

Climate Change and Cleanup

Vulnerability Assessment and Adaptation Strategy for Washington's Contaminated Sites

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Bioremediation Symposium

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Today's Presentation

- **What**
Pacific Northwest science
- **Why**
Need for an adaptation strategy
- **How**
Adaptation guidance

Washington

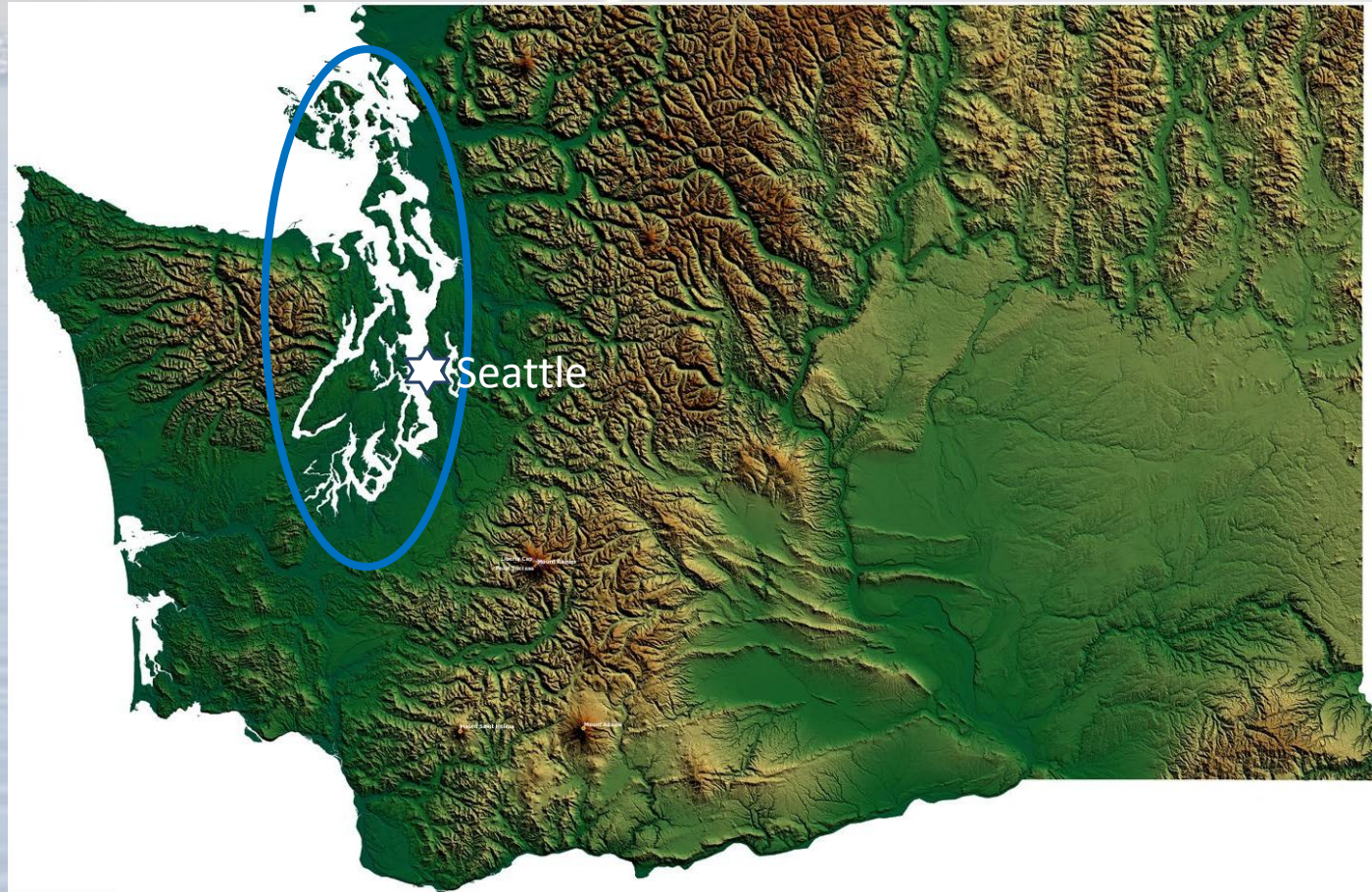
The Evergreen State



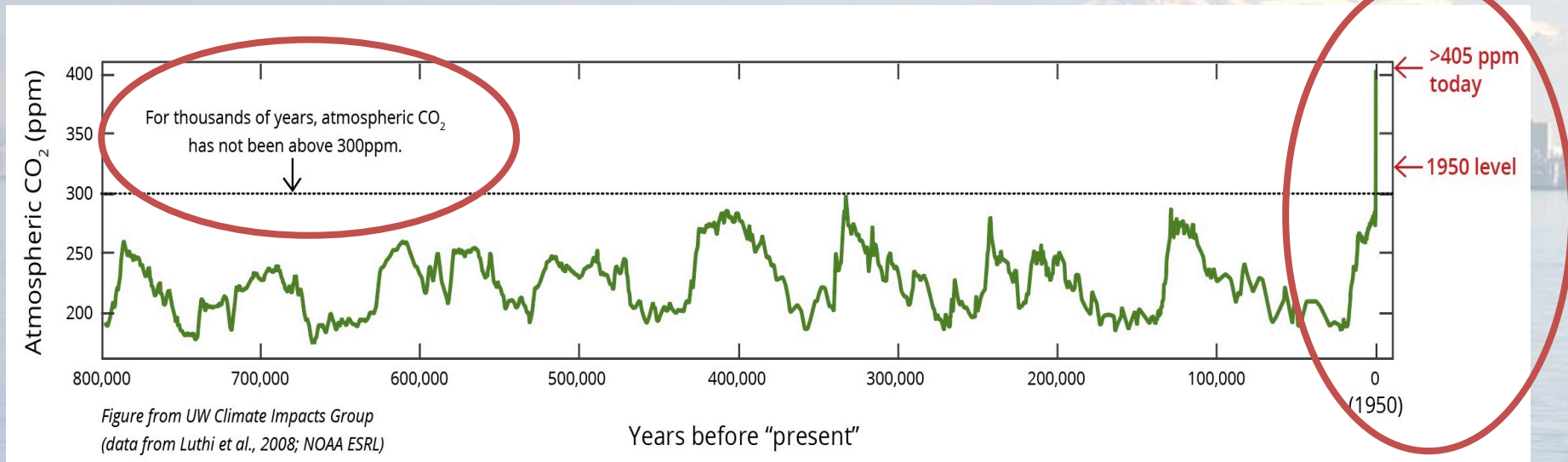
Washington

The Evergreen State

- 25 mountains >8,000 feet
- 28,000 miles of shoreline
- Puget Sound: 2nd largest estuary in U.S.
- 30 – 200 inches rain per year



Climate Change is Happening



"...Warming of the climate is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen."

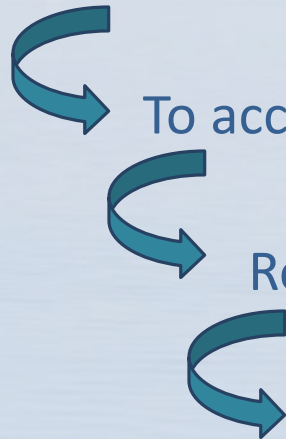
Climate change is happening now

"...It is extremely likely that more than half of the observed increase in global average surface temperature from 1951 to 2010 is caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together."

People are major contributors to climate change

Intergovernmental Panel on Climate Change - Findings

A threshold of 1.5° C warming

- 
- To accomplish: shrink net carbon emissions to zero by 2050
 - Requires 50% decrease in emissions by 2030:
 - Carbon dioxide removal
 - Rapid and unprecedented transition of energy, land, infrastructure, industrial systems

