

# Assessing the Vulnerability of Wastewater Facilities and Conveyance System for Sea-Level Rise

September 9, 2014  
Pacific Northwest Climate Science Conference  
John Phillips



King County

**CLIMATE  
CHANGE**

# Adaptation



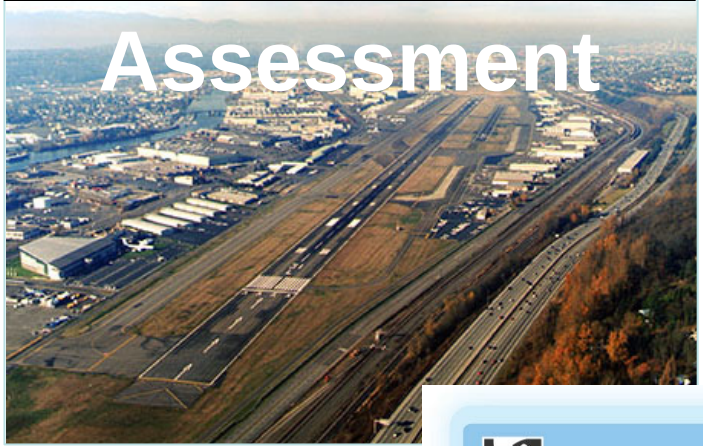
## Flood Planning and Control



## Reclaimed Water



## Sea Level Risk Assessment



King County

**CLIMATE  
CHANGE**

# Adaptive Planning

“Planning backward”

“Asking the Climate Question”



**“The key is to listen to scientists, not politicians.”**

– Former King County Executive Ron Sims,  
US News and World Report, June 5, 2006

# King County Climate Policies

*King County will be a leader in prevention and mitigation of, and adaptation to, climate change effects. Recommends that the County incorporate climate change considerations into County plans, programs and projects and collaborate with others to raise awareness*

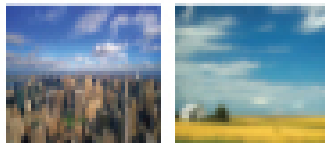
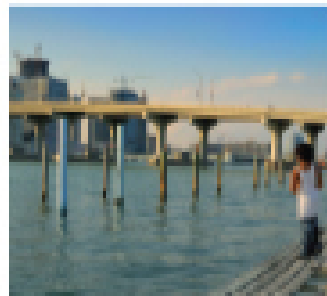
*..the county should inventory essential county facilities, including roads and wastewater treatment and conveyance facilities, that are subject to climate change related impacts including sea level rise and exacerbated river flooding, and develop strategies for reducing risks and mitigating future damages*

