MBTA Green Line Climate Change Vulnerability Assessment

Project Summary Presentation

June 14, 2022

Agenda

1 Introductions

2 Overview

3 Methodology

4 Results

5 Recommended Actions

PROJECT OVERVIEW

Project Objectives

1.

Conduct an assessment **aligned with existing methodology** to support MBTA's ongoing systemwide CCVA

2.

Assess the GL's **historical, near and far term vulnerabilities** to climate change-related extreme weather

3.

Identify vulnerable assets requiring attention

4.

Provide **recommended actions to improve MBTA's climate change resilience** through the capital investment plan
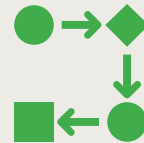
Project Overview

General Approach

Data collection & desktop review

- Identify Climate Stressors
- Identify data gaps
- Confirm climate projection scenarios and time horizons
- Develop inventory of GL assets

Data consolidation & methodology review

- Confirm study boundaries
- Develop detailed risk assessment methodology
- Compile background data
- Define asset sub-types for assessment

Interviews & site visits

- Understand & document site conditions
- Understand operations & maintenance protocol
- Confirm assets on site
- Identify potential adaptation options / quick wins

Vulnerability Analysis & Assessment

- Assess exposure
- Assess sensitivity
- Assess adaptive capacity
- Develop adaptation strategies

Project Approach
Data Collection

Contextual Information

- Green Line Asset Inventory
- Climate Science Review
- Historical Challenges
- Policy Context

Stakeholder Engagement

- Municipal Meetings
  - Boston
  - Brookline
  - Newton
- MBTA Meetings
  - OCE
  - MOW
  - O&M
  - Emergency Planning

Site Visits

- Riverside Yard
- Reservoir Carhouse
- Lake Street Carhouse
- Science Park Station
- North Station
- Haymarket Station
- Park Street Station
- Hynes Convention Center Station
- Kenmore Station
- Fenway Station
- Longwood Station
- Brookline Village Station
- Prudential Station
- Symphony Station
- Heath Street Station
- Fenway to Brookline Village Corridor
- Northeastern University to Longwood Medical Area Corridor
- Riverway to Heath Street Corridor

Project Parameters

5 Climate Stressors

- Extreme Heat
- Precipitation
- Sea Level Rise / Storm Surge
- Wind
- Winter Weather

2 Analysis Timeframes

- Near-term (2030)
- Long-term (2070)

196 Assets (with asset-specific critical systems)

Maintenance Yards & Facilities (3)

- Rail, ties, and roadbed surface
- Switches and switch heaters
- Maintenance equipment
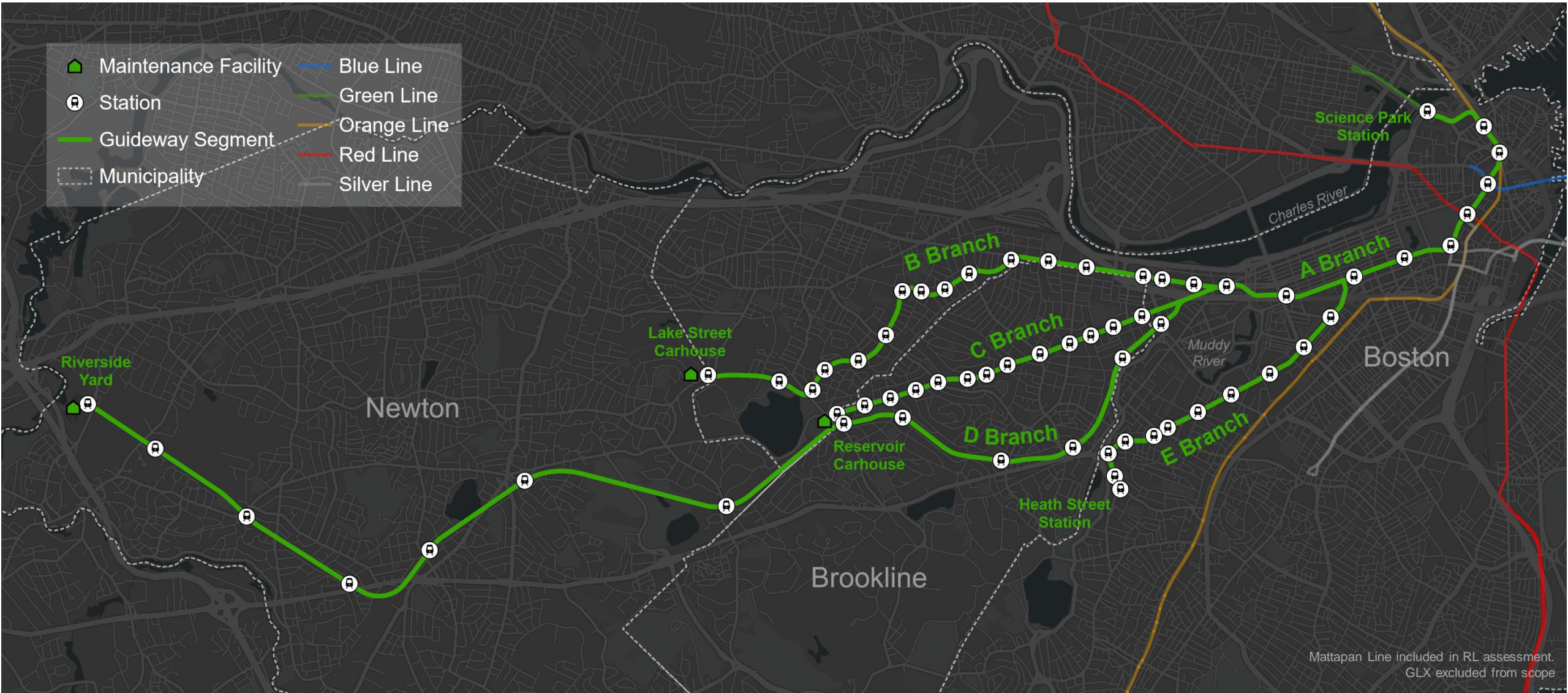- Building envelope

Stations (63)

- Transformers
- Switch gears
- Generators
- Customer site access and lobby
- Elevators and escalators

Guideway Segments (130)

- Rail, ties, and roadbed surface
- Signals, switches, and switch heaters
- Tunnel fans
- Vent shafts
- Tunnel structures and portals
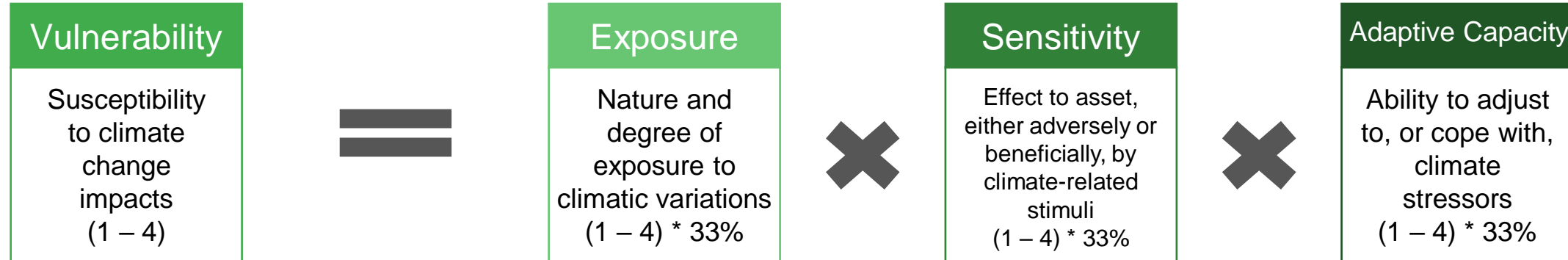- Bridge structures
- Catenary

Project Context
GL Scope of Assessment

Maintenance Facility
Station
Guideway Segment
Municipality
Blue Line
Green Line
Orange Line
Red Line
Silver Line

B Branch
A Branch
C Branch
D Branch
E Branch

Science Park Station
Lake Street Carhouse
Riverside Yard
Newton
Reservoir Carhouse
Heath Street Station
Muddy River
Boston
Brookline
Charles River

Mattapan Line included in RL assessment.
GLX excluded from scope.

