

Flooding in the lower Snohomish: *Sea Level Rise, Flooding, and Inundation*



Source: WSDOT

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*Climate Science in the
Public Interest*

In the Northwest, we expect flood risk to be particularly sensitive to climate change.

Why?

- 1. Sea Level Rise:*** Coastal floodplains
- 2. Storms:*** Heavier rain events
- 3. Snow:*** Rising snowlines

What's missing:

1. Need to look at *inundation*: which areas are flooded?
2. Consider *combined effects* of sea level and streamflow

e.g.: Skagit River:

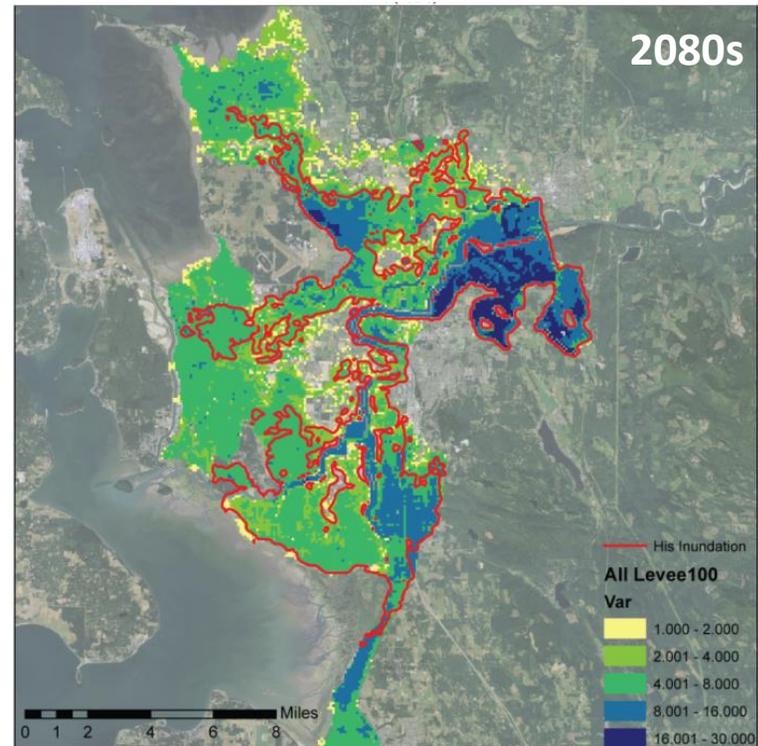
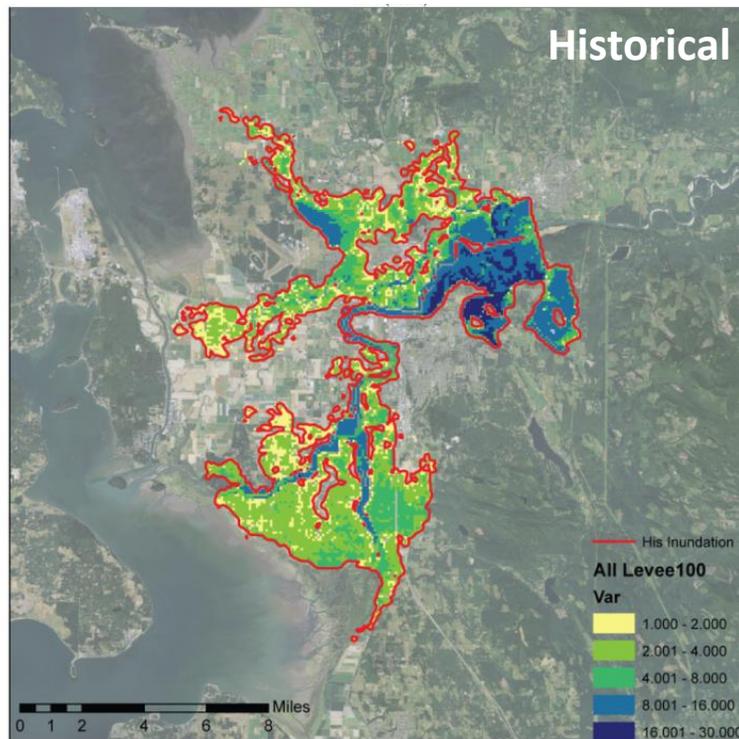
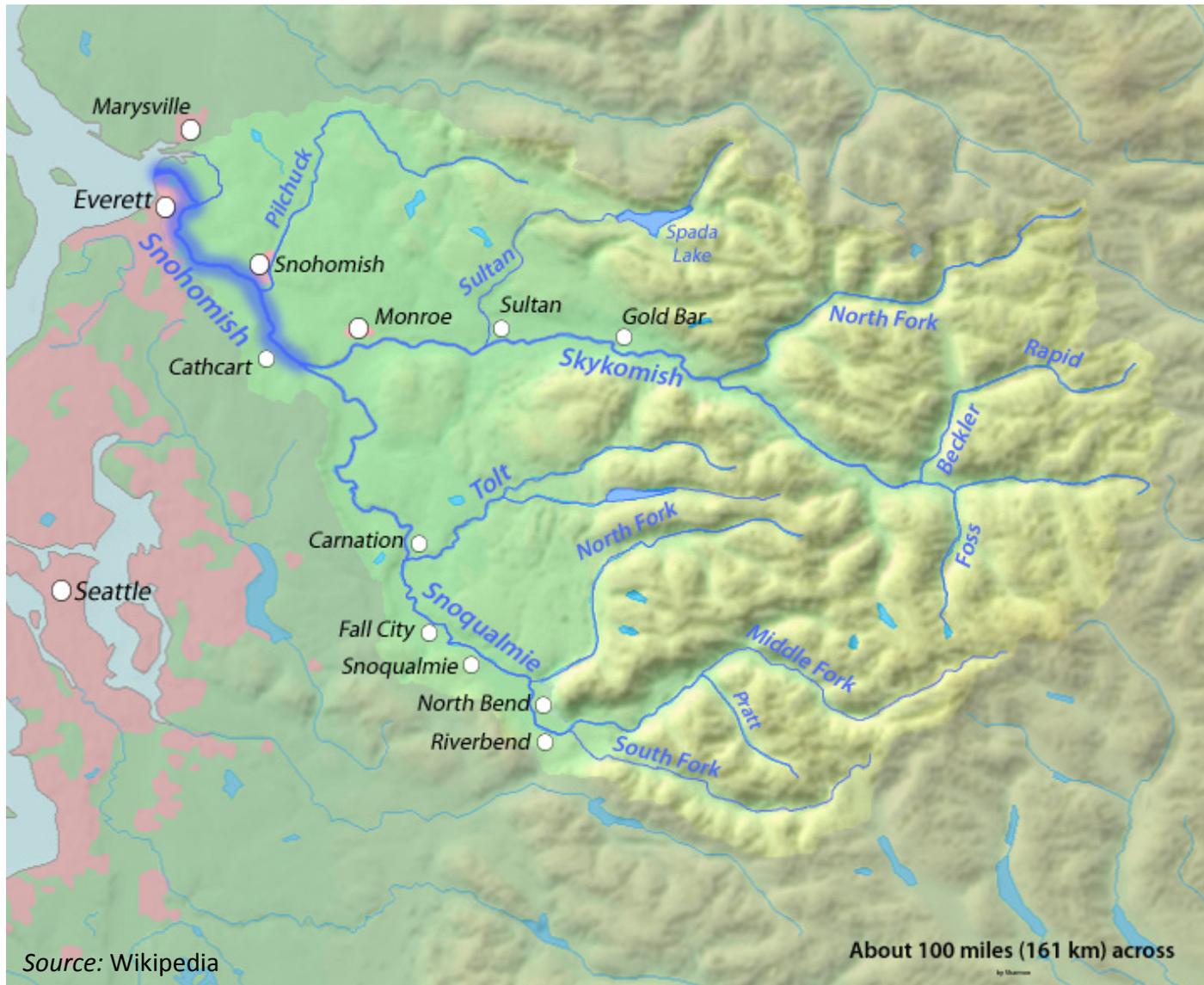