# *Preparing for Climate Change*

## A Guidebook for Local, Regional & State Governments

### PREPARING FOR CLIMATE CHANGE

A Guidebook for Local, Regional,  
and State governments

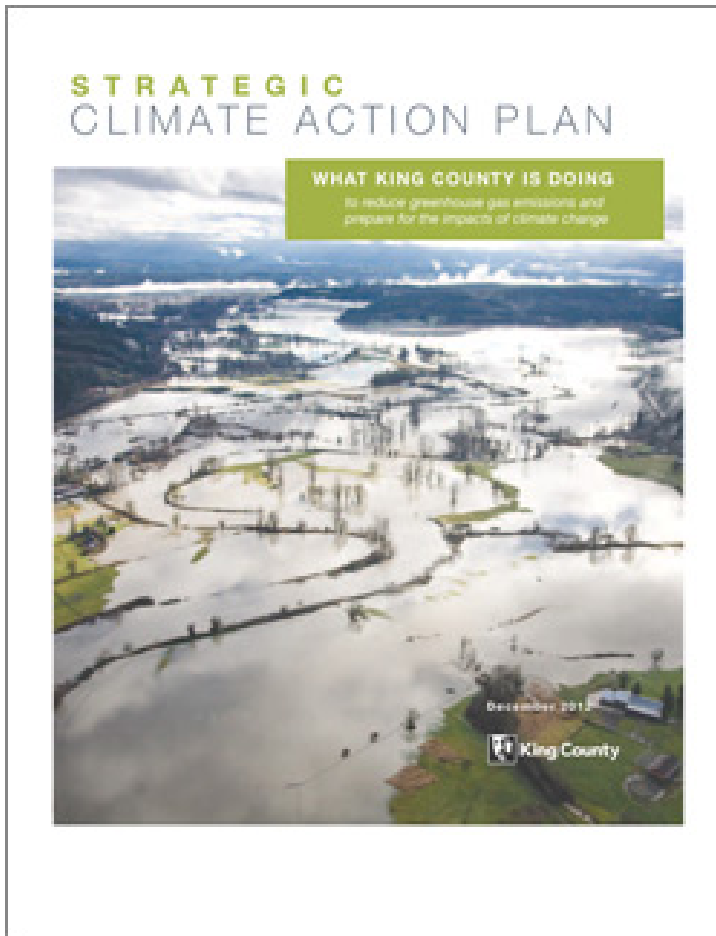


**Written by**  
Center for Science in the North Pacific (The Climate Impact Group)  
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University of Washington  
King County, Washington

