North South Rail Link Feasibility Reassessment

June 2018

massDOT
Massachusetts Department of Transportation

Agenda

Update and present key findings on the North South Rail Link Feasibility Reassessment:

- Project Background / Scope
- Tunnel Alignments, Portals and Stations
- Service Plans
- Ridership
- Cost Estimates
- Questions

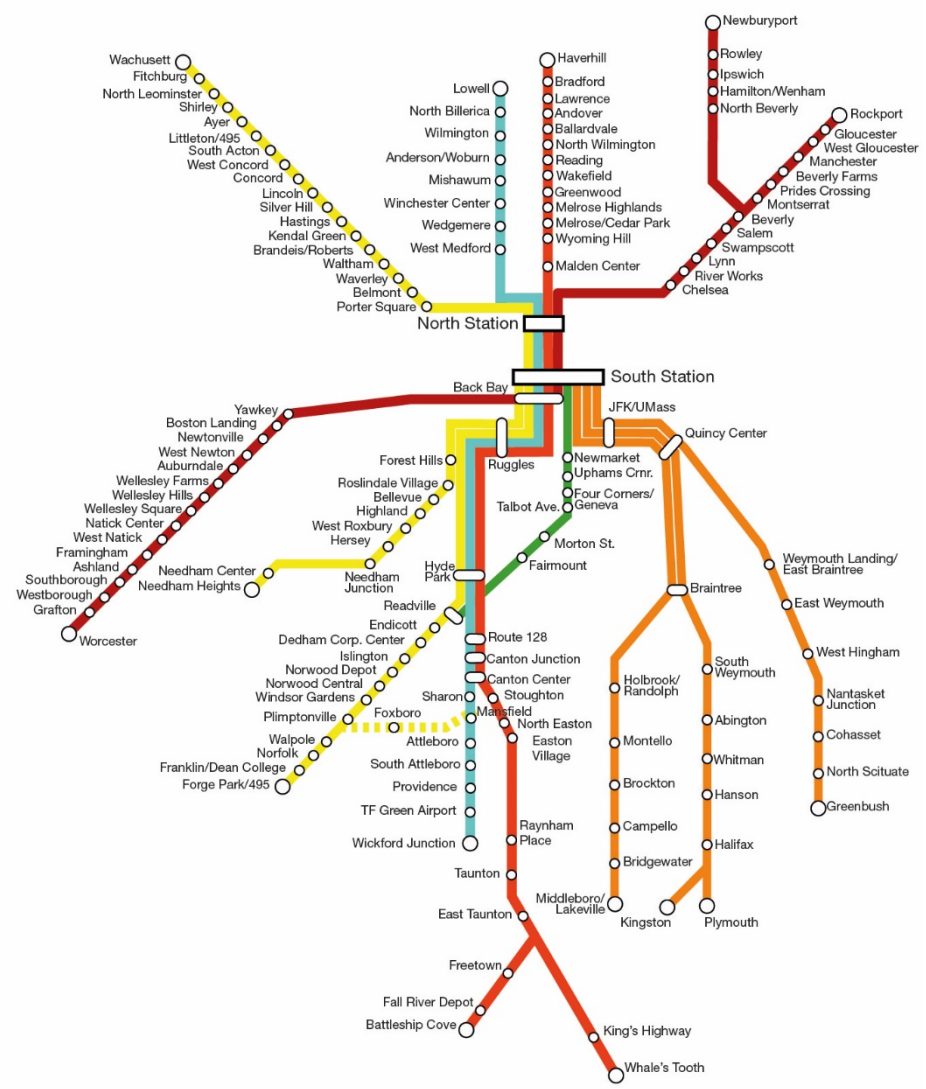
Photo Source: Osman Rana

PROJECT BACKGROUND + PROJECT SCOPE

What is the North South Rail Link (NSRL)?

The North South Rail Link is a concept to connect the MBTA's north and south commuter rail networks through the construction of a rail tunnel under downtown Boston. The potential benefits of such a connection could be:

- Increase commuter rail capacity
- Improve access to employment
- Relieve rapid transit crowding
- Improve maintenance flexibility through easier access to facilities
- Reduce highway congestion and emissions
- Create redevelopment opportunities by repurposing property no longer needed for rail layover



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Rail Link History

1893 – North Station is completed after consolidation of regional rail system

1900 – South Station is completed in similar consolidation

1912 – Mass Legislature, City of Boston, and Railroads contemplate a tunnel connection

Central Artery era NSRL planning

- 1993 – The NSRL was studied as part of the Central Artery Rail Link Task Force
- 1995-2003 – Engineering and environmental study of NSRL leading to Draft Environmental Impact Report
- 2003 – NSRL project discontinued due to a lack of both a partner for the federal environmental process and funding for implementation

2016-2018 – The Baker/Polito Administration and Massachusetts Legislature authorize Feasibility Reassessment of the North South Rail Link

Photo Source: www.goodoldboston.blogspot.com

Scope of Feasibility Reassessment

Project is charged with:

- Identifying changes in the urban form, demographics, and transportation choices since the DEIR era
- Identifying a right of way envelope
- Estimating order of magnitude cost
- Summarizing high level benefits (ridership, reductions in VMT, air quality benefits, development potential along the project corridor)

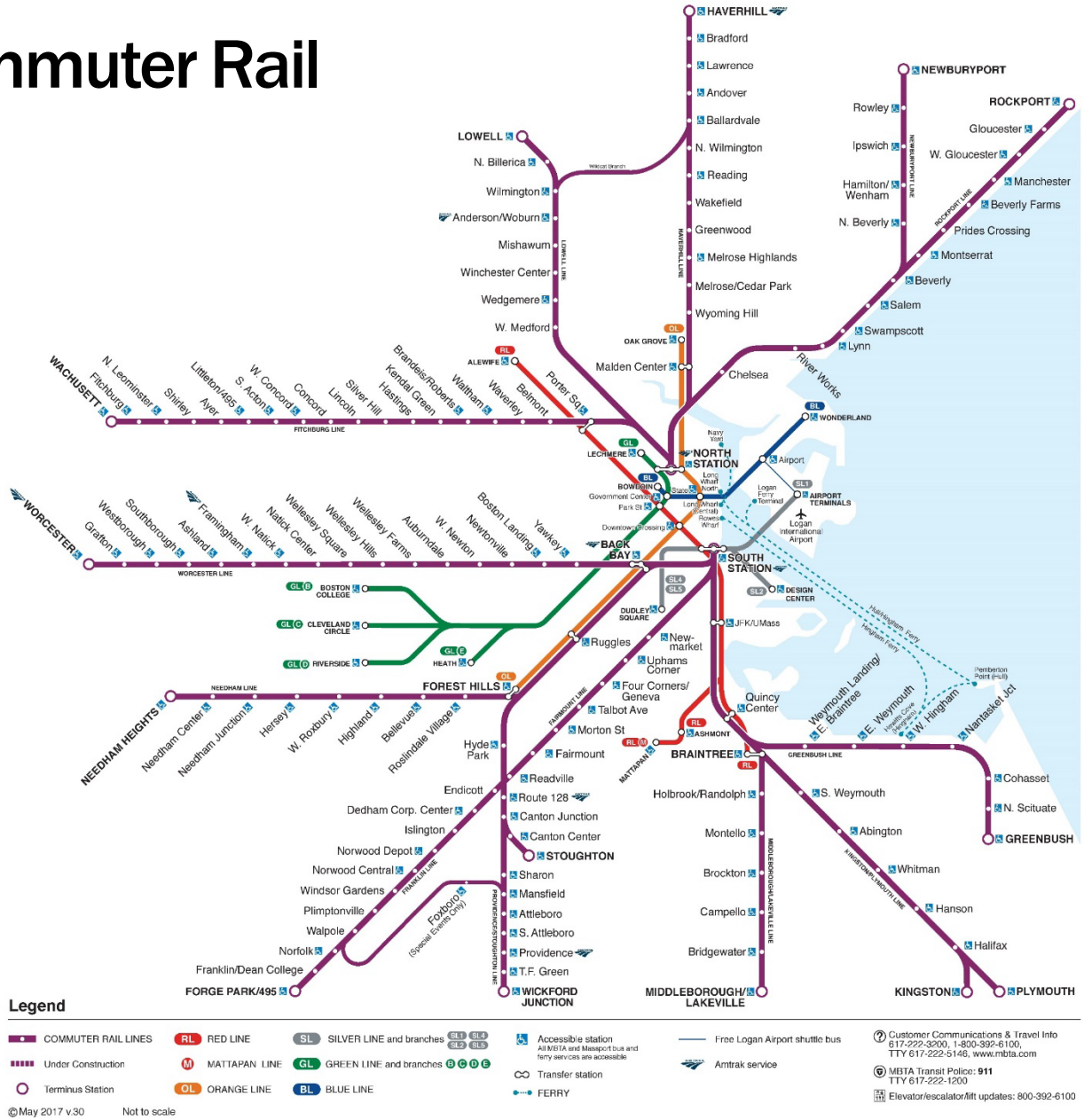
Scope does not:

- Identify potential financing options
- Evaluate impacts on development potential beyond the project corridor
- Develop a full operations simulation model
- Include a health impact assessment

MBTA COMMUTER RAIL TODAY

Today's MBTA Commuter Rail Network

- 14 routes – five north, nine south
- 138 stations
- 90 locomotives
- 410 coaches
- 17 facilities for maintenance or layover
- 129,000 weekday boardings



Commuter Rail Ridership

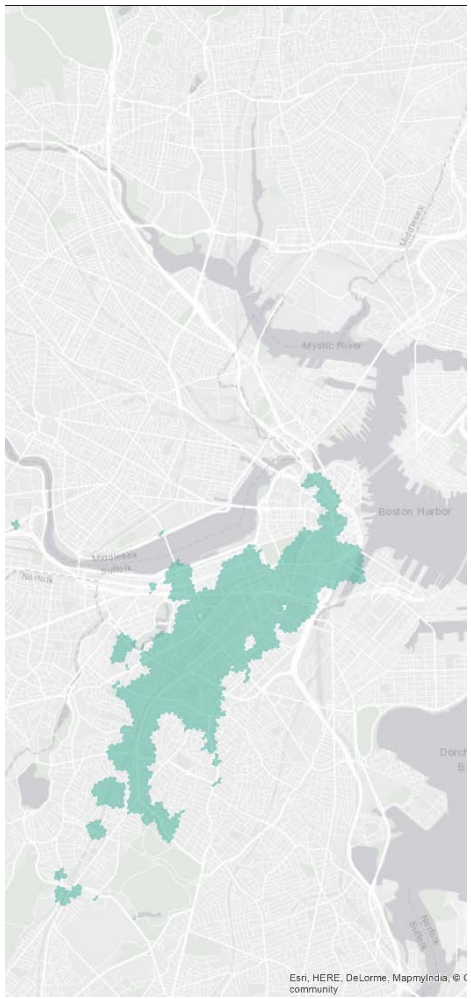
MBTA Commuter Rail Weekday Passenger Counts by Line

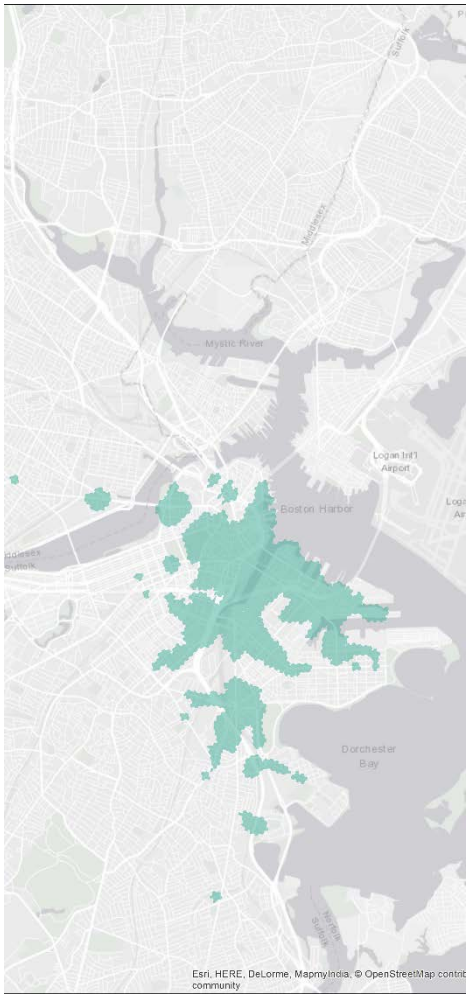
	Commuter Rail Line	Daily Inbound Riders	Daily Outbound Riders	Total Daily Riders	Daily Inbound Trains	Daily Outbound Trains	Total Daily Trains
Northern Lines	Newburyport/Rockport	6,958	7,045	14,003	30	30	60
	Haverhill	3,489	3,502	6,991	24	24	48
	Lowell	4,988	4,639	9,627	31	27	58
	Fitchburg	3,955	3,969	7,924	17	17	34
Southern Lines	Worcester/Framingham	6,451	6,336	12,787	21	20	41
	Needham	2,724	3,090	5,814	16	16	32
	Franklin	4,959	5,121	10,080	19	18	37
	Providence/Stoughton	10,887	10,610	21,497	35	37	72
	Fairmount	376	413	789	17	15	32
	Middleborough/Lakeville	2,461	2,545	5,006	12	12	24
	Kingston/Plymouth	2,802	2,711	5,513	12	12	24
	Greenbush	2,191	2,162	4,353	12	12	24

Source: 2012 CTPS Commuter Rail Passenger Counts

Southside Accessibility – Major Nodes

- Southside lines have direct access to:
  - Financial District
  - Back Bay
  - Longwood Medical Area
- Via transfer, also access to:
  - Kendall Square
  - Boston Logan Airport
  - Seaport





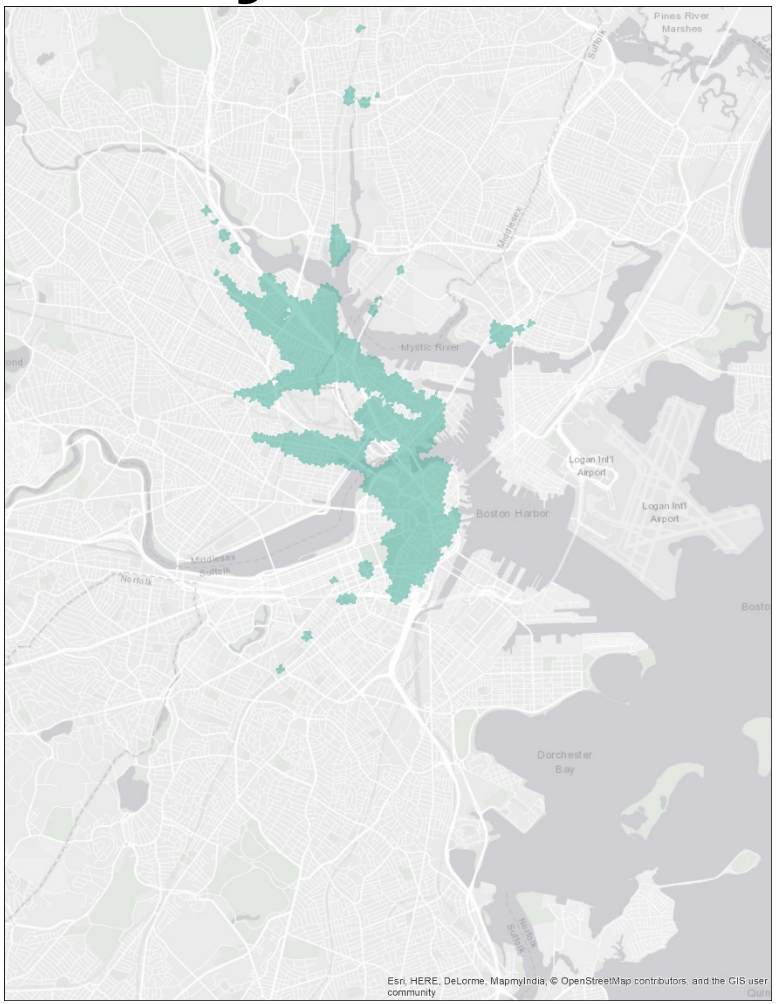
15 min walk/transit from:

