for highly performing sites. The owner criteria was designated was designated G for government-owned or P for privately-owned, while the environmental criteria was designated as Yes or No.

The Beazer-East site in Nashua was eliminated from further consideration due to the nature of its poor relation to potential rail service, site access constraints, and existing soil contamination. The Queen City Avenue site was eliminated early in the site selection process due to its weak relationship to the existing downtown and distance from other transit services. Finally, the Depot Street site in Concord was eliminated because local officials are more supportive of the nearby Stickney Avenue site where the railway station could be built on public land and would be much closer to the existing intercity bus terminal.

Table 9.12: Site Evaluation Summary

	Market	Access	Track	Parcel	Land Use	Noise	Environmental	Ownership	Assessment
Nashua Sites									
Crown Street	4	4	5	4	5	3	Y	G	*Advanced*
Beazer-East	2	2	5	3	5	3	Y	P	Eliminated
Bedford Site									
Ray Wieczorek Drive (Bedford/MHT site)	5	5	5	4	5	5	Y	G/P	*Advanced*
Manchester Sites									
Queen City Avenue	-	-	-	-	-	-	-	-	Eliminated
Granite Street	5	5	5	5	4	4	N	P	*Advanced*
Bridge Street	5	4	3	4	5	4	N	P	*Advanced*
Concord Sites									
Depot Street	5	5	4	5	4	5	N	P	Eliminated
Stickney Avenue	5	4	3	5	5	4	Y	G	*Advanced*

9.6 Cost Estimates

Capital cost estimates were developed for each of the advanced station sites using unit costs that were generated for a directly applicable peer site. The MBTA Fitchburg Commuter Rail-Wachusett Extension Project is currently underway and moving into construction. Detailed capital costs were prepared by Jacobs Engineering and partner Keville Enterprises, Inc. in January 2013. The estimated construction cost with escalations and contingencies came to $13,303,000 for a single-track siding station with one 800-foot high-level side platform and 360 parking spaces.

These detailed costs were used to inform cost estimates for each of the proposed station sites through the use of allocation factors: variables such as the number of parking spaces, number of platforms, number of side tracks, square feet of existing wetlands, and the possibility of contaminated soils (see Table B-1 in Appendix B to this report). This allowed for the application of the Wachusett station unit costs even where characteristics of the sites were different. The costs for Pheasant Lane Mall include a parking garage that was estimated at 10 times the cost per space of a surface space. This figure is consistent with Jacobs estimates for other parking garages. The summary of unit costs is shown in Table 9.13, and a detailed accounting of the capital cost calculation is contained in Table B-2 in Appendix B to this report.

Table 9.13: Estimated Station Construction Costs for Intercity Passenger Rail Development

	Nashua Crown Street	Bedford/MHT	Manchester Granite Street	Manchester Spring Street	Concord Stickney Avenue
MP	38.8	50.1	55.5	56.4	73.3
Parking	255	190	0	0	100
Platforms	1	1	1	1	1
Contaminated Soils	0.5	0	0.5	0	0
Square Feet of Wetlands	0	0	0	0	0
Side Tracks	0	0	0	0	0
Total direct cost	$4,212,500	$3,594,256	$2,761,239	$2,512,925	$3,082,046
Estimated contractor cost	$5,200,037	$4,436,858	$3,408,557	$3,102,030	$3,804,571
Estimated contractor allowances	$987,537	$842,602	$647,318	$589,105	$722,525
Escalation to Oct 2013 (3.8%/year)	$226,747	$193,346	$152,938	$138,351	$167,296
Escalated estimated construction cost	$5,730,308	$4,886,203	$3,865,020	$3,496,381	$4,227,866
Construction contingency	$573,030	$488,620	$386,501	$349,638	$422,786
Estimated construction cost	**$6,303,339**	**$5,374,824**	**$4,251,522**	**$3,846,019**	**$4,650,653**

Unit cost resources: MBTA Fitchburg Commuter Rail-Wachusett Extension Project: PS&E Construction Estimate; Jacobs/Keville Enterprises, Inc.; January, 2013

Beyond the railroad right-of-way that will be shared with PAR freight trains, land will be required for stations facilities and parking. The cost for this land was estimated by consulting local public assessor records in Tyngsborough, Nashua, Bedford, Manchester, and Concord to determine the current assessed value of each parcel that had been identified as necessary for a station (see Table B-3 in Appendix B). Where only a portion of the parcel would be required for the rail facility, GIS tools were used to determine what fraction of the overall parcel would be necessary and to prorate the cost accordingly.

Acquisition of private land for transportation improvements can be a litigious process. The summary of estimated land costs in Table 9.14 includes an allowance of 220 percent to account for negotiations, takings, eminent domain, and legal costs. The 220 percent was derived from the Study team's experience working on similar projects in other jurisdictions, but it is possible that New Hampshire's experience may be different.

Table 9.14: Assessed Land Value and Estimated Cost for Selected Station and Layover Sites

	Parcel Size (Acres)	Required Portion	Assessed Value per Acre	Estimated Value	Estimated Cost with 220% Assemblage Factor
Crown Street	6.826	1.0	$ 45,224	$308,700	$987,840
Bedford/MHT	6.000	0.33	$ 29,416.67	$444,400	$1,422,080
Granite Street	0.5544	1.0	$ 279,132.58	$148,800	$476,160
Stickney Avenue	6.08	1.0	$ 237,990	$1,447,000	$4,630,400

9.7 Station Recommendations

Stations at ***Crown Street*** in Nashua and the ***Bedford/Manchester Airport*** site below Ray Wieczorek Drive are recommended for the Intercity 8 service option. The station site at ***Granite Street*** in Manchester is favored over the Spring Street/Bridge Street site as it provides better access to Route 3 and the existing intercity bus terminal. Finally, a station at ***Stickney Avenue*** in Concord is recommended for the intercity rail service.

9.8 Layover Facilities

This section describes potential sites for overnight storage and servicing of the intercity rolling stock in the vicinity of the proposed northern terminus in Concord.

9.8.1 Layover Design Requirements

Wherever the eventual layover facility is located, the project would need to provide a small railroad yard capable of storing 1,000-foot long train sets (one locomotive and up to nine coaches allowing for service expansion). Only one track would be required for the Intercity 8 service. Three potential locations in Concord were identified for a layover facility for overnight storage and light servicing for one train set with expansion space for at least one additional train set:

- Langdon Avenue Industrial Area
- Depot Street
- Stickney Avenue

A crew building would be required at each site and include a materials and equipment storage locker for mechanical personnel to store cleaning and maintenance materials onsite and perform running repairs on equipment. The facility's entrance would be paved, and have parking for a minimum of six cars. There would be 20-foot wide service lanes located on at least one side of each track with 4-foot-wide walkways built between the tracks. High-mast lighting with walkway lights would be located in the service walkways. The entire layover facility should be fenced in, and, if necessary, noise walls could be constructed at additional expense beyond preliminary cost estimates.

Spill pans would be required under the locomotive (northern) end of each track, complemented by oil/water separators. Near the track's locomotive, air compressor and electric power hookups would be required so that locomotives could be shut down while still allowing for lights and HVAC in the coaches.

These power and air connections would eliminate the need for locomotives to do a cold startup each morning. Two separate small buildings housing the power and air compressor would be required. Potable water along the tracks and sanitary service equipment would also be provided onsite. An inspection pit located under the yard lead, prior to the ladder leading towards the tracks, would also be desirable.

9.8.2 Site Evaluation Criteria

In addition to ensuring that a site is of sufficient size and of a suitable configuration to support storage and maintenance, overnight noise is the overwhelming consideration in the siting of commuter rail layover facilities. Engines in the yard will need to be started at least 30 minutes before the first southbound train, and the last train engine to pull into the layover yard would be shut down approximately 30 minutes after arrival of the last train of the night (see Table 9.15). At Concord, locomotives would power up before 6:30am and be powered down after midnight.

Table 9.15: First and Last Trains of the Day at Concord for the Intercity Service

Time of First Morning Train	Time of Last Evening Train
6:38 am	11:37 pm

A diesel locomotive can often be as loud as a jackhammer when pulling or pushing a string of cars and approximately as loud as a lawnmower while idling. Nighttime noise is the number one source of complaints relative to layover facilities. Given these characteristics, an acceptable site must be distant from homes, hospitals, and other sensitive receptors. Sites with the lowest levels of complaints tend to be at locations where there is already a high-level of ambient noise, such as on the skirt of a busy highway.

The following list of evaluation criteria was developed to guide the layover site selection process. The evaluation criteria measures were given a rating of one for poorly performing sites to five for highly performing sites. The environmental criteria were designated as Yes or No, while the ownership criteria was designated G for government-owned or P for privately-owned.

1. Terminus
    - Does the site adequately serve the proposed rail service options with northern terminals in Concord?
    - What are deadhead cost savings and travel time efficiencies?
2. Track Operational Characteristics
    - Is the track straight and free of existing sidings?
    - Are there any grade crossings adjacent to the site?
    - Is there a requirement for new traffic/train signals?
    - Are any bridge structures required for roadway access or yard leads?
    - Are freight train movements/clearances maintained?

3. Access
    - Would new roads be required for access for staff and deliveries?
    - Are local roadways compatible with the site to allow yard movements efficiently in a manner that would not extensively conflict with local roadways?
4. Parcel Size/Configuration
    - Is there adequate land available for layover tracks and maintenance facilities?
    - Would displacement of residents/businesses be required?
5. Land Use
    - Is the site currently zoned for industrial or compatible land uses?
    - What are the predominant surrounding land uses?
    - What are municipality and community aspirations/priorities?
    - Are there any environmental justice issues, including possible impacts on minority populations and low-income households?
6. Sensitive Receptors
    - Are there any residential buildings or educational, medical, or religious facilities near the site that would have a heightened sensitivity to noise or vibration impacts?
7. Environmental
    - Is the site adjacent to a river or within a flood zone?
    - Is the site in or adjacent to jurisdictional wetlands?
    - Does the site have a history of contamination?
    - Has the site been designated as a threatened or endangered species habitat?
8. Ownership
    - Is the property owned by state or local government or is it privately held?
    - Is the property for sale, single-owner or multiple, publicly owned land?
    - What are potential land acquisition costs based on assessed value per acre?
    - Would there be relocation costs resulting from displacement of residents/businesses?

9.8.3 Preliminary Layover Facility Sites

Based on field inspections, interviews with local officials, and review of earlier studies, three potential sites were identified for the Concord layover facility. The evaluated sites are listed in Table 9.16. Several tentative sites were eliminated very early during the preliminary assessment, while three were advanced for formal preliminary evaluation.

Table 9.16: Potential Concord Layover Facilities

Sites Evaluated	MP
Langdon Avenue Industrial Area	72.0
Depot Street	72.6
Stickney Avenue	73.3

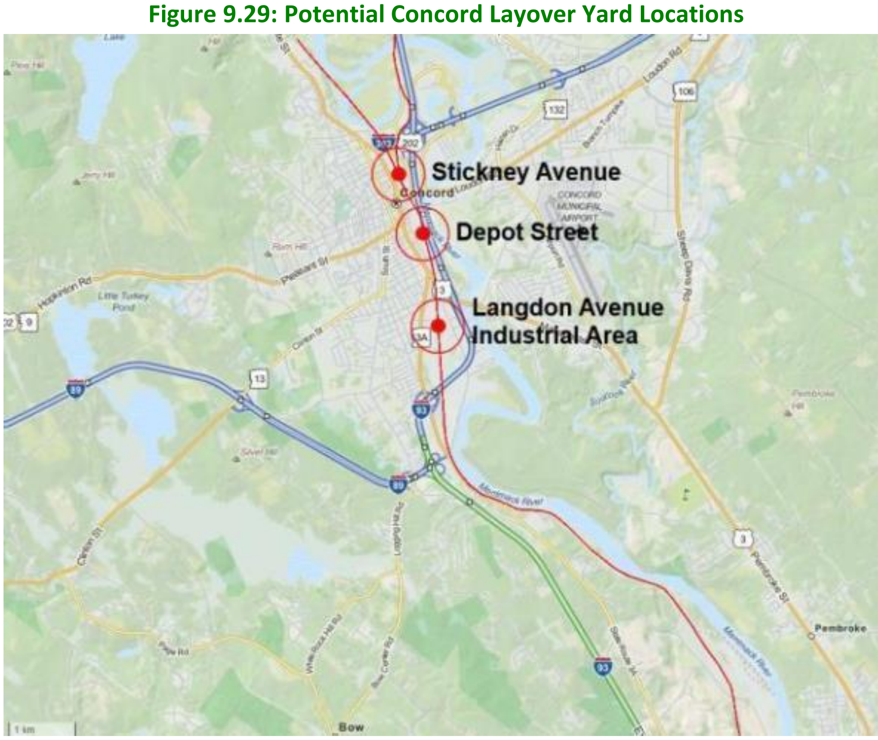
Once the layover facility sites were identified, schematic designs were overlaid on annotated aerial imagery prepared by Jacobs Engineering in September 2013. These schematic designs include tracks, switches, platforms, roadways, pathways, parking, circulation, buildings, and other related features. Parcel mapping information provided by the municipalities and NHDOT was also included in the schematic designs. It will be necessary for the designs to be reviewed by Amtrak, MBTA, PAR, NHDOT, and other stakeholders before being finalized.

The following sections describe and document each layover facility site with findings from the initial site review. Parcel mapping, site photos, and earlier plans (where appropriate) and preliminary schematic designs are included for environmental and financial review.

9.8.4 Concord Layover Facility Options

Figure 9.29 shows the location of the three potential layover yards that could be implemented to serve the Intercity 8 option: Langdon Avenue Industrial Area, Depot Street, and Stickney Avenue.

Figure 9.29: Potential Concord Layover Yard Locations



Concord: Langdon Avenue Industrial Area

The industrial area located near Langdon Avenue in Concord is 1.3 miles south of the proposed Stickney Avenue terminal station could be developed as a layover yard. Table 9.17 summarizes the evaluation.

Table 9.17: Evaluation of Langdon Avenue Layover Facility

Category	Rating	Notes
Terminus	4	Over one mile south of the proposed Concord terminal station at Stickney Avenue
Track	5	Long, straight track section
Access	4	Access to South Main Street via Lehoux Ave.
Parcel	4	Adequate space for storage tracks and facilities
Land Use	5	Vacant/existing industrial uses
Sensitive Receptors	2	Nearby residential neighborhood
Environmental	N	Nothing obvious
Ownership	P	Privately-owned

Assessment: Eliminated

The site lies within 1,000 feet of residential neighborhoods west of Main Street and development would require the taking of privately-owned land. The availability of land to develop a combined station and layover yard at Stickney Avenue eliminated this site from further consideration.

Concord: Depot Street

This state-owned parcel near Depot Street and adjacent to I-93 would make an ideal site for a layover yard since the busy highway would help attenuate the sound of the trains overnight. Table 9.18 summarizes the evaluation.

Table 9.18: Evaluation of Depot Street Layover Facility

Category	Rating	Notes
Terminus	5	One-half mile south of the proposed Concord terminal station at Stickney Avenue
Track	4	Straight track section, former rail yard
Access	4	Access to Storrs Street via mall parking lot access roads
Parcel	4	Adequate space for storage tracks and facilities, located between existing strip mall and I-93
Land Use	5	Vacant/transportation/existing commercial uses
Sensitive Receptors	5	Adjacent to I-93 and removed from downtown Concord
Environmental	N	Nothing obvious
Ownership	P	Privately-owned railroad right-of-way

Assessment: Eliminated

The city and state have other development plans for this site, which is located one-half mile south of the proposed Stickney Avenue terminal station, so it was eliminated from further consideration.

Concord: Stickney Avenue

This option would co-locate the layover facility with the proposed station on a state-owned parcel near the existing intercity bus terminal. As noted earlier in this section, Stickney Avenue extends approximately 2,000 feet between I-393 and Loudon Road and runs parallel to I-93 and PAR NHML. The railroad forks at this location, which is several blocks north of the Depot Street site. The NHML heads northwest toward Lebanon, White River Junction, and Montpelier, and is the anticipated route of a restored passenger rail service between Boston and Montreal. The NEGS branch diverges northerly towards the Lakes Region and the White Mountains. The design of the layover facility at this site should not preclude any future extension of passenger rail service along either branch. See Table 9.19 for an evaluation summary.

The Study team determined that the Intercity 8 option would require overnight storage for only one train set and that the train could be stored and serviced at the Concord terminal station. This would be consistent with current practice for the *Downeaster* operations in both Portland and Brunswick, Maine and other minor intercity rail services such as Oklahoma City's *Heartland Flyer*. This site and the proposed station were discussed extensively earlier in this section.

Table 9.19: Evaluation of Stickney Avenue Layover Facility

Category	Rating	Notes
Terminus	5	Co-located with proposed Concord terminal station at Stickney Avenue
Track	3	Track realignment necessary due to proposed Storrs Street extension and to maintain freight access north of Concord
Access	5	Access via Stickney Avenue
Parcel	5	Adequate space for storage tracks and facilities
Land Use	5	Former NHDOT buildings
Sensitive Receptors	4	Adjacent to I-93, but proximate to commercial and residential uses
Environmental	Y	Potential remediation
Ownership	G/P	Government-owned parcels and privately-owned railroad right-of-way

Assessment: Advanced

This site is highly rated as it could accommodate both a station and layover yard. Current requirements call for only one track, but two storage tracks may eventually be required with the future expansion of intercity service. The station would have one platform serving one or both tracks and at the joint station/layover facility. Preliminary design shows ample land within the larger site for the construction of a railway station with parking, train layover on the station tracks or on an adjacent track, and a NEGS run around track – and still allow for the City of Concord's redevelopment plans to proceed. Figure 9.30 shows the preliminary station and layover facility design.

Figure 9.30: Concord – Stickney Avenue Preliminary Station and Layover Design

9.8.5 *Evaluation of Layover Facility Sites*

Table 9.20 summarizes the evaluation criteria used to guide the layover site selection process. Criteria were given a rating of one for poorly performing sites to five for highly performing sites. The owner criteria was designated was designated G for government-owned, P for privately-owned or ROW for railroad right-of-way, while the environmental criteria was designated as Yes or No.

The Langdon Avenue site and the Depot Street site in Concord were eliminated because local officials are more supportive of the nearby Stickney Avenue site where the railway station could be built on public land and would be much closer to the existing intercity bus terminal.

Table 9.20: Concord Layover Site Evaluation Summary

	Terminus	Track	Access	Parcel	Land Use	Sensitive Receptors	Environmental	Ownership	Assessment
Langdon Avenue Industrial Area	4	5	4	4	5	2	N	P	Eliminated
Depot Street South	5	4	4	4	5	5	N	ROW	Eliminated
Stickney Avenue	5	3	5	5	5	4	Y	G	Advanced

9.8.6 Cost Estimates

Costs to develop layover yards for overnight storage and light maintenance of the service rolling stock were estimated for the one site that advanced through preliminary evaluation (Table 9.21). Estimates relied on unit costs recently generated by Jacobs Engineering for a directly applicable peer site. The MBTA Fitchburg Commuter Rail-Wachusett Extension Project is currently underway and moving into construction. The estimated Wachusett layover construction cost with escalations and contingencies came to $13,303,000 for a layover facility with six tracks, including 9,655 track-feet available for the storage of trains.

These detailed costs were used to inform cost estimates for each of the proposed layover facility sites through the use of allocation factors. These allocation factors included variables such as the number of storage positions, total track length (feet), and the possibility of contaminated soil disposal. This allowed for the application of the Wachusett layover facility unit costs even where the characteristics of the sites were different. The summary of unit costs is shown in Table C-1 in Appendix C. Detailed capital cost calculations are documented in Table C-2 in Appendix C.

Table 9.21: Estimated Layover Facility Capital Costs (2013$)

MP	73.3
Number of storage positions	1
Total track length (feet)	800
Possibility of contaminated soils	1
Total direct cost	$3,100,795
Estimated contractor cost	$3,827,716
Estimated contractor allowances	$737,600
Escalation to Oct 2013 (3.8%/year)	$188,091
Escalated construction cost	$4,753,407
Construction contingency	$475,340
Estimated cost with contingency	**$5,228,747**

Source: MBTA Fitchburg Commuter Rail-Wachusett Extension Project: PS&E Construction Estimate; Jacobs/Keville Enterprises, Inc.; January, 2013

Beyond the railroad right-of-way that will be shared with PAR freight trains, additional land will be required for layover yards. The cost for this land was estimated by consulting local public assessor records in Concord to determine the current assessed value of each parcel that had been identified as necessary for a layover yard (see Table C-3 in Appendix C). Where only a portion of the parcel would be required for the rail facility, GIS tools were used to determine what fraction of the overall parcel would be necessary and to prorate the cost accordingly.

Acquisition of private land for transportation improvements can be a litigious process. The summary of estimate land costs in Table 9.22 includes an allowance of 220 percent to account for negotiations, takings, eminent domain, and legal costs. The 220 percent was derived from the Study team's experience working on similar projects in other jurisdictions, but it is possible that New Hampshire's experience may be different.

Table 9.22: Assessed Land Value and Estimated Cost for Concord Layover and Station Site

Site	Parcel Size (Acres)	Assessed Value per Acre	Estimated Value	Estimated Cost with 220% Assemblage Factor
Stickney Avenue	6.08	$ 237,990	$1,447,000	$4,630,400

10 Preferred Intercity Rail Required Capital Improvements and Capital Costs

10.1 General Infrastructure Requirements

To build Intercity 8, the Study team consulted with MassDOT, MBTA, and PAR and determined that no improvements would be required south of MBTA's Lowell Gallagher Terminal. North of Lowell the railroad would be upgraded to permit safe, reliable operation of eight daily passenger trains at speeds of up to 75 mph. Recommended upgrades to track, bridges, crossings, and signals are summarized below.

The Intercity 8 service option would require more extensive infrastructure upgrades than the proposed commuter rail options as it is approximately 18 miles longer than the Manchester Regional Commuter Rail service. The service would also operate at higher maximum speeds: up to 75 mph between Nashua and Bedford/Manchester Airport and 70 mph north of Manchester.

10.1.1 Track

Study team engineers had originally recommended that this option be supported by replacing all 70-plus-year-old main line rail between Lowell and Concord with new continuous welded rail (CWR) of a similar weight. The infrastructure requirements for each of the three remaining rail options were revisited in meetings with PAR, MassDOT, MBTA, and NHDOT as the Study progressed. The Study team refined the preliminary infrastructure requirements based on their feedback and with the aid of two Hi-Rail trips along the corridor with railroad officials. Principal adjustments in the track upgrades necessary for Intercity 8 service include the following:

- Reconsidered needs and limits of industrial freight sidings designed to avoid conflicts with passenger trains. MP locations denote distance from Boston North Station. Required sidings:
    - Nashua Corporation (B41.8 to B42.5)
    - Anheuser-Busch (B43.8 to B44.8)
    - Merrimack Running Track/Jones Chemical (B45.6 to B47.9)
    - Public Service of New Hampshire Receiving Track (B66.4 to B 68.5)

- Reappraisal of existing track conditions to reduce required track upgrades:
  - Replace only one-third of all ties due to better-than-anticipated tie conditions. One-half of all ties had initially been slated for replacement at Study outset.
  - Retaining or relaying existing rail on tangent track and industrial sidings instead of replacing all rails to utilize all life left in existing rail and minimize initial required capital outlays. Relay and retained rail would need to be replaced in a multi-year program that would begin approximately 10 years after start-of-service.

