

Creating a more resilient Sound Transit
Climate change adaptation overview

10/12/22



Climate change is breaking news



Seattle sees hottest day on record, and worst is yet to come

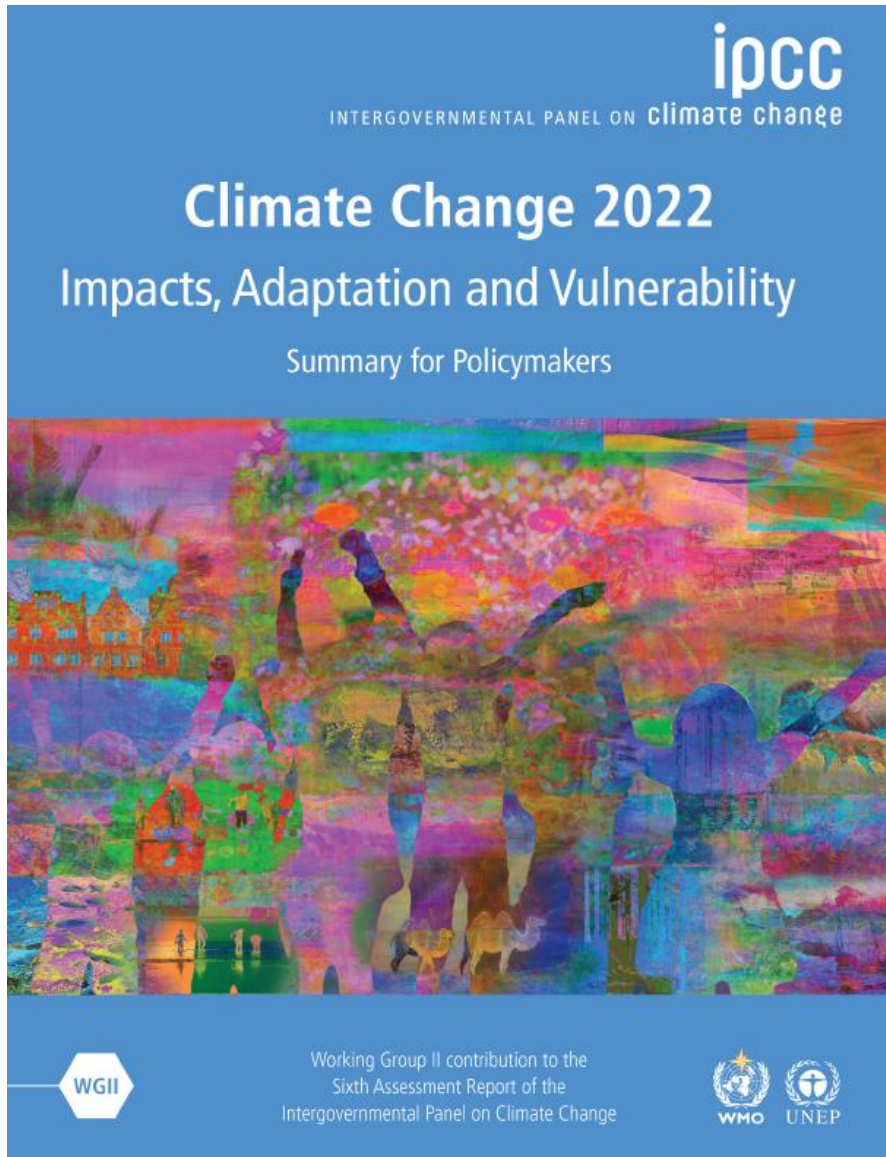
Heat wave serves WA a lesson in climate adaptation, mitigation

“Washington state was not built for triple digit temperatures,”

Hospitals taxed by heat-related illnesses

Seattle and Portland are sizzling in hottest weather of the summer

In both cities, this Pacific Northwest heat wave could reach a historically long duration