Back Bay

South Station

Northside Accessibility – Major Nodes

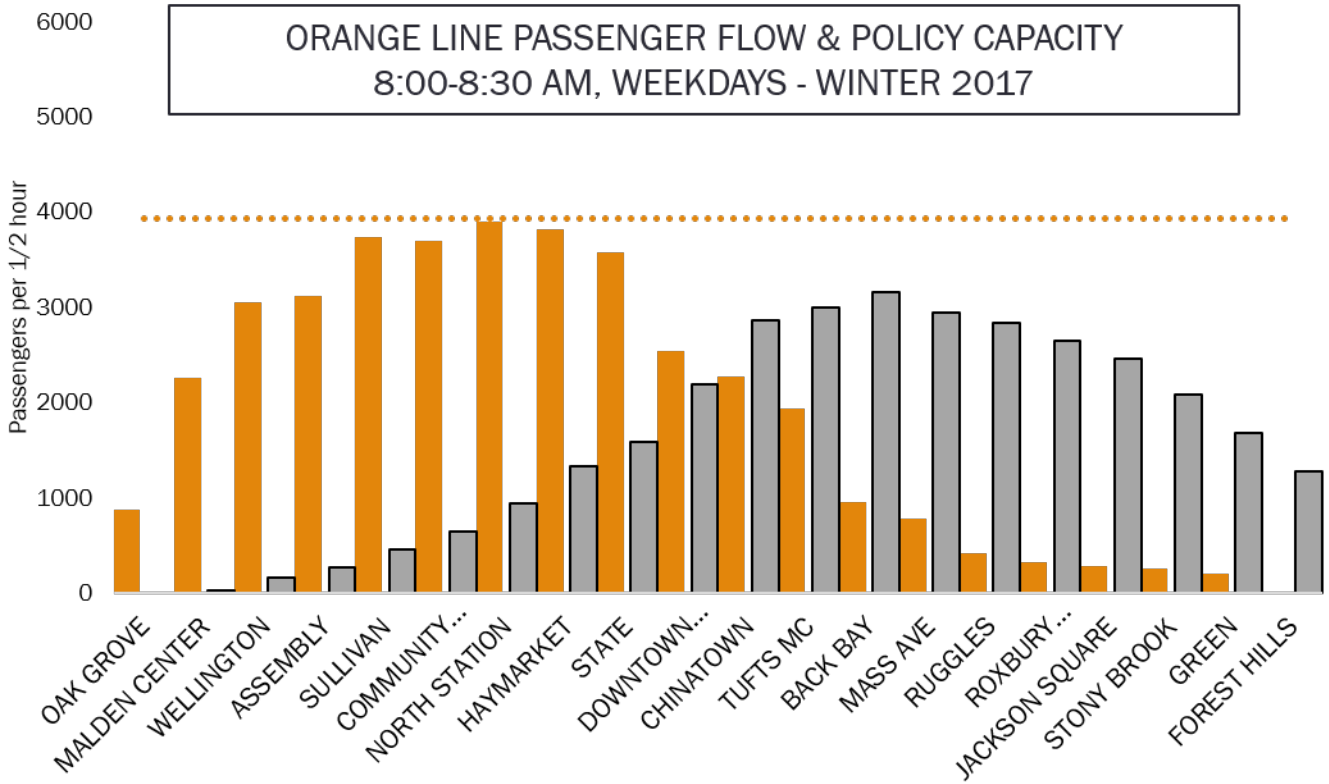
- Northside lines have direct access to:
  - Downtown North
- Via transfer, also access to:
  - Back Bay
  - Longwood Medical Area
  - Financial District
- Via multiple transfers:
  - Kendall Square
  - Seaport
  - Boston Logan Airport



15 min walk/transit access from North Station

Rapid Transit Congestion

Completing Commuter Rail trips on the rapid transit network can add to existing capacity constraints – particularly between North Station and Back Bay



The dotted line shows policy capacity, assuming one train every 6 minutes, even distribution of passengers and even headways.

SOUTHBOUND

NORTHBOUND

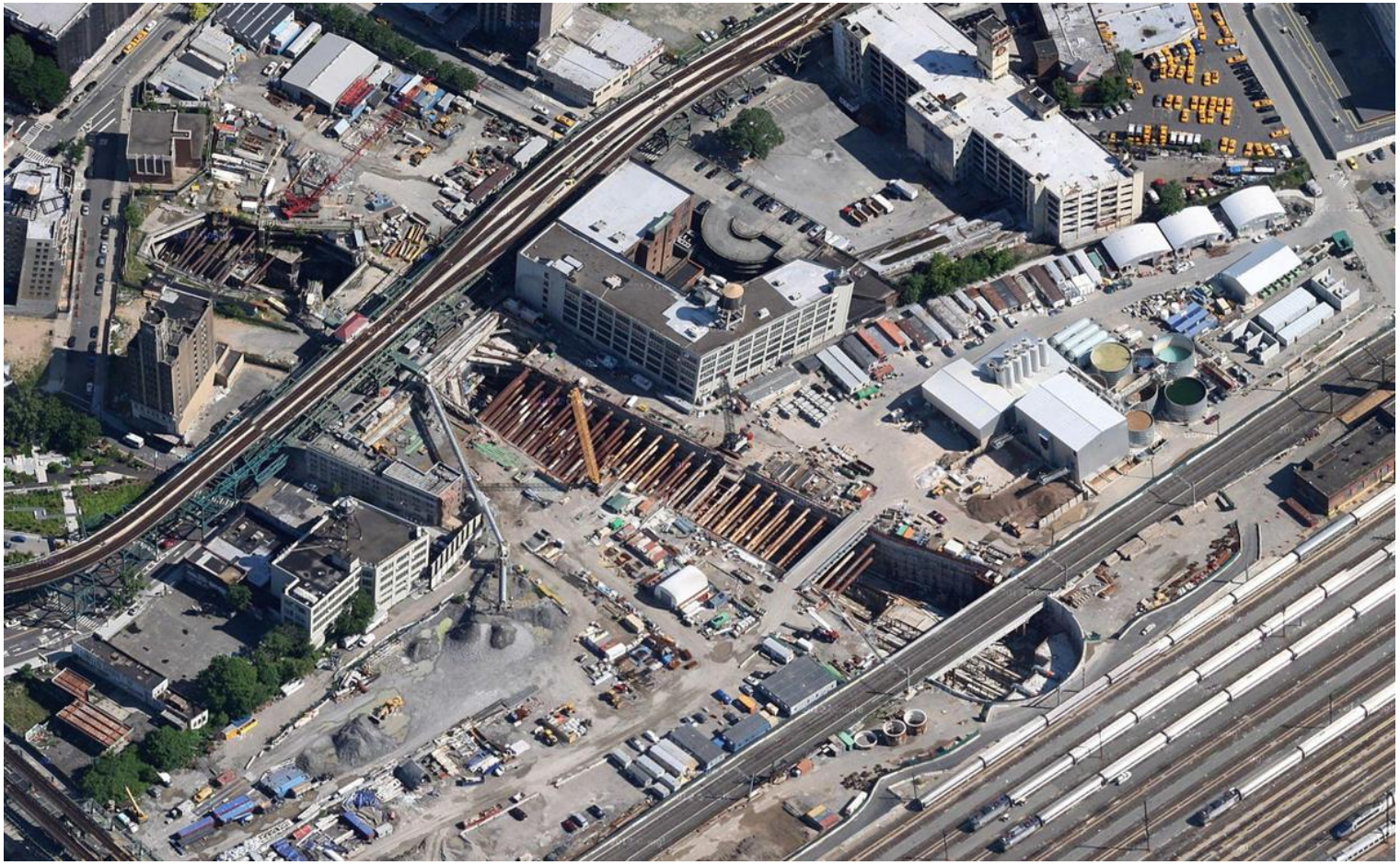
Tunnel Alignments, Portals and Stations

Tunneling – TBM Technology

Given the complexities of tunneling through downtown Boston (underground utilities, existing rail and highway tunnels), the NSRL would be built by a tunnel boring machine (TBM) at a depth below these obstructions.

Photo Source: National Geographic, Tunnel Boring Machine

Tunneling – Aerial View of TBM Launch Pit



East Side Access NY

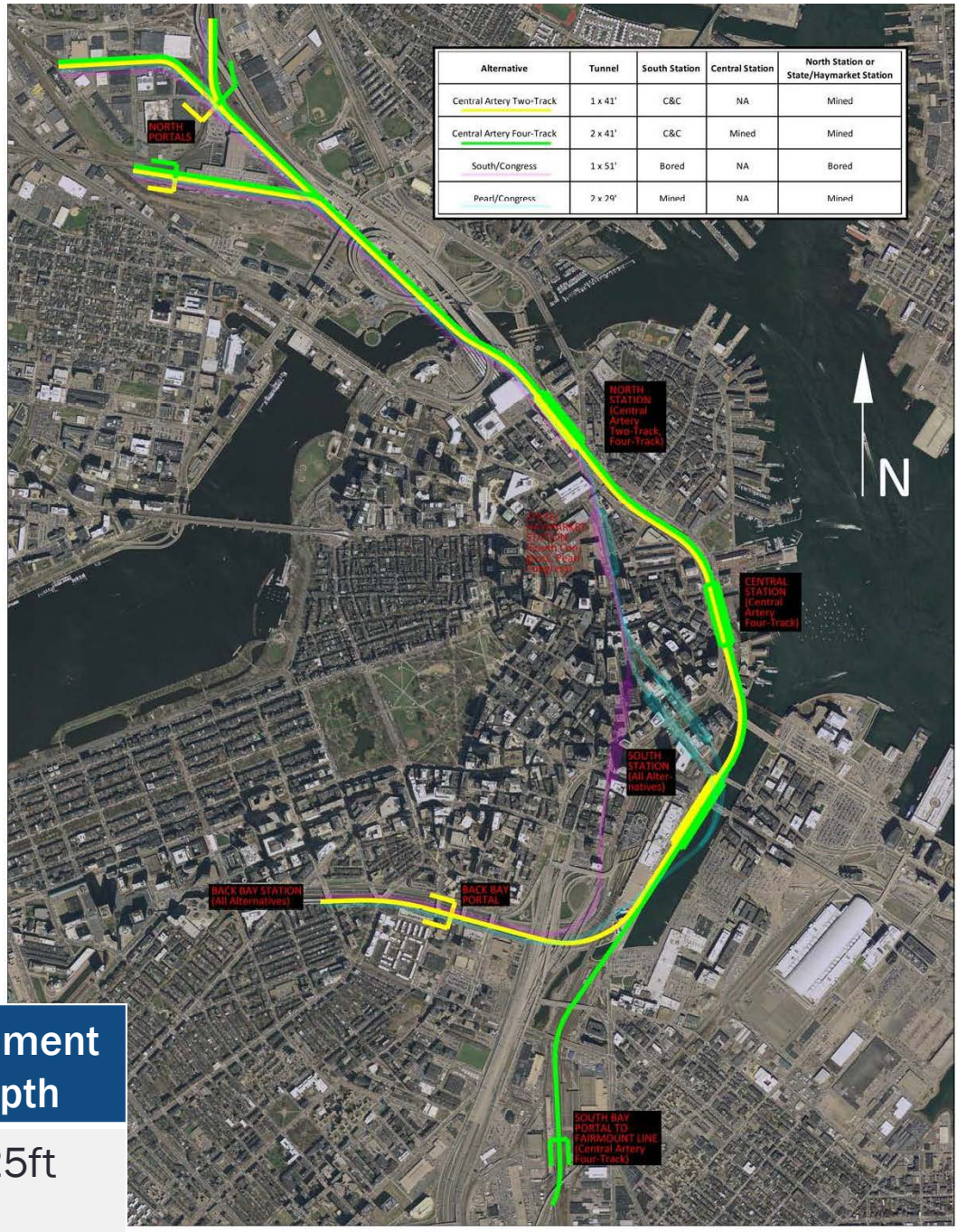
Central Artery Two-Track

- Two stations
- Cut-and-cover construction in Fort Point Channel, mining around South Bay interchange ramps
- Alignment accommodated in a 38-foot internal diameter tunnel built using a 41-foot-diamter TBM.
- Tunnels under the Orange Line, I-90 Ramps, the Red, Silver, and Blue Lines.
- Fairmount and Old Colony Lines continue to terminate at South Station at grade

Tracks	Tunnel Diameter	Stations	Alignment Depth
2	1 x 41ft	2	125ft

Central Artery Four-Track

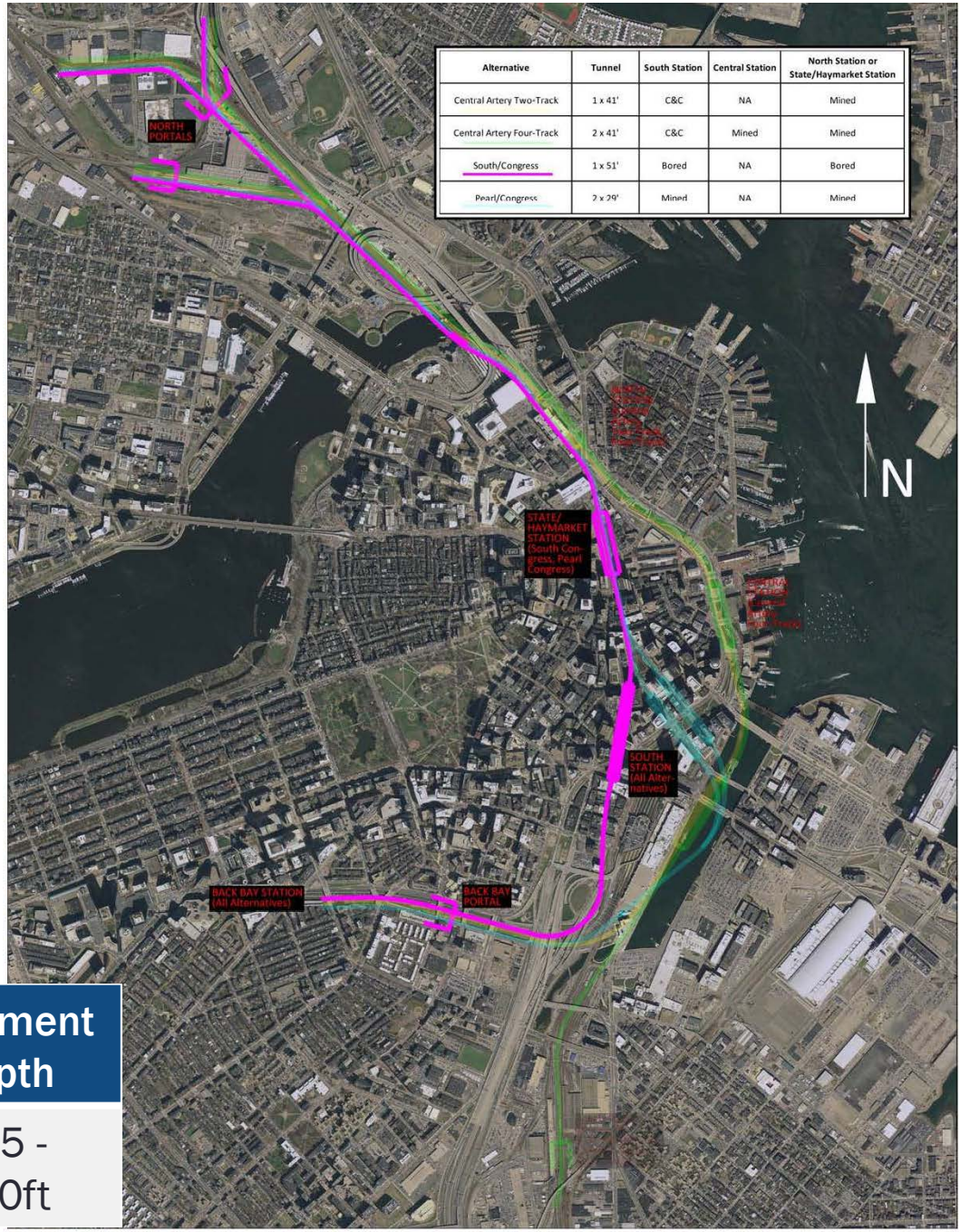
- Three stations – Includes Central Station
- Cut-and-cover construction in Fort Point Channel, mining around South Bay interchange ramps
- Uses two 41-foot TBMs to form two 38-foot internal dimension tunnels
- Tunnels under the Orange Line, I-90 Ramps, the Red, Silver and Blue Lines.
- Fairmount Line uses the tunnel. Old Colony Lines continue to terminate at South Station at grade