**With an introduction by King County Executive Dow Constantine**



# Climate Action Plan 2007 & 2012



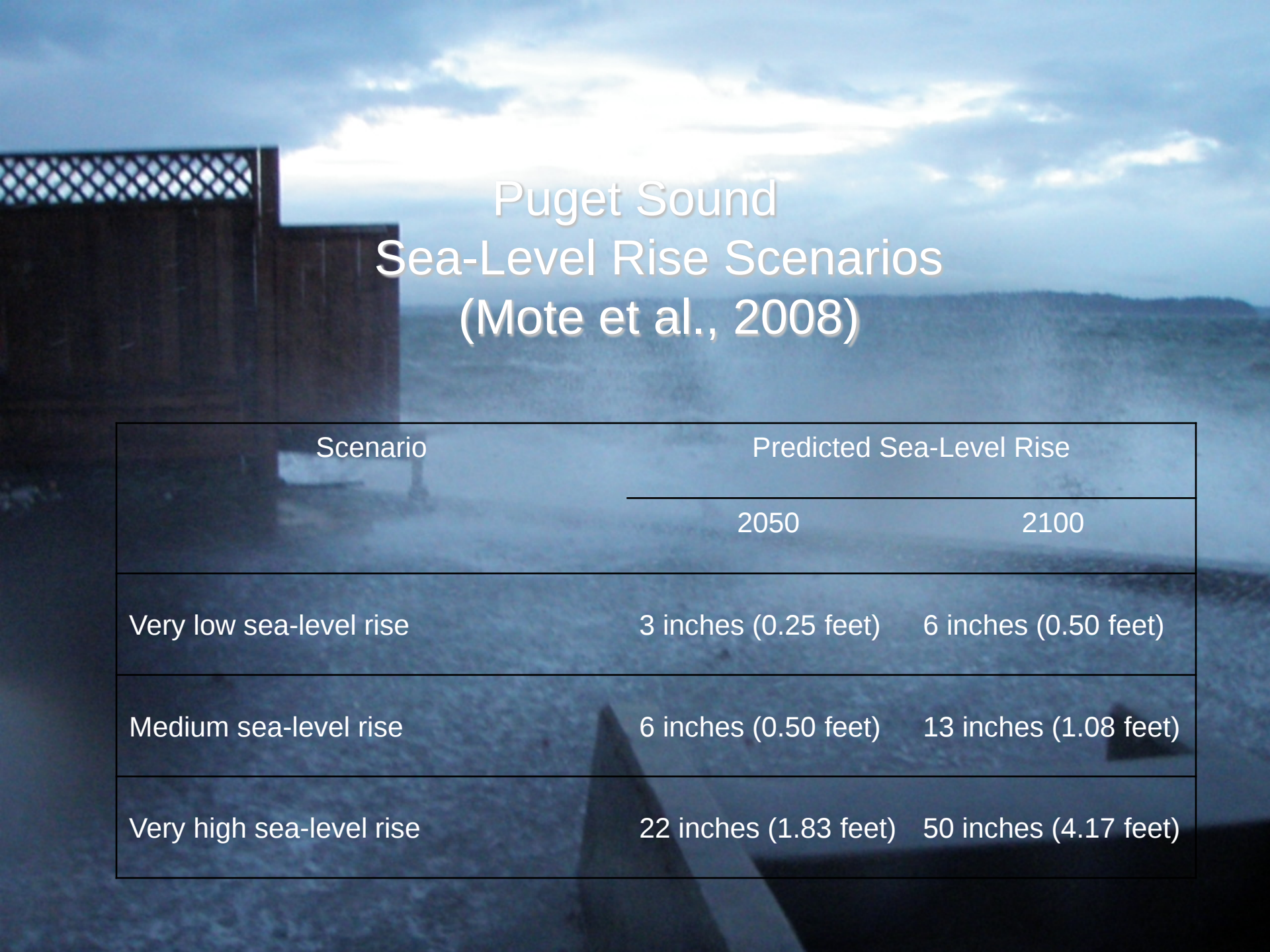
## *Climate Action Plan...*

- Climate science
- Public health, safety and emergency preparedness
- Surface water management, freshwater quality and water supply