METHODOLOGY OVERVIEW

Methodology Overview

Vulnerability Formula

Vulnerability		Exposure		Sensitivity		Adaptive Capacity
Susceptibility to climate change impacts (1 – 4)	**=**	Nature and degree of exposure to climatic variations (1 – 4) * 33%	**✕**	Effect to asset, either adversely or beneficially, by climate-related stimuli (1 – 4) * 33%	**✕**	Ability to adjust to, or cope with, climate stressors (1 – 4) * 33%
		What is the degree of exposure of assets to climate hazards?		**When a certain climate exposure occurs, what is the degree of impact on an asset?**		**How does the asset respond to, or cope with, climate exposure given the sensitivity of its components?**

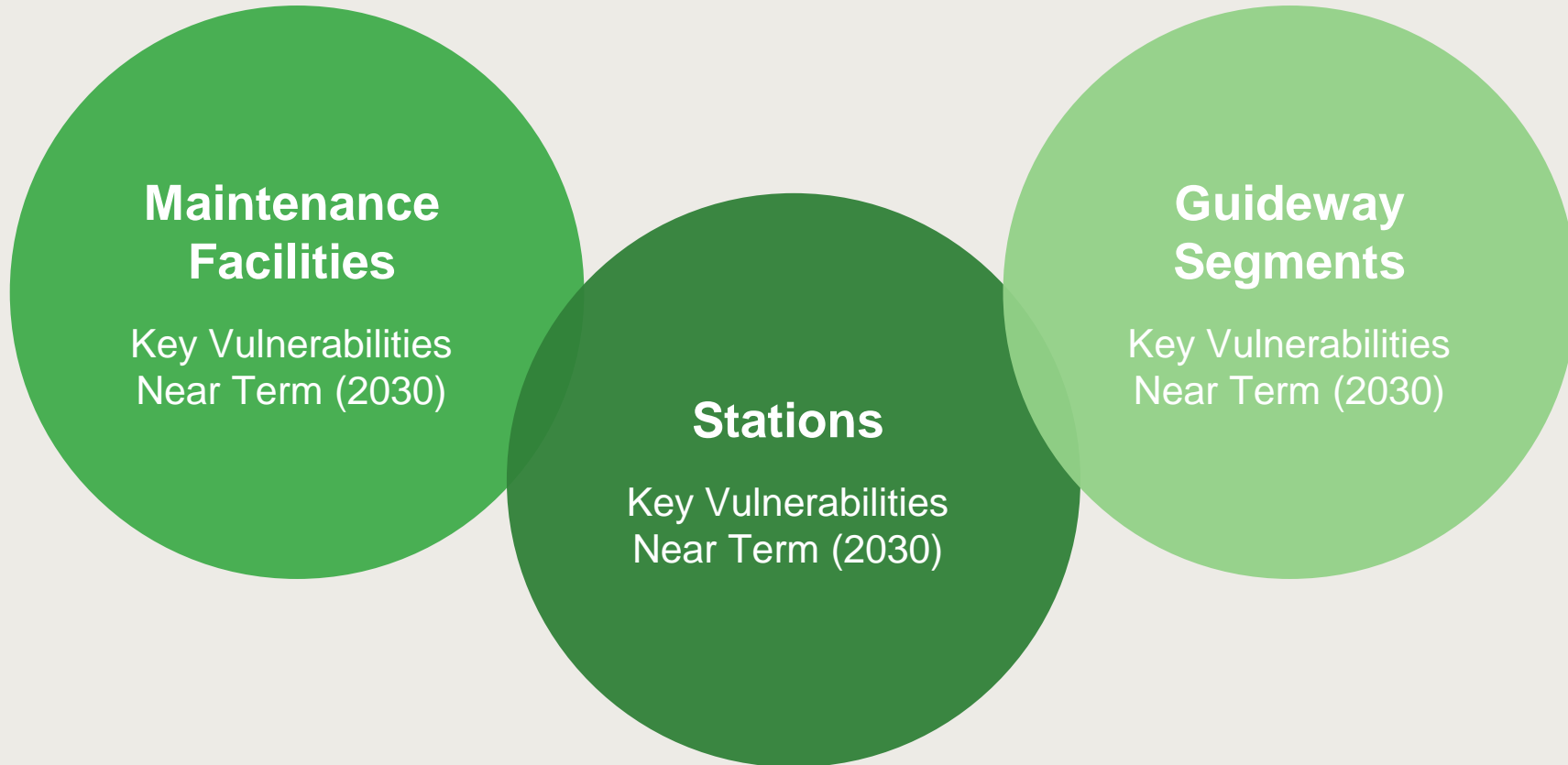# Methodology Overview

Assessment Variables and indicators

Asset Complexity	Critical Systems Sensitivity*
Past Impact / Failure*	Climate Specific Impacts*

Distance from Central Point	Redundancy
Backup Generator	Flood Protection System

Exposure
calculate for 2030 and 2070

Sensitivity
calculate for 2030 and 2070

Adaptive Capacity
same for 2030 and 2070

Asset Vulnerability
2030 and 2070
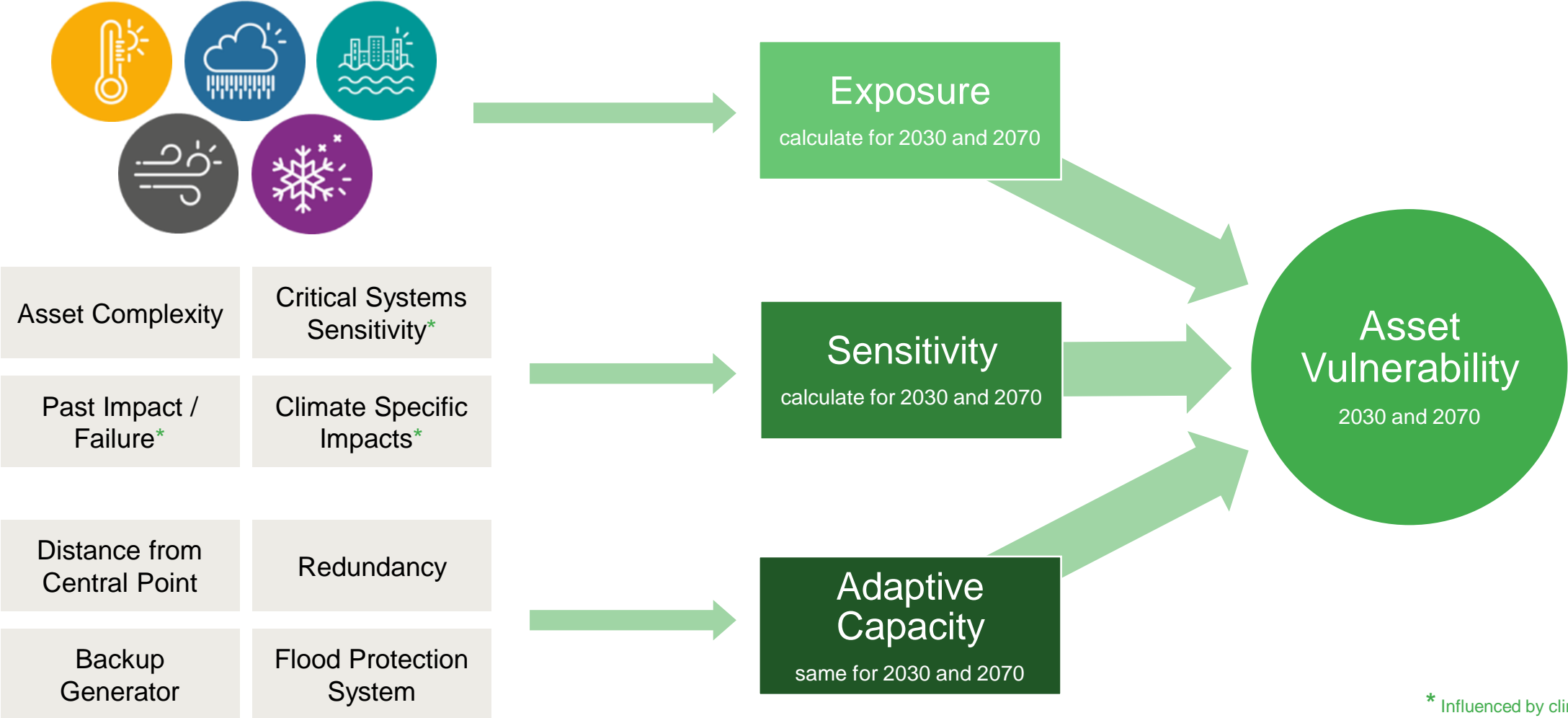
* Influenced by climate stressors