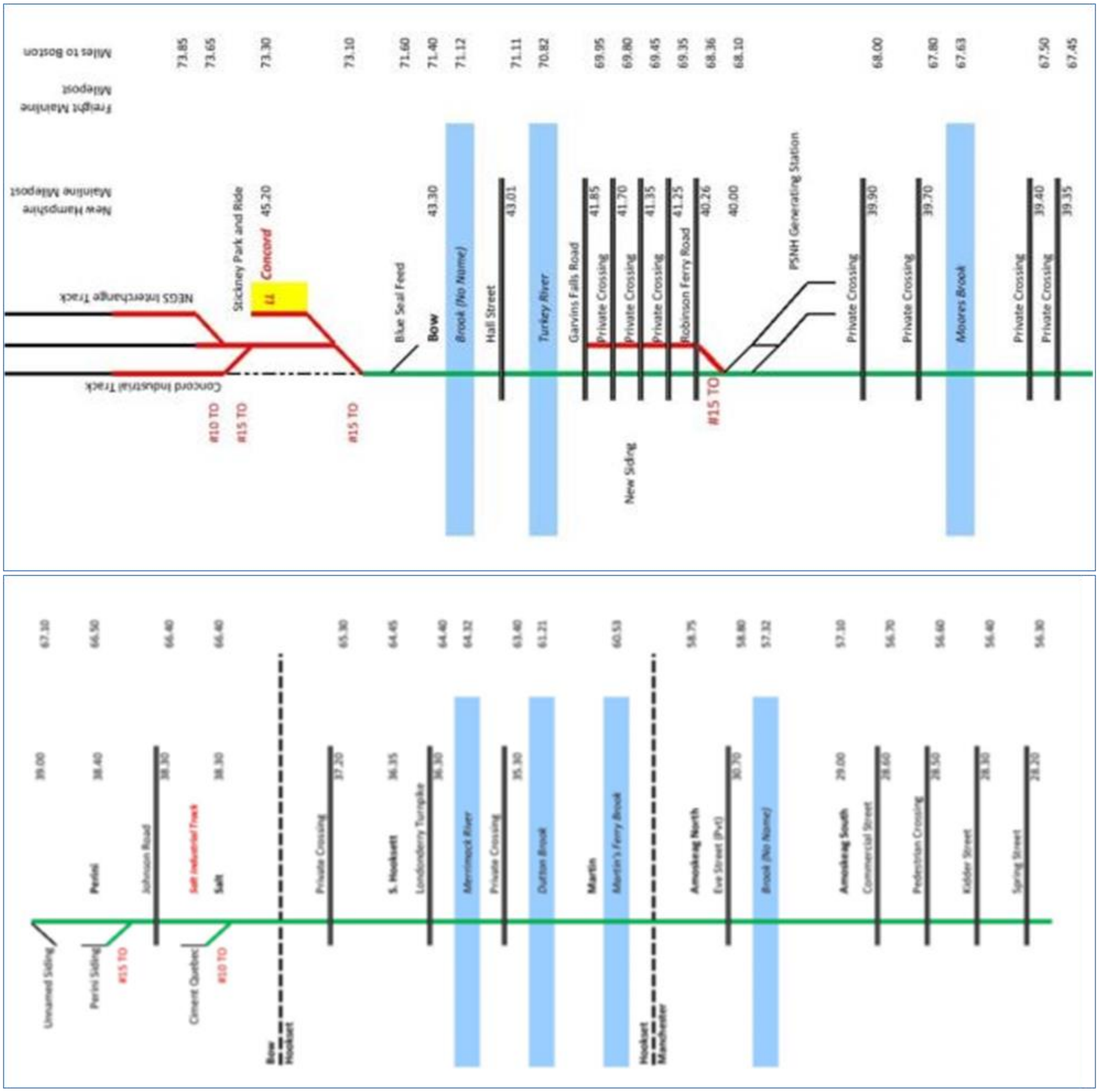
PAR supplied more detailed data on bridge conditions, track conditions, crossings, and other infrastructure in March of 2014. Using this information together with field inspections of track, crossings, and selected bridges, Study team engineers assembled more detailed evaluations of the conditions of existing assets and revised their cost estimates accordingly.

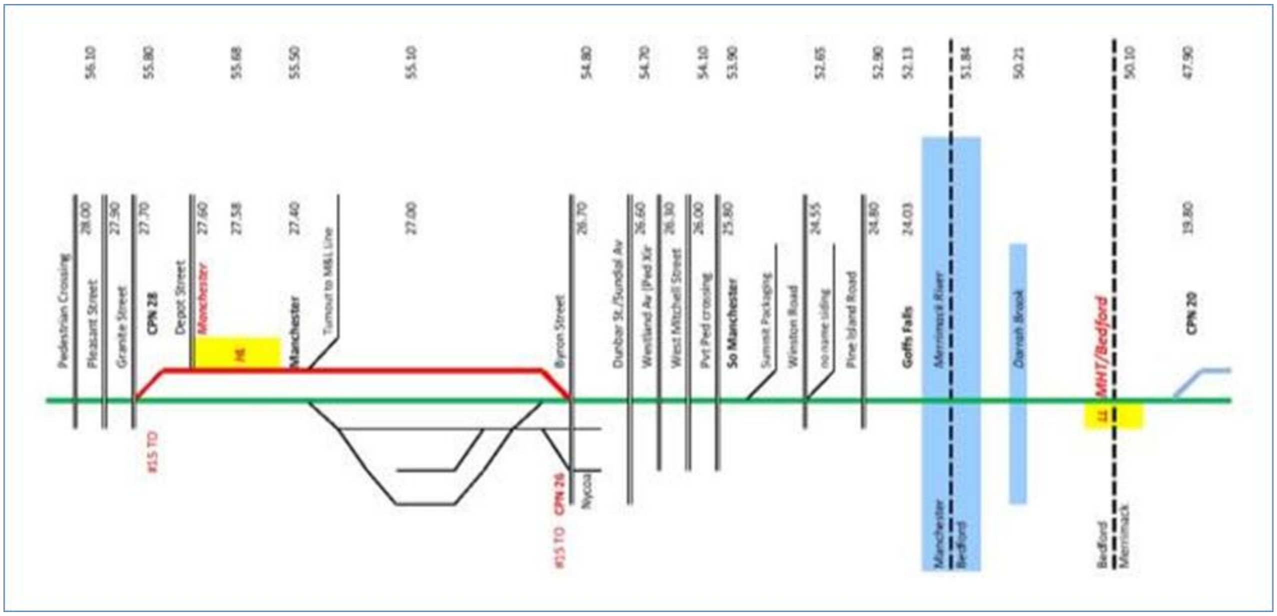
The track configuration necessary to support the Intercity 8 service was identified by inspection of the time-distance stringline diagrams, considering the timing and nature of freight uses on the line.

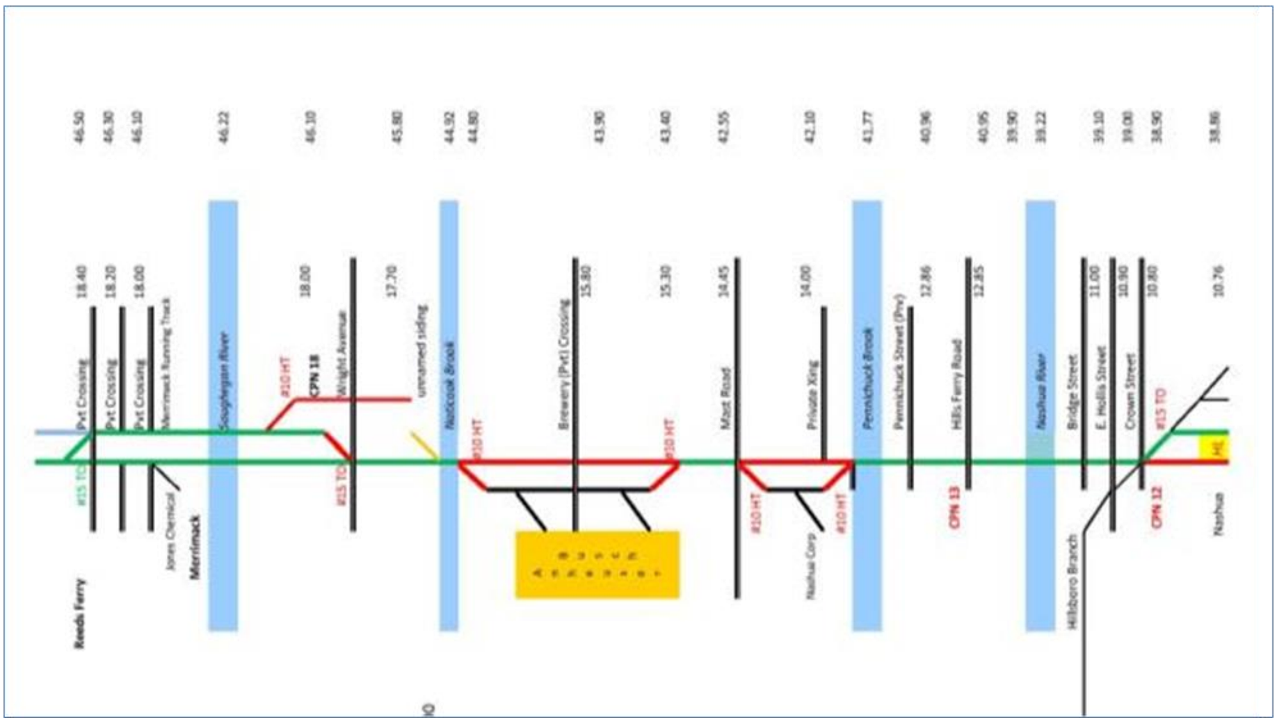
- Between Boston and Lowell, the line is busy with passenger service, but has only limited unscheduled local freight service. No upgrades to the well-maintained, double-track rail network would be required along this segment.
- Between Lowell and North Chelmsford, the line is a segment of PAR's east-west main line. This three-mile segment of double-tracked railway carries up to eight through-freight trains and several local freight trains each day. Threading eight non-stop intercity trains through this short double-track segment should not prove challenging.
- From North Chelmsford to Concord, the line is 45 miles of mostly single track. Segments of second main line track are recommended through yards in Nashua and Manchester. Industrial sidings are recommended at locations where local trains stop to serve customers. Industrial sidings will keep local freight trains from blocking the main while they serve customers.

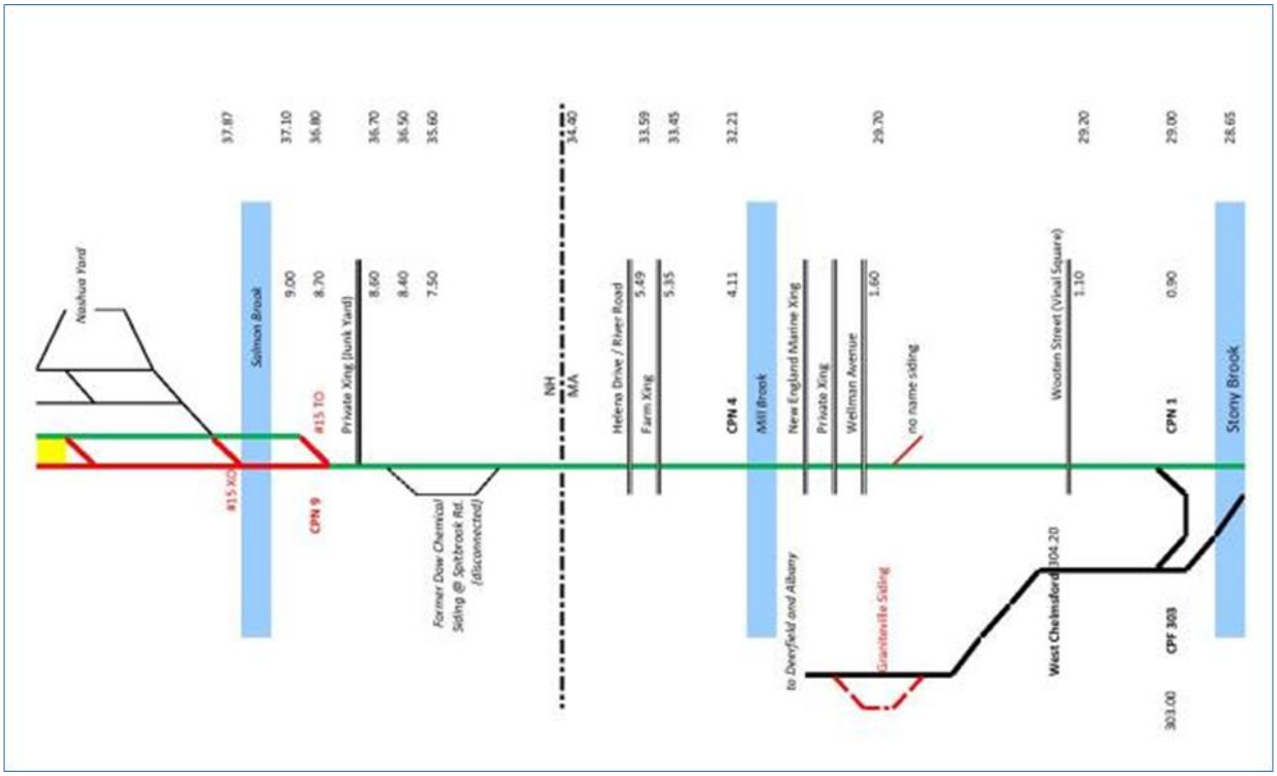
The proposed track configuration is shown in Figure 10.1. No improvements are recommended for the tracks shown in black. Rail and ties will be replaced or renewed on existing tracks shown in green. Red tracks and switches represent new construction.

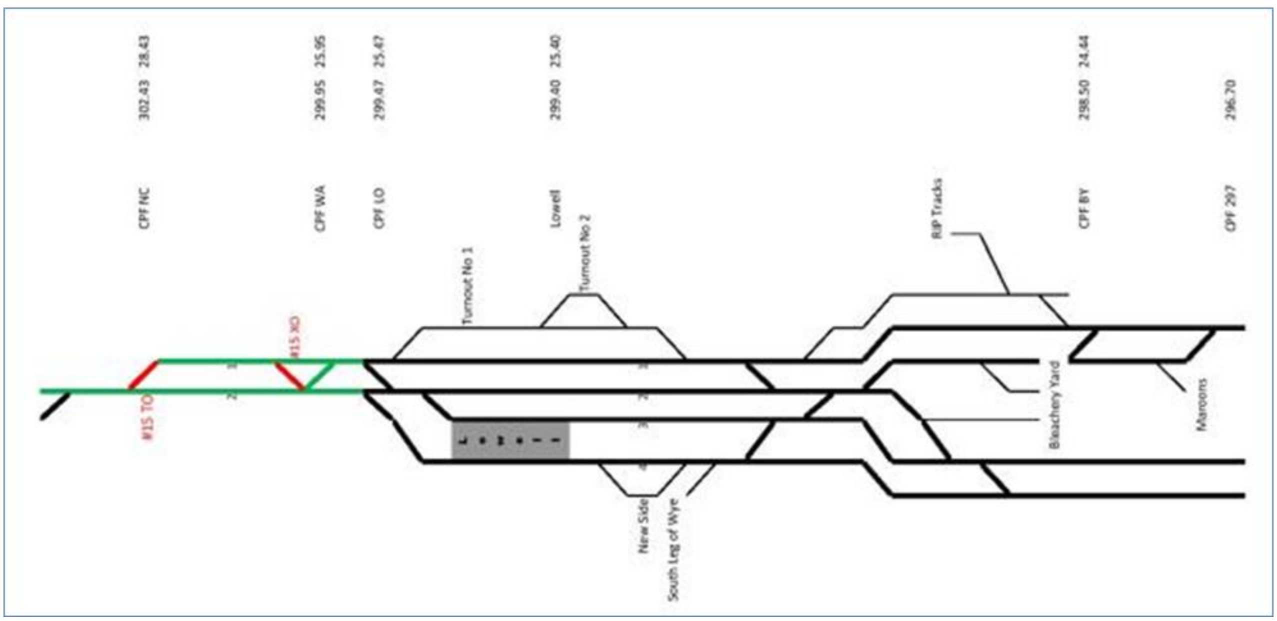
Figure 10.1: Intercity 8 Proposed Track Configuration











Unlike the higher frequency commuter rail options, no double track would be required between North Chelmsford (MP 28.5) and the southern end of the Tyngsborough Curve (MP 32). As noted above, industrial sidings would be created at three key areas of freight activity in Nashua and Merrimack to eliminate conflicts between local freight deliveries and through passenger trains. At these locations, the existing main line track would be retained as an industrial siding with an entirely new parallel main line track constructed in the same alignment for use by through trains. Adding a second track would be straight-forward, as the railway was once entirely double-tracked with the double-track bed still largely intact.

10.1.2 NHML Track Profile, Alignment, and Maximum Allowable Speeds

The NHML north of Lowell to Concord runs along the banks of the Merrimack River. This alignment has mostly gentle grades, with none steeper than 0.35 percent. The horizontal alignment curves to follow the river with few tangent (straight) segments more than one-mile long. Between Lowell and Concord, 29.6 of the 48.5 track miles are curved. This constitutes 61 percent of the route. Many of the curves are sufficiently tight to impact maximum train speeds. The engineering required to achieve trains speeds of 80 mph or higher is substantially more challenging when the radius of the railway curve is less than 3,820 feet (1.5 degrees of curvature). Between Lowell and Concord there are 19.6 miles of such restrictive curves, which constitute 40 percent of the route miles.

As noted earlier, the maximum historic passenger speed along the NHML was 70 mph. This reflects what clearly had been a long and careful analysis balancing the desire for passenger speed with maintenance costs, safety, and freight economy. The calculation of maximum speeds through tight curves on tracks shared with freight trains involves a number of factors. Freight trains place operational and physical limits on maximum passenger train speeds through curves on tracks shared by freight and passenger trains. To ensure passenger comfort and safety through curves at higher speeds, tracks can be banked or *superevelated*. The extent of the bank is measured in inches reflecting the difference in elevation between the outside rail and its corresponding inside rail along the curve. With increased train speeds and sharper curves, more superelevation is required. However, when heavy freight trains move slowly (or stop) along a curve with high superelevation, the weight of the train can put unacceptable stresses on the curve's lower inside rail. Consequently the maximum speed for a passenger train through a curve that is shared with freight trains is limited by the physical and operational demands of the freight service.

Passenger trains often run through curves at speeds that generate centrifugal forces somewhat greater than that compensated by the superelevation. In these circumstances, known as *underbalance*, the train and passengers tend to sway toward the outside of the curve. Using underbalance elevation in the geometric design of curves allows both a nominal amount of sway, considered safe and acceptable practice, and alleviates some of the undue weight that heavy freight trains place on the low rail through the curves. A few specifics concerning the process of mathematically balancing freight and passenger train requirements are provided in the following paragraphs.

Concerning Railway Curve Design

Finding the right mix of superelevation and underbalance on curves is referred to as Equilibrium Elevation or Ee and is calculated by factoring the square of the speed, the degree of the curve, and a derived constant value of 0.0007, shown in written form as $Ee = 0.0007 \times Dc \times V^2$. Once Ee is found, its value is split between the sum of Ea (actual superelevation) and Eu (underbalance or unbalance elevation), shown in written form as $Ee = Ea + Eu$. The amount of actual elevation sets the maximum amount of cross-level that is tolerated as a train stands on the curve. Unbalanced elevation sets the amount of residual centrifugal force or sway that is tolerated as the passenger train traverses the curve at maximum speed.

Maximum values for Eu and Ea are guided by the American Railway Engineering and Maintenance-of-Way Association (AREMA), but the controlling railway authority generally dictates its own standards within AREMA guidelines.

- Underbalance (Eu) – Maximum values for Eu are typically three inches for passenger trains traveling on shared track.[26] MBTA tries to use a more conservative value for the amount of unbalanced (deficiency) elevation allowed, using 1.5 inches as the preferred limit and allowing up to 2.75 inches as a maximum. This provides improved passenger comfort, better compatibility with freight operations, and a margin below the FRA-mandated three-inch maximum.[27] A three-inch maximum is used in this analysis.
- Actual Elevation (Ea) – MBTA limits Ea to a maximum of six inches, but recommends that Ea be limited to four inches on shared use track.[28] “Maximum Ea shall be six inches except it is desirable to limit Ea to four inches on routes where through freights operate and where trains are likely to stop or operate below the design speed on a regular basis.” Amtrak track design standards allow an Ea maximum of six inches for passenger-only track, but face similar constraints as MBTA when sharing track with heavy freight trains.[29]

Using the strictest design guidelines of Max Ea = 4 and Max Eu = 2.75, Table 10.1 shows how the maximum allowable passenger speed decreases as a function of increasing curvature. Also note that passenger trains speeds of 80 mph cannot be sustained on shared track on curves greater than 1.5 degrees. However, as is often the case, design standards and other criteria used to determine geometric railroad alignments can be relaxed or otherwise modified, depending on numerous factors, including operational and maintenance input from predominate users. Other wayside factors like crossings, adjacent curves, station platforms, average train speeds vs. posted zone speed, yard limits, train make-up and equipment types, bridge/culvert conditions, and other physical constraints also need to be considered in setting superelevation and train speeds during final track design.

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[26] American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, Volume 1 - Track, Chapter 5, Part 3, 2012

[27] Massachusetts Bay Transportation Authority (MBTA) Railroad Operations, Commuter Rail Design Standards Manual, Volume 1, Section I – Track and Roadway, Chapter 3 – Geometric Design Criteria, Revision No. 1, April 19, 1996, page 3.7

[28] Massachusetts Bay Transportation Authority (MBTA) Railroad Operations, Commuter Rail Design Standards Manual, Volume 1, Section I – Track and Roadway, Chapter 3 – Geometric Design Criteria, Revision No. 1, April 19, 1996

[29] Amtrak Engineering, Track Design Specification, Spec No. 63, Revised August 1, 2013

Table 10.1: Maximum Passenger Train Speeds through Curves on Shared Track

Degree of Curvature	Radius of Curve (feet)	Maximum Passenger Train Velocity (mph)
1.0	5,730	98
1.5	3,820	80
1.6	3,581	78
2.0	2,865	69
2.5	2,292	62
3.0	1,910	57
3.5	1,637	52
4.0	1,433	49
4.5	1,274	46
5.0	1,146	44
5.5	1,042	42
6.0	955	40
6.5	882	39
7.0	819	37

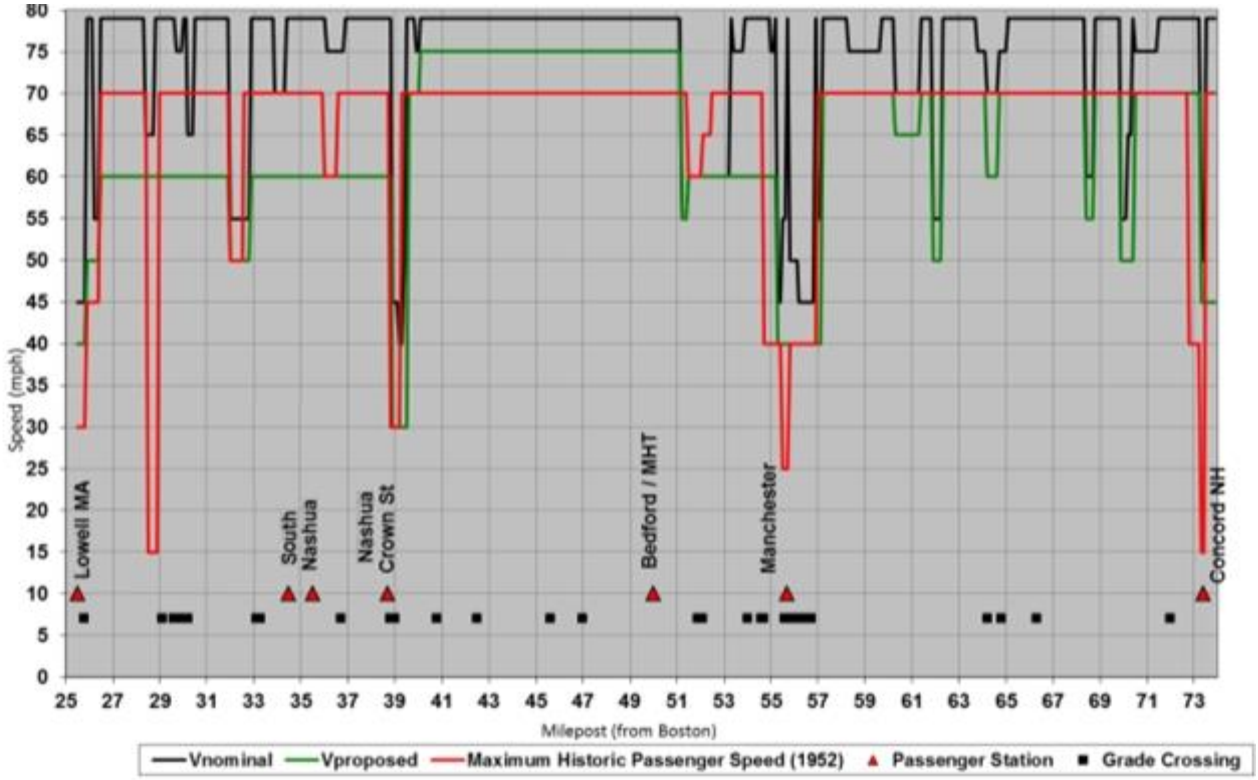
10.1.3 Setting New Passenger Speeds on the NHML

An inventory and geometric analysis of the existing main line horizontal curvature was prepared to evaluate the restoration of passenger rail service on the NHML north of Lowell to Concord, New Hampshire with Class 4 speeds. The following three vectors were computed for the 48.5 miles of new passenger railroad using the formulae described above.

