Appendix 4

TECHNICAL REPORT
Task 4: Initial Conceptual Transit Alternatives

December 2013

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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List of Acronyms

AA	Alternatives Analysis
BX	Boston Express
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
MBTA	Massachusetts Bay Transportation Authority
O&M	Operations and Maintenance
PAR	Pan Am Railways

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

This report summarizes the initial conceptual (preliminary) transit and intercity rail alternatives, which were developed to accomplish five objectives:

1. Address key transportation and related issues identified in the Study's purpose and need
2. Provide commuter bus (Boston Express, BX), commuter rail (Massachusetts Bay Transportation Authority, MBTA), and intercity rail (possibly Amtrak) service and operating plans, to accommodate Federal Transit Administration (FTA) and Federal Railroad Administration (FRA) Study funding sources
3. Develop plans with alternative northern terminus stations in Nashua, Manchester, and Concord
4. Develop a range of service levels (train and/or bus frequencies)
5. Develop a range of capital and operating costs and benefits

[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

Appendices A and B to this report describe the methodologies used to develop preliminary capital and operations and maintenance (O&M) costs for the initial conceptual alternatives. Using these estimates, decision-makers will select the most promising alternatives for detailed evaluation (see Task 5/Appendix 5 to the AA Final Report). Following that in-depth evaluation, officials will be able to select an investment strategy.

2.1 Initial Conceptual Alternatives

2.1.1 Commuter Rail

Capital costs – including locomotives and passenger cars, track and signal improvements, and stations – range from $124 to $226 million; annual operating costs range from $5.2 to $13.3 million (see Table 2.1). Although no decision has been made on an operator, MBTA is a likely operator.

Table 2.1: Capital and O&M Costs for Preliminary Commuter Rail Alternatives

Alternative	Daily Rail Service	Capital Cost (In Millions, 2014$)	Annual O&M Cost (In Millions, 2009$)
Concord Regional	8 trains (4 round trips) to Concord and Manchester 30 trains to Nashua	$226	$11.1
Concord Commuter	18 trains to Concord 22 trains to Manchester 26 trains to Nashua	$206	$13.3
Manchester Regional	16 trains to Manchester 34 trains to Nashua	$164	$9.7
Manchester Commuter	20 trains to Manchester 30 trains to Nashua	$164	$9.9
Nashua Commuter	34 trains to Nashua only	$124	$6.8
Nashua Minimum	16 trains to Nashua only	$124	$5.2

2.1.2 Intercity Rail

Capital costs range from $162 to $174 million; annual operating costs from $7.7 to $17.3 million. No decision has been made on an operator (see Table 2.2).

Table 2.2: Capital and O&M Costs for Preliminary Intercity Rail Alternatives

Alternative	Daily Rail Service	Capital Cost (In Millions, 2014$)	Annual O&M Cost (In Millions, 2012$)
Intercity 18	18 trains (9 round trips) to Nashua, Manchester, and Concord	$174	$17.3
Intercity 12	12 daily trains to Nashua, Manchester, and Concord	$174	$11.6
Intercity 8	8 trains to Nashua, Manchester, and Concord	$162	$7.7

2.1.3 Express Bus Only

Capital costs range from $2 to $9 million; annual incremental operating costs from $0 to $3 million (see Table 2.3). BX currently provides commuter bus service within the corridor and would likely be the operator of this service.

Table 2.3: Capital and O&M Costs for Express Bus Alternatives

Alternative	Bus Service	Capital Cost (In Millions, 2014$)	Annual Incremental O&M Cost (In Millions, 2012$)
Base (Existing Bus Service)	Total buses (inbound/outbound) Manchester 18 N. Londonderry (Exit 5) 46 Londonderry (Exit 4) 17 Salem (Exit 2) 39 Nashua (Exit 8) 24 Tyngsborough (Exit 35) 23 South Station 80 Logan Airport 58	$0	$0
Expanded Base	Total buses (inbound/outbound) Manchester 32 N. Londonderry (Exit 5) 40 Londonderry (Exit 4) 39 Salem (Exit 2) 40 Nashua (Exit 8) 38 Tyngsborough (Exit 35) 38 South Station 120 Logan Airport 120	$6.4	$3
Bus on Shoulder (in Massachusetts only) on I-93 south of I-495	Total buses (inbound/outbound) Manchester 18 N. Londonderry (Exit 5) 46 Londonderry (Exit 4) 17 Salem (Exit 2) 39 Nashua (Exit 8) 24 Tyngsborough (Exit 35) 23 South Station 80 Logan Airport 58	$2.2	$0
Expanded Bus on Shoulder	Total buses (inbound/outbound) Manchester 32 N. Londonderry (Exit 5) 40 Londonderry (Exit 4) 39 Salem (Exit 2) 40 Nashua (Exit 8) 38 Tyngsborough (Exit 35) 38 South Station 120 Logan Airport 120	$8.6	$3

2.2 Next Steps: Alternative Evaluation and Screening

A "No-Build" scenario is also an alternative. Each alternative will be evaluated in Task 5/Appendix 5 to the AA Final Report against the following criteria:

- Costs (capital and operating)
- Ridership (total and by station)
- Land Use and Economic Development Impacts
- Environmental Fatal Flaws (including environmental justice)
- Likelihood of Qualifying for Federal Funding

Based on that evaluation, the number of alternatives will be reduced, and the most promising ones subjected to more detailed evaluation (Appendix 7 to the AA Final Report).

Appendix A
Preliminary Capital Cost Methodology Memorandum

TECHNICAL MEMORANDUM

This memorandum describes the assumptions and methods applied to derive preliminary capital cost estimates for the Capitol Corridor Alternatives Analysis (AA) Study. The Study team's approach to estimating capital costs was different for rail and bus service options. Each of the two approaches is described below.

Commuter Rail – A conceptual schedule was prepared for each rail service option. During the schedule design process, efforts were applied to limit the number of locations where meets between northbound and southbound passenger trains would occur. This, in turn, limits the extent of double track that would be required for each option. Schedules were also designed to minimize impacts on existing passenger rail services and to provide windows for through and local freight operations north of Lowell. Based on that analysis and information on the existing track configuration, the Study team determined the extent of additional infrastructure that would be required to operate each service option. Rail stakeholders that currently use some or all of the line and/or could operate the proposed services (including the Massachusetts Bay Transportation Authority, MBTA, Pan Am Railways [PAR], and Amtrak) were briefed on the service designs and infrastructure proposals.

Feedback from MBTA, PAR, and Amtrak was applied to finalize the infrastructure requirements for each of the nine preliminary rail options. Schematic track diagrams showing crossovers, turnouts, stations, and new tracks were prepared for each option (see Appendices A-1 and B-1 to this memorandum). Approximate capital cost estimates sufficient for a screening of preliminary alternatives were prepared based on those diagrams and using the assumptions and cost drivers summarized in Table A.1.

One key source for cost elements and unit cost estimates came from similar work on the same corridor prepared for the Nashua Regional Planning Council (NRPC) in 2005. Figures from this source were updated at four percent per year to account for inflation. Where costs from the earlier project were missing or questionable, Study team engineers drew on their recent experience working for and with MBTA on passenger rail renewal projects, including work on the Fitchburg Main Line, the Boston and Albany Line, and the new Cape Flyer Service. Estimates of direct costs were subject to various multipliers, management costs, and contingency allowances as summarized in Table A.2.

Table A.1: Key Cost Drivers, Assumptions, Unit Costs (2014$), and Sources

Cost Driver	Assumptions	Units	Unit Costs	Source
New Track to MBTA Standard	132#, Pandrol	Track Miles	$1,372,800	NRPC Passenger Rail Study
New Track to PAR Standard	132#, Cut spikes	Track Miles	$1,056,000	NRPC Passenger Rail Study
Replace Worn Rail (MBTA)	132#, Pandrol	Track Miles	$652,081	NRPC Passenger Rail Study
Replace Worn Rail (PAR)	132#, Cut spikes	Track Miles	$545,356	NRPC Passenger Rail Study
Tie Replacement (1/3rd)	3250 ties per mile	Ties	$106	NRPC Passenger Rail Study
Cut and Chip Brush on ROW	Northern Branch	Route Miles	$20,925	NRPC Passenger Rail Study
Reestablish Ditches on ROW	Northern Branch	Route Miles	$39,600	NRPC Passenger Rail Study
Shoulder Ballast Cleaning	Northern Branch	Route Miles	$39,930	NRPC Passenger Rail Study
New or Replaced Turnout		Each	$125,000	Recent MBTA projects
New or Replaced Crossover		Each	$250,000	Recent MBTA projects
Passenger Stations		Each	$10,000,000	Recent MBTA projects
Rolling Stock Layover Facility		Each	$13,950,000	Recent MBTA projects
Renew Grade Crossing Panels	Replace all	Grade Xing	$109,050	NRPC Passenger Rail Study
New AHCW Devices	Keep where extant	Grade Xing	$150,000	Recent MBTA projects
Relocate Fiber Optic Lines	Where necessary	Route Miles	$150,000	Recent MBTA projects
PTC Wayside Devices		Track Miles	$121,000	FRA documentation
Signal Upgrades	Where necessary			NRPC Passenger Rail Study

Table A.2: Multipliers, Management, and Contingency Factors

Bridge, culvert and retaining wall work	10% of direct cost
Environmental (soil disposal, noise abatement, solar, LEED)	3% of direct costs
Final design and construction phase services	12% of direct cost
Land acquisition	3% of direct cost
Railroad project management and construction management	3% of direct cost
Maintenance and protection of railroad (180 to 420 days depending on physical scope)	$2,000 per day (2014$)
Railroad flagging support (180 to 420 days depending on physical scope)	$2,000 per day (2014$)
Contingency	20% of total costs

During the preliminary screening of alternatives, the New Hampshire Department of Transportation (NHDOT) assumed that costs for developing stations at in Nashua, Manchester, and Concord would be local municipal expenses and were excluded from the project costs for screening purposes. (This assumption was reversed in developing final cost estimates based on feedback from stakeholders and elected officials.) The resulting estimates of overall infrastructure costs as applied to the preliminary screening of commuter rail options are shown in Table A.3.