- Land use, buildings and transportation infrastructure
- Economic impacts
- Biodiversity and ecosystems

# Sources of information – Listen to Science

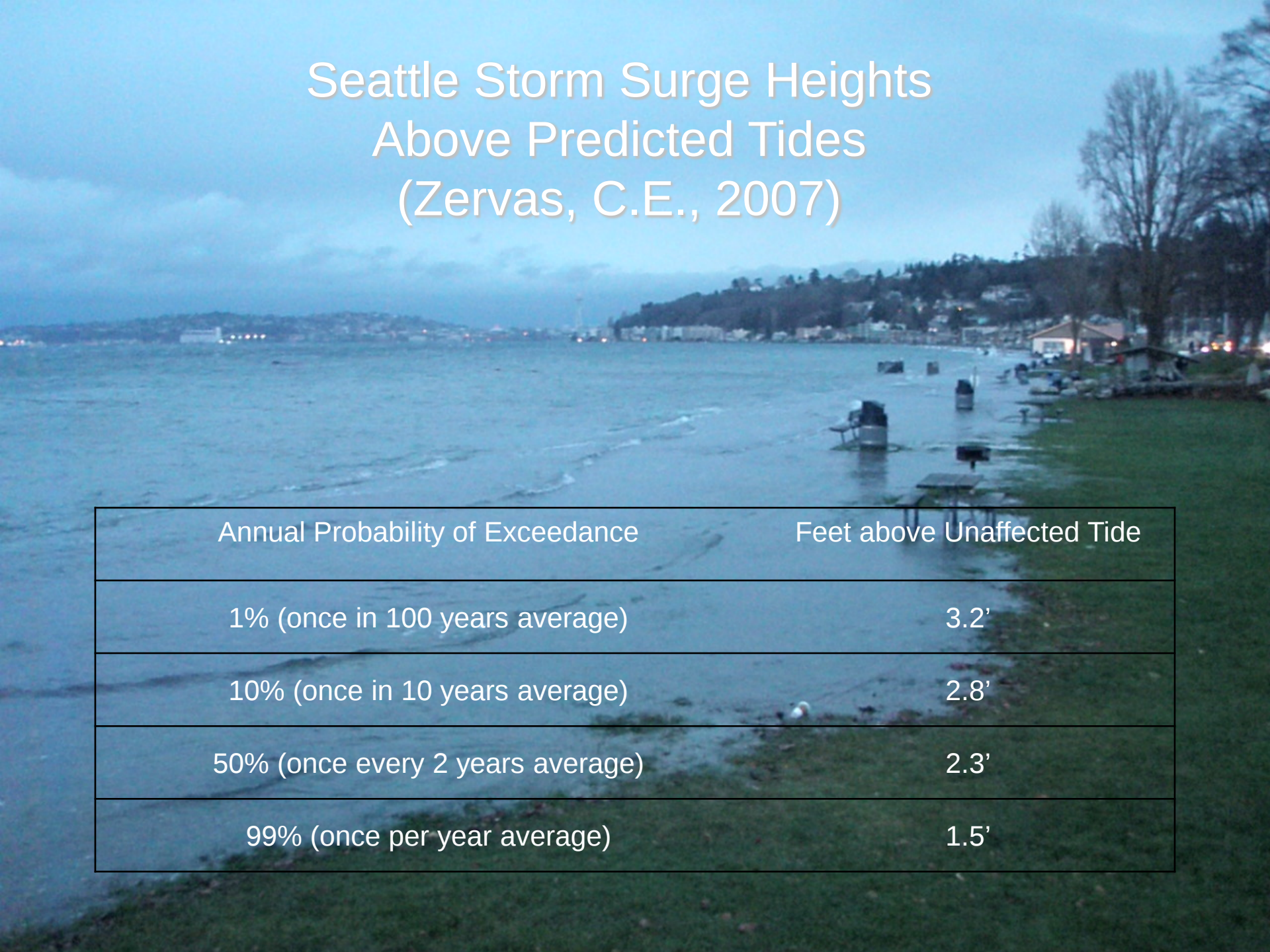
- University of Washington Climate Impacts Group (CIG)
- PNW Climate Impacts Research Consortium (CIRC)
- Intergovernmental Panel on Climate Change (IPCC)