- **Vnominal:** Shows the maximum allowable Class 4 passenger speed at all points along the line assuming the least restrictive criterion of Max Ee = 9 is applied (Ea = 6, Eu = 3)
- **Vproposed**: Is manually derived from Vnominal to smooth out speed limits and keep the value of Ea under five inches
- **Ea based on Vproposed**: Is the calculated superelevation (Ea) at each point along the railway necessary to support Vproposed

Figure 10.2 compares the values of Vnominal and Vproposed with historic maximum speeds along the NHML before FRA established maximum values for Ea and Eu. The maximum allowable speed in miles per hour is plotted on the Y-axis and the distance in miles from Boston is plotted on the X-axis.

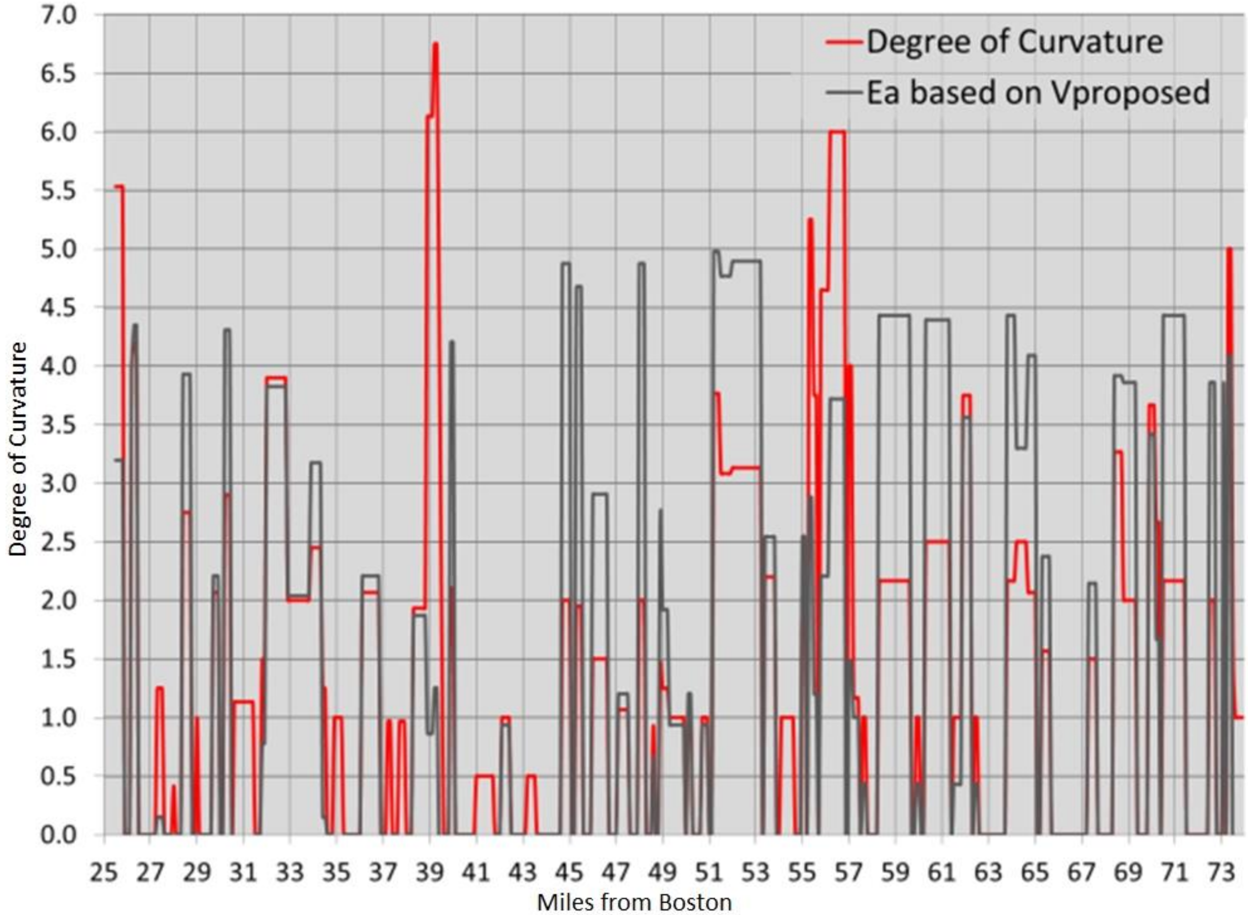
Figure 10.2: Historic, Nominal and Proposed Speed Profiles for NHML from Lowell to Concord



The proposed maximum speed profile for passenger trains would generally provide for maximum speeds of 60 mph northward to Nashua, then 75 mph to Bedford/Manchester Airport and 60 mph to Manchester. North of Manchester the maximum passenger speed would be 70 mph with five areas of speed restrictions as low as 50 mph. The proposed speeds (Vproposed) are in some cases less than the historic maximum speeds that required superelevation and underbalance standards in several areas not possible in the 21st century. The proposed speeds are also generally below the maximum allowable passenger speed to keep the required superelevation below five inches.

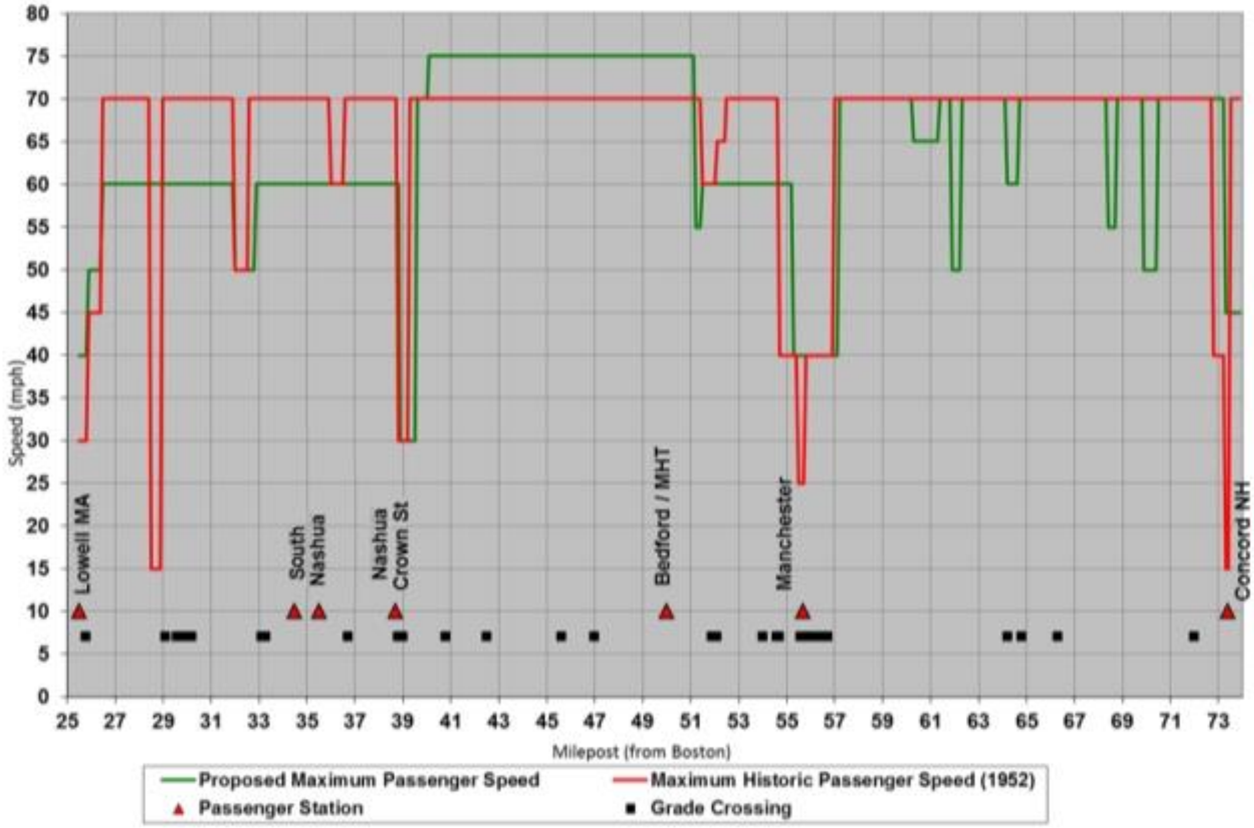
Figure 10.3 shows the degree of curvature and superelevation inches at each point along the rail corridor that would be necessary to support the speed profile described by Vproposed. In no case is the proposed superelevation in excess of five inches. A total 6.5 miles of track with superelevation greater than four inches, but less than five inches, is necessary to support Vproposed speeds. This track with high superelevation would constitute 13 percent of the route between Lowell and Concord.

Figure 10.3: NHML Curvature and Proposed Superelevation



In summary, the Study team's evaluation of tradeoffs between speed and maintenance expense suggest that the railway can be economically restored to a 60 mph (FRA Class 3) passenger speed standard for most of its length with only a few geometrically imposed speed restrictions. FRA Class 4 operations allowing a 75 mph maximum speed may be economically achievable between the Nashua River and the point where the railway crosses the Merrimack River into Manchester. North of Manchester some substantial segments of 70 mph may be achievable for a modest increase in capital cost and maintenance expense (see Figure 10.4).

Figure 10.4: Historic and Proposed Speed Profiles for NHML from Lowell to Concord



With these track improvements in-place, the Study team's analysis indicates that travel times of 89 minutes for the 73 miles between Concord and Boston would be achievable making intermediate stops at Manchester, Bedford/Manchester Airport, Nashua, Lowell, and Woburn.

10.1.4 Estimated Costs for Track Upgrades

Study team engineers developed cost estimates of the various necessary upgrades using information from current and recent passenger rail development projects elsewhere in New England together with inventory prices from MBTA's commuter rail department.

10.1.5 New and Rebuilt Track

Costs for labor and materials for new and rebuilt track were developed using track construction metrics, costs on MBTA's recent and current work improving its line to Fitchburg, and current prices for materials in the MBTA/Massachusetts Bay Commuter Railroad Company (MBCR) inventory system. The length in miles of new and rebuilt track required for each service option is summarized in Table 10.2.

Table 10.2: Estimated Miles of New and Rebuilt Track by Type of Rail for Intercity 8 Service

Replace Rail with CWR	Replace Rail with Relay Rail	New Track with CWR	New Track with Relay Rail
26.1	27.0	4.6	6.8

Retaining or relaying ('Relay') existing rail from another location on tangent track sections and industrial sidings instead of replacing all rails can maximize the lifespan left in existing rail and minimize initial required capital outlays. Relay and retained rail would need to be replaced in a multi-year program that would begin approximately 10 years after start-of-service. Cost parameters for new and rebuilt track are summarized in Table 10.3.

Table 10.3: Cost Parameters and Unit Costs (2014$) for New Track

Cost Element	Quantity	Unit Cost	Subtotal	Source
Cost of New Track (New 115# CWR)			$1,155,088/mile	$218.77/foot
Materials			$616,894	
Wood ties	3,249	$47.21	$153,396	MBCR Inventory Value
Ballast (tons)	1,500	$33.64	$50,460	Fitchburg Main Line (ML) Improvement Project
Subballast (tons)	1,000	$36.13	$36,130	Fitchburg ML Improvement Project
Plates	6,498	$15.00	$97,477	MBCR Inventory Value
Spikes	19,495	$0.50	$9,748	MBCR Inventory Value
Anchors	6,498	$1.50	$9,748	MBCR Inventory Value
Thermite welds	6.6	$512.23	$3,381	Fitchburg ML Improvement Project
CWR rail (LF)	10,560	$24.30	$256,555	Fitchburg ML Improvement Project
Labor	5,280	$101.93	$538,193	Fitchburg ML Improvement Project
New Track (Jointed Relay Rail)			$970,381/mile	$183.78/foot
Materials			$432,188	
Wood ties	3,249	$47.21	$153,396	MBCR Inventory Value
Ballast (tons)	1,500	$33.64	$50,460	Fitchburg ML Improvement Project
Subballast (tons)	1,000	$36.13	$36,130	Fitchburg ML Improvement Project
Plates	6,498	$15.00	$97,477	MBCR Inventory Value
Spikes	19,495	$0.50	$9,748	MBCR Inventory Value
Anchors	6,498	$1.50	$9,748	MBCR Inventory Value
Joint bars	271	$65.00	$17,600	Fitchburg ML Improvement Project
Bolts	1,625	$2.50	$4,062	Fitchburg ML Improvement Project
Bond wires	135	$5.67	$768	MBCR Inventory Value
Relay rail (LF)	10,560	$5.00	$52,800	Jacobs Engineering Estimate
Labor	5,280	$101.93	$538,193	Fitchburg ML Improvement Project
Cost of New 115# CWR Replacement Rail			$662,678/mile	$125.51/foot
Materials			$353,914	

Cost Element	Quantity	Unit Cost	Subtotal	Source
CWR rail (LF)	10,560	$24.30	$256,555	Fitchburg ML Improvement Project
Ties (33% of ties)	1,083	$47.21	$51,132	MBCR Inventory Value
Anchors	6,498	$1.50	$9,748	MBCR Inventory Value
Plates (10%)	650	$15.00	$9,748	MBCR Inventory Value
Thermite welds	6.6	$512.23	$3,381	Fitchburg ML Improvement Project
Spikes (67%)	13,062	$0.50	$6,531	MBCR Inventory Value
Ballast (tons)	500	$33.64	$16,820	Fitchburg ML Improvement Project
Labor	3,029	$101.93	$308,763	Adjusted down for reduced material
Cost of Used (Relay) Replacement Rail			**$477,971/mile**	**$90.52/foot**
Materials			$169,208	
Relay rail (LF)	10,560	$5.00	$52,800	Jacobs Engineering Estimate
Ties (33% of ties)	1,083	$47.21	$51,132	MBCR Inventory Value
Anchors	6,498	$1.50	$9,748	MBCR Inventory Value
Plates (10%)	650	$15.00	$9,748	MBCR Inventory Value
Joint bars	271	$65.00	$17,600	Fitchburg ML Improvement Project
Bolts	1,625	$2.50	$4,062	Fitchburg ML Improvement Project
Bond wires	135	$5.67	$768	MBCR Inventory Value
Spikes (67%)	13,062	$0.50	$6,531	MBCR Inventory Value
Ballast (tons)	500	$33.64	$16,820	Fitchburg ML Improvement Project
Labor	3,029	$101.93	$308,763	Adjusted down for reduced material

10.1.6 Track Switches

The need for new and renewed switches in the track structure was identified as the track configuration was finalized for each option. Costs for new switches were derived using reported costs for installed switches on MBTA's ongoing Fitchburg Line Improvement Project. Switch renewals were estimated at two-thirds of the installed cost for an entirely new switch. New and renewed switches for Intercity 8 is listed in Table 10.4.

Table 10.4: New and Renewed Switches for Intercity 8 Option

Switch Location and Type	Installed Cost (2014$)	Quantity
New #15 Crossover (B25.8)	$632,475	1
Renew #15 Crossover (B25.9)	$421,650	1
New #15 Turnout (CPF-NC*)	$316,238	1
Renew #15 Turnout (CPF-NC)	$210,825	1
New #15 Crossover (B29)	$632,475	1
New #10 Turnout (B29.7) Courier Corp	$184,000	1
New #20 Turnout (B32.1) Tyngsborough Curve	$434,526	1
New #15 Turnout (B34.2) to Layover Facility	$316,238	1
Renew #15 Turnout (CPN9)	$210,825	1
Renew #15 Crossover (B37.9) Robies	$421,650	1
Renew #15 Turnouts Nashua Yard/Station (B38.7)	$210,825	1
New #10 Hand Throw (B42.3) Nashua Corp Siding	$184,000	2
Renew #10 Turnout to Nashua Corp	$122,667	2
New #10 Hand Throw (B43.5) Anheuser Busch	$184,000	2
Renew #10 Turnout (B43.6) Anheuser Busch	$122,667	1
New #15 Turnout (B45.4) Merrimack Running Track	$316,238	1
New #10 Hand Throw (B45.6) to NE Pole Siding	$184,000	1
Renew #10 Hand Throw (B46.1) Jones Chemical	$122,667	1
Renew #15 Turnout (B47.8) CPN 20	$210,825	1
Renew #10 Turnouts to Manchester Customers	$122,667	1
Renew #15 Turnout (B55.3) Manchester Yard	$210,825	1
New #15 Turnout (B55.6) to Layover Facility	$316,238	1
New #15 Turnout (B55.7) CPN 28 to Concord	$210,825	1
Renew #10 Hand Throw (B66.1) Cement Quebec	$122,667	1
Renew #15 Turnout (B66.4) Perini Siding	$210,825	1
Renew #10 Hand Throw (B67) Coastal Wood	$122,667	1
New #10 Hand Throw (B68) PSNH Siding	$122,667	1
Renew #15 Turnout (B72.7) Concord Yard	$210,825	1
Renew #10 Hand Throw (B73) Scrap Yard	$122,667	1
New #15 Turnout (B73.3) Loudon Rd/Concord Station	$316,238	1
**CPF-NC = Control Point: Freight Main Line – North Chelmsford*		

Interlockings and Block Signals

The NHML has a fully functioning Centralized Traffic Control (CTC) signal system in-place between Lowell and CPN28 in Manchester that would be renewed and upgraded for the new passenger service. Existing block signals were identified by reference to PAR documentation. New and renewed interlockings (an interconnected system of signals and track elements designed to ensure safe railroad operations) were identified in the track configuration planning process (see Table 10.5). Estimated signal costs for new interlockings were based on the average value for six new interlockings constructed on the nearby MBTA Fitchburg Main Line. Estimated costs to renew block signals were derived from the same source. Costs for interlocking renewal were estimated at two-thirds the cost of a new interlocking.

Table 10.5: New and Renewed Interlockings and Block Signals for Intercity 8 Option

Interlocking Location and Treatment	Installed Cost (2014$)	Quantity
Renew CPF-LO	$683,295	1
Renew Western Avenue	$683,295	1
New CPF-NC	$1,024,942	1
New CPN2 Crossover (B29)	$1,024,942	1
New CPN4	$1,024,942	1
Renew CPN6 So Nashua Station	$1,024,942	1
Renew CPN9	$683,295	1
Renew Nashua	$683,295	1
Renew CPN13 (12.86) Hills Ferry	$683,295	1
New CPN 18	$1,024,942	1
Renew CPN20	$683,295	1
New Manchester	$1,024,942	1
Renew CPN28 (Granite Street)	$1,024,942	1
New Concord	$1,024,942	1
Block Signals		
Renew 27/27.1	$147,872	1
Renew 30.6/30.7	$147,872	1
Renew 352/353 (So Nashua) MP7	$147,872	1
Renew 14.4/14.5 Mast Road	$147,872	1
Renew 16.0/16.1 Anheuser Busch	$147,872	1
Renew 500/499 (MP22)	$147,872	1
Renew 540/539 (West Mitchell Street)	$147,872	1
Renew 28.6 (Commercial Street)	$147,872	1

10.1.7 Automatic Highway Warning Devices (AHWD) Systems

The rail line has 35 highway and pedestrian crossings between Lowell and Concord. The Study team inspected each crossing with an accompanying PAR signalman to determine its condition and identify necessary signal and warning system upgrades for each crossing. The site survey ran south to north to view the conditions at each of the 35 crossings from Wotton Street in Chelmsford, Massachusetts to Hall Street in Bow, New Hampshire. Specific cities and towns visited and the number of active crossings include Chelmsford (3), Tyngsborough (2), Nashua (6), Merrimack (4), Manchester (14), Hooksett (2), and Bow (4).

The Study team's estimate includes all material and labor to purchase and install new equipment and remove and dispose of old equipment, including a five percent design contingency. The estimate includes costs for crossing houses complete with racks, crossing controllers, relays, and wiring necessary to control the wayside equipment. Constant warning time control equipment has been included in the estimate due to variation in speeds between passenger trains and freight trains that will both coexist on the line. Wayside equipment has been determined for each location to be either a two- or four-quadrant gate system or flasher-only system with foundations, cable, lights, and bells. A cost for a power service up-grade at each location has been included. All estimated backup details are based on 2014 dollars. This estimate does not include any costs for the operating contractor (force account), future escalation, contractor's general conditions, overhead, profit, bond, or any other allowances. Other general information and assumptions used in developing this cost estimate follow:

1. Review of information contained in USDOT Crossing Inventory
2. Material and labor costs for contractor work are based on various sources, including estimating publications, historical contractor rates from similar project bids, estimators' experience, and a material list estimate from Safetran Systems dated 2004 as reference (material costs from that estimate were escalated to be consistent with recent cost information)
3. Assumption of manpower; assumes all work will be done on straight time
4. Does not include any credit for salvageable equipment
5. Does not include any cost for wayside signal system upgrades
6. Costs included for interface at locations where electric switch locks may be required
7. Cost was added at Crown Street and E. Hollis Street in Nashua between the main line and Hillsboro Branch line specifically for a crossing control interface between the two locations
8. From the site survey it was observed that the Manchester traffic signals along Canal Street provide signage and a steady flashing yellow light in advance of the crossing for warning motorists, so cost for an upgrade to this traffic system is not included
9. From the site survey it was observed that several locations have traffic signals within 200 feet of the Highway Rail Grade Crossing Warning System and will need to be interconnected to pre-empt the traffic signals in accordance with the Manual on Uniform Traffic Control Devices (MUTCD)

The resulting signal cost estimates for each crossing are enumerated in Table 10.6.