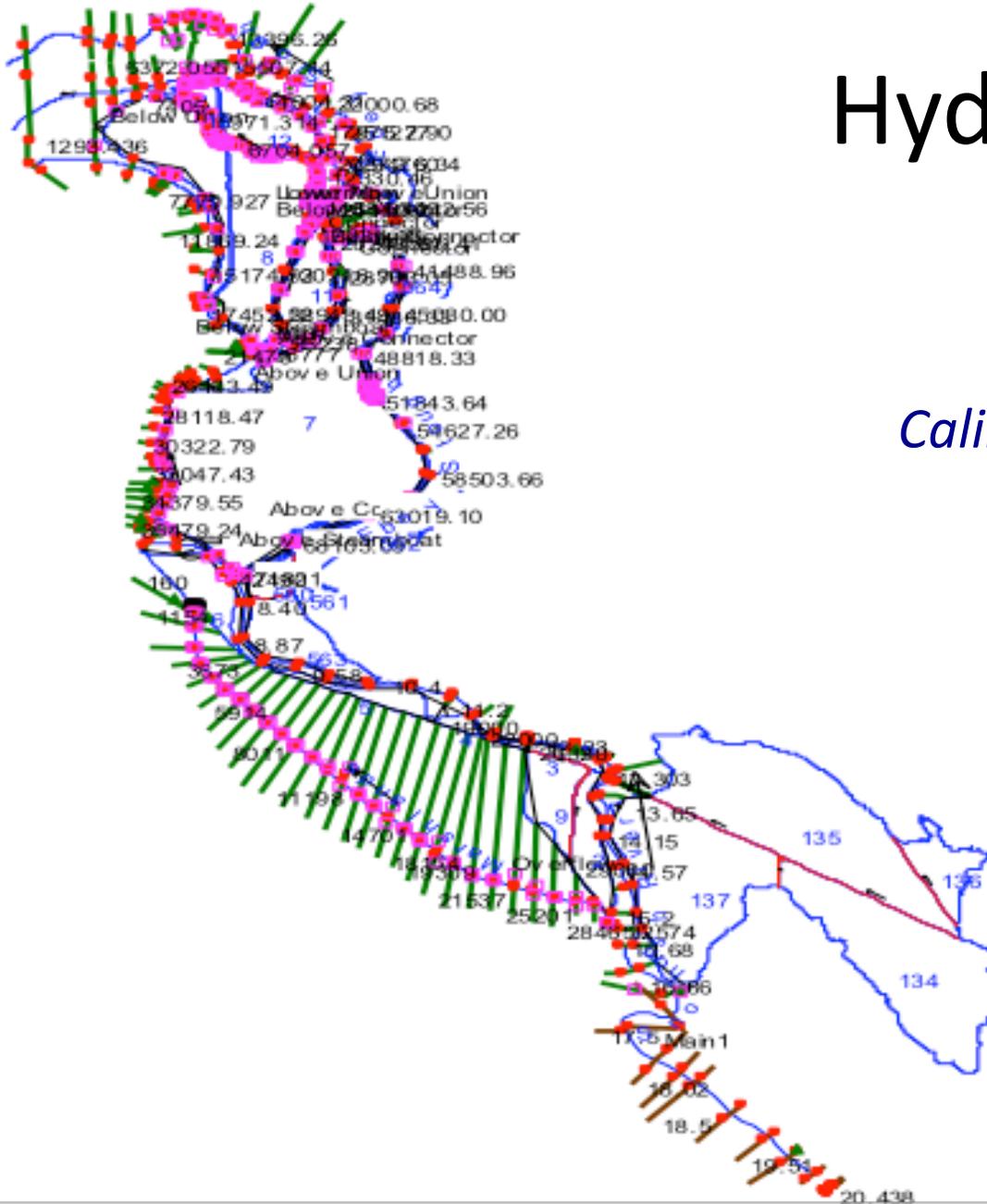
Figure Source: Joe Hamman, UW

Lower Snohomish River Basin



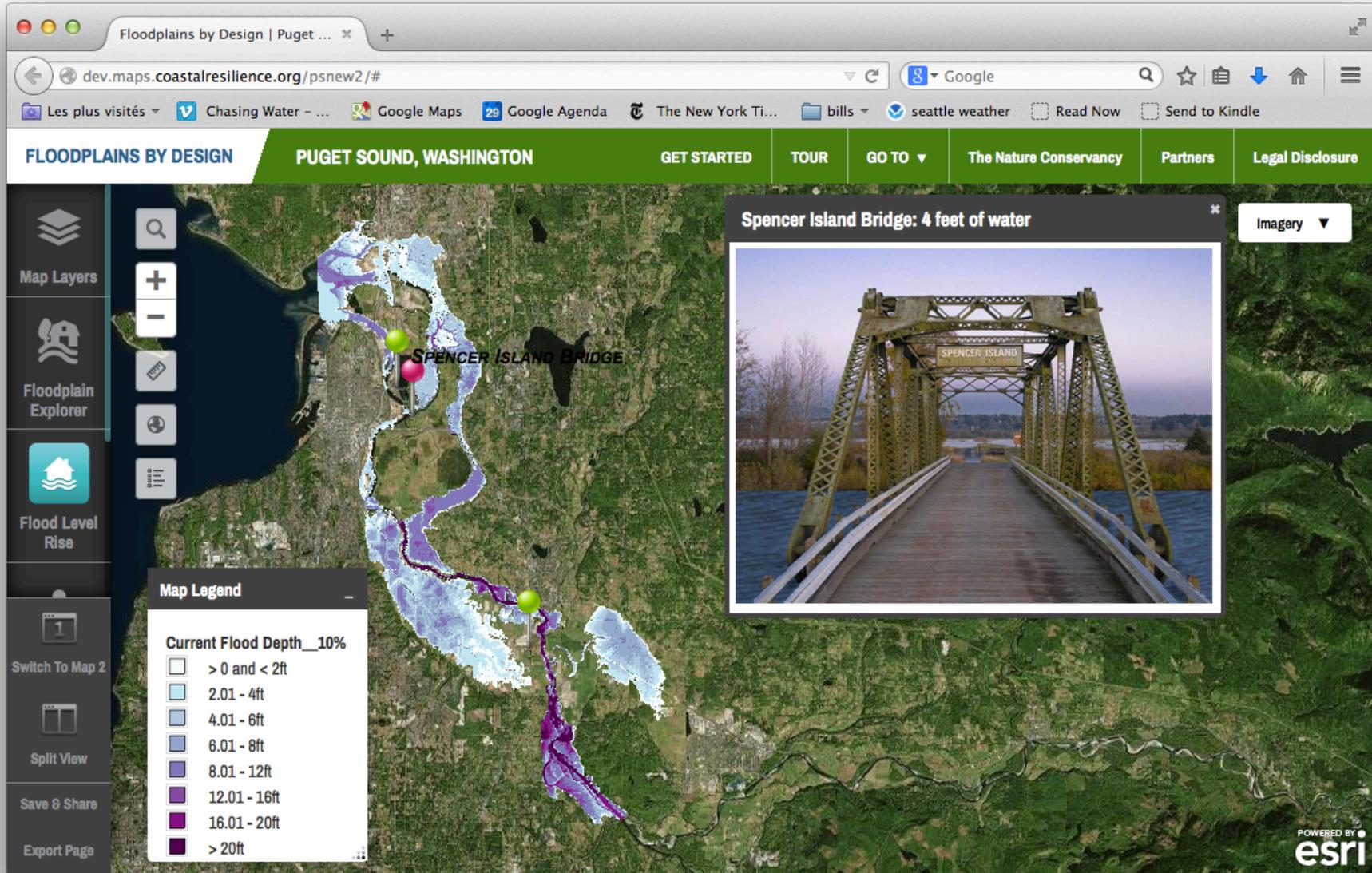
Hydraulic model: 1D HEC-RAS

*Calibrated on Nov 1990 and
Jan 2009 floods*



Preview: Results

10-year Flood, Historical (1980s)



www.maps.coastalresilience.org/pugetsound

Coastal Flooding =

Storm Surge +

Tides +

Waves +

Freshwater Runoff +

Sea Level Rise



Storm Surge

Storm Surge, Seattle (peak annual, rel. to MHHW)

← Highly correlated with
Everett gauge ($r^2 = 0.98$)

10-year	+24 inches
100-year	+32 inches

Based on the “skew surge,”
estimated using observed and
predicted tides from Seattle

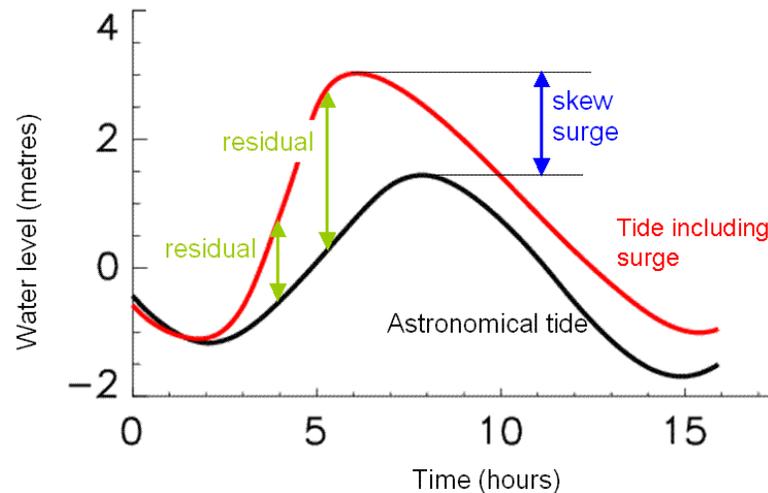


Figure Source: McMillan et al., 2011

Coastal Flooding =
Storm Surge* +
Tides +
Waves +
Freshwater Runoff +
Sea Level Rise

**Current projections do not show a change in storm surge*

Coastal Flooding =

Storm Surge +

Tides +

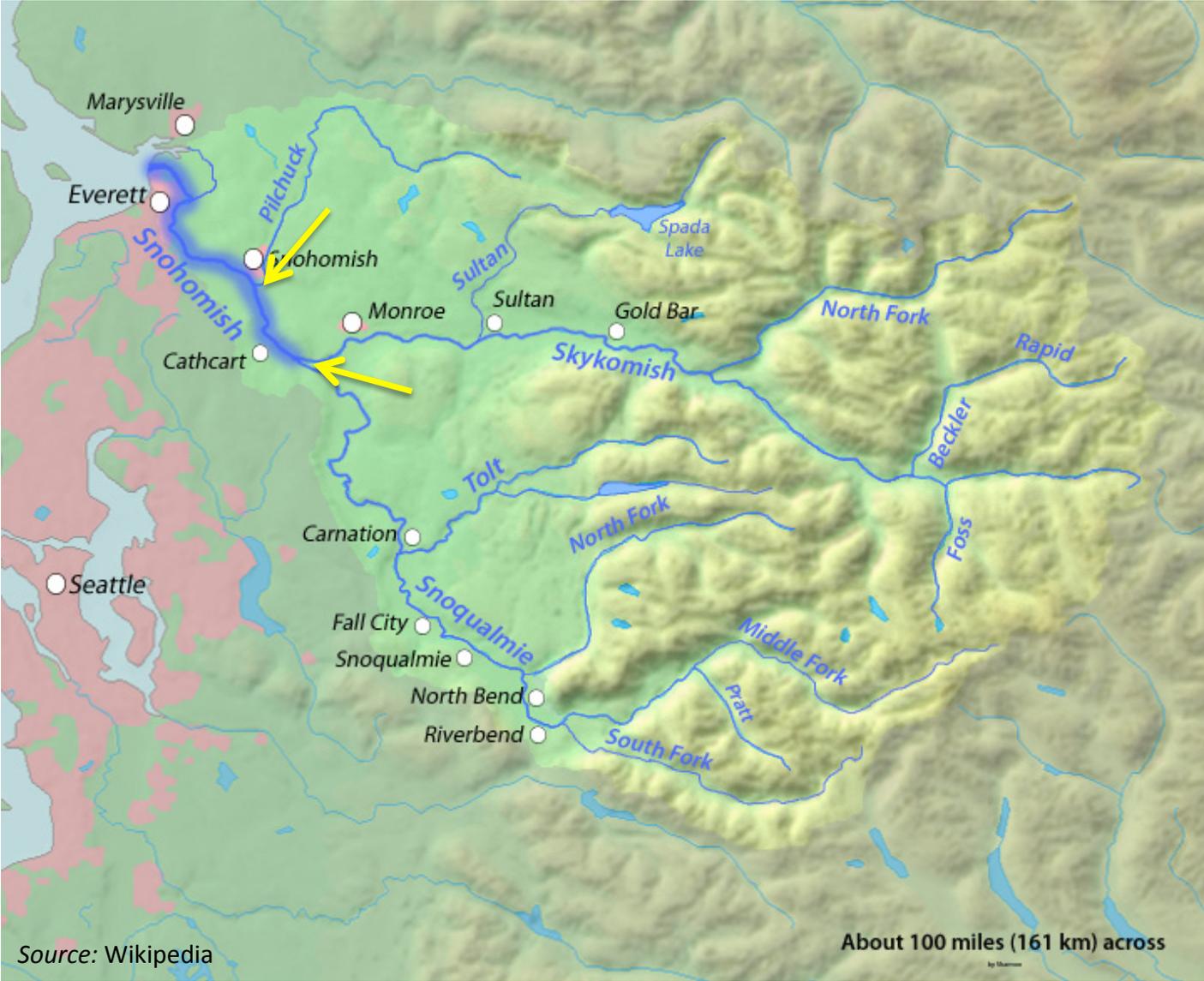
~~Waves +~~ (sheltered by Whidbey Island to the West)