Tracks	Tunnel Diameter	Stations	Alignment Depth
4	2 x 41ft	3	125ft

South/Congress Alignment

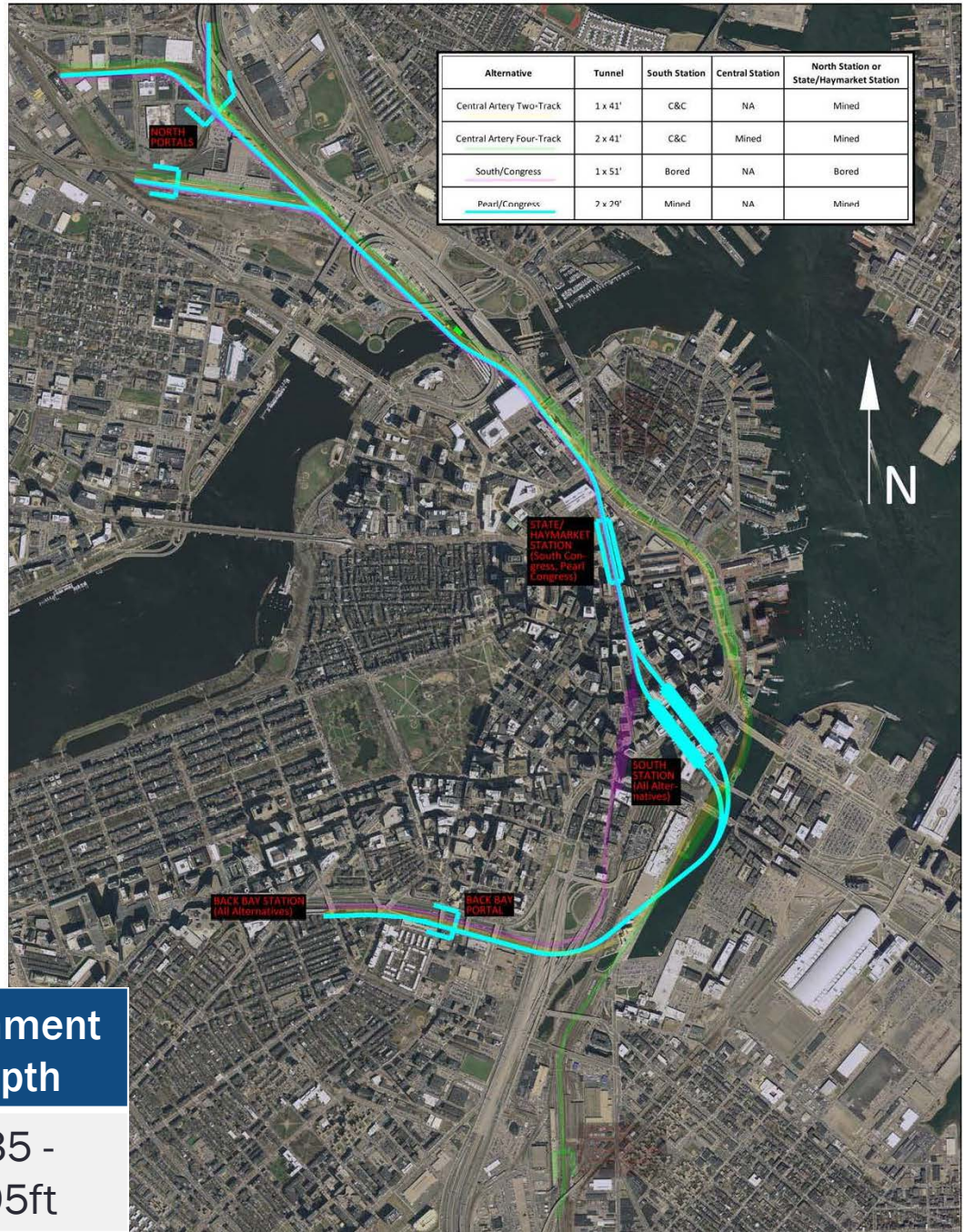
- Two stations
- Single 51-foot TBM bored tunnel with stacked tracks and platforms within the tunnel bore
- Tunnels under Red, Blue, Orange and Green Lines and the southbound lanes of I-93
- Fairmount and Old Colony Lines continue to terminate at South Station at grade



Tracks	Tunnel Diameter	Stations	Alignment Depth
2	1 x 51ft	2	115 - 130ft

Pearl/Congress Alignment

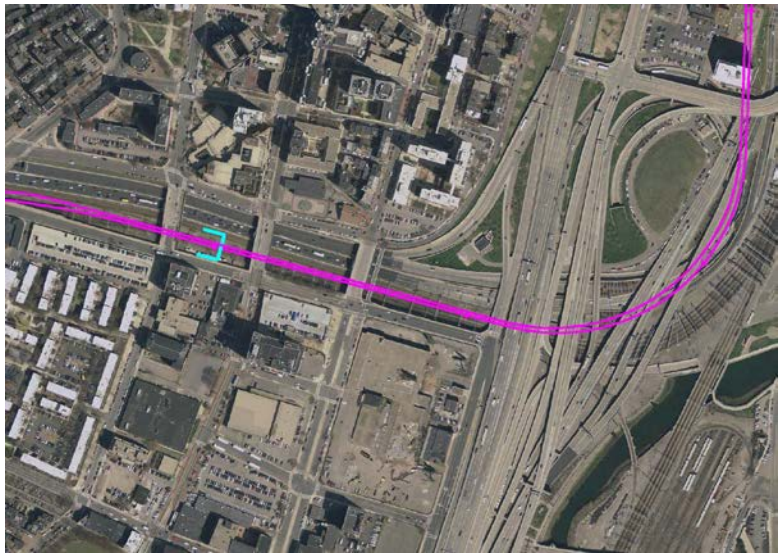
- Two stations
- Mining around South Bay interchange ramps
- Uses two 29-foot-diameter TBM bored tunnels
- Tunnels under Orange Line, I-90 Ramps, the Red and Silver Lines, I-93 northbound lanes, I-93, the Blue and Green Lines
- Fairmount and Old Colony Lines continue to terminate at South Station at grade



Tracks	Tunnel Diameter	Stations	Alignment Depth
2	2 x 29ft	2	135 - 195ft

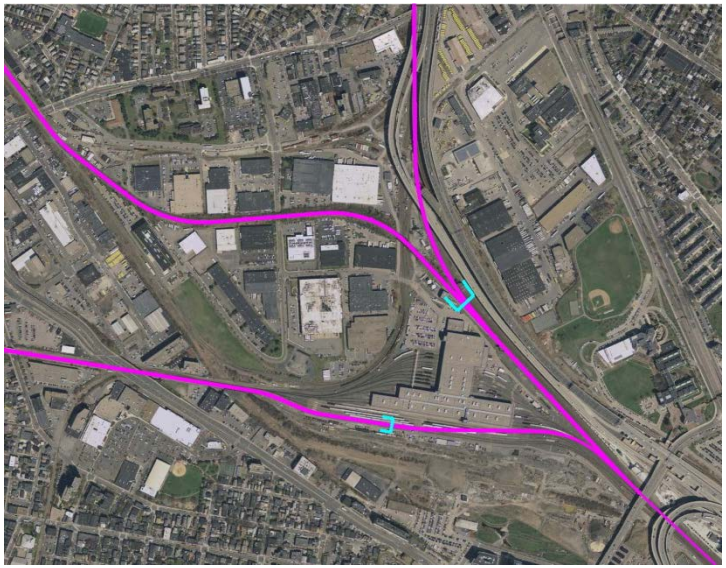
Back Bay Portal

- Back Bay Portal utilized in all alternatives.
- **Location:** Maximum allowable 3% grade means approach to portal must begin immediately east of Back Bay station, with portal located between Shawmut Avenue and Washington Street
- **Method of Construction:** Constructed using boat sections and cut-and-cover.
- **Construction Impacts:**
  - Limited single-tracking from Back Bay into South Station
  - Temporary rerouting of some or all Amtrak, Providence, Stoughton, and Franklin Line service via the Fairmount Line into South Station (this requires electrification of the Fairmount line to allow electric Amtrak service into South Station during construction)
  - Termination of the Worcester Line and Amtrak Lakeshore Limited service west of Back Bay unless a viable rerouting (i.e. via the Grand Junction Line into North Station) is identified.



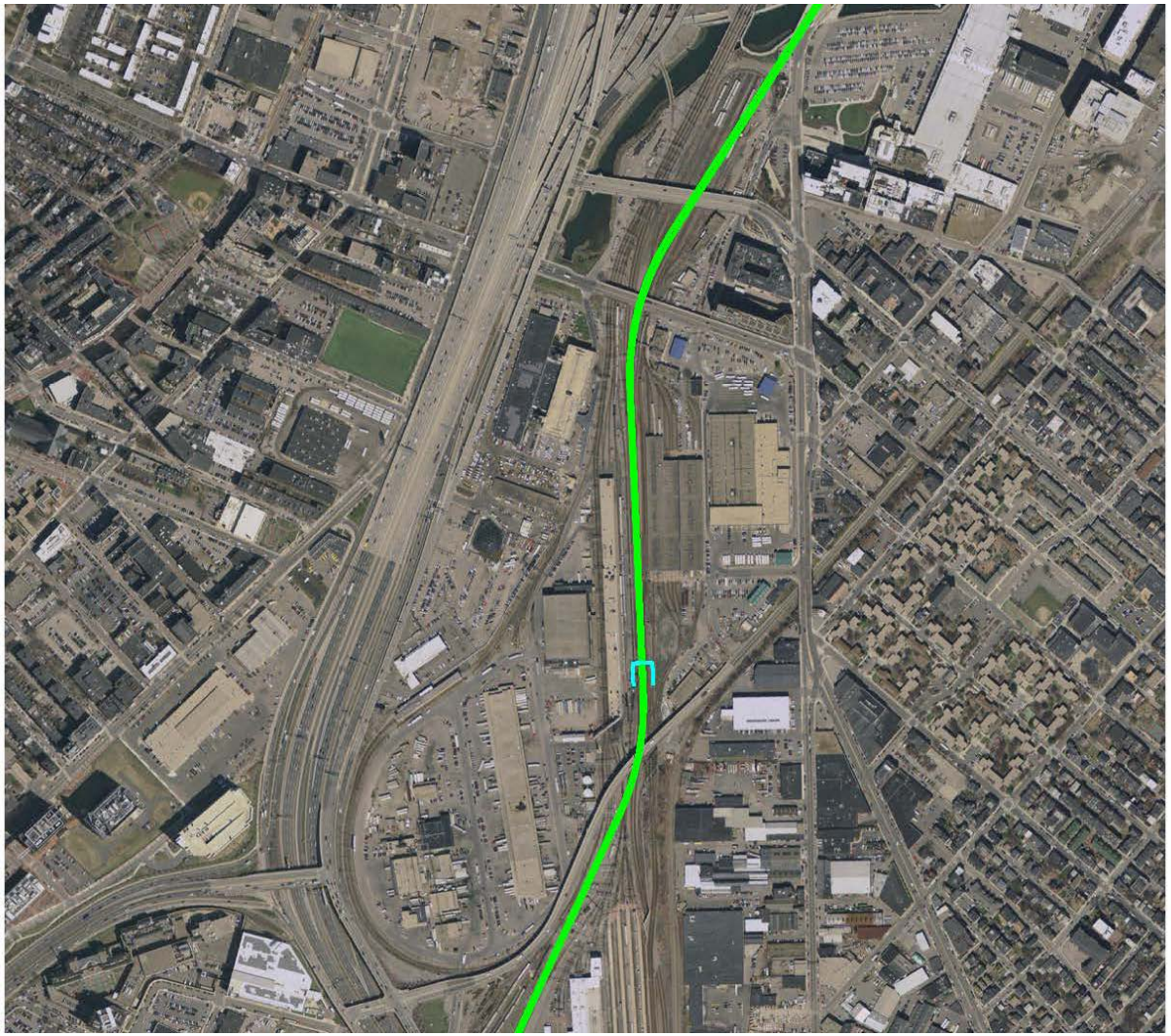
North Portals

- The North Portals are utilized in all alternatives. The TBM would be launched from these portals and driven south.
- **Location:** After passing north under the Charles River, theFitchburg Line tracks climb to reach the surface via a portal directly south of the MBTA Boston Engine Terminal (BET) on the Cambridge/Somerville border. The other tracks (to the Lowell, Haverhill, and Newburyport/Rockport Lines) emerge from a portal due east of BET.
- **Method of Construction:** Constructed using boat sections (a U-shaped section with a continuous base slab and supporting retaining walls) and cut-and-cover.
- **Construction Impacts:** Service delays and interruptions as the north portal grade separations are constructed.



South Bay Portal

- South Bay Portal only utilized in Central Artery Four-Track alternative. Necessary to accommodate Fairmount or Old Colony Lines.
- **Location:** On the Fairmount Line, just east of Widett Circle
- **Method of Construction:** Constructed using boat sections and cut-and-cover.
- **Construction Impacts:** Service delays and interruptions.

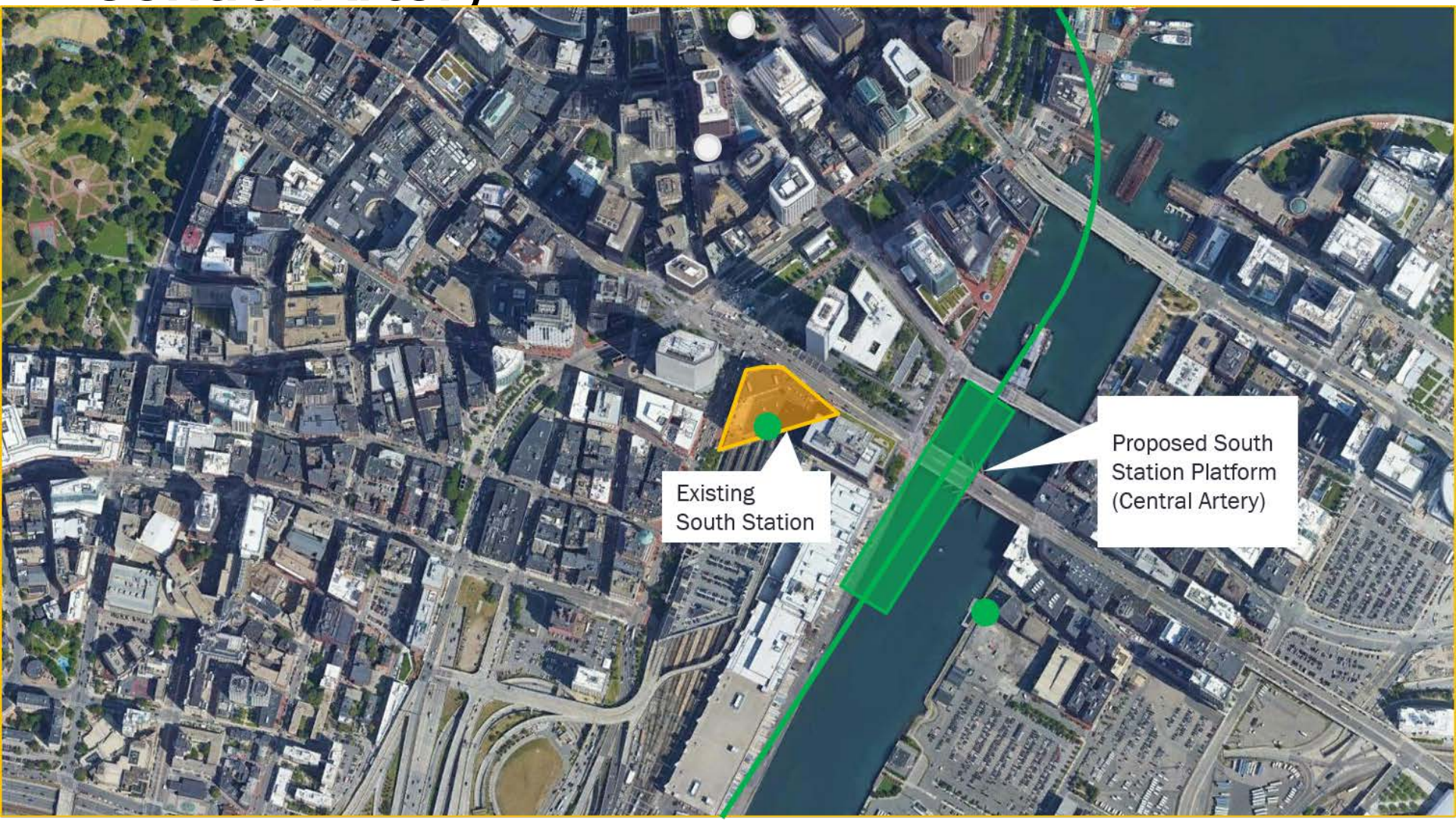


Stations Overview

- **All NSRL station platforms will be underground and will not be located directly underneath North or South Station due to technical feasibility constraints. All alternatives maintain current connections into today's South Station headhouse and North Station subway station***
- The exact location of platforms will be governed by:
  - Path and depth of each tunnel alignment in relation to existing North and South Stations
  - Locations of tangent (straight) track
  - Ability to preserve connections (both to neighborhoods and other transit) available at today's North and South Stations
- While much of today's surface tracks and platforms at South Station are preserved (to serve Amtrak and MBTA lines not using the tunnel), there is the potential to shift all of North Station's commuter rail and Amtrak service below grade to the new NSRL station.