Table 10.6: Estimated Signal Costs for AHCW System Upgrades

City	State	Grade Crossing	MP	Cost (2014$)
Chelmsford	MA	Wotton Street	29.1	$241,750
Chelmsford	MA	Wellman Road	29.6	$260,650
Chelmsford	MA	Cross Street	30.0	$298,576
Tyngsborough	MA	New England Marine	30.5	$298,576
Tyngsborough	MA	Helena Drive/River Road	33.5	$258,203
Segment Total				$1,357,755
Nashua	NH	East Glenwood	36.9	$258,203
Nashua	NH	Crown Street	38.8	$324,364
Nashua	NH	East Hollis Street	38.9	$297,767
Nashua	NH	Bridge Street	39.0	$266,267
Nashua	NH	Hills Ferry Road	40.8	$258,203
Merrimack	NH	Mast Road	42.4	$258,203
Merrimack	NH	Anheuser-Busch	43.7	$258,203
Merrimack	NH	Star Drive	44.1	$258,203
Merrimack	NH	New England Pole	45.7	$258,203
Manchester	NH	Pine Island Road	52.1	$220,403
Manchester	NH	Winston Road	52.6	$225,653

City	State	Grade Crossing	MP	Cost (2014$)
Manchester	NH	West Mitchell Street	54.0	$291,635
Manchester	NH	Sundial Avenue (Dunbar Street)	54.6	$225,653
Manchester	NH	Bryon Street	54.7	$238,757
Manchester	NH	Depot Street	55.6	$13,304
Segment Total				**$3,653,026**
Manchester	NH	Granite Street	55.7	$26,174
Manchester	NH	Pleasant Street	55.9	$288,485
Manchester	NH	Pedestrian Crossing #1	56.0	$132,190
Manchester	NH	Spring Street	56.2	$288,485
Manchester	NH	Kidder Street	56.3	$288,485
Manchester	NH	Pedestrian Crossing #2	56.5	$132,190
Manchester	NH	Commercial Street	56.6	$288,485
Manchester	NH	Eve Street (Chauncey Ave)	58.7	$263,453
Hooksett	NH	Old Londonderry Turnpike	64.3	$263,453
Hooksett	NH	Edgewater Drive	64.8	$263,453
Bow	NH	Johnson Road	66.3	$263,453
Bow	NH	Robinson Ferry	68.3	$263,453
Bow	NH	Gavins Falls Road	69.8	$263,453
Bow	NH	Hall Street	71.0	$284,453
Segment Total				**$3,309,669**

10.1.8 Grade Crossing Track Renewals

Each of the highway grade crossings would also be renewed with new track and paving material. The estimated cost for upgrading each highway grade crossing was based on the average value to upgrade the track and crossing material for six substantial crossings on MBTA's ongoing Fitchburg Line Improvement Project at $165,950 per crossing.

10.1.9 Bridges

There are 25 railroad bridges along the route between Lowell and Concord spanning an aggregate 2,100 feet over waterways and roadways. The Study team obtained inspection reports, plans, and documentation for each bridge from PAR and MBTA. The Study team combined this information with selected field inspections to estimate costs to rehabilitate each railroad bridge along the route. The assessment of the bridge structures was limited to review and evaluation of this available information only. The scope of this Study does not include bridge inspection and/or development of an independent load capacity rating for any of the bridges. Available information used to asses and evaluate the 25 bridges within the Study limits includes the following:

1. Bridge Inspection Reports obtained from MBCR
2. Bridge Inspection Reports obtained from PAR
3. Bridge Rating Reports obtained from PAR
4. Bridge Plans obtained from PAR
5. Video and photos from a Hi-Rail trip along the rail corridor
6. Photographs of some bridges where access was possible
7. GIS mapping and online aerial photos of the bridges

A Bridge Summary Sheet was developed for each bridge to summarize the basic information and condition of each bridge as identified in available bridge inspection reports. Based on condition ratings, inspector notes, and available photographs, a recommended scope of repairs is presented, with concept-level cost item quantities identified. The recommended repairs are also given a weighted rating of "Minor," "Moderate," or "Extensive" based on a subjective evaluation of the available information. Unit costs for various repair/rehabilitation work items are utilized for each of the three weighted ratings, and the appropriate unit cost is then applied to the specific cost item quantity for the given bridge.

The condition of each bridge is summarized in Table 10.7. Bridge repair cost information was developed for the purpose of establishing order-of-magnitude capital investment levels and considered as representative of preliminary conceptual repair/rehabilitation requirements. As project design advances, development of more accurate needs and associated costs at each bridge based on further engineering assessment will be required, including hands-on inspections and load capacity ratings for two bridges that have not recently been rated.

Table 10.7: Estimated Bridge Rehabilitation Costs (2014$)

City/Town	Bridge No.	Length (Feet)	Bridge Structure	Deck Type	Spans	Costs
Lowell, MA	25.6	30' +/-	Deck Plate Girder	Open	1	$41,000
	25.7	154'-6"	Deck Plate Girder	Open	4	$99,000
	26.2	163'-0"	Thru Truss	Open	1	$183,000
Chelmsford, MA	28.6	43'-8"	Stone Arch	Ballast	2	$29,000
	29.1	13'-0"	I-Beam	Open	1	$58,000
Tyngsborough, MA	32.5	45'-9"	Frame Trestle	Open	6	$1,647,000
	32.6	12'-3"	Reinforced Concrete	Ballast	1	$50,000
Nashua, NH	37.9	17'-3"	Stone Arch	Ballast	1	$5,000
	39.2	113'-2"	Thru Truss	Open	1	$72,000
	39.4	35'-0"	Reinforced Concrete	Ballast	2	$75,000
	41.8	47'6"	Deck Plate Girder	Ballast	1	$422,000
Merrimack, NH	44.7	16'-0"	Reinforced Concrete	RCS	1	$95,000
	44.9	108'-8"	Deck Plate Girder	Ballast	3	$1,011,000
	46.2	111'-6"	Deck Plate Girder	Ballast	2	$980,000
	47.8	10'-0"	Reinforced Concrete	RCS	1	$8,000
Bedford, NH	51.8	655'-3"	Thru Truss	Ballast	4	$5,956,000
Hooksett, NH	60.5	12'-0"	Reinforced Concrete	RCS	1	$50,000
	61.2	15'-0"	Reinforced Concrete	RCS	1	$21,000
	64.3	487'-6"	Thru Truss	Ballast	3	$4,478,000
Bow, NH	67.6	15'-0"	Reinforced Concrete	RCS	1	$21,000
	70.8	17'-0"	Reinforced Concrete	RCS	1	$21,000
	71.1	11'-0"	Reinforced Concrete	RCS	1	$21,000
Concord, NH	71.5	16'-0"	Reinforced Concrete	RCS	1	$23,000
	71.5	10'-0"	Reinforced Concrete	RCS	1	$21,000
	73.3	Unknown	I-Beam	Timber	1	$16,000

10.1.10 Stations

Costs for station development were estimated for a number of alternative sites. Estimates relied on unit costs recently generated for MBTA's on-going improvements to the Fitchburg line. Those detailed capital costs were prepared by Jacobs Engineering and Keville Enterprises, Inc. in January 2013. The estimated Wachusett station construction cost with escalations and contingencies came to $13,303,000 for a station facility with a single track siding station with one 800-foot high-level side platform and 360 parking spaces.

Detailed costs for Wachusett were used to inform cost estimates for each of the proposed station sites through the use of allocation factors: variables such as the number of parking spaces, number of platforms, number of side tracks, square feet of existing wetlands, and the possibility of contaminated soil disposal. This enabled application of the Wachusett station unit costs even where site characteristics were different. The costs for a station at the Pheasant Lane Mall site include a parking garage estimated at 10 times the cost per space of a surface parking space. This figure is consistent with Jacobs' estimates for other parking garages.

10.1.11 *Layover Facilities*

Costs to develop layover yards for overnight storage and light maintenance of the service rolling stock were estimated for a number of alternative sites. Estimates relied on unit costs recently generated the MBTA's on-going improvements to the Fitchburg line. The estimated Wachusett layover construction cost with escalations and contingencies came to $13,303,000 for a layover facility with six tracks, including 9,655 track-feet available for the storage of trains.

These detailed costs were used to develop cost estimates for each of the proposed layover facilities through the use of allocation factors: variables such as the number of storage positions, total track length (feet), and the possibility of contaminated soil disposal. This enabled application of the Wachusett layover facility unit costs even where site characteristics were different.

10.1.12 *Right-of-Way Improvements*

Restoration of passenger service on the NHML will require some right-of-way improvements including relocation of fiber optic lines where new tracks are being restored to the right-of-way, vegetation removal, reestablishing ditches, and cleaning shoulder ballast. The right-of-way hosts three separate private fiber optic installations north from Lowell to Nashua, two between Nashua and Manchester and one from Manchester north to Concord. Based on the experience of Jacobs' telecommunications engineers, an allowance of $290,400 per route mile was used to estimate the costs of installing replacement fiber optic lines where new tracks were being laid. Allowances for other improvements were derived from earlier studies of the same right-of-way with costs escalated to 2014 dollars and are listed in Table 10.8.

Table 10.8: Allowances for Right-of-Way Improvements

Right-of-Way Improvement	Unit	Unit Cost (2014$)
Relocate fiber optic lines	Route Mile	$290,400
Vegetation management	Route Mile	$20,925
Reestablish ditches	Route Mile	$39,600
Shoulder ballast cleaning	Track Mile	$39,930

10.1.13 *Positive Train Control*

The Rail Safety Improvement Act of 2008 (RSIA) created a new infrastructure requirement for all U.S. passenger railroads. This new requirement should reduce the likelihood of the following:

- Train-to-train collisions
- Injuries to rail roadway workers
- Over-speed derailments
- Accidents due to misaligned switches to sidings

Under the RSIA, all conventional passenger railroads must operate with PTC as soon as possible after December 2015. The MBTA installation of PTC is lagging the 2015 deadline like most of its peers and its ultimate costs are unknown. The Study team employed a 2009 economic analysis prepared by the FRA[30] to account for PTC cost, and then escalated the estimates to 2014 dollars at four percent per annum.

At the most basic level, all PTC systems require three equipment elements:

- Wayside Devices: Equipment to detect, monitor, and communicate the status of track and switches installed in the field
- Locomotive/Cab Car Devices: Equipment to monitor and control train status relative to information on field conditions communicated from central control and wayside equipment
- Central Office Equipment: To integrate and communicate information concerning the status of trains, track maintenance crews, switches, signals, and tracks

The relevant work to install onboard locomotive and cab car devices should be completed for MBTA, PAR, and Amtrak fleets well before the proposed passenger rail service north of Lowell would be implemented. Similarly PAR and MBTA dispatching offices should have the relevant Central Office Equipment by that time. Any new passenger railway mileage will require the installation of wayside devices.

Using information from the above referenced FRA study, the Study team conservatively estimated that the more expensive Advanced Civil Speed Enforcement System (ACSES) wayside equipment would be deployed on the route with an average cost of $147,215 per track mile. If Enhanced Traffic Management System (ETMS) is installed, the PTC costs may be lower than estimated here.

10.1.14 Railroad Appliances

Various appliances such as train defect detectors, rail lubricators, and electric locks for hand-thrown turnouts would be required on the refurbished line. Installed unit costs for these appliances and estimated quantities required are listed in Table 10.9.

Table 10.9: Unit Costs and Quantities of Railroad Appliances for Intercity 8

Railroad Appliance	Installed Cost (2014$)	Quantity
Train Defect Detector	$45,000	1
Rail Lubricator Unit	$8,000	6
Electric Locks for Industrial Sidings	$75,000	5
Electric Locks for Customer Turnouts	$75,000	12

10.2 Non-Infrastructure Costs

[30] Roskind, Frank D, Senior Industry Economist, Federal Railroad Administration, Office of Safety Analysis POSITIVE TRAIN CONTROL SYSTEMS: ECONOMIC ANALYSIS. DEPARTMENT OF TRANSPORTATION, FEDERAL RAILROAD ADMINISTRATION, 49 CFR PARTS 229, 234, 235, AND 236 [DOCKET NO. FRA-2006-0132, NOTICE NO. 1] RIN 2130-AC03 July 10, 2009 202 302 9704 pp 112-119 (Retrieved from http://www.fra.dot.gov/downloads/PTC_/RIA_/Final.pdf on July 21, 2009)

10.2.1 Multipliers for Allowances

As per typical practice, costs for various professional services and incidental non-itemized expenditures are estimated on the basis of total costs for all rail infrastructure improvements. These multipliers for professional services and incidental work are listed in Table 10.10.

Table 10.10: Professional Services and Incidental Items

Culverts and retaining walls	3% of infrastructure cost
Environmental (soil disposal, noise abatement, LEED*)	3% of infrastructure cost
Final engineering design	8% of infrastructure cost
Construction phase engineering services	4% of infrastructure cost
*LEED – Leadership in Energy and Environmental Design	

10.2.2 Railroad Services

Mechanisms for estimating the costs for railroad project management, inspections, and protective flagging are shown in Table 10.11.

Table 10.11: Railroad Services and Estimated Costs (2014$) of Inspections and Flagging for Intercity 8

	Unit Cost	Quantity
Railroad Project Management	3% of Infrastructure cost	N/A
Maintenance & Protection of Railroad (Inspections)	$2.00/day	270
Flagging	$2.00/day	540

10.2.3 Land

Beyond the railroad right-of-way that will be shared with PAR freight trains, land will be required for stations, parking, and overnight train storage yards. The cost for this land was estimated by consulting local public assessor records in Tyngsborough, Nashua, Bedford, Manchester, and Concord to determine the current assessed value of each parcel identified for a potential station or layover yard. Where only a portion of the parcel would be required for the rail facility, GIS tools were used to determine what fraction of the overall parcel would be necessary and to prorate the cost accordingly.

Acquisition of private land for transportation improvements can be a litigious process. An allowance of 220 percent was added to all raw land costs to allow for negotiations, takings, eminent domain, and legal costs. The 220 percent was derived from the Study team's experience working on similar projects in other jurisdictions; New Hampshire's experience may be different. Table 10.12 shows the assessed land values and estimated costs for selected station and layover sites.

Table 10.12: Assessed Land Value and Estimated Cost (2014$) for Selected Station and Layover Sites or Intercity 8

Facility Type	Parcel Size (Acres)	Required Portion	Assessed Value per Acre	Estimated Value	Estimated Cost with 220% Assemblage Factor
Stations					
Nashua Crown Street	6.826	1.0	$ 45,224	$308,700	$987,840
Bedford/MHT	6.000	0.33	$ 29,416.67	$444,400	$1,422,080
Manchester Granite Street	0.5544	1.0	$ 279,132.58	$148,800	$476,160
Concord Stickney Avenue	6.08	1.0	$ 237,990	$1,447,000	$4,630,400
Layover Yards					
Concord Stickney Avenue	6.08	1.0	$ 237,990	$1,447,000	$4,630,400

10.2.4 Infrastructure Contingency

In accordance with federal recommendations, a 35 percent contingency was applied to the sum of all infrastructure, engineering, and land costs described above to allow for unforeseen and unusual circumstances that might have been unaccounted for in this conceptual engineering cost estimate.

10.2.5 Rolling Stock

For Intercity 8, the Amtrak *Downeaster's* standard consist of four coaches with a locomotive used as a model (see Table 10.13). It was further assumed that the Intercity 8 service would operate in the same equipment pool with the *Downeaster's* five train sets adding one more four-car train set, one spare coach, and one spare locomotive to Amtrak's North Station complement.

Table 10.13: Unit Costs (2014$) and Quantities of Railroad Rolling Stock for Intercity 8

Rolling Stock	Purchase Price	Quantity
Coaches	$2,530,000	5
Locomotives	$5,320,000	2

10.2.6 Trackage Rights

The proposed rail services would be operated on a mix of tracks owned by MBTA in Massachusetts and by successors to B&M in New Hampshire. MBTA recently transferred $35 million dollars to PAR in exchange for the right to offer commuter rail service on B&M/PAR tracks approximately 37 miles north from Tyngsborough, Massachusetts to Concord, New Hampshire. The value of these rights to MBTA and PAR is approximately $946,000 per route mile. Without this transaction, MBTA and NHDOT would need to purchase trackage rights from PAR to operate into New Hampshire. Consequently one of the cost elements for the commuter rail options is the $946,000 per route mile one-time trackage fee for every route mile operated into New Hampshire.

Intercity routes operated by Amtrak, in contrast to MBTA, have statutory rights to operate over every railroad in the nation without paying trackage fees. Consequently, the trackage rights and resulting fees would not be a concern or a cost for the Intercity 8 service option.

10.3 Total Estimated Costs

The Intercity 8 service option is projected to cost $172.7 million for infrastructure and land, plus a $60.5 million contingency allowance and $23.3 million for the purchase of rolling stock that would be NHDOT's responsibility – for a total of $256.5 million. These costs are 2014 dollars. See Table 10.14 for a summary.

Table 10.14: Summary of Projected Capital Costs (2014$) for Intercity 8

Main Line Tracks	$42.1
Track Switches	$7.8
Interlockings	$12.0
Block Signals	$1.2
Grade Crossing Signals	$8.3
Grade Crossing Track Renewals	$5.6
Bridges	$15.4
Stations	$18.7
Layovers	$4.8
Right-of-way Improvements	$8.8
Positive Train Control	$9.5
Railroad Appliances	$1.0
Direct Construction Expense Subtotal	**$135.2**
Multipliers for Allowances	$24.3
Railroad Services	$5.7
Land for Stations	$0.9
Land for Layovers	$1.4
Assemblage Allowance (220%)	$5.2
Subtotal Land	**$7.5**
Contingency	$60.5
Grand Total (infrastructure)	**$233.2**
Coaches	$12.7
Locomotives	$10.6
Grand Total (rolling stock)	**$23.3**
Trackage Rights	**$0.0**
Total Project Value	**$256.5**

11 Forecast Operating Costs and Revenues

11.1 O&M Costs

Operations & Maintenance (O&M) costs are expenses necessary for operating the railway service:

- **Transportation:** Train crews, fuel, dispatching, train supplies, revenue collection, station staffing (if any), and transport supervision
- **Maintenance-of-Equipment (MoE):** Sometimes referred to as "Mechanical," includes the maintenance and cleaning of locomotives and coaches
- **Maintenance-of-Way (MoW):** Sometimes called "Engineering," includes maintenance of track, signals, communications, right-of-way, bridges, stations, and other facilities
- **Administration:** General management, marketing, human resources, accounting, material management, and other similar support functions

Two stages of O&M cost estimates were prepared for the Study:

1. A set of preliminary estimates for the three intercity rail, six commuter rail, and three bus options
2. Refined final estimates for the preferred Intercity 8, two commuter rail, and three bus options

11.1.1 Preliminary Estimates of O&M Cost

The Study team's approach for estimating O&M costs were different for the intercity rail, commuter rail, commuter bus and feeder bus service components. The intercity rail estimates are described below.

Service and operations planning for each intercity rail option was developed to include estimates of daily train miles, rolling stock requirements, track miles required, number and location of stations, and service schedules. The three preliminary options were reviewed with Amtrak staff assigned to advise the Study team and revised to reflect their feedback. The Study team also consulted with Amtrak for guidance on preparing preliminary estimates of operating costs for the SDP. The team was referred to documentation from several SDPs:

- *Feasibility Report on Proposed Amtrak Service: Chicago-Rockford-Galena-Dubuque*; prepared by M.W. Franke, Sr. Director – Corridor Planning and R.P. Hoffman Principal Officer – Midwest Corridors, Amtrak, Chicago, Illinois; revised June 22, 2007
- *Feasibility Report on Proposed Amtrak Service: Quad Cities-Chicago*; prepared by M.W. Franke Assistant Vice President – State and Commuter Partnerships (Central), R. P. Hoffman Principal Officer – Midwest Corridors and B.E. Hillblom Senior Director – State Partnerships; Amtrak Chicago, Illinois; January 7, 2008
- *Feasibility Report of Proposed Amtrak Service: Chicago – Peoria*; prepared by Policy and Development Department (Central) Amtrak, Chicago, Illinois; September 26, 2011
- *New York-Vermont Bi-State Intercity Passenger Rail Study: Identification and Evaluation of Alternatives*; March 9, 2012

Review of these documents revealed that the preliminary (and final) operating cost estimates for SDPs are typically derived in two ways: a measure of annual train miles is often the only cost factor used to derive a very simple and transparent operating cost estimate while other studies rely on Amtrak staff to develop estimates. The Study team elected to use the annual train mile approach, as documentation concerning Amtrak's methodology is not publicly available. The cost-per-train-mile figures from the referenced reports ranged from $29.78 to $33.08 in the Amtrak Chicago-Quad Cities Report (Table 11.1) to $66.01 in the Amtrak Ethan Allen Report (Table 11.2).

Table 11.1: Amtrak Chicago-Quad Cities Operating Cost Calculations (2007$)

	Route A UP* Belvidere	Route B ICE* Airport	Route C CN* Direct	Route D ICE-CN* Hybrid
Length of Route (miles)	184.0	188.6	182.2	181.0
No. of Rail Carriers	4	5	2	4
Proposed Scheduled Running Time (hours:minutes)	5:25	5:42	5:10	5:22
"Order of Magnitude" Capital Cost (In Millions)	$43.8	$48.9-$55.4	$32.3	$34.5
Estimated Annual Ridership	53, 600	44, 300	74, 500	58, 400
Estimated Annual Revenue (In Millions)	$1.1	$1.0	$1.5	$1.2
Estimated Annual Operation Expense (In Millions)	$4.1	$4.1	$4.4	$4.2
Estimated Annual Operation Contract (In Millions)	$3.0	$3.1	$2.9	$3.0
Train Hours	5.4	5.7	5.2	5.4
Annual Ridership				
Annual Train Miles	134,320	137,678	133,006	132,130
Annual Train Hours	3,954	4,161	3,772	3,918
Cost-per-Train Mile	$30.52	$29.78	$33.08	$31.79
Cost-per-Train Hour	$1,036.88	$985.34	$1,166.59	$1,072.07
*UP – Union Pacific, ICE – Iowa, Chicago and Eastern Railroad, CN – Canadian National Railroad, ICE-CN – Iowa, Chicago and Eastern Railroad/Canadian National Railroad				

Source: Feasibility Report on Proposed Amtrak Service: Chicago-Rockford-Galena-Dubuque; M.W. Franke, Amtrak Sr. Director – Corridor Planning and R.P. Hoffman, Amtrak Principal Officer – Midwest Corridors; Revised June 22, 2007

Table 11.2: Amtrak Ethan Allen Operating Cost Calculation (2012$)

Fully Allocated Unit Operating Cost" per Train Mile	$66.01

Source: New York – Vermont Bi-State Intercity Passenger Rail Study Identification and Evaluation of Alternatives – Phase One; March 9, 2012

Amtrak reviewed these findings and agreed that the average costs per train mile published for the Amtrak *Downeaster* service would be used to estimate operating costs for Capitol Corridor intercity rail options. The use of the *Downeaster* service between Portland, Maine and Boston, Massachusetts is especially appropriate since this service also operates on tracks owned by MBTA and PAR and runs into Boston's North Station. Table 11.3 summarizes the cost factors that contribute to that service's $36.02 cost-per-train mile figure. This metric is roughly equivalent to the costs applied for Midwestern and New York/Vermont services reviewed in the studies recommended by Amtrak. Using the simple cost of $36 per train mile, the preliminary estimates of operating cost in Table 11.4 were derived for the three intercity service options.

Table 11.3: Preliminary *Downeaster* Operating Cost Calculation (2012$)

Annual Budget	$15,000,000
One Way Trip Length	114
Trips per Day	10
Trips per Year	3,652.5
Annual Train Miles	416,385
Cost per Train Mile	$36.02

Source: Northern New England Passenger Rail Authority (NNEPRA) 2012

Table 11.4: Derivation of Preliminary Estimates of Intercity Rail Operating Costs

Intercity Service Option	Trips per Day	Train Miles per Day	Train Miles per Year	Annual Operating Cost (@ $36/train mile)	Preliminary Estimate of Annual Operating Cost (In Millions, 2012$)
Intercity 8	8	586	214,036	$7,705,296	$7.7
Intercity 12	12	880	321,054	$11,557,944	$12
Intercity 18	18	1,319	481,581	$17,336,916	$17

11.1.2 Final Estimates of O&M Costs

O&M costs evolved over the Study's preliminary stages and then were updated at the project close to reflect newer, but not substantially different information concerning operating costs for the *Downeaster* service used as a cost model for this service. An updated O&M cost estimate is discussed below.