Scientific consensus

- Climate impacts are already **more widespread** and severe than expected
- **Risks will escalate quickly** with higher temperatures, often causing irreversible impacts of climate change
- **Inequity, conflict and development challenges heighten vulnerability** to climate risks
- **Adaptation is crucial.** Feasible solutions already exist, but more support must reach vulnerable communities

“Code red for humanity”

UN Secretary-General Guterres

[World Resources Institute](https://www.wri.org/)

2022 – so far

Likely Ranking for 2022, globally (NOAA)

- < 1.0% chance of warmest year
- 11.0% chance of a top 5 year
- >99.0% chance of a top 10 year
- 95% confidence interval of 4th to 8th warmest year on record
- January-June surface temperature is 6th warmest on record

2022 - 9 U.S. weather disasters which have exceeded \$1billion (January-June) – (NOAA)

Heatwaves, flooding events (Kentucky and elsewhere), winter wildfires in Texas, spring wildfires in the SW, summer wildfires in CA and PNW

- Widespread heatwaves, including the one we just experienced here in the PNW
- For the January-June 6-month period, the 2022 disaster count ranks the fifth highest \$ (after 2017, 2020, 2011, and 2021).

“

Puget Sound Climate Impacts

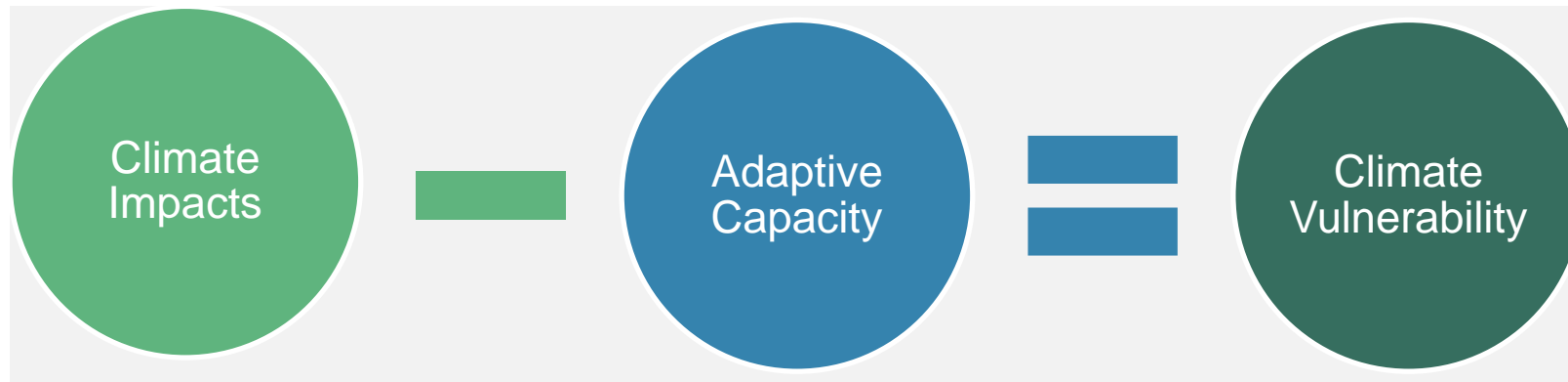
- Substantial warming across the Northwest; expected to continue
- Wetter winters, drier summers; natural variability may dominate trends
- Increases in heavy rainfall; more extreme heat, rain events likely
- Reduced snowpack, increased winter flood risk
- Higher sea level, increasing tidal and storm surge reach



Climate adaptation and resilience

Response to climate change must include **mitigation** (reducing greenhouse gas levels) and **adaptation** (reducing the vulnerability of human and natural systems to climate impacts) - *FTA, 2021*

Climate **resilience** is successfully coping with and managing climate change and understanding our **adaptive capacity**



Climate Change Risk Reduction Project



Sound Transit
Climate Risk Reduction Project

SEPTEMBER 2013

FTA Report No. 0075
Federal Transit Administration

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Key findings remain relevant

- Climate change exacerbates existing issues.
- Many climate change impacts will likely be minor to moderate, although significant impacts are possible
- Sound Transit already possesses some degree of climate resilience and adaptive capacity
- The probability, timing, and degree of climate change impacts depends on many factors