Table A.3: Preliminary Capital Cost Estimates for Commuter Rail Options (In Millions, 2014$)

Service Option	From MP	To MP	Route Miles	Track	Stations	Signal	Layover	Allowances	Contingency	Total
Concord Regional	25.4	73.5	48.1	$51	$20	$34	$28	$37	$56	**$226**
Concord Commuter	25.4	73.5	48.1	$51	$20	$31	$14	$37	$53	**$206**
Manchester Regional	25.4	55.7	30.3	$37	$20	$24	$14	$27	$43	**$164**
Manchester Commuter	25.4	55.7	30.3	$37	$20	$24	$14	$27	$43	**$164**
Nashua Commuter	25.4	38.9	13.5	$24	$10	$20	$14	$24	$32	**$124**
Nashua Minimum	25.4	35.2	9.8	$24	$10	$20	$14	$24	$32	**$124**

Costs for commuter rail rolling stock were excluded from the preliminary commuter rail estimates because MBTA indicated they were in the process of receiving a substantial number of new locomotives and coaches that would render a large fraction of the current fleet as surplus. Massachusetts Department of Transportation (MassDOT)/MBTA indicated that MBTA would be able to supply the necessary rolling stock from this surplus equipment should New Hampshire and Massachusetts advance the project in the near future. The additional locomotive and coaches that would be required for each preliminary commuter rail option was valued at $28 million.

Intercity Rail – Preliminary intercity (Amtrak) capital costs (see Table A.4) were estimated using a methodology similar to the commuter rail methodology, but with assumptions for less double track and fewer stations. Schematic track diagrams showing crossovers, turnouts, stations, and new tracks were prepared for each option (see Appendix B-1 to this memorandum). Cost of rolling stock was included in the intercity options, as Amtrak indicated they could not operate the new service from within their existing fleet. The principal difference in costs between the options corresponds to fleet requirements necessary for each different level of service. An eight-train-per-day service could be operated with one train set sharing spares with the existing *Downeaster* service; the more extensive services would require an additional train set and more spare equipment.

Table A.4: Preliminary Capital Cost Estimates for Intercity Rail Options (In Millions, 2014$)

Service Option	Infrastructure Upgrades	Rolling Stock	Total
Intercity 8	$144	$18	**$162**
Intercity 12	$144	$30	**$174**
Intercity 18	$144	$30	**$174**

Bus – Preliminary estimates of capital costs for the bus options were driven by two factors: the additional buses required to operate more frequent service and the roadway upgrades that would be required to allow for bus on shoulder operations, which would provide more reliable peak service for some options.

The Expanded Base and Expanded Bus on Shoulder options entailed increasing the frequency of bus service. Additional vehicles would be required to operate the proposed services and both NHDOT and Boston Express (BX) indicated that new vehicles would be expected to cost $400,000 each. The Study team estimated the number of additional buses that would be required by consulting with NHDOT and BX to determine the size and utilization of the current BX fleet. Study team analysis indicated that amending the current schedule of peak service to operate direct non-stop half-hourly peak service from all six park-and-ride lots currently served by BX would require 16 additional buses be added to the current BX fleet of 22 vehicles (see Table A.5).

Table A.5: Boston Express Vehicle Requirements by Service Option

	Base	Expanded Base	Bus on Shoulder	Expanded Bus on Shoulder
Vehicles to Operate Minimum Service	16	30	16	30
Fleet	22	38	22	378
Spares	6	8	6	8
Percent Spare	27%	21%	27%	21%

The Bus on Shoulder and Expanded Bus on Shoulder options entailed providing more reliable service by allowing buses to operate within highway shoulders during peak periods to bypass congestion in the general travel lanes. Study team analysis of existing and forecast traffic conditions found that Bus on Shoulder operations could reduce bus delays on I-93 south of I-495. This assumption was also made by the Merrimack Valley Regional Planning Commission in their 2014 Study on Bus Use of Shoulders. Analysis of existing right-of-way conditions found sufficient shoulder width on I-93 between I-495 and Somerville to allow Bus on Shoulder operation without substantial investment in new right-of-way. An allowance of $100,000 per route mile[2] (based on experience in Minnesota) was included for upgrades to drainage, striping, and signage that would be required for each of the 22 affected route miles. A more recent estimate of $250,000 per route mile[3] (2007) was used for final screening and analysis. Table A.6 shows the preliminary capital cost estimates for the bus options.

[2] *TCRP Synthesis 64, Bus Use of Shoulders*; Peter C. Martin, Wilbur Smith Associates, San Francisco, CA 2006, page 20
[3] *TCRP Report 151 A Guide for Implementing Bus On Shoulder (BOS) Systems;* Peter C. Martin, Herbert S. Levinson, Texas Transportation Institute 2012, pages 2-5

Table A.6: Preliminary Capital Cost Estimates for Bus Options (In Millions, 2014$)

	Base	Expanded Base	Bus on Shoulder	Expanded Bus on Shoulder
Vehicles Cost *	$0.0	$6.4	$0.0	$6.4
Infrastructure Cost **	$0.0	$0.0	$2.2	$2.2
Total Capital Cost	$0.0	$6.4	$2.2	$8.6

** New coaches at $400,000 each ** Infrastructure cost of $100,000 per route mile based on Minnesota experience*

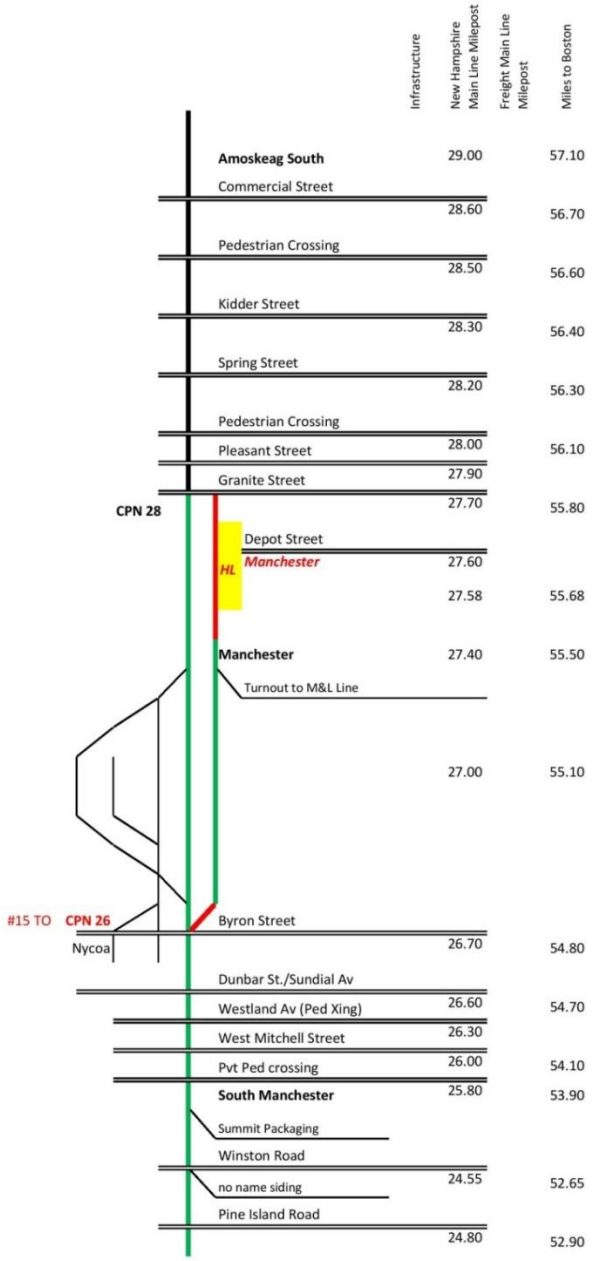
Preliminary Capital Costs – In summary, the preliminary estimates of capital cost for each rail and service option are found in Table A.7.