Limited scenarios to avoid 1.5°C warming

Pacific Northwest Observations

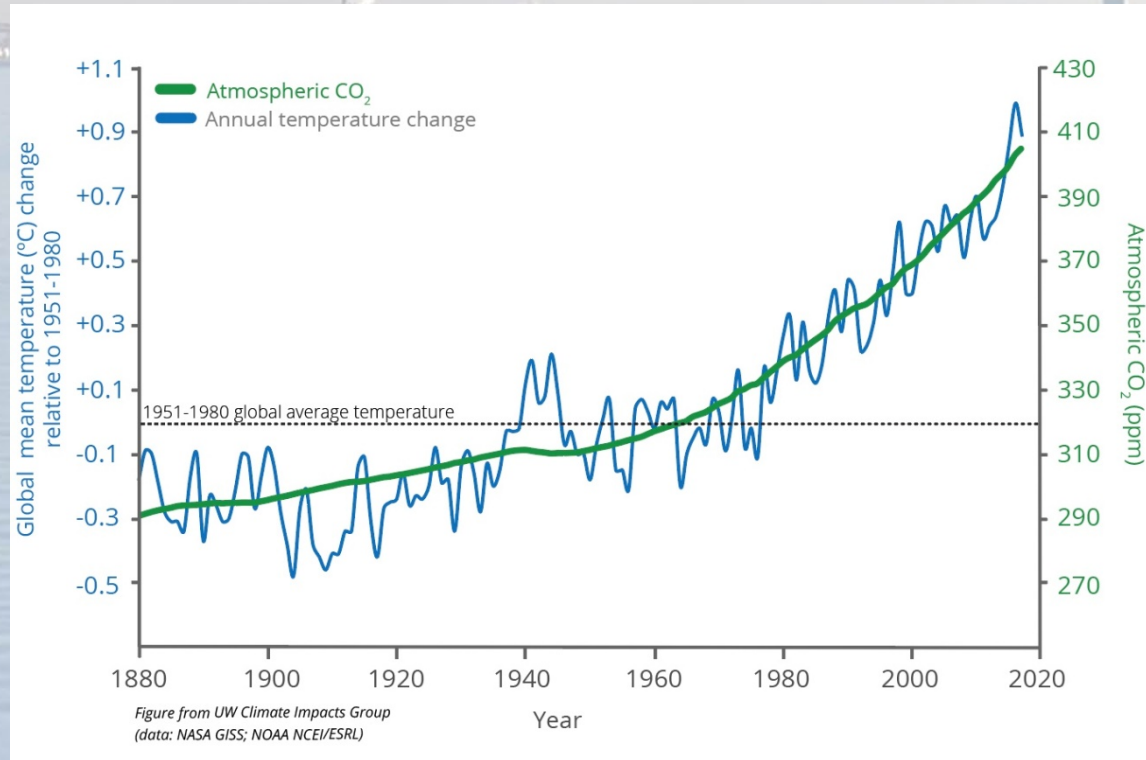
Sea level rise: Increase of 8.6 inches

Coastal flooding: From ~1 to ~3 flood days/year and nuisance tidal floods

Heavy rain events (24-hour rainfall): Wetter springs

Wildfires: Number and extent - since 1970s

Spring snowpack: Decline in Western states



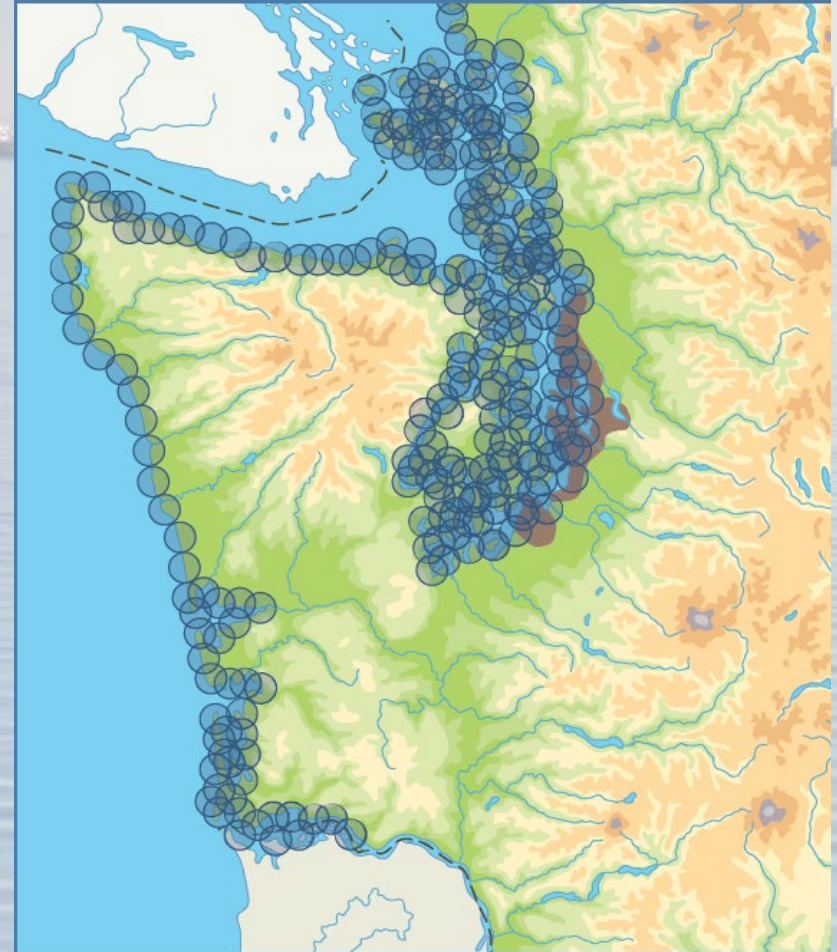
Pacific Northwest Projections

Sea Level Rise

Probabilistic Sea Level Rise Projections

- 171 locations along coastline
- Absolute and relative sea level rise projections
- Includes vertical land movement
- Access the report:

<http://www.wacoastalnetwork.com/>



Pacific Northwest Projections

Sea Level Rise

PROJECTED RELATIVE SEA LEVEL CHANGE FOR 2100 (feet, averaged over a 19-year time period)

Location	Vertical Land Movement Estimate	Greenhouse Gas Scenario	Central Estimate (50%)	Likely Range (83-17%)	Higher magnitude, but lower likelihood possibilities		
					10% probability of exceedance	1% probability of exceedance	0.1% probability of exceedance
Tacoma (47.3N, 122.4W)	-0.5 ± 0.2	Low	2.1	1.5-2.7	3	4.6	7.9
		High	2.5	1.9-3.3	3.6	5.3	8.8
Neah Bay (48.4N, 124.6W)	1.1 ± 0.3	Low	0.5	-0.1 - 1.2	1.5	3.1	6.3
		High	1	0.3 - 1.7	2	3.8	7.4
Taholah (47.4N, 124.3W)	0.3 ± 0.5	Low	1.3	0.6-2.1	2.4	3.9	7.1
		High	1.7	1.0-2.6	2.9	4.6	8.1

Pacific Northwest Projections

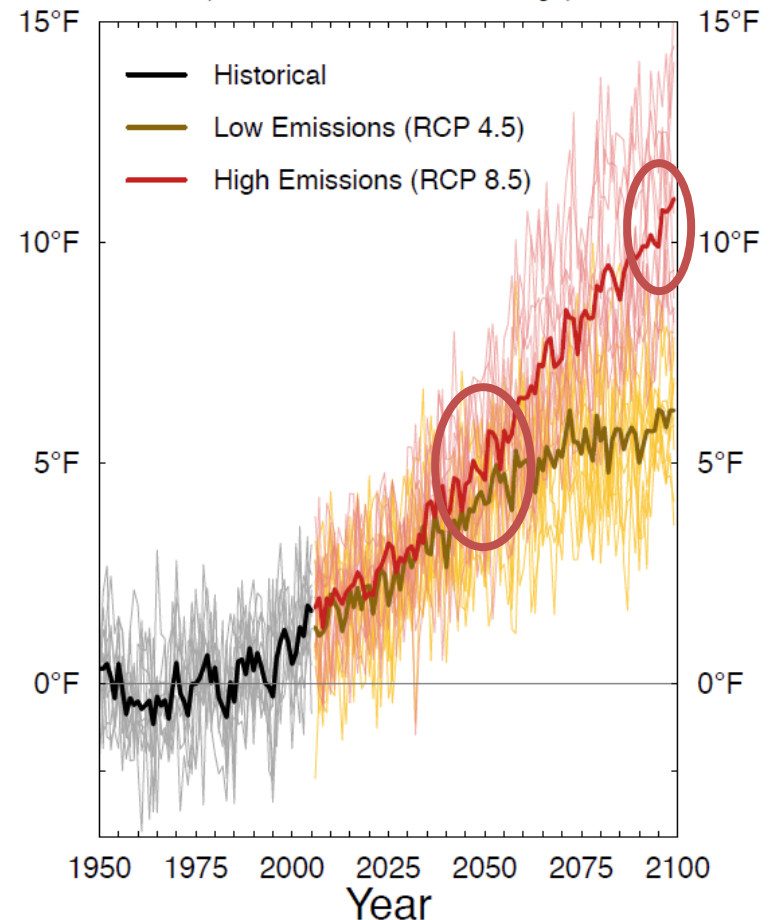
Temperature by 2100

Average annual air temperatures

- Increase up to 9.1° F
- Warming for all seasons
- Greatest increase in summer
- More frequent extreme heat events
- Less frequent extreme cold events

Temperature Difference

(Relative to 1950–1999 average)



Pacific Northwest Projections

Precipitation by 2050s

- **Heavy 24-hour rain events**
 - 2 days/year to **7 days/year** on average
- **Annual Average Precipitation**
 - 22% decrease in summer
 - **Increase** up to 11% other seasons

Pacific Northwest Projections

Snow, Glaciers, Streamflow

- Early snowmelt
- Snow to rain transition
- Loss spring snowpack
- Loss of glaciers
- Annual streamflow change



Climate Change & Cleanup

Why Develop Guidance?