Freshwater Runoff +

Sea Level Rise

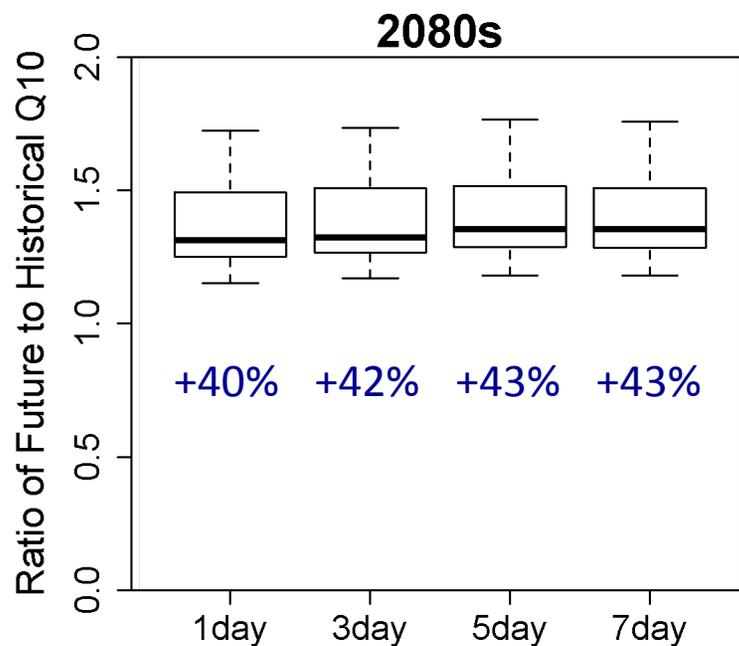
Coastal Flooding =
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Lower Snohomish River Basin



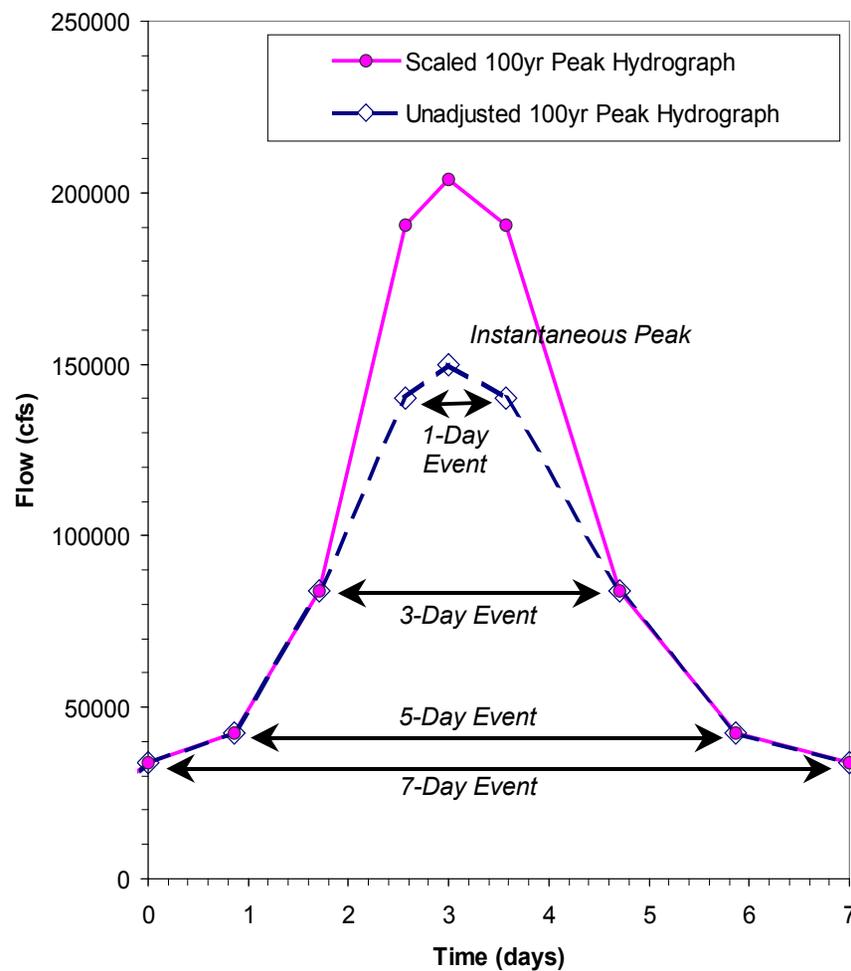
Synthetic peak flow hydrograph

e.g.: 10-year event,
Snohomish R. at Monroe:



Pilchuck:

+25% +25% +24% +24%



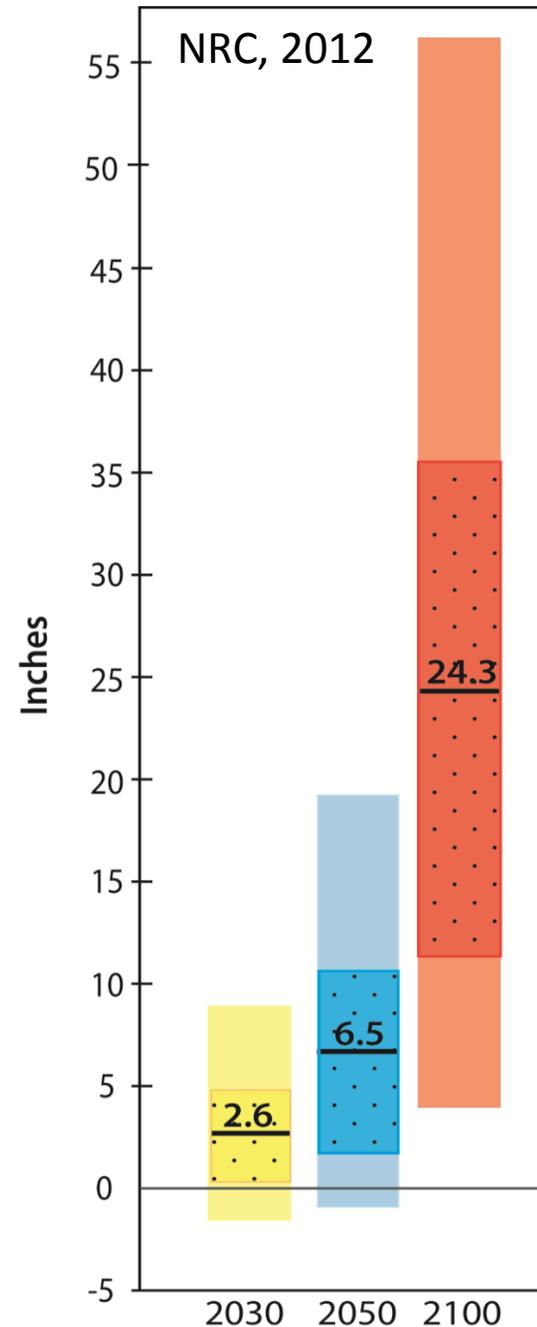
Source: Snohomish County, Restudy Flood Insurance Study, 2001

Coastal Flooding =
Storm Surge +
Tides +
Waves +
Freshwater Runoff +
Sea Level Rise

Sea Level Rise

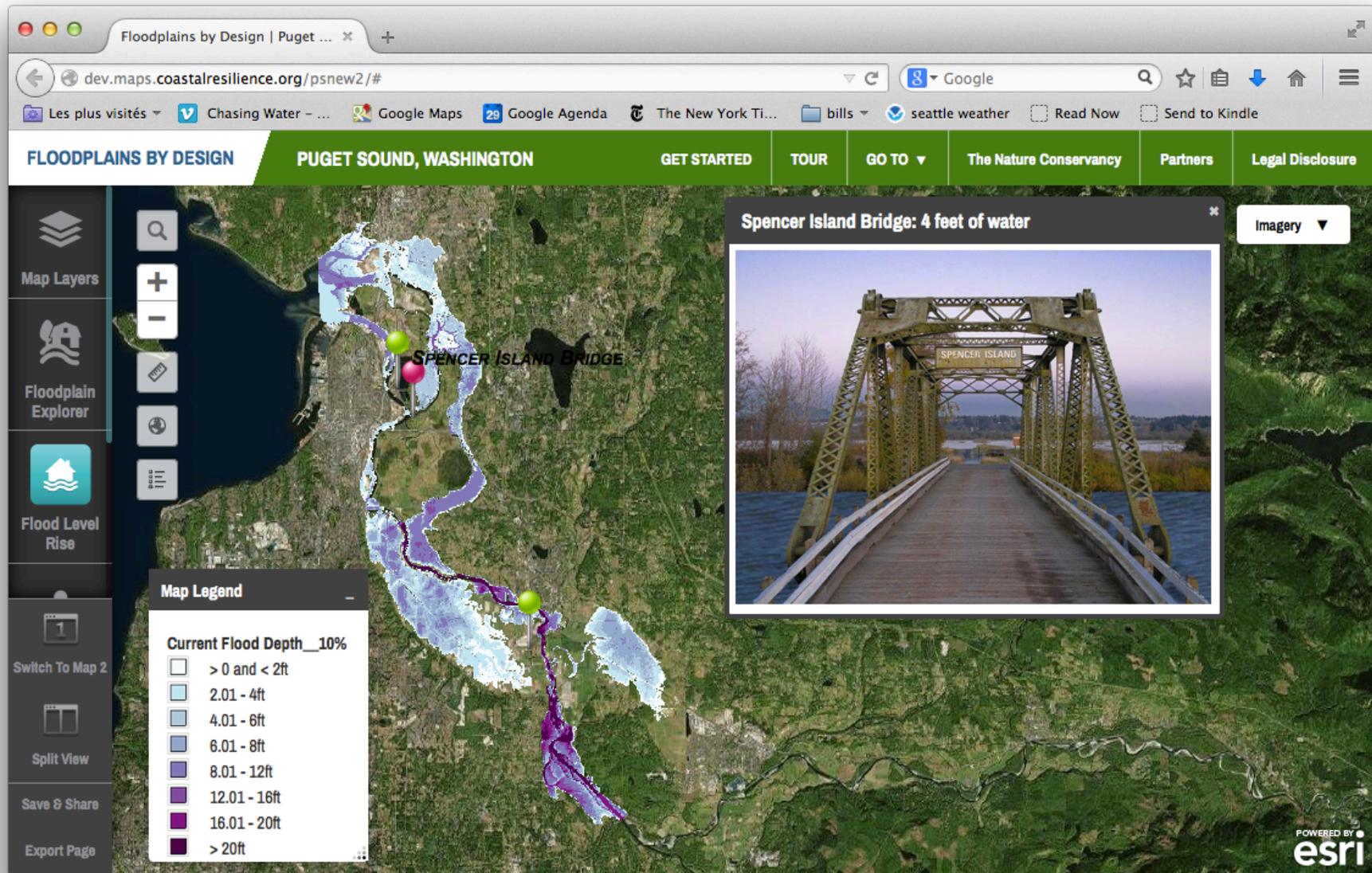
Projected Range, Snohomish <i>Relative to 2000 (NRC, 2012)</i>	
2040s	+5.5 to +9.1 inches
2080s	+13.2 to +25.3 inches

Based on estimated subsidence rate of 1 mm/yr for Anacortes, WA (NRC 2012)