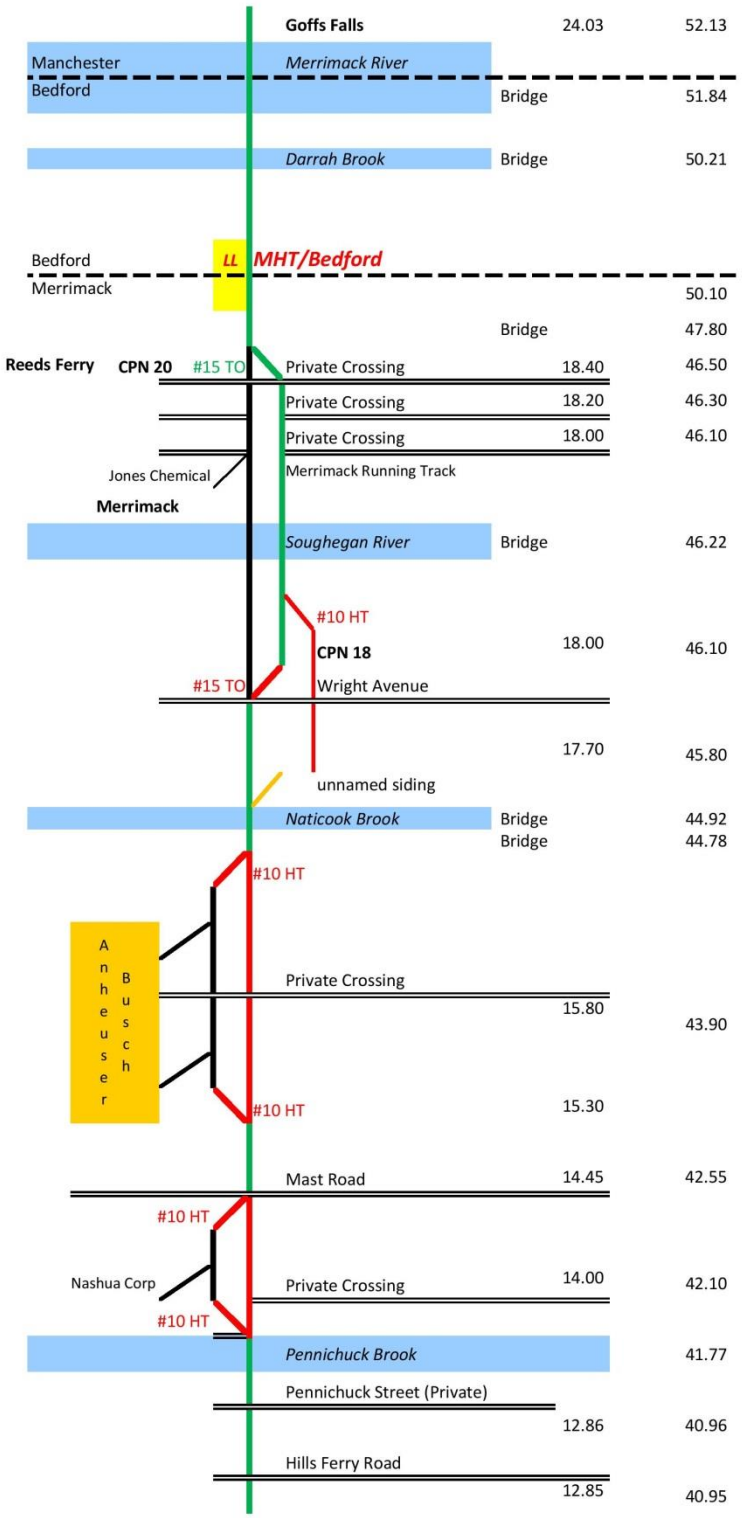
Table A.7: Preliminary Estimates of Capital Costs (In Millions, 2014$)

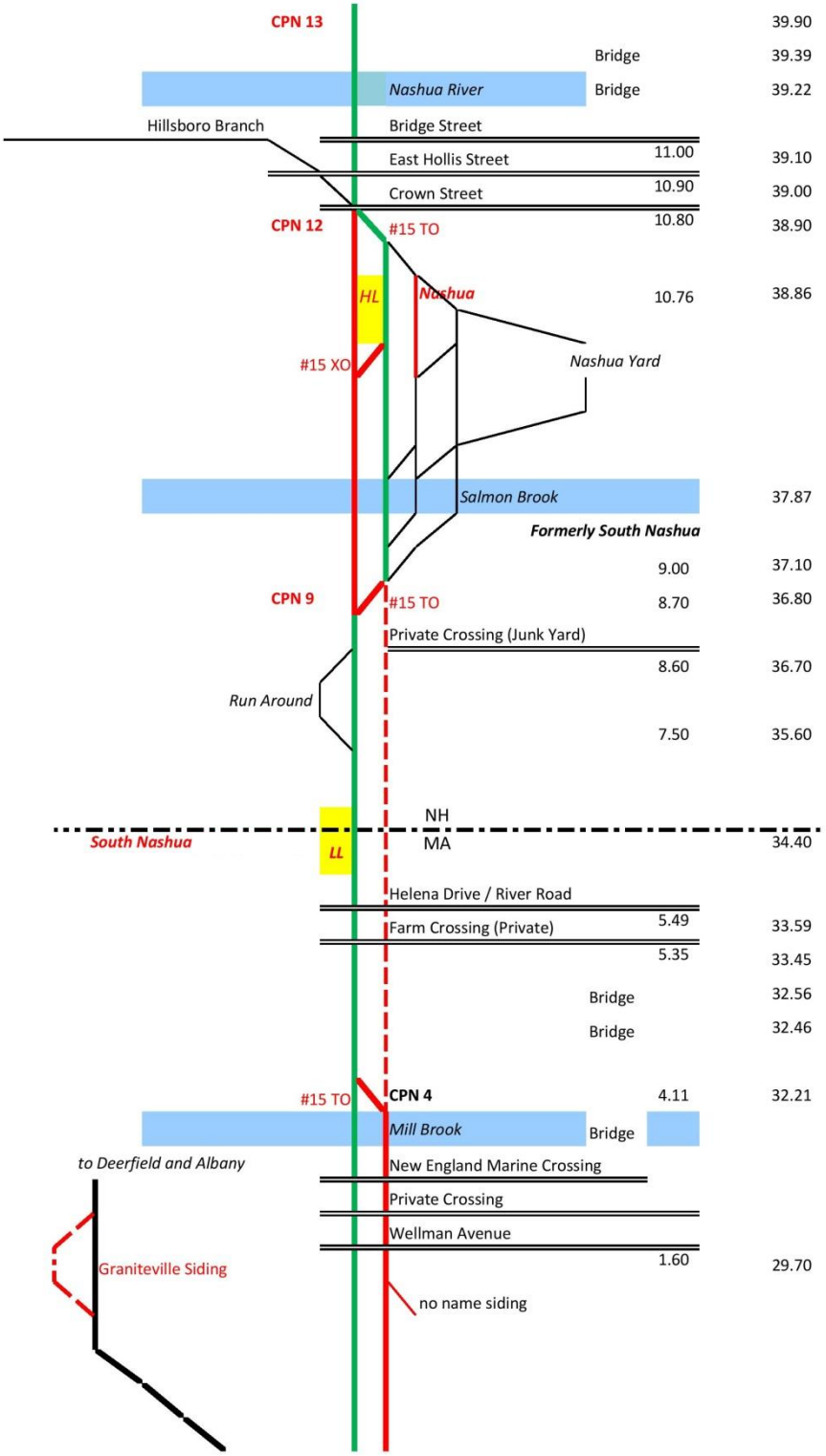
Service Option		Total
Commuter Rail Options		
	Concord Regional	$226
	Concord Commuter	$206
	Manchester Regional	$164
	Manchester Commuter	$164
	Nashua Commuter	$124
	Nashua Minimum	$124
Intercity Rail Options		
	Intercity 8	$162
	Intercity 12	$174
	Intercity 18	$174
Bus Service Options		
	Base	$0
	Expanded Base	$6
	Bus on Shoulder	$2
	Expanded Bus on Shoulder	$9

Appendix A-1
Proposed Commuter Rail Service Option Track Configuration

Figure A-1.1: Manchester Regional Proposed Track Configuration




Goffs Falls
24.03
52.13
Manchester
Bedford
Merrimack River
Bridge
51.84
Darrah Brook
Bridge
50.21
Bedford
Merrimack
LL
MHT/Bedford
50.10
Bridge
47.80
Reeds Ferry
CPN 20
#15 TO
Private Crossing
18.40
46.50
Private Crossing
18.20
46.30
Private Crossing
18.00
46.10
Jones Chemical
Merrimack Running Track
Merrimack
Soughegan River
Bridge
46.22
#10 HT
CPN 18
18.00
46.10
#15 TO
Wright Avenue
17.70
45.80
unnamed siding
Naticook Brook
Bridge
44.92
Bridge
44.78
#10 HT
Anheuser Busch
Private Crossing
15.80
43.90
#10 HT
15.30
Mast Road
14.45
42.55
#10 HT
Nashua Corp
Private Crossing
14.00
42.10
#10 HT
Pennichuck Brook
41.77
Pennichuck Street (Private)
12.86
40.96
Hills Ferry Road
12.85
40.95


