E. Cost Estimate

Estimate Format and Work Breakdown Structure

The Work Breakdown Structure (WBS) for the NSRL project has been laid out as follows:

- South Station Expansion (No NSRL) alternative
  - **Dorchester Avenue improvements:** divided into pavement works, landscaping, appurtenances, traffic management, drainage, utilities, etc.
  - **South Station headhouse:** divided into its major components, such as foundation, substructure, superstructure, mechanical, electrical and plumbing (MEP), and furnishings
  - **South Station Expansion:** divided into civil works (drainage, noise barriers) and track work
  - **Readville & Widett Circle layover facilities:** divided into pavement works, drainage and other civil components, track work, and buildings
- Tunnel alternatives (all alignments follow the same WBS)
  - **Tunneling works:** including tunnel boring machine (TBM), mined tunnels, tunnel systems, and fit-out
  - **Station work:** including excavation, access shafts, station fit-out, systems, and conveying equipment
  - **Trackwork:** including civil works for at-grade track, track work per mile, systems (signaling and electrification)
  - **Portal works:** including civil works, track work, and electrification
  - **Allowances:** including underpinning and utility relocations
- Upstream/downstream improvements (all alternatives follow the same WBS)
  - **Additional layover facilities:** pavement works, drainage and other civil components, track work, and buildings (in NSRL alternatives only)
  - **Fitchburg Line:** including additional platform capacity and double-track work
  - **Old Colony Line:** including double-tracking
  - **Newbury/Rockport Lines:** including double-tracking
  - **Needham Line:** including double-tracking
  - **Providence/Stoughton Line:** including additional platform capacity
  - **Worcester Line:** including additional platform capacity and resignaling works
  - **Haverhill Line:** including double-tracking
  - **Franklin Line:** including double-tracking and additional turnback crossover
  - **Fairmount Line:** including double-tracking and electrification (priced separately)
  - **Lowell Line:** electrification (priced separately)

Table E1 summarizes the main scope differences between this Feasibility Reassessment and the 2003 study.

To obtain the total project costs, a cost estimating algorithm was applied to incorporate all relevant costs, such as indirect costs, overhead and profit, soft costs, contingencies, and escalation. Figure E-1 summarizes the estimating algorithm that applies to all performed estimates.

The accuracy range based on AACEi cost classification matrix was then applied to the total project cost.

	2003 Study	2018 Study
Tunneling	Diameter of 41.5ft No detail on launch pits	Diameter of 41.5ft Larger diameter requires deeper tunnels for the benefit of complete tunnel containment in bedrock Cost includes launch pit of one TBM for the Central Artery 2-track alternative, and launch pit for two TBMs for the Central Artery 4-Track alternative
Portals	Includes level junctions	Includes level junctions and grade separation for both alignment alternatives (Central Artery 2-Track and 4-Track)
Vertical Alignment	Maximum grade of 3%	Maximum grade of 2.75%
Horizontal Alignment	Alignment goes under the Federal Reserve property at 600 Atlantic Avenue	Alignments avoid Federal Reserve property at 600 Atlantic Avenue
Back Bay Station	Unaffected	Need to split and lower an entire platform to fit underneath the Orange Line and to maintain a connection to the Worcester Line with the NSRL tunnel
Existing Buildings	No detail provided	Deeper knowledge of existing foundations and obstacles throughout the alignment, which has resulted in allowances made for underpinning works

Table E1: High-Level Scope Comparison Between Current Feasibility Reassessment and 2003 Study

Estimate Methodology

Cost is used for the comparison of similar alternatives. The cost estimates were generated to meet the level of accuracy in accordance with the current design.

The estimate was developed by establishing the full scope for all alternatives, assigning appropriate unit costs for each line item, and applying the relevant markups to arrive at a total project cost in the desired year of analysis.

Standard Estimating Algorithm

Design Build Entity	TDC	Total Direct Costs	TDC
	TIC	Total Indirect Costs	TIC
	TC	**Total Cost**	**TDC+TIC=TC**
	OH&P	Overhead & Profit	OH&P
	STP	**Sub Total Price**	**OH&P+TC = STP**
	C	Contractor's Contingency	C
	TP	**Total Price**	**STP+C=TP**
	PE FD	Preliminary Engineering / Final Design	PE FD
	T DB	**Total Design Build Price**	**TP+PE FD**
Owner	SC	Soft Costs	SC
	ST SC	**Sub Total with Soft Costs**	**T DB + SC = ST SC**
	RC	Risk Contingency	RC
	TPC	**Total Project Cost**	**ST SC + RC = TPC**
	E	Escalation	E
	TPCT	**Total Project Cost at a Specific Point in Time in the Future**	**TPC + E = TPCT**

Figure E1: Estimating Algorithm

Quantity Development

For each component or specific element of work, a measurement of the quantities needed for completion (or a "quantity takeoff") was performed with the available information, considering that the level of engineering is below 5%. Based on alignment lengths, the following scope items were calculated:

- Tunnel lengths (by type of tunneling method: TBM bore, mined)
- Tunnel excavation volumes based on tunnel cross sections
- Tunnel fit-out concrete volumes based on tunnel cross sections
- Trackwork length

Based on 3-D models created in-house, the following quantities were calculated:

- Station excavation volumes (cut-and-cover or mined)
- Station access shafts
- Station platform and concourse areas
- Underpinning needs

Table E2 summarizes the main scope components for the tunnel alternatives and their key driver quantities.

	Central Artery 2-Track	South/Congress	Pearl/ Congress	Central Artery 4-Track
TBM launch pit (area in ft^2)	86,112	131,072	37,845	172,225
TBM launch pit (volume in cubic yards [cy])	264,716	397,682	225,824	529,432
TBM excavation length (route miles)	2.22	2.04	2.15	2.65
Mined excavation length (route miles)	0.91	0.99	1.16	1.23
Portal works – retained cut (route miles)	2.27	2.46	2.46	2.74
Total Alignment Lengths (miles)	**5.40**	**5.49**	**5.77**	**6.62**
South Station Exc. Volume (cy)	287,141	72,349	279,414	563,152
Central Station Exc. Volume (cy)	N /A	N /A	N /A	314,456
North Station (or Haymarket) Exc. Volume (cy)	161,517	72,349	279,414	314,456
Total Station Excavation Volume (cy)	**448,658**	**144,698**	**558,828**	**1,192,064**

Table E2: Main Scope Component Quantification

Table E3 summarizes the scope added for the upstream/downstream improvements.

Allowances and assumptions were made in order to include items that are not quantifiable from the current level of design.

Quantity takeoffs were performed on the 30% Preliminary Engineering drawings provided by the South Station Expansion team for the South Station Expansion (No NSRL) alternative, which encompasses Dorchester Avenue improvements, the South Station headhouse and trackwork, and new layover facilities at Readville and Widett Circle.

	South Station Expansion (No NSRL)	Central Artery 2-Track	South/ Congress	Pearl/ Congress	Central Artery 4-Track
Additional Platforms (Each)	4	3	3	3	4
Double-Track Length (track miles)	8.2	9.6	9.6	9.6	9.6
Additional Turnback Crossovers (Each)	2	3	3	3	3
Resignaling of Critical Points (miles)	30	30	30	30	30

Table E3: Scope of Upstream/Downstream Improvements

Benchmarks and Unit Price Buildup

A combination of unit cost approaches was used to determine the total cost for all scope items. For tunneling works, where tunnel cross sections and construction methodology are the only parameter, benchmarks from historical databases were used based on excavation and lining costs per mile of tunnel. For all other scope items, unit rates were derived using the unit method of costing, which uses single-functional unit rates based on historical data from previous and similar construction projects. Assumptions were made to assess the quantities and costs of certain scope items (e.g., sheet pile types for the cofferdams and retaining wall types for the portals).

Figures E2 and E3 summarize the benchmarks for TBM bores and sequential-excavation-method mined shafts/tunnels. Each graph contains the NSRL estimate's data point, shown as a dashed line. Tables E-4 to E-6 provide supporting detail for the information contained in the graphs.

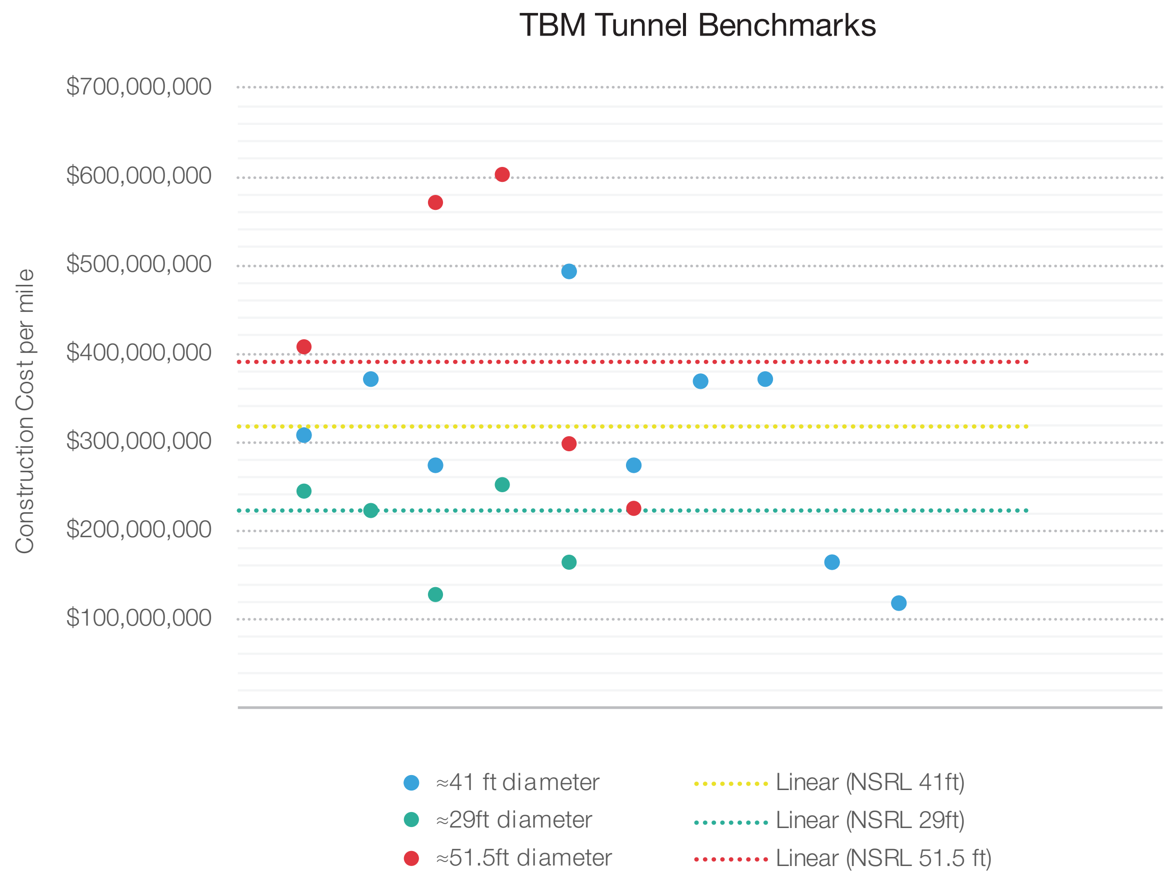

Figure E2: TBM Tunnel Construction Cost Benchmarks by Tunnel Diameter Compared to NSRL Costs (2018 USD)