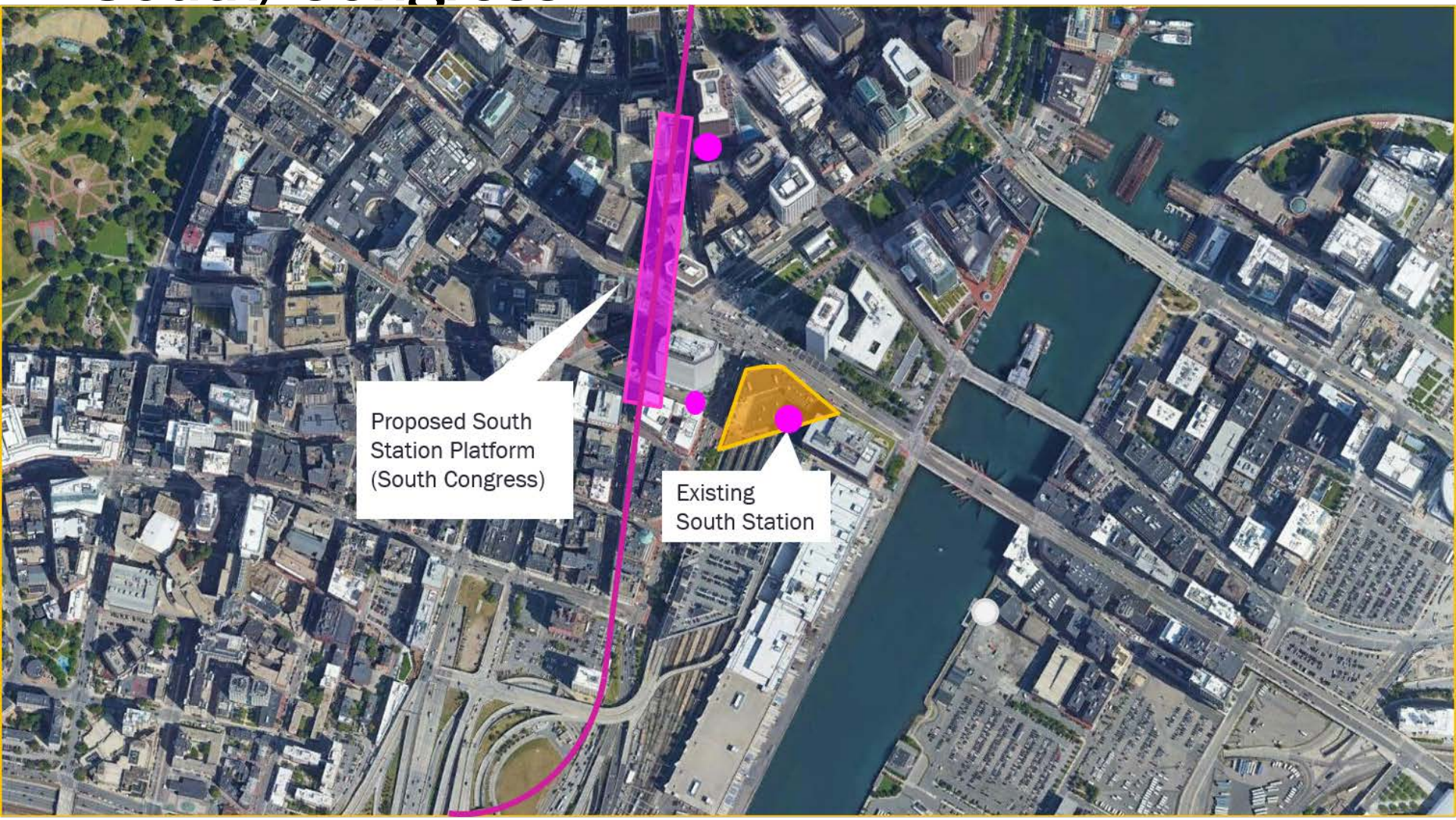
*with the exception of South Congress and Pearl Congress alignments

South Station: Platform Alternatives
Central Artery



= Indicates potential headhouse locations

South Station: Platform Alternatives South/Congress



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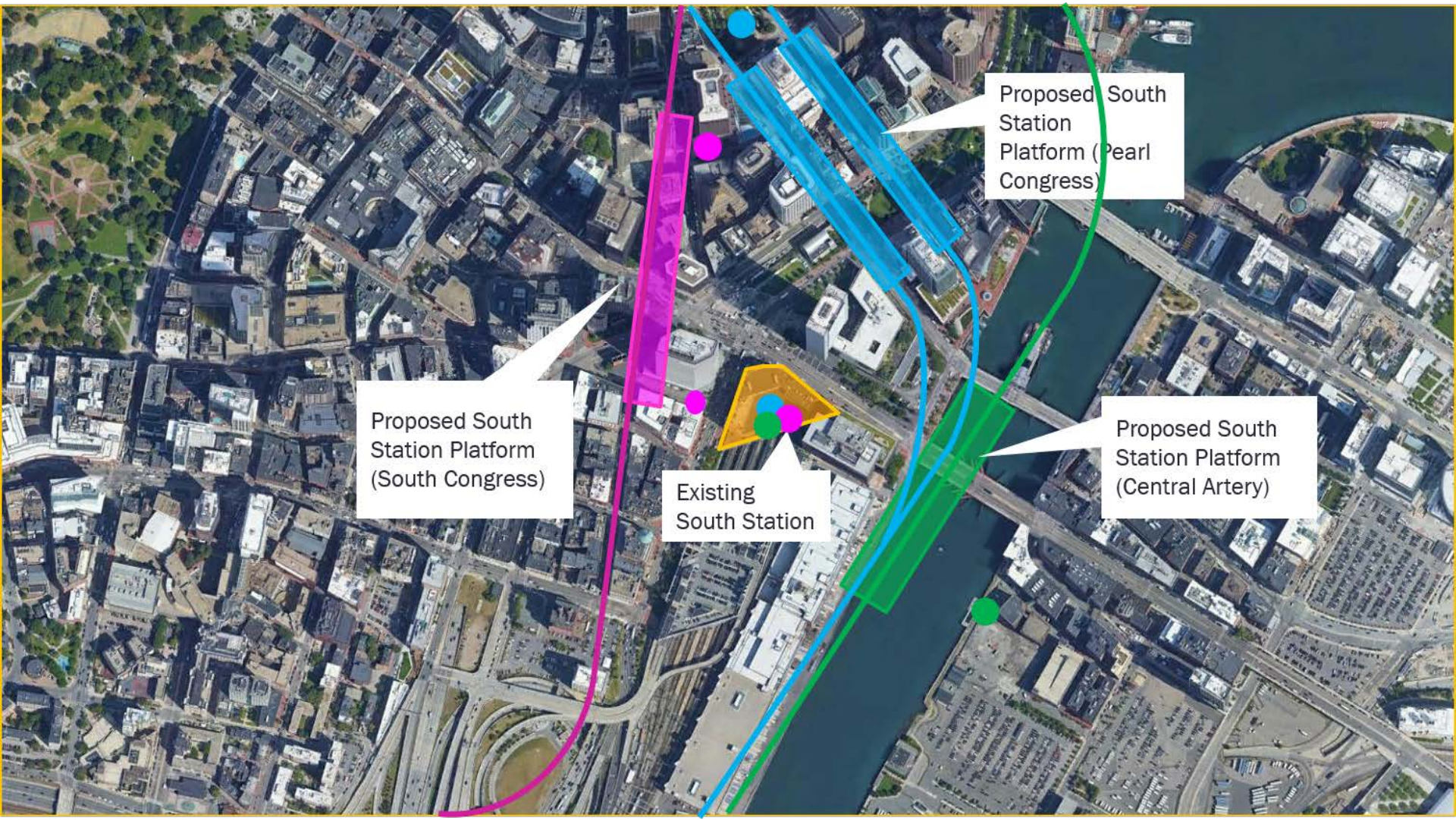
South Station: Platform Alternatives Pearl/Congress

= Indicates potential headhouse locations

South Station: Platform Alternatives



= Indicates potential headhouse locations

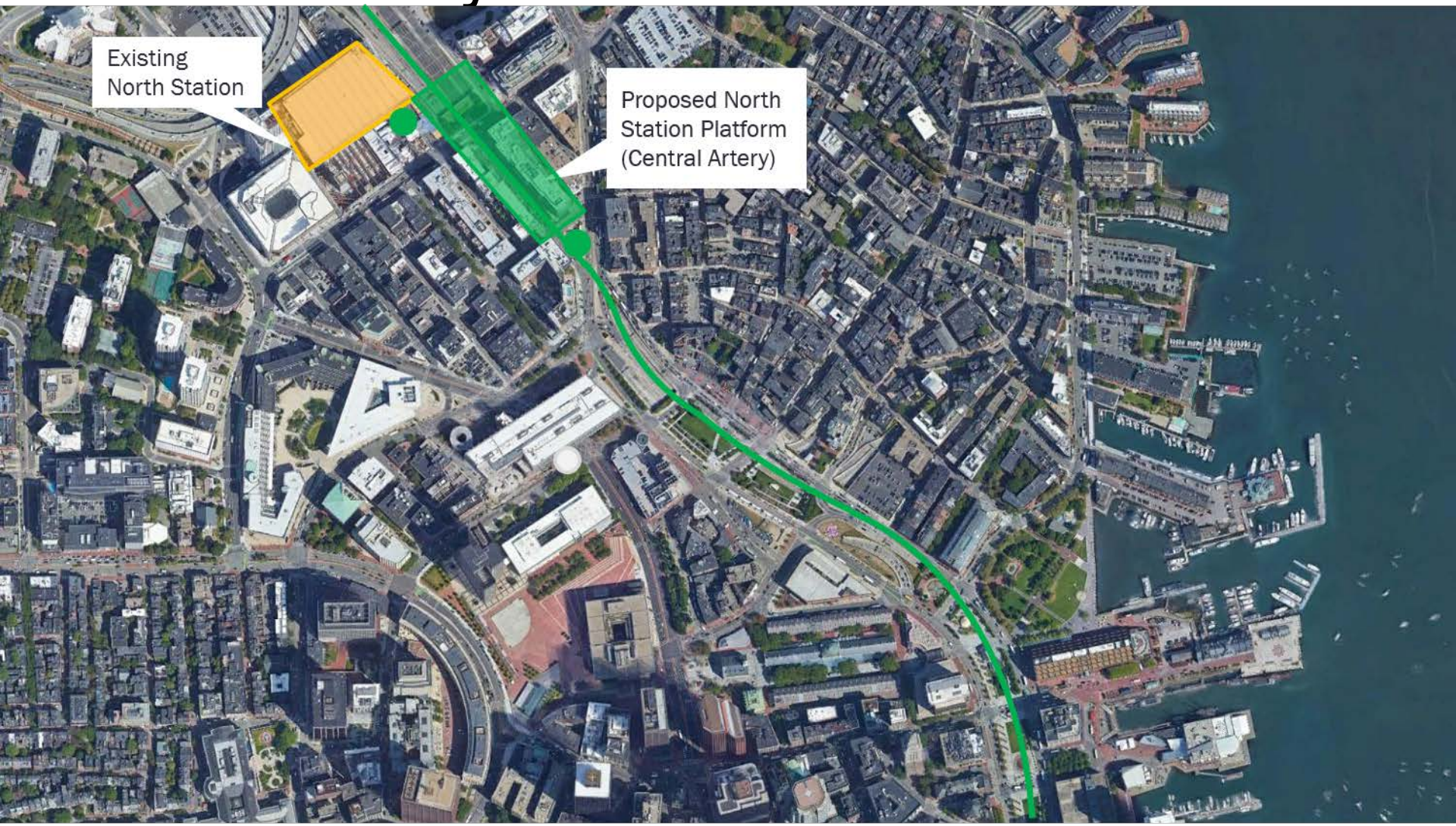
South Station: Platform Alternatives (continued)

The following table shows the change in walk times and access to rapid transit connections from the existing surface South Station

The numbers show how walking times increase/decrease to local destinations

Alignment	Station Depth (ft.)	Change in walking distance - from center of platform	
		To Post Office Square	To Seaport
Central Artery	135	+4	+1
South Congress	130	-1	+6
Pearl Congress (southbound track)	130	-1	+6
Pearl Congress (northbound track)	185	-1	+7

North Station: Platform Alternatives
Central Artery



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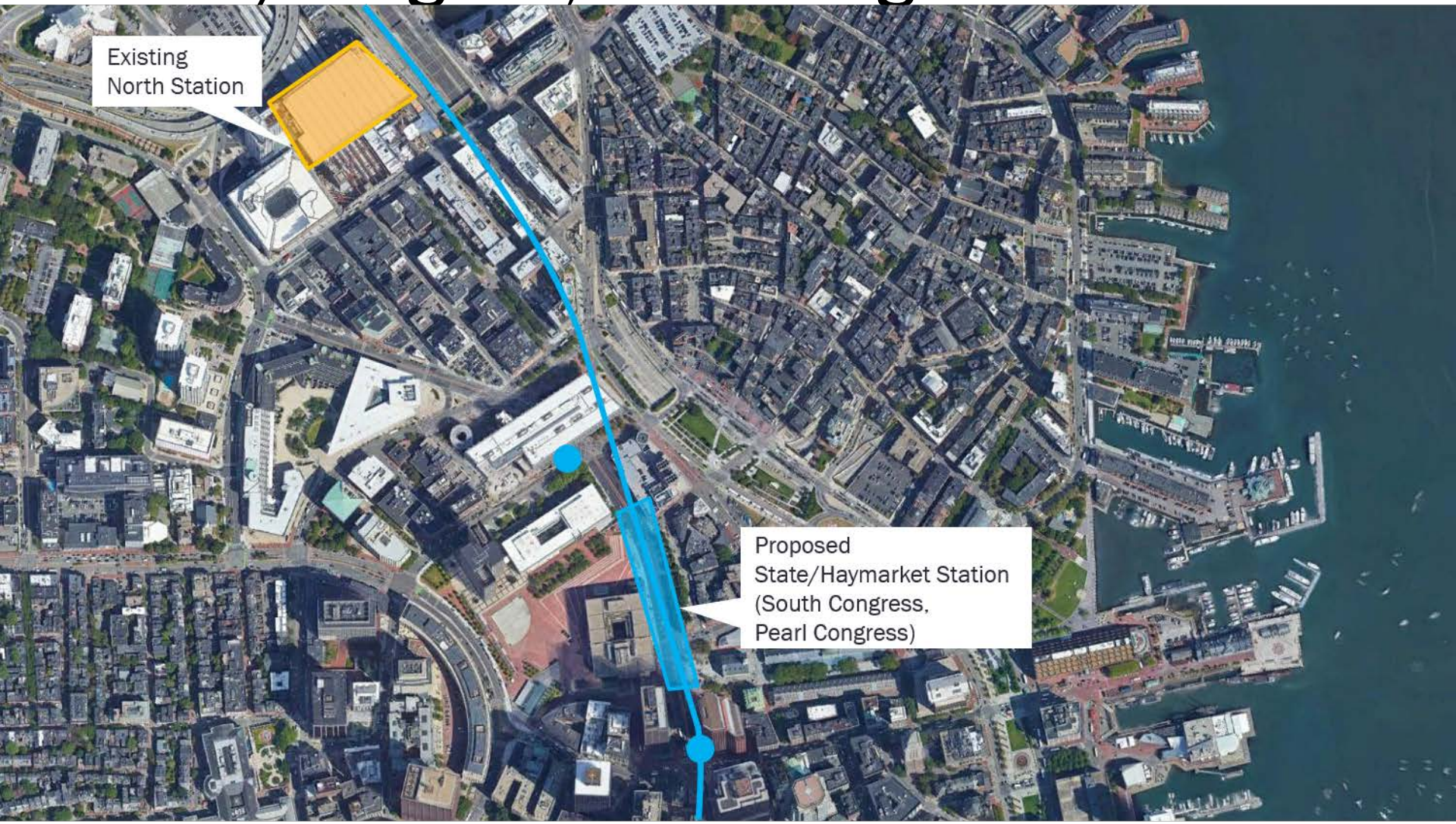
= Indicates potential headhouse locations