- **By law, cleanup remedies must be:**
 - Protective of human health
 - Protective of environmental health
 - Effective over the long term
- **Climate change adaptation guidance supports:**
 - Cleanup laws and rules
 - Long-term adaptive management of contained remedies
 - Risk management tools - extreme weather events

Climate Change

The Issues for Cleanup Sites

↑

- Sea levels
- Storm severity
- Rainfall
- Landslides
- Wildfires – number and extent
- Droughts – length and intensity

} Flooding & Erosion



Issues for Cleanup Sites

Sea Level Rise and Inundation

Sea level rise exacerbates

Storm Surge – inland reach

6 inches of sea level rise \approx “100-year” storm event every 18 years

Present



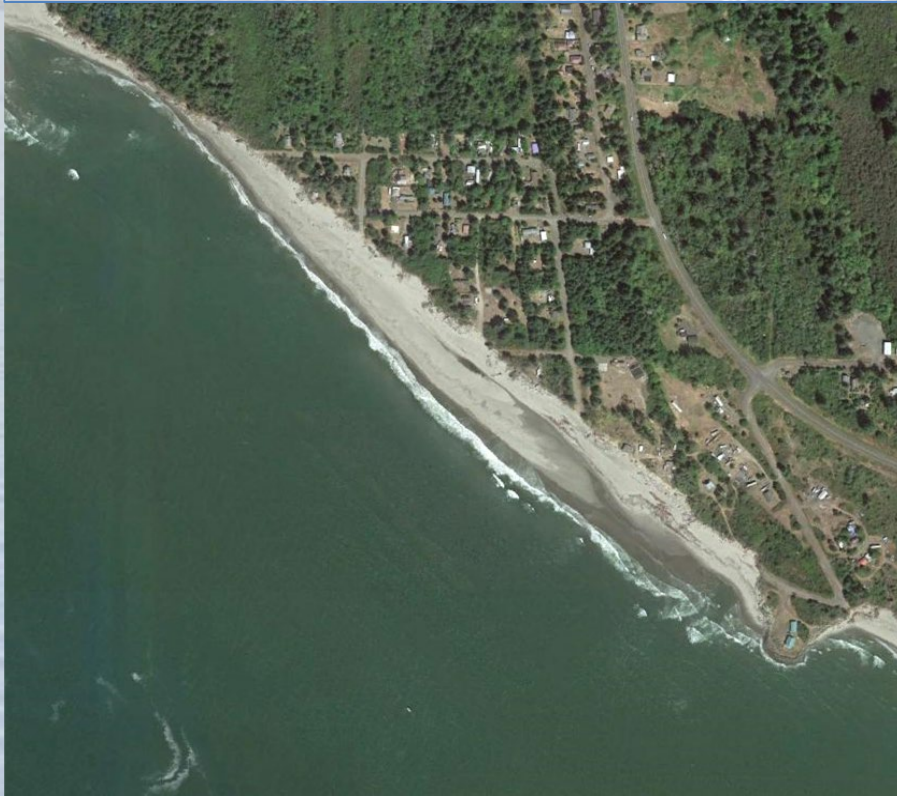
Future - 1.75 meters SLR



Issues for Cleanup Sites

Erosion and Storm Severity

2016 – Washaway Beach



1990 – Washaway Beach



Pacific Northwest Convergence of Events

Wet spring
+
Heavy rain events
+
Saturated soils & snowmelt
influenced rivers at capacity
+
Early spring snowmelt
=
Unprecedented Flooding