## Puget Sound Sea-Level Rise Scenarios (Mote et al., 2008)

| Scenario                 | Predicted Sea-Level Rise |                       |
|--------------------------|--------------------------|-----------------------|
|                          | 2050                     | 2100                  |
| Very low sea-level rise  | 3 inches (0.25 feet)     | 6 inches (0.50 feet)  |
| Medium sea-level rise    | 6 inches (0.50 feet)     | 13 inches (1.08 feet) |
| Very high sea-level rise | 22 inches (1.83 feet)    | 50 inches (4.17 feet) |



# Seattle Storm Surge Heights Above Predicted Tides (Zervas, C.E., 2007)

| Annual Probability of Exceedance | Feet above Unaffected Tide |
|----------------------------------|----------------------------|
| 1% (once in 100 years average)   | 3.2'                       |
| 10% (once in 10 years average)   | 2.8'                       |
| 50% (once every 2 years average) | 2.3'                       |
| 99% (once per year average)      | 1.5'                       |

# WTD Sea-Level Rise Capital Project Design Guidance

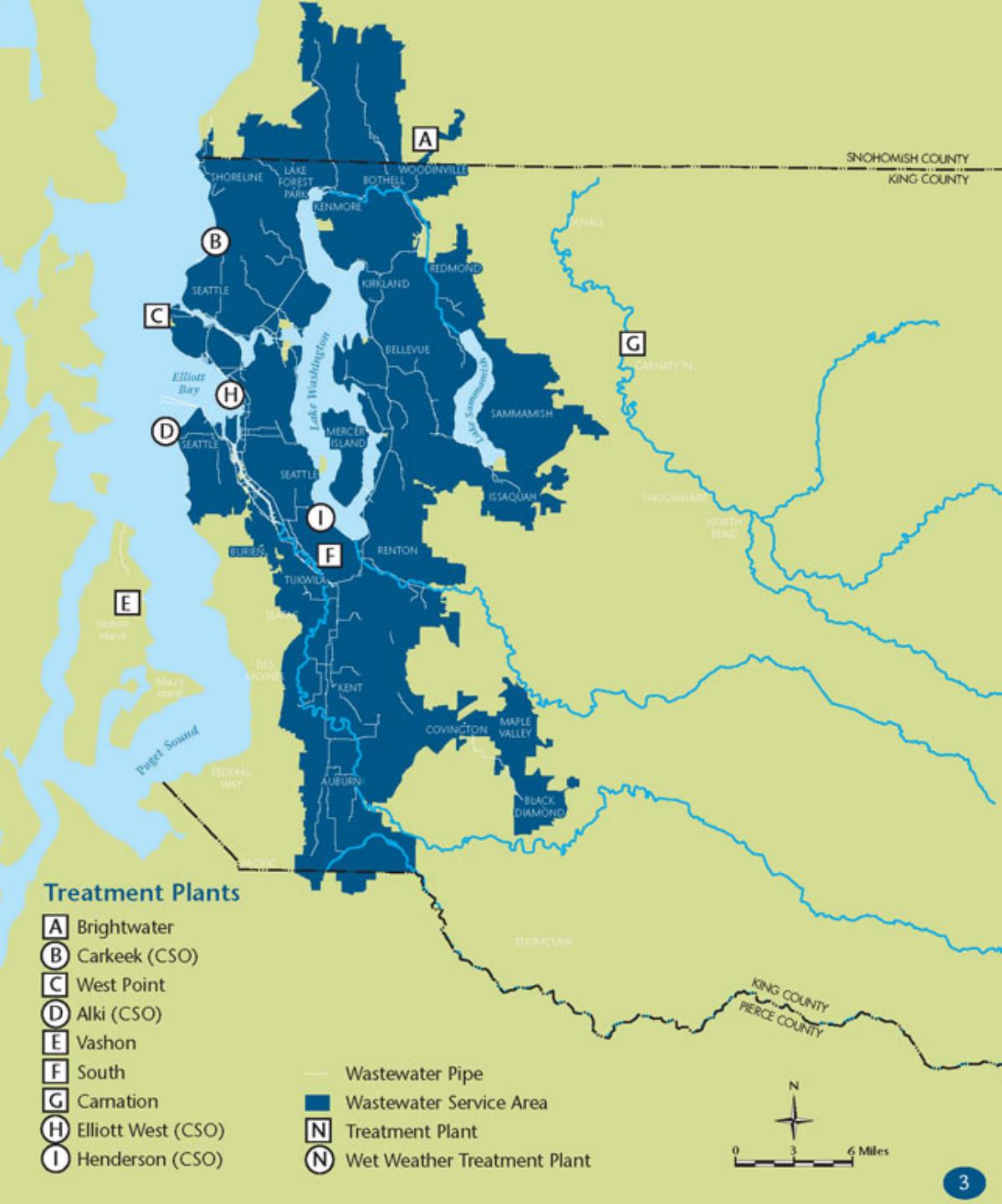
**Table 5-1. Puget Sound High Tides Under Sea-Level Rise–Storm Surge Scenarios**

| Scenario                       | No<br>Storm<br>(MHHW) | Storm Surge Plus MHHW (feet Metro Datum) |                                |                                 |                                  |
|--------------------------------|-----------------------|------------------------------------------|--------------------------------|---------------------------------|----------------------------------|
|                                |                       | 1-Year<br>Storm<br>(1.48 feet)           | 2-Year<br>Storm<br>(2.27 feet) | 10-Year<br>Storm<br>(2.79 feet) | 100-Year<br>Storm<br>(3.19 feet) |
| Current conditions             | 105.36                | 106.84                                   | 107.63                         | 108.15                          | 108.55                           |
| Medium SLR 2050 (6 inches)     | 105.86                | 107.34                                   | 108.13                         | 108.65                          | 109.05                           |
| Medium SLR 2100 (13 inches)    | 106.44                | 107.92                                   | 108.71                         | 109.23                          | 109.63                           |
| Very High SLR 2050 (22 inches) | 107.19                | 108.67                                   | 109.46                         | 109.98                          | 110.38                           |
| Very High SLR 2100 (50 inches) | 109.53                | 111.01                                   | 111.8                          | 112.32                          | 112.72                           |

SLR = sea-level rise; MHHW = mean higher high water.