See full methodology in Appendix 3

RESULTS

Results

Maintenance Facilities

Key Vulnerabilities
Near Term (2030)

Stations

Key Vulnerabilities
Near Term (2030)

Guideway Segments

Key Vulnerabilities
Near Term (2030)

Maintenance Yards & Facilities
Composite Vulnerability 2030
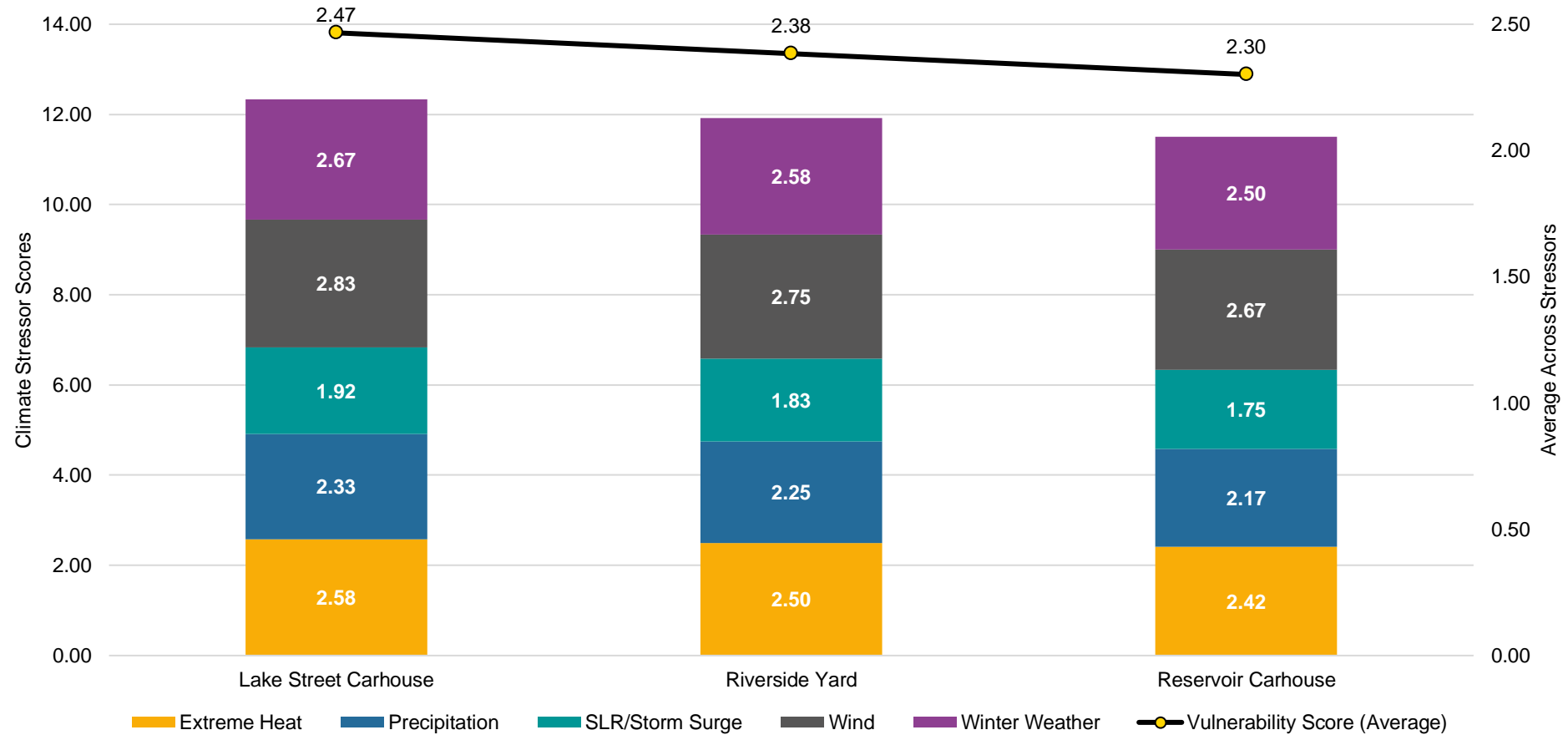
Maintenance Facilities
Key Vulnerabilities at Riverside Yard
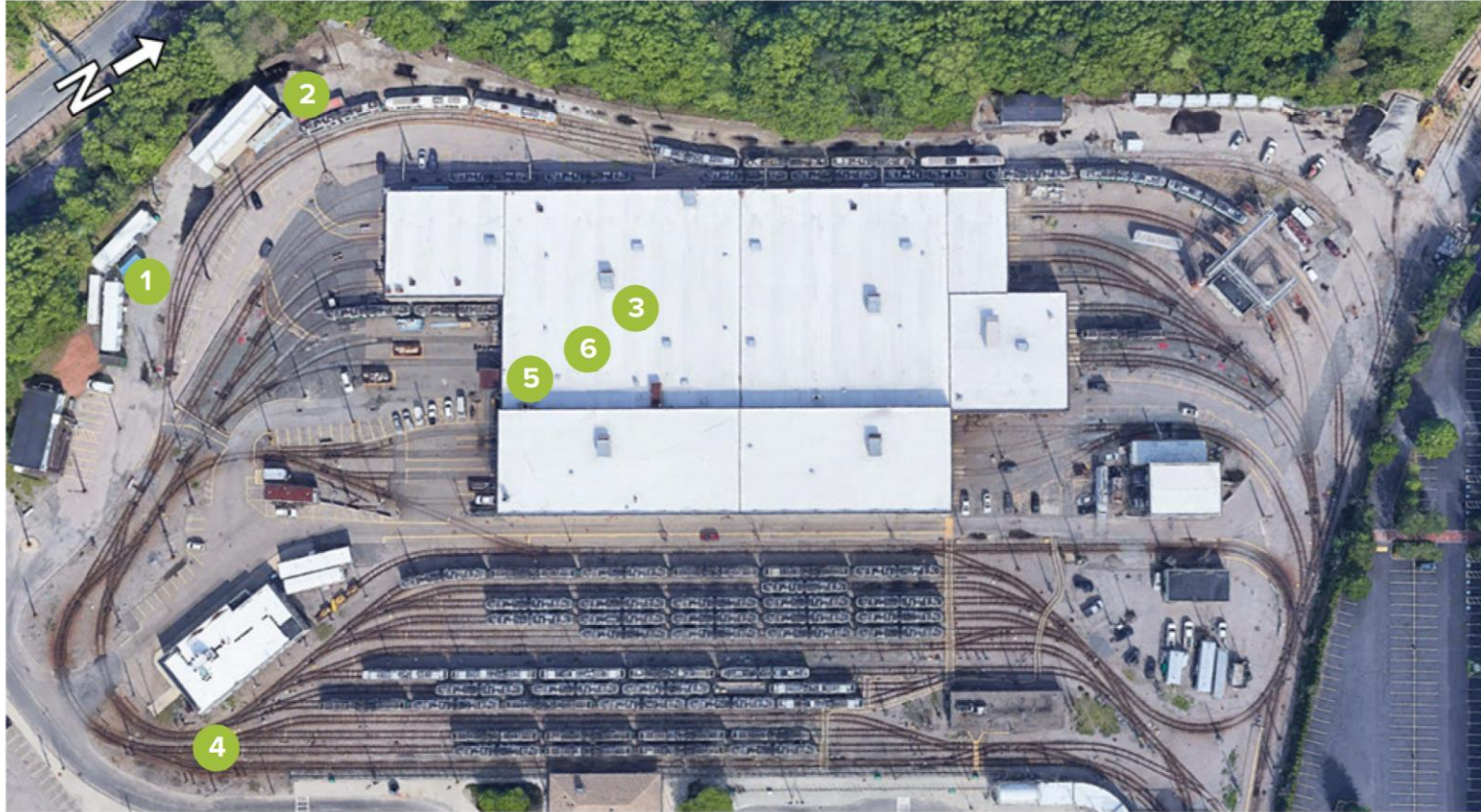
1. **Auxiliary buildings** are modular and may be susceptible to damage in severe storm events but also allow for easy replacement.