CPN 13
39.90
Bridge
39.39
Nashua River
Bridge
39.22
Hillsboro Branch
Bridge Street
East Hollis Street
11.00
39.10
Crown Street
10.90
39.00
10.80
38.90
CPN 12
#15 TO
HL
Nashua
10.76
38.86
#15 XO
Nashua Yard
Salmon Brook
37.87
Formerly South Nashua
9.00
37.10
CPN 9
#15 TO
8.70
36.80
Private Crossing (Junk Yard)
8.60
36.70
Run Around
7.50
35.60
NH
South Nashua
LL
MA
34.40
Helena Drive / River Road
Farm Crossing (Private)
5.49
33.59
5.35
33.45
Bridge
32.56
Bridge
32.46
#15 TO
CPN 4
4.11
32.21
Mill Brook
Bridge
to Deerfield and Albany
New England Marine Crossing
Private Crossing
Wellman Avenue
1.60
29.70
Graniteville Siding
no name siding

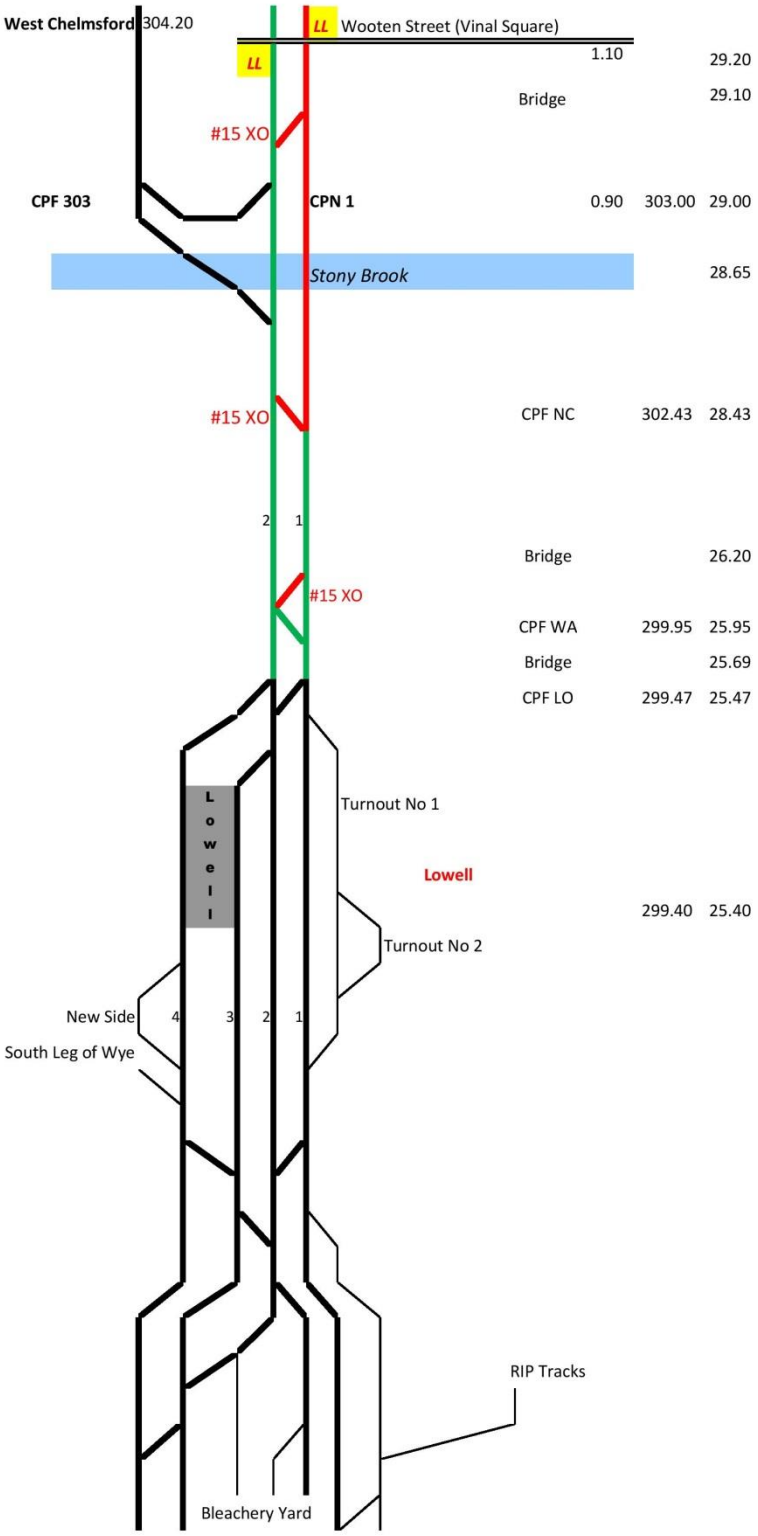
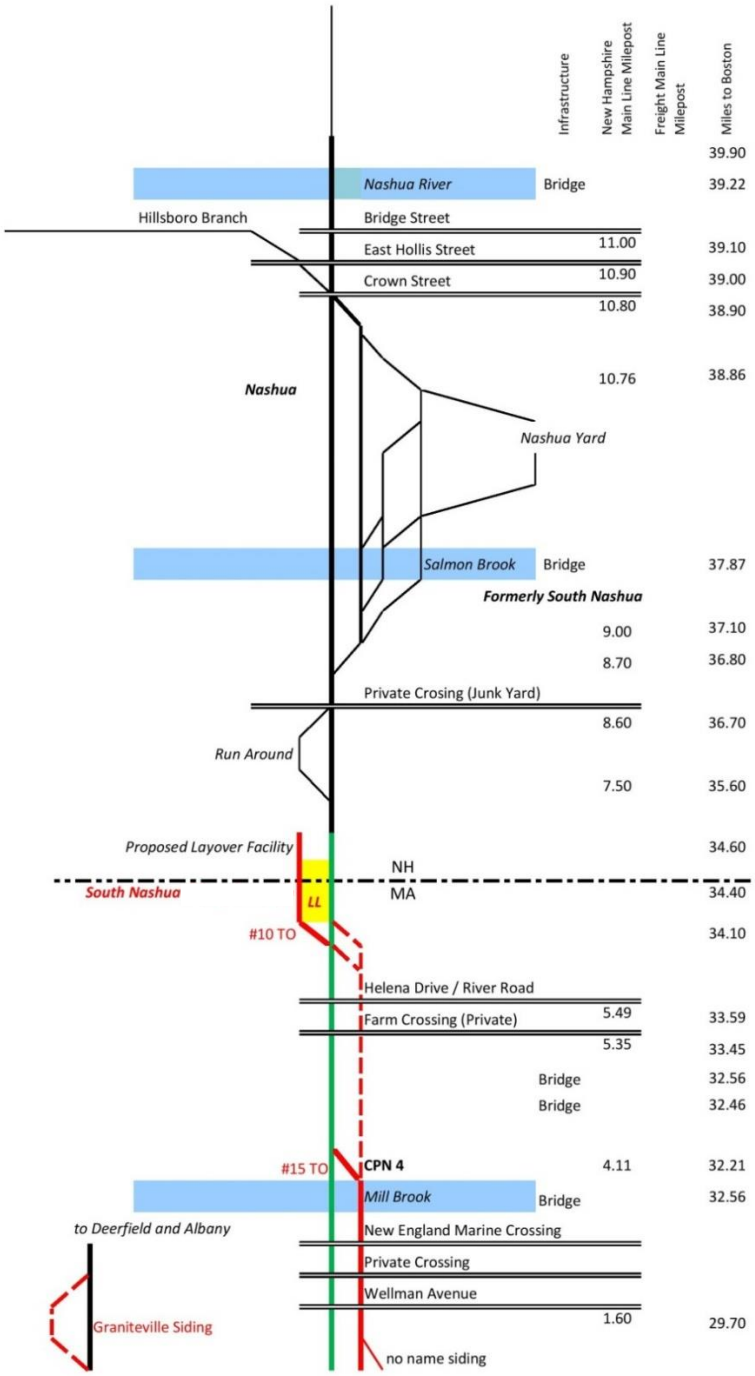
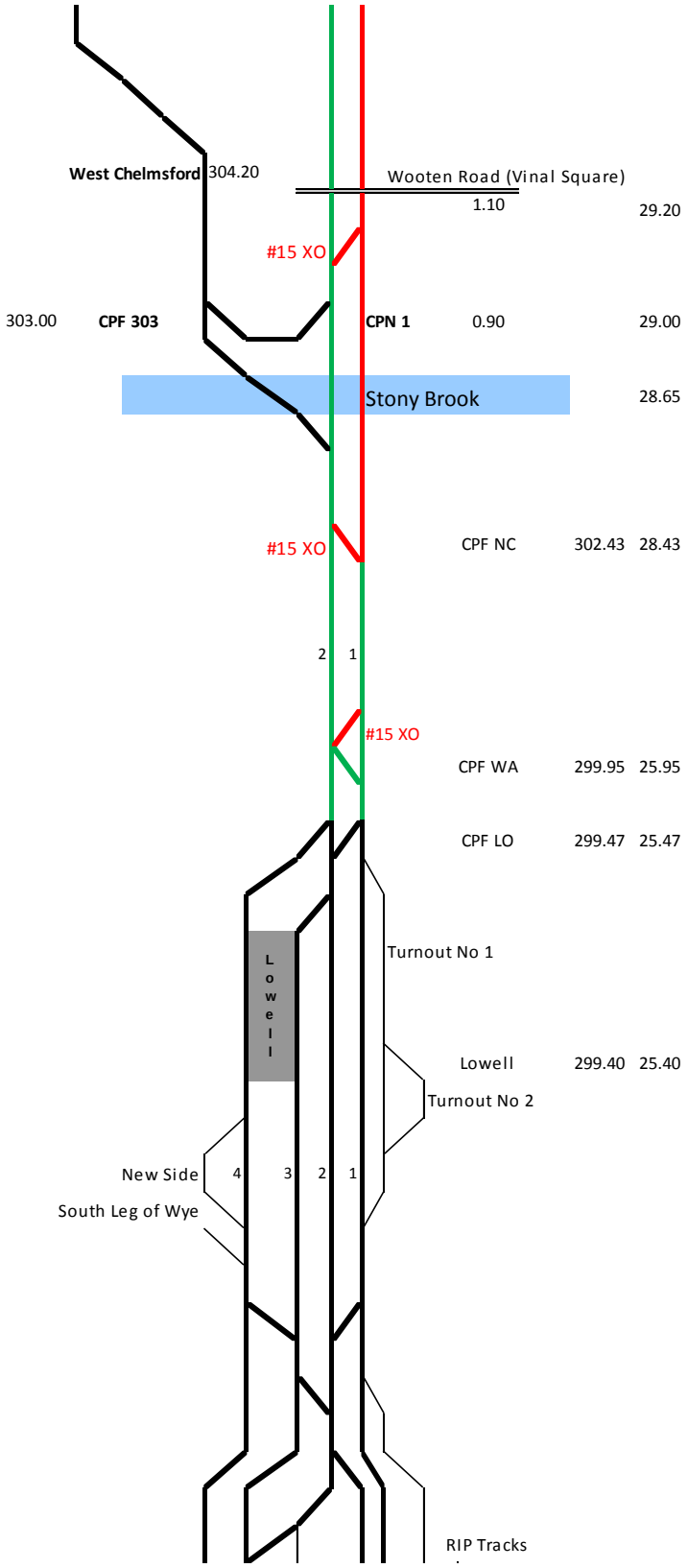