The intercity rail service options that advanced through preliminary screening were developed to a higher level of detail, including estimates of daily train miles, rolling stock requirements, track miles required, number and location of stations, and service schedules.

Revenue forecasts were then prepared so that the required operating support could be identified. Table 11.5 contains final estimates of boardings and passenger miles for Intercity 8 and identifies new transit trips that would be attracted to the service.

Table 11.5: Final Estimates of Demand and Passenger Miles for Intercity 8

	Boardings	Miles to Boston	Passenger Miles
Concord	78	73.3	11,497
Manchester	186	55.5	20,758
Bedford/MHT	77	50.1	7,715
Nashua	132	38.8	10,217
New NH Boardings	473		
Annual Boardings (In Millions)	2.78		
Annual NH Project Boardings (In Millions)	0.24		
Incremental Daily Passenger Miles			48,853
Annual Passenger Miles (In Millions)			17.8

11.2 Estimated Passenger Revenues

Two rounds of revenue forecasts were prepared for the Study. Preliminary forecasts were used to screen the options down to an intermediate and then final set of multi-modal transportation investment options, including the preferred Intercity 8 option. The final revenue forecast was based on the Intercity 8 final ridership forecast.

11.2.1 Preliminary Estimates of Passenger Revenue

Preliminary estimates of passenger revenue were based on the ridership forecasts described in *Section 7: Market Analysis*. For screening purposes, the service was assumed to use a fare structure similar to MBTA's commuter rail fares and that daily ridership would be converted to an annual estimate using a factor of 284.4 based on MBTA experience. The use of a commuter rail annualization factor was considered prudent since the forecast model used for preliminary estimates was a commuter rail model. The resulting preliminary forecasts of annual revenue are shown in Table 11.6.

Table 11.6: Preliminary Forecasts of Intercity Ridership and Revenue

Intercity Rail Station	One Way Fare	Average Revenue per Passenger	Forecast SB Boardings			Annual Revenue (In Millions, 2012$)		
			Intercity 8	Intercity 12	Intercity 18	Intercity 8	Intercity 12	Intercity 18
Concord	$12.00	$11.26	60	70	90	$0.4	$0.4	$0.6
Manchester	$11.00	$10.01	130	160	190	$0.7	$0.9	$1.1
Bedford/MHT	$11.00	$10.01	120	140	160	$0.7	$0.8	$0.9
Nashua	$10.00	$9.41	320	370	440	$1.7	$2.0	$2.4
Totals			630	740	880	$3.5	$4.1	$4.9
Revenue per Passenger Mile						$0.21	$0.20	$0.20

11.2.2 Final Estimates of Passenger Revenue

The final estimate of passenger revenue for the Intercity 8 option (Table 11.7) was based on the *Downeaster* ridership model forecasts prepared by Amtrak and the *Downeaster's* average revenue per passenger mile of $0.173. Since the Amtrak model generated annual ridership estimates, it was unnecessary to apply an annualization factor.

Table 11.7: Final Forecasts of Intercity 8 Ridership and Revenue for Eight-Train-per-Day Service

	Miles to Boston	Typical Daily Boardings	Annual Boardings	Annual Passenger Miles	Annual Revenue (In Millions, 2014$)
Concord	73.3	78	28,350	4,156,110	$0.7
Manchester	55.5	186	67,800	7,552,920	$1.3
Bedford/MHT	50.1	77	28,150	2,820,630	$0.5
Nashua	38.8	132	48,350	3,771,300	$0.7
Totals		473	172,650	18,300,960	$3.2

11.3 Estimated Operating Cost Performance

Table 11.8 lists performance metrics for Intercity 8 that can be used to compare its productivity and required operating support against the other Study options. Intercity 8 is forecast to require $4.5 million of annual operating support beyond proceeds from passenger revenues.

Table 11.8: Final Intercity 8 Service Option Performance Metrics

Performance Metric	Cost (*$)
Operating Cost per New Transit Passenger Trip	$31.91
Operating Cost per New Transit Passenger Mile	$0.43
Revenue per New Transit Passenger Mile	$0.173
Operating Deficit (In Millions)	$4.53
Operating Deficit per New Transit Passenger Trip	$18.78
Operating Deficit per New Transit Passenger Mile	$0.25
Required Operating Support (In Millions)	$4.5

**Note: Operating costs are based on unit costs in 2012$. Ridership and fare rates are current to 2014. Therefore, estimates of operating deficit and required support may vary when operating unit costs become available for 2014$.*

12 Preferred Intercity Rail Public Benefits

This section reviews quantifiable public benefits that would be derived from the construction and operation of the Intercity 8 service in the Capitol Corridor:

- Reduced VMT on parallel highways leading to reduced congestion and improved air quality
- Station area benefits stimulating and supporting sustainable land use patterns
- Economic development benefits resulting from rail service construction and operation
- Positive equity impacts on low income and minority populations in New Hampshire
- Freight service benefits

12.1.1 VMT

Public transportation investments generally have some impact in reducing automobile traffic in the corridors where they operate. Reduced automobile traffic in turn tends to have a positive impact on air quality and roadway congestion. As estimated in *Section 7: Market Analysis*, the preferred Intercity 8 service option would reduce daily vehicle miles on the corridor's limited access highways by 44,794.

12.1.2 Station Area Benefits and Recommendations

Restoration of intercity passenger rail service between Concord and Boston along the NHML is expected to result in positive benefits that will stimulate and support new development. Ideally this would lead to sustainable development in the dense downtown cores of Concord, Manchester, and Nashua and help encourage sustainable development in the vicinity of the proposed airport station.

The Study carefully considered existing development and zoning in each proposed station area to reach the findings and recommendations summarized below.

All three cities within the New Hampshire Study area have, to varying degrees, existing transit-supportive zoning and land use plans and policies. Some potential station locations would be better suited for TOD and supporting growth in transit use than others. Station locations in the urban centers of Concord, Manchester, and Nashua are all primed for future transit growth and TOD.

Following are recommendations to build on existing transit-supportive zoning and land use plans and policies:

Concord

- Continue to implement the Opportunity Corridor Performance (OCP) district plan; this plan has many of the elements necessary to promote a transit-supportive environment
- Create policies to limit parking and consider charging a higher rate; consider updating the zoning code to allow for parking maximum requirements instead of parking minimums for new development; parking supply can require less land if managed in parking structures, as opposed to surface lots
- Allow for the greater residential and commercial densities and zoning incentives for increased development in station area
- Define maximum setbacks to encourage higher density development; consider removing minimum setbacks
- 150-foot minimum lot frontages are too large to allow for the diverse mix of uses that the OCP district permits; a smaller frontage, such as the 22-foot minimum allowed in the Central Business District (CBD), would create a more walkable and pedestrian friendly environment
- Update the floor area ratio to at least one, to promote more density in the OCP district

Manchester

- Implement recommendations in the Master Plan to update the zoning ordinance to allow for mixed use and high-density residential properties
- Allow multi-family and elderly housing as a permitted use instead of as a conditional use
- Define specific parking maximums to allow for consistent development and ensure parking supply does not exceed demand; consider charging a higher rate for parking
- Allow for residential and commercial densities – zoning incentives for increased development in the station area
- Dimensional regulations are not defined for the CBD, the zoning immediately around the station, other than a floor area ratio of five
- The city should further define the maximum setbacks and other dimensional regulations to ensure that the urban design of new development enhances walkability of the area

Bedford/Manchester Airport

- The proposed station area lacks strong existing mixed-use or TOD zoning
- The Town of Bedford has prepared plans and policies that support the development of a mixed use transit hub at the proposed station location, but no progress has been made towards achieving this vision.
- The potential station would primarily be used by residents who live in south suburban Manchester and for passengers traveling to and from the airport
- This station would likely function as a park-and-ride location, with less of a focus on TOD
- The area could potentially benefit from more commercial development, serving the needs of passengers traveling to and from the airport

Nashua

The area surrounding the proposed station is currently zoned General Industrial. The potential station could benefit from a zoning change to allow for more development, such as commercial and/or mixed use. Former industrial spaces could also be redeveloped into commercial properties. Commercial uses could lead to more jobs near the transit station, making this a strong location in terms of FTA criteria. Mixing uses would add residential development opportunities, thereby increasing the population that lives within a half-mile of the proposed Crown Street station.

- The allowed uses by zoning are not optimal for encouraging TOD and a more walkable and urban environment
- Specific urban design principles should be created, such as small or no minimum setbacks and narrow lot frontages to encourage higher-density development
- The existing City of Nashua TOD land use code would be appropriate to apply to this location
- Recommend policies to limit parking and potentially charge for parking
- Consider updating the zoning code to allow for parking maximum requirements instead of parking minimums for new development
- Consider working with residential developers to unbundle parking from the residential unit

12.1.3 Economic Benefits

Building upon the land use and economic development analyses, the Study team prepared an economic development assessment aimed at capturing the potential economic benefits of the corridor alternatives. The Study team's analysis focused on the final alternatives, including intercity passenger rail to Concord and commuter rail to Nashua or Manchester. It also considered improvements to the existing commuter bus network. The SDP only reports findings for the preferred Intercity 8 option compared to the No Build alternative.[31]

Economic Benefits of Transportation Investments

The Study team examined the literature and findings from recent studies of similar regional public transportation enhancement projects. Numerous studies have identified a net positive benefit of transport investment to the regional economy, resulting in travel time savings and congestion reduction, expanded access to jobs and the workforce, and new development attracted to station areas. Studies have also found a positive impact on property values within station areas. While only a few studies have specifically examined intercity passenger rail, evidence from other rail system expansions in the greater Boston region similarly suggests that transit investment will have a positive effect on the communities it serves.

Station Area Economic Development Benefits

The Study team conducted interviews with local stakeholders to gather information on the impact that the various proposed services could have in encouraging new development over the next 20 years. There was general consensus that passenger rail service (intercity or commuter) to Boston is important for southern New Hampshire's future development. While some high-tech, residential, and institutional development is currently occurring near several proposed station locations, respondents felt that this would be difficult to maintain or boost (particularly in the case of high-tech) without expanded passenger rail service. It was widely expressed that these sorts of transportation enhancements can help to attract the type of workers necessary to facilitate growth, namely a younger demographic looking for urban to semi-urban living with walkable amenities.

The Study team also assembled data on land use and zoning to evaluate the potential impact of the various project alternatives on development and redevelopment. The Study team estimates were measured in terms of commercial square footage (office and retail) and housing units. Table 12.1 shows that the eight trains per day serving Nashua, Manchester, and Concord in the Intercity 8 option could potentially encourage development of approximately 2,200 new residential units and 1.3 million square feet of commercial space supporting 3,700 new jobs by the year 2030.

Table 12.1: Total Development Potential for Intercity 8

Commercial (Square Feet)	Residential (Units)	Jobs
1,284,000	2,200	3,700

[31] For more information on economic development impacts, see Appendix 7 to the Capitol Corridor AA Final Report (Task 7 Detailed Evaluation of Alternatives)

Regional Economic Benefits

The economic modeling tool IMPLAN was used to estimate the economic benefits to the southern New Hampshire region of each intercity and commuter rail alternative. The following economic benefits were evaluated:

- Short-term benefits as a result of spending on construction of rail improvements in New Hampshire
- Long-term benefits as a result of the attraction of more residents and jobs to southern New Hampshire; these include benefits from construction of new real estate, as well as ongoing benefits from new worker earnings reinvested in the local economy

Time-savings benefits to travelers cannot be directly monetized in this type of economic analysis. However, they are capitalized into land values, and, therefore, are indirectly considered through the real estate effects. Benefits of bus alternatives were not estimated, as they would involve minimal capital investment, and stakeholder interviews suggested that associated development impacts would also be minimal.

The economic modeling found that the preferred Intercity 8 option would generate the greatest construction impacts of all the final alternatives (intercity rail, commuter rail, bus) under consideration (see Table 12.2). It would, however, have less development-related benefits when compared to the Manchester Regional Commuter Rail option due its lower service frequency. Overall, Intercity 8 has the potential to generate 350 new jobs over the construction period (2019-2022), 2,460 jobs related to new real estate development between 2021 and 2030, and 1,140 new jobs annually in 2030 and beyond (with benefits beginning to accrue after 2021) due to reinvested worker earnings. Table 12.3 shows this new real estate development is projected to add $750 million to the state's output between 2021 and 2030, with reinvested earnings adding $140 million per year beyond 2030.

Table 12.2: Employment Impacts of Intercity 8 (Number of Jobs)

Project Construction (2019-2022)	Real Estate Development (2021-2030)	Reinvested New Resident Earnings (Annual, 2030+)
350	2,460	1,140

Table 12.3: Forecast Gross Regional Product Impact of Intercity 8 (In Millions, 2014$)

Project Construction (2019-2022)	Real Estate Development (2021-2030)	Reinvested New Resident Earnings (Annual, 2030+)
$100	$750	$140

12.1.4 Equity Impacts[32]

Equitable access to transportation services – and the mobility benefits that these services confer on riders – is an important consideration when assessing the alternatives developed in the Study. Any major new public transportation (intercity rail, commuter rail, or express bus) service would support broad improvements in mobility. They are also a particularly critical tool in increasing the mobility of transit-reliant or -dependent populations, generally including households below the poverty line, minorities, and households in affordable housing units. U.S. Census data was used to calculate statistics related to income, race, and housing for households and individuals in Census tracts within a half-mile of the various Capitol Corridor alternatives:

- PAR right-of-way between the state lines of New Hampshire and Massachusetts and the proposed rail station locations en route to Concord
- BX bus route between the state lines of New Hampshire and Massachusetts and the existing Manchester, New Hampshire BX station
- Concord Coach bus route between the state lines of New Hampshire and Massachusetts and the existing Concord, New Hampshire Concord Coach station

These data were also collected for the states of New Hampshire and Massachusetts and the U.S. as a whole. Comparison between the alternatives within the larger geographic context supported the analysis of which alternatives minimize potential adverse impacts on concentrations of households below the poverty line, minority populations, and households in affordable housing units, while supporting equitable transit access by these populations.

It is notable that no cuts to intercity or express bus services are contemplated should the Intercity 8 service be implemented. The overall scope of transport services would actually be increased under this scenario. It is likely that the collocation of the bus and rail terminals in Concord and Manchester would strengthen both the bus and rail services as it has at the *Downeaster's* joint bus/rail terminal in Portland, Maine.

Table 12.4 summarizes findings of the Intercity 8 equity analysis compared with the status quo of continued express and intercity bus services. The Intercity 8 option would offer service to the following concentrations:

- Households below the poverty line
- Minority populations
- Households living in affordable housing units

[32]For more information on economic development impacts see Appendix 7 to the Capitol Corridor AA Final Report (Task 7 Detailed Evaluation of Alternatives)

This option would also expand access to new transportation alternatives in downtown Nashua, Manchester, and Concord, which have among the state's largest concentrations of transit-reliant or -dependent persons and households.

Table 12.4: Equity Comparison of Intercity Rail and Base Service

Station	Rail	Express Bus	Average Median Income	Pop Below Poverty Line	Minority Pop	Affordable Housing Units	Base Services	Intercity 8 Rail
Concord, NH	X	X	$39,000	18.0%	9.7%	398	X	X
Manchester, NH	X	X	$30,300	29.5%	26.1%	675	X	X
Bedford/MHT	X		$65,500	4.5%	5.2%	0		X
N. Londonderry, NH		X	$82,900	1.7%	4.7%	minimal	X	
Londonderry, NH		X	$84,700	3.9%	5.2%	minimal	X	
Nashua, NH		X	$80,500	4.4%	12.9%	minimal	X	
Nashua, NH: Crown St	X		$52,500	14.9%	12.2%	28		X
Salem, NH		X	$75,300	3.7%	5.9%	minimal	X	

Sources: U.S. Census, American Community Survey 2008-2012; various local New Hampshire Housing Authorities

The three populations considered as part of this equity analysis – population below the poverty line, minority populations, and households living in affordable housing units – tend to be concentrated in the central areas of Concord, Manchester, and Nashua. When compared against the existing commuter bus services, Intercity 8 would offer comparatively higher levels of service and transit access to these populations with minimal adverse impacts anticipated. The equity of and access to the rail alternatives would improve as transit service extends north to Concord. Intercity 8 would reach more individuals and households living below the poverty line, minority households, and households living in affordable housing units. The existing commuter bus service (or improved bus services) would also not adversely impact these populations, but it would not offer expanded access to these populations through new station locations.

12.1.5 Freight Service Benefits

As noted in the discussion of existing services in Section 5, the NHML carries most of the state's inbound rail freight, receiving three quarters of all rail freight tonnage shipped into New Hampshire. While the freight received is quite diverse, traffic flow is dominated by coal for electric generation shipped to Bow, New Hampshire. Clay, concrete, glass, and stone also comprise much of the remaining rail freight tonnage moving on the corridor. Other freight shipped along the corridor includes farm products, lumber and wood products, food, chemicals, and some nonmetallic minerals. Significantly more freight rail traffic is shipped into southern New Hampshire than is shipped out. Shippers categorize the small amount of outbound freight rail traffic as miscellaneous freight.

Most rail traffic currently shipped to New Hampshire is for local consumption and the volume of outbound rail traffic other than building materials (predominately sand and gravel) is quite minor.

Unless there is major shift New Hampshire's economy to produce, process, or consume large volumes of bulk commodities, it is unlikely that the total volume of rail traffic to or from the Granite State will grow at a rate that varies significantly from expected population growth. That is not to say that rail freight in the state would not benefit from improvements to a key rail line serving the state's major population centers. This portion of the SDP briefly discusses how investment in intercity passenger rail service might benefit freight services and commodity shippers along the NHML.

The largest rail shipper on the NHML (and the largest in the state) is PSNH Merrimack Generating Station. Merrimack Station is PSNH's largest power plant constituting approximately 10 percent of the state's power generation capacity. At 496 megawatts it produces enough energy to supply 190,000 New Hampshire households, and employs about 100 people. Its two coal-fired units were built in the 1960s and were once the cheapest source of electricity for the state.

But in recent years, New England has been become increasingly tied to natural gas. In 2013, natural gas powered plants produced 46 percent of the region's power, up from 15 percent in 2000. At this time, natural gas is cheaper than all other forms of energy. Further growth in the use of natural gas, however, is limited by pipeline capacity to supply the region. Until deficiencies in the capacity of the regional gas supply network are addressed, it is likely that Merrimack Station will continue to receive eight to 10 unit trains of coal each month using the NHML. However, in the long run, it seems likely that the gas network bottleneck will be addressed. At that time, the economic attractiveness of Merrimack Station might be reduced and eventually close. When, and if, it does close, the economic sustainability of this 45-mile branch will be jeopardized.

PSNH is not the only rail shipper on the NHML. The Nashua Corporation in Nashua, Anheuser-Busch and Jones Chemical in Merrimack, and Nylon Corporation of America in Manchester are among the more-prominent of perhaps a score of firms that ship or receive rail freight via the NHML. Should PSNH close its operations, the economic attractiveness of rail shipping for these smaller firms could be substantially degraded as the fixed cost of maintaining the line is spread over fewer tons of freight. These enterprises and their contribution to the regional economy could be in peril.

The operation of intercity passenger (or commuter) rail on the line would provide one more user for the line that would defray some of the shared costs for its upkeep and operation. With a passenger rail service on the line, the cost of providing existing freight service would be somewhat reduced, potentially improving conditions for PSNH to keep operating its plant at Bow. No tangible estimate of this impact has been produced, but the positive influence of the passenger rail service on the economic operation of the 45-mile freight branch seems clear.

To facilitate shared operation of the line by freight and passenger services, the infrastructure improvements were designed to minimize the potential for conflicts between passenger and freight trains. The track configuration would offer two main lines through Nashua and Manchester Yards. Industrial sidings would be established to allow local trains to service Nashua Corporation and the Anheuser-Busch brewery without blocking the main line. The Merrimack Running Track would be restored to provide similar capacity for joint use by freight and passenger trains in this section and a new receiving track would be built at the PSNH facility to keep coal trains from standing on the main line.

Sidings are at locations where local land use plans encourage industrial growth and development. Therefore, the investment in passenger rail service that encourages TOD may also encourage rail freight use by enhancing the capacity for freight operations in areas designated for heavy industry and facilitating the creation of "freight villages."

12.1.6 Conclusion

The proposed intercity rail service would have demonstrable positive impacts in several areas. The following public benefits would be expected with the implementation of improved intercity or commuter rail service in the corridor:

- Reduced VMT on parallel highways, leading to reduced congestion and improved air quality
- Support for sustainable development patterns and uses within station areas
- Economic development in the form of jobs, commercial development, and home construction
- Positive mobility impacts on low income and minority populations in New Hampshire
- Sustaining current industrial development in southern New Hampshire and supporting possible future growth in heavy industry

13 Preferred Intercity Rail Implementation and Finance

13.1 Implementation

The New Hampshire Capitol Corridor project was initiated to inform New Hampshire officials and interested stakeholders of the costs, benefits, requirements, and obligations associated with substantially expanding non-automotive passenger transportation services in the Route 3 corridor encompassing Nashua, Manchester, and Concord and linking them with Boston. The range of alternatives considered in the overall joint FRA/FTA project included intercity passenger rail service, extensions of existing MBTA commuter rail service, and enhancements to the existing express bus network that serves south central New Hampshire.

As the Study is complete, New Hampshire officials have made no decisions regarding which public transportation enhancement, if any, they are prepared to support and pursue at this time.

Should New Hampshire officials decide that they are interested in developing an intercity rail service, the Study and this SDP provides a "blueprint" for service design, infrastructure investment, likely ridership, revenues, and costs. The Study also provides full NEPA documentation. This collection of analyses together with the NEPA documentation poises the Intercity 8 project for implementation, provided that New Hampshire officials and the FRA identify a mutually attractive mechanism for project financing.

Should New Hampshire elect to develop the Intercity 8 eight-train-per-day intercity passenger rail service, they would need to notify Amtrak, PAR, and MBTA of their intention to develop and operate the service. It has been presumed that Amtrak would be the operator, but under some of the most recent federal passenger rail legislation it is possible that MBTA, PAR, or a third party could operate the service. Depending upon the selected operator, details concerning how PAR would be engaged in service operation would need to be identified and resolved. Under Amtrak operation, the model for PAR/Amtrak cooperation is found in the parallel *Downeaster* Corridor. Should MBTA be asked to operate the service, it already owns passenger rail trackage rights to Concord. The model for MBTA operation would include elements of its Pilgrim Partnership Agreement with Rhode Island and elements of its new seasonal Cape Flyer intercity service between Boston and Hyannis. It is also possible that PAR might elect to operate the service for NHDOT. These political and institutional considerations have not been fully explored in this Study.

It is likely that service implementation would involve the NHRTA. The NHRTA was legislatively created in 2007 as a mechanism to implement passenger rail service in the state, especially between Boston and Manchester and to stand as a liability buffer between the service and the state. It acts under a Memorandum of Understanding with NHDOT to promote passenger rail. The NHRTA was given bonding authority, but has no independent source of revenue that would allow it to issue (or retire) bonds that it might issue. The 28-member Board of Directors represents potential host communities and state government; new members are to be added if service expands to areas not already represented. It is notable that many, if not most, state-supported passenger rail services are operated through an independent authority rather than directly by the state DOT. Such authorities, among other considerations, provide a liability buffer between the railway operation and the state.