Project	Location	Diameter	Year	Normalized cost per mile
California High Speed Rail	Los Angeles	40ft	2009	306,976,500
Wesertunnel	Germany	38ft	2001	370,036,200
I-710 (C3)	Los Angeles	42ft	2017	273,125,000
Airport Link Brisbane	Brisbane, Australia	41ft	2012	491,121,000
A86W	Paris, France	38ft	2010	368,828,500
Dublin Port Tunnel	Dublin	38ft	2006	162,703,900
Westerschelde	Netherlands	37ft	2002	117,958,300
California High Speed Rail	Los Angeles	30ft	2009	242,725,600
Crossrail - C300 Western Running Tunnels	UK	20ft	2010	222,361,200
Crossrail - C305 Eastern Running Tunnels	UK	20ft	2010	127,064,900
Beacon Hill Tunnel	Seattle	21ft	2009	250,447,000
Pannerdenschkanaal	Netherlands	32ft	2003	163,356,100
California High Speed Rail	Los Angeles	50ft	2009	406,922,300
Groene Hart Tunnel	Leiderdorp, Netherlands	48ft	2006	568,792,300
4th tube of the Elbe	Hamburg, Germany	47ft	2002	601,830,300
I-710 (A3)	Los Angeles	50ft	2017	297,767,900
M-30	Madrid, Spain	50ft	2008	223,174,500

Table E4: Data points of Figure E-2 TBM Tunnel Construction Cost Benchmarks, with normalized costs to 2018 USD, Boston Location Factor

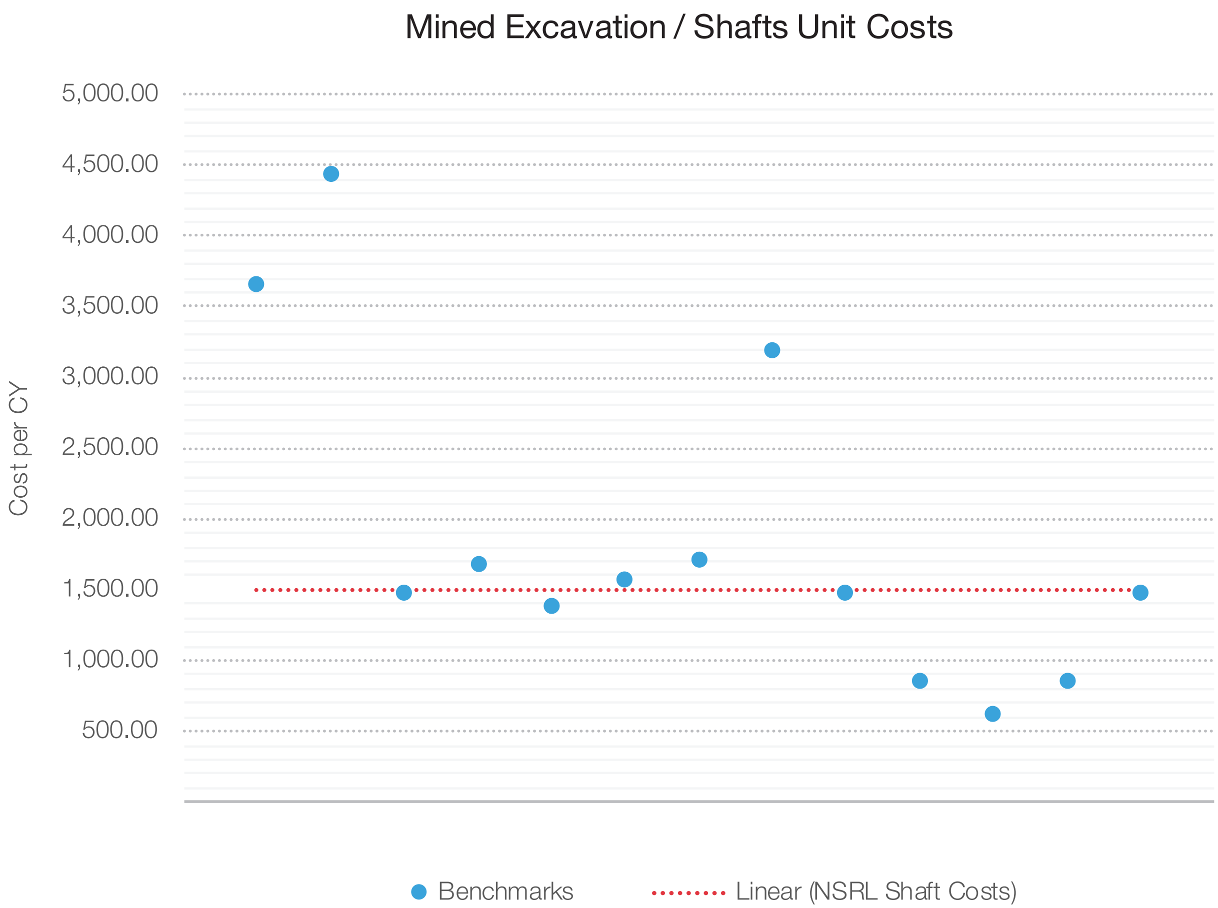

Figure E3: Mined Excavation / Shaft Excavation Data Points (2018 USD)

These figures correspond to benchmarks with similar tunnel parameters (diameters, constraints) as the ones analyzed for the NSRL project. To corroborate the validity of these benchmarks, tunneling expert input was obtained. All analyzed benchmarks have been normalized to reflect the location of the project (Boston, Massachusetts) and the year of analysis (2018). Table E6 summarizes the most important tunnel parameters used to assess the benchmarks.

Project	Location	Year	Normalized cost per CY
California High Speed Rail	Los Angeles	2009	3,667
California High Speed Rail	Los Angeles	2009	4,442
California High Speed Rail	Los Angeles	2009	1,482
California High Speed Rail	Los Angeles	2009	1,685
California High Speed Rail	Los Angeles	2009	1,394
California High Speed Rail	Los Angeles	2009	1,580
CTRL (220), 2 Shafts	UK	2001	1,712
CTRL (240), 2 Shafts	UK	2001	3,195
Beckton Overflow (Drive) Shaft	UK	2009	1,483
Beckton Connection Shaft	UK	2009	856
Beckton Pump Station Shaft	UK	2009	628
Abbey Mills Station F Shaft	UK	2009	856
Abbey Mills Station A Shaft	UK	2009	1,483

Table E5: Data points of Figure E-3 Mined Excavation / Shaft Excavation, with normalized costs to 2018 USD, Boston Location Factor

Geometric	Tunnel diameter	Tunnel length
Constructive	Type of tunnel excavation	
Economic	Location of project	Year of construction

Table E6: Tunneling Parameters Analyzed in Benchmarks

Figure E4 shows the impact of tunnel diameter in the TBM construction costs per mile.Table E7 contains the supporting detail.

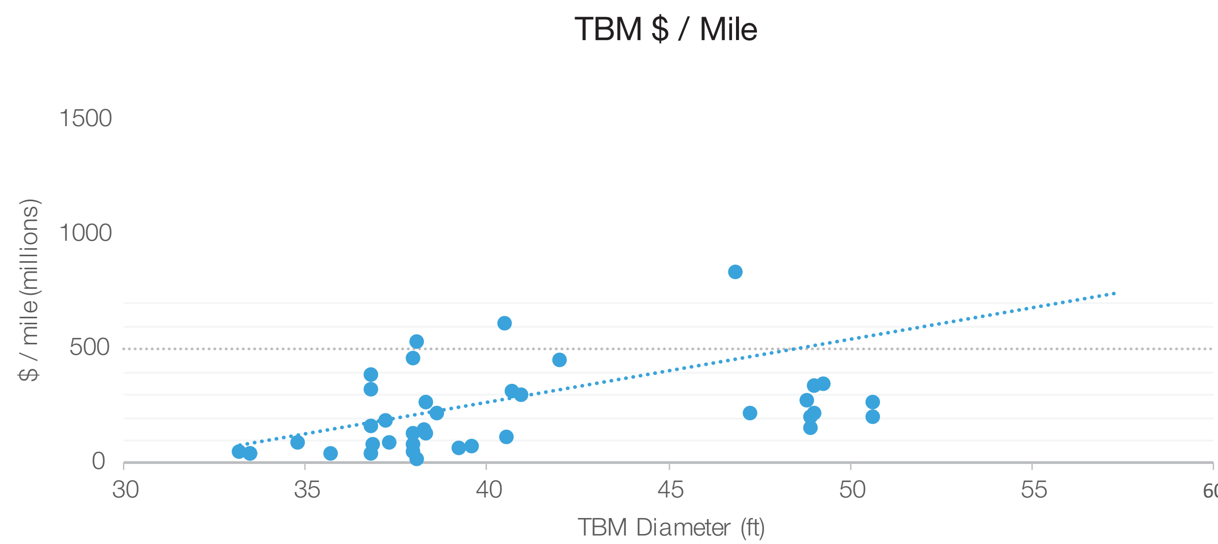

Figure E4: TBM Tunnel Construction Cost Benchmarks by Tunnel Diameter (2018 USD)

TBM Tunnel	Location	Year	Diameter (ft)	$ / mile
Alaskan Way	USA	2012	57	989
Qianjiang Subaqueous Tunnel	China	2010	51	189
Yangtze River Tunnel	China	2005	51	253
M-30 Orbital Motorway South Bypass	Spain	2005	49	350
Nanjing River Crossing 1st	China	2005	49	203
Nanjing River Crossing 2nd	China	2010	49	322
Hong Mei Road South	China	2010	49	194
Groene Hart Tunnel	Netherlands	2002	49	167
Jungong Road - Shangzhong Road	China	2004	49	255
Niagara	Canada	2006	47	230
Bund Tunnel	China	2007	47	782
Lefortovo	Russia	2002	47	1116
Port of Miami	USA	2011	42	497
Airport Link Brisbane	Australia	2008	41	328
Legacy Way	Australia	2012	41	338
Oenzberg Tunnel	Switzerland	2000	41	134
North South Bypass	Australia	2006	40	658
Barcelona Metro: Drive 3	Spain	2003	40	75
Barcelona Metro: Drive 1	Spain	2003	39	71
Dublin Port Tunnel: Whitehall to Fairview Park Drive 1	Ireland	2002	39	236
Qingchung Road Subaqueous Tunnel	China	2006	38	127

TBM Tunnel	Location	Year	Diameter (ft)	$ / mile
Herren Tunnel: South Drive	Germany	2002	38	286
Weser Tunnel: Southern Drive	Germany	1998	38	154
Paris, A86 - East Drive	France	2000	38	18
Paris, A86 - West	France	1999	38	564
Chengjiang River Road West	China	2010	38	51
Xiangyin Road (South)	China	2005	38	81
Dapu Road 2nd Tunnel	China	2006	38	429
Xiangyin Road Tunnel	China	2003	38	120
Wuhan Yangze River Crossing	China	2004	37	90
Westerschelde	Netherlands	2003	37	201
Weinberg Tunnel	Switzerland	2010	37	95
Yan'an Road East Tunnel	China	1994	37	362
Fuxing Road Tunnel	China	2001	37	153
Dalian Road Tunnel	China	2001	37	303
Katzenberg Tunnel	Germany	2005	37	50
Finne Tunnel	Germany	2012	36	51
Hallandsas	Sweden	2004	35	95
Abdalajis Rail Tunnel: East Tube	Spain	2003	33	44
Abdalajis Rail Tunnel: West Tube	Spain	2003	33	46
New Kaiser Wilhelm Tunnel	Germany	2009	33	56

Table E7: Data points of Figure E-4, normalized to 2018 USD

When quantities were not readily obtainable due to the level of engineering available, allowances were made to incorporate the potential cost for specific scope items (e.g., utility relocations, detailed underpinning scope, and roadway reconstruction).