Potential Climate Impacts to ST

Related to Temperature <i>Increased potential for...</i>	Related to Precipitation <i>Increased potential for...</i>	Related to Sea Level Rise <i>Increased potential for...</i>
<ul style="list-style-type: none"> • Rail buckling • Heat stress on electrical and safety equipment • Heat stress on overhead catenary system • Heat stress on pavement, structures • Heat stress on landscaping and environmental mitigation sites 	<ul style="list-style-type: none"> • Mudslides and slope instability • Larger and/or more frequent river and stream flooding • Increased localized flooding due to more stormwater runoff or poor drainage • Seepage due to higher groundwater tables • Summer drought 	<ul style="list-style-type: none"> • Temporary flooding of low-lying areas • Permanent inundation of low-lying areas • Higher tidal and storm surge reach • Erosion • Drainage problems • Corrosion from more frequent or prolonged exposure to saltwater

Table ES-3 Projected Climate Change Impacts by Degree of Potential Impact and Estimated Probability *

Estimated Impact on Operations and Infrastructure	<i>Significant</i>	<ul style="list-style-type: none"> • Inundation of Mukilteo and Edmonds Sounder facilities (possible only with sea level rise of 50 inches or more, which is currently at high end of projections for 2100) 	<ul style="list-style-type: none"> • Increased mudslide activity causing more than 70 train cancellations in a season (Sounder) 	<p><i>SUMMARY FROM 2013 FTA REPORT</i></p>
	<i>Moderate</i>	<ul style="list-style-type: none"> • Increased major flooding in both rain-dominant and rain/snow mix rivers • Potential for rail buckling 	<ul style="list-style-type: none"> • Increased mudslide activity causing 33–70 train cancellations in a season (Sounder) • Increased localized flooding due to more stormwater runoff or poor drainage (previously unaffected areas) • Increased storm surge reach, higher high tides, and more temporary flooding related to moderate amounts of sea level rise (e.g., in range of 22 inches, near the mean value for 2100) 	<ul style="list-style-type: none"> • Increased localized flooding due to more stormwater runoff or poor drainage (where already an issue) • Increased storm surge reach, higher high tides, and more temporary flooding related to lower amounts of sea level rise (less than 22 inches)
	<i>Minor</i>	<ul style="list-style-type: none"> • Heat stress on: <ul style="list-style-type: none"> ▪ auto-tension overhead catenary system (OCS) (Link) ▪ air-conditioned electrical equipment ▪ environmental mitigation projects (established wetland sites) 	<ul style="list-style-type: none"> • Heat stress on: <ul style="list-style-type: none"> ▪ facility landscaping (established sites) ▪ environmental mitigation projects (pre-established wetland sites) • Increased minor to moderate flooding in rain-dominant rivers and streams • Increased groundwater seepage into tunnels 	<ul style="list-style-type: none"> • Heat stress on: <ul style="list-style-type: none"> ▪ facility structures ▪ non-tunnel fixed termination OCS (Link) ▪ natural ventilated electrical equipment ▪ facility landscaping (during establishment) • Increased minor to moderate flooding in rain/snow mix rivers • Increased mudslide activity causing less than 33 train cancellations in a season (Sounder)
		<i>Low</i>	<i>Medium</i>	<i>High</i>