Landslide

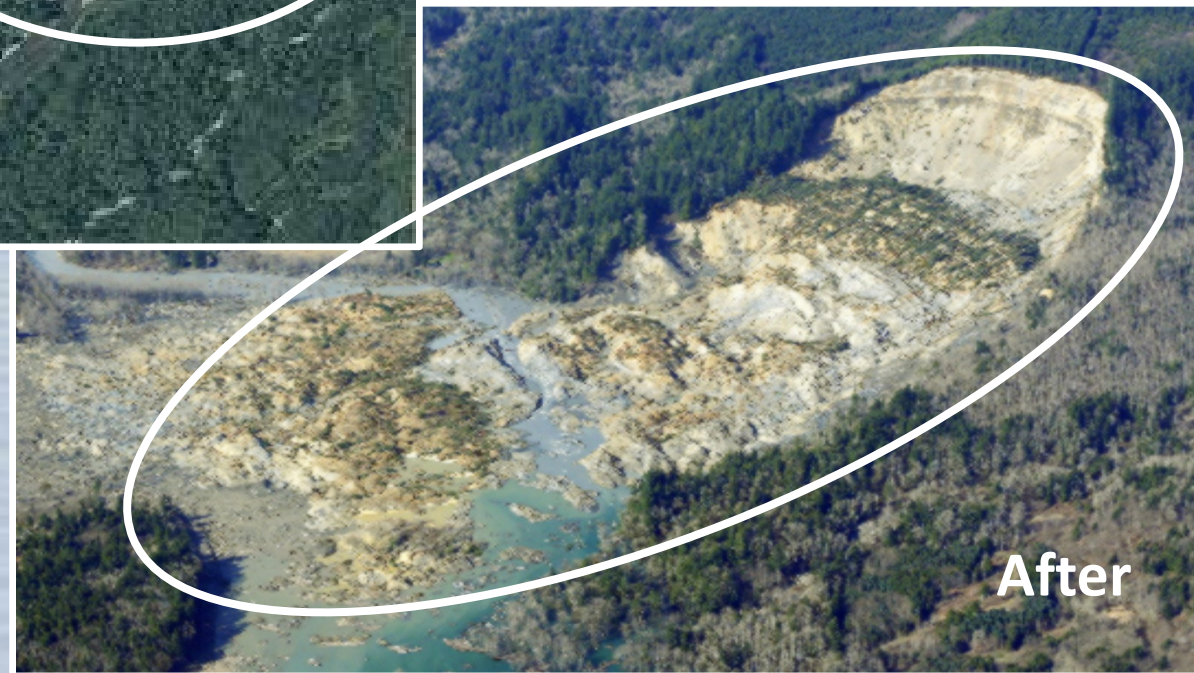
Upland Containment and Sediment



Oso, WA



Before

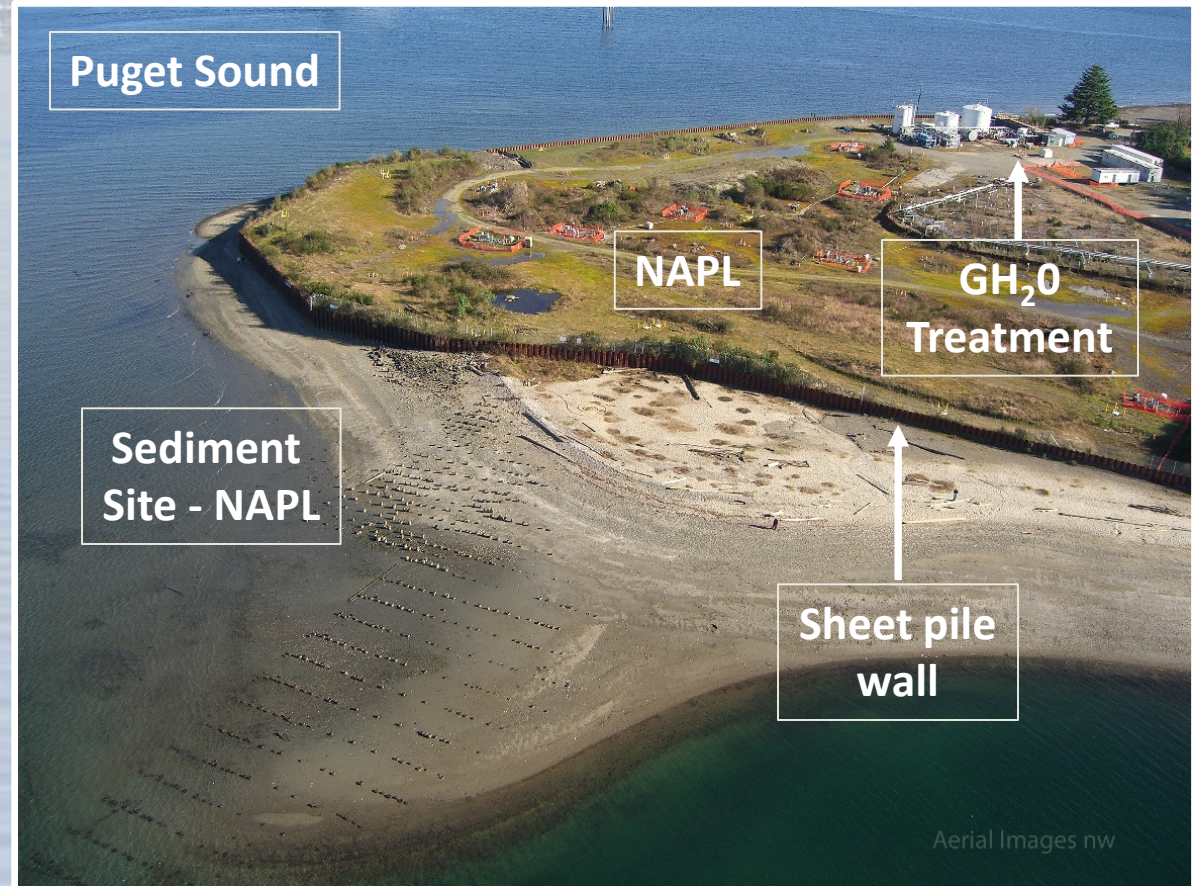


After

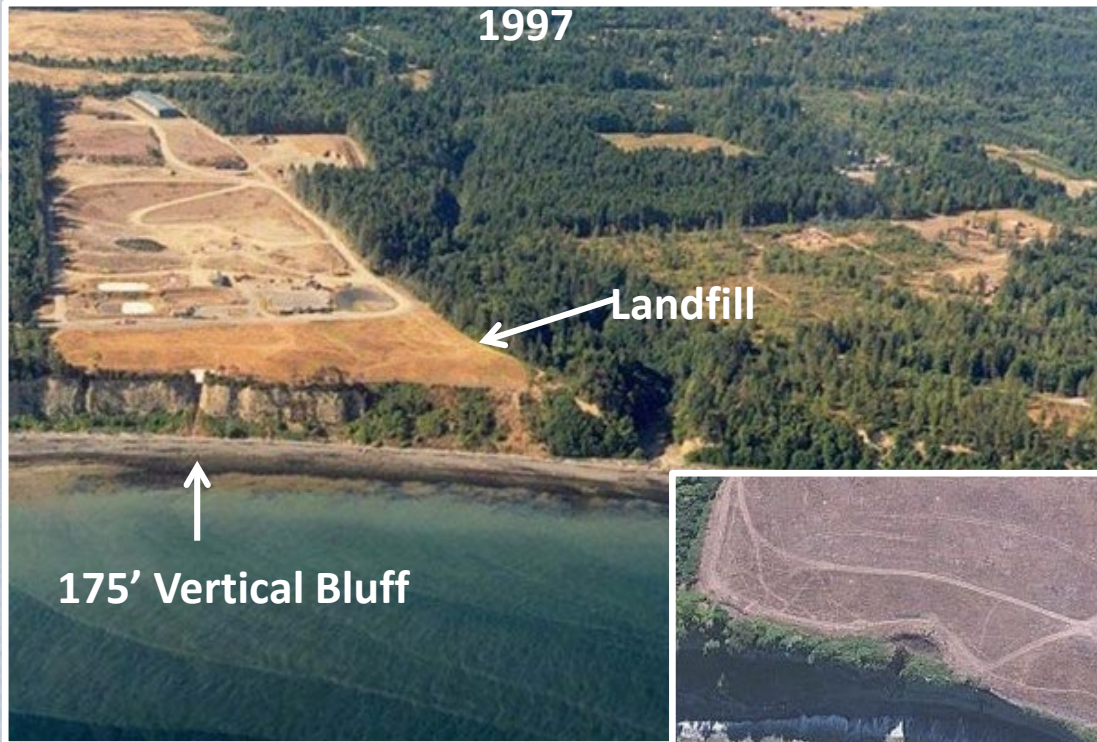
Sea Level Rise

Upland Containment & Groundwater

- Containment remedy failure
- Damage to equipment
- Saltwater intrusion
- Spills
- Fire & explosions
- Groundwater flow or aquifer storage capacity