North Station: Platform Alternatives South/Congress, Pearl Congress



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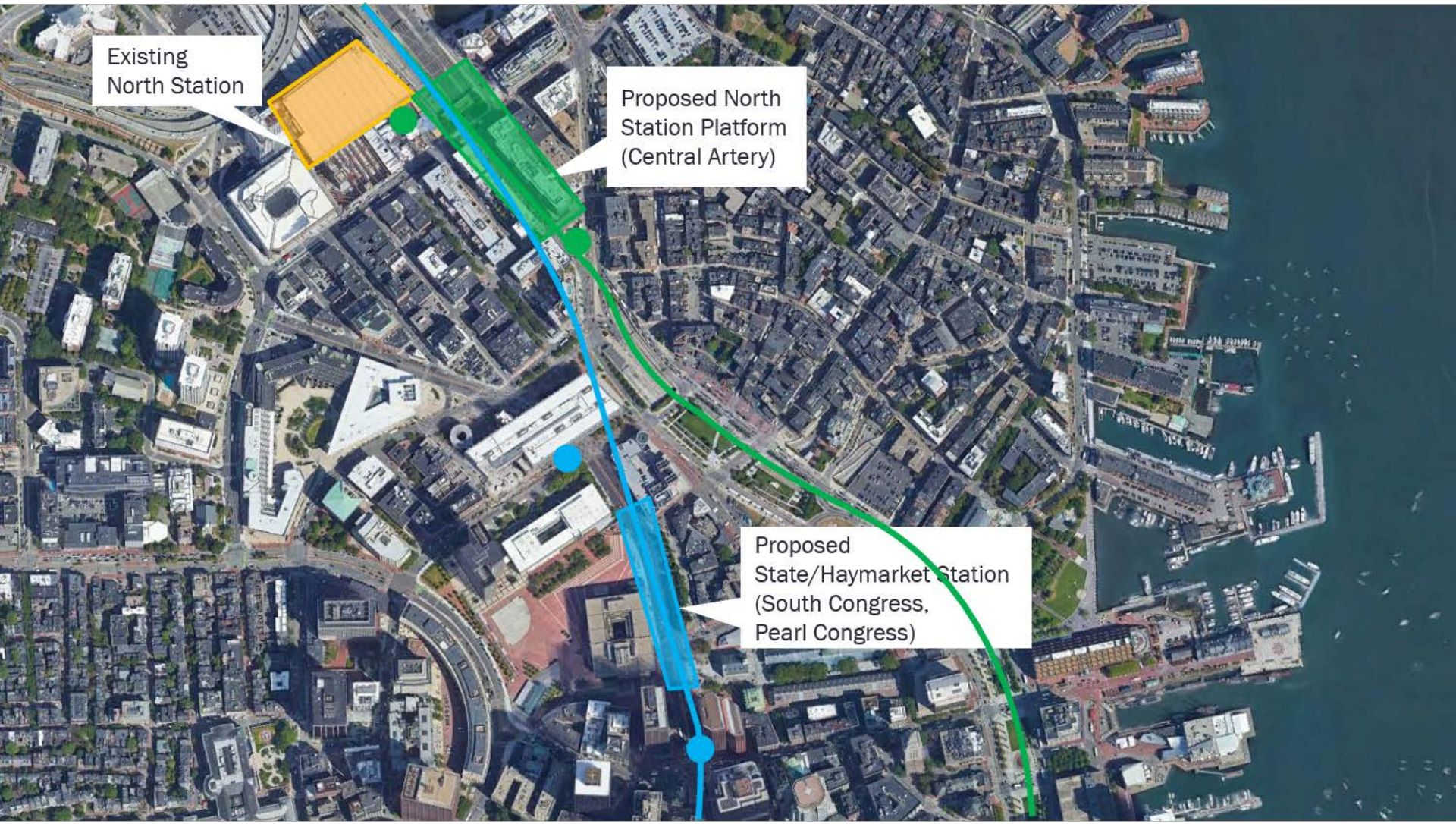
North Station: Platform Alternatives



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= Indicates potential headhouse locations

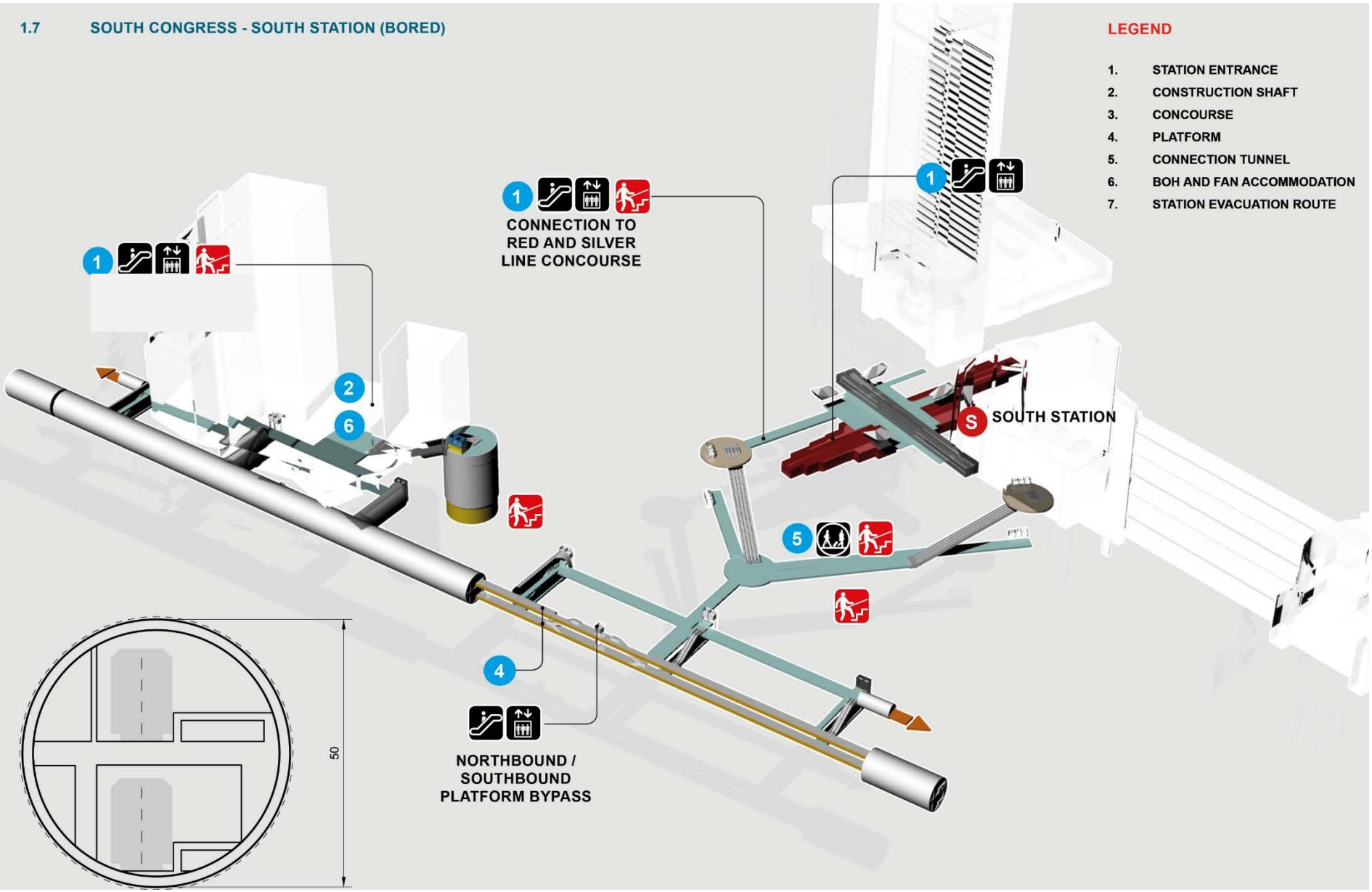
North Station: Platform Alternatives (continued)

The following table shows the change in walk times and access to rapid transit connections from the existing surface North Station

The numbers show how walking times increase/decrease to local destinations

Alignment	Station Depth (ft).	Change in walking distance - from center of platform to State Street
Central Artery	140	+1
South Congress	140	-8
Pearl Congress (southbound track)	135	-8
Pearl Congress (northbound track)	195	-7

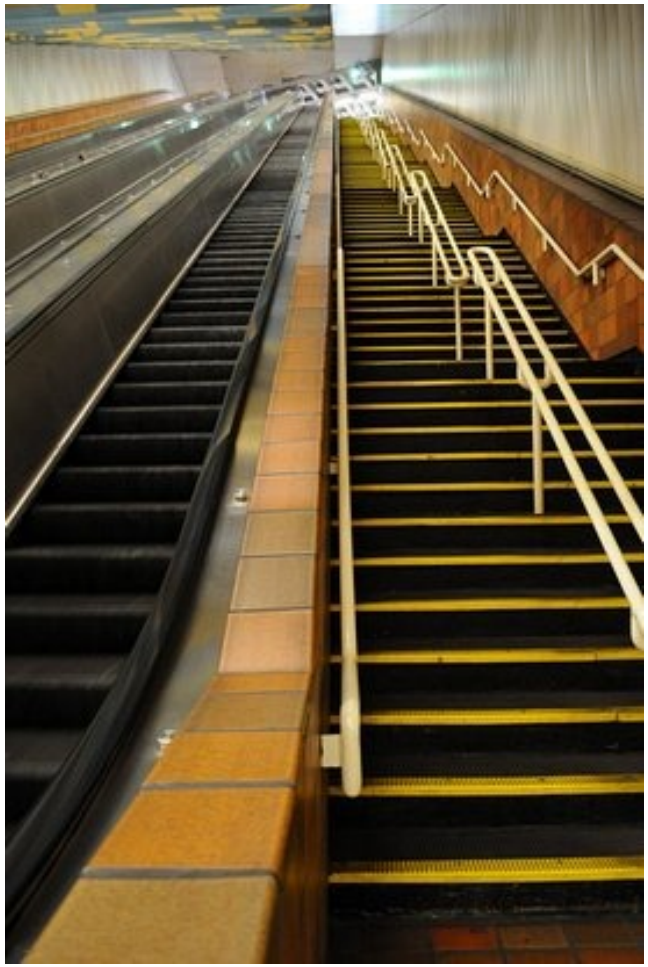
1.7 SOUTH CONGRESS - SOUTH STATION (BORED)



Station Depth Comparison

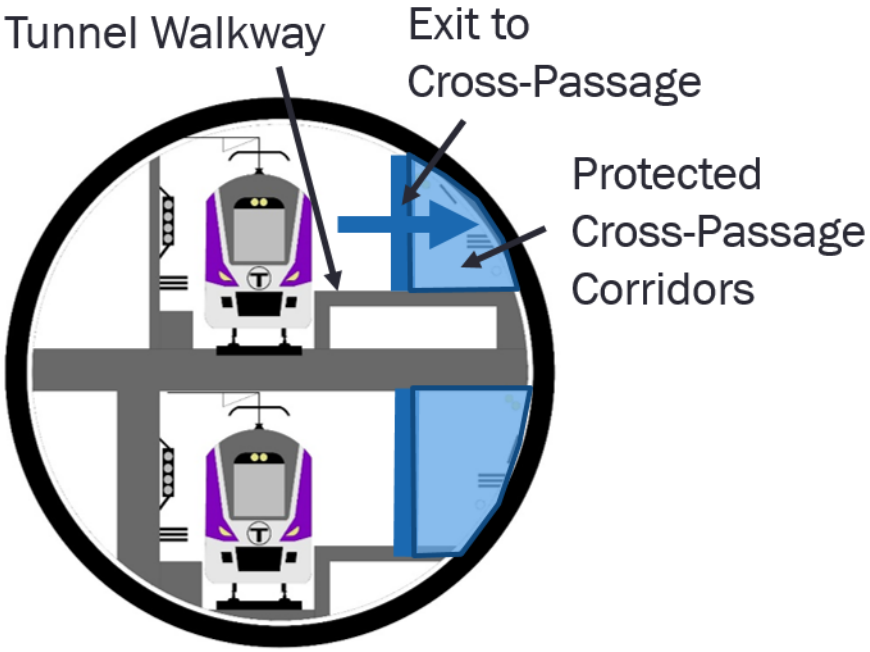
Station	Station Depth
NSRL Stations	**115 - 195 feet**
MBTA Aquarium	50 feet
MBTA Porter Square	105 feet
WMATA Dupont	114 feet
WMATA Bethesda	165 feet
NYC MTA 191st Street	180 feet
Portland Washington Pk	260 feet

NOTE: We are assuming a walk time of 3-4 minutes from the underground platforms to the station entrances



Porter Square escalators/stairway

Tunnel Egress



NFPA 130 requires:

- Tunnel walkways

and

- 800 ft. between cross-passages, exit portals, or station platforms

or

- 2500 ft. between protected exit stairs to grade

The NSRL design provides:

Tunnel walkway and both cross-passages **and** protected exit stairs to grade

Tunnel egress last resort

Standard operating procedure – drive trains to stations or stop train before entering tunnel

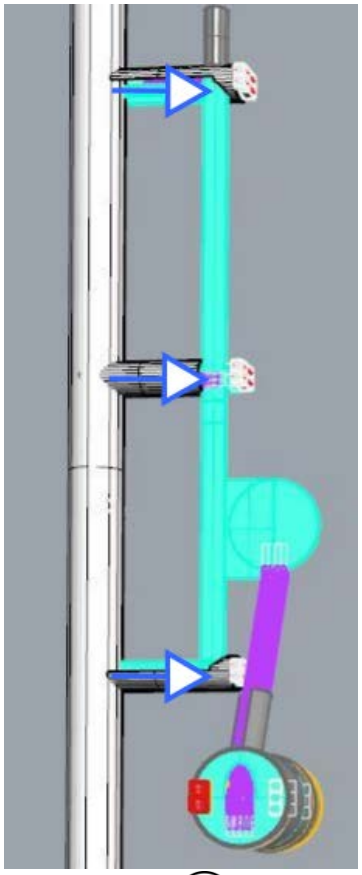
If Necessary:

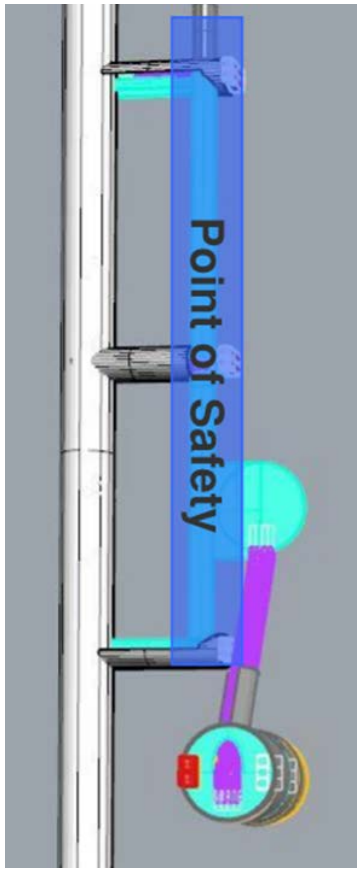
- Occupants walk along tunnel walkway (away from fire)
- Exit into cross-passage corridors (or exit portals/station platforms)
- Exit from protected cross-passage corridors through stairs to grade

Station Egress

A Exit Station

B Reach 'Point of Safety'





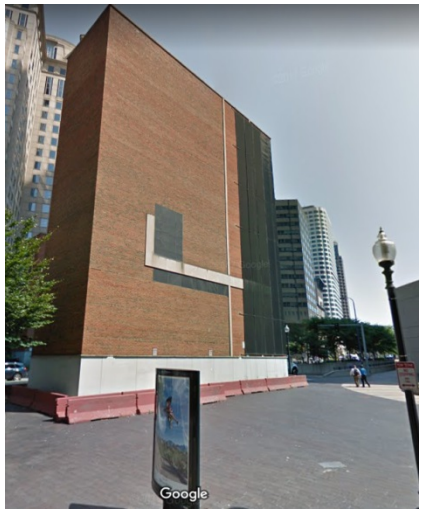
A **Four minutes** to exit platform:
Occupants exit from train platform to platform corridors