Results

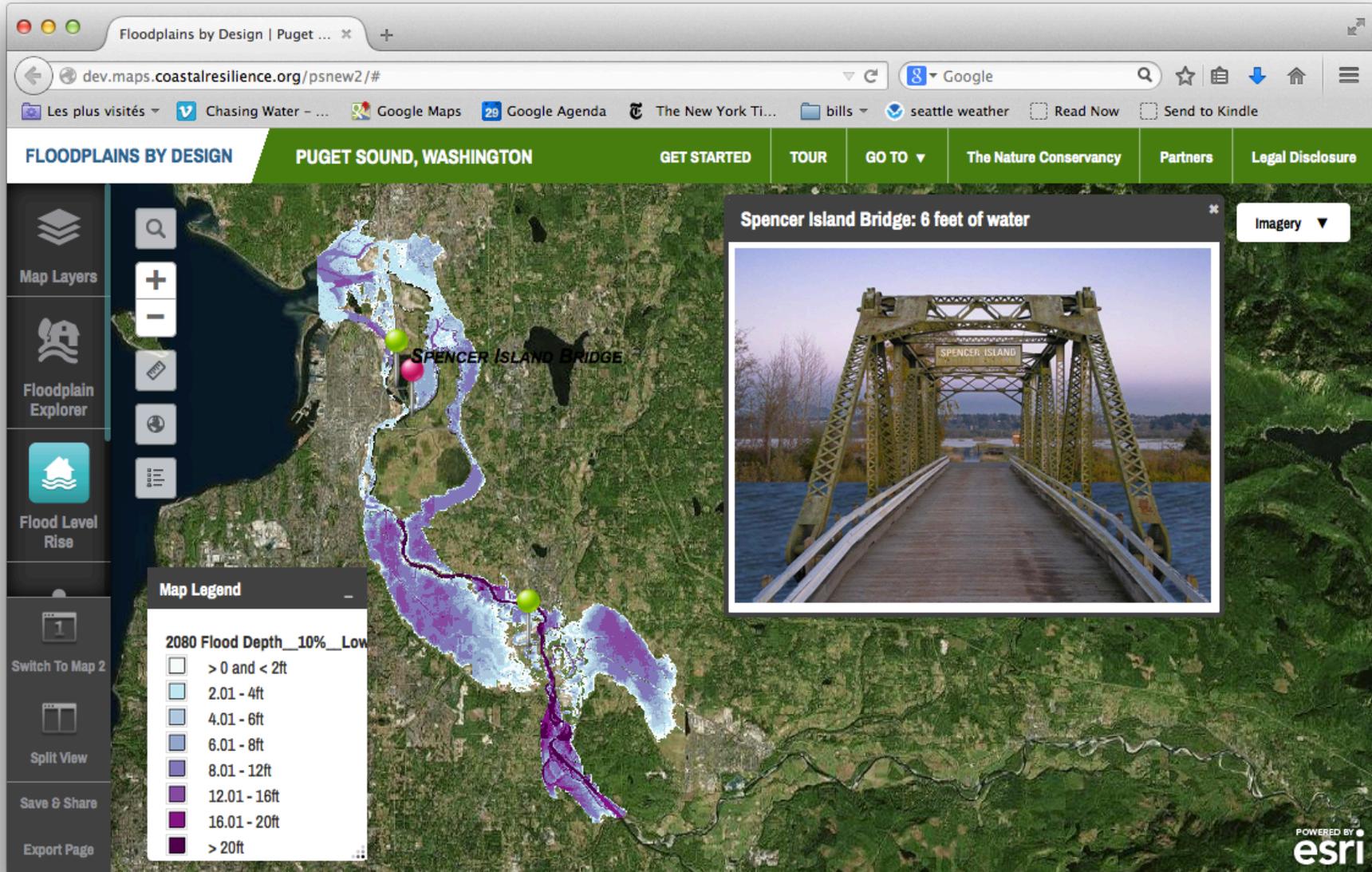
10-year Flood, Historical (1980s)