Based on the total costs of the NSRL project, excluding escalation, Tables E8 and E9 and Figure E5 were created as part of a peer matrix produced for this Feasibility Reassessment. They are based on total cost and scope of similar projects, reflecting a total cost per alignment mile. The diameters of all benchmarked projects in the peer matrix are different than the diameters of the tunnels in the NSRL project.

Average Cost per Route Mile (Benchmarks USA) (2018 USD, Boston Location Factor)	$1,343,370,129
Average Cost per Route Mile (Benchmarks, Global) (2018 USD, Boston Location Factor)	$1,147,138,767

Table E8: Average of Global and USA benchmarks (2018 USD)

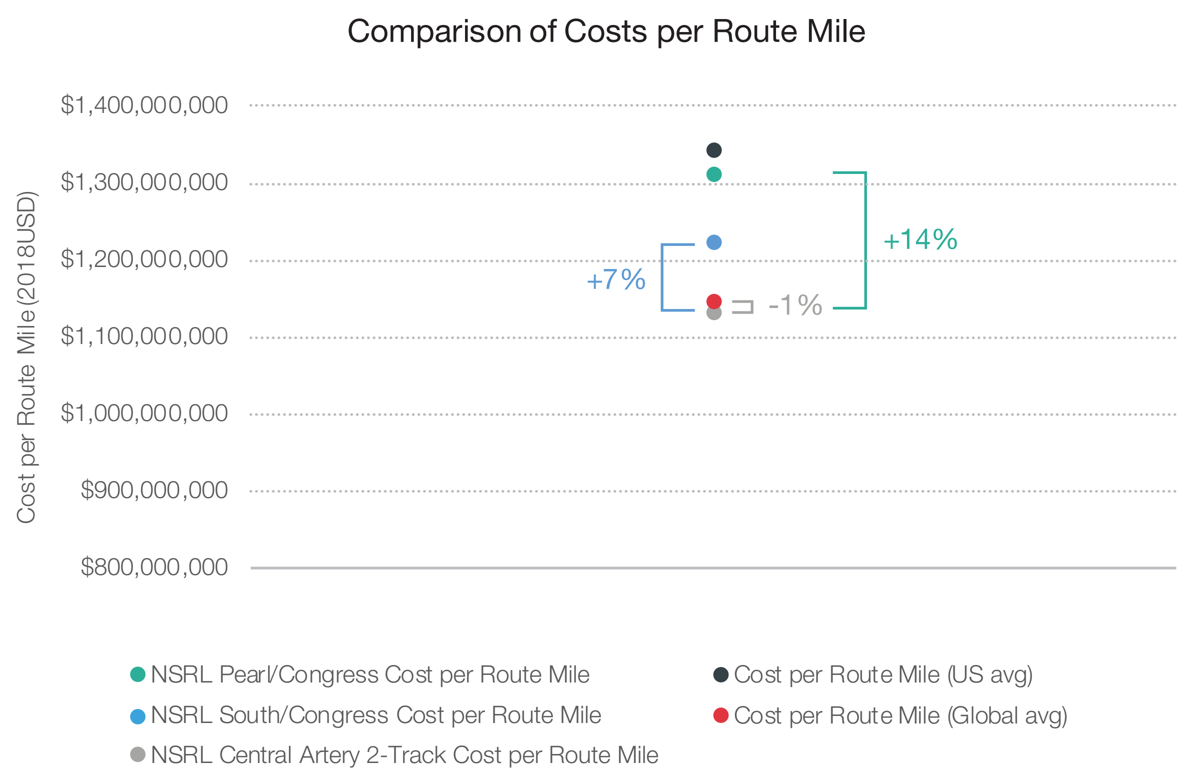

Figure E5: Comparison of Total Project Cost per Route Mile of Multiple Benchmarks Compared to NSRL Estimates (2018 USD).

Figure E5 shows how the NSRL Central Artery 2-Track Cost per route mile is 1% below the global average. The South/Congress cost per route mile is 7% above the global average due to its large diameter, and the Pearl/Congress cost per route mile is 14% above the global average due to the fact that all its stations are mined.

Project	Los Angeles Regional Connector	Los Angeles Purple Line Extension PH. 1	Los Angeles Purple Line Extension PH. 2	San Francisco Central Subway	NYC Second Ave. Subway Ph. 1	Leipzig City Tunnel	Zurich Durchmesserlinie	NSRL Central Artery 2-Track	NSRL South/ Congress	NSRL Pearl/ Congress
Alignment Length (miles)	1.9	3.92	2.59	1.7	2	3.3	6	5.40	5.49	5.77
Tunnel Diameter	22ft	19.10ft	19.10ft	19.8ft	22ft	29.4ft	36.7ft	41.5ft	51.5ft	29ft
Cost	$1,744,000,000	$3,114,000,000	$2,525,000,000	$1,578,000,000	$4,450,000,000	$1,030,000,000	$2,000,000,000	$6,117,156,950	$6,729,692,200	$7,585,932,000
Year	2014	2015	2018	2010	2017	2001	2001	2018	2018	2018
Location Factor (City or US Average)	112	112	112	124	102	97	106	N / A	N / A	N / A
Location Factor (Boston)*	115	115	115	115	115	115	115	N / A	N / A	N / A
Cost (Boston - 2018)	$2,054,885,830	$3,545,026,413	$2,592,633,929	$1,927,107,548	$5,192,757,353	$2,191,539,371	$3,894,107,328	$6,117,156,950	$6,729,692,200	$7,585,932,000
Cost per Route Mile	$1,081,518,858	$904,343,473	$1,001,016,961	$1,133,592,675	$2,596,378,676	$664,102,840	$649,017,888	$1,133,283,813	$1,225,268,097	$1,313,236,752

Table E9: Comparison of Total Project Cost per Route Mile of Multiple Benchmarks Compared to NSRL Estimates (2018 USD)

Location factors include material prices, labor rates, and all other market conditions inherent to each city. Boston is generally higher than most US cities, excluding San Francisco

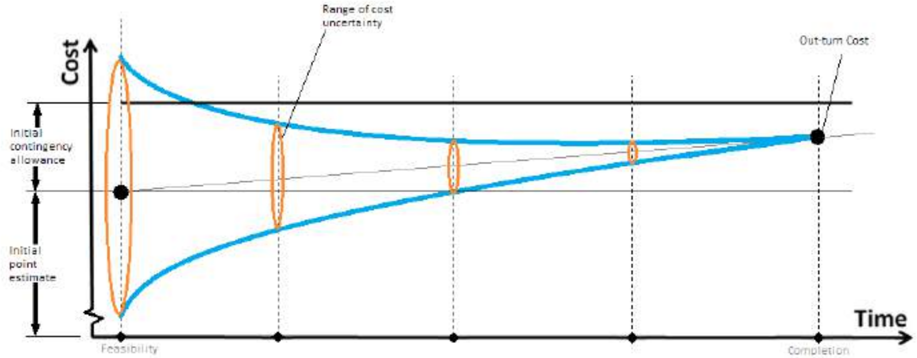

Figure E6: Evolution of Contingency Allowance and Estimate Over Time
*Source: Ian Gardner, **Achieving Successful Construction Projects: A Guide for Industry Leaders and Programme Managers** (New York, NY: Routledge, 2015), 96.*

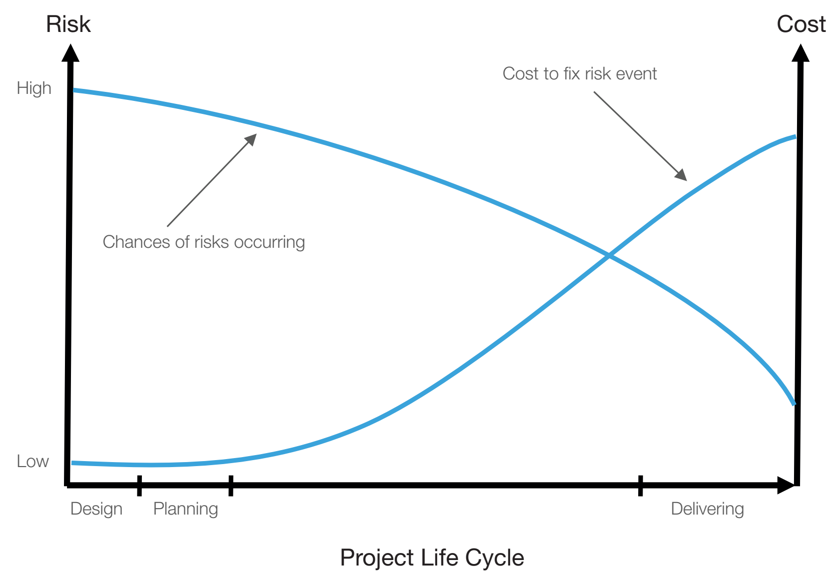

Figure E7: Evolution of Risk Occurrences and Costs
*Source: Ian Gardner, **Achieving Successful Construction Projects: A Guide for Industry Leaders and Programme Managers** (New York, NY: Routledge, 2015), 96.*

Indirect Costs / General Conditions

- Indirect costs for the scope of work have been developed based on a typical build-up for similar construction projects. The included indirect cost categories are as follows:
- Mobilization – cost to establish a working construction activity at different jobsite locations; includes transportation of all equipment and labor to the site, establishment of requisite services, and commencement of construction activities
- Demobilization/punch list – cost for final closeout of the project, cleaning the facility, fixing and remedying any items not satisfactory, or finishing minor construction activities not directly affecting the project's substantial completion but required for final project closeout
- Contractor management staff – cost for management personnel, such as project managers, construction managers, and assistant project managers
- Additional staff – cost for the procurement manager, procurement staff, document controllers, office manager, schedulers, office engineers, and similar
- Field supervision staff and survey – cost for all site management above a project foreperson or shifter; included as project direct costs and include the general superintendent, project superintendent, assistant superintendent, engineering supervision, staff engineers, project controls, purchasing, warehouse, contractor quality assurance/controls, safety supervision, and survey
- Barges and tugboats for cofferdam works
- Automotive – cars, pickups, trucks, loaders, tractors, trailers
- Field office, office furniture, equipment, engineering supplies, and monthly utilities
- Small tools and supplies
- Health, safety, and sanitary costs
- Permits, bonds, and insurances

Different percentages were applied based on the complexity of the scope of work performed. All civil works have an indirect markup of 25% over the total direct costs. All tunneling works have an indirect cost markup of 40%. This difference is intended to account for the complexity of tunnel construction, which requires more on-site staff to survey and monitor the tunneling operations.

Additional Costs

- To estimate the total construction price, the following additional costs were added to direct and indirect construction costs:
- Contractor's contingency – assumed at 10% of total direct and indirect cost; what a contractor would price for uncertainty in quantities, labor rates, and other items outside of the scope they can control
- Contractor's overhead and profit – assumed at 12% of total construction cost, including design and estimate's contingency
- Design / engineering – assumed at 9% of the total construction cost, including contractor's overhead and profit; accounts for all design and engineering works to be performed by the entity designing and building the final project

Soft Costs

Soft costs are added on total estimated construction costs as a certain percentage in order to include additional scope of work to be completed for the project to be successfully delivered. The percentages used respond to industry standards for this type of project complexity and delivery. (The project is assumed to be completed via design-build, a project delivery method that implies contracting both the design and construction services to a single entity.) It is anticipated that this percentage may change as the project is further refined and stakeholder roles and involvement are assessed and agreed upon. A 15% markup for soft costs was applied over the total design-build price.

