Incorporating future climate predictions into today's ecosystem restoration design

Caitlin Alcott, CFM

Matt Cox, PE

April 10, 2018

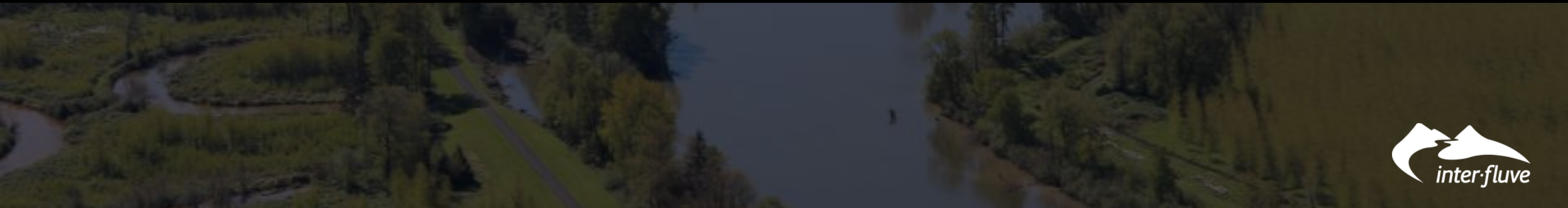
inter·fluve

Overview

1. Consider climate change
2. The current applied-design toolbox
3. Case study: Bear Mary Ferris
4. Next steps, thoughts

Kerry Island, OR, Photo: PC Trask

1. Consider climate change



FEMA ADMINISTRATOR POLICY

2011-OPPA-01

FEMA CLIMATE CHANGE ADAPTATION POLICY STATEMENT

I. Purpose

The purpose of this policy statement is to establish an Agency-wide directive to integrate climate change adaptation planning and actions into Agency programs, policies, and operations.

Kerry Island, OR, Photo: PC Trask

Climate Preparedness and Resilience

Climate Change Adaptation

Comprehensive Evaluation of Projects with Respect to Sea-Level Change

Sea-Level Change Curve Calculator (2017.55)

Version 2017.55 employs the same computations as previous versions, yielding the same projections along with some additional functionality, the 2014 NOAA rates, and several additional gauges. Previous versions include Version 2015.46 and its manual (*pdf, 1.4MB*), 2014.88 and its manual (*pdf, 4.5 MB*), and the original superseded calculator.

EC 1165-2-212 (*pdf, 845 KB*) and its successor ER 1100-2-8162 (*pdf, 317 KB*) were developed with the assistance of coastal scientists from the NOAA National Ocean Service and the US Geological Survey. Their participation on the USACE team allows rapid infusion of science into engineering guidance. ETL 1100-2-1 (*pdf, 9.87 MB*) , Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation.

EC 1165-2-212 (*pdf, 845 KB*) and its successor ER 1100-2-8162 (*pdf, 317 KB*) use the historic rate of sea-level change as the rate for the "USACE Low Curve". ETL 1100-2-1 (*pdf, 9.87 MB*) , Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation.