Estimated Probability of Climate Change Impacts

Climate adaptation efforts to date

2013
Climate Risk
Reduction
Project

- Climate vulnerability assessment
- 70+ potential adaptation options

2014 – 2015
Prioritization

- Memo with 49 sorted adaptation options
- Resilience targets and metrics

2016 – 17
Climate
Adaptation
Strategy

- Overarching goals
- Near- and long-term actions

2017 – Today
Implementation

Research and collaboration support for short-term actions

Climate Adaptation Strategy – Actions

Operations	
Include extreme weather event information in asset management systems and tracking.	2016
Incorporate projected climate change impacts into the Continuity of Operations and Emergency Management plans.	2016
Continue collaborating with other agencies to monitor, model, and address changing landslide risks.	Ongoing
Raise staff awareness of FTA Climate Risk Reduction Project findings.	2016-2017
Inter-Departmental and Jurisdictional Coordination	
Raise staff awareness of FTA Climate Risk Reduction Project findings.	2016-2017
Engage in conversations with other jurisdictions and agencies regarding climate change adaptation planning and best practices.	2016 and Ongoing
Approve the proposed process for design team application of the Sustainability Checklist at 30% design.	2016
Explore funding opportunities with local partners.	Ongoing



Current implementation

- Require Climate Vulnerability Analysis for all major capital projects
- Developing resources:
 - 2021 Puget Sound Climate Change Impacts overview (UW)
 - GIS layers mapping flooding and sea level rise
 - Develop Adaptation Vulnerability Assessment Guidance
- Assessing success of Adaptation Strategy

Climate Impacts & Affected Elements

Table 1-1. Summary of Climate Change Impacts and Potentially Affected Systems

Sound Transit System	Extreme Heat	Sea Level Rise	Rain/ Storms	Hydrology Changes	Mudslides/ Landslides
Rail/Track	●	●	●	●	●
Overhead Catenary System	●		●		
Other Electrical Equipment	●	●	●	●	
Tunnels		●	●	●	
Bridges	●	●	●	●	
Rail Service Operations	●	●	●	●	●

Sustainability Workgroup Process

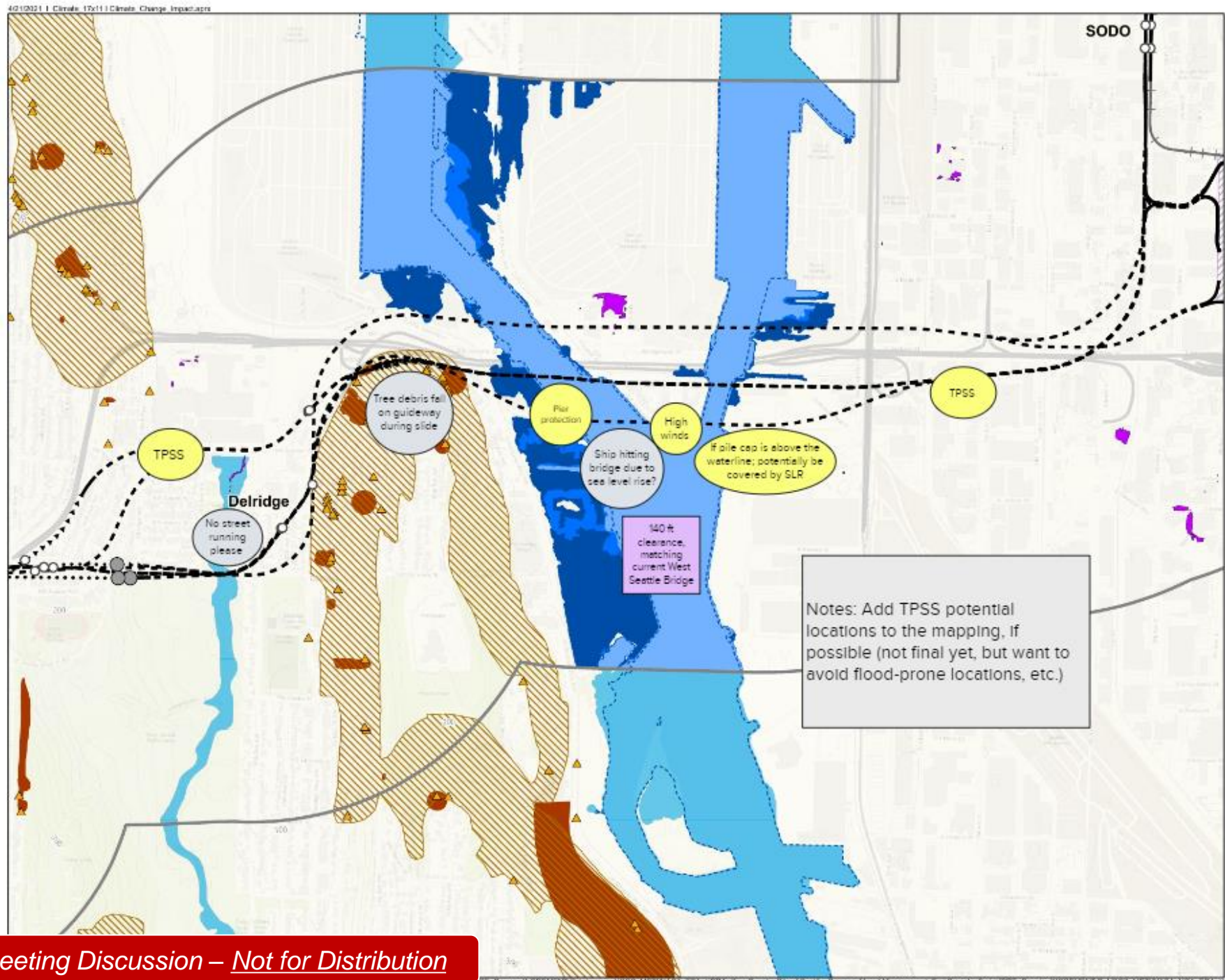
Climate Change Vulnerability Analysis workshops:

- ***Climate impacts of concern (3/26/2021)***
- ***Site-specific climate impacts – mapping (4/21/2021)***
- ***Climate adaptation considerations (5/19/2021)***
- ***Climate vulnerability ratings (6/30/2021)***

WSBLE Impacts Mapping

Sample Section

4/21/2021
meeting



Climate Change Impacts in Duwamish Crossing

West Seattle and Ballard Link Extensions

- Alternatives**
 - Elevated
 - Tunnel
 - At-Grade
 - Retained Cut
- Station**
 - Proposed
 - Tunnel Entrance/Exit
 - Existing Link Light Rail
 - Sound Transit Operations and Maintenance Facility (ST OMF)
- Flood-prone Areas**
 - 2 Feet Sea Level Rise
 - 3 Feet Sea Level Rise
 - 5 Feet Sea Level Rise
 - Additional Flood-prone Areas
- Other**
 - Centerline Half Mile Buffer
 - FEMA 100 year floodplain
 - FEMA 500 year floodplain
 - Shoreline
 - 20 ft Contour
 - Known Landslide
 - Known Landslide Area
 - Potential Landslide Area



Climate Adaptation for WSBLE

Three primary climate adaptation levers:

- **Siting and location**
- **Design**
- **Operations**

WSBLE Adaptive Capacity

Interactive whiteboard example

5/19/2021 meeting

Sound Transit Infrastructure/ System	Climate Impacts	Adaptive Capacity Considerations			Draft Vulnerability Ranking
		Siting / Location	Design	Operations	
Rail/Track	Extreme heat impacts on: 5 * Rail buckling * Fatigue cracking * Pavement rutting * Switch failures	- less impact in tunnels - where is most likely location to have rail buckling? - where to put sensors for monitoring - mapping of current urban heat island effects to identify potential trouble spots	Shading? * Install sensors to detect high track temperatures - rail expansion joints to relieve heat stress - design criteria for design temperature range - is the current DCM conservative enough? - canopy usually only provided as required by code (expensive and hard to maintain) - (shading usually only provided during construction to aid concrete curing) - are there examples?	* Run garden hose to cool switches during hot hours or days of heat. * Slow rail traffic during heat. * Increase visual monitoring of tracks and issue heat advisories	Low Policies re: forecasts of rain, windspeed, hi/low temperatures - East Link brings new potential flooding areas Policies related to temperature, wind speed and rainfall forecasts for when to begin monitoring rail buckling, etc. Extremes in the future will change thresholds, but systems are in place.
	SLR + Heavy Rains + Hydrological Impacts: 4 * Flooding and corrosion of infrastructure & damage to rail corridors	* Ensure top rail elevation is above 500-yr floodplain and 3 ft above 100-year floodplain levels. - Locate TPSS and other sensitive equipment above/away from floodprone areas	* Partner with other jurisdictions on design standards and planning. Floodgate at tunnel portal? Pumps in tunnel? Size the drain on elevated structure accordingly design not following specs (both design and construction issue, not always at lowest point - complex geometry) - overflow from guideway onto roadways below - needs careful coordination if design & construction re: drainage TCO analysis - South OMF on Midway Landfill siting - considered costs, operations, customer experience, probability and impacts of events, how much it costs to address, cost of response Elevating "housekeeping pad" high to avoid flooding impacts DRE example - stormwater piping in trackbed (elevated may have been preferable)	* Increase visual monitoring of riverbanks and bridge supports. * Maintain infrastructure and equipment with drainage problems * Raise/relocate ground-level and underground equipment. (6/16) Retrofits are capital projects - not part of Operations. Goal is to avoid needing to do that if possible.)	Medium