B **Six minutes** to reach a 'Point of Safety':
Occupants travel along platform corridors through stairs or escalators to reach the station 'mezzanines'
Station 'mezzanines' are designed as 'points of safety' by providing smoke control to limit smoke movement from a train fire

C **Exits to grade** on stairs of escalators:
Occupants use dedicated stairs or normal station entrance paths (stairs or escalators) to exit to the surface

Station Emergency Smoke Exhaust

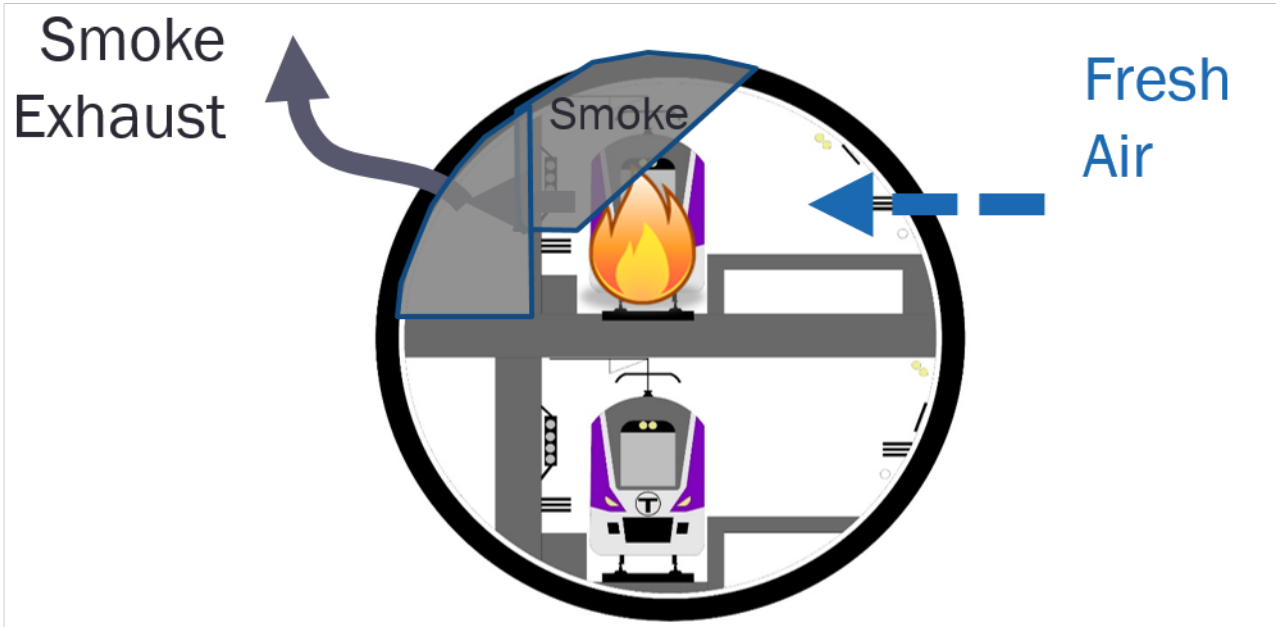
Typical Fan Plant
Fans located on surface (or sub-surface TBD) pull smoke from the station to the outside through mined shafts



Fresh air pulled in:
(1) through shafts next to exit stairs
(2) through the open escalators

NFPA 130 requires smoke exhaust to:

- Keep smoke from moving to the mezzanine
- Pull smoke away from the platform
- Exhaust at surface



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Service Plans

Service Plans (continued)

	Peak Service Levels	Off-Peak Service Levels	South Coast Rail
No Build 2040	Current service schedules	Current service schedules	South Coast line via Middleborough
South Station Expansion All-Day Peak Service (No NSRL)	Maximum achievable service levels (trains every 10-30 minutes, depending on the line)	Maximum achievable service levels (trains every 10-30 minutes, depending on the line)	South Coast line via Stoughton (fully electrified)
NSRL Regular Service (2-track)	Maximum achievable service levels (trains every 10-30 minutes, depending on the line)	Hourly Service	South Coast line via Stoughton (fully electrified)
NSRL All-Day Peak Service (2-track and 4-track)	Maximum achievable service levels (trains every 10-30 minutes, depending on the line)	Maximum achievable service levels (trains every 10-30 minutes, depending on the line)	South Coast line via Stoughton (fully electrified)

Note: Unlike typical ridership modeling , all service plans assume no constraints on station parking

Service Assumptions

- All trains operating through the tunnel are interlined with another line on the other side of the system
- NSRL 2 Track Tunnel can support 17 trains per hour, per direction (for context, this is more frequent service than currently provided on the Red Line); NSRL 4 Track Tunnel can support 21 trains per hour, per direction
- Passengers would be able to board and alight through all doors on a train and more quickly than is typical today, similar to rapid transit operations
- Service on the individual lines would be managed such that trains would be able to arrive precisely as scheduled for their slot to enter the tunnel and maintain the 17 trains/hour frequency
- Significant infrastructure investments beyond those necessary for the tunnel itself are made in order to meet the above assumptions.

Risks in Implementing Service Plans

The following represent some of the biggest concerns MBTA Operations has with the study's assumptions:

- No system has yet operated aspirational level of frequency with Positive Train Control
- Service disruptions on one or two tracks in the tunnel will cause ripple effects throughout the entire commuter rail system
- Assumptions about train loading/unloading time are much more aggressive than current experience
- Depth of stations is a concern during evacuation (and possible negative impact on customer experience due to longer time to exit stations)
- Rapid transit stations were not designed to accommodate transfers from commuter rail in the way they would happen now and may lack platform capacity to adequately do so
- Locations for additional layover and maintenance capacity have not been identified and are challenging to site

Amtrak

Our interpretation of the NEC Future service plan, as it would work with a tunnel, is as follows:

Route/Service Type	Northern Terminal	Frequency, per direction	Routing
Amtrak Express (i.e., Acela):	South Station – Surface Tracks	4 trains per hour	These trains originate on the NEC, serve Back Bay, and operate via Providence.
Amtrak Metropolitan (i.e., Regional):	Lowell	2 trains per hour	These trains originate on the NEC, serve Back Bay, and operate via Providence. These trains continue through the tunnel, stop at the subway portion of South Station, with the next stop at Anderson, and the terminal at Lowell.
Amtrak Intercity (Other - Inland) via Springfield	Maine	1 trains per 120 minutes	These trains operate from New Haven via the Inland Route to Springfield and then via the Worcester Route into Back Bay, with a stop at the subway portion of South Station, and then on the Downeaster Route via Anderson. This route replaces the Downeaster route and merges it with the Springfield (Inland Route).
Amtrak Intercity (Other – Chicago)	South Station – Surface Tracks	1 train per DAY	This is the long distance train that operates via the Worcester Route to Springfield and then Chicago.

Note: the Amtrak NEC Future Preferred Alternative proposes a significant amount of infrastructure improvements in order to enable this service frequency.

South Station Expansion

- In 2009, the Commonwealth received a $32.5 million grant from FRA to complete design and environmental review
- MEPA process completed 2016; NEPA process completed in 2017
- 30% design plans under review
- Preparing near-term signal/power plan for Tower 1.
- No funding in CIP for implementation
- SSX assumes South Station Air Rights project; development agreement with MBTA and City of Boston set to expire in October
- South Station expansion would not preclude NSRL

Conceptual Fare Structure for NSRL Planning Process

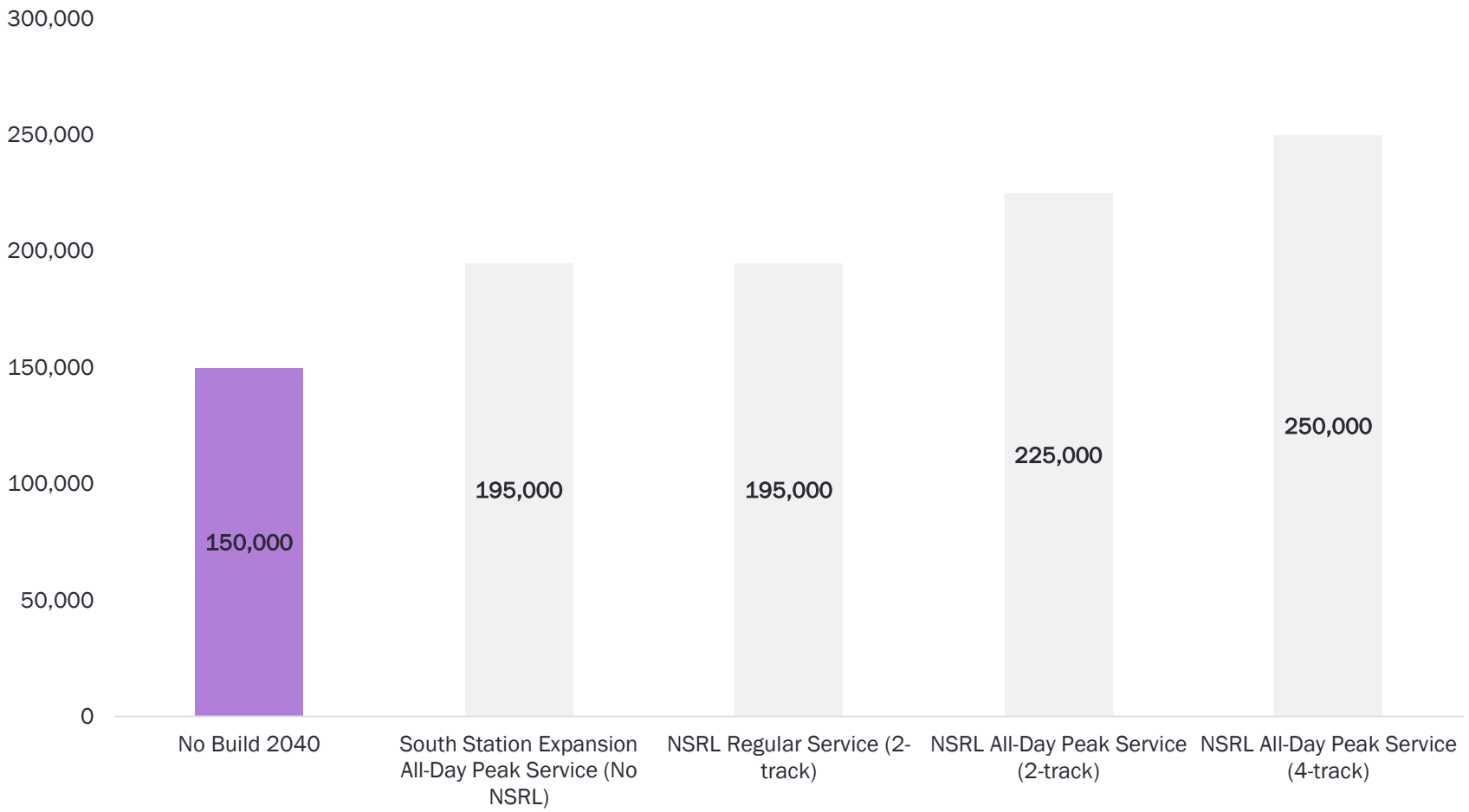
- Aims to balance issues of equity, travel cost and transfer impacts
- The policy is identical to the present system for trips to and from downtown, and trips that do not cross through the NSRL tunnel
- A flat fare identical to the subway fare is used for travel between any two Zone 1A stations
- A distance fare based on an average cost per mile is used for suburb to suburb trips
- New fare collection system (AFC2) that is to be implemented in 2020 could change fare structure for Commuter Rail

Ridership and Benefits

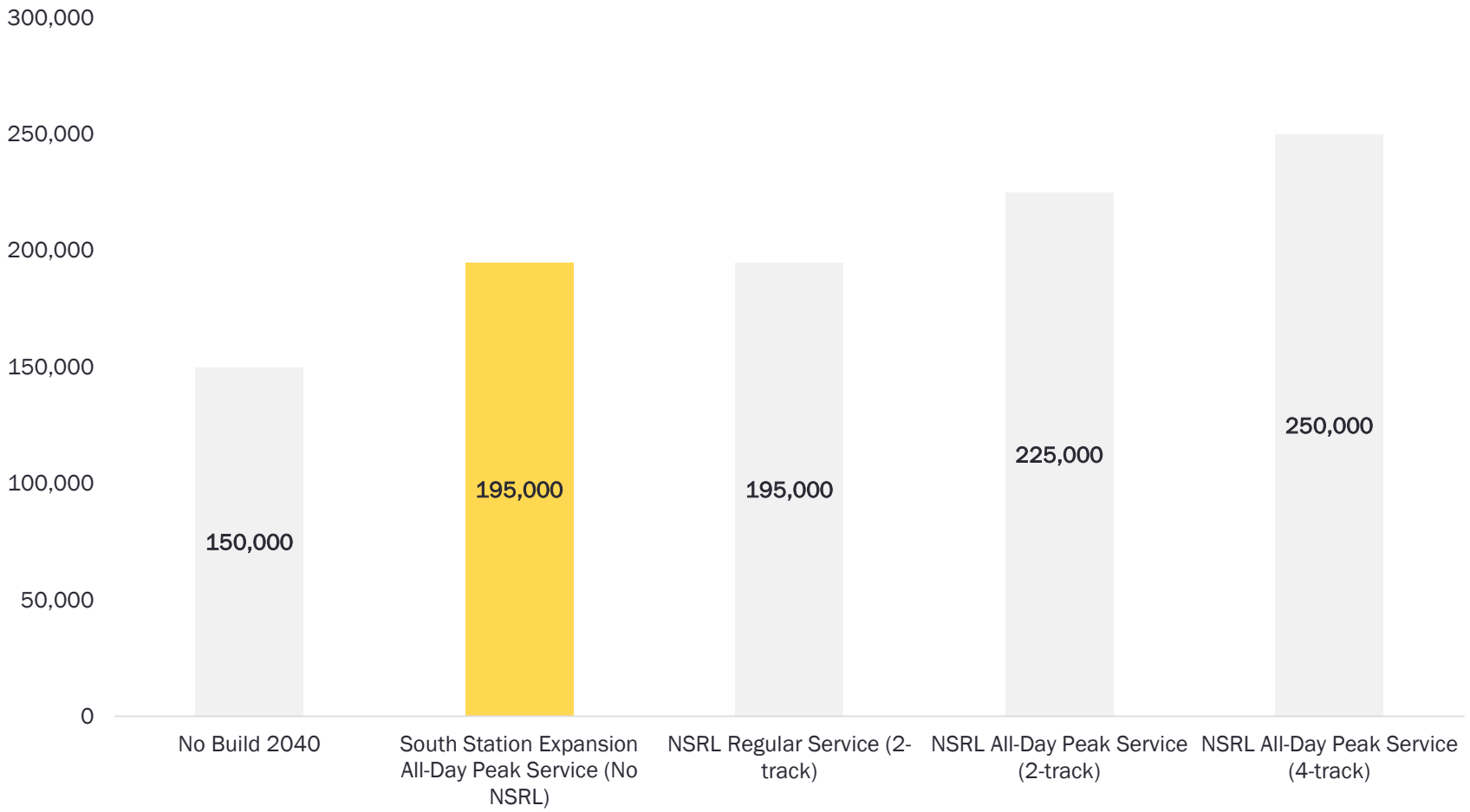
CTPS Regional Travel Demand Model

- Federally approved tool to project ridership on projects seeking federal funding support – same tool used for all major MBTA/MassDOT investments (example: GLX, South Station Expansion)
- Projects how trips are made (drive vs transit; which route or transit service) in horizon year (currently 2040)
  - Assuming future population/employment across >5,000 zones in Eastern Massachusetts, consistent with regionally adopted land use forecasts developed by MAPC
  - Model is not dynamic (transportation investments don't change land use)
- Investments (such as NSRL) are compared to a future "No Build" that doesn't include that investment, but where today's network is enhanced by other funded or otherwise committed projects in the pipeline (i.e. GLX)
- Model does not typically constrain capacity except for parking supply
  - Since model looks at a 3 hour peak period, *transit* capacity not typically an issue
- For this project, commuter rail parking was treated unconstrained in all model runs

