Apr 6th, 10:45 AM - 11:00 AM

Guidelines for mapping sea level rise and uncertainty

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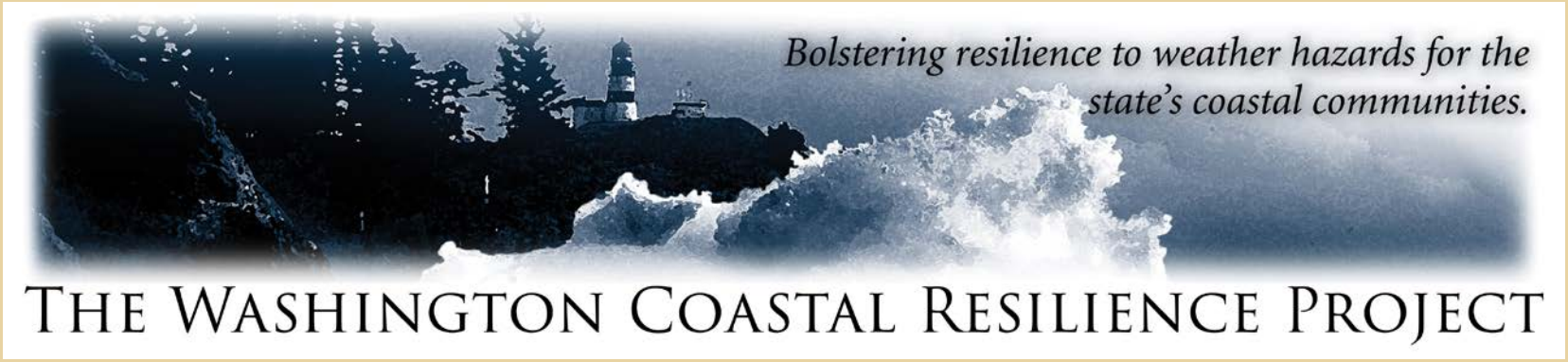