The Study team has conferred with NHDOT and the NHRTA concerning their potential roles in operating passenger rail service, but until funding is identified, no commitments have been made concerning the mechanism for management and oversight of the railway service. NHDOT and MassDOT have conferred extensively concerning their possible operation of passenger rail service in the state. Most of those discussions have focused on extensions of MBTA commuter rail service north into Manchester, but Massachusetts expressed willingness to cooperate with an intercity passenger rail service operated by others. Massachusetts in general is quite supportive of any new Boston-based rail services, including those that cross interstate borders.

PAR entered into an engineering agreement with NHDOT to help manage the Study and is working with MassDOT and Amtrak on the provision of new intercity passenger rail services elsewhere in New England. They have been generally supportive of the project and accommodating to the Study team.

13.2 Finance[33]

Implementation of intercity passenger rail service in the Capitol Corridor will require decisions about how to pay for the service. Two types of costs must be considered:

- Costs of implementing the new service – either via buying more rail cars, operating longer trains, or constructing new rail infrastructure; referred to as capital costs, these are incurred up-front, before revenue service can begin
- Costs to operate and maintain the service, referred to as O&M costs; these costs occur annually once service has begun

This portion of the SDP identifies different sources of funds that can be used to fund these two types of costs. All funding options focus on ways to leverage available federal funds. The federal funds of most interest are those considered "discretionary" in nature; in other words, they would not otherwise be available to New Hampshire for other purposes. The majority of discretionary federal funds are available to cover capital costs. To a far lesser extent, other types of federal dollars – so called "formula funds" – are available to pay for O&M. Receipt of federal funds is subject to a variety of eligibility rules, and most federal funds must be "matched" by state and/or local funds. A typical minimum non-federal match requirement is 20 percent, but many programs in practice require a 50 percent match for discretionary funds (20 percent is more typical of formula funding schemes).

Given the local match requirement, this assessment also identifies potential state and local sources of funds that could provide this match.

No recommendation on preferred sources of funds is made as part of this assessment. Each option identified and evaluated will be subject to more discussion and decision-making once an alternative is identified as the preferred project for detailed development and ultimate implementation.

13.3 Passenger Rail and Public Transportation Funding in the U.S.

To provide context for understanding how public surface transport projects are funded across the U.S., this section describes how other agencies have paid for new public transportation projects. A very broad range of funding sources is used to pay for the capital and O&M costs of projects across the country. As noted above, federal funds typically contribute a fairly large share of transit project capital costs; this section focuses on the non-federal (state/local) sources of funding typically used to match federal dollars.

13.3.1 Common Sources of State Funding

Most state transit funding comes from General Fund appropriations, or through traditional taxes and fees, such as motor fuel taxes, sales taxes, and vehicle fees. State transit funding provides both operating

[33] For more information on project finance, see Appendix 3 to the Capitol Corridor AA Final Report (Task 3 Financial Plan)

assistance and capital funds, but only a few states provide dedicated funding either for capital expenses (Arkansas, Idaho, Kentucky, and Nevada) or operating expenses (Maine, South Dakota, and Wisconsin).

13.3.2 Common Sources of Local Funding

Local transit funding is primarily provided through General Fund allocations, dedicated local option taxes and fees, and value capture mechanisms. Applying dedicated local taxes and value capture mechanisms for transit is dictated by enabling legislation that allows or restricts the use of these funding sources. Table 13.1 provides a description of common local funding options.

Table 13.1: Common Sources of Local Funding

Revenue Source	Popularity[34]	Comments
Sales tax	High	Dedicated sales tax rates typically range from 0.25 to 1.0 percent
Property tax	Medium	Some states provide enabling legislation that allows property tax revenues to be dedicated to public transport
Motor fuel tax	Low	Some local governments apply a tax on fuel to transportation
Vehicle fee	Medium-Low	Registration fees, driver license fees, car rental taxes, and tolls
Employer/payroll tax	Low	Taxes imposed directly on employers for the amount of gross payroll paid are not commonly applied at the local level
Utility tax/fee	Low	Mainly used for local roads and streets
Room/occupancy tax	Low	Typically dedicated to tourism or tourism-related facilities; can be tied to transportation investments needed to enhance visitor experience, mobility, and accessibility
General revenue	High	Funding provided by local governments for public transport services, whether through a jurisdiction’s annual budget or an appropriations process
Value capture mechanism	Medium-Low	Special types of “property taxes” targeted to capture the benefits of services that improve property development; typically low (less than five percent) yield relative to project cost
Impact fees	High	One-time charges to developers on new development; commonly used for roads, seldom for public transport
Tax Increment Financing	Medium-Low	Specific, common value capture mechanism; additional levies typically pledged to bonds issued to finance new transport services
Special assessment districts	Medium-Low	Another value capture mechanism; additional property taxes dedicated to new services for the district
Joint development	Medium-Low	Partnership between the rail agency and a private developer, commonly applied to TOD on land at or adjacent to train stations

13.3.3 Recent History in Passenger Rail Funding

To provide context for understanding how a passenger rail investment in the Capitol Corridor might be funded, information was assembled on eight new commuter or intercity rail systems that have opened in the U.S. over the past 15 years, as shown in Table 13.2.

[34] “Popularity” indicates how commonly used to finance major public transport investments like new passenger rail services

Table 13.2: New Commuter Rail Systems in the U.S. and Primary Capital Funding Sources

System	Location	Year Opened	Length (mi)	Federal	State	Local General	Sales Tax	Other Local
Sounder Commuter Rail	Puget Sound, WA	2000	33	●			●	●
Rail Runner Express	Albuquerque, NM	2006	97		●			
Music City Star	Nashville, TN	2006	32	●	●	●		
FrontRunner	Salt Lake City, UT	2008	44				●	
Northstar Line	Minneapolis, MN	2009	40	●	●	●		●
Capital MetroRail	Austin, TX	2010	32				●	
Westside Express Service	Portland, OR	2009	15	●		●		
A-Train	Denton County, TX	2011	21				●	●

Capital funding for these projects comes from a variety of sources. The most common source, used in half of the projects, is FTA Section 5309 New Starts funding, which accounted for an average of 43 percent of these projects' capital costs. One project, the Rail Runner Express extending between Albuquerque and Santa Fe, was funded entirely through state bonds backed by state road and highway revenues, including gasoline and diesel fuel taxes and federal highway aid. Local funding was more diverse: three systems used General Funds, mostly from local counties. Four projects used bonds backed by local sales taxes. Other local funding sources include a motor vehicle excise tax by Sounder Commuter Rail, and road tolls, which paid for 80 percent of the A-Train capital costs. The Northstar Line in Minneapolis received a contribution from the Minnesota Twins major league baseball team, helping to fund the terminal station next to Target Field.

For operating costs, local sales taxes are the most common primary source, used by six of the eight new rail systems: Sounder Commuter Rail (Puget Sound, Washington), Rail Runner Express (Albuquerque, New Mexico), FrontRunner (Salt Lake City, Utah), Northstar Line (Minneapolis, Minnesota), Capital MetroRail (Austin, Texas), and A-Train (Denton County, Texas). The Westside Express Service in Portland, OR is primarily funded through a payroll tax. Operating costs for the Music City Star in Nashville< Tennessee are primarily funded through federal grants and contributions from Metro Nashville.

It is also useful to consider how other passenger rail projects in the Northeast have been funded, particularly projects that represent extensions of MBTA's system. For projects wholly located within the Commonwealth of Massachusetts, funding for extensions has been provided by a mix of state and federal sources:

- Extension of peak-period commuter rail service from Framingham to Worcester was completed in 1994 and paid for with MBTA funds. Off-peak service was added in 1996, and a number of infill stations were added in 2000 and 2002 with no federal contribution.
- The 27.6-mile Greenbush Line to Scituate was a state air quality commitment project that opened for service in 2007. The $534 million project was also paid for with MBTA funds (no federal contribution).
- Half of the capital costs of improvements to the Fitchburg commuter rail line were paid for with an FTA Section 5309 Small Starts grant; the other half was paid for by state transportation bond proceeds. A 4.5 mile extension to a new Wachusett station was paid for by a USDOT

Transportation Investment Generating Economic Recovery (TIGER) grant (see Appendix 3 to the AA Final Report). Construction is underway with completion expected in 2015.

Intercity passenger rail service between Portland, Maine and Boston was restored in 2001. The construction cost of approximately $66 million was paid for by Congressional appropriations matched by state and local sources. Today, operation of the service is paid for through fares, which account for just under 50 percent of operating costs, federal funds allocated to operations, an annual subsidy from Maine of approximately $8 million, and an in-kind contribution from Massachusetts consisting of trackage rights. New Hampshire, which has three *Downeaster* stations in Exeter, Durham-UNH, and Dover, does not contribute financially.

Extensions of MBTA service south into Rhode Island have been implemented in accordance with the "Pilgrim Partnership," a 1989 cooperative agreement between the MBTA and Rhode Island Department of Transportation (RIDOT). These have included extension of MBTA commuter rail service to Providence, which was funded by RIDOT in part with "earmarks" in transportation appropriation bills (transportation earmarks have subsequently been prohibited by federal law) and state funds. In exchange for operation of the service by MBTA, RIDOT conveys its portion of federal formula funds to MBTA. Extension further south to Wickford Junction was paid for by an FTA Section 5309 Small Starts grant (50 percent of capital costs) and the remainder with a mixture of federal formula funds and state bonds.

In all cases, both nationally and in the Northeast, state sources of funding have been an integral part of each project's financial plan, including both construction and ongoing operations.

13.4 Annual Funding Needs

This section reviews the capital and O&M costs needed to construct and operate the Intercity 8 option. Capital and O&M costs were estimated in 2014 dollars.

A four-year construction period is assumed, beginning in 2019. The annual O&M costs for each alternative were also estimated based on costs for similar services provided elsewhere in New England.[35]

- Capital Costs (2014): $256.5 million
- Capital Costs (Year-of-Expenditure): $316.9 million
- Annual O&M Costs: $7.7 million

[35] See Section 11: Forecast Operating Costs and Revenues for more details

13.5 Federal Funding Sources

This section describes the sources of federal funding that might be used to help pay for intercity passenger rail service in the Capitol Corridor. A key objective of any Capitol Corridor project financial plan will be to leverage federal sources to the greatest extent possible

13.5.1 Federal Funding Sources and Financing Tools

Within the USDOT, the FRA administers the Railroad Rehabilitation and Improvement Financing (RRIF) program, which can be used for passenger rail projects, and in the past it has provided capital funding through the High-Speed Intercity Passenger Rail (HSIPR) program. The FTA administers the primary funding programs available for public transportation investment. It has funded intercity passenger rail programs, most notably the *Downeaster* service running between North Station in Boston and Brunswick, Maine. The FHWA administers some federal-aid highway programs with flexible provisions that allow the transfer of funds for public transportation investments.

In addition, federal finance tools are available that can be used to advance project implementation by leveraging future revenue streams of dedicated funding.

This section summarizes potential federal funding and financing tools and their eligibility to fund Intercity 8 option. Examples of other projects that have used these sources as part of their funding plan are identified. Table 13.3 provides a high-level summary of the possible federal funding sources and tools discussed in this section.

Table 13.3: Federal Funding Sources and Tools

Funding Source	Capital, O&M, Both	Eligible Modes	Comments
FHWA Congestion Mitigation and Air Quality Improvement Program (CMAQ)	Both	Commuter Rail Intercity Rail Intercity Bus	Flex
FRA HSIPR	Capital	Intercity Rail	No funding currently available
USDOT TIGER	Capital	Commuter Rail Intercity Rail	No funding currently available
USDOT Transportation Infrastructure Finance and Innovation Act (TIFIA)	Capital	Intercity Rail Commuter Rail Intercity Bus	Loan Program
FRA RRIF	Capital	Intercity Rail Commuter Rail	Loan Program

13.5.2 FHWA Congestion Mitigation and Air Quality Improvement Program

The FHWA CMAQ program funds transit system capital expansion and improvements projected to realize an increase in ridership, travel demand management strategies and shared ride services, and pedestrian and bicycle facilities. Projects must have a transportation focus, reduce air emissions, and be located in or benefit an air quality nonattainment or maintenance area. Funding is distributed based on a formula that considers the severity of air quality problems. The federal share is 80 percent for most CMAQ projects.

In FY2013, New Hampshire received $10.3 million in CMAQ funds. Using these funds for a project in the Capitol Corridor would require reallocation of some portion of the total New Hampshire apportionment. Under current rules, CMAQ funds can be used for the project's capital expenses, as well as operating costs, for a limited period of time. Operating assistance is limited to certain activities, including new transit, commuter, and intercity passenger rail services. Under the Moving Ahead for Progress in the 21st Century (MAP-21) Act, the operating funding period was extended from three to five years.

13.5.3 FRA Discretionary Programs

FRA occasionally makes funding available through discretionary programs that provide grants to eligible projects through a competitive application process. For example, the HSIPR was created to make investments in a network of passenger rail corridors across the country. The program's objectives are to build new high-speed rail corridors, upgrade existing intercity passenger rail corridors, and lay the groundwork for future high-speed rail services through planning efforts. More than $10 billion in grant funding was provided after the enactment of the program through the Passenger Rail Investment and Improvement Act (PRIIA) of 2008, including a FY2010 grant of $2 million to the Capitol Corridor for engineering and environmental analysis. The program was highly competitive, with over $75 billion in total funding requests from 39 states, Washington D.C., and Amtrak. While the program is not currently funded and no new funding appears to be likely in the near-term (thus no applications are being accepted), the intercity rail alternative could be eligible for future grant solicitations should additional funding be allocated.

13.5.4 USDOT Transportation Investment Generating Economic Recovery (TIGER)

Another discretionary funding source is USDOT's TIGER program. Competitive grant applications are solicited on a periodic basis; there have been six rounds of funding since 2009, providing $4.1 billion to eligible road, rail, transit, and port projects. Rail and transit projects awarded TIGER funding have accounted for more than 40 percent of total awards to date. The average award for transit projects was $17.6 million. The last round of awards was announced in September 2014. Should another round of funding be made available, the commuter rail and intercity alternatives could be eligible projects.

13.5.5 USDOT Transportation Infrastructure Finance and Innovation Act (TIFIA)

The TIFIA program is a credit assistance program administered by USDOT providing direct loans, loan guarantees, and standby lines of credit. Surface transportation projects that cost $50 million or more are eligible, including those for state and local governments, transit agencies, railroad companies, special authorities, special districts, and private entities. Any transit project eligible for grant assistance under the transit title of the U.S. Code (chapter 53 of 49 U.S.C.) and intercity bus vehicles and facilities are eligible for TIFIA credit assistance. In addition, rail projects involving the design and construction of intercity passenger rail facilities or the procurement of intercity passenger rail vehicles are also eligible. The TIFIA loan or loan guarantee amount should not exceed 49 percent of eligible costs; for standby lines of credit, the limit is 33 percent of the project costs. Dedicated revenues for repayment are required. Tax revenues, including sales taxes, are a common revenue pledge for TIFIA. A total of $1.0 billion was authorized for this program in 2014.

13.5.6 FRA Railroad Rehabilitation and Improvement Financing (RRIF) Program

The RRIF is an FRA loan program enacted under the Transportation Equity Act for the 21st Century (TEA-21) that provides direct federal loans and loan guarantees to finance development of railroad infrastructure. Eligible applicants are railroads, state and local governments, government-sponsored authorities and corporations, joint ventures that include at least one railroad, and limited option freight shippers who intend to construct a new rail connection. Loans can cover up to 100 percent of project costs with interest rates equal to U.S. Treasury rates. The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) made amendments to the program; no changes were included in MAP-21. There have been few RRIF loans: Out of $35 billion in authorized funds, only $1.7 billion in loans have been awarded through FY2012. Reasons for the program's underutilization include that unlike TIFIA, there is no federal subsidy; therefore, costs associated with FRA's review of the RRIF loan application are covered by the applicants. In addition to this investigative fee, the applicant also pays a credit risk premium unless collateral is provided. Other issues include long loan processing times and the perception that applicants bear the full risk of default.

Eligible projects include acquisition, improvement, or rehabilitation of intermodal or rail equipment or facilities; refinancing existing debt incurred for the purposes above; or developing or establishing new intermodal or railroad facilities. The NNEPRA, which operates the *Downeaster* passenger rail service between Brunswick and Boston, was approved for a RRIF loan in 2009, but this was foregone in favor of HSIPR grant funding awarded for the project.

13.6 Non-Federal Match Options for New Hampshire Services

This section reviews possible options for providing non-federal match for a transportation service investment along the NHML. These options were narrowed down from the longer list above, since some of the most commonly used sources of local funding are not available in New Hampshire. These include dedicated sales tax revenues (which is the most common source of local match in the U.S.), payroll taxes, and fuel taxes.

New Hampshire does not impose any sales or payroll taxes, and it assumed that they would not be implemented solely for a project on the NHML. Fuel taxes are constitutionally restricted in New Hampshire for use on construction, reconstruction, and maintenance of public highways.[36] Because of this, a rail project on the NHML would be ineligible for this source of funds, and a change to the constitution is not perceived to be possible.

For each funding option discussed below and summarized in Table 13.4, a definition is first provided, followed by an assessment of the feasibility and potential revenue estimate for each source. Ratings for feasibility reflect an assessment of 1) whether the source currently exists in New Hampshire; 2) whether

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[36] Part II, Article 6-a of the New Hampshire Constitution

transit is an eligible expenditure for the funding source; 3) the extent of likely support for the source; and 4) actions (e.g., legislative) that would be required for use of the source as part of the project's financial plan to cover costs.

The amount of revenue that might be generated from each source also is estimated. Each estimated yield is subject to change with alternative input assumptions and charge rates. The range of annual yield rating estimates are greater than $5 million = High; $1-$5 million = Medium; less than $1 million = Low. Table 13.4 summarizes the funding options. In general, each of the feasible funding sources will require significant effort and commitment to implement. As potential sources are evaluated, it will be important to consider the level of required effort in the context of likely yield. While revenue estimates are provided for all options, sources with low feasibility are unlikely to be available given significant implementation challenges, and are not considered as part of potential funding approaches.

Table 13.4: Summary of Funding Options for Intercity 8

Funding Source	Feasibility	Yield	Annual Estimate (In Millions)	Comments
NH State Capital Program	High	High	$10.0	7.6% of 2014 debt payment (principal + interest)
NH Parking Fees	High	Low	$0.7	Based on $4.00 per day parking fee
Vehicle Registration Fees	Medium	High	$5.9	$5.00 fee on passenger vehicles and trucks statewide
Municipal Contribution	Medium	Medium	$1.0-3.0	$1 million/city with new stations; city discretion regarding source
Regional Greenhouse Gas Initiative (RGGI)	Medium	Low	$0.5	Based on historical awards
Property Tax	Low	High	$15.7	0.1 mill applied statewide
Lottery Revenues	Low	Medium	$3.7	5% of net proceeds
Passenger Facility Charges	Low	Medium	$1.0	½ of $1.50 passenger facility charge (PFC) increase beginning in 2016
Value Capture	Low	Low	--	Need more study to estimate

13.6.1 New Hampshire State Capital Program

New Hampshire State (Legislature/Governor) approves a capital budget every two years. The last approved budget, for 2014-2015, was $219.4 million (for all projects, including highways, which are paid for with restricted revenues, i.e., fuel tax and highway user fees). The next cycle to approve the budget is initiated in the fall (projects are submitted by November 15). The budget is approved on February 15th of odd numbered years (i.e., the next budget will be approved in February 2015).

The most recent budget included bond authority for the entire cost of the capital program ($219.4 million). Of this, $128.7 million are for projects funded with bonds that are repaid with unrestricted General Fund revenues.

For NHDOT, bonds for highway projects are repaid with highway revenues (restricted). The capital budget included $2.2 million in General Fund bonds for NHDOT's Aeronautics, Rail and Transit Division. The proceeds provide matching funds to Federal Aviation Administration (FAA) and FTA grants.

As of June 2013, the state had $963.2 million in outstanding general obligation debt, including bonds for highways and the University of New Hampshire.

Feasibility	***Yield***
▪ Existing source of funding for state capital investments through bonds repaid with unrestricted General Funds ▪ Currently providing matching funds to federal grants for NHDOT's Aeronautics, Rail and Transit Division ▪ Governor/Legislature support required ▪ Only for capital expenses	▪ Would need to assess feasibility of fully or partially providing Capitol Corridor project capital funding needs through the State Capital Program, while maintaining reasonable debt-to-state revenue ratios ▪ The largest single funding allocation from bond proceeds in recent years was for $38 million, which is less than 15 percent of total funding needed for most costly alternatives ▪ Assumes an annual allocation of $10 million in unrestricted General Funds to repay bonds issued through the capital budget to pay for construction of the selected alternative; at the current debt service level (FY2014 = $132.2 million), $10 million represents about 7.6 percent of unrestricted General Fund revenues required to repay bonds

13.6.2 Parking Fees

New parking facilities associated with the alternatives could generate funding to support O&M expenditures. Only the rail alternatives include planned new parking, so this potential revenue source is not available for the bus alternatives.

The methodology to estimate revenues is based on parking occupancy and the number of vehicles that use the parking facility in an average day. If most travel is work-related, chances are that most parking spaces are occupied by a single vehicle any given day, and the parking turnover rate would be low.

Feasibility	***Yield***
▪ Parking at rail stations will be provided, so parking would be considered a future available source for funding	▪ Based on data provided by Jacobs Engineering, an estimated 470 to 925 parking spaces would available at planned commuter and intercity rail park-and-ride lots, depending on the alternative; if fully occupied 240 days per year, with a per-day parking fee of $4.00, parking revenues would total between $0.5 million and $0.9 million annually; a midrange of parking yields $0.7 million annually; for comparison, most MBTA commuter rail park-and-ride facilities charge $4.00 per day; in Lowell, garage parking is priced at $5.00 per day

This fee could be extended to other park-and-ride facilities, specifically those used by riders of intercity bus service between New Hampshire and Boston.

13.6.3 Vehicle Registration Fees

New Hampshire currently collects vehicle registration fees at the state and local level that vary by type, size, value, and age of the vehicle. State fees are restricted to use on highways, but municipalities have more latitude on the use of at least a portion of their revenue.

Feasibility	***Yield***
▪ Changes to registration fees would require legislative action to modify Section 261:141 (Registration Fees)[37] and/or Section 261:153 (Municipal Permits for Registration)[38] of Title XXI (Motor Vehicles) in the state statutes ▪ State-level registration fees are constitutionally restricted to be used for construction and maintenance of public highways,[39] while local-level fees have a broader range of uses ▪ Fees are assumed to be applied statewide	▪ In 2011, nearly 840,000 passenger vehicle registrations and 334,000 truck registrations were processed in New Hampshire;[40] assuming a $5.00 fee statewide translates to approximately $5.9 million annually ▪ This yield assumes a small statewide increase; other assumptions could be made, including geographies covered – i.e., only the municipalities served by the project in the Capitol Corridor – and fee rates

13.6.4 Municipal Contributions

Cities often help pay for implementation and/or ongoing O&M of transit projects, particularly cities that receive a substantial new station that generates accessibility benefits and increases in development opportunities and property values. For this assessment, it is assumed that only cities that will have rail stations – Nashua, Manchester, and Concord, depending on the alternative – could make an annual contribution.