West Chelmsford
304.20
LL
Wooten Street (Vinal Square)
1.10
29.20
LL
Bridge
29.10
#15 XO
CPF 303
CPN 1
0.90
303.00
29.00
Stony Brook
28.65
#15 XO
CPF NC
302.43
28.43
2
1
Bridge
26.20
#15 XO
CPF WA
299.95
25.95
Bridge
25.69
CPF LO
299.47
25.47
Lowell
Turnout No 1
Lowell
299.40
25.40
Turnout No 2
New Side
4
3
2
1
South Leg of Wye
RIP Tracks
Bleachery Yard

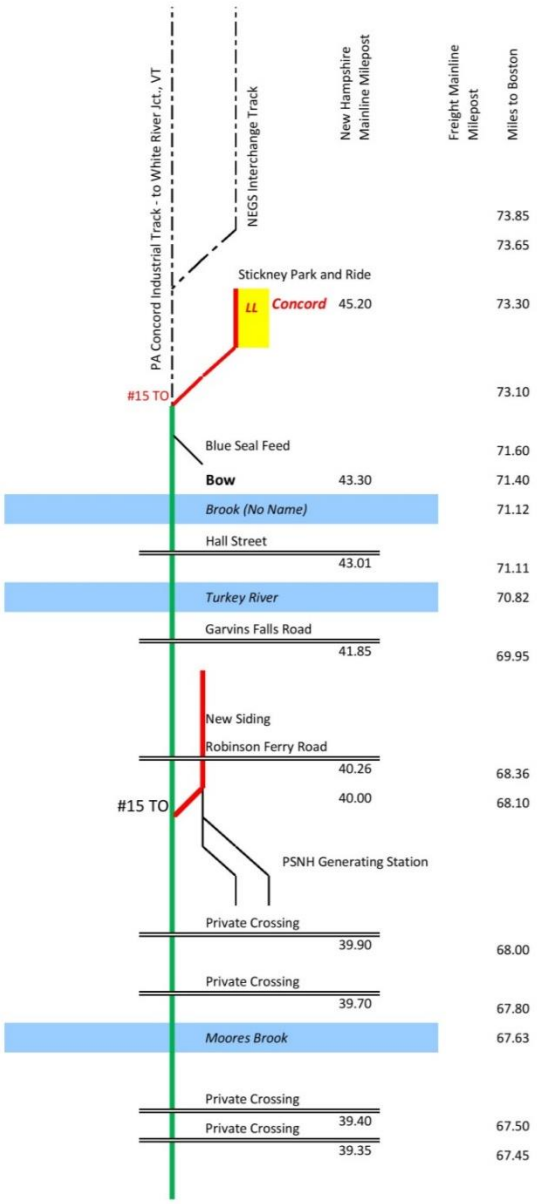
Figure A-1.2: Nashua Minimum Proposed Track Configuration

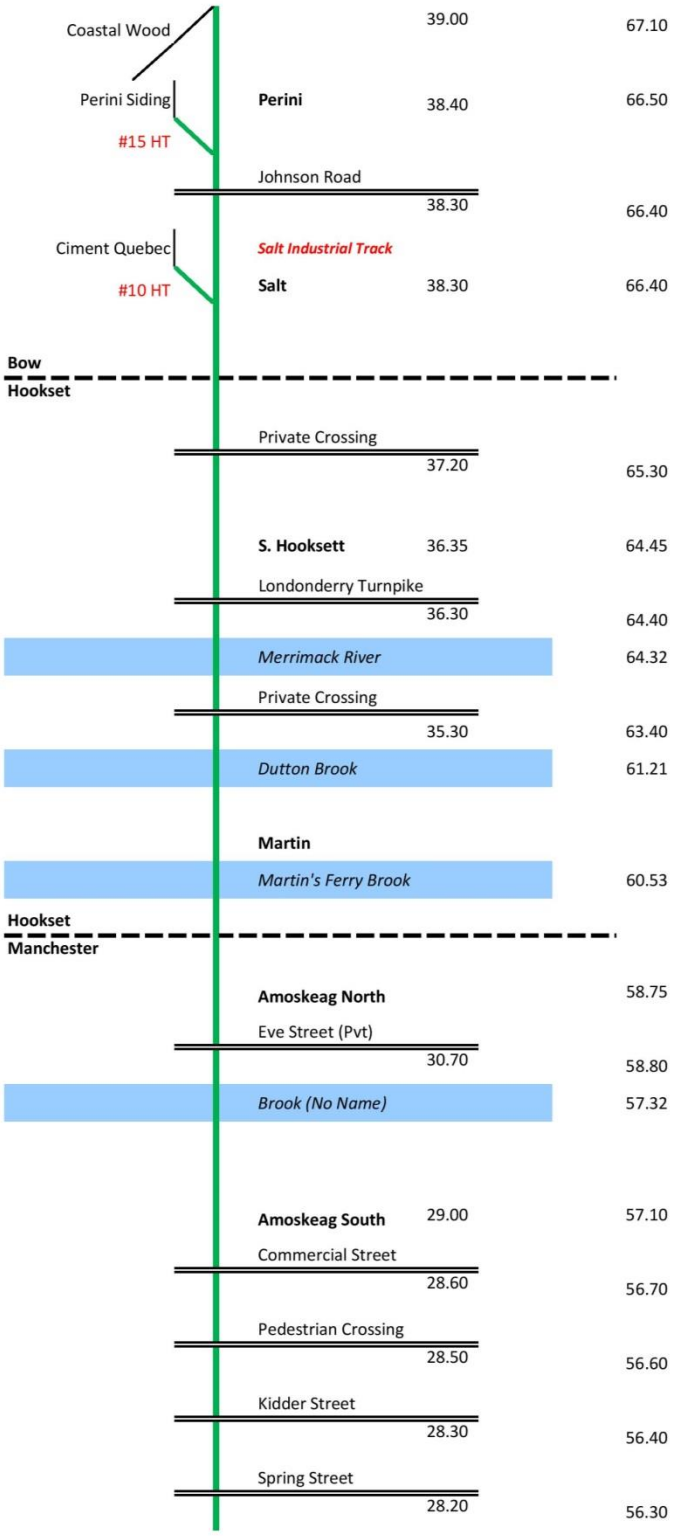



West Chelmsford
304.20
Wooten Road (Vinal Square)
1.10
29.20
#15 XO
303.00
CPF 303
CPN 1
0.90
29.00
Stony Brook
28.65
#15 XO
CPF NC
302.43
28.43
2
1
#15 XO
CPF WA
299.95
25.95
CPF LO
299.47
25.47
Turnout No 1
Lowell
Lowell
299.40
25.40
Turnout No 2
New Side
4
3
2
1
South Leg of Wye
RIP Tracks