# King County Regional Wastewater System

- Serves 1.4 M people  
– 2.4 M by 2030
- 420 sq.mi.
- 47 pump stations
- 25 regulator stations
- 391 miles of pipe
- 200 mgd average treatment
- 34 Local agencies contribute flow



# On-Site Flooding



Alki Beach

# Summary of Results

|                                                   |                          |       | Mote et al                       |                                  |                                  |                                 |                                   |                                   |                               |
|---------------------------------------------------|--------------------------|-------|----------------------------------|----------------------------------|----------------------------------|---------------------------------|-----------------------------------|-----------------------------------|-------------------------------|
| Combined Sea Level Rise with Extreme Storm Events |                          |       | 2050 Low Level (<5% Likelihood ) | 2100 Low Level (<5% Likelihood ) | 2050 Medium Level (Most Likely ) | 2100 Medium Level (Most Likely) | 2050 High Level (<5% Likelihood ) | 2100 High Level (<5% Likelihood ) | Rapid Ice Sheet Melt Scenario |
|                                                   |                          |       | 3"                               | 6"                               | 6"                               | 13"                             | 22"                               | 50"                               | 20'                           |
| Zervas                                            | No Event                 | -     | 0.25'                            | 0.50'                            | 0.50'                            | 1.08'                           | 1.83'                             | 4.17'                             | 20'                           |
|                                                   | Once a Year Event 100%   | 1.48' | 1.73'                            | 1.98'                            | 1.98'                            | 2.56'                           | 3.31'                             | 5.65'                             | 21.48'                        |
|                                                   | Once every two years 50% | 2.27' | 2.52'                            | 2.77'                            | 2.77'                            | 3.35'                           | 4.10'                             | 6.44'                             | 22.27'                        |
|                                                   | Once every 10 years 10%  | 2.79' | 3.04'                            | 3.29'                            | 3.29'                            | 3.87'                           | 4.62'                             | 6.96'                             | 22.79'                        |
|                                                   | Once every 100 years 1%  | 3.19' | 3.44'                            | 3.69'                            | 3.69'                            | 4.27'                           | 5.02'                             | 7.36'                             | 23.19'                        |

 No facilities at risk of on site flooding.

 Three facilities at risk of on site flooding

 Five facilities at risk of on site flooding

 Eight facilities at risk of on site flooding

 Fourteen facilities at risk of on site flooding

 30 or more facilities at risk of on site flooding

# Saltwater Intrusion Study



Testing for Saltwater  
Kingdome Regulator Station



# Inundation

The image shows a flooded industrial or utility area. On the left, a yellow metal frame with horizontal bars is partially submerged. A black metal grate covers the floor, through which dark, turbulent water is flowing. In the top left corner, a coiled blue cable is visible, with the word "SIGMA" printed on it. The right side of the image shows a concrete wall with some white patches. The overall scene suggests a significant water leak or overflow.