Feasibility	***Yield***
▪ Cities would have the flexibility to identify their own sources of revenue, whether an existing source or a new source associated more directly with the project, such as a tax increment financing district or some other value capture mechanism	▪ For purposes of this assessment, it is assumed that Nashua, Manchester, and Concord would contribute (e.g., $1 million annually) depending on the alternative/whether it includes a rail station in the municipality

[37] http://www.gencourt.state.nh.us/rsa/html/XXI/261/261-141.htm
[38] http://www.gencourt.state.nh.us/rsa/html/XXI/261/261-153.htm
[39] Part II, Article 6-a of the New Hampshire Constitution
[40] https://www.nh.gov/safety/documents/2011-annual-report.pdf

13.6.5 Regional Greenhouse Gas Initiative

Proceeds from the auction of RGGI emissions allowances in New Hampshire go to the Greenhouse Gas Emissions Reduction (GHGER) Fund. Ten percent of funds are set aside for a low-income residential energy reduction program; the remainder is awarded in grants through a Request for Proposal (RFP) process focused on electric and fossil fuel energy efficiency programs. A list of eligible programs includes nothing transportation-related, only buildings, although the list indicates eligibility is not limited to that list.[41]

As of 2013, New Hampshire had received more than $57 million in allowance auction revenues over five years.[42] Grant awards have ranged from as little as $8,000 to as much as $5 million.

No New Hampshire transportation project has yet been awarded grants from the GHGER Fund. In the 10 states participating in RGGI, one percent of CO_2 allowance proceeds have been used "for a wide variety of greenhouse gas reduction programs, including programs to promote the development of carbon emission abatement technologies, efforts to reduce vehicle miles traveled, and programs to increase carbon sequestration." Therefore, there is some precedent in at least one of these states to use these funds for a transportation project.

Feasibility	***Yield***
▪ Use of RGGI proceeds for transit improvements in the Capitol Corridor would need to be confirmed	▪ For the purposes of this assessment, it is assumed that a project in the Capitol Corridor could receive annual grants of the same order of magnitude of historical grant awards through this program, or approximately one-half million per year

41 https://www.puc.nh.gov/SustainableEnergy/GHGERF.htm
42 http://www.rggi.org/docs/Investment_of_RGGI_Allowance_Proceeds.pdf

13.6.6 Property Tax

Four types of property taxes are assessed in New Hampshire: town tax, local education tax, state education tax, and county tax. Property taxes are a common source of funding for transit projects in the U.S.

Feasibility	***Yield***
▪ Major existing local source of revenue ▪ Currently, all state-levied property taxes are dedicated to education; using this revenue source for the Capitol Corridor would require legislative action	▪ In 2012, total assessed property value in New Hampshire was $156.6 billion;[43] the weighted statewide average of property tax rates was 20.71 mill ▪ Applying a tax rate of 0.1 mill (10 cents per $1,000 in assessed value) would generate approximately $15.7 million per year

13.6.7 Lottery Revenues

New Hampshire has the oldest legal lottery in the U.S. The state participates or hosts a variety of lottery games, including scratch tickets and draw games.

Feasibility	***Yield***
▪ Currently, all net lottery revenues in New Hampshire are dedicated to the state education fund ▪ A new lottery game dedicated to the Capitol Corridor or more broadly for transportation use would likely be needed, rather than diverting revenues from existing games; in either case, legislative action would be required	▪ Lottery revenues in New Hampshire, net of prizes and administrative expenses, totaled $74.3 million in 2013 ▪ Five percent applied to a Corridor project would result in $3.7 million per year

13.6.8 Passenger Facility Charges

Manchester Airport currently collects the maximum $4.50 per enplanement PFC. Eligible projects include those improvements related to enhancing airport safety, capacity, security, and environmental concerns. Under its current approvals, the airport is authorized to collect PFC through November 2022.

In the near-term, PFC revenues at the $4.50 level are fully committed, including payments to debt service on outstanding bonds, approved pay-as-you-go projects for which the airport has not yet reimbursed itself, and additional projects identified in the Capital Improvement Program.

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[43] New Hampshire Department of Revenue Administration

Feasibility	Yield
▪ In the current FAA reauthorization proposals, the cap on PFC levels may be raised beyond the $4.50 level to provide additional funding available outside of FAA's Airport Improvement Program (AIP); beginning in FY2016, the airport is assumed to increase its PFC level to $6.00 and additional collections are assumed to be used on a pay-as-you-go basis for future projects[44] ▪ It appears possible, but difficult, for a transit project to use this funding source given restrictions on project eligibility and the existing cap on PFC levels; if an eligible project could be developed, negotiations would be needed with the airport and FAA to include it in the airport's future capital plan	▪ Enplanements have fallen since their 2.2 million peak in 2006, and totaled 1.36 million in 2011;[45] an additional $1.50 PFC would create an estimated $2 million annually; if half of this increment could be directed towards a corridor project, then this would provide $1 million annually to the project pending eligibility considerations

13.6.9 Value Capture

Value capture includes revenue mechanisms such as impact fees, tax increment financing, and special assessment districts. Without specifics on future development and potential development to result from implementation of new transit corridor service, it is difficult to generate estimates for impact fees or tax increment financing. An option is to estimate how much revenue could be generated through a special assessment district. Data needs/basic assumptions (for special assessment district example) include the following:

- Taxable property values in the cities/towns served by each corridor alternative (New Hampshire Department of Revenue), or within some agreed upon distance from the corridor and/or station locations
- Historical trends on property value growth
- Property tax rate
- Alternatively, calculate tax rate, based on capital and O&M needs

It should be noted that changes in development patterns and property values take time – and often considerable time – to be realized based in large part on market conditions and demand. Therefore, value capture would not be a near-term source of revenue for the Intercity 8 project.

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[44] http://www.flymanchester.com/sites/default/files/public-documents/ManchesterAirportMasterPlanUpdate.pdf
[45] http://www.flymanchester.com/sites/default/files/statistics/MHTEnplanements2000-2012.pdf

13.6.10 Fares

The O&M costs for Intercity 8 will be offset by the fares collected from riders. The Study team estimates that the Intercity 8 service would cover approximately 40 percent of its operating costs from fare revenues (Table 13.5).

Table 13.5: Annual Fare Revenue and Farebox Recovery Ratio (2012$)

Annual O&M Cost (A)	$7.7 million
Fare Revenue (B)	$3.2 million
Required Operating Support (A-B)	$4.5 million
Farebox Recovery Ratio (A-B)/A	41 percent

14 Summary

While final decisions on any major public transportation investment on the NHML will necessarily incorporate a broad range of considerations including benefits and impacts, the ability to identify stable and reliable sources of revenue will be critical to the advancement of passenger rail service in the Capitol Corridor. Leveraging available discretionary federal funds will be a key objective of any future funding plan.

This section summarized key findings regarding the potential to leverage federal funds for Intercity 8. Suggestions were also provided on other sources of potential revenue to provide match for federal funds. Any new source of revenue to help pay for a new intercity passenger rail service will be subject to considerable review and input by New Hampshire officials and corridor stakeholders.

Intercity 8 would rely on federal programs, namely FRA's HSIPR Program. However, the HSIPR currently has no funding available. For purposes of this assessment, it is assumed that half pf the capital costs of the project might be paid for by a future HSIPR appropriation. With Intercity 8 being the most costly project considered and with the considerable uncertainty regarding available federal funding, this alternative likely would place a high burden on other state sources. Local sources of funding could include CMAQ, parking revenue, and contributions for the three municipalities with stations (Nashua, Manchester, and Concord).

To help understand what this might mean in terms of an annual "bill" to New Hampshire for Intercity 8, debt service is calculated for the New Hampshire share of capital costs as well as construction payments made in advance of receipt of FTA funds. This annual debt service, which lasts only for the period of the bonds issued, is then added to the annual operating cost for Intercity 8, net of fares. The annual debt service must be viewed as a best case, since agreements with Massachusetts on cost sharing arrangements are subject to additional discussion and negotiation.

Table 14.1 is a summary of the Intercity 8 Financial Assessment. All numbers are subject to change as additional work and coordination with potential funding partners is advanced.

Table 14.1: Intercity 8 Financial Assessment Summary (In Millions)

Infrastructure Cost	$233.2
Rolling Stock Cost	$23.3
Total Project Value	**$256.5**
Potential Federal Grant	$128.2**
New Hampshire Share (after federal contributions)	**$128.2**
Annual Payment to Retire NH Share[46]	$10.3
Annual Operating Cost	$7.7
Annual Passenger Revenue	$3.2
Required Operating Support	$4.5
Annual NH Cost	**$14.8**

**Note: Capital costs are in 2014$ and operating costs are based on 2012$ unit costs. Ridership and fare rates are current to 2014. Therefore, estimates of operating costs and required support may vary when operating unit costs become available for 2014$.*
*** Assumes that 50% of capital funds are provided under FRA's HSIPR program*

[46] Assumes 20-year bonds at five percent to retire the state/local match; short-term financing to cover lags in the federal reimbursement process during the construction process is not included in this estimate; the interest on the short term debt at three percent per annum to cover a $128.2 million grant would average approximately $1.9 million per year over a four-year construction period

Appendix A: Intercity 8 Rail Service Option Schedule

Figure A.1: Intercity 8 Rail Service Option Schedule

New Hampshire Main Line: Proposed ***Intercity 8*** *Service Schedule Class IV*

READ DOWN		302	304	352	306	208	680	308	380	310	212	356	312	358	314	682	316	318	382	320	322	222
Concord NH	73.3								6:39										10:39			
Manchester NH	55.7								6:58										10:58			
MHT (Bedford)	50.1								7:07										11:07			
Nashua Crown St	39.0								7:20										11:20			
South Nashua	35.2								#N/A										#N/A			
Lowell	25.5	5:35	6:18		6:51			7:18	7:36	7:46			8:25		9:15		10:15	11:15	11:36	12:15	13:15	
North Billerica	21.8	5:43	6:26		6:59			7:26	#N/A	7:54			8:33		9:23		10:23	11:23	#N/A	12:23	13:23	
Wilmington	15.2	5:51	6:34		7:06	7:22		#N/A	#N/A	#N/A	8:07		8:41		9:31		10:31	11:31	#N/A	12:31	13:31	13:37
Anderson/ Woburn	12.6	5:55	6:38	6:55	7:13	#N/A	7:31	7:38	7:52	8:05	8:12	8:30	8:45	9:15	9:35	10:04	10:35	11:35	11:52	12:35	13:35	13:43
Winchester Center	7.8	6:02	6:46	7:04	7:21	#N/A	#N/A	7:46	#N/A	#N/A	8:20	8:39	8:52	9:23	9:42	#N/A	10:42	11:42	#N/A	12:42	13:42	13:50
Wedgemere	7.3	6:04	6:49	7:06	7:24	#N/A	#N/A	7:49	#N/A	#N/A	8:23	8:41	8:54	9:26	9:44	#N/A	10:44	11:44	#N/A	12:44	13:44	13:52
West Medford	5.5	6:08	6:53	7:10	7:28	#N/A	#N/A	7:53	#N/A	#N/A	8:27	8:45	8:58	9:30	9:48	#N/A	10:48	11:48	#N/A	12:48	13:48	13:56
North Station	0.0	6:22	7:05	7:22	7:40	7:48	7:55	8:05	8:15	8:26	8:39	8:57	9:10	9:42	9:59	10:30	10:59	11:59	12:15	12:59	13:59	14:07

READ DOWN		324	684	326	384	686	360	232	330	334	336	DH333	236	338	340	342	#REF!	386	344	346	DH345	DH347
Concord NH	73.3				10:39													10:39				
Manchester NH	55.7				10:58													10:58				
MHT (Bedford)	50.1				11:07													11:07				
Nashua Crown St	39.0				11:20													11:20				
South Nashua	35.2				#N/A													#N/A				
Lowell	25.5	14:15		15:15	11:36				17:10	17:45	18:20	18:10		18:55	19:25	20:30		11:36	21:30	22:35	23:34	1:04
North Billerica	21.8	14:23		15:23	#N/A				17:18	17:53	#N/A	18:18		19:03	19:33	20:38		#N/A	21:38	22:43	#N/A	#N/A
Wilmington	15.2	14:31		15:31	#N/A				17:26	18:01	#N/A	18:26	19:00	19:11	19:41	20:46		#N/A	21:46	22:51	#N/A	#N/A
Anderson/ Woburn	12.6	14:35	14:54	15:35	11:52	16:39	16:55	17:11	17:30	18:05	#N/A	18:30	19:04	19:15	19:45	20:50	20:59	11:52	21:50	22:55	#N/A	#N/A
Winchester Center	7.8	14:42	#N/A	15:42	#N/A	#N/A	#N/A	#N/A	17:37	18:12	#N/A	18:37	#N/A	19:22	19:52	20:57	#N/A	#N/A	21:57	23:02	#N/A	#N/A
Wedgemere	7.3	14:44	#N/A	15:44	#N/A	#N/A	#N/A	#N/A	17:39	18:14	#N/A	18:39	#N/A	19:24	19:54	20:59	#N/A	#N/A	21:59	23:04	#N/A	#N/A
West Medford	5.5	14:48	#N/A	15:48	#N/A	#N/A	#N/A	#N/A	17:43	18:18	#N/A	18:43	#N/A	19:28	19:58	21:03	#N/A	#N/A	22:03	23:08	#N/A	#N/A
North Station	0.0	14:59	15:15	15:59	12:15	17:05	17:15	17:32	17:56	18:31	19:00	18:54	19:25	19:41	20:09	21:14	21:20	12:15	22:14	23:20	0:14	1:44

READ UP		3801	3803	301	3805	351	305	307	355	309	381	357	681	311	315	317	683	383	319	321	323
Concord NH	73.3										9:59							14:14			
Manchester NH	55.7										9:38							13:53			
MHT (Bedford)	52.0										9:30							13:45			
Nashua Crown St	39.0										9:17							13:32			
South Nashua	35.2										#N/A							#N/A			
Lowell	25.5	5:20	6:03	6:29	7:00		7:30	8:11		8:56	9:02			9:54	10:54	11:54		13:17	12:54	13:54	14:54
North Billerica	21.8	#N/A	#N/A	6:22	#N/A		7:21	8:02		8:47	#N/A			9:47	10:47	11:47		#N/A	12:47	13:47	14:47
Wilmington	15.2	#N/A	#N/A	6:14	#N/A		7:13	7:54		8:39	#N/A			9:39	10:39	11:39		#N/A	12:39	13:39	14:39
Anderson/ Woburn	12.6	#N/A	#N/A	6:10	#N/A	6:45	7:08	7:50	8:17	8:35	8:46	9:02	9:23	9:35	10:35	11:35	11:53	13:01	12:35	13:35	14:35
Winchester Center	7.8	#N/A	#N/A	6:03	#N/A	#N/A	7:01	7:43	#N/A	8:28	#N/A	#N/A	#N/A	9:28	10:28	11:28	#N/A	#N/A	12:28	13:28	14:28
Wedgemere	7.3	#N/A	#N/A	6:01	#N/A	#N/A	#N/A	7:41	#N/A	8:26	#N/A	#N/A	#N/A	9:26	10:26	11:26	#N/A	#N/A	12:26	13:26	14:26
West Medford	5.5	#N/A	#N/A	5:57	#N/A	#N/A	6:57	7:37	#N/A	8:22	#N/A	#N/A	#N/A	9:22	10:22	11:22	#N/A	#N/A	12:22	13:22	14:22
North Station	0.0	4:40	5:23	5:45	6:20	6:25	6:45	7:25	7:55	8:10	8:30	8:40	9:05	9:10	10:10	11:10	11:35	12:45	12:10	13:10	14:10

READ UP		325	327	359	359	685	331	385	333	335	337	687	237	339	341	343	387	345	689	347
Concord NH	73.3							18:49									23:29			
Manchester NH	55.7							18:28									23:08			
MHT (Bedford)	52.0							18:20									23:00			
Nashua Crown St	39.0							18:07									22:47			
South Nashua	35.2							#N/A									#N/A			
Lowell	25.5	15:54	16:58		17:31		17:59	17:52	18:10	18:39	19:12			20:15	21:14	22:24	22:32	23:24		0:54
North Billerica	21.8	15:47	16:51		17:21		17:52	#N/A	18:03	18:32	19:05			20:08	21:07	22:17	#N/A	23:17		0:47
Wilmington	15.2	15:39	16:43		17:13		17:43	#N/A	17:55	18:23	18:57		19:23	20:00	21:00	22:09	#N/A	23:09		0:39
Anderson/ Woburn	12.6	15:35	16:38	16:45	17:08	17:18	17:38	17:36	17:50	18:18	18:52	19:03	19:19	19:55	20:55	22:05	22:16	23:05	23:18	0:35
Winchester Center	7.8	15:28	16:30	16:38	17:00	#N/A	17:30	#N/A	#N/A	18:10	18:44	#N/A	19:12	19:48	20:48	21:58	#N/A	22:58	#N/A	0:28
Wedgemere	7.3	15:26	16:27	16:36	16:57	#N/A	17:27	#N/A	#N/A	18:07	18:41	#N/A	19:10	19:46	20:46	21:56	#N/A	22:56	#N/A	0:26
West Medford	5.5	15:22	16:23	16:32	16:53	#N/A	17:23	#N/A	#N/A	18:03	18:37	#N/A	19:06	19:42	20:42	21:52	#N/A	22:52	#N/A	0:22
North Station	0.0	15:10	16:10	16:20	16:40	17:00	17:10	17:20	17:30	17:50	18:25	18:45	18:55	19:30	20:30	21:40	22:00	22:40	23:00	0:10

Appendix B: Detailed Cost Estimates of Stations

Table B.1: Cost Factors Used to Calculate Proposed Station Capital Costs

Description	Materials			Material Cost Total	Labor		Total Direct Cost	Allocation Factor	Calculated Unit Cost
	Quantity	Units*	Unit Costs		Man-Hrs	Cost ($)			
SITE WORK									
Remove & Dispose Existing Pavement	1,988	SY		-	95	$33,987	$33,987	0	$0
Remove & Stock Curbing	160	LF		-	85	$2,040	$2,040	0	$0
Clearing & Grubbing	3.17	Acre		-	85	$4,311	$4,311	Half-fixed, half-variable based on parking spaces	$2,156 + $6 per space
Cut, Cap, & Abandon Monitoring Well	2	EA		-	85	$340	$340	1 if contaminated, 0 if not	$340
Site Preparation – Remove & Dispose of Boulders	4	EA	$50.00	$200.00	110	$880	$1,080	0	$0
Cleaning & Sweeping Roadway	109	HR		-	120	$13,080	$13,080	Unit	$13,080
Water for Dust Control	44,500	GL	$0.04	$1,780.00	85	-	$1,780	Unit	$1,780
Erosion Control System (Straw Bale & Silt Fence)	4,677	LF	$1.00	$4,677.00	72	$15,153	$19,830	Unit	$19,830
Silt Sack	23	EA	$100.00	$2,300.00	72	$1,656	$3,956	Unit	$3,956
Mobilization & Demobilization for Bulk Excavation	1	LS	$6,000.00	$6,000.00	110	-	$6,000	Unit	$6,000
Unclassified Excavation	18,768	CY		-	110	$92,902	$92,902	Unit	$92,902
Unclassified Excavation – Handling & Off-Site Disposal	22,800	TN	$18.00	$410,400.00	110	-	$410,400	1 if contaminated, 0 if not	$410,400
Dispose of Contaminated Soil at In-State Lined Landfill	630	TN	$35.00	$22,050.00	110	$3,119	$25,169	1 if contaminated, 0 if not	$25,169
Dispose of Contaminated Soil at In-State Recycling Facility	630	TN	$75.00	$47,250.00	110	$3,119	$50,369	1 if contaminated, 0 if not	$50,369
Rock Excavation	1,632	CY		-	110	$31,416	$31,416	Unit	$31,416
Rock Excavation – Haul & Disposal	2,203	TN	$15.00	$33,048.00	110	-	$33,048	Half-fixed, half-variable based on parking spaces	$16,524 + $46 per space
Soils Testing Services (LSP, Licensed Site Professional)	364	HR		-	110	$40,040	$40,040	Half-fixed, half-variable based on parking spaces	$20,020 + $56 per space
Soil Sampling & Testing (Assume 50-ft Grid)	146	EA	$180.00	$26,280.00	150	-	$26,280	Half-fixed, half-variable based on parking spaces	$13,140 + $37 per space
Grading	364,800	SF		-	85	$124,032	$124,032	Half-fixed, half-variable based on parking spaces	$62,016 + $172 per space
Ordinary Fill (Processed Gravel)	14,540	CY	$0.80	$11,632.00	110	$151,943	$163,575	Half-fixed, half-variable based on parking spaces	$81,788 + $227 per space
Crushed Stone – Platform	50	CY	$30.00	$1,500.00	110	$880	$2,380	Half-fixed, half-variable based on parking spaces	$1,190 + $3 per space
Wetland Replication Area	3,000	SF	$6.00	$18,945.00	85	$11,820	$30,765	Square feet of wetlands	$10.26
Subtotal				$586,062.00	5,325	$530,718	$1,116,780		
Subtotal Retaining Walls				$943,440.00		$1,265,872	$2,209,316	Based on site	$220,932
Subtotal Drainage				$204,092.00	2,301	$198,634	$402,726	Half fixed half variable based on parking spaces	$201,363 + $559 per space
Subtotal Site Work – Parking Lot & Drop-Off Area				$862,032.00	4,123	$375,564	$1,237,598	Parking spaces (*10 for garage)	$3,438
Subtotal Landscaping				$183,659.00	3,459	$250,968	$434,626	Quarter fixed/3/4parking spaces	$108,657 + $905 per space
STATION ELEMENTS									
Subtotal Rail Road Components (Lead Track at Station)				$233,283.00	1,163	$145,611	$378,894	Side tracks	$378,894
Subtotal Platforms				$584,900.00	2,037	$275,225	$860,125	Half platforms	$430,063
Subtotal Electrical				$289,435.00	4,650	$391,260	$680,696	Platforms	$680,696
Subtotal Variable Message Signs				$61,194.00	264	$22,903	$84,097	Platforms	$84,097
Subtotal Division 10 – Specialties				$25,792.00	104	$8,867	$34,659	Unit	$34,659
Subtotal Division 2 – Site Improvements				$38,250.00	85	$6,120	$44,370	Parking Spaces	$123
Subtotal Division 5 – Metals				$271,227.00	2,230	$217,289	$488,516	Platforms	$244,258
Subtotal Water Supply System				$46,463.00	473	$43,424	$89,887	Unit	$89,887
DIRECT COST SUBTOTAL							**$8,062,290**		

Description	Materials: Quantity	Units*	Unit Costs	Material Cost Total	Labor: Man-Hrs	Cost ($)	Total Direct Cost	Allocation Factor	Calculated Unit Cost
CONSTRUCTION									
Subtotal General Requirements				-	224	$33,600	$33,600	Direct Costs	$33,600
Subtotal Construction Staging Provisions				$13,200.00	32	$2,304	$15,504	Direct Costs	$15,504
Subtotal Safety & Protection				$58,900.00	884	$63,619	$122,519	Direct Costs	$122,519
TOTAL DIRECT COST				$4,402,000	39,878	$3,832,000	**$8,234,000**		
General Conditions @		13%				$1,070,420	$1,070,420		
General Contractor Overhead @		4%				$372,176	$372,176		
General Contractor Profit @		4%				$387,064	$387,064		
General Contractor Bond @		1%				$100,637	$100,637		
ESTIMATED CONTRACTOR COST							**$10,164,000**		
Traffic Officers' Services	1	AN				$54,000	$54,000	Unit	$54,000
Rodent Control	1	AN	$64,000	$64,000			$64,000	Unit	$64,000
Site Utilities (Existing, National Grid Verizon Poles)	1	AN	$24,000	$24,000			$24,000	Unit	$24,000
Electric Company	1	AN	$105,000	$105,000			$105,000	Unit	$105,000
Install Water System	1	AN	$9,000	$9,000			$9,000	Unit	$9,000
Risk Allowance	1	AN	$1,100,000	$1,100,000			$1,100,000	0	$1,100,000
Dispose Contaminated Material (MCP** Compliance) at In-State Facility	630	TN	$30	$18,900			$18,900	1 if contaminated, 0 if not	$18,900
Dispose Contaminated Material at Non-RCRA^ Out-of-State Facility	630	TN	$65	$40,950			$40,950	1 if contaminated, 0 if not	$40,950
Hazardous/Special Waste Handling	1	LS	$10,000	$10,000			$10,000	1 if contaminated, 0 if not	$10,000
LSP Services for Contaminated Soils Disposal	1,260	TN	$20	$25,200			$25,200	1 if contaminated, 0 if not	$25,200
ALLOWANCES				$1,397,050		$54,000	$1,451,050		
SUBTOTAL							**$11,615,000**		
Escalation to Oct 2013 (based on 3.8% per year) @		4.12%					$478,899		
ESCALATED ESTIMATED CONSTRUCTION COST							**$12,094,000**		
Construction Contingency		10%					$1,209,400		
ESTIMATED CONSTRUCTION COST WITH CONSTRUCTION CONTINGENCY							**$13,303,000**		