Guidelines for Mapping Sea Level Rise and Uncertainty

Robert Norheim and Guillaume Mauger

Climate Impacts Group, University of Washington

Coastal Resilience Project Partners

King County

Funding provided by NOAA Regional Coastal Resilience Grants Program

Mapping Coastal Inundation

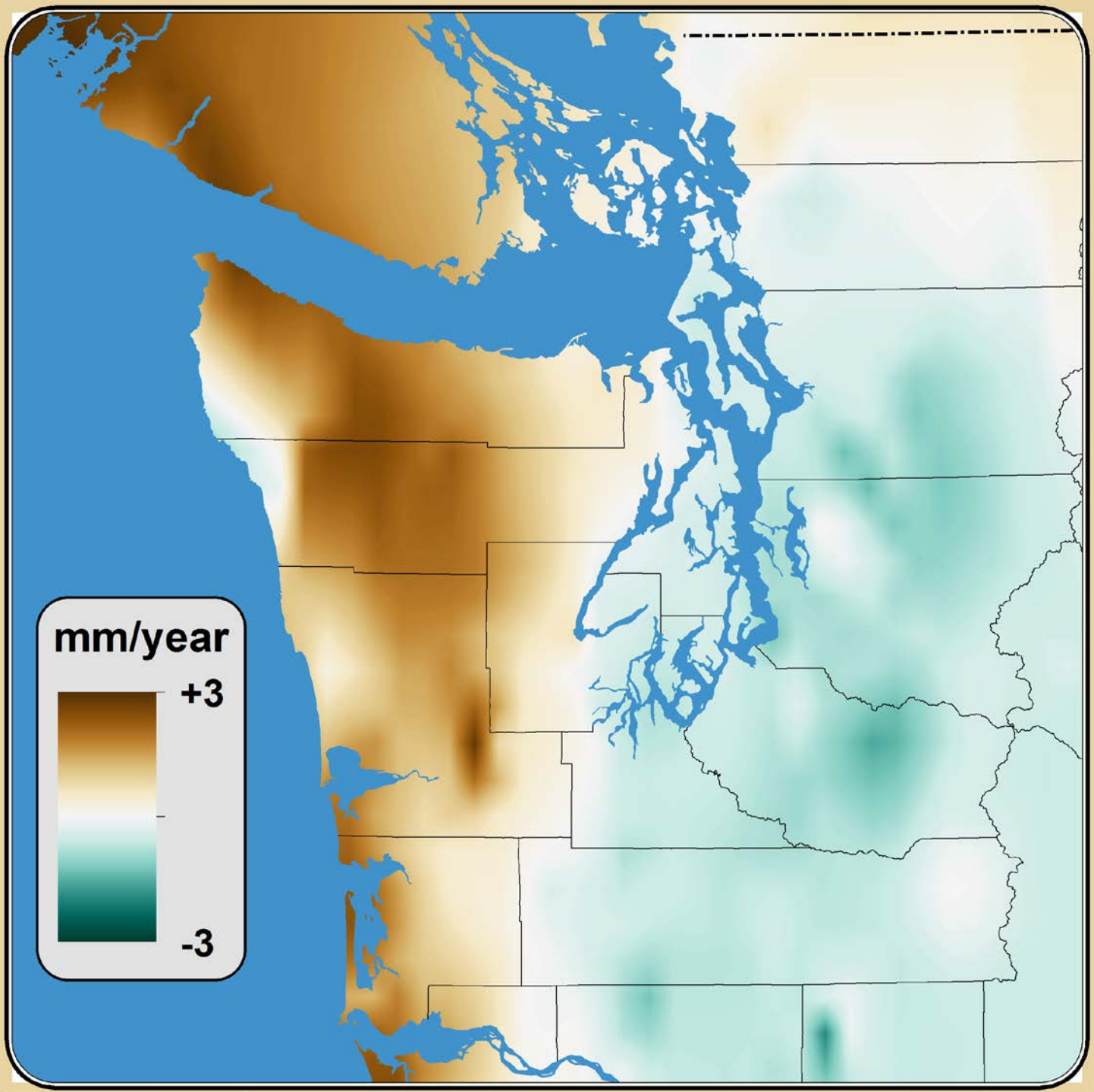
- NOAA's Office of Coastal Management provides excellent guidelines, data, and training for mapping inundation
- Our project adds to this
  - Local relative sea level rise projections
  - Advice on choosing which projections to use
  - Recommendations for local elevation data
  - Instructions for preparing the elevation data
  - Recommendations on symbolization

This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement PC-01J22301 through the Washington Department of Fish and Wildlife.

Relative Sea Level Rise

- Sea level rise (SLR) varies spatially due to many factors
  - Ocean currents
  - Wind patterns
  - Gravitational potential
- SLR can be mitigated or enhanced by vertical land motion (VLM)
  - Tectonic forces
  - Post-glacial (Isostatic) rebound
  - Sediment compaction
  - Groundwater pumping
- SLR + VLM = Relative Sea Level Rise

Vertical Land Motion



Probabilistic Projections: Relative SLR in Seattle

		Most Likely to Occur		Lower Likelihood of Exceedance		
20-year period centered on:	Green House Gas Scenario	Central Estimate (50%)	Likely Range (83-17%)	Very Unlikely (10%)	Exceptionally Unlikely (1%)	Project Upper Limit (0.1%)
2050	RCP 2.6	0.7	0.5 – 1.0	1.0	1.4	2
	RCP 4.5	0.8	0.6 - 1.0	1.1	1.4	2
	RCP 6.0	0.8	0.6 - 0.9	1.0	1.3	1.9
	RCP 8.5	0.8	0.6 – 1.1	1.1	1.5	2.2
2100	RCP 2.6	1.7	1.1 – 2.3	2.6	4.3	7.6
	RCP 4.5	1.9	1.3-2.5	2.8	4.4	7.6
	RCP 6.0	1.9	1.4-2.5	2.8	4.4	7.8
	RCP 8.5	2.3	1.7-3.1	3.4	5.1	.6
2150	RCP 2.6	2.4	1.5 – 3.6	4.2	8.5	16.4
	RCP 4.5	3.0	1.9-4.3	4.9	8.9	16.7
	RCP 6.0	*	*	*	*	*
	RCP 8.5	3.9	2.8-5.4	6.1	10.4	18.7