Soft costs include the following:

- Design quality assurance/controls and approvals process
- Agency project management and construction management support
- Quality assurance and quality control during construction, including inspections
- Environmental and other agencies' involvement
- Legal and other fees

Project Risk Contingency

Project risk management is the systematic process of planning for, identifying, analyzing, responding to, and monitoring project risk. Project risks are uncertain events or conditions that, should they occur, have a positive or negative impact on at least one of the project's objectives, such as time, cost, scope, or quality. As the project advances from the feasibility stages into preliminary engineering and design phases, a quantitative calculation of the risk contingency is performed as part of a Risk Management Plan. Risk contingencies would be then determined through a systematic approach of identification, assessment, and simulation through Monte Carlo analysis, a quantitative technique commonly used in project risk management.

The estimate includes a total project risk contingency (also referred to as Owner's contingency) applied to the construction price and soft costs. It accounts for procurement risks, contract administration, change order management, tunneling risk, political and economic risks, and others deemed relevant to the project. The risk contingency for the current Feasibility Reassessment has been applied based on recommended percentages and experience on other projects. Different factors for risk contingency have been applied to civil works (15%) and tunneling works (40%) to account for the higher risk potential in tunneling construction.

Escalation

To account for the value of money in time, and based on the rough total procurement duration for the project, the total cost of the project has been escalated from 2018 US dollars to midpoint of construction US dollars (estimated as 2028).

Tables E10 and E11 summarize the Construction Cost Index. Data were obtained from Engineering News Record (ENR) specifically for Boston and the average of the 20 major US cities. The Construction Cost Index is obtained by analyzing the changes in costs of labor and common construction materials. The average percent change for the national average is 3.37% per annum, and the average percent change for Boston is 4.06%. Based on these percentages, a rate of 3.5% per annum was included in the estimate.

$$\text{Escalation } (E)_{2028\ MP} = (1+3.5\%)^{10}-1 = 41\%$$

Year	Avg. Base Points	% Change
2017	10,737	3.86%
2016	10,338	3.02%
2015	10,035	2.34%
2014	9,806	2.71%
2013	9,547	2.57%
2012	9,308	2.62%
2011	9,070	3.08%
2010	8,799	2.67%
2009	8,570	3.13%
2008	8,310	4.32%
2007	7,966	2.77%
2006	7,751	4.10%
2005	7,446	4.65%
2004	7,115	6.29%
2003	6,694	2.39%
2002	6,538	

Table E10: Construction Cost Index — National Average (2002–2017)

Source: ENR https://www.enr.com/economics/historical_indices/construction_cost_index_history

Year	Avg. Base Points	% Change
2018	14,234	3.44%
2017	13,761	3.54%
2016	13,290	5.77%
2015	12,566	1.22%
2014	12,414	1.11%
2013	12,279	2.09%
2012	12,027	4.15%
2011	11,548	3.69%
2010	11,136	4.13%
2009	10,695	4.63%
2008	10,221	5.05%
2007	9,730	5.02%
2006	9,264.	6.68%
2005	8,685	5.53%
2004	8,230	3.18%
2003	7,976	5.69%
2002	7,547	

Table E11: Construction Cost Index — Boston (2002–2018 June)

Source: ENR https://www.enr.com/economics/historical_indices/Boston

The total construction duration for the South Station Expansion (No NSRL) alternative has been assumed as four years, with a construction/procurement start date in 2026 (this aligns the midpoint of construction to the schedule for the tunnel alternatives). The total construction/procurement duration for the tunnel alternatives is on average approximately eight years for all alignments, with a 2024 start date. The markup applied for escalation is as follows:

Tier 3 Costs

This section provides details on the Tier 3 costs referred to in Chapter 6.

Electrification

As part of the upstream/downstream improvements, electrification of the Lowell Line from West Medford Station to Lowell Station is identified as an option. Table E13 summarizes the total probable project costs for this discrete project component, at approximately $498m ($700m in 2028).

	South Station Expansion (No NSRL)	Central Artery 2-Track	South/Congress	Pearl/Congress	Central Artery 4-Track
Electrification of Lowell Line (route miles)	N / A	20	20	20	20
Electrification of Fairmount Line (route miles)	N / A	9	9	9	9

Table E12: Scope of Electrification

Table E13 summarizes the scope included in Tier 3 for the electrification works.

Electrification of the Fairmount Line from Readville into South Station is also identified as an option to assist in construction staging, allowing Amtrak access into South Station during construction at Back Bay. Table E14 summarizes the total probable project costs for this discrete project component, at approximately $223m ($314m in 2028).

Description	Total Cost ($)
Lowell Line Electrification (route miles)	224,081,300
Total Direct Costs	**224,081,300**
Indirect Costs (25%)	56,020,400
Subtotal D + I	**280,101,700**
Contractor's Contingency (10%)	28,010,200
Subtotal	**308,111,850**
Overhead & Profit (12%)	36,973,500
Total Construction Costs	**345,085,400**
Design / Engineering (9%)	31,057,700
Total Design Build Price	**376,143,100**
Soft Costs (15%)	56,421,500
Subtotal Incl. Soft Costs	**432,564,600**
Project Risk Contingency (15%)	64,884,700
Total Project Costs Qtr. 1 2018 USD	**497,449,300**
Escalation to 2028 MP Construction (41%)	204,252,100
Total Cost Qtr. 1 2028 USD	**701,701,400**

Table E13: Summary of Costs for Lowell Line Electrification

Description	Total Cost ($)
Fairmount Line Electrification (route miles)	100,350,000
Total Direct Costs	**100,350,000**
Indirect Costs (25%)	25,087,500
Subtotal D + I	**125,437,500**
Contractor's Contingency (10%)	12,543,800
Subtotal	**137,981,300**
Overhead & Profit (12%)	16,557,800
Total Construction Costs	**154,359,100**
Design / Engineering (9%)	13,908,600
Total Design Build Price	**168,447,700**
Soft Costs (15%)	25,267,200
Subtotal Incl. Soft Costs	**193,714,900**
Project Risk Contingency (15%)	29,057,300
Total Project Costs Qtr. 1 2018 USD	**222,722,200**
Escalation to 2028 MP Construction (41%)	91,470,000
Total Cost Qtr. 1 2028 USD	**314,242,200**

Table E14: Summary of Costs for Fairmount Line Electrification

Salem Tunnel Costs

Salem Tunnel costs include the tunneling works, retained cuts, trackwork, and allowances. Table E15 summarizes the total probable project costs for the Salem Tunnel, at approximately $364m ($513m in 2028).

The Tier 3 project cost estimate was performed with the following assumptions:

- Allowances have been made for all underpinning works identified for the tunnel alignments, including Salem Tunnel.
- Allowances based on square footage of retained cut have been made for all civil works associated with the portals and Salem Tunnel works.

Description	Salem Tunnel Costs ($)
Tunneling Works	82,018,300
Other Excavation Works	29,534,800
Salem Tunnel Trackwork	7,796,100
Allowances	14.723,500
Total Direct Cost	**134.072,700**
Indirect Costs	45,821,000
Subtotal D + I	179,893,700
Contractor's Contingency (10%)	17,989,400
Subtotal	**197,883,100**
OH & P (12%)	23,746,000
Total Construction Costs	**221,629,100**
Design / Engineering (9%)	19,946,600
Total DB Price	**241,575,800**
Soft Costs (15%)	36,236,400
Subtotal incl. Soft Costs	**277,812,200**
Tunneling Risk (40%)	70,930,700
Civil Works Risk (25%)	15,072,800
Subtotal Risk Costs	**86,003,500**
Total Project Costs Qtr. 1 2018 USD	**363,815,700**
Escalation to 2028 (41%)	149,382,300
Total Project Costs Qtr. 1 2028 USD	**513,198,000**

Table E15: Summary of Costs for Salem Tunnel

F. Evaluation Weighting and Application of Scores

Evaluation Weighting

Weighting allows the owners and users to value some benefits (or impacts) of the projects differently than others, based on the Guiding Principles and their needs.

Each criterion is assigned a weighting factor based on these considerations; these range from 1 to 5, with 5 assigned the greatest importance. The following table provides guidance on the weighting for each criterion:

Importance of Criterion	Weight
Minor importance; Guiding Principles and owner/user goals will still be met if criterion is not or minimally achieved	1-3
Moderate importance; not critical to achieving Guiding Principles and owner/user goals, but clearly desirable to do so.	4-7
Extreme importance; vital to achieving Guiding Principles and owner/user goals; highly influential in gaining public support.	8-10

Table F1: Weighting Scale

Performance

A range of 1 (as a minimum) and up to 5 as a maximum) is assigned to the performance rank of each criterion. Most of these scores are relative to the other alternatives (for example, User Benefits of 100,000 hours per day, 150,000 hours per day, 200,000 hours per day, 250,000 hours per day, and 300,000 hours per day would be assigned scores of 1, 2, 3, 4 and 5). Criteria are either objective and quantitative (which will be noted as calculations) or qualitative (which will be explained).

Scoring Methodology

A broad assignment of the weighting of each category is proposed as follows:

- Economy: 70%
- Environment: 15-30% (depending on whether 'Equity' scoring is present)
- Equity: 15-30% (depending on whether 'Environment' scoring is present)

In the scoring mechanics, a total possible score is 100 points. Economy is allotted up to 70 points, with Environment and Equity each having a possible 15-30 points (depending on the situation).

Scoring is performed at each screening level (Number of tracks, Construction Methodology, Alignment) and where the Economy Category is present with cost, it is always assigned 70% of the total score. When cost is present, it is always 50% within the 70%, resulting in cost always having up to 50% of the total score.

The economy scoring is as follows:

Criteria	Range	Weight	Total
Estimated Construction Cost	1-5	10	10-50
Total Commuter Rail Weekday Riders	1-5	4	4-20
User Benefit (Downtown Catchment Areas)	1-5	4	4-20
Risks – Permitting, Construction Risk, and Operations Risk	1-5	2	2-10
Potential for Phasing	1-5	2	2-10

Table F2: Economy Scoring

The environment scoring is as follows:

Criteria	Range	Weight	Total
Construction Impacts	1-5	2	2-10
Resilience in Disasters and Events	1-5	4	4-20
Increased Impacts of Commuter Rail Operations	1-5	2	2-10

Table F3: Environment Scoring

The equity scoring is as follows:

Criteria	Range	Weight	Total
Low-income households served	1-5	2	2-10
Low-income increases in ridership	1-5	2	2-10
Reduced crowding reductions on bus and rapid transit lines in low-income areas	1-5	4	4-20

Table F4: Equity Scoring

G. Environmental Evaluation and Permitting Summary

Introduction

As part of this NSRL Feasibility Reassessment, a Preliminary Environmental Evaluation and Permitting Summary has been completed. The goals of the preliminary environmental evaluation were specific to all proposed alignments (except the No Build) in order to:

- Identify the regulatory agencies that may have jurisdictional authority of cultural, historical, or natural resources that may be affected by this project
- Characterize the environmental conditions in the area of the NSRL project
- Identify sensitive resources and receptors
- Determine potential impacts to the design and proposed construction activities

As part of this preliminary evaluation, available sources for information on existing wetlands, floodplains, surface geology, protected and recreational open space, Areas of Critical Environmental Concern (ACECs), hazardous materials sites, air quality, greenhouse gas impacts, noise, cultural, historical and archaeological resources, and other constraints, were reviewed to analyze each alignment.

Proposed Project Alternatives

The alignments being considered included the construction of tunnels under the Charles River, the Fort Point Channel, the Red, Blue, Orange, Green, and Silver Lines, and the Central Artery. The evaluated alignments were as follows:

- Central Artery Two-Track – consists of one 41-foot-diameter tunnel
- Central Artery Four-Track – consists of two 41-foot-diameter tunnels
- South/Congress – consists of one 51-foot-diameter tunnel
- Pearl/Congress – consists of two 29-foot-diameter tunnels

The majority of the proposed project construction is below ground at depths between the surface and 150 feet below the surface. With the 51-foot-diameter tunnel alignments, stations can fit within the tunnel created by the boring. With the smaller bore alignments, the construction of stations would be completed separate from the tunnel bore via mining and/or cut-and-cover methods. Some of the evaluated alignments included construction of a station within the Fort Point Channel utilizing coffer dams. All alignments would require exhaust/air supply plants to properly ventilate the proposed tunnels and stations.