2. The west end of the yard is surrounded by **tall trees** that hang over catenary cables in some areas. Potential for impacts from extreme wind and storm events.

3. **Compressors** are prone to overheating due to constant use, leading to staff discomfort or equipment shutdown which could be exacerbated by extreme heat events.

4. **Switch heaters** are sufficient to manage gradual snowfall but may not be sufficient during severe winter storms.

5. An **emergency generator** is located in the basement and may be susceptible to flooding during extreme precipitation events.

6. **Truing machine** is located below grade in a pit and may be susceptible to flooding during extreme precipitation events which could damage machinery and impact operation.

Maintenance Facilities

Key Vulnerabilities at Lake Street Carhouse

1. **Trees** overhang catenary cables in some areas. Potential for downed branches during extreme wind or storm events which may damage catenary.

2. **Carhouse** overheats during heat waves, including **compressor room** due to constant use, which can inhibit maintenance work or lead to equipment shutdown. This may be further exacerbated by increases in extreme heat events.

3. **Trough drains** at facility entrances are undersized and have flooded in the past, introducing water into **maintenance pits**. This may be exacerbated by extreme precipitation due to climate change.

Maintenance Facilities

Key Vulnerabilities at Reservoir Carhouse

1 & 2. The upper yard is flanked by **trees** towards the main line connection, with trees hanging over walls and catenary. This may cause damage in extreme wind events.

3. Some **switches** do not have **switch heaters**, and manual snow clearance is required. This may result in additional manual labor in extreme winter weather events.
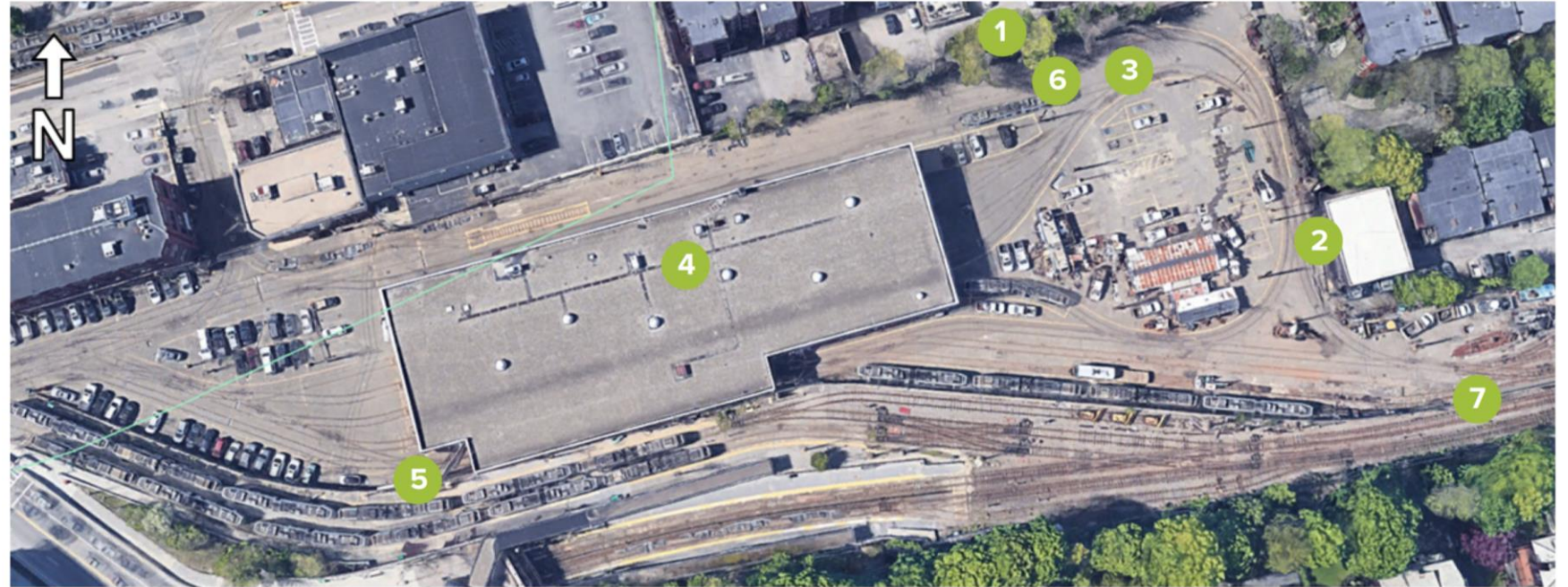
4. Facility **roof** is nearing end of life and will be replaced. When replaced, ensure roof is re-designed for future climatic conditions.

5. Clogged **weep holes** in retaining walls can lead to increased groundwater and higher hydrostatic pressure on the wall. This may be exacerbated by extreme precipitation.

6. Clogged **trench drains** resulting in a reduced drainage capacity and increased flood vulnerability under current precipitation conditions. This may be exacerbated by extreme precipitation.

7. The **ballast** throughout the yard was flooded with sand from sweeping out train cars leading to reduced permeability. This may result in flooding with increased precipitation.