- Erosion



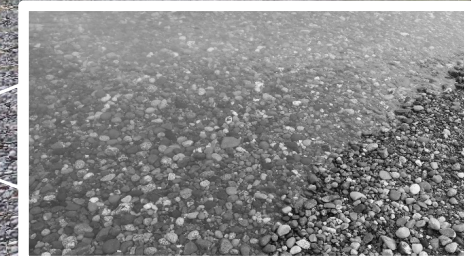
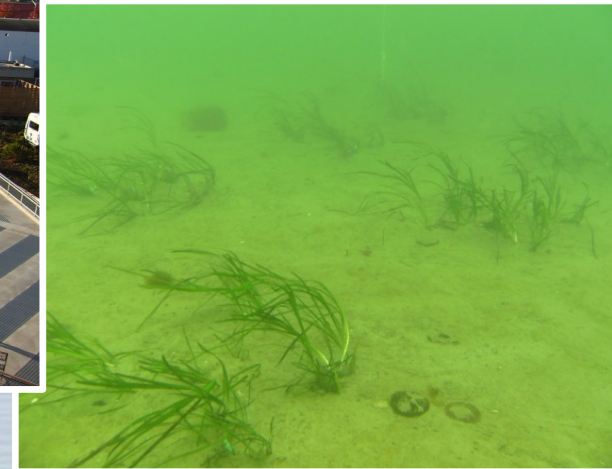
Sea Level Rise – Storm Events Upland Containment - Landfills



Sea Level Rise and Storm Events

Sediment Sites

- Infrastructure damage
- Habitat loss
- Shifting intertidal zone & shoreline
- Scour of sediment cap
- Sedimentation and erosion
- Upland and upstream debris
- Contaminated groundwater