www.maps.coastalresilience.org/pugetsound

Results

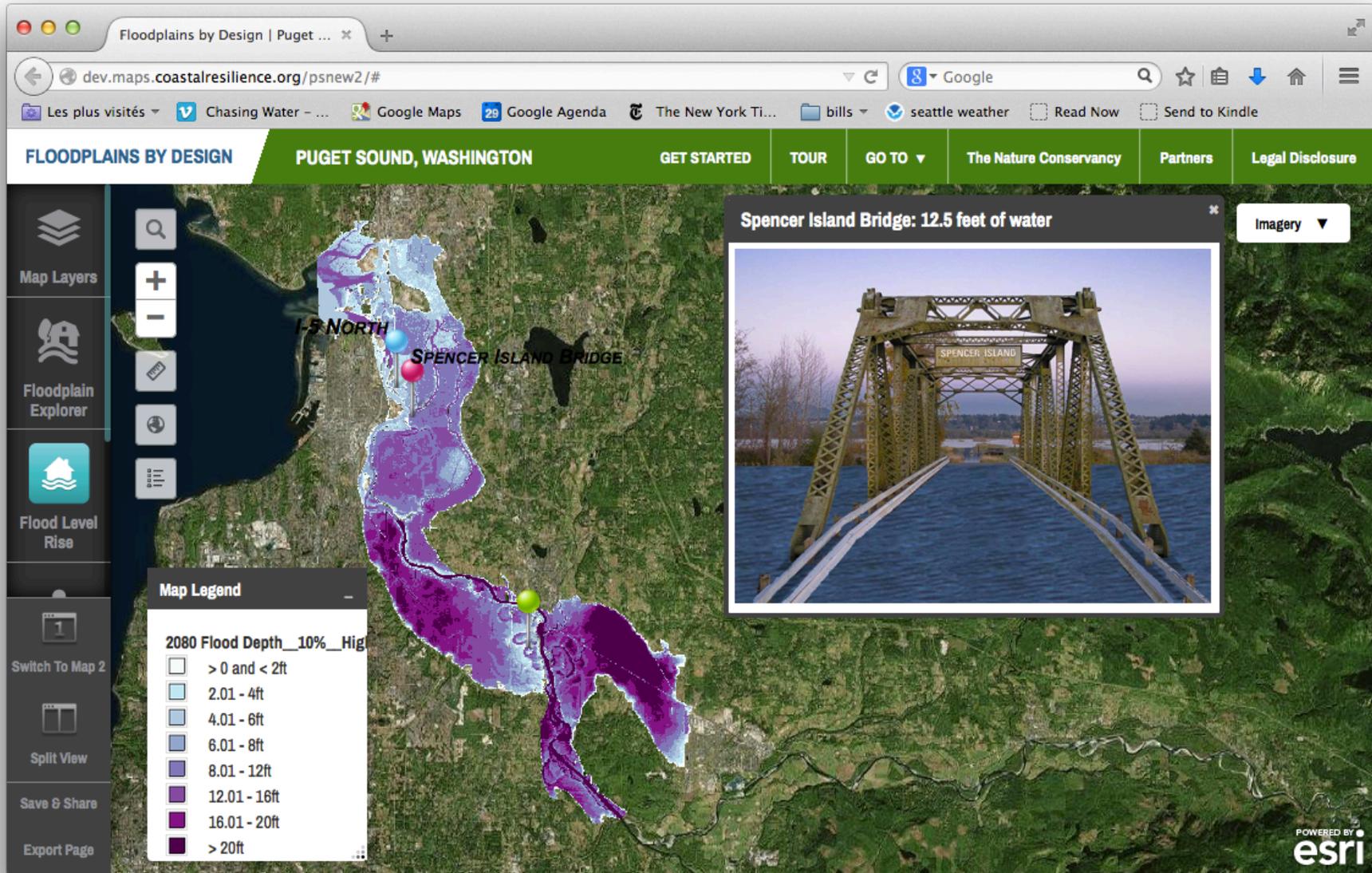
10-year Flood, A1b 2080s, Low



www.maps.coastalresilience.org/pugetsound

Results

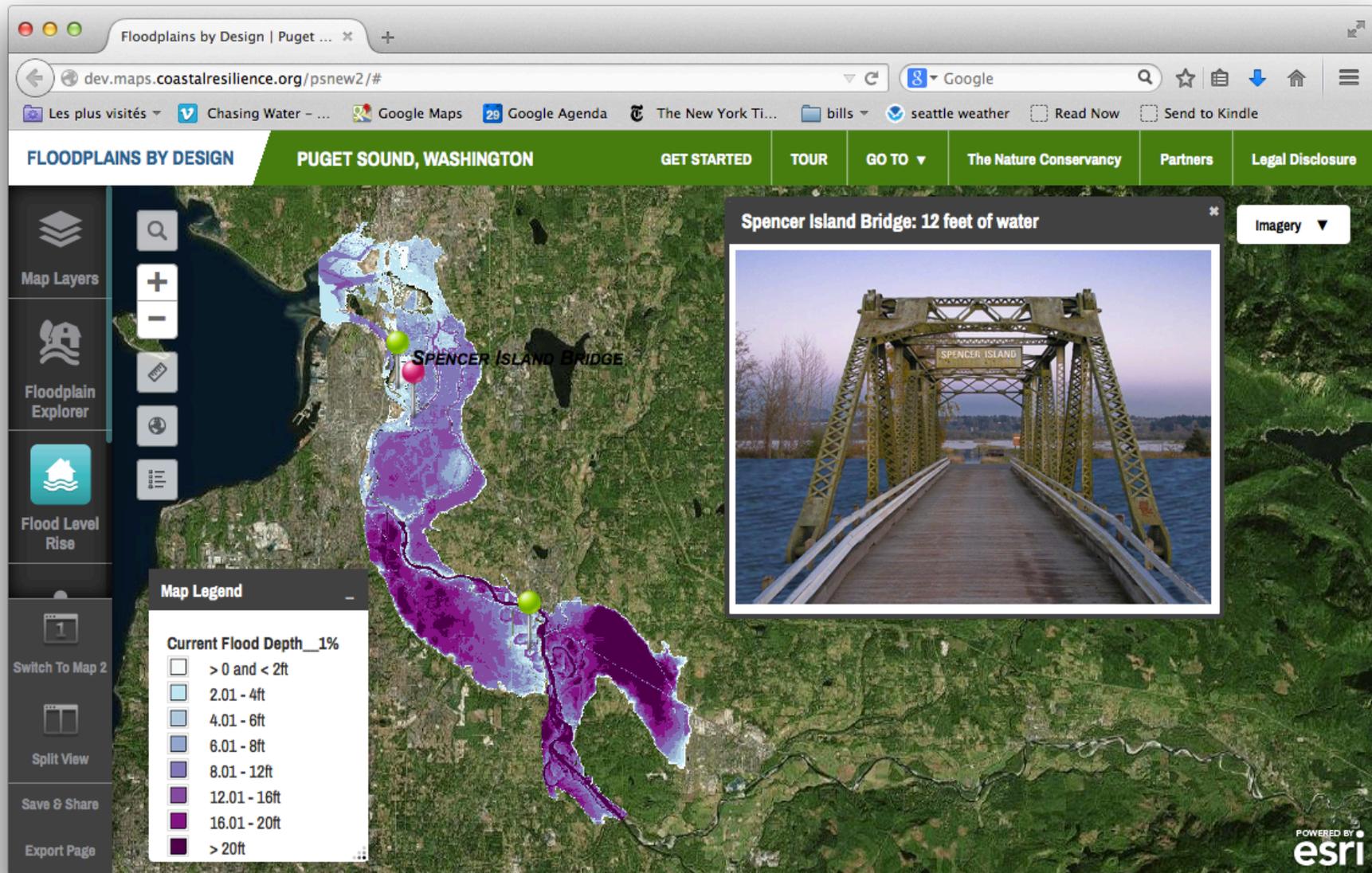
10-year Flood, A1b 2080s, High



www.maps.coastalresilience.org/pugetsound

Results

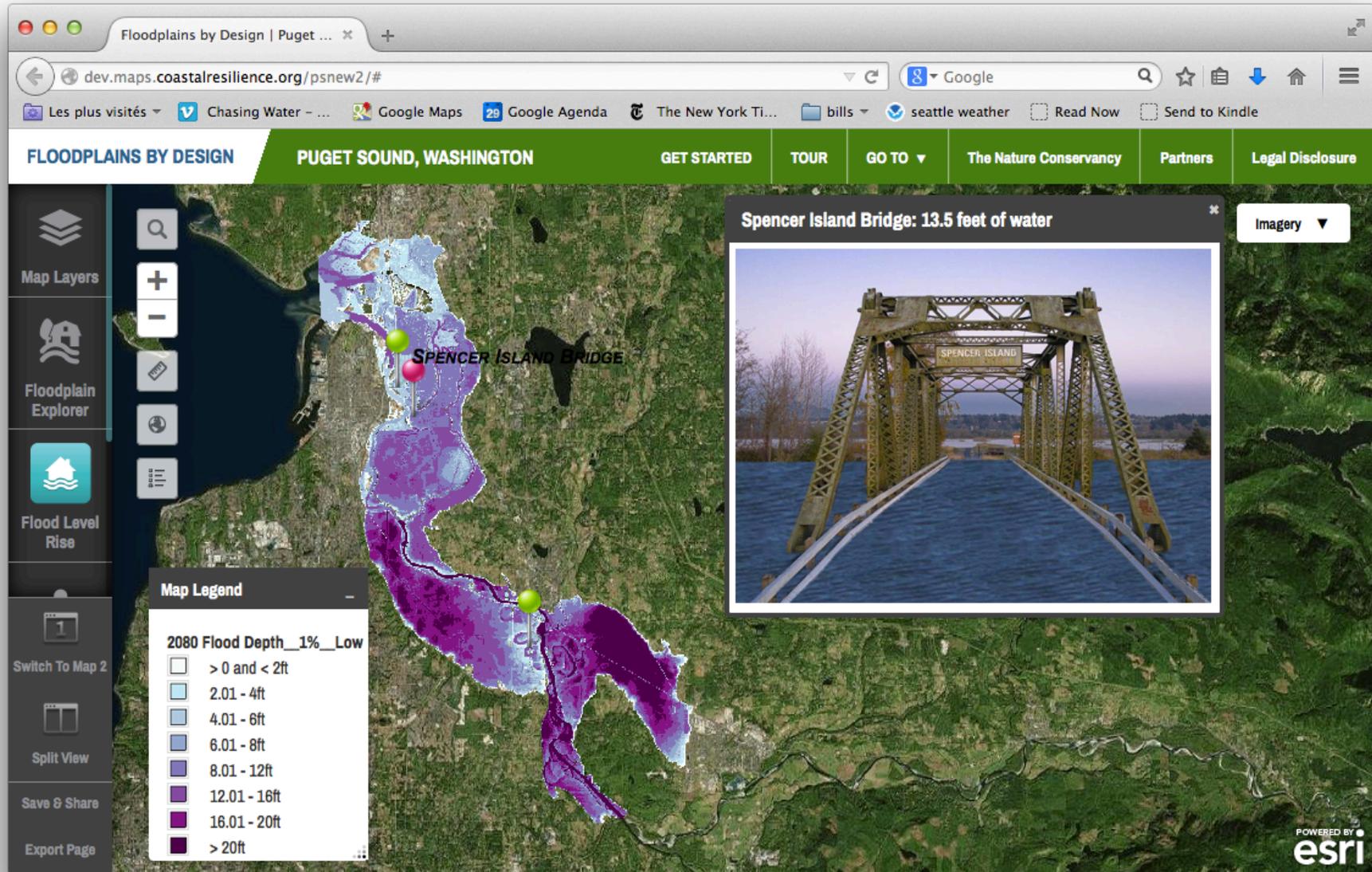
100-year Flood, Historical (1980s)



www.maps.coastalresilience.org/pugetsound

Results

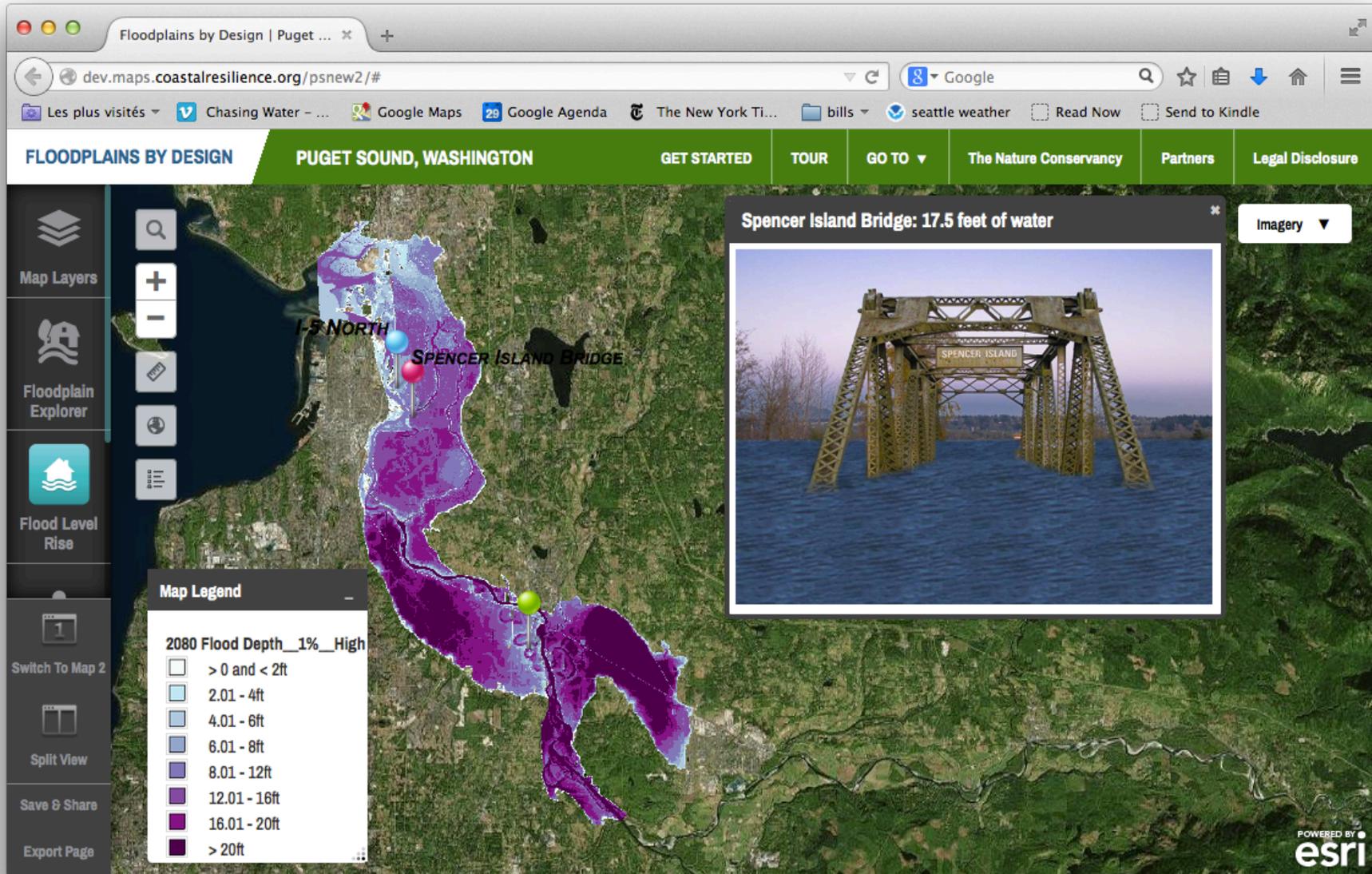
100-year Flood, A1b 2080s, Low



www.maps.coastalresilience.org/pugetsound

Results

100-year Flood, A1b 2080s, High



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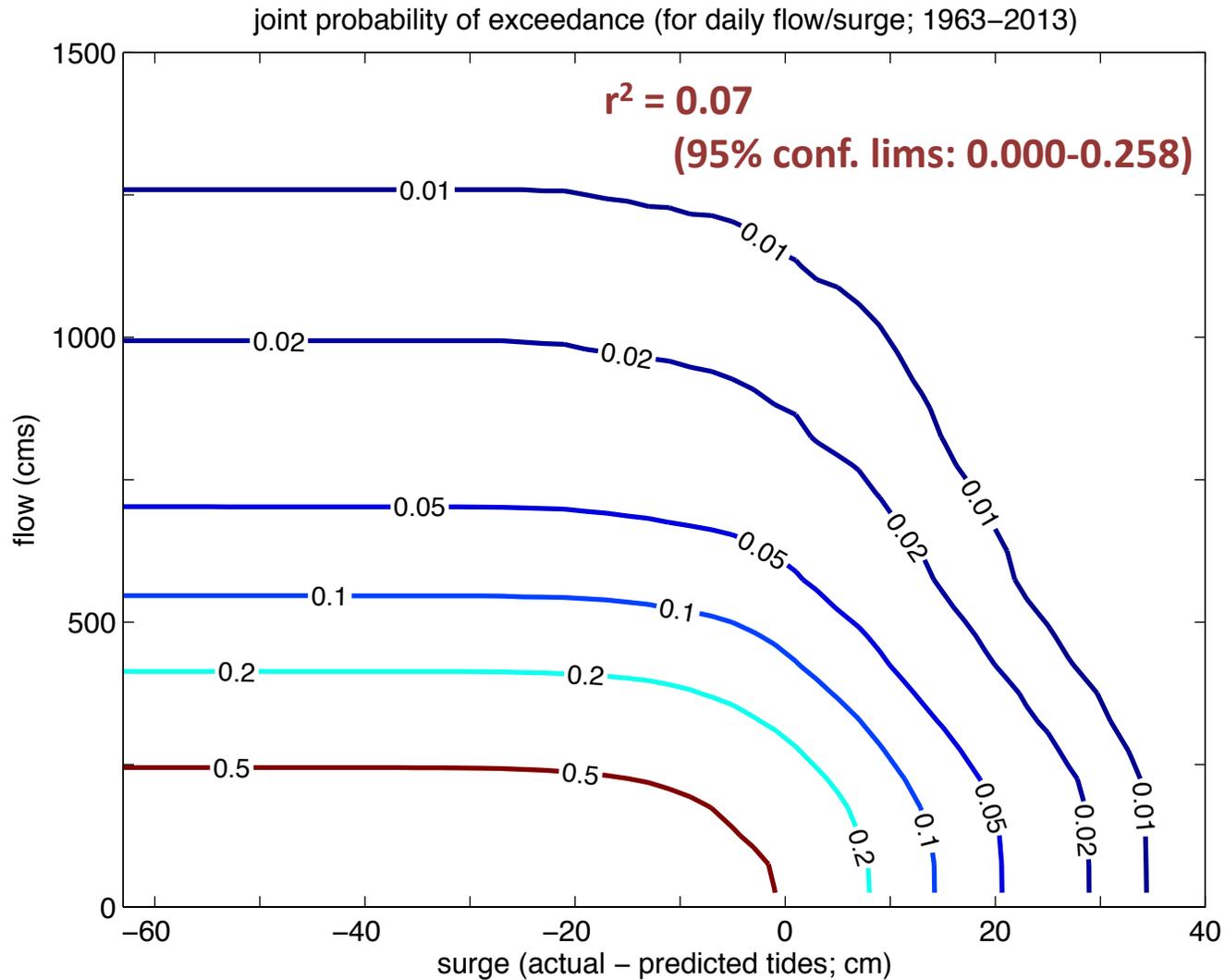
*Climate Science in the
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UW Climate Impacts Group