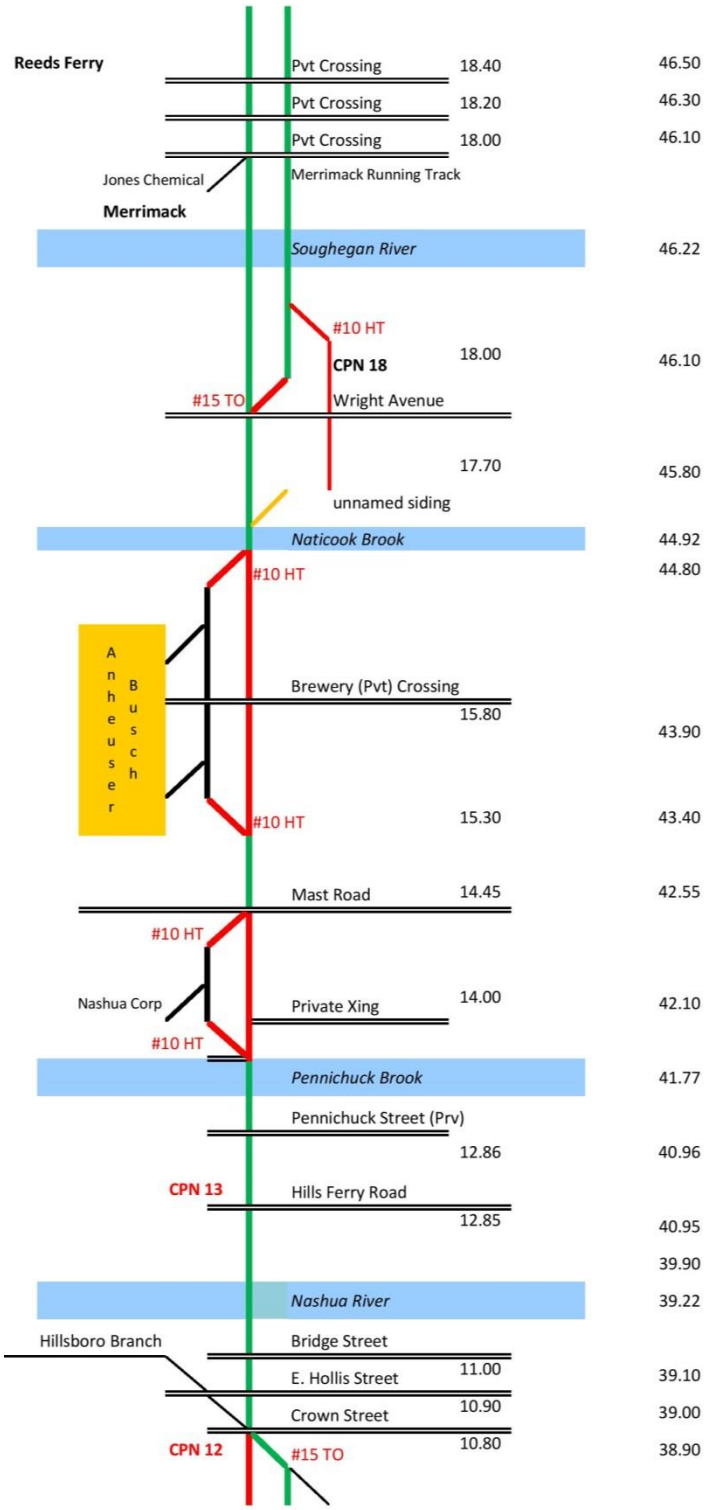
Appendix B-1
Proposed Intercity Rail Service Option Track Configuration

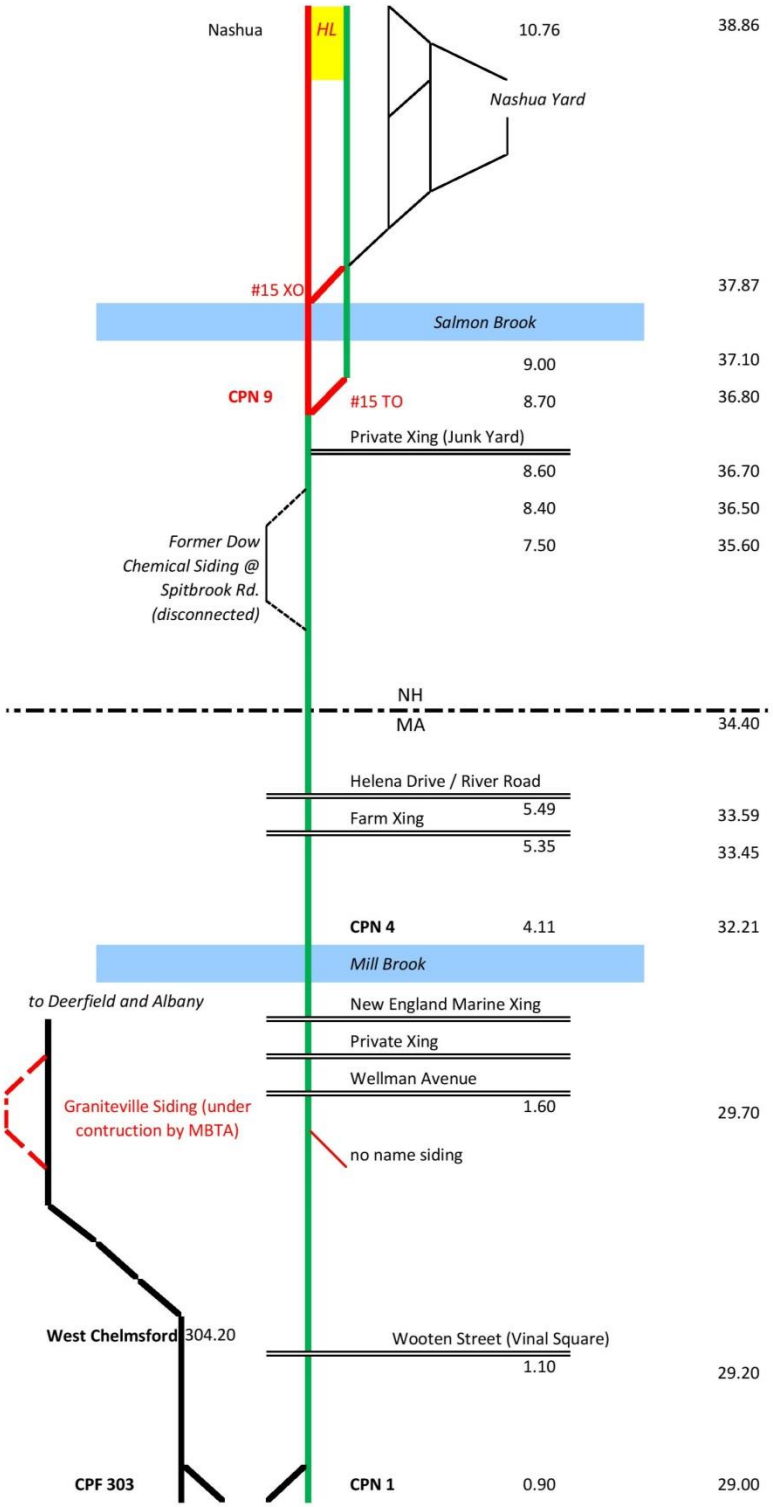
Figure B-1.1: Intercity 8 Proposed Track Configuration