Severe Storm Events

Sediment Sites

Sinclair Inlet Puget Sound

- Vessel broke loose from moorings
- Sediment cap damaged



Severe Storm Events Sediment Sites

Port Gamble, WA

- Cap designed for a 100-year storm event
- Two severe storm events in one week
- New cap and armoring eroded



Adaptation Strategy Guidance

- Climate science
- Vulnerabilities assessment
- Adaptation Strategy
- Appendices



Adaptation Strategies for Resilient Cleanup Remedies

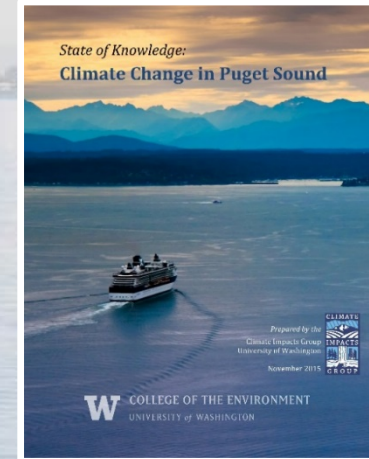
*A Guide for Cleanup Project Managers to
Increase the Resilience of Toxic Cleanup Sites to
the Impacts from Climate Change*

November 2017
Publication no. 17-09-052

Adaptation Strategy Guidance

Authors

- Chance Asher
- Scott O'Dowd
- Hugo Froyland
- Teresa Michelsen,
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Hart Crowser



WA Sea Grant



Rand Corporation

Adaptation Strategy Guidance

The Process

Vulnerability Assessment Phase I

- Identified:
 - High risk impacts to cleanup sites
 - Sensitivity, exposure, adaptive capacity

Vulnerability Assessment Phase II

- Revealed vulnerable:
 - Types of sites and locations
 - Aspects of remedies

Adaptation Strategy

- Identified resilient aspects of remedies
- Developed resiliency recommendations at each cleanup stage
- Developed risk management options

Vulnerability Assessment

High Risk Impacts and Methods

GIS analysis

- Cleanup sites
- Base flood elevation & MHHW
- WA DNR mapped landslides
- 100- & 500-year flood plains
- FEMA Floodways
- Snowmelt influenced rivers
- Potential increases in burned areas

Sea level rise



Landslide



Wildfire



Flooding



Vulnerability Assessment Remedy Specific Analysis

- **Cleanup Sites:**

- Groundwater
- Landfills
- Soil
- Mining
- Sediment
- Underground storage tanks

- **Media Specific Experts**

- Types of remedies
- Specific areas
- Extrapolate on current vulnerabilities



Sea level rise



Landslide



Wildfire



Flooding

Adaptation Strategy Guidance

- **Vulnerabilities identified based on:**
 - Flooding
 - Sea level rise
 - Wildfire
 - Landslide
 - Drought

- **Resilience recommendations based on:**
 - Location of site
 - Type of site
 - Type of remedy
 - Cleanup phase

Adaptation Strategy Guidance

- **A chapter for each cleanup stage:**
 - Conceptual Site Model
 - Remedial Investigation
 - Remedy Selection
 - Remedial Design
 - Monitoring
- **Subsections dedicated to site type and location:**
 - Sediment
 - Groundwater
 - Upland Containment
 - Landfill
 - Mining
 - Underground storage tanks

Conclusions

- Highest risk impacts: **sea level rise and flooding**
- Greatest vulnerability: **inundation**
- Most effective responses:
 - Education and training
 - Remedial investigation – climate related variables
 - Remedy selection - increased reliance on:
 - Risk management
 - Adaptive management
 - Removal
 - Analysis of permanence
 - Changes to long-term monitoring
 - More prominent maintenance of contained remedies

And Finally

Adaptation Strategies for Resilient Cleanup Remedies

Guidance for cleanup project managers to increase the resilience of toxic cleanup sites to the impacts from climate change

Publication No. 17-09-052

<https://fortress.wa.gov/ecy/publications/SummaryPages/1709052.html>

NEXT STEPS

2019 – Finalize GIS web application

2019 – Finalize Green Cleanup guidance

2019 and beyond – Keep our head above water and implement guidance

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Thank you!



Bunny

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- For more references, see Adaptation Strategies for Resilient Cleanup Remedies: Guidance for cleanup project managers to increase the resilience of toxic cleanup sites to the impacts from climate change. WA Department of Ecology, Toxics Cleanup Program. Publication No. 17-09-052 <https://fortress.wa.gov/ecy/publications/SummaryPages/1709052.html>