Stations Results

Composite Vulnerability 2030

Stations Results
Composite Vulnerability 2030 – Top 5 Most Vulnerable
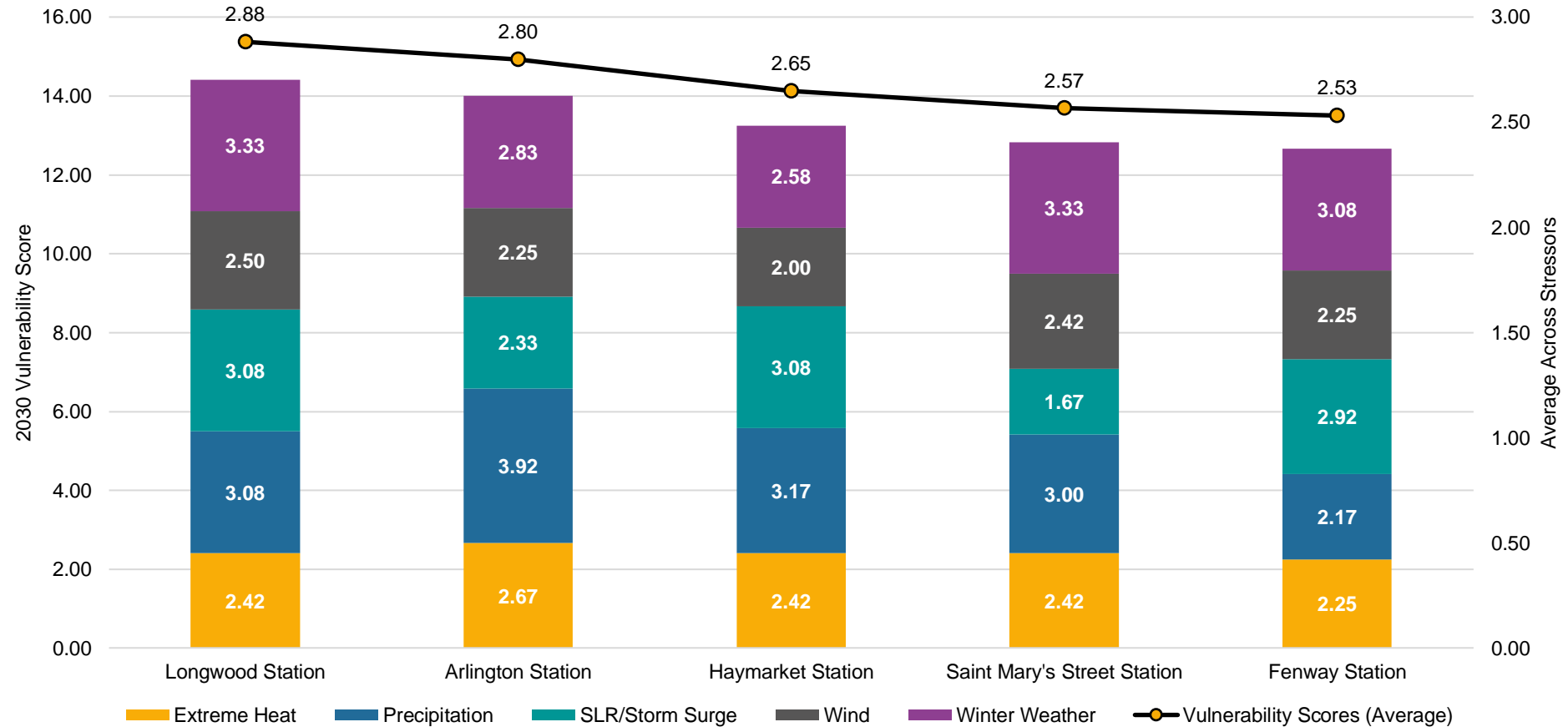
Stations

Key Vulnerabilities 2030

1 Longwood Station
Score: 2.88

High exposure to precipitation, SLR/storm surge and winter weather

Moderate sensitivity as station is not enclosed and has experienced major winter weather impacts

Low adaptive capacity as station is not redundant, has no backup generator and no flood protection system

Muddy River is in close proximity

2 Arlington Station
Score: 2.80

High exposure to precipitation

High sensitivity as station has many critical systems, has experienced extreme heat, precipitation and winter weather impacts, and is below ground

Low adaptive capacity as station is far from Riverside, is not redundant, has no backup generator, and no flood protection system

Current issues with water ingress in adjacent tunnel

3 Haymarket Station
Score: 2.65

Moderate exposure to precipitation and SLR/storm surge

High sensitivity as station has many critical systems, has experienced extreme heat, precipitation and winter weather impacts, and is below ground

Low adaptive capacity as station is far from Riverside, has no backup generator and no flood protection system

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Legend:

High Vulnerability: > 3 — High Vulnerability — 🌡 Extreme Heat

Increased Vulnerability: 2.5 - 3 — Increased Vulnerability — Precipitation

Moderate Vulnerability: 2 - 2.5 — Moderate Vulnerability — SLR / Storm Surge

Reduced Vulnerability: < 2 — Reduced Vulnerability — Wind

Winter Weather

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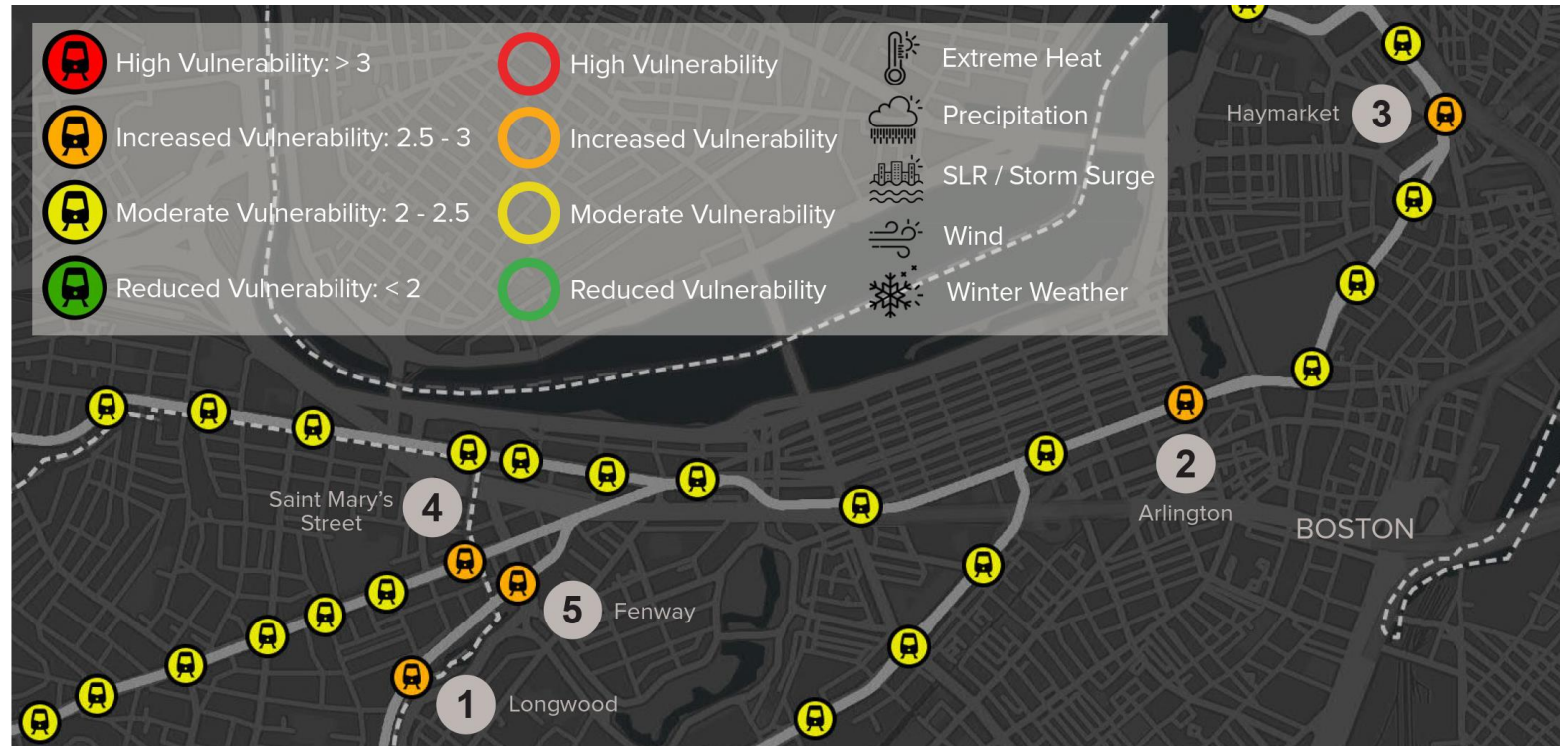
4 Saint Mary's Street Station
Score: 2.57