	Mud/landslides: 3 * Damage to rail infrastructure (e.g., Pigeon Point, Queen Anne)	- Haven't experienced recent slides in project area (vs. Sounder, for example) - also making slope improvements as part of the project - tunnel portals mostly located from slide-prone areas - some at-grade options in West Seattle/Pigeon Pt under consideration - Explore different siting options	* Adopt seismic standards for construction to prepare for erosion impacts and lateral forces. (How does that relate? may need to be modified or expanded) - less impact on elevated structures; need to design column for sufficient lateral impact - biggest impact on retained cut slopes - on track, derailment	Install CCTV around Pigeon Point and Queen Anne to monitor that there is no mud on the rail. Example: Sounder operations, USGS program, monitoring of slope conditions and environmental events	Low

ex. Northgate station design - some elements up so high, need special equipment to reach/maintain

Climate Vulnerability Ratings

Climate Impacts	Adaptive Capacity	Vulnerability
Lower impact	High capacity	Lower vulnerability
Moderate impact	Moderate capacity	Moderate vulnerability
Higher impact	Low capacity	Higher vulnerability

WSBLE Project Elements & Effects	Impacts	Adaptive Capacity	Vulnerability
Bridges and Elevated Structures			
Extreme heat and air pollution	Moderate	Moderate	Low
Flooding	Minor	High	Low
Extreme events and winter storms	Minor	Moderate	Low
Rail Service Operations (<i>cross-cutting</i>)			
Extreme heat	Minor	Moderate	Low
Flooding	Moderate	Limited	Moderate
Mudslides and landslides	Minor	Moderate	Low
Customer Experience (<i>cross-cutting</i>)			
Heavy rains and storms	Moderate	Moderate	Low
Flooding	Moderate	Moderate	Low
Construction (<i>cross-cutting</i>)			
Extreme Heat	Minor	Moderate	Low
Flooding	Moderate	Moderate	Low

DRAFT

- **Low vulnerability** generally means a sufficient ability to adapt to or lessen most, or all, of a climate impact.
- **Moderate or high vulnerability** generally means an insufficient ability to adapt to or lessen a climate impact.
- The vulnerability ratings are **mutually exclusive**. Cumulative or cascading impacts can worsen the impacts.

Capital Projects Vulnerability Analyses

Key findings:

- Localized flooding and increasing heat stress across system
- Cost effective engineering solutions can mitigate vulnerabilities

Next Steps

- Integrate findings into project/agency engineering standards
- Ensure analyses inform planning, design and construction

Next Steps



- Finalize Climate Vulnerability Analysis Guidelines
- Update Sound Transit Climate Adaptation Strategy (2023 – 2025)
- Participate in development of APTA's Planning and Design Standards for Climate Adaptation (2022 – 2024)
- Participate in regional collaboratives:
 - Puget Sound Climate Preparedness Collaborative
 - PSRC Vision 2050

Thank you.



 soundtransit.org/wsblink