www.cses.washington.edu/cig

W COLLEGE OF THE ENVIRONMENT
UNIVERSITY of WASHINGTON

Surge and Peak Streamflow are *uncorrelated* in the Snohomish

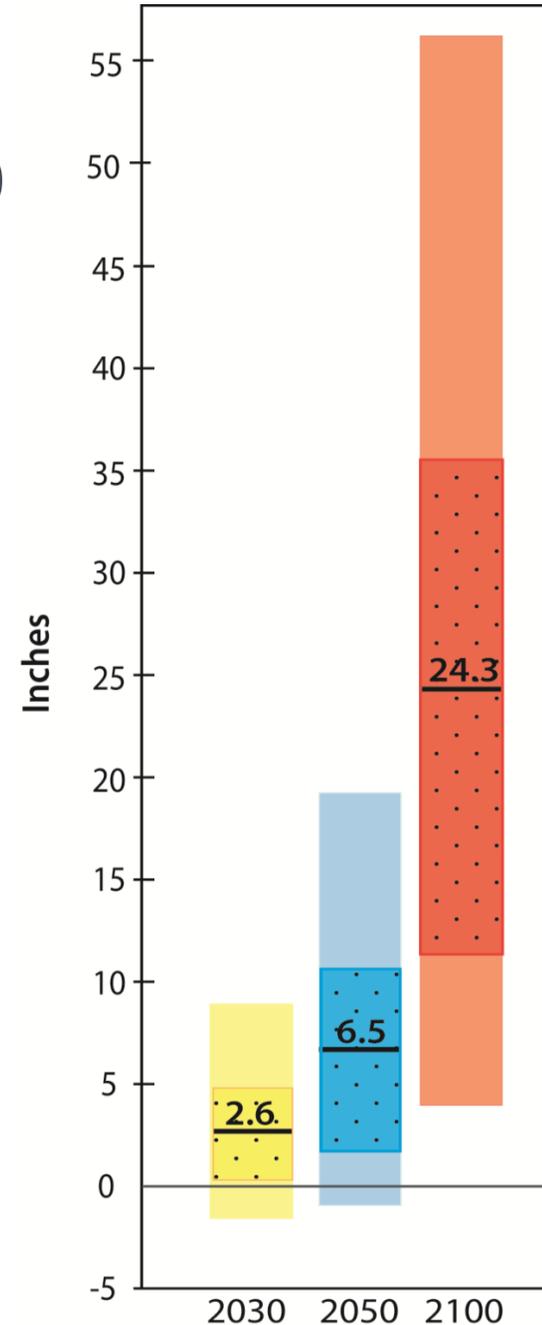




1. Sea Level Rise:

Projected in All Scenarios by 2100

Projected Range, Seattle <i>Relative to 2000 (NRC 2012)</i>	
2030	-1.5 to +8.8 inches
2050	-1.0 to +18.8 inches
20100	+3.9 to +56.3 inches



NRC 2012 vs. Mote et al. 2008

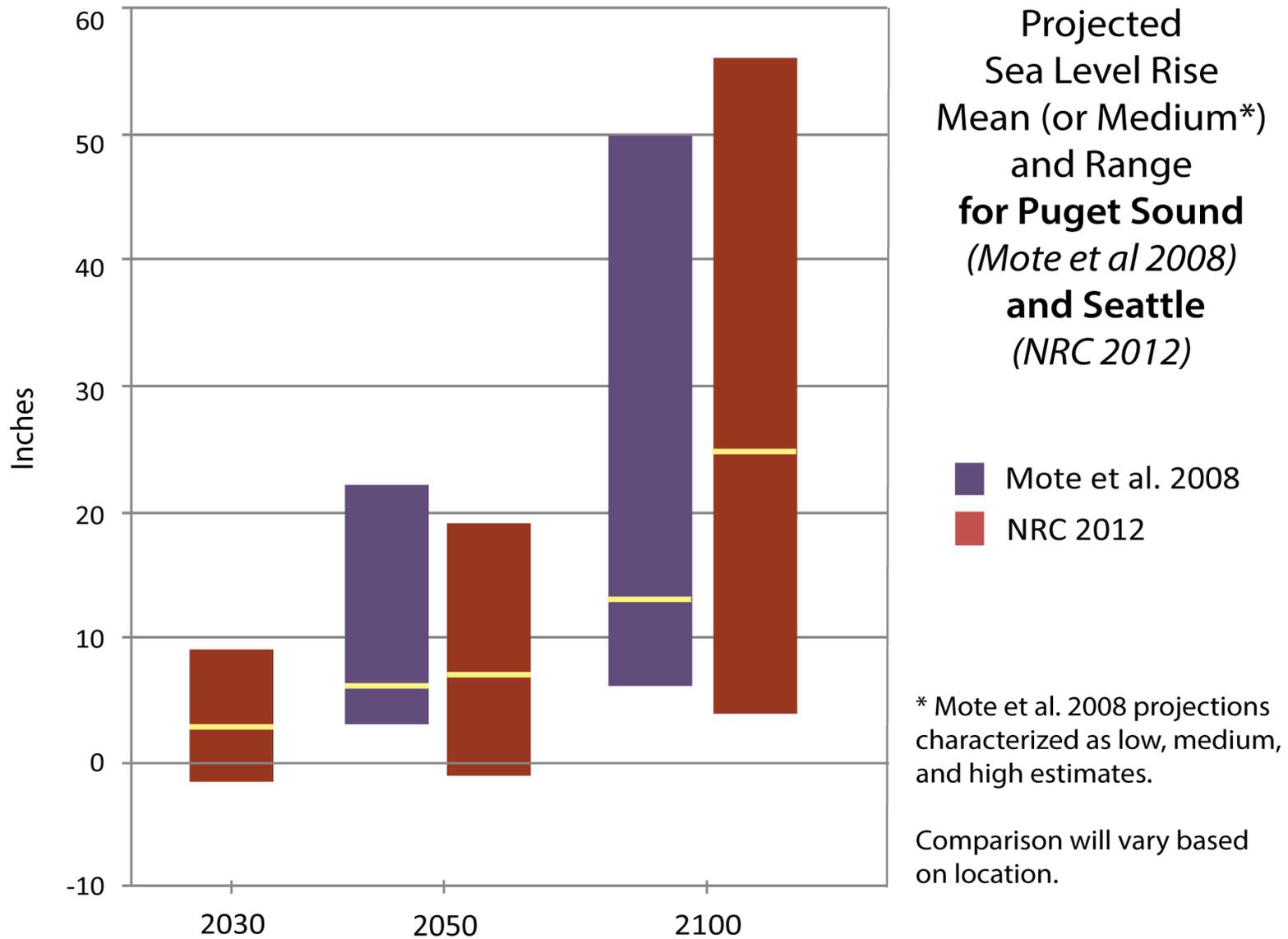
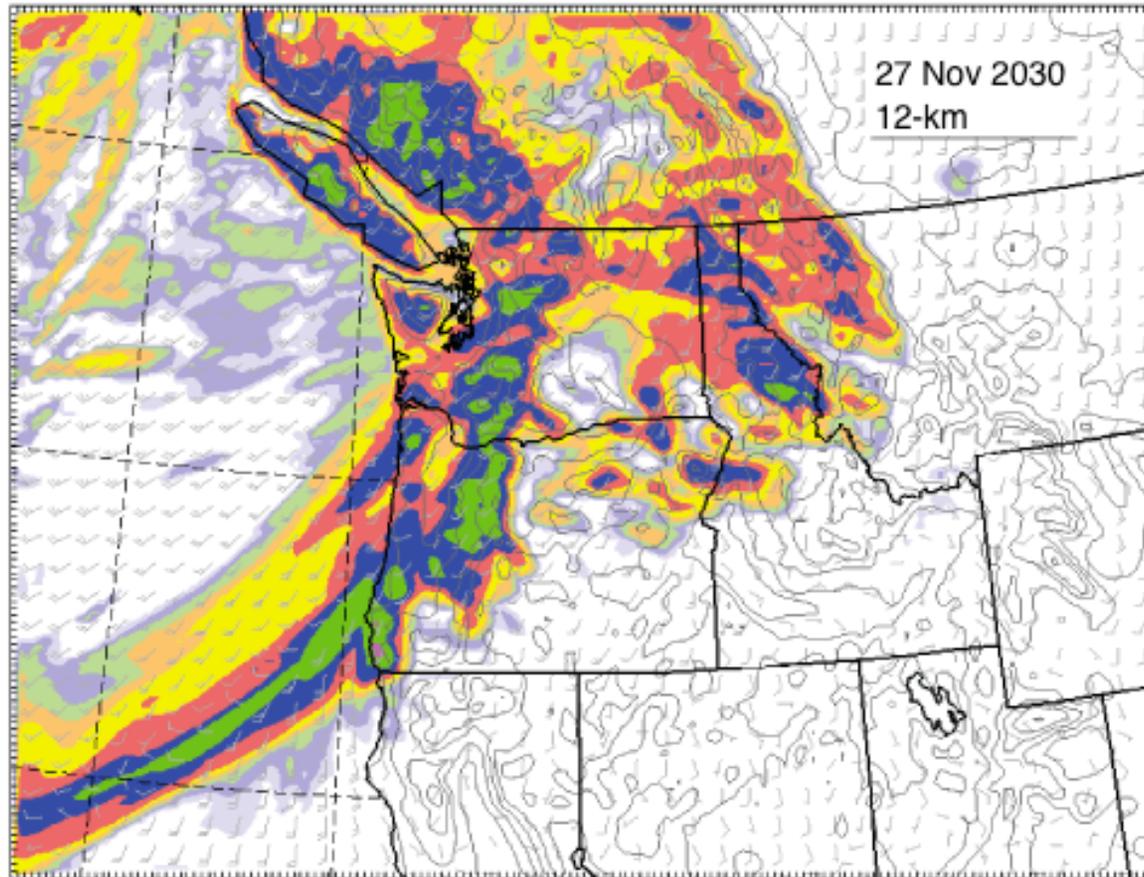


Figure source: Climate Impacts Group

EX5071-000028-TRB

2. Storms:

There is growing evidence that the frequency and intensity of severe storms will increase.



Simulated future storm from the WRF regional model.