High exposure to precipitation and winter weather

Low sensitivity as station has no critical systems though it is not enclosed and has experienced major winter weather impacts

Low adaptive capacity as station is not redundant, has no backup generator and no flood protection system
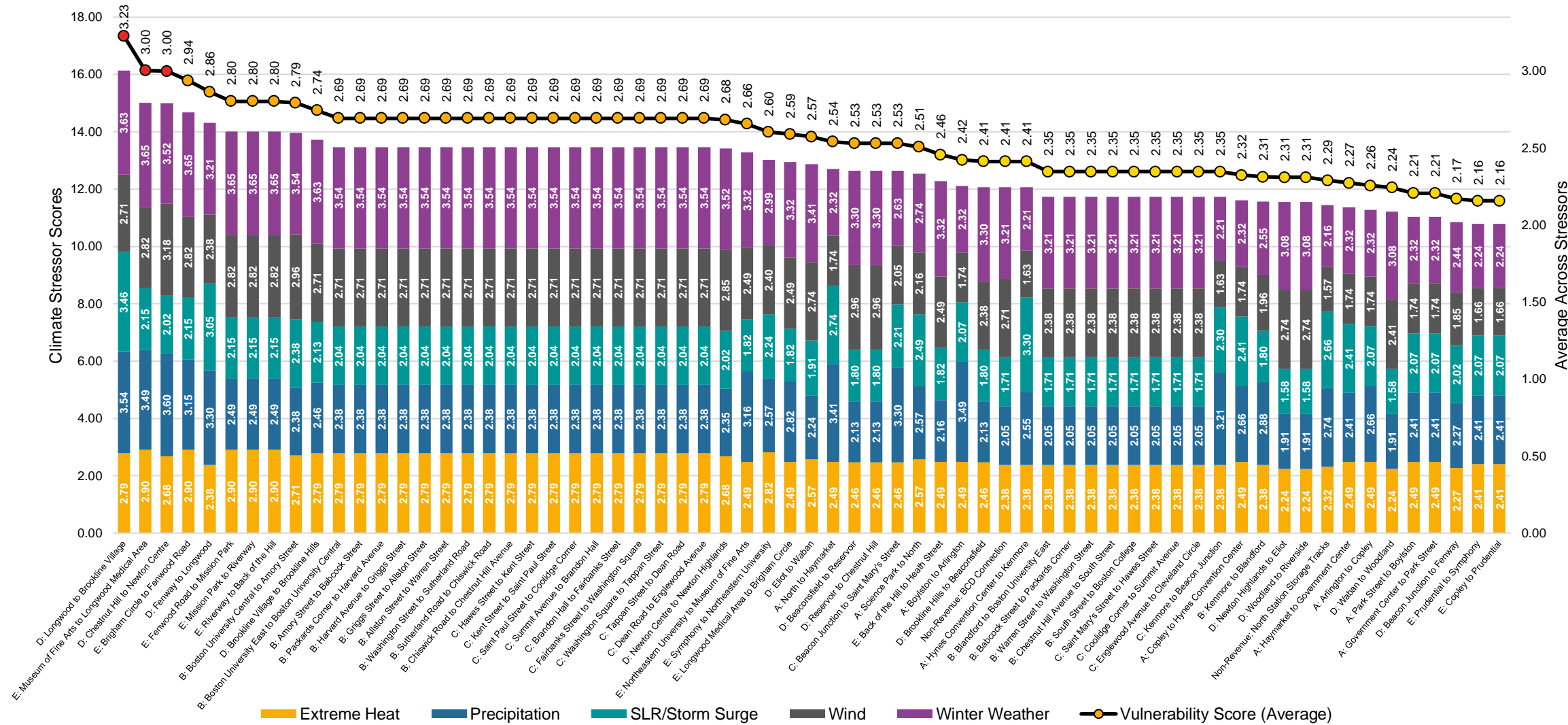
5 Fenway Station
Score: 2.53

High exposure to SLR/storm surge and winter weather

Moderate sensitivity as station is not enclosed and has experienced major precipitation and winter weather impacts

Moderate adaptive capacity as station offers redundancy and has a deployable flood protection system
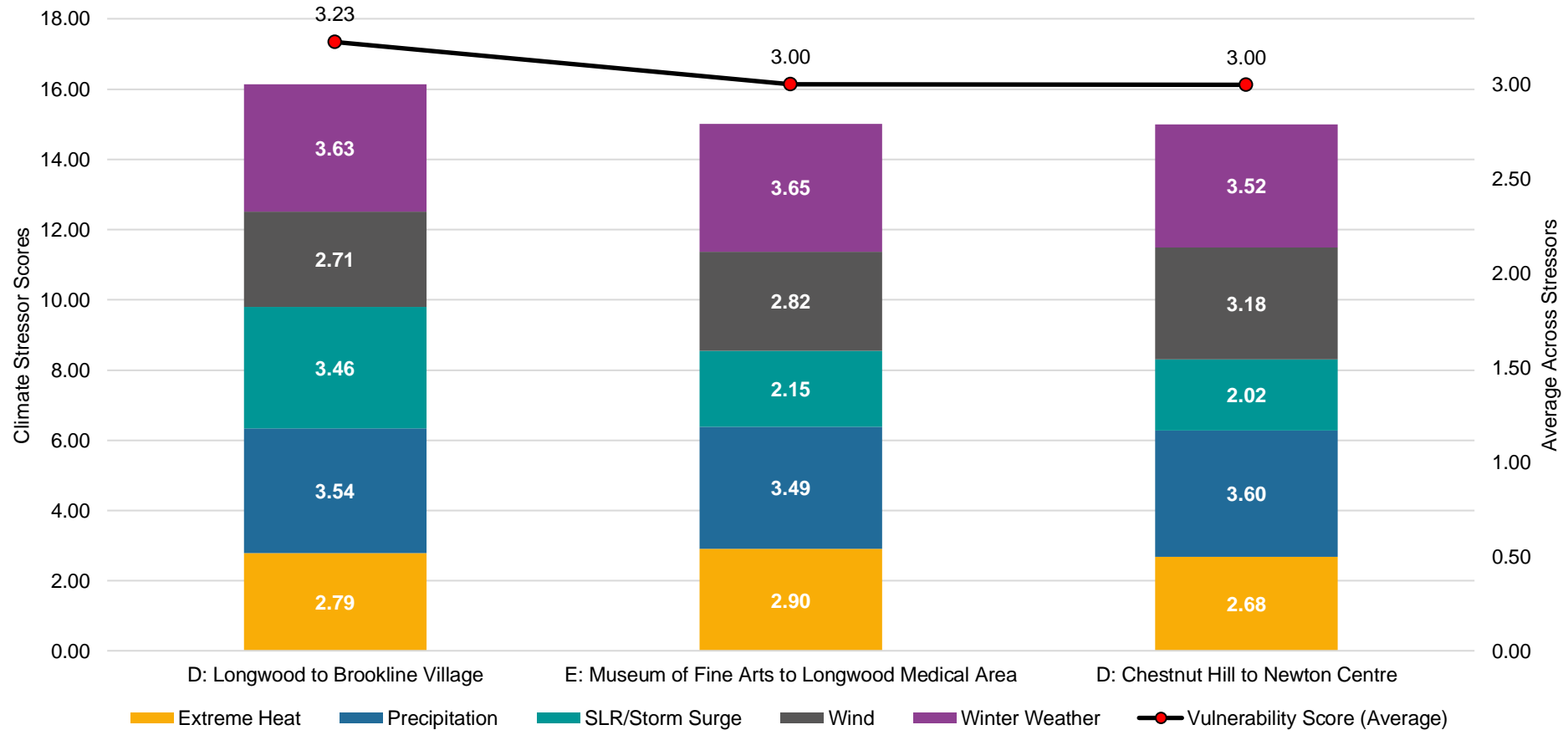
Muddy River is in close proximity