*Projections are expressed in **ft.** relative to 1990-2010 avg.*

Elevation data

- Central estimate of RSLR is about 2 feet by 2100
- Elevation data with excellent vertical accuracy and resolution is essential to mapping inundation
- Lidar data ideal for this purpose
- Lidar data available for most of the Washington coast from the Puget Sound Lidar Consortium
- Data also available from the WA DNR Lidar Portal

Preparing elevation data

- Hydraulic continuity
  - Low-lying inland areas may or may not be hydraulically connected to the sea
  - Dykes, levees, culverts, stormwater infrastructure: not accurately represented in DEM
  - Need to correct DEM with accurate elevations
  - Alternatively, map inundation and look for low-lying areas, then determine whether connected hydraulically
- Hydro-flattening
  - Lidar DEM may average heights across narrow bodies of water
  - Need accurate coastline geodata to correctly mask DEM

Hydro-flattening example

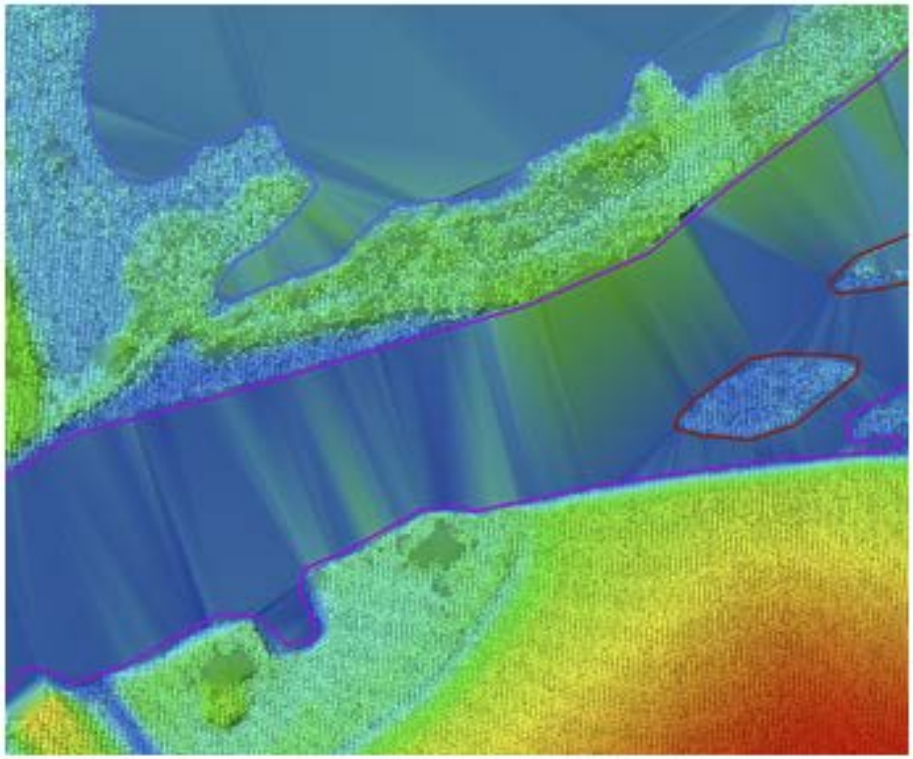


Figure 1. Sample – Hydro Flattening Not Applied