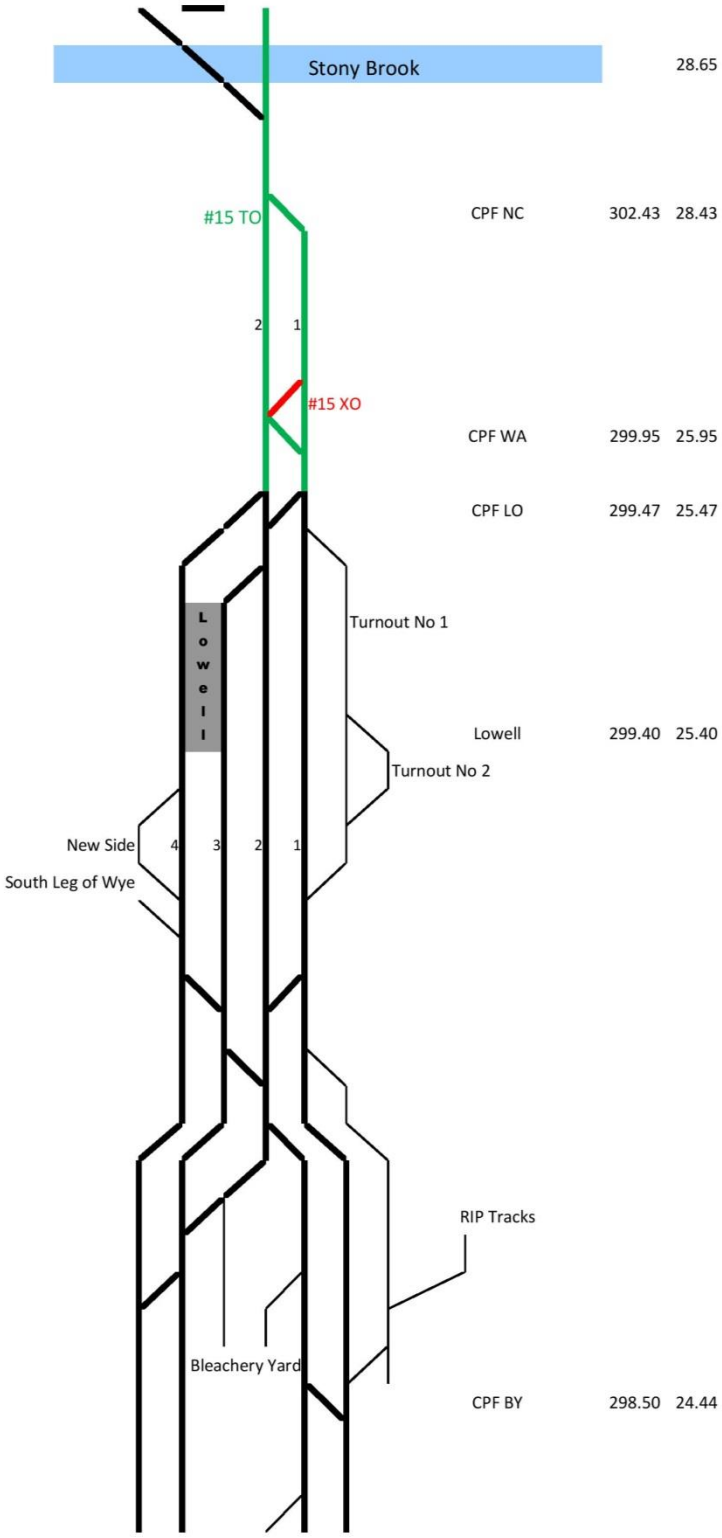



Coastal Wood
39.00
67.10
Perini Siding
#15 HT
Perini
38.40
66.50
Johnson Road
38.30
66.40
Ciment Quebec
#10 HT
Salt Industrial Track
Salt
38.30
66.40
Bow
Hookset
Private Crossing
37.20
65.30
S. Hooksett
36.35
64.45
Londonderry Turnpike
36.30
64.40
Merrimack River
64.32
Private Crossing
35.30
63.40
Dutton Brook
61.21
Martin
Martin's Ferry Brook
60.53
Hookset
Manchester
Amoskeag North
58.75
Eve Street (Pvt)
30.70
58.80
Brook (No Name)
57.32
Amoskeag South
29.00
57.10
Commercial Street
28.60
56.70
Pedestrian Crossing
28.50
56.60
Kidder Street
28.30
56.40
Spring Street
28.20
56.30


Pedestrian Crossing
Pleasant Street
28.00
56.10
Granite Street
27.90
#15 TO
CPN 28
27.70
55.80
Depot Street
Manchester
27.60
HL
27.58
55.68
Manchester
27.40
55.50
Turnout to M&L Line
27.00
55.10
#15 TO
CPN 26
Byron Street
Nycoa
26.70
54.80
Dunbar St./Sundial Av
Westland Av (Ped Xir
26.60
54.70
West Mitchell Street
26.30
Pvt Ped crossing
26.00
54.10
So Manchester
25.80
53.90
Summit Packaging
Winston Road
no name siding
24.55
52.65
Pine Island Road
24.80
52.90
Goffs Falls
24.03
52.13
Manchester
Merrimack River
Bedford
51.84
Darrah Brook
50.21
Bedford
LL
MHT/Bedford
Merrimack
50.10
#15 TO
CPN 20
19.80
47.90


Reeds Ferry
Pvt Crossing
18.40
46.50
Pvt Crossing
18.20
46.30
Pvt Crossing
18.00
46.10
Jones Chemical
Merrimack Running Track
Merrimack
Soughegan River
46.22
#10 HT
CPN 18
18.00
46.10
#15 TO
Wright Avenue
17.70
45.80
unnamed siding
Naticook Brook
44.92
#10 HT
44.80
Anheuser Busch
Brewery (Pvt) Crossing
15.80
43.90
#10 HT
15.30
43.40
Mast Road
14.45
42.55
#10 HT
Nashua Corp
Private Xing
14.00
42.10
#10 HT
Pennichuck Brook
41.77
Pennichuck Street (Prv)
12.86
40.96
CPN 13
Hills Ferry Road
12.85
40.95
39.90
Nashua River
39.22
Hillsboro Branch
Bridge Street
E. Hollis Street
11.00
39.10
Crown Street
10.90
39.00
CPN 12
#15 TO
10.80
38.90


Nashua
HL
10.76
38.86
Nashua Yard
#15 XO
37.87
Salmon Brook
9.00
37.10
CPN 9
#15 TO
8.70
36.80
Private Xing (Junk Yard)
8.60
36.70
8.40
36.50
Former Dow Chemical Siding @ Spitbrook Rd. (disconnected)
7.50
35.60
NH
MA
34.40
Helena Drive / River Road
5.49
Farm Xing
33.59
5.35
33.45
CPN 4
4.11
32.21
Mill Brook
to Deerfield and Albany
New England Marine Xing
Private Xing
Wellman Avenue
1.60
29.70
Graniteville Siding (under contruction by MBTA)
no name siding
West Chelmsford
304.20
Wooten Street (Vinal Square)
1.10
29.20
CPF 303
CPN 1
0.90
29.00


Stony Brook
28.65
#15 TO
CPF NC
302.43
28.43
2
1
#15 XO
CPF WA
299.95
25.95
CPF LO
299.47
25.47
Turnout No 1
Lowell
Lowell
299.40
25.40
Turnout No 2
New Side
4
3
2
1
South Leg of Wye
RIP Tracks
Bleachery Yard
CPF BY
298.50
24.44

Appendix B
Preliminary O&M Cost Methodology Memorandum

TECHNICAL MEMORANDUM

This memorandum describes the assumptions and methods that were applied to derive the preliminary O&M cost estimates. The Study team's approach for estimating O&M costs was different for the commuter rail, intercity rail, commuter bus, and feeder bus service components. Each approach is described below.

Commuter Rail – A conceptual schedule was prepared for each rail service option. Each schedule included estimates of weekday train miles and estimates of rolling stock that would need to be added to the MBTA fleet for each service. A plan for track improvements to support each service option was prepared, allowing the team to assign a number of track miles to each service option. MassDOT and MBTA, rail stakeholders that would operate the proposed services, were briefed on the service designs and infrastructure proposals. Copies of the briefing documents with service statistics are found in Appendix A-1 to this memorandum.

Feedback from MassDOT and MBTA was applied to finalize the service designs and infrastructure requirements for each of the nine preliminary rail options. Those designs were used to prepare rough O&M cost estimates to a level sufficient for screening preliminary alternatives. The assumptions and cost drivers used to develop the estimates are summarized below.

MBTA cost reports to the FTA from 2009 were used to estimate components of cost for current MBTA service. Detailed operating information on MBTA's commuter rail service is limited because it is operated by a private contractor that is not required to disclose limited financial information for competitive reasons. Total annual costs for operations, mechanical (revenue vehicle) maintenance, and infrastructure (non-vehicle) maintenance are reported along with basic service statistics relating to transit service, fleet size, and infrastructure components. The Study team was able to disaggregate that basic information on MBTA commuter rail costs into four broad categories with allocation factors for each:

1. **Operations** – train and engine crews, train fuel, train dispatchers, crew callers, supervision, and train supplies; allocated by train mile
2. **Infrastructure maintenance** – inspection and maintenance of track, signals, stations, and structures, including non-revenue vehicles; allocated by track mile
3. **Mechanical maintenance** – inspection and maintenance of locomotives and coaches; allocated by vehicles in fleet; locomotives and coaches are estimated separately assuming that each locomotive requires four times more maintenance attention than the typical coach
4. **Administration** – human resources, information technology, safety, marketing, revenue management, and other central office oversight and support functions; it was presumed for the relatively small extension of the MBTA network into New Hampshire that cost impacts on MBTA administration would be negligible

Based on previous work with MBTA and other agencies, the Study team assumed that 15 percent of costs for operations, mechanical, and infrastructure were fixed overhead activities related to central office functions such as crew scheduling, mechanical facilities, and engineering management. Eighty-five percent of the average costs per train mile, locomotive, coach, and track mile shown in Table B.1 were used to estimate variable costs associated with the proposed service extension.

Table B.1: Derivation of Preliminary Estimates of Commuter Rail Operating Costs (2009$)

	Reported Annual Cost	Units	Reported Quantity	Ratio	% Variable	Variable Cost Ratio
Operations	$99,766,101	Train Miles	4,113,978	$24.25	85%	$20.61
Mechanical	$79,580,205	Peak Vehicles	418	$190,383.27	85%	$161,826
Locomotive Maint.	$31,938,544	Locomotives	60	$532,309	85%	$452,463
Coach Maintenance	$47,641,661	Coaches	358	$133,077	85%	$113,116
Infrastructure Maint.	$72,483,639	Track Miles	666	$108,850.64	85%	$92,523

Based on 2009 Financial Reports of MBTA to Federal Transit Administration

The Study team used the information in Table B.2 to estimate O&M cost drivers for each commuter rail option. These cost drivers are increased train miles, increased rolling stock (locomotives and coaches), and increased track miles.