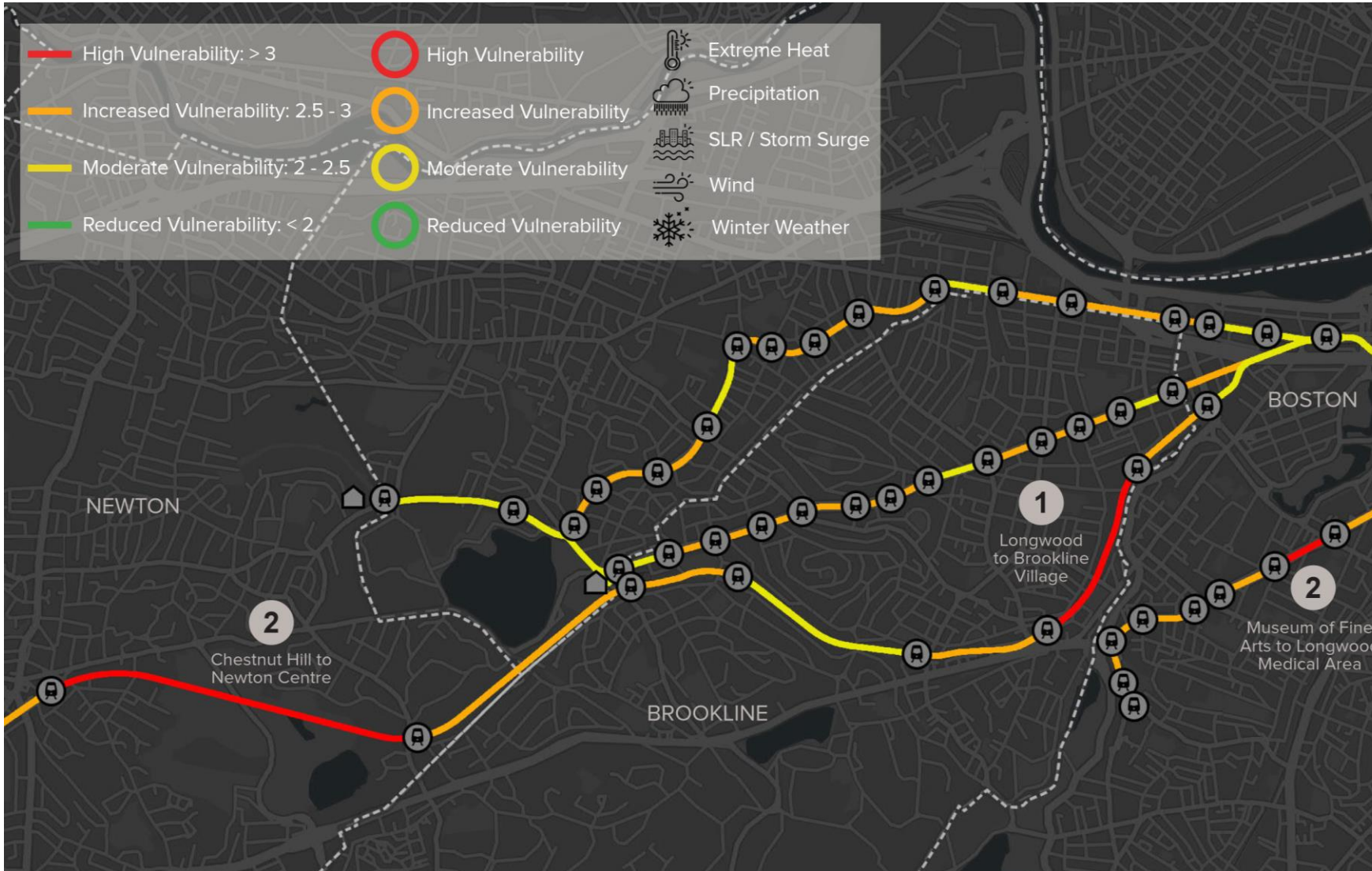# Guideway Segments
Composite Vulnerability 2030

Guideway Segments
Composite Vulnerability 2030 – Top 3 Most Vulnerable

	D: Longwood to Brookline Village	E: Museum of Fine Arts to Longwood Medical Area	D: Chestnut Hill to Newton Centre
Vulnerability Score (Average)	3.23	3.00	3.00
Winter Weather	3.63	3.65	3.52
Wind	2.71	2.82	3.18
SLR/Storm Surge	3.46	2.15	2.02
Precipitation	3.54	3.49	3.60
Extreme Heat	2.79	2.90	2.68

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Guideway Segments

Key Vulnerabilities 2030

1 Longwood to Brookline Village Guideway Segment
Score: 3.23

High exposure to precipitation, SLR/storm surge and winter weather

High sensitivity as segment has several critical systems, has experienced precipitation and winter weather impacts, and is not enclosed

Moderate adaptive capacity as segment is not redundant and has no flood protection system

Muddy River is in close proximity

2 Chestnut Hill to Newton Centre Guideway Segment
Score: 3.00

High exposure to precipitation and winter weather

High sensitivity as segment has several critical systems, has experienced precipitation, wind and winter weather impacts, and is not enclosed

Moderate adaptive capacity as segment is not redundant and has no flood protection system

Passes through FEMA floodplain

Previous major track washout

2 Museum of Fine Arts to Longwood Medical Area Guideway Segment
Score: 3.00

High exposure to precipitation and winter weather

Moderate sensitivity as segment has experienced major winter weather impacts and is not enclosed

Low adaptive capacity as segment is far from Riverside, not redundant and has no flood protection system

Proximal to the Muddy River

Key Findings

Recommendations

Recommended Adaptation Measures

Generic Recommendations

Policy

Design & Infrastructure

Operations & Maintenance

Asset-Specific Recommendations

Maintenance Facilities

Stations

Guideway Segments

Recommended Adaptation Measures

Sample Matrix of Recommended Actions

How many **climate stressors** are relevant	What is the relative **impact** on resilience	How much **effort** is required to implement	How **critical** is the issue being addressed	How much **time** will it take to implement and take effect

Action	Description	Extreme Heat	Precipitation	SLR/Storm Surge	Wind	Winter Weather	Impact	Effort	Criticality	Time Frame
P 1	Continue to improve integration of climate risk into agency emergency response plans and policies	•	•	•	•	•	Medium	Medium	Low	Long
P 2	Undertake continued coordination across departments at MBTA and with municipalities on adaptation actions	•	•	•	•	•	Medium	High	Low	Medium
P 3	Consider mechanisms for keeping vulnerability scoring up to date with the latest climate science	•	•	•	•	•	Medium	Low	Low	Long
D 1	Undertake detailed flood risk and drainage system assessments for underground stations and tunnels		•	•			High	High	Medium	Short
D 2	Undertake detailed extreme heat risk assessments for underground stations and tunnels	•					Medium	High	Medium	Short