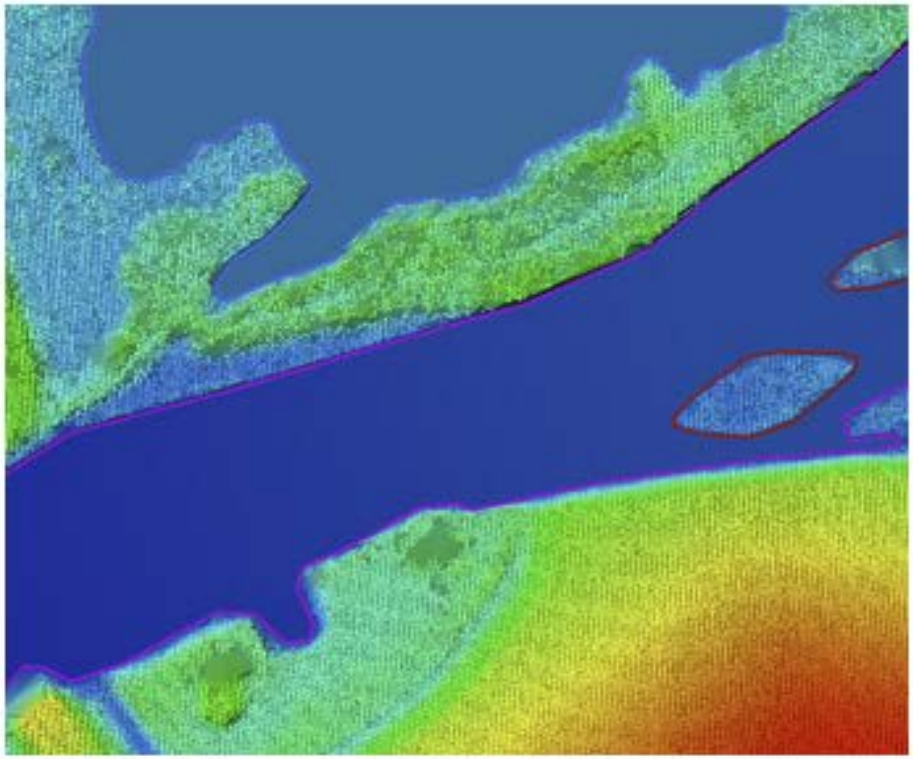


Figure 2. Sample – Hydro Flattening Applied

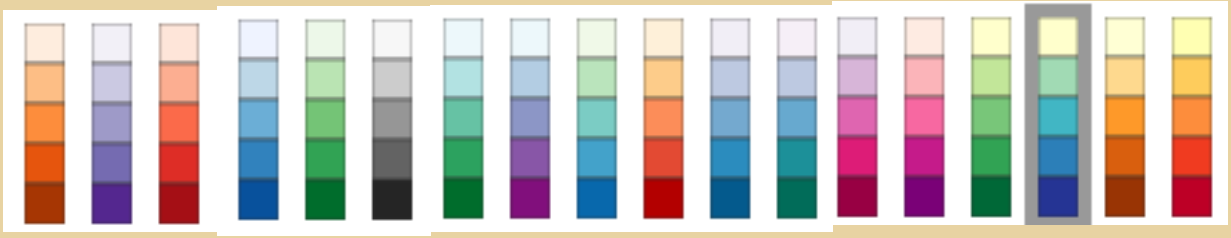
http://www.sanborn.com/hydro-flattening-case-study/

Vertical datums

- To map coastal inundation, RSLR is added to high tide (mean higher high water, MHHW)
- MHHW is a tidal datum -- locally specific
  - Accuracy depends on distance from tide gages
- Digital elevation models (DEM) from lidar surveys are based on mean sea level on NAVD88, an orthometric datum
- Need to create a MHHW surface based on NAVD88
- NOAA's VDATUM tool accomplishes this
- NOAA provides a MHHW surface for the entire USA excluding Alaska

Map symbolization

- Different attributes of RSLR projections can be mapped
  - Decade, Greenhouse Gas Scenario, Probability of Exceedence, Inundation Depth
- Best to map an even number of scenarios
  - Users tend to use central scenario if odd number shown
- Ordered numerical data: use sequential color scheme
  - Light to dark represents “less” to “more”
  - Examples from ColorBrewer2:

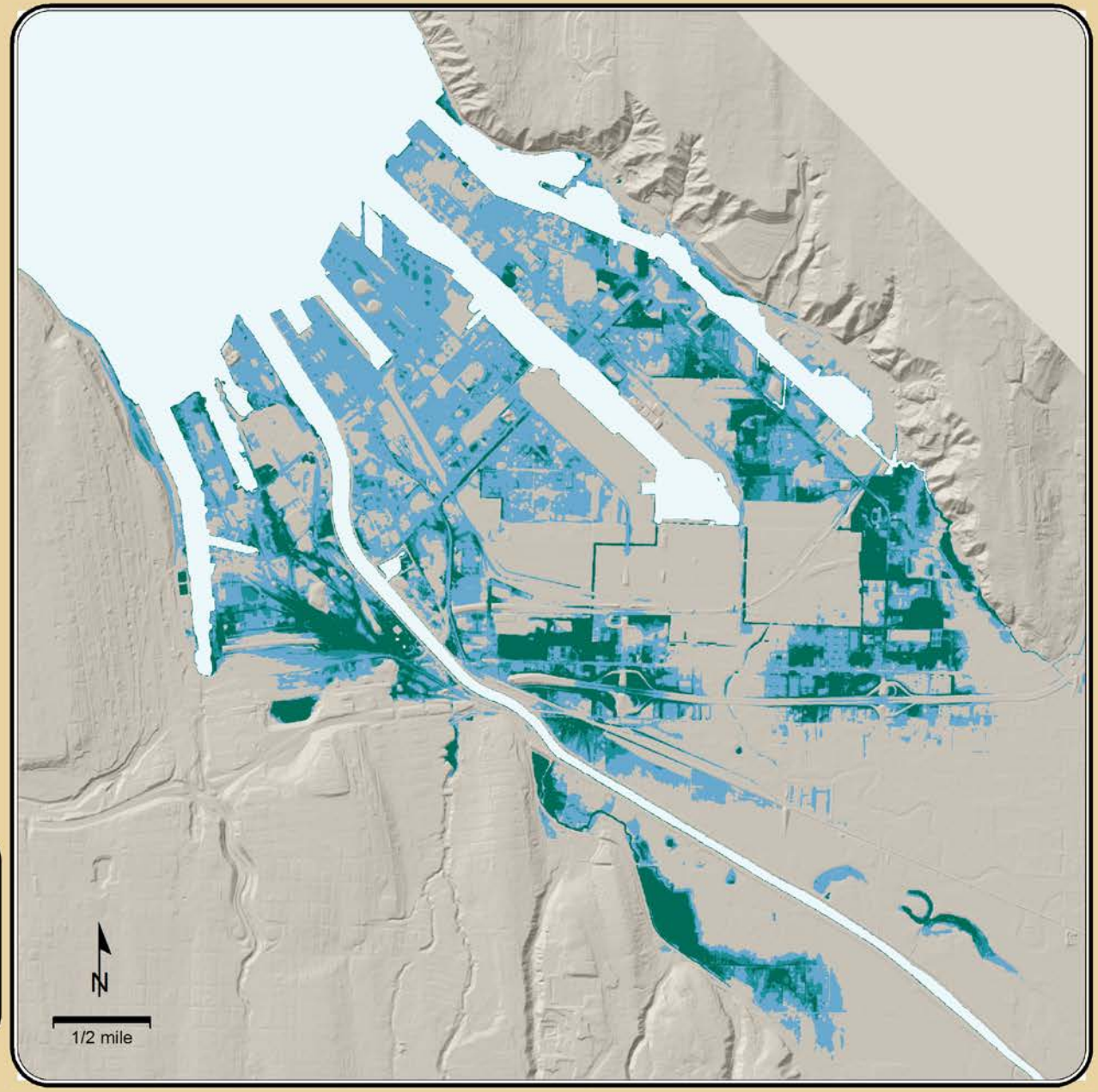


Mapping Sea Level Rise

Port of Tacoma

Symbology Examples

Varying Greenhouse Gas Scenario