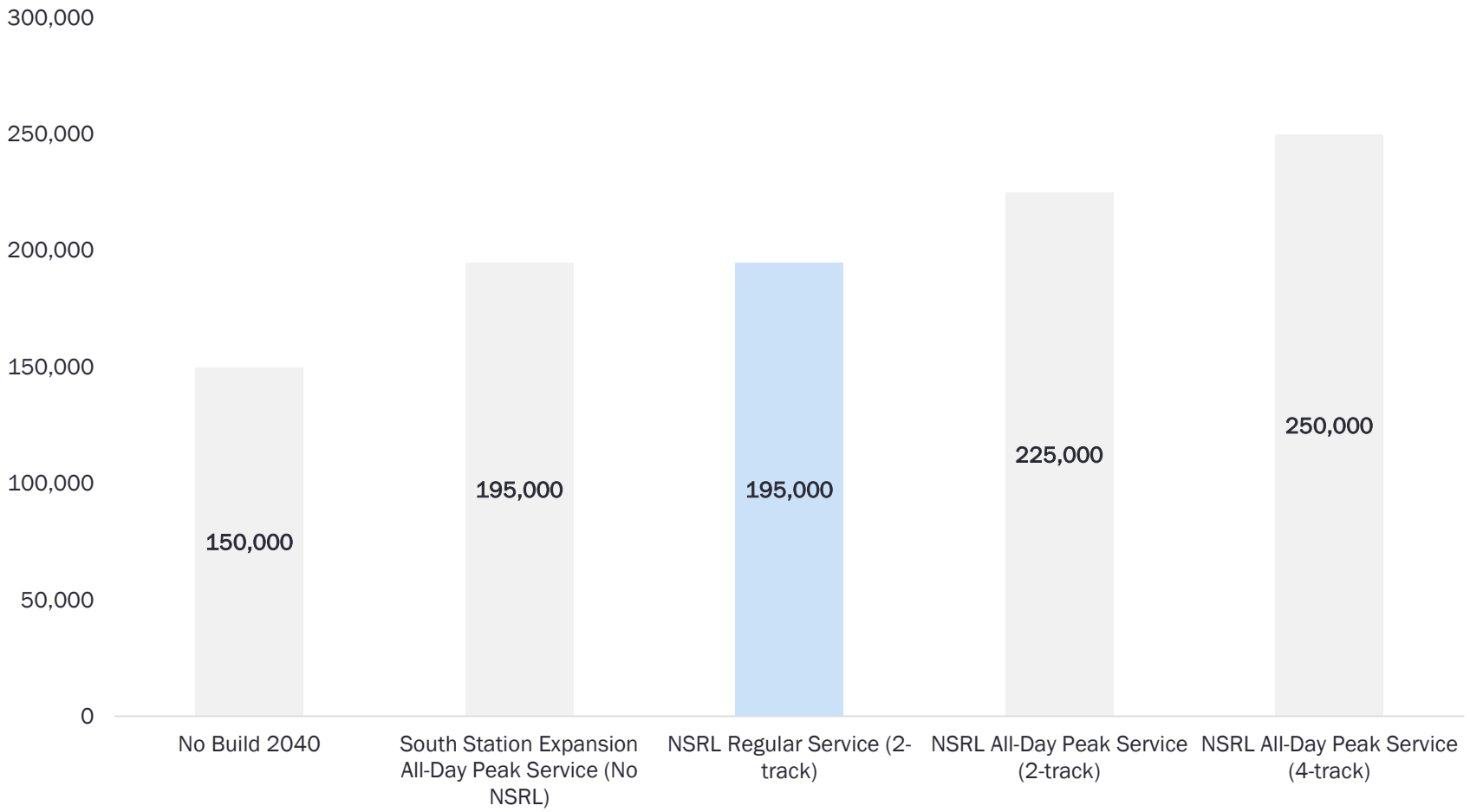
Ridership by Alternative: No Build 2040
All Day Boardings



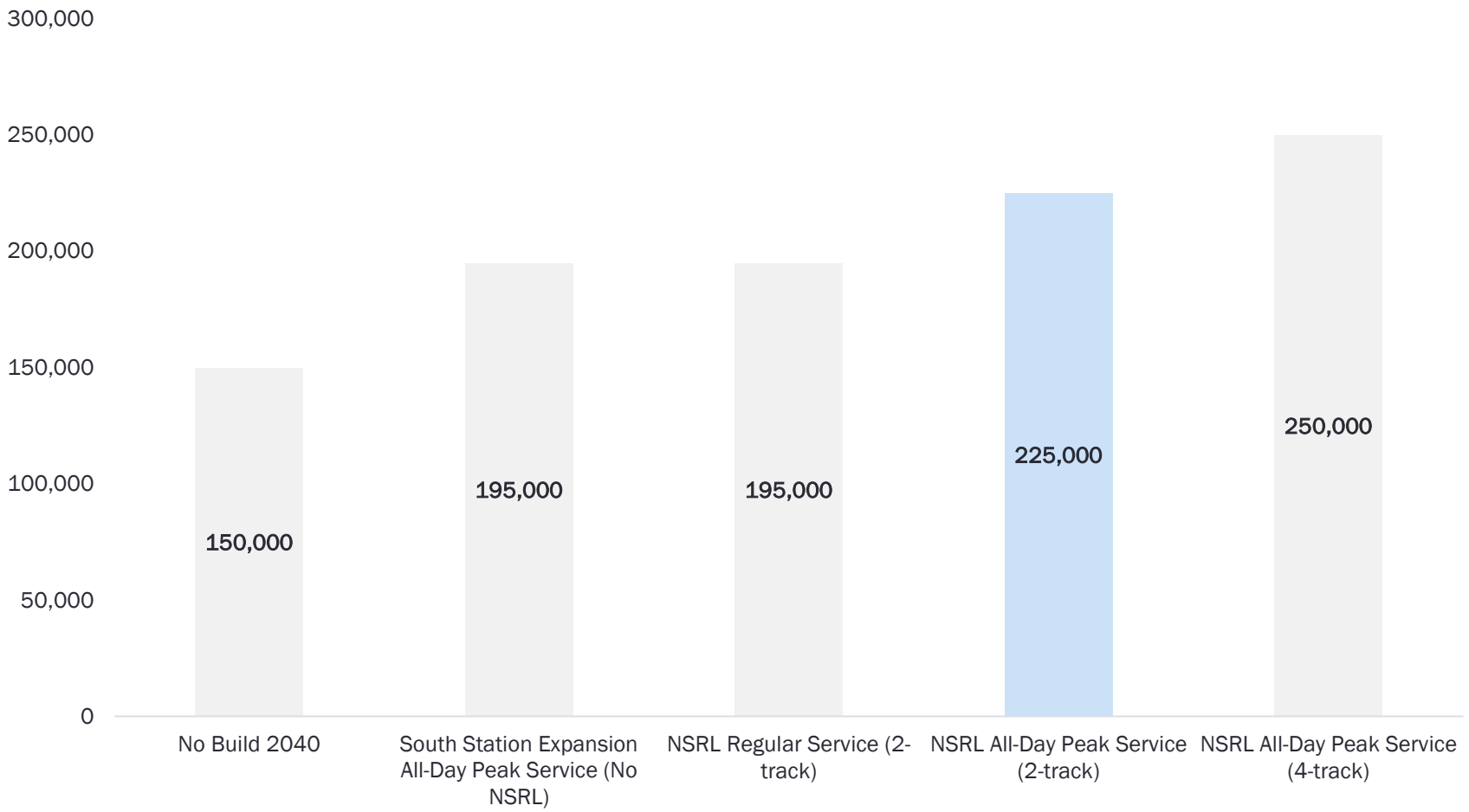
Ridership by Alternative: SSX All-Day Peak Service All Day Boardings



Ridership by Alternative: NSRL Regular Service (2-track) All Day Boardings



Ridership by Alternative: NSRL All-Day Peak Service (2-track All Day Boardings



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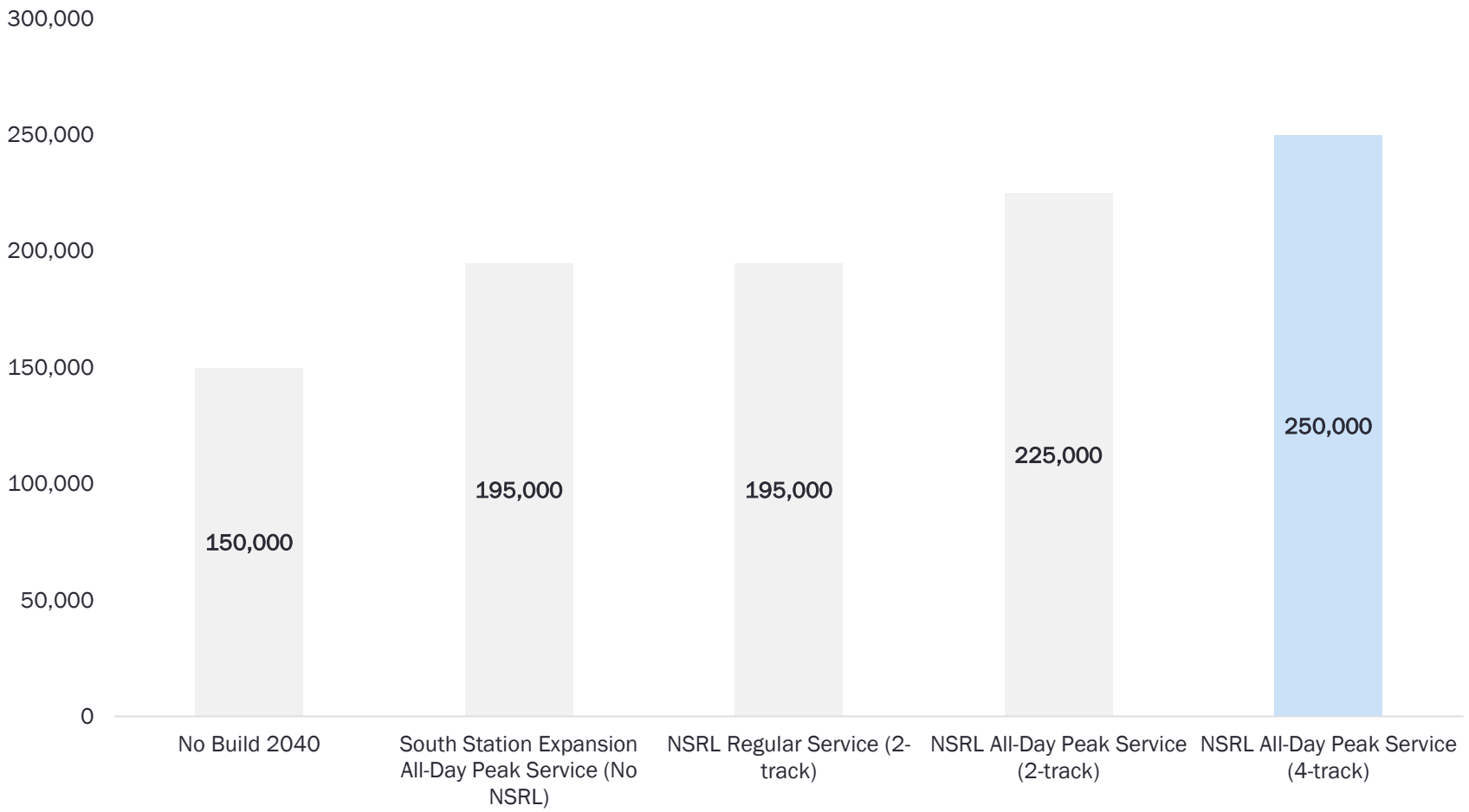
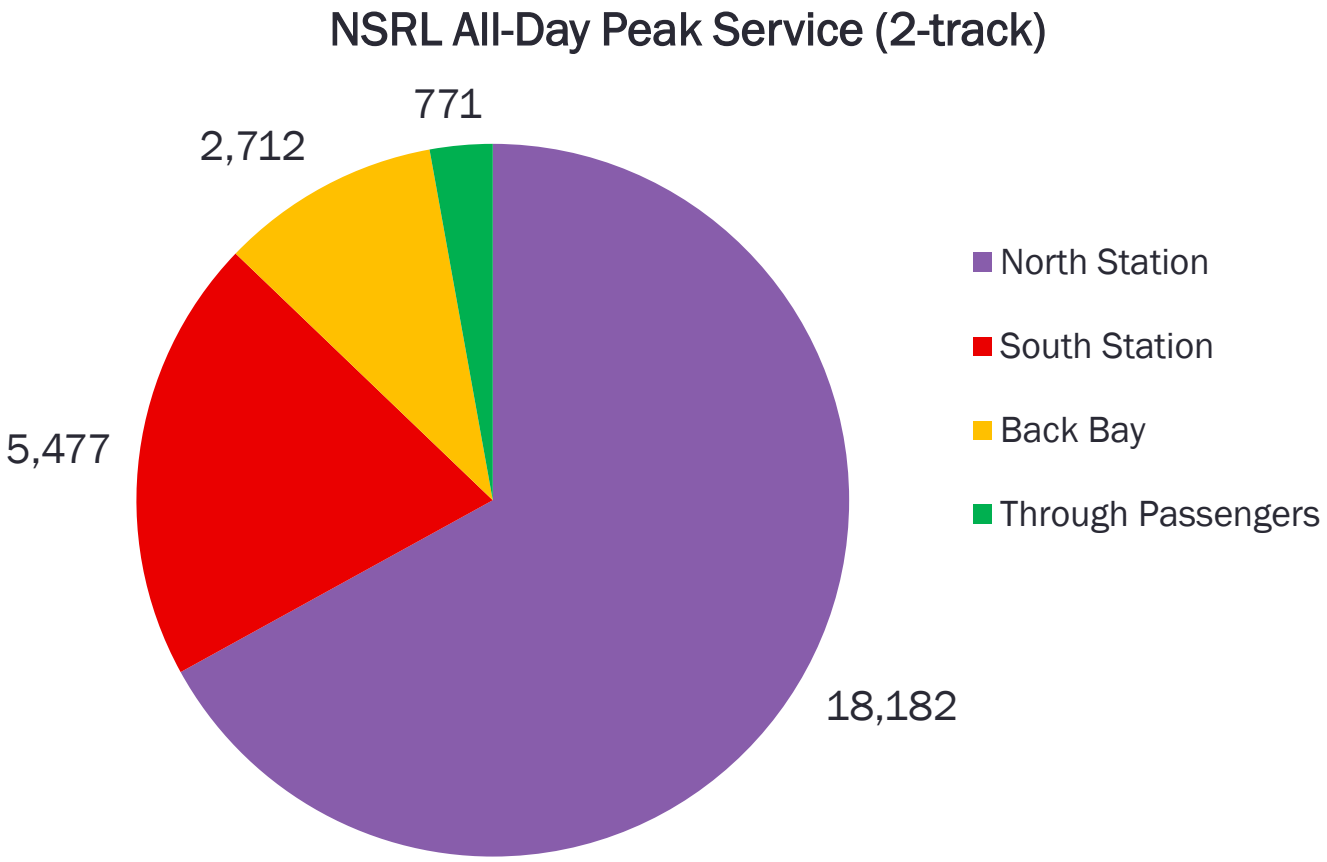
Ridership by Alternative: NSRL All-Day Peak Service (4-track)

All Day Boardings



Ridership Destinations

Northside (Southbound) AM PEAK



Rail Air Quality Impacts

	No Build 2040	South Station Expansion All-Day Peak Service (No NSRL)	NSRL All-Day Peak Service (2-Track)	NSRL Regular Service (2-track)	NSRL All-Day Peak Service (4-Track)
VMT	15,666	42,827	53,745	30,590	58,033
% Diesel	100%	95%	68%	70%	73%
CO2 (kg/day)	124,861	323,460	292,308	171,024	336,152
VOC (kg/day)	9	22	20	12	23
NOX (kg/day)	207	536	484	283	557
CO (kg/day)	263	682	616	361	709