Source: MBTA Fitchburg Commuter Rail-Wachusett Extension Project: PS&E Construction Estimate; Jacobs/Keville Enterprises, Inc.; January, 2013
**SY – Square Yard, LF – Linear Foot, EA – Each, HR – Hour, GL – Gallon, LS – Lump Sum, CY – Cubic Yard, TN – Ton*
*** MCP – Massachusetts Contingency Plan*
^RCRA – Resource Conservation and Recovery Act

Table B.2: Estimated Concord Station Capital Costs

			Manchester		Concord
	Nashua Crown Street	Bedford/MHT	Granite Street	Spring Street	Stickney Avenue
MP	38.8	50.1	55.5	56.4	73.3
Parking	255	190	0	0	100
Platforms	1	1	1	1	1
Contaminated Soils	0.5	0	0.5	0	0
Square Feet of Wetlands	0	0	0	0	0
Side Tracks	0	0	0	0	0
SITE WORK					
Remove & Dispose Existing Pavement	$0	$0	$0	$0	$0
Remove & Stock Curbing	$0	$0	$0	$0	$0
Clearing and Grubbing	$3,682	$3,293	$2,156	$2,156	$2,754
Cut, Cap, and Abandon Monitoring Well	$170	$0	$170	$0	$0
Site Preparation – Remove & Dispose of Boulders	$0	$0	$0	$0	$0
Cleaning & Sweeping Roadway	$13,080	$13,080	$13,080	$13,080	$13,080
Water for Dust Control	$1,780	$1,780	$1,780	$1,780	$1,780
Erosion Control System (Straw Bale & Silt Fence)	$19,830	$19,830	$19,830	$19,830	$19,830
Silt Sack	$3,956	$3,956	$3,956	$3,956	$3,956
Mobilization & Demobilization for Bulk Excavation	$6,000	$6,000	$6,000	$6,000	$6,000
Unclassified Excavation	$92,902	$92,902	$92,902	$92,902	$92,902
Unclassified Excavation – Handling & Off-Site Disposal	$205,200	$0	$205,200	$0	$0
Dispose of Contaminated Soil at In-State Lined Landfill	$12,585	$0	$12,585	$0	$0
Dispose of Contaminated Soil at In-State Recycling Facility	$25,185	$0	$25,185	$0	$0
Rock Excavation	$31,416	$31,416	$31,416	$31,416	$31,416
Rock Excavation – Haul & Disposal	$28,229	$25,245	$16,524	$16,524	$21,114
Soils Testing Services (LSP)	$34,201	$30,586	$20,020	$20,020	$25,581
Soil Sampling & Testing (Assume 50-ft Grid)	$22,448	$20,075	$13,140	$13,140	$16,790
Grading	$105,944	$94,747	$62,016	$62,016	$79,243
Ordinary Fill (Processed Gravel)	$139,720	$124,953	$81,788	$81,788	$104,506
Crushed Stone – Platform	$2,033	$1,818	$1,190	$1,190	$1,521
Wetland Replication Area	$0	$0	$0	$0	$0
Subtotal Site Preparation & Earthwork	$748,498	$469,820	$609,075	$365,936	$420,612
Subtotal Retaining Walls	$220,932	$220,932	$220,932	$220,932	$220,932
Subtotal Drainage	$343,995	$307,638	$201,363	$201,363	$257,297
Subtotal Site Work – Parking lot & Drop-Off Area	$876,632	$653,177	$0	$0	$343,777
Subtotal Landscaping	$339,552	$280,696	$108,657	$108,657	$199,204
STATION ELEMENTS					
Subtotal Rail Road Components (Lead Track at Station)	$0	$0	$0	$0	$0
Subtotal Platforms	$430,063	$430,063	$430,063	$430,063	$430,063
Subtotal Electrical	$680,696	$680,696	$680,696	$680,696	$680,696
Subtotal Variable Message Signs	$84,097	$84,097	$84,097	$84,097	$84,097
Subtotal Division 10 – Specialties	$34,659	$34,659	$34,659	$34,659	$34,659
Subtotal Division 2 – Site Improvements	$31,429	$23,418	$0	$0	$12,325
Subtotal Division 5 – Metals	$244,258	$244,258	$244,258	$244,258	$244,258
Subtotal Water Supply System	$89,887	$89,887	$89,887	$89,887	$89,887
DIRECT COST SUBTOTAL	$4,124,697	$3,519,339	$2,703,686	$2,460,547	$3,017,806
CONSTRUCTION					
Subtotal General Requirements	$17,190	$14,667	$11,268	$10,254	$12,577
Subtotal Construction Staging Provisions	$7,932	$6,768	$5,199	$4,732	$5,803
Subtotal Safety and Protection	$62,681	$53,482	$41,087	$37,392	$45,860
TOTAL DIRECT COST	$4,212,500	$3,594,256	$2,761,239	$2,512,925	$3,082,046
General Conditions @	$547,624.98	$467,253.28	$358,961.12	$326,680.21	$400,666.04
Subtotal	$4,760,125	$4,061,509	$3,120,201	$2,839,605	$3,482,712
General Contractor Overhead @	$190,405	$162,460	$124,808	$113,584	$139,308
Subtotal	$4,950,530	$4,223,970	$3,245,009	$2,953,189	$3,622,021
General Contractor Profit @	$198,021	$168,959	$129,800	$118,128	$144,881
Subtotal	$5,148,551	$4,392,928	$3,374,809	$3,071,317	$3,766,902
General Contractor Bond @	$51,486	$43,929	$33,748	$30,713	$37,669
ESTIMATED CONTRACTOR COST	$5,200,037	$4,436,858	$3,408,557	$3,102,030	$3,804,571
Traffic officers services	$54,000	$54,000	$54,000	$54,000	$54,000
Rodent control	$64,000	$64,000	$64,000	$64,000	$64,000
Site utilities (existing - National Grid Verizon poles)	$24,000	$24,000	$24,000	$24,000	$24,000
Electric company	$105,000	$105,000	$105,000	$105,000	$105,000
Install water system	$9,000	$9,000	$9,000	$9,000	$9,000
Dispose contaminated material (MCP compliance) at in-state facility	$9,450	$0	$9,450	$0	$0
Dispose contaminated material at non-RCRA out-of-state facility	$20,475	$0	$20,475	$0	$0
Hazardous/Special Waste Handling	$5,000	$0	$5,000	$0	$0
LSP Services for Contaminated Soils Disposal	$12,600	$0	$12,600	$0	$0
ALLOWANCES	$303,525	$256,000	$303,525	$256,000	$256,000
SUBTOTAL	$5,503,562	$4,692,858	$3,712,082	$3,358,030	$4,060,571
Escalation to Oct 2013 (based on 3.8% per year) @	$226,747	$193,346	$152,938	$138,351	$167,296
ESCALATED ESTIMATED CONSTRUCTION COST	$5,730,308	$4,886,203	$3,865,020	$3,496,381	$4,227,866
Construction Contingency	$573,030.83	$488,620.35	$386,501.98	$349,638.06	$422,786.63
ESTIMATED CONSTRUCTION COST WITH CONSTRUCTION CONTINGENCY	$6,303,339	$5,374,824	$4,251,522	$3,846,019	$4,650,653

Source: MBTA Fitchburg Commuter Rail-Wachusett Extension Project: PS&E Construction Estimate; Jacobs/Keville Enterprises, Inc.; January, 2013

Table B.3: Land Value of Proposed Intercity Passenger Rail Stations

Location	Address	Owner	Assessed Value	Land Use*	Size (acres)	Improvements	Land	Total	$/Acre	Portion	Land Cost
CONCORD SITE											
Stickney Ave.	11 STICKNEY AV	NEW HAMPSHIRE STATE OF	$4,068,400	Surplus Public Property	6.08	$2,621,400	$1,447,000	$4,068,400	$237,990	1	$1,447,000
MANCHESTER SITES											
Bridge/Spring St.	CANAL ST	BOSTON AND MAINE CORP	$64,300	Non-Taxable Easement	0.1695	$ -	$64,300	$64,300	$379,351.03	1	$64,300
Bridge/Spring St.	CANAL ST	BOSTON AND MAINE CORP	$73,700	Non-Taxable Easement	0.5357	$ -	$73,700	$73,700	$137,577.00	1	$73,700
Granite St.	100 GRANITE ST	BOSTON AND MAINE CORP	$78,700	Non-Taxable Easement	0.2300	$ -	$78,700	$78,700	$342,173.91	1	$78,700
Granite St.	CANAL ST	CITY OF MANCHESTER	$70,100	Non-Taxable Easement	0.3244	$ -	$70,100	$70,100	$216,091.25	1	$70,100
BEDFORD SITE											
Bedford/MHT	SOMERVILLE DR	NEW HAMPSHIRE STATE OF	$444,400	Surplus Public Property	6.000	$134,000	$176,500	$310,500	$29,416.67	0.33	$58,245
NASHUA SITE											
Crown St.	25 CROWN ST	NASHUA, CITY OF	$1,274,200	Surplus Public Property	6.826	$941,100	$308,700	$1,274,200	$45,224	1	$308,700

Appendix C: Detailed Cost Estimates of Layover Facilities

Table C.1: Cost Factors Used to Calculate Proposed Layover Facility Capital Costs

					Labor						
	Materials				Man-Hrs		Cost ($)		Total Direct Cost		
Description	Quantity	Units	Unit Costs	Total	Unit	Total	Unit	Total		Allocation Factor	Calculated Unit Cost
SITE WORK											
Miscellaneous Site Cleaning & Clearing	1	LS	$2,000.00	$2,000				-	$2,000	Track Feet	$0.21
Erosion & Sedimentation Control (Hay Bale & Silt Fence)	8,180	LF	$1	$8,180	0.045	368	72	$26,503	$34,683	Track Feet	$3.59
Silt Sack	15	EA	$100	$1,500	1	15	72	$1,080	$2,580	Track Feet	$0.27
Temporary Construction Access Road	56	ton	$68	$3,808	0.09	5	85	$428	$4,236	Track Feet	$0.44
Clearing & Grubbing	4	Acre	-	-	16	57	85	$4,811	$4,811	Track Feet	$0.50
Stripping & Stockpiling of Topsoil	745	CY	-	-	0.039	29	110	$3,155	$3,155	Track Feet	$0.33
Ordinary Excavation	52,812	CY	-	-	0.039	2,033	110	$223,659	$223,659	Track Feet	$23.17
Unclassified Excavation – Handling & Off-Site Disposal	64,170	TN	$18	$1,155,060			110	-	$1,155,060	Track Feet	$119.63
Dispose of Contaminated Soil at In-State Lined Landfill	1,780	TN	$35	$62,300				-	$62,300	Track Feet if contaminated, otherwise zero	$6.45
Dispose of Contaminated Soil at In-State Recycling Facility	1,780	TN	$75	$133,500				-	$133,500	Track Feet if contaminated, otherwise zero	$13.83
Rock Excavation	1,000	CY		-	0.175	175	110	$19,250	$19,250	Zero	$0
Rock Excavation – Haul & Disposal	1,350	TN	$18	$24,300			110	-	$24,300	Zero	$0
Soils Testing Services (LSP)	896	HR		-	1	896	110	$98,560	$98,560	Track Feet if contaminated, otherwise zero	$10.21
Soil Sampling & Testing (Assume 50-ft Grid)	194	EA	$180	$34,920				-	$34,920	Track Feet if contaminated, otherwise zero	$3.62
Tree Removal – Includes Stumps	10	EA	$1,200.00	$12,000			85	-	$12,000	Zero	$0
Processed Gravel Ordinary Fill	21,100	CY	$0.8	$16,880	0.095	2,005	85	$170,383	$187,263	Track Feet	$19.40
Gravel Borrow Sub-Base (Processed Gravel)	28	CY	$0.8	$22	0.095	3	85	$224	$247	Track Feet	$0.03
Grading & Finishing	483,958	SF		-	0.004	1,936	85	$164,546	$164,546	Track Feet	$17.04
DIRECT COST SUBTOTAL				$1,454,470		7,521		$712,599	$2,167,070	Total	
Subtotal Roadways & Walkways Pavements				$708,237		2,710		$220,993	$929,230	Storage Positions	$154,872
Subtotal Landscaping				$305,980		2,615		$188,294	$494,274	Number of track feet	$51.19
Subtotal Site Work – Drainage				$35,943		538		$46,357	$82,299	Number of track feet	$8.52
TRACK WORK											
Surface & Align Track	9,655	TF		-	0.1	966	145	$139,998	$139,998	Track Feet	$14.50
Tie with Assemblies	5,945	EA	$100	$594,500	0.18	1,070	145	$155,165	$749,665	Track Feet	$77.65
Ballast	7,575	TN	$15	$113,625	0.13	985	110	$108,323	$221,948	Track Feet	$22.99
Subballast	7,132	TN	$17	$121,240	0.13	927	110	$101,984	$223,224	Track Feet	$23.12
No. 10 Turnouts	6	EA	$48,000	$288,000	220	1,320	145	$191,400	$479,400	Storage Positions	$79,900
Bituminous Pavement Under Switches	460	TN	$68	$31,280	0.25	115	85	$9,775	$41,055	Storage Positions	$6,843
Switch Stands	6	EA	$7,600.00	$45,600	20	120	145	$17,400	$63,000	Storage Positions	$10,500
Bump Post	6	EA	$3,250.00	$19,500	2	12	85	$1,020	$20,520	Storage Positions	$3,420
Rubber Seal	2,470	LF	$42.25	$104,358	0.05	124	85	$10,498	$114,855	Storage Positions	$19,143
Cable Trough at Feeder Receptacle	4	EA	$2,500.00	$10,000	16	64	85	$5,440	$15,440	Storage Positions	$2,573
Snowmelters	6	EA	$9,000.00	$54,000	56	336	85	$28,560	$82,560	Storage Positions	$13,760
12'x60' Oil Pan	6	EA	$2,800.00	$16,800	16	96	85	$8,160	$24,960	Storage Positions	$4,160
DIRECT COST SUBTOTAL				1,398,902		6,134		777,721	2,176,625		
Subtotal Switch Heaters				$120,185		1,580		$132,740	$252,923	Storage Positions	$42,154

	Materials				Labor				Total Direct Cost		
					Man-Hrs		Cost ($)				
Description	Quantity	Units	Unit Costs	Total	Unit	Total	Unit	Total		Allocation Factor	Calculated Unit Cost
LAYOVER FACILITY ELEMENTS											
Subtotal Site Structural				$843,150		3,564		$315,656	$1,158,806	Unit	$1,158,806
Subtotal Division 3– Concrete Work				$21,865		217		$18,965	$40,831	Unit	$40,831
Subtotal Division 4 – Masonry				$12,454		554		$81,539	$93,993	Unit	$93,993
Subtotal Division 5 – Metals				$101,991		245		$21,897	$123,889	Unit	$123,889
Subtotal Division 6 – Wood and Plastics				$2,749		10		$805	$3,555	Unit	$3,555
Subtotal Division 7 – Thermal and Moisture Protection				$43,601		197		$16,749	$60,352	Unit	$60,352
Subtotal Division 8 – Doors and Windows				$33,754		124		$10,521	$44,277	Unit	$44,277
Subtotal Division 9 – Finishes				$20,393		410		$29,529	$49,923	Unit	$49,923
Subtotal Division 13 – Special Construction				$56,160				-	$56,160	Unit	$56,160
Subtotal Division 10 – Specialties				$45,252		197		$14,756	$60,008	Unit	$60,008
Subtotal Division 12 – Furnishings						1		$36	$236	Unit	$236
Subtotal Division 33 – Site Utilities				$170,320		2,792		$240,716	$411,036	Unit	$411,036
Subtotal Mechanical Work				$47,131		359		$29,467	$76,599	Unit	$76,599
Subtotal Fire Protection System				$9,701		102		$8,710	$18,412	Unit	$18,412
Subtotal Plumbing Systems						362		$30,774	$62,239	Unit	$62,239
Subtotal Electrical				$1,361,985		6,386		-	$1,897,024	Number of storage positions	$316,171 per storage position
Subtotal Communication Systems						1,214		$100,370	$290,393	Unit	$290,393
DIRECT COST SUBTOTAL									**$15,156,327**		
CONSTRUCTION											
Subtotal General Requirements				$71,095		622		$64,410	$135,505	Half fixed half variable based on number of storage positions	$67,753 + $271,010 per storage position
TOTAL DIRECT COST				$7,087,000		38453		$3,599,000	**$10,686,000**		
General Conditions @							13%	$534,300	$534,300		
General Contractor Overhead @							4%	$448,800	$448,800		
General Contractor Profit @							4%	$466,760	$466,760		
General Contractor Bond @							1%	$121,358	$121,358		
ESTIMATED CONTRACTOR COST									**$12,257,000**		
Traffic Officers' Services	1	AN						$54,000	$54,000	Unit	$54,000
Rodent Control	1	AN	$64,000	$64,000				-	$64,000	Unit	$64,000
Site Utilities (Existing)	1	AN	$48,300	$48,300				-	$48,300	Unit	$48,300
Electric Company	1	AN	$315,000	$315,000				-	$315,000	Unit	$315,000
Install Water System	1	AN	$6,000	$6,000				-	$6,000	Unit	$6,000
Risk Allowance	1	AN	$1,300,000	$1,300,000				-	$1,300,000	0	$0
Total Excavation	53800	**CY**									
Dispose Contaminated Material (MCP Compliance) at In-State Facility	1,780	TN	$30	$53,400				-	$53,400	1 if contaminated, 0 if not	$53,400
Dispose Contaminated Material at NON-RCRA Out-of-State Facility	1,780	TN	$65	$115,700				-	$115,700	1 if contaminated, 0 if not	$115,700
Hazardous/Special Waste Handling	1	LS	$10,000	$10,000				-	$10,000	1 if contaminated, 0 if not	$10,000
LSP Services for Contaminated Soils Disposal	3,560	TN	$20	$71,200				-	71,200	1 if contaminated, 0 if not	71,200

	Materials				Labor				Total Direct Cost		
					Man-Hrs		Cost ($)				
Description	**Quantity**	**Units**	**Unit Costs**	**Total**	**Unit**	**Total**	**Unit**	**Total**		**Allocation Factor**	**Calculated Unit Cost**
ALLOWANCES				$1,983,600				$54,000	$2,037,600		
SUBTOTAL									**$11,615,000**		
Escalation to Oct 2013 (based on 3.8% per year) @				4.12%					$478,899		
ESCALATED ESTIMATED CONSTRUCTION COST									$12,094,000		
Construction Contingency				10%					$1,209,400		
ESTIMATED CONSTRUCTION COST WITH CONTINGENCY									**$13,303,000**		

Source: MBTA Fitchburg Commuter Rail-Wachusett Extension Project: PS&E Construction Estimate; Jacobs/Keville Enterprises, Inc.; January, 2013

Table C.2: Estimated Concord Layover Facility Capital Costs

Category of Expense	Cost
SITE WORK (Over & Above Station Cost)	
Miscellaneous Site Cleaning & Clearing	$0
Erosion & Sedimentation Control (Hay Bale & Silt Fence)	$0
Silt Sack	$0
Temporary Construction Access Road	$0
Clearing & Grubbing	$0
Stripping & Stockpiling of Topsoil	$0
Ordinary Excavation	$0
Unclassified excavation – Handling & Off-Site Disposal	$0
Dispose of Contaminated Soil at In-State Lined Landfill	$0
Dispose of Contaminated Soil at In-State Recycling Facility	$0
Rock Excavation	$0
Rock Excavation – Haul & Disposal	$0
Soils Testing Services (LSP)	$0
Soil Sampling & Testing (Assume 50-ft Grid)	$0
Tree Removal – Includes Stumps	$0
Processed Gravel Ordinary Fill	$0
Gravel Borrow Sub-Base (Processed Gravel)	$0
Grading & Finishing	$0
Subtotal Division 2 – Site Preparation & Earthwork	$0
Subtotal Roadways & Walkways Pavements	$154,872
Subtotal Landscaping	$0
Subtotal Site Work – Drainage	$0
TRACK WORK (Over & Above Station Cost)	
Surface & Align Track	$0
Tie with Assemblies	$0
Ballast	$0
Subballast	$0
No. 10 Turnouts	$0
Bituminous Pavement Under Switches	$0
Switch Stands	$0
Bump Post	$0
Rubber Seal	$0
Cable Trough at Feeder Receptacle	$0
Snowmelters	$0
12'x60' Oil Pan	$0
Subtotal Track & Rail Work	$0
Subtotal Switch Heaters	$0
LAYOVER FACILITY ELEMENTS	
Subtotal Site Structural	$1,158,806.00
Subtotal Division 3 – Concrete Work	$40,831.00
Subtotal Division 4 – Masonry	$93,993.00
Subtotal Division 5 – Metals	$123,889.00
Subtotal Division 6 – Wood and Plastics	$3,555.00
Subtotal Division 7 – Thermal and Moisture Protection	$60,352.00
Subtotal Division 8 – Doors and Windows	$44,277.00
Subtotal Division 9 – Finishes	$49,923.00
Subtotal Division 13 – Special Construction	$56,160.00
Subtotal Division 10 – Specialties	$60,008.00

Category of Expense	Cost
Subtotal Division 12 – Furnishings	$236.00
Subtotal Division 33 – Site Utilities	$411,036.00
Subtotal Mechanical Work	$76,599.00
Subtotal Fire Protection System	$18,412.00
Subtotal Plumbing Systems	$62,239.00
Subtotal Electrical	$316,170.67
Subtotal Communication Systems	$290,393.00
DIRECT COST SUBTOTAL	$3,021,751
CONSTRUCTION	
Subtotal General Requirements	$79,044.58
TOTAL DIRECT COST	$3,100,795.92
General Conditions @	$403,103.47
Subtotal	$3,503,899
General Contractor Overhead @	$140,155.98
Subtotal	$3,644,055
General Contractor Profit @	$145,762
Subtotal	$3,789,818
General Contractor Bond @	$37,898.18
ESTIMATED CONTRACTOR COST	$3,827,716
Subtotal ALLOWANCES – Section 01020	$737,600
Traffic Officers' Services	$54,000
Rodent Control	$64,000
Site Utilities (Existing)	$48,300
Electric Company	$315,000
Install Water System	$6,000
Risk Allowance	$0
Dispose Contaminated Material (MCP Compliance) at In-State Facility	$53,400
Dispose Contaminated Material at NON-RCRA Out-of-State Facility	$115,700
Hazardous/Special Waste Handling	$10,000
LSP Services for Contaminated Soils Disposal	$71,200
SUBTOTAL	$4,565,316
Escalation to Oct 2013 (based on 3.8% per year) @	$188,091.01
ESCALATED ESTIMATED CONSTRUCTION COST	$4,753,407
Construction Contingency	$475,340.68
ESTIMATED CONSTRUCTION COST WITH CONTINGENCY	$5,228,747

Source: MBTA Fitchburg Commuter Rail-Wachusett Extension Project: PS&E Construction Estimate; Jacobs/Keville Enterprises, Inc.; January, 2013