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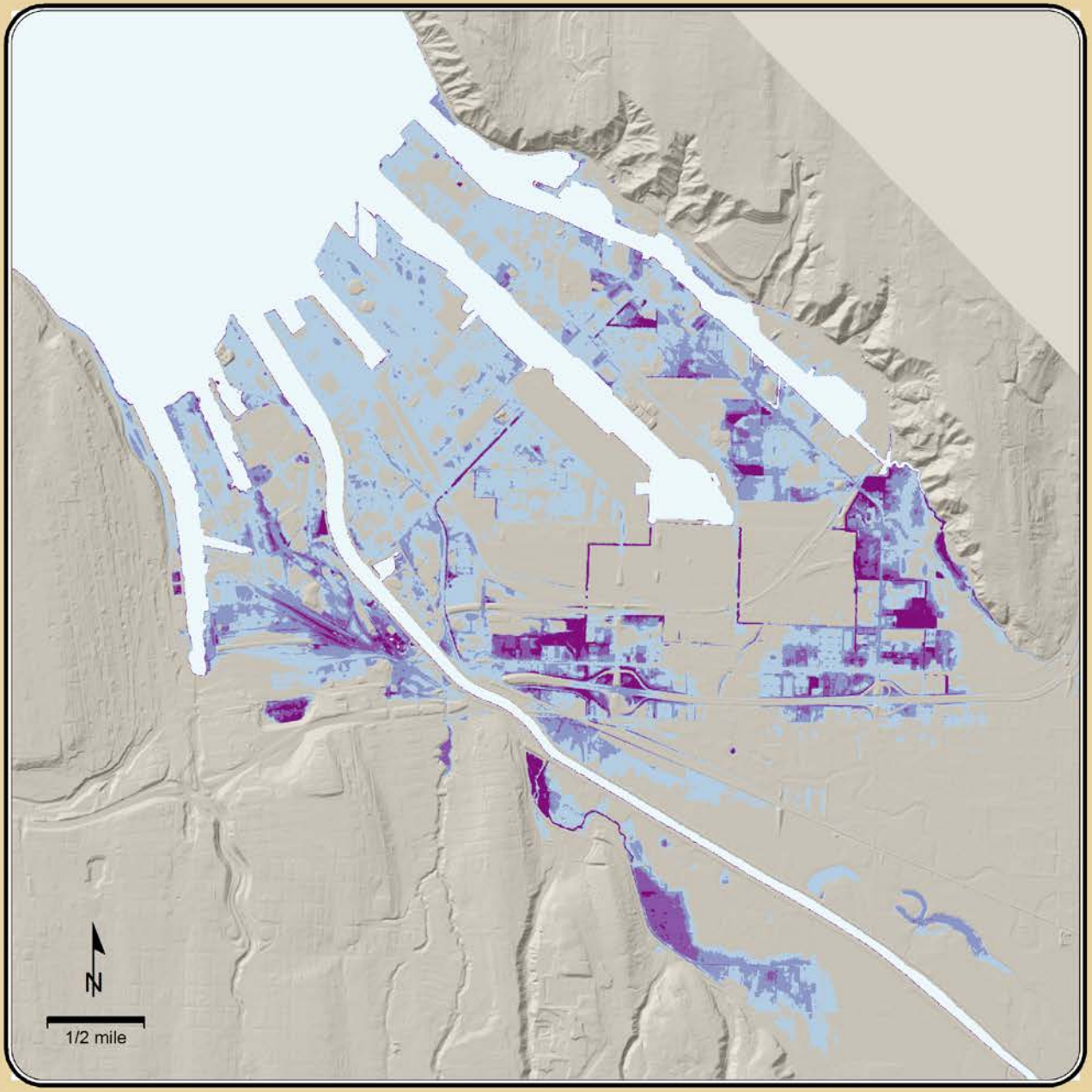
Symbology Examples