Table B.2: Cost Drivers used for Preliminary Estimates of Commuter Rail Operating Costs

Commuter Rail Service Options	Weekday Train Miles	Morning Peak Locomotives	Morning Peak Coaches	Track Miles
Base Service	1,452	4	24	53
Concord Regional	1,957	5	36	115
Concord Commuter	2,374	5	36	115
Manchester Regional	2,068	5	36	98
Manchester Commuter	2,091	5	36	98
Nashua Commuter	1,888	5	36	80
Nashua Minimum	1,496	5	36	72
Increments above Base Service				
Concord Regional	505	1	12	62
Concord Commuter	922	1	12	62
Manchester Regional	616	1	12	45
Manchester Commuter	639	1	12	45
Nashua Commuter	436	1	12	27
Nashua Minimum	44	1	12	19

An annualization factor of 300 weekday equivalents per year was used to convert weekday train miles into an estimate of annual train miles. The product of the cost drivers multiplied by the cost factors for each service option yielded the six sets of forecasts shown in Table B.3.

Table B.3: Preliminary Estimates of Commuter Rail Operating Costs (In Millions, 2009$)

Commuter Rail Service Options	Operations	Mechanical Maintenance	Infrastructure Maintenance	Total
Concord Regional	$3.16	$1.62	$6.23	**$11.10**
Concord Commuter	$5.60	$1.58	$6.04	**$13.30**
Manchester Regional	$3.76	$1.57	$4.37	**$9.70**
Manchester Commuter	$3.94	$1.58	$4.38	**$9.90**
Nashua Commuter	$2.58	$1.55	$2.58	**$6.80**
Nashua Minimum	$0.35	$2.25	$2.48	**$5.20**

Intercity Rail – Each intercity rail option was developed to the same level of detail as the commuter rail service options, including 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 Service Development Plan (SDP) (Appendix 9 to the AA Final Report). The Study team was referred to documentation from several recent 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 used the annual train mile approach as documentation concerning Amtrak's methodology is not publicly available. 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 Brunswick, 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.

The most recent data on the *Downeaster* service indicated that it costs roughly $36 per train mile to operate. 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 B.4 were derived for the three intercity service options.

Table B.4: Derivation of Preliminary Estimates of Intercity Rail Operating Costs (2012$)

Intercity Service Option	Trips per Day	Train Miles per Day	Train Miles per Year	Annual Operating Cost (@ $36/train mile)
Intercity 8	8	590	214,040	$7,705,300
Intercity 12	12	880	321,050	$11,557,940
Intercity 18	18	1,320	481,580	$17,336,920

Commuter Bus – Weekday service schedules were developed for each of the three commuter bus options, including estimates of vehicle requirements and bus miles. Each schedule was reviewed with BX and revised to reflect their advice and input. Service statistics and cost summaries used to develop a preliminary cost model were also provided by Boston Express (BX) and included in Appendix B-1 to this memorandum.

Cost drivers for the preliminary cost model were the size of the vehicle fleet and revenue vehicle miles traveled. BX provided an annual average maintenance cost per vehicle of $27,032 and information on total operating costs, including vehicle maintenance. The residual operating costs that remained after vehicle maintenance had been accounted for were used to derive an average operations and management cost of $4.17 per bus mile. These variables were used to estimate the annual operating costs for the three service options as summarized in Table B.5.

Table B.5: Derivation of Preliminary Estimates of Commuter Bus Operating Costs (2012$)

Service Statistics and Costs	Base	Expanded Base	Bus on Shoulder	Expanded Bus on Shoulder
Peak Vehicles	20	30	20	30
Total Fleet including Spares	22	38	22	38
Revenue Vehicle Miles Travelled (RVMT)	1,286,685	1,914,368	1,286,685	1,914,368
Fuel, Crew, and Supervision per RVMT	$4.17	$4.17	$4.17	$4.17
Maintenance Expense per Coach	$27,032	$27,032	$27,032	$27,032
Vehicle Maintenance Expense	$594,704	$1,027,216	$594,704	$1,027,216
Vehicle Operating Expense	$5,364,033	$7,980,768	$5,364,033	$7,980,768
Preliminary Estimate of Total Expense	**$5,958,737**	**$9,007,984**	**$5,958,737**	**$9,007,984**

Feeder Bus – A feeder bus service was proposed for the Nashua Minimum Commuter Rail option to provide supplemental midday connecting service between the MBTA station in Lowell, Massachusetts and the proposed South Nashua station. Another feeder bus was proposed for the Manchester Regional Commuter Rail option to provide supplemental midday connecting service between the proposed Nashua Crown Street station and the proposed station in downtown Manchester. Schedules for the two proposed services were included in the timetables prepared for the two commuter rail options so that values for the vehicles required, number of trips, vehicle miles, and vehicle hours could be developed. Information for three nearby transit agencies reported to the FTA in 2012 (see Appendix C-1 to this

memorandum) was used to estimate cost components for the proposed feeder bus service as shown in Table B.6. These transit agencies were the Lowell Regional Transit Authority (LRTA), Manchester Transit Authority (MTA), and the Nashua Transit System (NTS).

Table B.6: Derivation of Preliminary Estimates of Feeder Bus Operating Costs (2012$)

Service Statistics and Costs	Manchester Regional Commuter Rail	Nashua Minimum Commuter Rail
Vehicles Required	1	1
Bus Trips per Day	8	12
Daily Vehicle Miles	164	162
Daily Vehicle Hours	3.9	5.8
Annual Vehicle Miles	41,820	41,310
Annual Vehicle Hours	986	1,479
Mech. Cost per Vehicle Mile	$34,935	$34,509
Transport Cost per Vehicle Hour	$45,939	$68,908
Annual O&M Cost	**$80,874**	**$103,417**

Summary of Preliminary Estimates of O&M Costs – The preliminary estimates of O&M cost for each rail and bus service option are found in Table B.7.

Table B.7: Preliminary Estimates of Annual O&M Costs (In Millions, 2009$ for Commuter Rail Options, 2012$ for Intercity and Bus Options)

Service Option		Total
Commuter Rail Options		
	Concord Regional	$11.1
	Concord Commuter	$13.3
	Manchester Regional	$9.7
	Manchester Commuter	$9.9
	Nashua Commuter	$6.8
	Nashua Minimum	$5.2
Intercity Rail Options		
	Intercity 8	$7.7
	Intercity 12	$11.6
	Intercity 18	$17.3
Bus Service Options		
	Base	$5.9
	Expanded Base	$9.0
	Bus on Shoulder	$5.9
	Expanded Bus on Shoulder	$9.0

Appendix A-1
Commuter Rail Briefing Documents with Service Statistics

Table A-1.1: 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; 3/9/2012

Table A-1.2: Ethan Allen Operating Cost Calculation (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	$43.8	$48.9-$55.4	$32.3	$34.5
Estimated Annual Ridership	53, 600	44, 300	74, 500	58, 400
Estimated Annual Revenue	$1.1	$1.0	$1.5	$1.2
Estimated Annual Operation Expense	$4.1	$4.1	$4.4	$4.2
Estimated Annual Operation Contract	$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

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 A-1.3: *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

Appendix B-1
Boston Express Operating Statistics

Boston-Lowell-Nashua Manchester-Concord Transit Study Data Request
Boston Express Bus, Inc Responses

Annual Cost per Trip		
2012 Q1 Total Operating Expenses	$	6,120,387.64
Less 2012 Advertising Expense	$	161,661.11
Total Op Expense less Advertising	$	5,958,726.53
2012 Total Trips Operated		25,626
Total 2012 Cost per Trip	$	232.53
Annual Revenue per Trip		
		See Fare Recovery per trip
Annual Revenue Miles		
2012 Live/Revenue Miles Total		1,286,685
Annual Vehicle Miles		
2012 Total Miles Operated		1,466,723
Maintenance Costs per Vehicle		
2012 Total Operations + Maintenance Expense	$	594,696.25
Total Number of Motorcoaches		22
Total Annual Maintenance Cost per Motorcoach	$	27,031.65

Appendix C-1
Feeder Bus Cost Factors

Table C-1.1: Cost Factors Used to Estimate Feeder Bus O&M Costs (2012$)

	Bus Fleet	Annual Revenue Vehicle Miles (000's)	Annual Vehicle Hours	Mechanical Costs	Transport Costs	Mechanical Cost per Vehicle Mile	Transport Cost per Vehicle Hour
Lowell Regional Transit Authority (LRTA)	47	1,155.7	83.1	$1,113,424	$3,964,653	$0.96	$49.37
Manchester Transit Authority (MTA)	17	483.5	41.9	$457,661	$2,100,442	$0.95	$51.11
Nashua Transit System (NTS)	11	360.3	26.5	$214,765	$1,017,309	$0.60	$39.29
Average						$0.84	$46.59