Evaluation of Environmental Impacts

A review of environmental resource databases and maps was conducted to develop an overall evaluation relative to the potential impacts of the project to environmental receptors and the public welfare. The evaluation addressed specific potential impacts in order to consider the need for developing mitigating measures. The figures in this Appendix depict the resources located generally within the project corridor.

Wetlands and Waterways

A review of the current MassGIS mapped wetland resource areas showed that the project would not be located within the buffer zone of bordering vegetated wetlands; and, as the project develops this would be verified. The project could result in temporary impacts to land under water and navigational channel width if the alignment is directed through the Fort Point Channel.

Air, Dust, and Noise

The proposed project would not include industrial processes that will release air contaminants to the atmosphere. The construction of the proposed project could result in the generation of exhaust during use of equipment with combustion engines; dust may also be generated during equipment staging and earthwork. No additional automobile traffic would be expected as a result of the project; therefore, automobile exhaust emissions would be expected to remain as current conditions. It is assumed that additional trains would be running as a result of the project.

Construction noise would be generated during project work, as well as staging and support activities performed at grade level. Vibration could be anticipated as a result of earthwork, tunneling, and equipment staging and use. Construction noise and vibration mitigation measures could be required.

A detailed evaluation for greenhouse gas (GHG) emissions would be completed for the full environmental impact analysis. GHG emissions would likely increase as a result of the project, for any service alternative, from the addition of diesel train sets. It is anticipated that GHG impacts from the additional trains, however, would be at least partially offset by the commensurate reduction in automobile emissions from fewer vehicle trips.

Historical and Archaeological Resources

There are historic properties identified within the project corridor. Archaeological resources are also present within the corridor. Figures G3-G5 present historic and archaeological assets closest to each of the proposed new stations. In addition to consideration of historic and/or archaeological resources impacted by surface construction, a subsurface evaluation would also need to be completed to consider noise, vibration, and foundation impacts from both construction and operation of the corridor.

Endangered Species and Ecologically Sensitive Areas

The MassGIS maps for the Massachusetts Natural Heritage and Endangered Species Program (NHESP) and the online database provided for the U.S. Fish and Wildlife Service federally listed endangered species were reviewed. According to NHESP, there are no state-listed endangered species identified in the vicinity of this site. Also, there are no federally listed endangered species in the site vicinity. Also, according to MassGIS, the proposed project corridor is not located in a designated Area of Critical Environmental Concern.

Recreation and Open Space Resources

The project alignments do not appear to impact access to any existing open space or recreational area. Refer to Figure G9 for MassGIS delineation of Protected Open and Recreation Space.

Soil

The majority of all four proposed alignments are located within soils classified as Urban land, 0 to 15 percent slopes or Urban land, wet substratum, 0 to 3 percent slopes by the U.S. Soil Conservation Service, where soils have been altered or obscured by urban works or structures; areas where soil material has been excavated or deposited.[1] These are areas where 90 percent of the surface area is covered with impervious surfaces, such as buildings, pavement, industrial parks, and railroad yards. The southern portion of the Central Artery Four-Track alignment and the northern portions of both Central Artery alignments would also pass through areas classified as Udorthents, wet substratum.

For all proposed alignments, the project would generate a substantial amount of soil requiring management and off-site disposal or re-use.

Groundwater Resources

A portion of the project would be located above a medium-yield aquifer as shown on Figure G2. No part of the project alignments is located over a sole source aquifer or within the zone of influence of any public groundwater supply wells. Municipal water is available to the project area, and there are no public drinking water wells located within one mile. According to the City of Boston, there are no known private water or potable wells located along or near the project corridor. Current groundwater drinking water resources would not be impacted by the construction or operation of the proposed project.

Present stormwater drainage patterns in the immediate vicinity of the project would not be significantly affected. Stormwater is currently diverted from the alignment to existing drainage systems. Stormwater collected within the project area would continue to be directed into existing drainage systems if there is suitable capacity for the increased precipitation anticipated under current

1 *Soil Survey of Suffolk County, Massachusetts*

climate change models. Stormwater that needs to be collected and managed for construction would be treated and discharged under a permit from the EPA's National Pollutant Discharge Elimination System (NPDES) program. An evaluation of additional stormwater management system capacity and requirements for the project would be developed during more detailed design.

Construction and operation of the proposed project is not expected to result in the introduction of any pollutants to groundwater. Appropriate temporary erosion controls and construction management procedures, including groundwater management would be developed as part of the project. Once constructed, water management would be limited to activities to prevent tunnel leaks and portal flooding.

Surface Water

The surface waters within the project corridor are shown on Figures G6-G8. The use of the Fort Point Channel for temporary or permanent structures would be evaluated during future design, which would also evaluate appropriate mitigation or protective environmental controls to prevent adverse impacts to these surface waters. With proper controls, construction and operation of the proposed project would not be expected to result in the introduction of any pollutants, including sediments, into marine waters or surface fresh waters.

Traffic

No additional automobile traffic is expected as a result of this project. Traffic impacts as a result of construction of this project could include travel lane restrictions or closures, reduced speed zones, and/or vehicle detours. These impacts would be temporary.

Solid Waste Management

Miscellaneous construction and demolition debris are expected to be generated as a result of the project. Construction waste would require management, transportation and disposal by a licensed contract hauler to an approved landfill. Future design must include an evaluation of the types and locations of one or more dedicated off-site facilities able to accept the materials generated.

Hazardous Materials

The proposed project, when constructed, is not expected to involve the use, generation, transportation, storage, release, or disposal of potentially hazardous materials. Quantities of wastes, including hazardous materials and contaminated soils, would likely be generated during demolition and removal of surface structures.

Sensitive Receptors

A project-specific analysis of potentially sensitive receptors was not conducted. Since most of the project would be deep below the ground surface, sensitive receptors would be primarily those identified at tunnel entrances (portals) and/or open cuts within the Fort Point Channel. There are institutions (hospitals, schools, etc.) within 500 feet of the project corridor. The remainder of the surrounding area consists of dense commercial properties. Dust generated and noise impacts as a result of the project would need to be mitigated. Potential vibration impacts to cultural or historic structures or features would require advanced planning and follow-up monitoring. The appropriate traffic controls would be approved by MassDOT and implemented prior to the start of construction.

Potential Impacts to Design and Proposed Construction Activities

A preliminary mapping study has been completed to identify those areas that would need to be considered in the design development of the project. The areas evaluated are as follows:

FEMA Flood Hazard Zones

Approximately half of the Central Artery Two-Track alignment, the Central Artery Four-Track alignment, and the Pearl/Congress alignment and approximately one quarter of the South/Congress alignment are located within the FEMA Zone AE, 1% Annual Chance of Flooding with Base Flood Elevation (BFE). In addition, the existing North Station, the existing Aquarium Station, and the proposed Central Station in the Central Artery Four-Track alignment are all located in the FEMA

Zone AE. These Zone AE areas are located proximal to the Charles River, the Fort Point Channel, and Boston Inner Harbor. Another approximately one quarter of the Central Artery Four-Track alignment, located south of South Station and the Fort Point Channel, is located within the FEMA Zone X, 0.2% Annual Chance of Flooding.

Water Resource Areas

All four of the evaluated alignments would pass beneath the Charles River. Portions of the Central Artery Two-Track alignment, the Central Artery Four-Track alignment, and the Pearl/Congress alignment would be constructed beneath the Fort Point Channel, including the South Station expansions for both of the Central Artery alignments. Approximately 5% to 25% of each of the proposed alignments is located within the Boston Groundwater Conservation Overlay District (BGCOD) with the South/Congress alignment having the highest percentage of track within the BGCOD. A portion of the North Station expansion for both of the Central Artery alignments is located within the BGCOD and a portion of the South Station expansion for the South/Congress alignment is located within the BGCOD.

Historic Inventory & Landmarks

Dozens of Massachusetts Historical Commission (MHC) Historic Inventory Points are located within 500 feet of the proposed alignments. MHC Historic Inventory Points are most densely located along the