Murray PS

# Inundation



63<sup>rd</sup> Ave PS

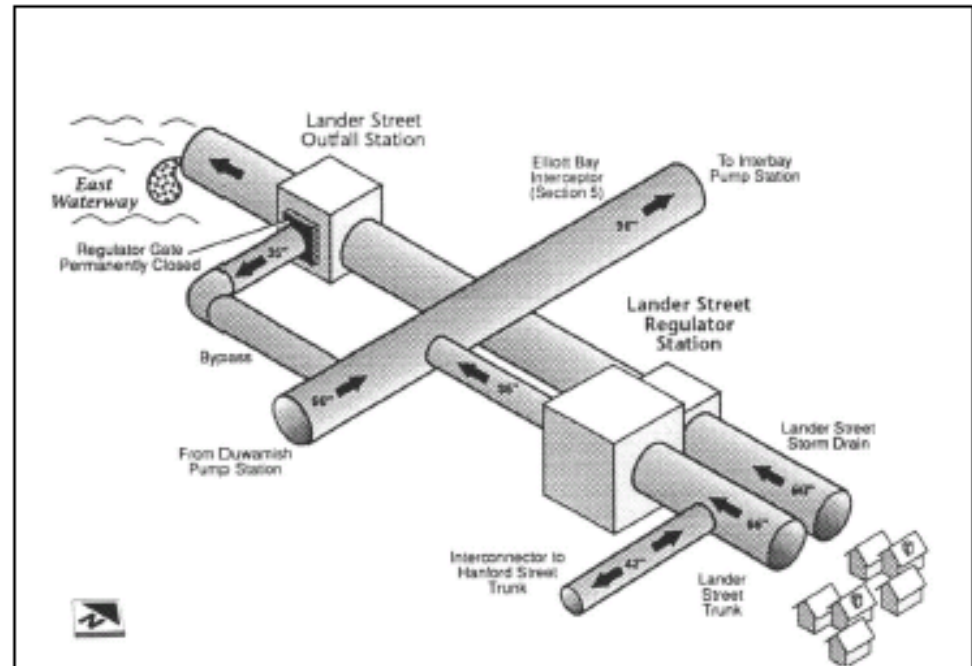
# Fixes



Barton  
PS

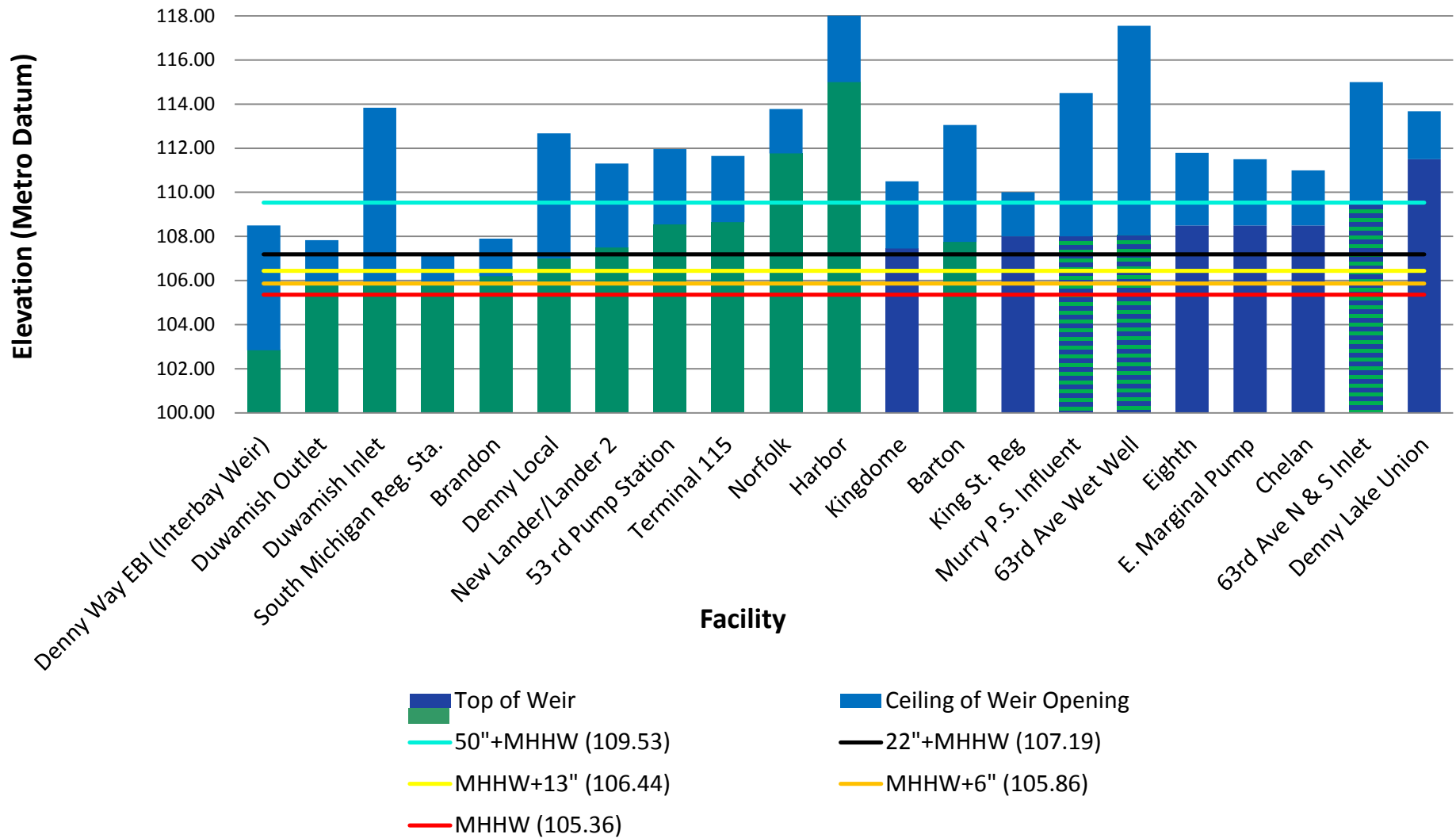
# Hydraulic Analysis

- Inventory Conveyance System
- Evaluate Sea Level Rise Scenarios on Inventory
- Estimate Inflow into System
- Conduct Vulnerability Assessment