Recommended Adaptation Measures

Maintenance Facility: Reservoir Carhouse

1 Site-wide drainage study
- Drainage assessment
- Clear drainage obstructions
- Increase capacity
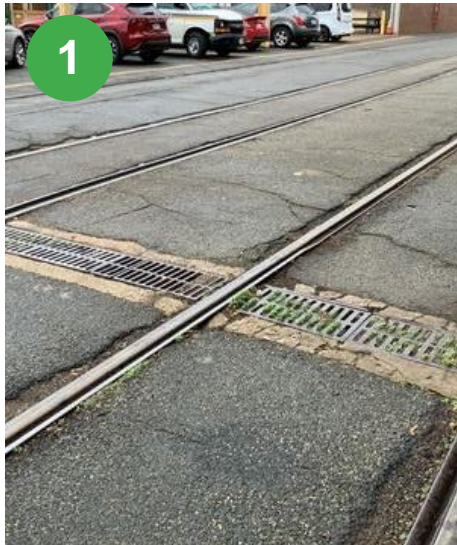
2 Maintenance pit flood mitigation
- Clear trough drains
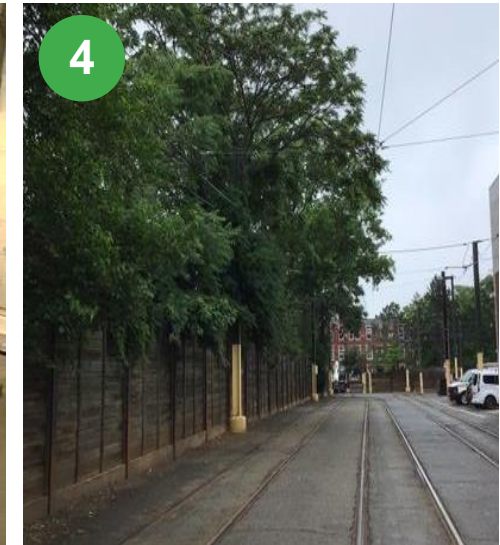- Assess capacity and discharge point
- Install pit drainage

3 Indoor heat management
- Ventilation assessment
- Install ventilation or cooling systems

4 Tree management
- Clear overhanging branches
- Pre- and post-climatic event inspections

5 Roof replacement
- Designed for future climatic conditions

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Recommended Adaptation Measures

Station: Hynes Convention Center

1. Extreme heat risk assessment
- Heat assessment
- Improve back-of-house ventilation and cooling systems

2. Improve thermal comfort
- Install front-of-house ventilation and cooling systems
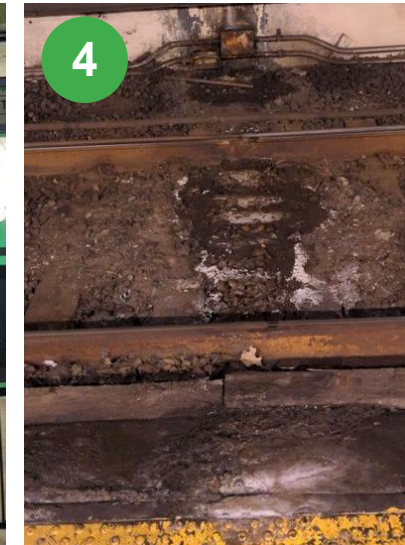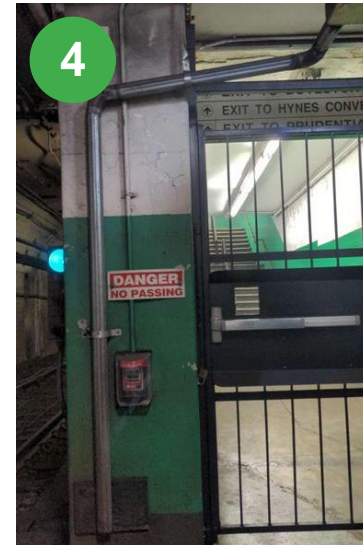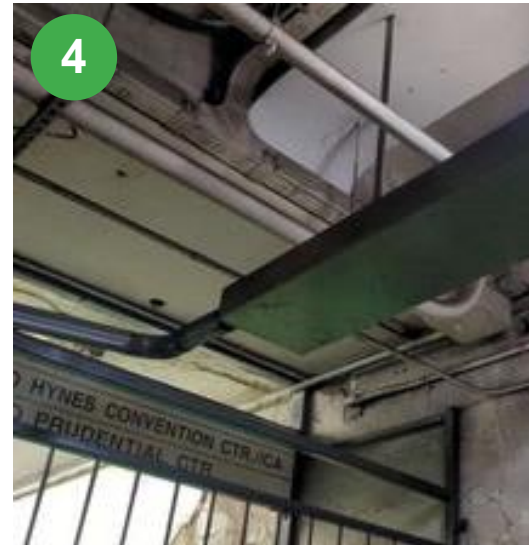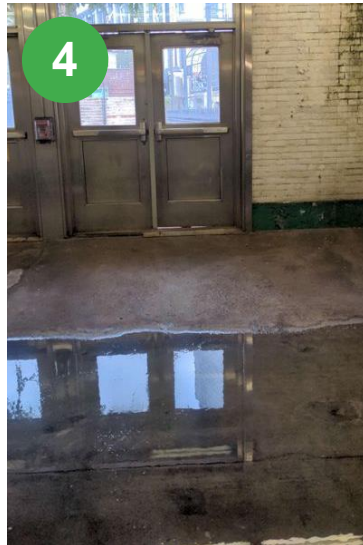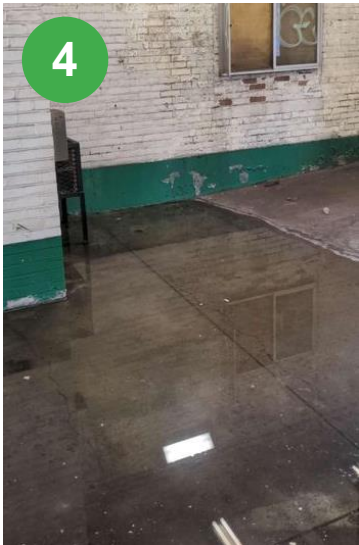
3. Assess back-up power system
- Confirm presence
- Test performance

4. Drainage assessment
- Identify points of water ingress
- Clear drainage obstructions
- Increase capacity

5. Relocate electrical equipment
- Elevate and/or enclose

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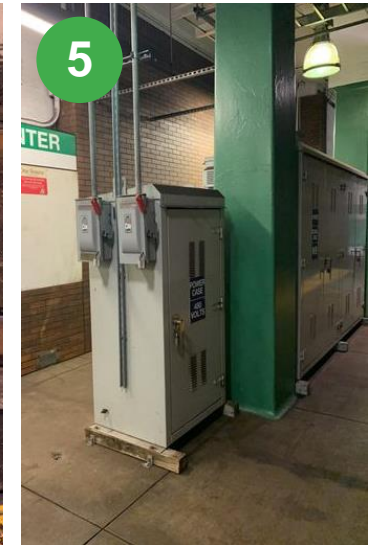
Recommended Adaptation Measures

Guideway Segment: Boylston to Arlington

1 **Extreme heat risk assessment**

- Heat assessment
- Improve ventilation

2 **Locate tunnel vents**

- Identify points of water ingress
- Raise vent discharge points at surface

3 **Segment-wide drainage study**

- Route cause of active water ingress

4 **Floodwater pumping**

- Install drainage/pump to remove water

Next steps

1 Integrate vulnerability scores into TRAPEZE asset management system

2 Conduct detailed assessments of assets with vulnerability scores > 2.5 in the 2030 and 2070 time horizons

3 Implement recommended adaptation measures to address assets vulnerable in the near term

4 Integrate climate change considerations into capital planning via the Capital Investment Plan

Thank you

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