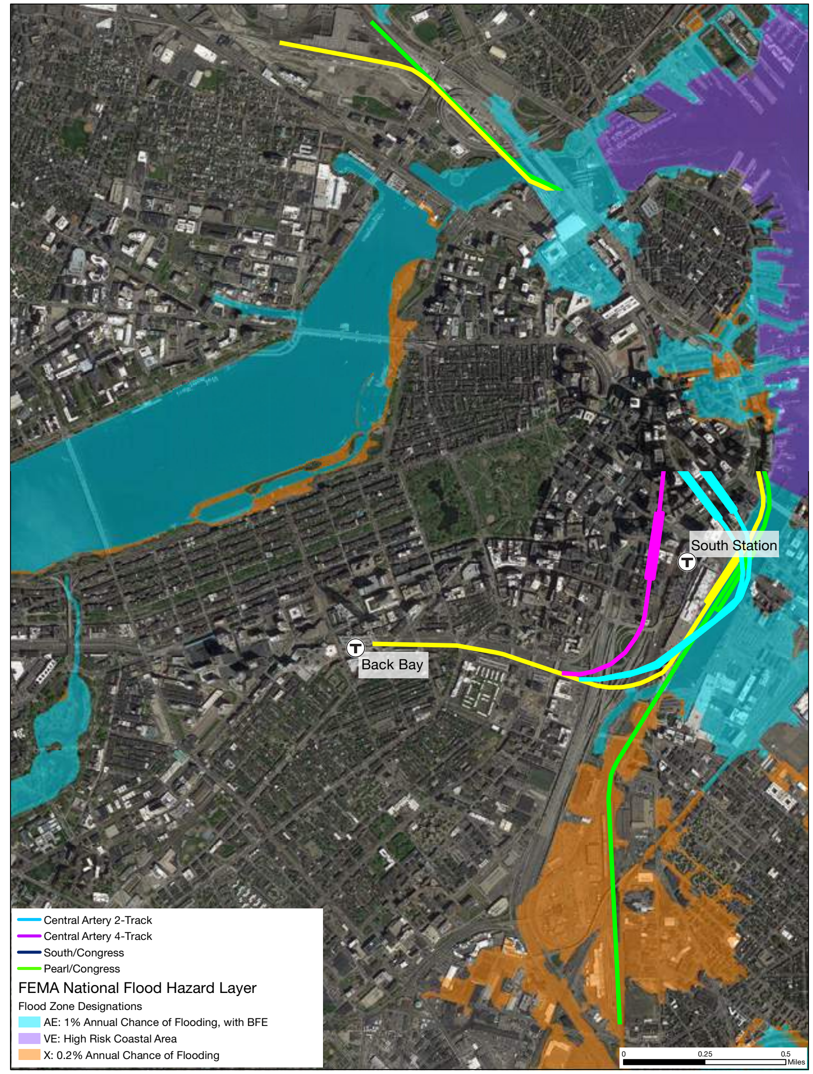

Figure G1: FEMA Flood Hazard Zones

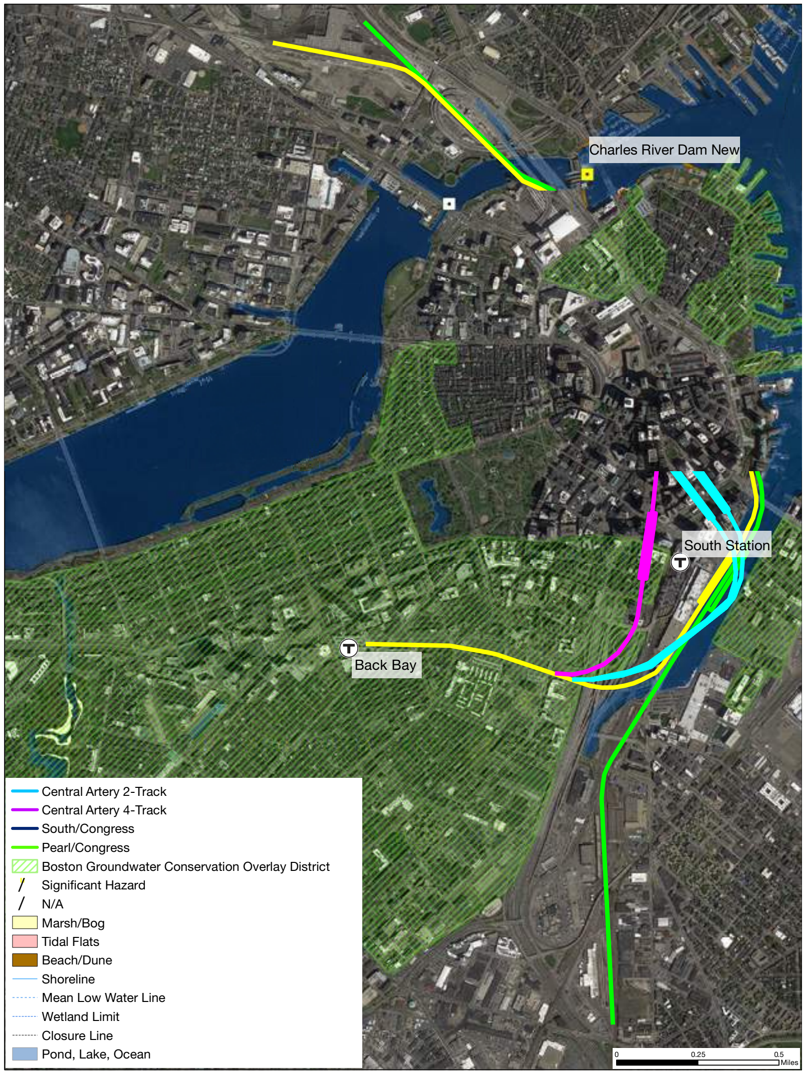

Figure G2: Water Resource Areas

Figure G3: Historic Inventory at North Station

Figure G4: Historic Inventory at Central Station

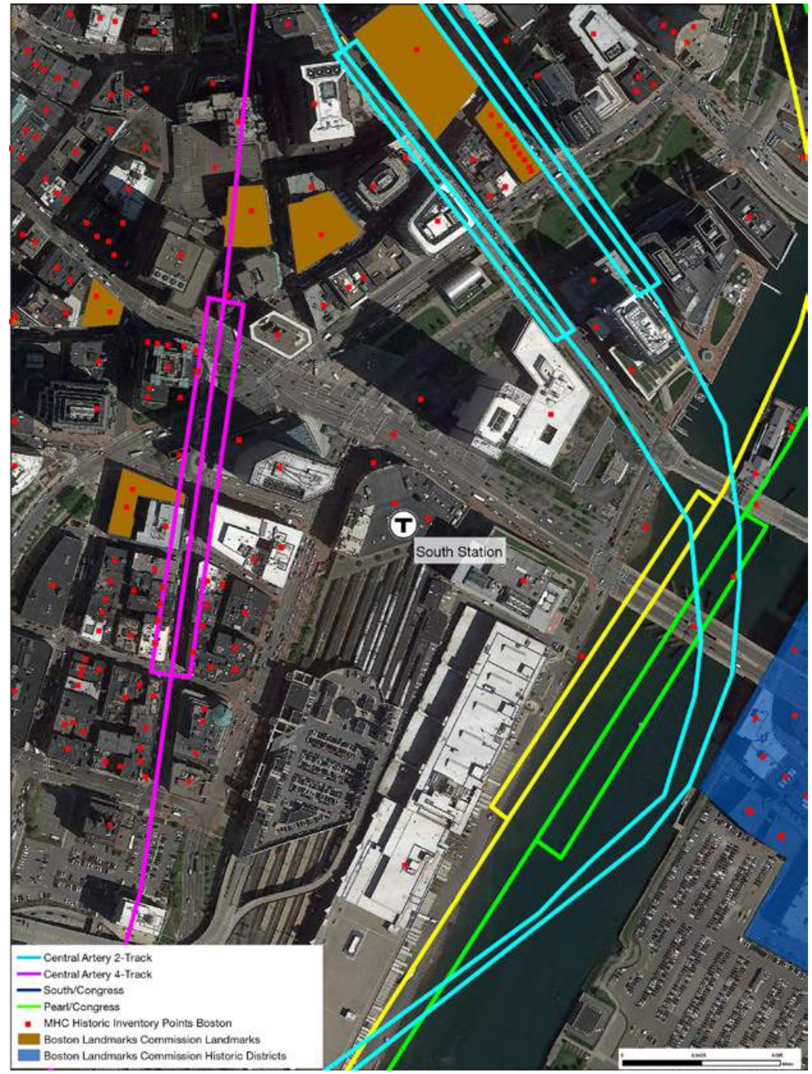

Figure G5: Historic Inventory at South Station alignments between the current South and North Stations. Portions of the proposed South Station expansion for the South/Congress and Pearl/ Congress alignments are located beneath Boston Landmarks Commission Landmarks. Portions of all four proposed alignments to the south of the current South Station also pass beneath a Boston Landmarks Commission Historic District.

Sea Level Rise Predictions

In 2016, the City of Boston completed an assessment of future climate change projections and impacts, including projections for sea level rise, precipitation and temperature. The study, *Climate Ready Boston*, identified three sea level rise scenarios for the City: near-term (2030s-2050s), mid-term (2050s-2100s), and later-term (2070s onwards).[2] Figures G6-G8 detail the projected future flood impacts during the average monthly high tide, the 10% annual chance flood, and the 1% annual chance flood, based on these three sea level rise scenarios. The greatest potential impact to the project from future coastal flooding is based on the locations of the portals and the stations; the potential impact to the tunnels is less of a concern.

The Average Monthly High Tide (with nine inches of sea level rise in the 2030s) appears to be fairly similar to the limits of existing 2018 surface water bodies, with a slight expansion of the tides along the north bank of the Fort Point Channel at the Pearl/Congress alignment. The 10% Annual Flood (with nine inches of sea level rise in the 2030s) is predicted to impact the proposed Central Station/ existing Aquarium Station as well as the current North Station for both the Central Artery Two-Track and Four-Track alignments. Aquarium Station is one of the most vulnerable rapid transit stations in the existing MBTA system and has previously flooded during past storm events. The 1% Annual Flood (with nine inches of sea level rise in the 2030s) is predicted to impact the proposed Central Station/ existing Aquarium Station and the current North Station for both the Central Artery alignments, a portion of the proposed underground North Station for the Central Artery alignments, and a portion of the proposed State/Haymarket Station for the South/Congress alignment.

The Average Monthly High Tide (with 21 inches of sea level rise in the 2050s) appears to be fairly similar to the limits of existing 2018 surface water bodies, with a slight expansion of the tides along the north bank of the Fort Point Channel at the Pearl/Congress alignment and near the existing Aquarium Station. This may result in impacts to the proposed Central Station for the Central Artery alignments. The 10% Annual Flood (with 21 inches of sea level rise in the 2050s) is predicted to impact the proposed Central Station, the current North Station, a portion of the proposed underground North Station, and the portion of the Central Artery Four-Track alignment located south of the Fort Point Channel. The 1% Annual Flood (with 21 inches of sea level rise in the 2050s) is predicted to impact the proposed Central Station, the current North Station, a portion of the proposed underground North Station, a portion of the proposed State/ Haymarket Station for both the South/Congress and Pearl/Congress alignments, a portion of the proposed South Station expansion for the South/ Congress alignment, and a portion of all four alignments located south of the current South Station.

The Average Monthly High Tide (with 36 inches of sea level rise in the 2070s) expands along the north bank of the Fort Point Channel at the Pearl/ Congress alignment, into a portion of the proposed State/Haymarket Station, into a portion of the proposed Central Station, and into both Central Artery alignments surrounding the proposed Central Station. The 10% Annual Flood (with 36 inches of sea level rise in the 2070s) is predicted to impact the proposed Central Station, the current North Station, a portion of the proposed underground North Station, a portion of the proposed South Station expansion for the South/ Congress alignment, a portion of the proposed State/Haymarket Station, a portion of the tracks surrounding the existing North Station and proposed underground North Station, a portion of the tracks surrounding the existing Aquarium Station/proposed Central Station, and a portion of all four alignments located south of the current South Station. The 1% Annual Flood (with 36 inches of sea level rise in the 2070s) is predicted to impact the proposed Central

2 *Climate Ready Boston, 2016.*

Station, the current North and South Stations, a portion of the proposed underground North Station, a portion of the proposed State/Haymarket Station, and a portion of the proposed South Stations for the South/Congress and Pearl/Congress alignments.

Additionally, flood impacts are predicted to affect the tracks surrounding the current North Station and proposed underground North Station, the tracks surrounding the current Aquarium Station/proposed Central Station, the tracks of all four alignments south of South Station, and a portion of the South/Congress and Pearl/Congress tracks surrounding the proposed State/Haymarket Station.