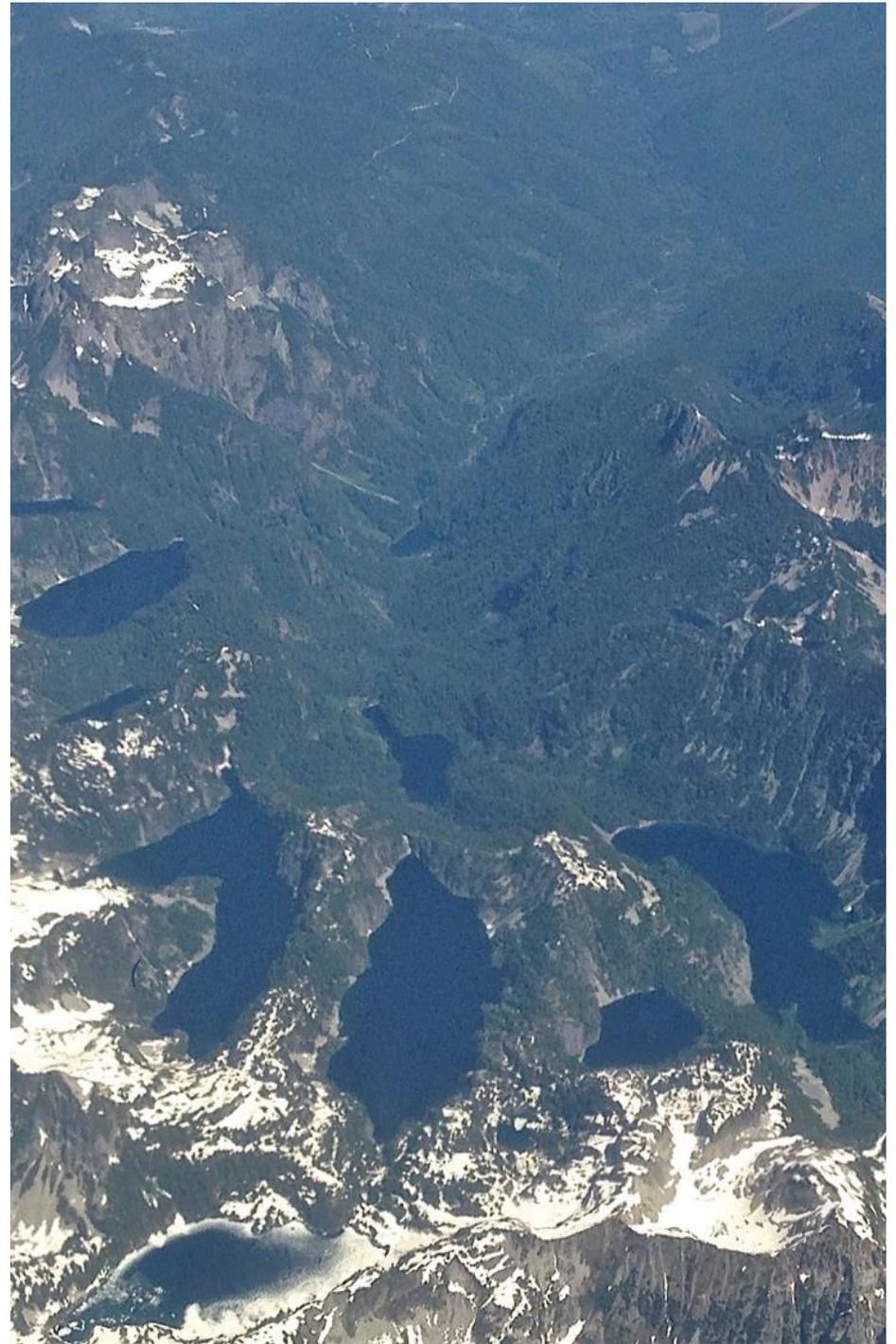
Salathé et al., in press, 2014

3. *Snow:*

Our primary mechanism for storing water – snow – is sensitive to warming.

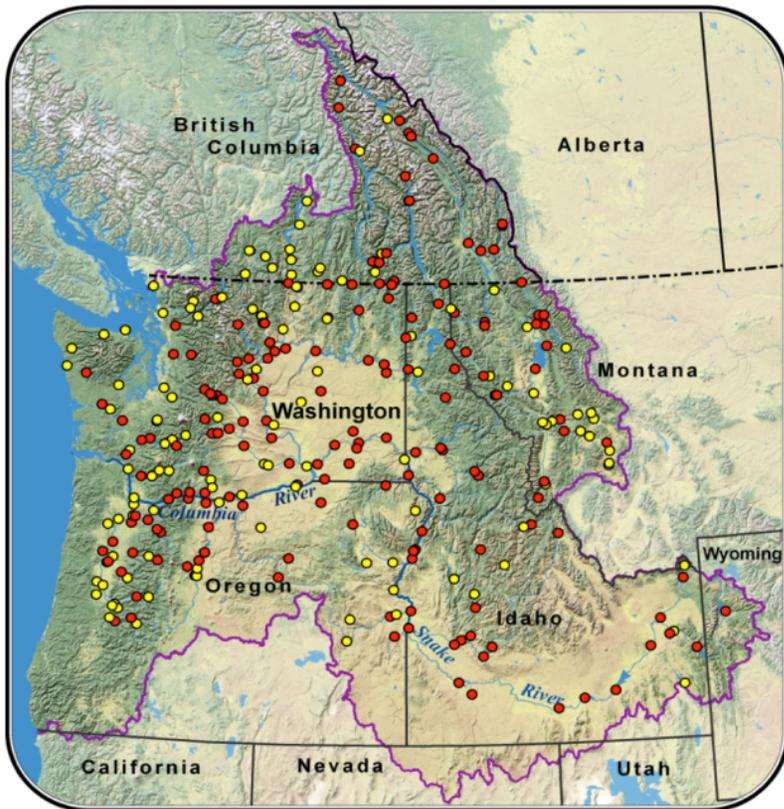
The Cascade and Olympic Mountains have the highest fraction of “warm snow” (snow falling between 27-32°F) in the continental U.S.

(Mote et al. 2008)