Varying Year



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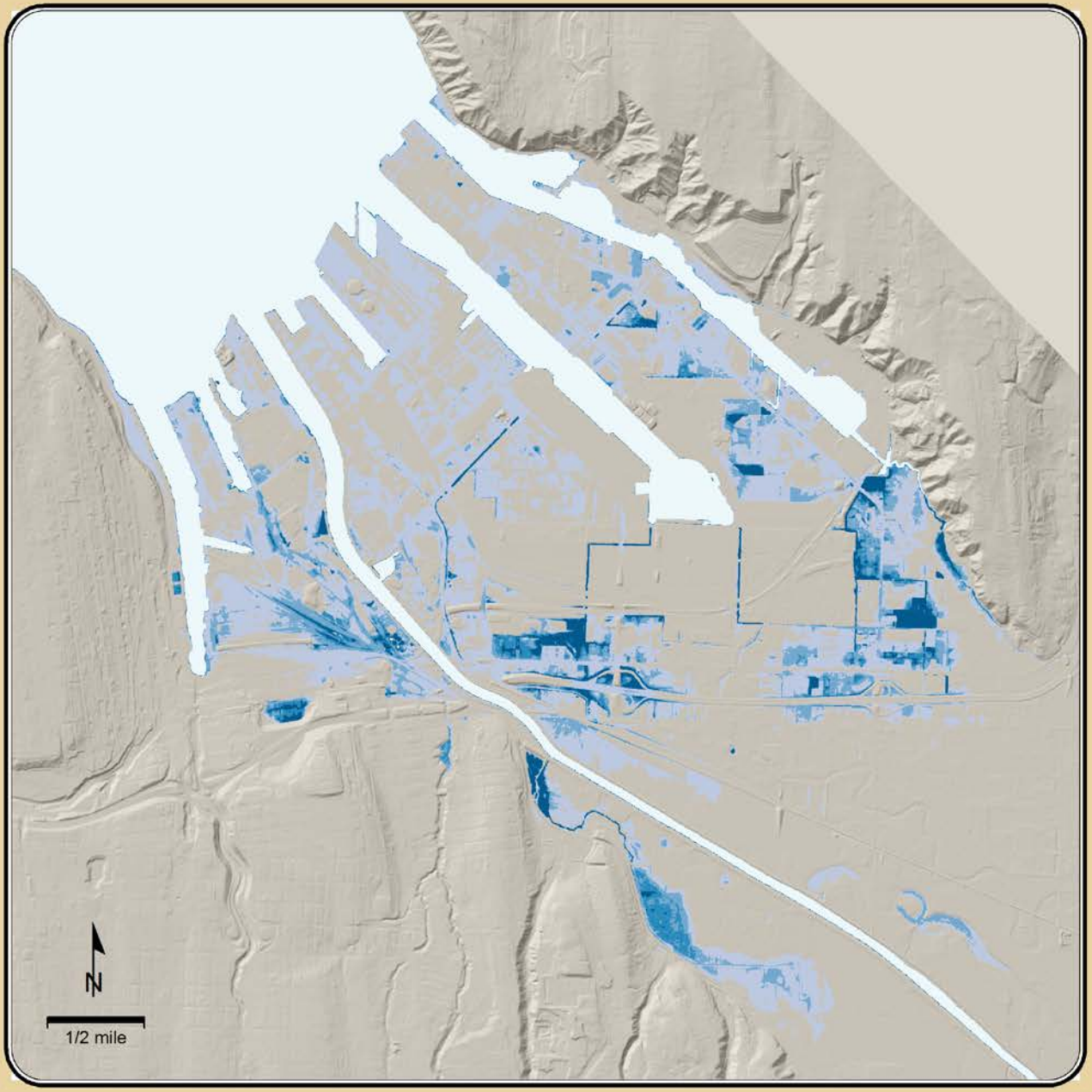
Symbology Examples