Flow through the Lander Regulator  
And Outfall Stations

# Sea Level Rise for 2050 & 2100 at Medium and High Scenarios (Green shows facilities with flap gates)



# Assess West Point

- Energy use through the tide cycle
  - The use of effluent pumping increase as tide level increased
  - But, it wasn't consistent
- Flooding from sea-level rise
  - Facility was protected from highest predicted sea-level rise

Areas lower than 109.05' Metro Datum - 119' Contour

6" SLR + 38"(3.19') Storm Surge = 44"

Open Water

Areas lower than 112.72' Metro Datum -

50" SLR + 38"(3.19') Storm Surge = 88"

\*SLR - Sea Level Rise

Grit/Screening  
Loading Dock  
102.25' Metro Datum

Oxygen Generation  
Building Loading Dock  
111.26' Metro Datum

Low Point: 119' Metro Datum

**Horizontal Vulnerability Analysis  
KC-WTD's  
Sunset Pump Station  
Based on 100yr Floodplain Data**

**Legend:**

- Facility in 100yr Floodplain
- Not Vulnerable
- Pump Station
- KC-WTD Sewer Conveyance
- 100 Year Floodplain
- River/Stream

**Scale:** 0 0.05 0.1 Miles

**North Arrow:** N

**Inset Map:** King County GIS Center

**Map Labels:** SE 29th St, SE 30th St, SE 31st St, SE 32nd St, SE 33rd St, SE 34th St, SE 35th St, SE 36th St, SE 37th St, SE 38th St, SE 39th St, SE 40th St, SE 41st St, SE 42nd St, SE 43rd St, SE 44th St, SE 45th St, SE 46th St, SE 47th St, SE 48th St, SE 49th St, SE 50th St, SE 51st St, SE 52nd St, SE 53rd St, SE 54th St, SE 55th St, SE 56th St, SE 57th St, SE 58th St, SE 59th St, SE 60th St, SE 61st St, SE 62nd St, SE 63rd St, SE 64th St, SE 65th St, SE 66th St, SE 67th St, SE 68th St, SE 69th St, SE 70th St, SE 71st St, SE 72nd St, SE 73rd St, SE 74th St, SE 75th St, SE 76th St, SE 77th St, SE 78th St, SE 79th St, SE 80th St, SE 81st St, SE 82nd St, SE 83rd St, SE 84th St, SE 85th St, SE 86th St, SE 87th St, SE 88th St, SE 89th St, SE 90th St, SE 91st St, SE 92nd St, SE 93rd St, SE 94th St, SE 95th St, SE 96th St, SE 97th St, SE 98th St, SE 99th St, SE 100th St, SE 101st St, SE 102nd St, SE 103rd St, SE 104th St, SE 105th St, SE 106th St, SE 107th St, SE 108th St, SE 109th St, SE 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- Map conveyance system
- Map 100-yr floodplain
- Identify facilities within floodplain
- Identify key infrastructure within floodplain
- Presented in Poster at PNWCSC

# Long-term Adaptation

- Temperature
  - No direct correlation between temperature extremes and significant increase in wastewater temperature especially for winter temperatures
- Precipitation
  - Range of uncertainty in precipitation is large
  - Uncertainty around extreme events or heavy precipitation
  - Adaptive management is the most cost effective solution

# Acknowledgements

- University of Washington Climate Impacts Group
- Vulnerable Facilities Inventory
  - Shaun O'Neil
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  - Darrell Myers
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- West Point
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- Floodplain Mapping
  - Shaun O'Neil & Crystal Bach-Murphy

# Questions

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