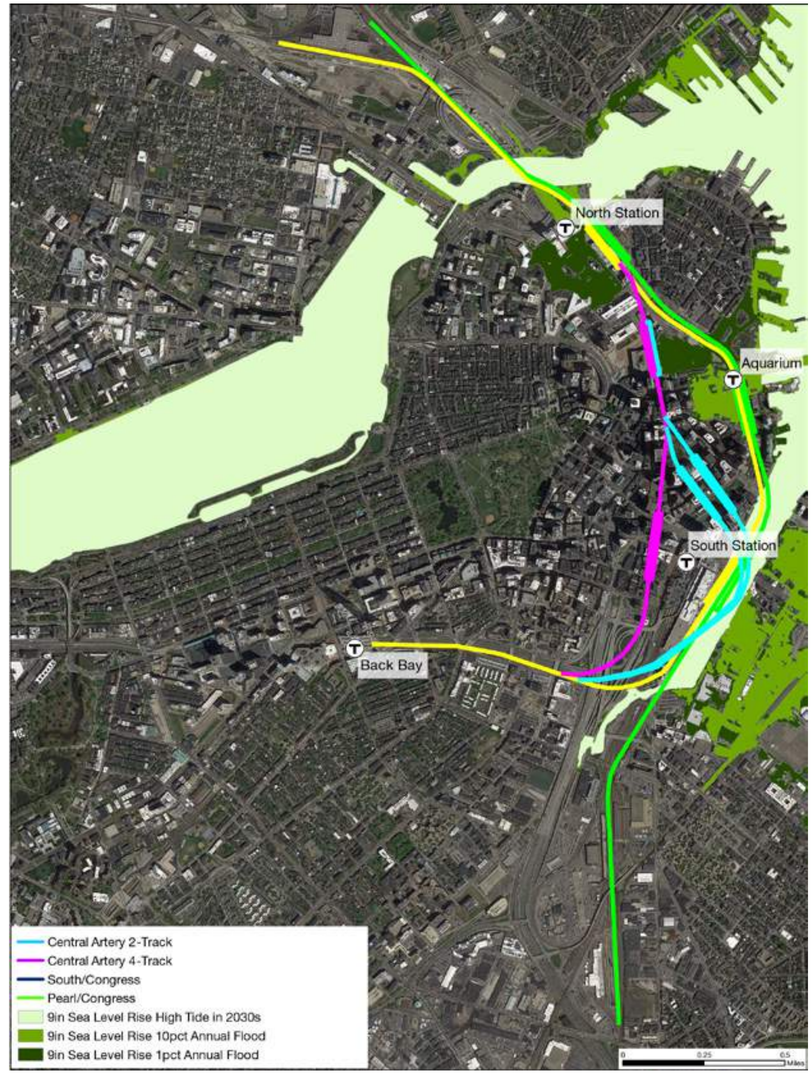

Figure G6: 2030s 9 Inch Sea Level Rise Projection

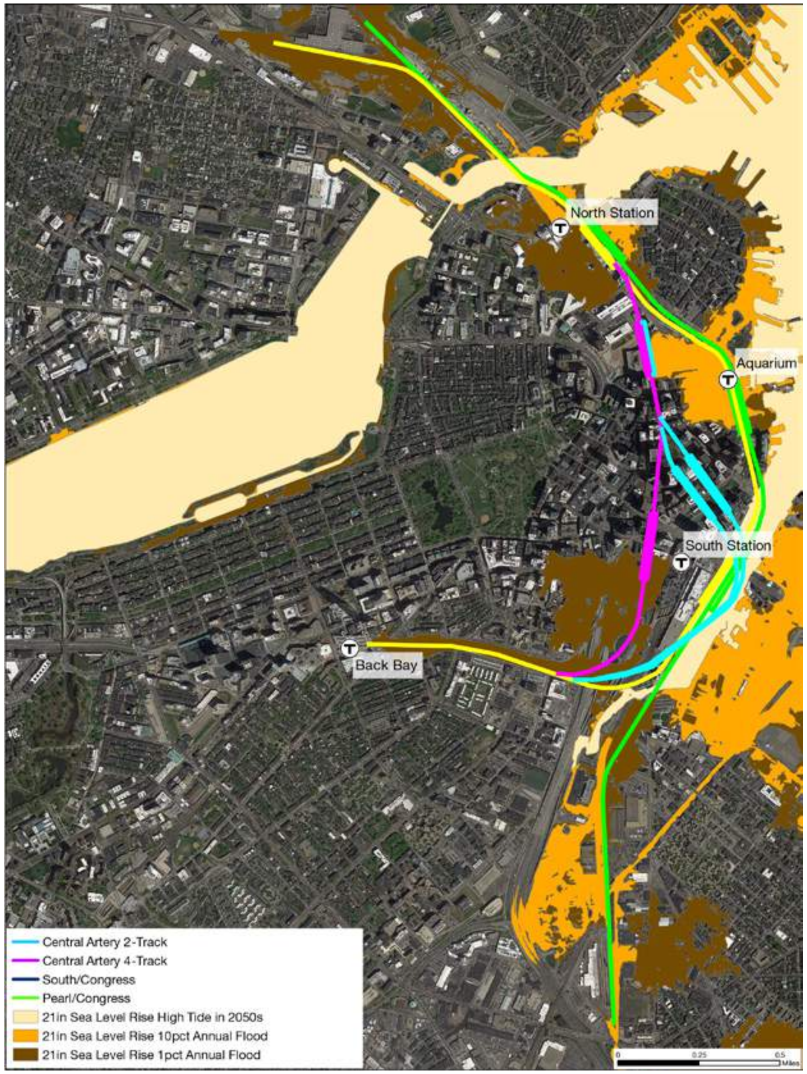

Figure G7: 2050s 21 Inch Sea Level Rise Projection

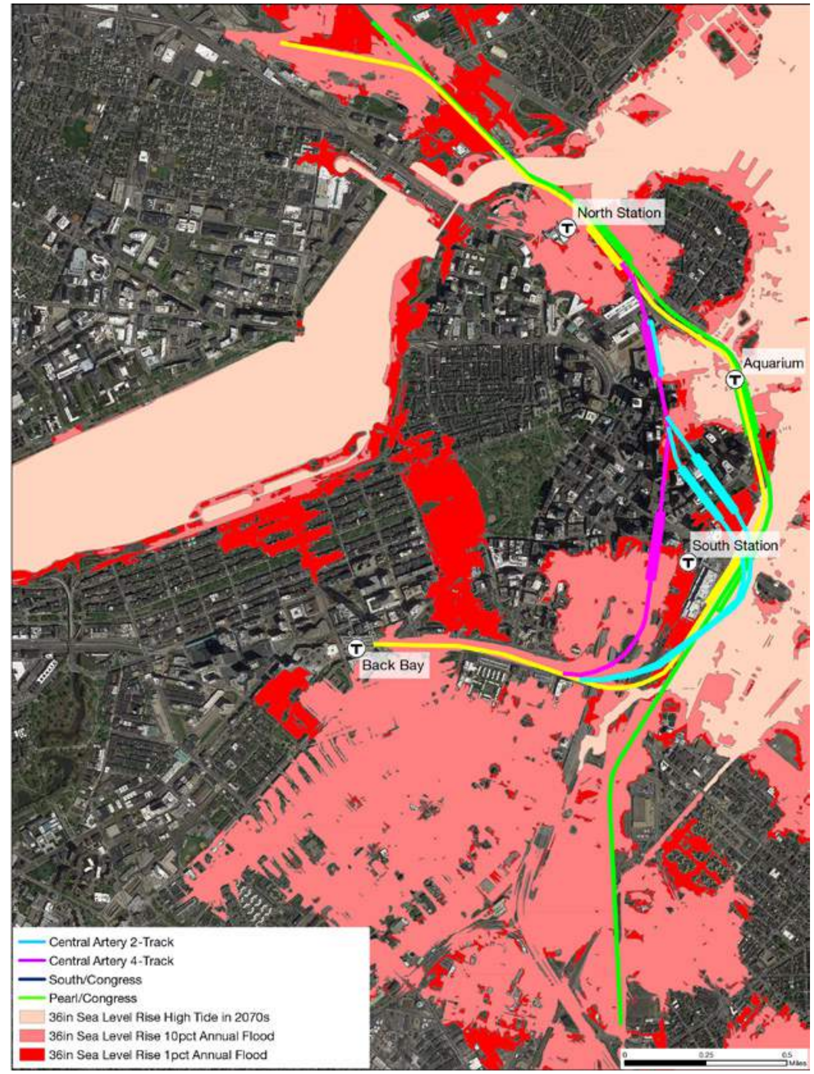

Figure G8: 2070s 36 Inch Sea Level Rise Projection

Open Space

Approximately 5% to 25% of each of the proposed alignments is located beneath areas designated as Boston Open Space – Malls, Squares, and Plazas. Nearly all of these areas are located between the current North and South Stations. The Central Artery alignments have the highest percentage of track within areas designated as Boston Open Space. Cut-and-cover portal locations would require a more detailed analysis of potential impacts to designated open space.

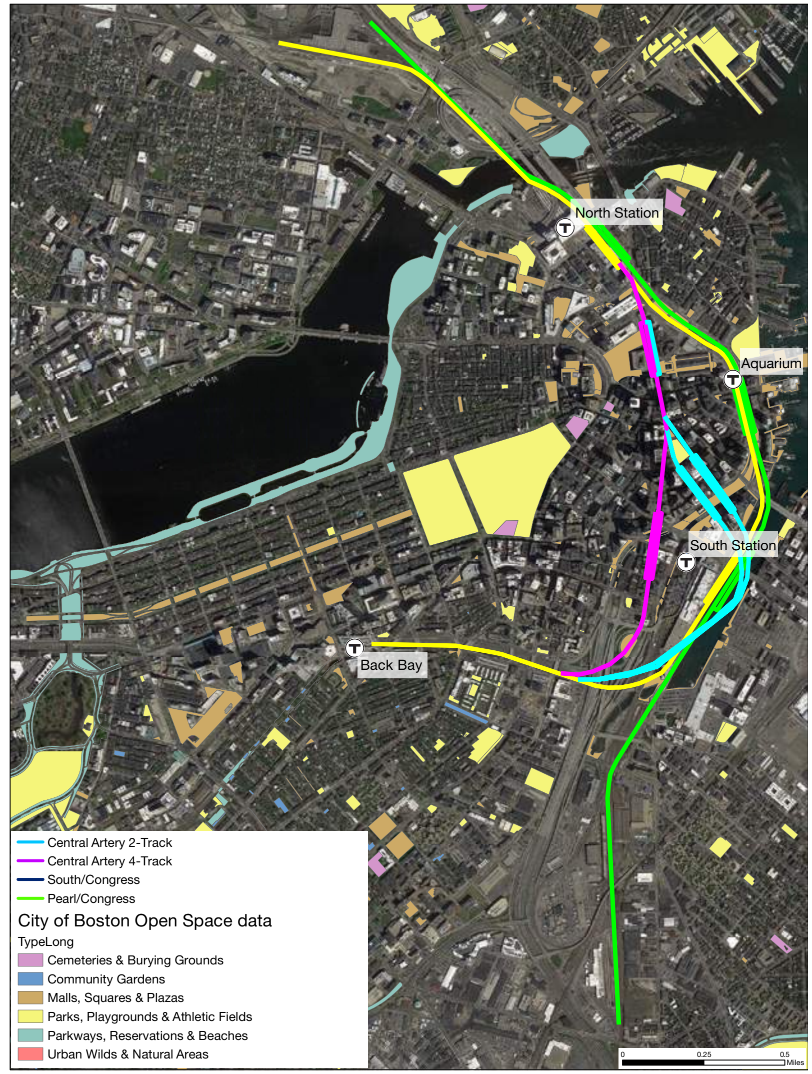

Figure G9: Open Spaces

Preliminary Project Permits and Approvals

With the exception of the No Build, construction of the project alignments would require environmental permits, approvals, and notifications and strategic coordination between multiple state and federal agencies. This is only a preliminary assessment of the approvals needed to advance the project. In addition, as the project design reaches its final stages, it could be determined that certain permits and approvals described are not necessary. Based on the feasibility study parameters and assumptions, the following agencies and related regulations, bylaws, and relevant resources were considered applicable:

Federal Agencies

The following are the federal agencies likely holding jurisdiction over the project:

- National Environmental Policy Act (NEPA)
- U.S. Coast Guard (USCG)
- U.S. Army Corps of Engineers (ACOE)
- U.S. Fish and Wildlife Service (USF&W)
- National Historic Preservation Act (NHPA)
- U.S. Environmental Protection Agency (EPA)

National Environmental Policy Act (NEPA)

It is anticipated that the proposed project will utilize federal funds. NEPA's basic policy is to assure that all branches of government give proper consideration to the environment prior to undertaking any major federal action that could significantly affect the environment. At a minimum, the project would require preparing a Categorical Exclusion (CE) Checklist for Federal-Aid Actions. An Environmental Assessment (EA), an Environmental Impact Statement (EIS), or both may also be required. Further environmental analysis would be dictated by the project scale and the lead federal agency. These studies would also document potential mitigation and off-setting benefits over the potential impacts. The previous environmental review process for the NSRL project, conducted in 2003, is now significantly outdated and the recommended alignment has changed; therefore, an updated federal environmental review process will likely be required in order for the project to be eligible for federal funding or loan guarantees.

U.S. Coast Guard

Any permanent construction that would change the horizontal or vertical clearance of navigable waters under the jurisdiction of the USCG would require a Section 9 permit. This would be applicable for any alignment that would permanently interfere with navigation in the Fort Point Channel.