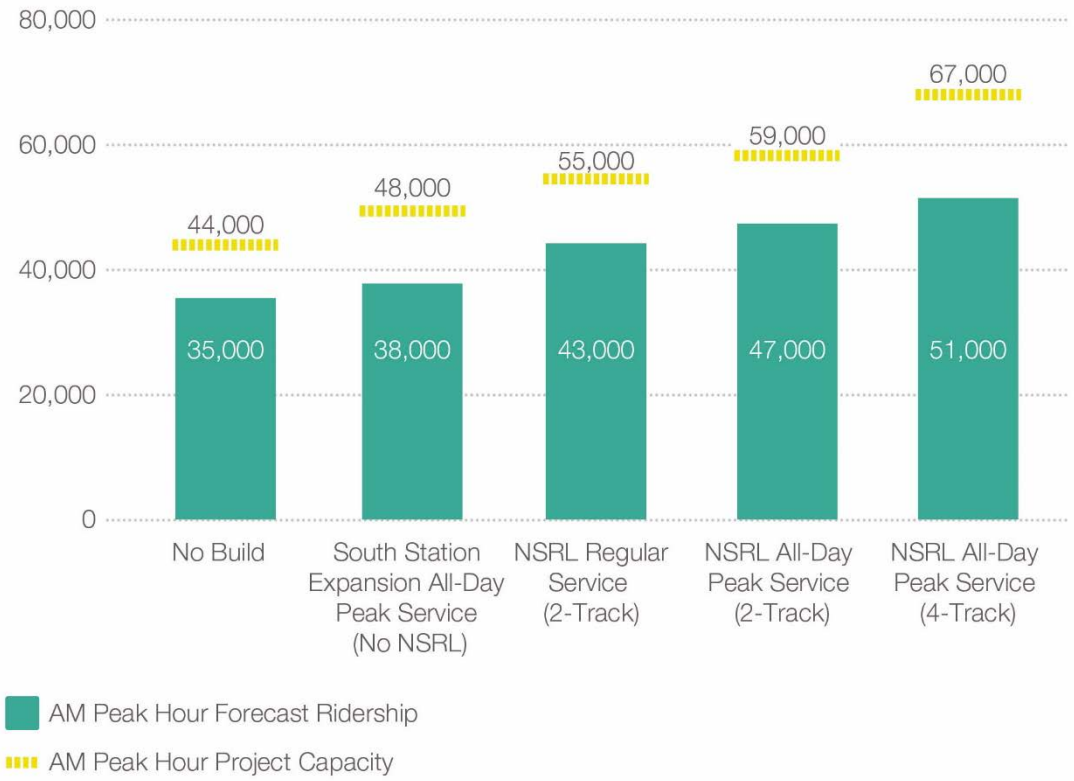
Auto Travel and Air Quality

	No Build	South Station Expansion Plus	2 Track Aspirational	2 Track Maximum	4 Track Aspirational
VMT	136,248,900	136,045,900	136,005,400	136,058,300	135,810,200
VHT	6,104,900	6,095,500	6,090,900	6,096,200	6,081,100
Avg. Speed	22.32	22.32	22.33	22.32	22.33
CO2 (kg/day)	36,733,400	36,678,600	36,667,700	36,682,000	36,615,100
VOC (kg/day)	3,050	3,045	3,045	3,046	3,040
NOX (kg/day)	6,740	6,730	6,728	6,731	6,718
CO (kg/day)	132,660	132,462	132,423	132,474	132,233

- While all alternatives result in reductions in VMT and automobile emissions, the use of dual mode locomotives combined with the significant increase in service result in little or no overall air quality benefit

Development Opportunities

Increased Capacity



- The NSRL could increase capacity (in terms of the number of commuter rail seats that arrive in Downtown Boston during the peak period) by 25%

Cost Estimates

Cost Estimating Methodology

- **Escalation to midpoint of construction (2028):** Standard practice for construction costs. Aims at simplifying the cost-loading strategy of a project by assuming that 50% of the project cost will be incurred in 50% of the project's duration.
- Every cost estimate includes an annual escalation rate of **3.5%** (compounded annually)
- **Costs include:** Alignment lengths, tunnel types, station areas, trackwork, portals, and allowances
- **Allowances:** underpinning works, roadway reconstruction, and utility relocations

Total Design Build Costs: Direct Costs + Indirects + Contractor's Overhead / Profit + Design Engineering

Total Project Costs: Total Design Build Costs + Owner's Soft Costs + Project Risk Contingency + Escalation to Midpoint of Construction

Cost Estimating Methodology (continued)

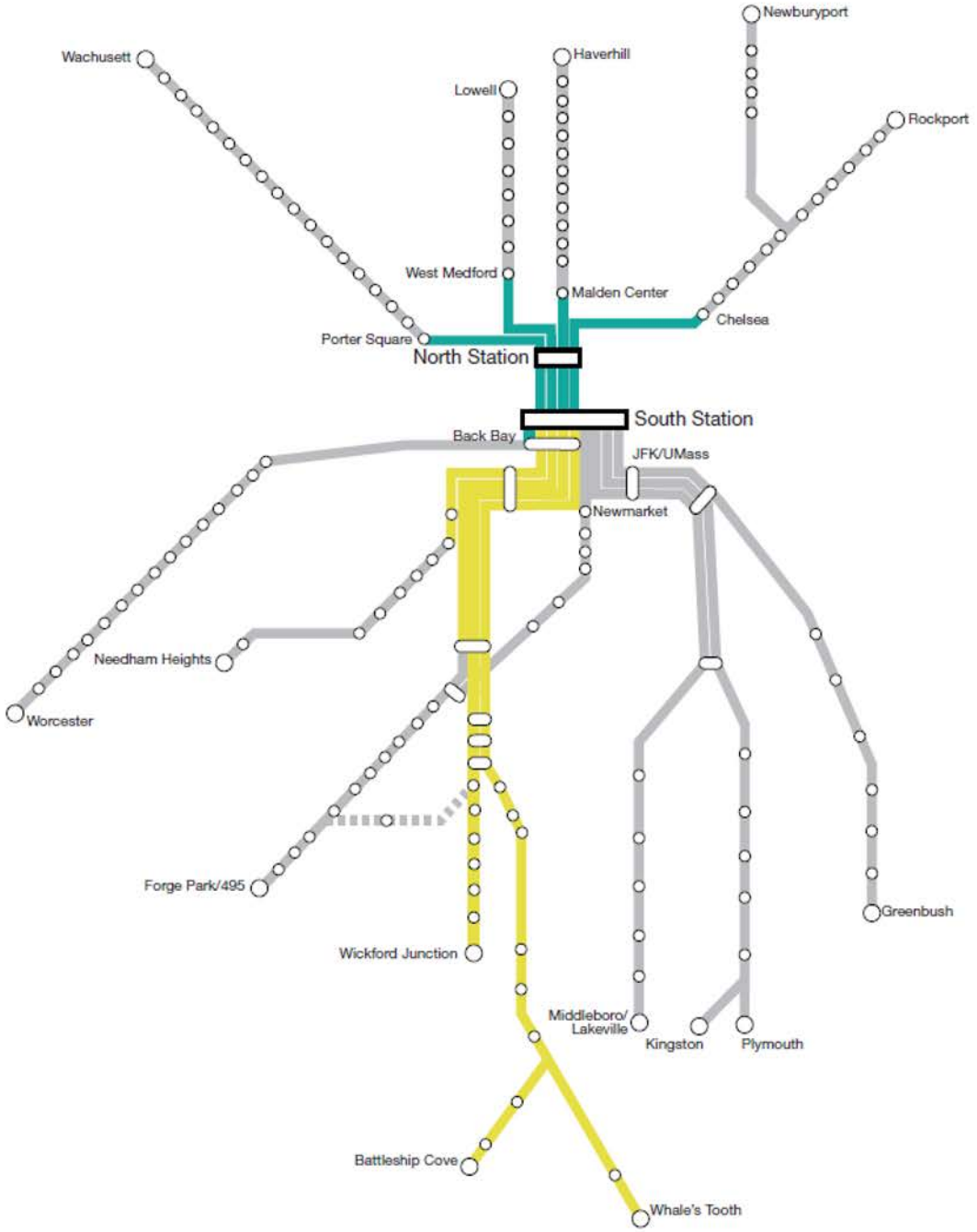
Calculation of Project Costs

- Use of Arup tunneling experts input
- Composite unit rate build-up based on construction technique which was then compared to Arup's cost databases and cost benchmarks
- Use of International Best Practices to assign accuracy ranges and contingencies (AACEi)
- Estimating mark-ups applied based on experience on other projects: Green Line Extension Project, Tappan Zee Bridge (The New NY Bridge), Texas Central Rail, Windsor Tunnel
- Use of benchmarks:
  - CHSRL (California) → Similar scope (TBM /SEM and diameter)
  - London Cross Rail (UK) → Similar scope (TBM / diameter, constructability)
  - M-30 tunnel (Spain) → Similar scope (TBM / diameter)
  - I-710 (California) → Similar scope (TBM / diameter)
  - Pannerdenschkanaal (Netherlands) → Similar scope (TBM / diameter)
  - San Francisco Central Subway → station construction type
  - Green Line Extension estimate → trackwork scope

Electrification Proposal

Already electrified (including SCR Phase 2)

Electrified as part of NSRL project



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Dual Mode Locomotives + Coaches

Dual-mode locomotives are proposed for the NSRL tunnel alternatives as they are able to travel on both the electrified and non-electrified portions of the commuter rail system, switching between diesel and electric operations as appropriate

Bombardier ALP-45DP Locomotive (NJ Transit)

GE P32AC-DM Locomotive (Metro-North Railroad)

	Diesel Locos	Dual-Mode Locos	TOTAL Diesel + Dual-Mode Locos	TOTAL Coaches
No Build	90	0	90	397
SSX All-Day Peak (No NSRL)	145	0	145	583
NSRL 2-Track Tunnel	42	120	162	600
NSRL 4-Track Tunnel	32	130	162	600

Other Investments Needed to Increase Service

Upstream Improvement	Location
Resignaling	• 30 track miles of signaling assumed to support increased service
Double Tracking	• Worcester, Fitchburg, Newburyport/Rockport (between McNall & Northey Point Junctions - between Swampscott and Salem stations)
Additional Platforms	• Fitchburg, Lowell, Worcester
Turnback Crossovers	• Fitchburg, Franklin, Fairmount
Crossing and Passing Loops	• Needham, Old Colony (passing loop between Abington and Whitman Stations), Haverhill

Cost Estimates – Summary

	South Station Expansion All-Day Peak Service	Central Artery 2 - track	South Congress	Pearl / Congress	Central Artery 4 - Track
Tunneling	NA	$8,629,000,000	$9,493,000, 000	$10,701,000,000	$17,730,000,000
Vehicles	$1,397,000,000	$2,380,000,000	$2,380,000,000	$2,380,000,000	$2,439,000,000
Upstream Investments to Support Increased Service	$ 833,000,000	$1,307,000,100	$1,307,000,100	$1,307,000,100	$1,321,000,000
SSX*	$2,466,000,000	NA	NA	NA	NA
Total	**$4,696,000,000**	**$12,317,000,000**	**$13,181,000,000**	**$14,388,000,000**	**$21,491,000,000**

All costs escalated to midpoint of construction (2028) and rounded to the nearest Million

****includes only project elements from MassDOT's South Station Expansion Federal Environmental Filing***

NOTE: Additional Vehicles costs are part of increased service in all alternatives

Cost Estimates – NSRL Tunnel Costs

	Central Artery 2 - Track	South Congress	Pearl / Congress	Central Artery 4 - Track
Tunneling Works	$4,282,000,000	$5,698,000,000	$5,046,000,000	$10,179,000,000
Stations	$1,396,000,000	$827,000,000	$2,643,000,000	$4,214,000,000
Trackwork/Civils	$197,000,000	$174,000,000	$189,000,000	$390,000,000
Portals	$1,723,000,000	$1,723,000,000	$1,723,000,000	$1,770,000,000
Electrification Back Bay Portal to Chelsea, W. Medford, and Malden	$469,000,000	$456,000,000	$466,000,000	$598,000,000
Layover Facilities	$106,000,000	$106,000,000	$106,000,000	$106,000,000
Allowances	$456,000,000	$508,000,000	$528,000,000	$472,000,000
Total	**$8,629,000,000**	**$9,493,000,000**	**$10,701,000,000**	**$17,730,000,000**

2028 MP Construction USD rounded to the nearest Million

Assumptions:

- Every alternative has 2 stations except for the Central Artery 4-track which has 3 stations

Cost Estimates – Vehicles

	South Station Expansion All-Day Peak Service	Central Artery 2 - track	South Congress	Pearl / Congress	Central Artery 4 - Track
Dual Mode Locomotives to support tunnel	$0	$391,000,000	$391,000,000	$391,000,000	$391,000,000
Additional Locomotives and Coaches to support increased service levels	$1,397,000,000	$1,989,000,000	$1,989,000,000	$1,989,000,000	$2,048,000,000
Total	**$1,397,000,000**	**$2,380,000,000**	$2,380,000,000	$2,380,000,000	**$2,439,000,000**

2028 MP Construction USD rounded to the nearest Million

Cost Estimates – Upstream Investments to Support Increased Service

	South Station Expansion All-Day Peak Service	Central Artery 2 - track	South Congress	Pearl / Congress	Central Artery 4 - Track
Layover Facilities Widett Circle (Surf. Asp.)	Included in MassDOT's SSX cost estimate	$405,000,000	$405,000,000	$405,000,000	$405,000,000
Additional Platforms	$53,000,000	$40,000,000	$40,000,000	$40,000,000	$53,000,000
Double Track	$298,000,000	$376,000,000	$376,000,000	$376,000,000	$376,000,000
Turnback Crossovers	$9,000,000	$14,000,000	$14,000,000	$14,000,000	$14,000,000
Resignaling Critical Points	$472,000,000	$472,000,000	$472,000,000	$472,000,000	$472,000,000
TOTAL	**$833,000,000**	**$1,307,000,000**	**$1,307,000,000**	**$1,307,000,000**	**$1,321,000,000**

2028 MP Construction USD rounded to the nearest Million

Comparison of South Station Expansion Cost Estimates

Element	VJ Associates Cost Estimate: South Station Expansion	Keville Independent Cost Estimate: South Station Expansion	Arup Cost Estimate: South Station Expansion All-Day Peak Service
Dorchester Ave. including USPS Demo	$36,700,391	$56,623,715	$28,000,000
South Station Headhouse	$210,533,210	$331,207,324	$235,000,000
South Station Track	$157,737,210	$132,605,815	$181,000,000
Layover Facilities – Widett	$115,331,637	$97,360,704	$130,000,000
Layover Facilities – Readville	$15,156,522	$18,628,863	$34,000,000
ROW Acquisition	$348,308,000	$348,308,000	$400,000,000
Sub totals w/o contingencies	$883,766,890	$984,734,421	$1,008,000,000
Contingencies	$979,058,737	$935,892,663	$741,000,000
Totals in Year 2017/2018 dollars	**$1,862,825,627**	**$1,920,627,084**	**$1,749,000,000**
Totals in Year 2028 dollars			**$2,466,000,000**

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NSRL Cost Comparisons

2002 MassDOT Study

Alternative	Infrastructure Cost (2002 USD)	Infrastructure Cost (2028 USD)
Two-Track (Back-Bay)/Two Station	$ 3,368,700,000	$ 8,240,000,000
Two-Track (South-Bay)/Two Station	$ 3,317,100,000	$ 8,114,000,000
Four-Track/Three Station	$ 5,748,000,000	$14,060,000,000

Executive Summary Table ES-7 Summary of Capital Costs (2002 Dollars) escalated to 2028 MP Construction

2017 Harvard Study

Alternative	Total Cost (2025 USD)	Total Cost (2028 USD)
Minimum (Two Track)	$ 3,820,000,000	$ 4,236,000,000
Maximum (Four Track)	$ 5,940,000,000	$ 6,586,000,000

Figure 2 and Figure 3 of NSRL White Paper_Silver_Final.PDF escalated to 2028 USD. ***Note: The Harvard Study did not include cost for the tunnel boring machine launch pit and only accounted for a 2.9 mile corridor (the current study accounted for a 5 mile corridor), and no contingency for owner's risk.***

2018 MassDOT Study

Alternative		Infrastructure Cost (2028 USD)
Central Artery Two-Track / Two Station		$ 8,629,000,000
South Congress Alignment / Two Station		$ 9,493,000,000
Central Artery Four Track / Three Station		$17,730,000,000

Arup analysis (2018 Dollars) escalated to 2028 MP Construction

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Operating costs - Inputs

Train miles and hours per service alternative

	Weekday Daily Totals			
Service Alternative	Revenue Miles	Revenue Hours	Non-revenue Miles	Non-revenue Hours
No Build 2040	16,420	530	800	30
South Station Expansion All-Day Peak Service	41,550	1,370	1,630	60
NSRL Regular Service (2-track)	28,290	950	2,300	80
NSRL All-Day Peak Service (2-track)	51,470	1,690	2,480	80
NSRL All-Day Peak Service (4-track)	55,230	1,780	2,800	90

Operating costs - Estimates

Operating costs have been estimated for the No Build, South Station Expansion All-Day Peak Service (No NSRL), and the NSRL All-Day Peak Service (2-track) alternatives

	No Build 2040	South Station Expansion All-Day Peak Service	NSRL All-Day Peak Service (2-track)
Vehicle revenue miles/day	16,420	41,550	51,470
Operating expenses/year	$400 million	$775 million	$929 million

2018 US Dollars

Questions