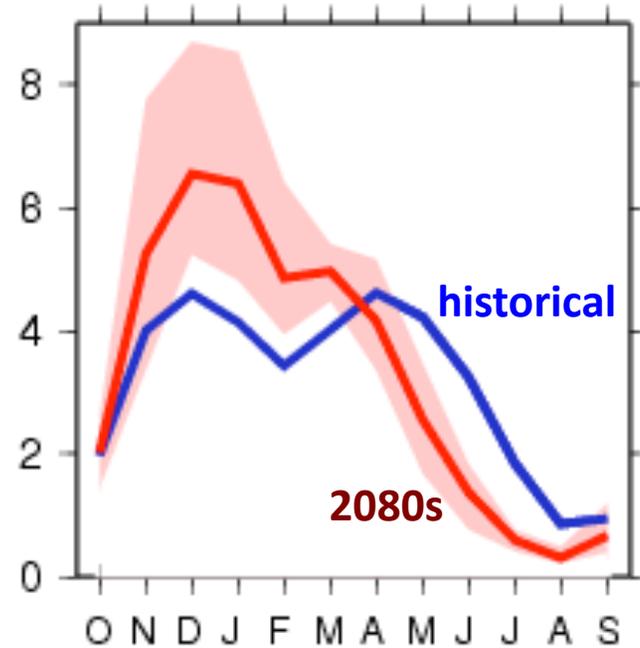




Higher peak streamflow



*Change in Monthly Streamflow
Snohomish at Monroe*

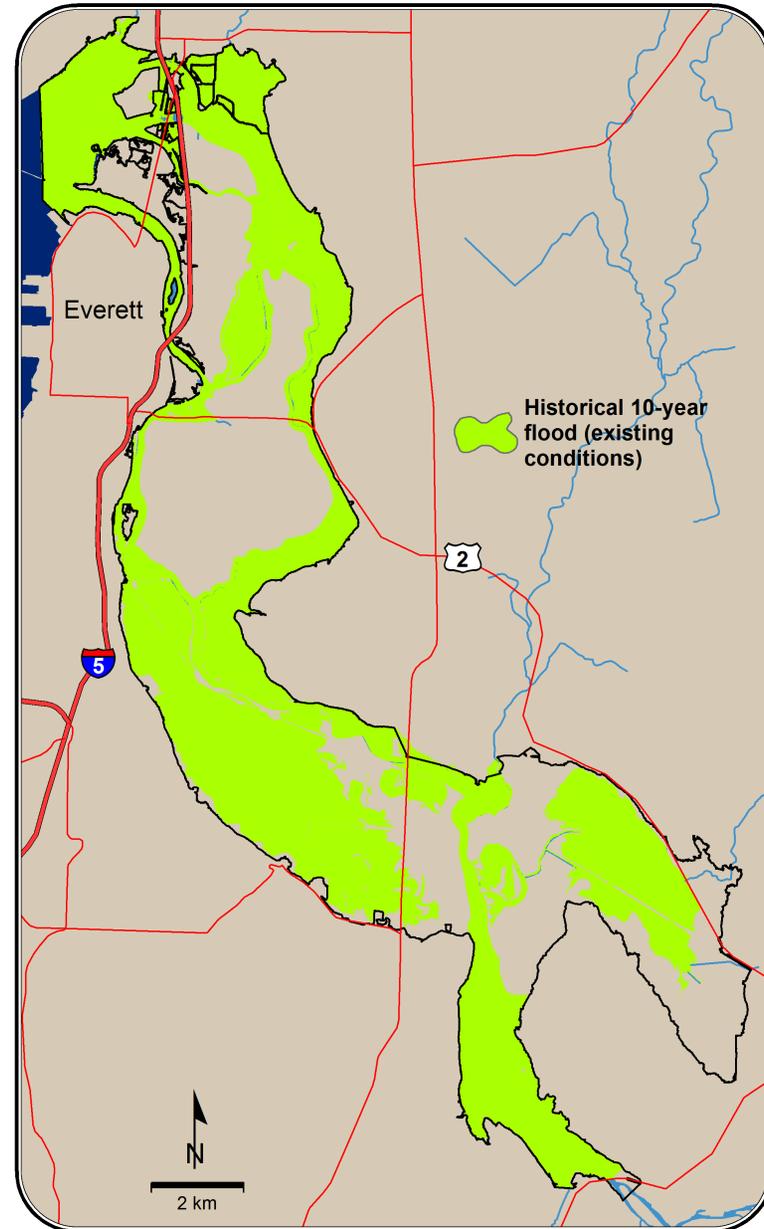


<http://warm.atmos.washington.edu/2860/>

Supported by Ecology (HB2860), BPA, NWPCC, ODWR, BC Ministry of Enviro

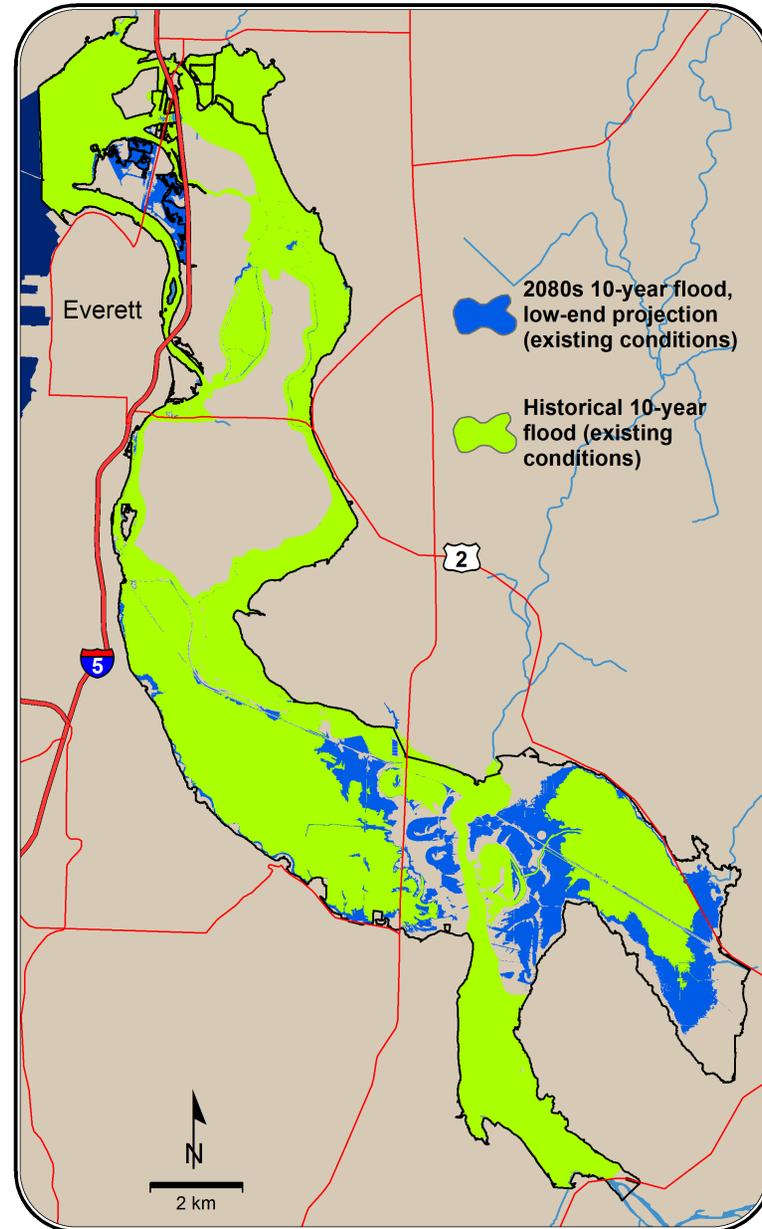
Flooded Area

10-year Flood
Historical (1980s)



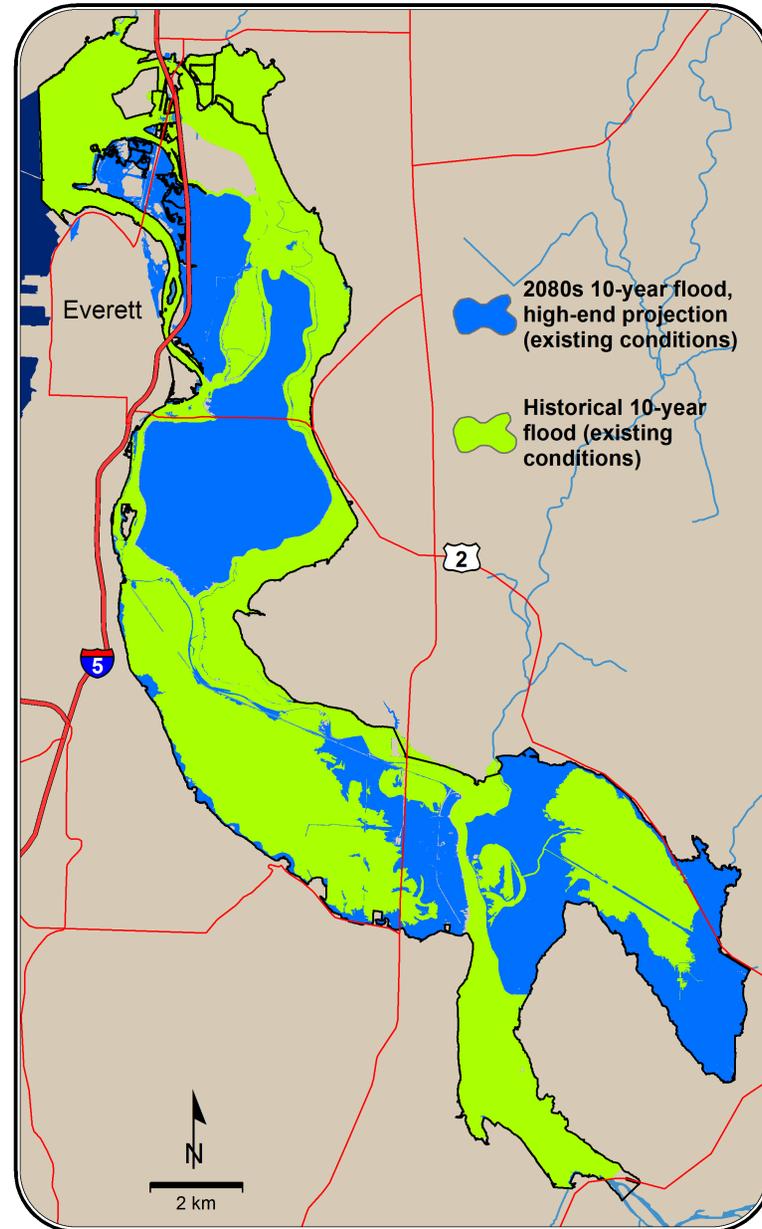
Flooded Area

10-year Flood
2080s, Low



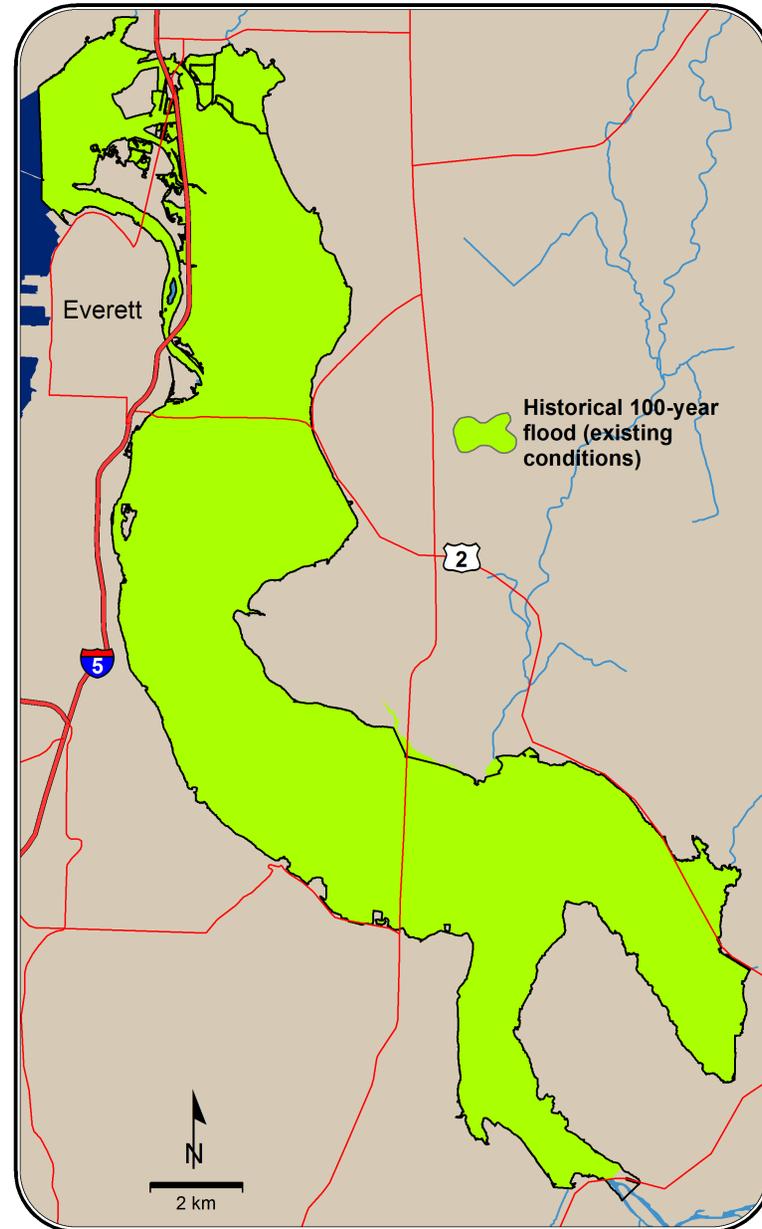
Flooded Area

10-year Flood
Historical



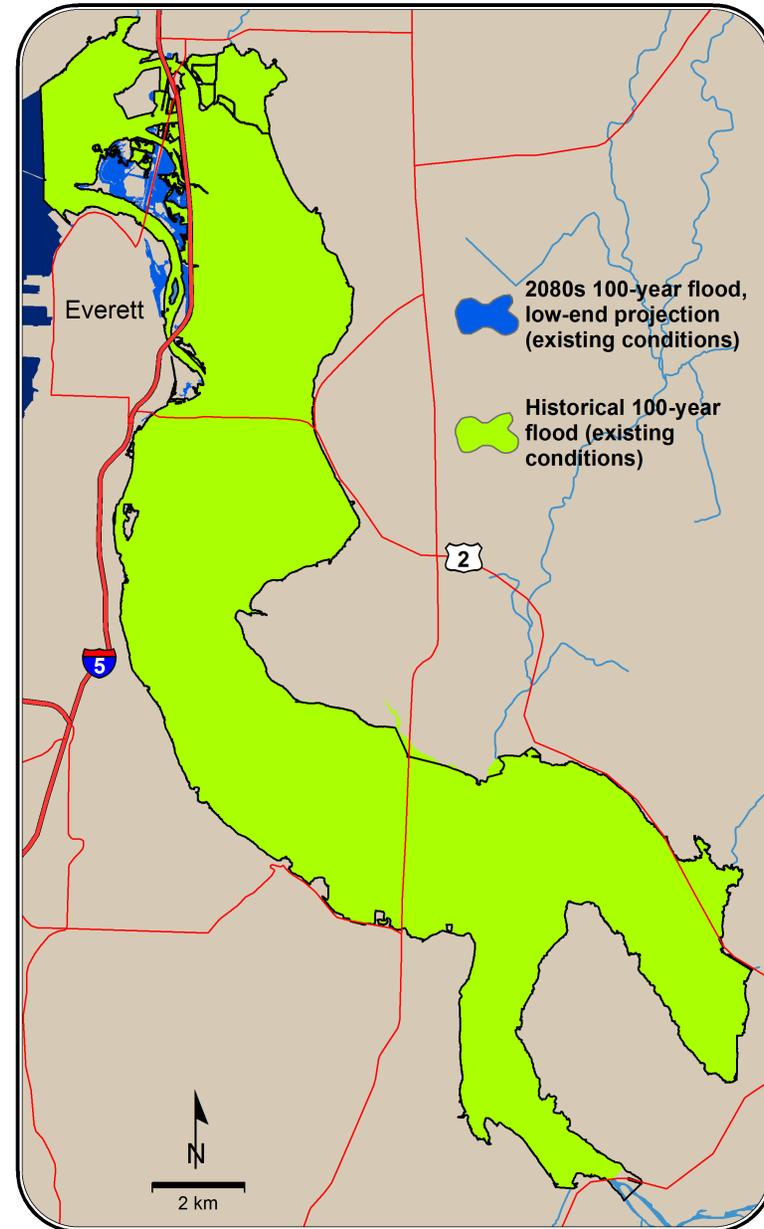
Flooded Area

100-year Flood
Historical (1980s)



Flooded Area

100-year Flood
2080s, Low



Flooded Area

100-year Flood *Historical*