Varying Probability of Exceedence



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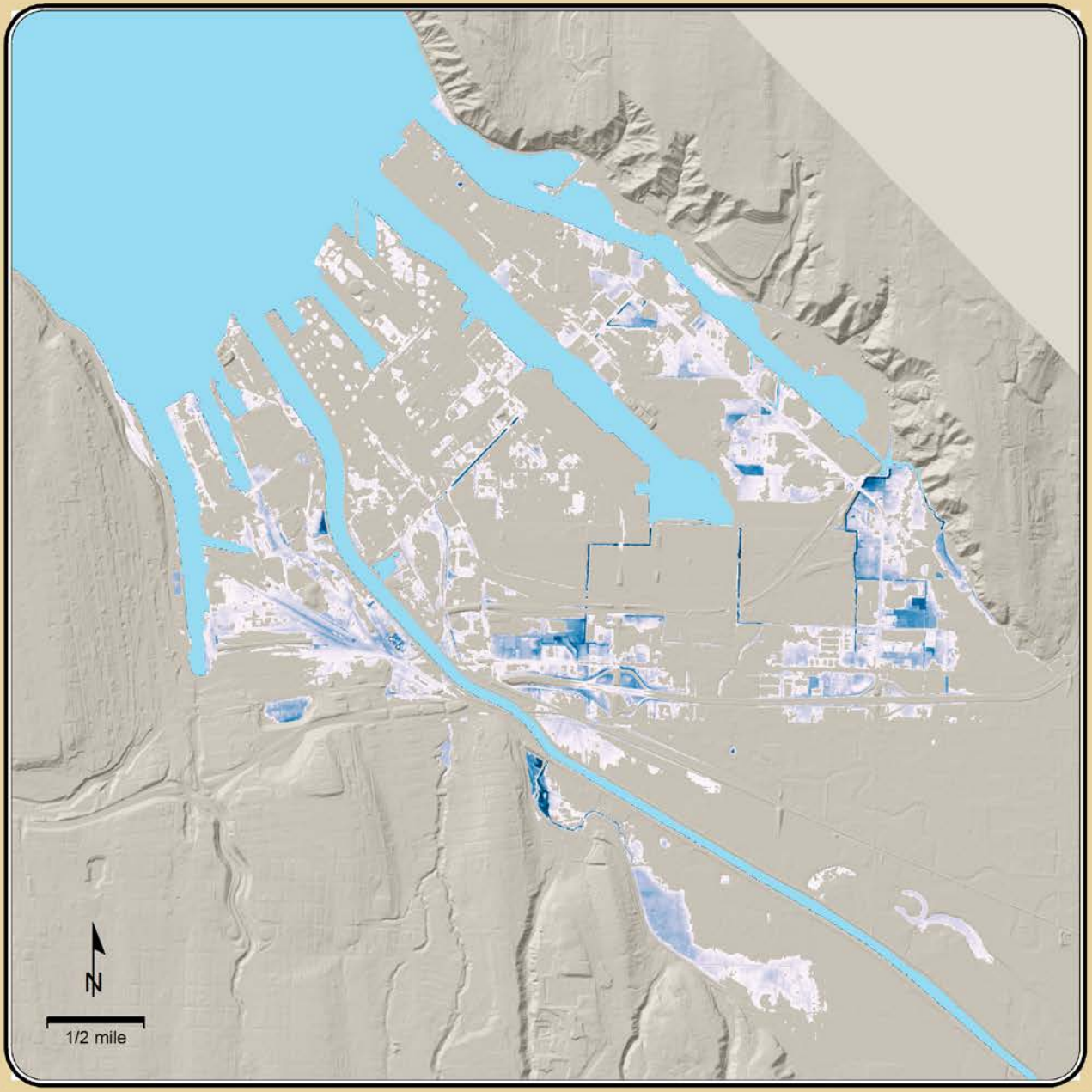
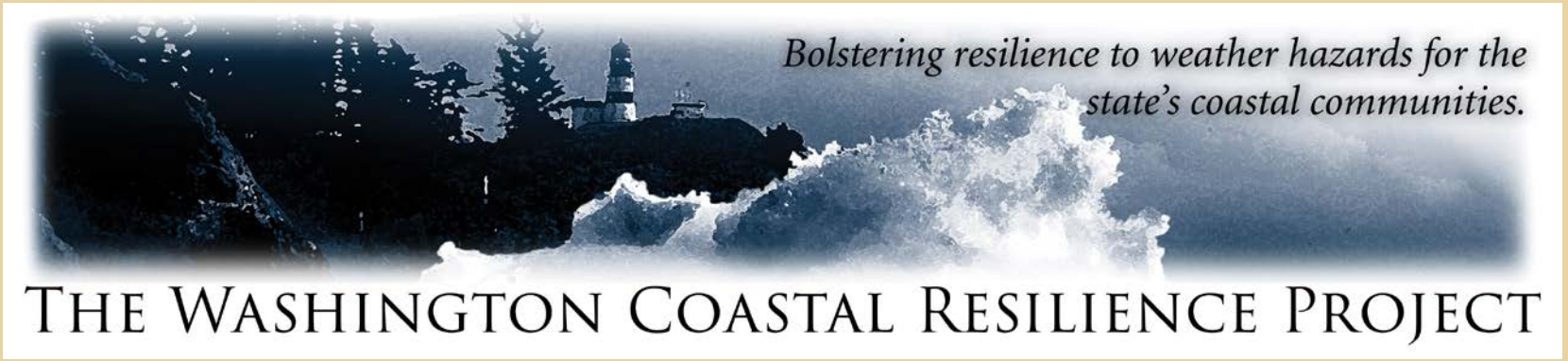
Symbology Examples

Inundation Depth





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coast.noaa.gov/data/digitalcoast/pdf/slr-inundation-methods.pdf