U.S. Army Corps of Engineers

The ACOE carries jurisdiction in the civil works projects centered around navigation, flood control, and under the Water Resources Development Acts. Also, the ACOE regulates dredging or filling that may alter the embankment at/or below the high-water mark within ACOE jurisdictional waterways. Such work would require a permit under Section 404 of the Clean Water Act (CWA). This project could also fall under the jurisdiction of more intensive permitting with the ACOE due to potential dredging and/or filling of the Fort Point Channel.

U.S. Fish and Wildlife Service

The USF&W, under Section 7(c) of the Endangered Species Act (16 USC 1533) and Section 2 of the Fish & Wildlife Coordination Act (16 USC 661) maintain jurisdiction over designated areas subject to the protection of threatened or endangered species. Coordination and possibly mitigation would be required if threatened or endangered species are identified within the project corridor or in the project area.

National Historic Preservation Act (NHPA)

Section 106 of the NHPA requires Federal agencies to consider the effects of federally funded projects on historic properties and to afford the Advisory Council on Historic Preservation an opportunity to comment on such projects prior to the expenditure of any federal funds. The Massachusetts Historical Commission, the State Historic Preservation Officer (SHPO), coordinates the state's historic program and consults with federal agencies during the Section 106 review. The intent of the Section 106 review is to both determine what the potential adverse effects may be; and where possible, mitigate the potential of adverse effects. Several historic sites are identified within the project corridor; therefore, further analysis would be required to determine potential impacts.

U.S. EPA

The EPA issues stormwater general permits under the Clean Water Act (CWA) for discharge of stormwater runoff from construction sites. Such permits, which are issued by the EPA's National Pollutant Discharge Elimination System (NPDES) program, would be required for construction activity which disturbs one or more acres of land surface. If dewatering with discharge to a navigable waterway of contaminated groundwater is required during the Project, authorization under the NPDES Remediation General Permit (RGP) may also be required for the project.

The EPA regulates the generation, handling, management, treatment, and disposal of hazardous wastes under the Resource Conservation and Recovery Act (RCRA). If storage or generation of hazardous waste is anticipated under this project, including the disposal of hazardous material as a result of demolition of structures, a RCRA permit could be required. If the project involves the generation of polychlorinated biphenyl (PCB) wastes, including PCB contaminated soil, the Project would have to meet requirements for storage and disposal of PCB waste under the Toxics Substances Control Act (TSCA) which is regulated by the EPA. If oil and/or hazardous materials are released or encountered during construction, the project would be subject to requirements under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) which is administered by the Massachusetts DEP under the MGL c21E program.

The Clean Air Act (CAA) Requirements for mobile and stationary sources impacting air which apply to construction activities are implemented primarily through State Implementation Plans (SIPs) which are approved by the EPA. The relevant requirements of the Massachusetts SIP are discussed in the following section.

State Agencies

The following are the state agencies likely holding jurisdiction over the project:

- Massachusetts Executive Office of Environmental Affairs
- Massachusetts Office of Coastal Zone Management (CZM)
- Massachusetts Department of Environmental Protection (MassDEP)
- Massachusetts Historical Commission (MHC)
- Massachusetts Water Resources Authority (MWRA)
- Massachusetts Division of Fisheries and Wildlife (MassWildlife)

Massachusetts Executive Office of Environmental Affairs

The Commonwealth of Massachusetts Executive Office of Environmental Affairs established the Massachusetts Environmental Policy Act (MEPA) regulations, which set criteria for the threshold permit and submittal requirements for proposed projects that may have environmental impacts upon the Commonwealth and require a state permit. The Act requires that agencies use all feasible means and measures to avoid or minimize damage to the environment. MEPA thresholds would be reviewed to determine whether this project requires the filing of an Environmental Notification Form (ENF)/ Environmental Impact Report (EIR) requirements. The previous environmental review process for the NSRL project, conducted in 2003, is now significantly outdated and the recommended alignment has changed; therefore, an updated state environmental review process and DEIR will likely be required under state law.

Also under MEPA, the project would be evaluated for historic impacts, and may require a Determination of No Adverse Effect or mitigation negotiated within a Memorandum of Agreement with the Massachusetts Historical Commission. MEPA is a parallel review with NEPA and provides the framework under Massachusetts Law within which the environmental impacts of a proposed action must be evaluated. The MEPA program permits coordination of MEPA requirements with

NEPA documents. MEPA makes clear that Draft and Final Environmental Impact Statements (EISs) under NEPA may be submitted in lieu of an Environmental Impact Report (EIR), provided that the NEPA documents comply with applicable State requirements and policies.

Massachusetts Office of Coastal Zone Management

The CZM was established to implement the Commonwealth's coastal zone management plan in response to the federal Coastal Zone Management Act. Under the Massachusetts Coastal Zone Management Program Federal Consistency Review Procedures (301 CMR 21.00), CZM is given the authority to implement the federal consistency review of any project requiring a federal action to ensure that the project is consistent with the Commonwealth's coastal zone program policies. CZM looks to established environmental review thresholds to gauge when projects significantly impact the coastal zone and cooperates with federal agencies to develop general permits for projects of minimal environmental impact. Depending upon the selected alignment, the NSRL project could require a consistency review if it is within CZM jurisdiction.

Massachusetts Department of Environmental Protection

The project team reviewed the requirements of the various MassDEP divisions as they may relate to this project.

Bureau of Resource Protection – Wetlands Protection Act (WPA, 310 CMR 10.00)

In accordance with MassDEP Wetlands Protection Act (WPA), which regulates designated resource areas, MassDOT would file a Notice of Intent (NOI) at the local level for review and file a copy with MassDEP. A filing would be made to the Boston Conservation Commission and, if appropriate, the Cambridge Conservation Commission.

Waterways (310 CMR 9.00)

If cofferdams, barges or other temporary structures will be required for the work within the Fort Point Channel, filings could be required with Waterways Division. The installation of temporary or permanent obstructions in the channel will require Department review with or without federal agency coordination. As the project design becomes more advanced a multi-agency meeting would be coordinated to discuss the jurisdiction and approvals needed for temporary or permanent impacts to the Fort Point Channel.

Water Pollution Control, 401 Water Quality Certificate (314 CMR 9.00)

If the selected option includes work within the Fort Point Channel (dredging and/or filling), it is estimated that there will be greater than 5,000 square feet of disturbed land under water, and over 100 cubic yards of displaced sediment; therefore, a 401 Water Quality Certification would be required. Individual project requirements, including sediment testing, to secure the Water Quality Certificate would depend upon the extent of potential impact.

Air Pollution Control for Mobile Sources, (310 CMR 60.00)

The purpose of 310 CMR 60.00 is to implement §176(c) of the Clean Air Act, with respect to the conformity of transportation plans, programs and projects which are developed, funded or approved by the U.S. Department of Transportation, and by metropolitan planning organizations or other recipients of funds. or the Federal Transit Act. The regulation sets forth policy, criteria and procedures for demonstrating and assuring conformity of such activities to the Massachusetts State Implementation Plan. This includes accounting for the air quality impacts of large transportation projects within the long range regional transportation plans (RTPs) of the Commonwealth's metropolitan planning organizations (MPOs).

Massachusetts is currently required to perform a transportation conformity determination on any new RTP and transportation improvement program (TIP), updates, and amendments that include the addition of a project that is not exempt (also known as a regionally significant project) from transportation conformity. As a regionally significant project, NSRL would need to be included in the Boston MPO's transportation model in future milestone years, which produce aggregated estimates of changes to ozone precursor pollutants based on the inclusion of all the non-exempt projects. The results would then be combined with all the other MPOs in the Eastern Massachusetts Ozone Non-Attainment Area to demonstrate air quality conformity of the latest RTP and TIP.

Massachusetts Historical Commission (MHC)

This project would be subject to the applicable requirements of the National Historic Preservation Act, administered by the MHC as the SHPO, as described previously.

Massachusetts Water Resources Authority (MWRA)

In accordance with M.G.L. Ch. 372 Acts, 1984, Section 8, any work performed within a MWRA easement requires an 8(m) Permit. Contractors would be responsible for submitting the 8(m) Permit application to the MWRA.

Massachusetts Division of Fisheries and Wildlife (MassWildlife)

MassWildlife is responsible for the conservation, restoration, protection and management of fish and wildlife resources for the benefit and enjoyment of the public. Also, MassWildlife is responsible for enforcing the Massachusetts Endangered Species Act (MESA). This Project is exempt from MESA consultation since, based on Massachusetts Bureau of Geographic Information (MassGIS) mapping, it appears that there are currently no Estimated Habitats for Rare Wildlife or Priority Habitats for Rare Species, no Certified or Proposed Vernal Pools, and no Areas of Critical Environmental Concern within the project corridor.

Local Agencies

The local environmental permitting requirements include filing a Notice of Intent with the local Conservation Commission in Boston in accordance with the MassDEP Wetlands Protection Act (310 CMR 10.00). There are no other local environmental permits required for this project; also, MassDOT is exempt from local bylaws. However, there could be permit requirements for construction that are not related to environmental permitting.

The Boston Planning and Development Agency (BPDA) oversees proposed projects within the Boston Groundwater Conservation Overlay District (BGCOD) under Article 32. Any applicant seeking a building permit for a proposed project within a Groundwater Conservation Overlay District is subject to the requirements of Article 32 where such applicant seeks:

- The erection or extension of any structure, where such new structure or extension will occupy more than fifty (50) square feet of lot area
- The erection or extension of any structure designed or used for human occupancy or access, mechanical equipment, or laundry or storage facilities, including garage space, if such construction involves the excavation below grade to a depth equal to or below seven (7) feet above Boston City Base (other than where such excavation is necessary for, and to the extent limited to, compliance with the requirements of Article 32)
- To substantially rehabilitate any structure
- Any paving or other surfacing of lot area

In addition to complying with the BPDA's Article 32, Boston Water and Sewer Commission (BWSC) reviews plans for projects within the BGCOD to verify that projects include a suitably-designed infiltration system equivalent to no less than 1.0 inches across the portion of the surface area of the lot occupied by the proposed project. The project proponent would be required to obtain a license from the Public Improvement Commission if the infiltration system proposed is located under the public rights-of-way (sidewalk or roadway).

H. Public Engagement

This Appendix summarizes the public engagement that has been conducted on this Feasibility Reassessment – primarily through public meetings focused on different areas of the project and a comment period for the draft final report, posted online.

Public Meetings

Three public meetings were held over the course of this Feasibility Reassessment. MassDOT staff gave detailed presentations, experts were on hand to explain various aspects of the project, and attendees from the public were allocated time for comment.

- The first public meeting was held on October 17, 2017. The main focus of this meeting was to explain the history of the NSRL concept, the scope, objectives and timeline for this Feasibility Reassessment, and lay out next steps for the project.
- The second public meeting was held on June 21, 2018. This meeting introduced the public to the proposed service plans and tunnel alignments, including locations for tunnel portals and stations. The meeting also provided ridership and cost estimates, based on the work completed so far.
- A third and final public meeting was held on December 10, 2018. This meeting concluded the Feasibility Reassessment process, providing a summary and responses to general public comments received, presenting detailed cost methodology to back up the costs presented at the second public meeting, and revealing the proposed preferred alignment from the four presented at the second public meeting. The proposed alignment is intended to inform MassDOT's future decision-making through the normal project development process.

Comments on the Project

The first seven chapters of the draft final report were posted on MassDOT's website in September of 2018. A draft Chapter 8 and Appendix F (detailing the preferred alignment) were posted online in early December of 2018. These chapters were open for public comment through December 21st, 2018. In total, comments from 79 people (including from Amtrak, three organizations and three elected officials) were received on the draft report and have been considered in the final version of the report.

All public meeting and report materials are available on MassDOT's website at the following link: https://www.mass.gov/lists/north-south-rail-link-feasibility-reassessment-study-documents