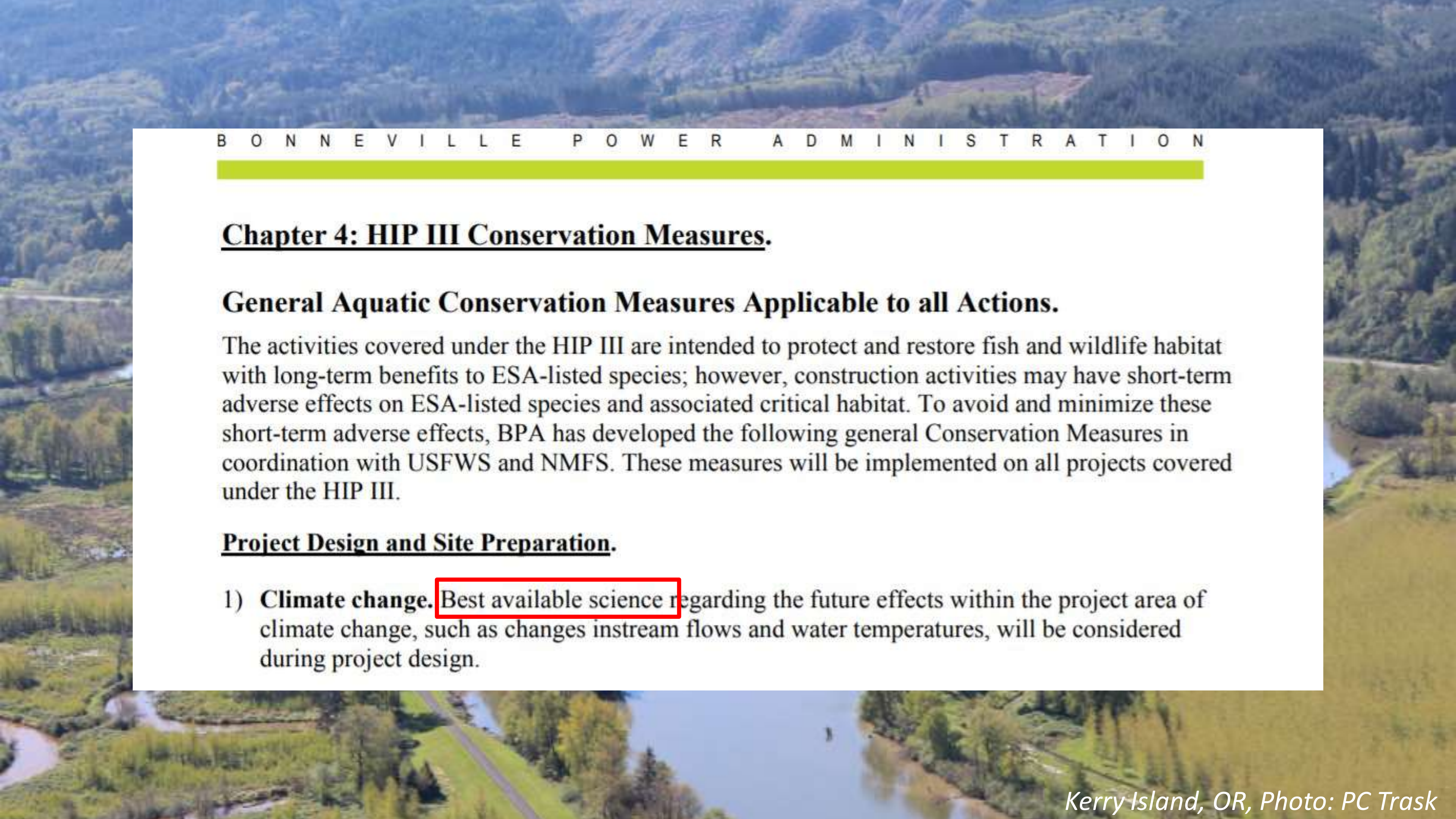
The rate for the "USACE Intermediate Curve" is computed from the modified NRC Curve I considering both the most recent IPCC projections and modified NRC projections with the local rate of vertical land movement added.

The rate for the "USACE High Curve" is computed from the modified NRC Curve III considering both the most recent IPCC projections and modified NRC projections with the local rate of vertical land movement added.

The three scenarios proposed by the NRC result in global eustatic sea-level rise values, by the year 2100, of 0.5 meters, 1.0 meters, and 1.5 meters. Adjusting the equation to include the historic GMSL change rate of 1.7 mm/year and the start date of 1992 (which corresponds to the midpoint of the current National Tidal Datum Epoch of 1983-2001), instead of 1986 (the start date used by the NRC), results in updated values for the coefficients (b) being equal to 2.71E-5 for modified NRC Curve I, 7.00E-5 for modified NRC Curve II, and 1.13E-4 for modified NRC Curve III.

The three local relative sea level change scenarios updated from EC 1165-2-212 (*pdf, 845 KB*) (and and its successor ER 1100-2-8162), Equation 2 are depicted in the Figure to the right of

Kerry Island, OR, Photo: PC Trask



BONNEVILLE POWER ADMINISTRATION

Chapter 4: HIP III Conservation Measures.

General Aquatic Conservation Measures Applicable to all Actions.

The activities covered under the HIP III are intended to protect and restore fish and wildlife habitat with long-term benefits to ESA-listed species; however, construction activities may have short-term adverse effects on ESA-listed species and associated critical habitat. To avoid and minimize these short-term adverse effects, BPA has developed the following general Conservation Measures in coordination with USFWS and NMFS. These measures will be implemented on all projects covered under the HIP III.

Project Design and Site Preparation.

1) **Climate change.** Best available science regarding the future effects within the project area of climate change, such as changes instream flows and water temperatures, will be considered during project design.

Kerry Island, OR, Photo: PC Trask

6.4 Climate Variation Change and Restoration

Climate change threatens the quality and function of the LCRE by altering three aspects of the system: river flow, water temperature, and sea level. The National Research Council Columbia River basin report concluded that "…flows and the temperature requirements for salmonid resources and the threatened and endangered stocks should be evaluated in the context of historic and potential future variability and change in both water temperature and stream flow" (NRC 2004, page 152). However, the NRC could not resolve the actual dynamics (i.e., periodicity, volumes, water levels) of the flow regime associated with climate change scenarios because of uncertainties associated with the models. In the estuary, flows affect water level and thus access by juvenile salmon to productive shallow-water floodplain habitats for feeding and rearing. Diking and flow regulation have resulted in a 62% reduction of the shallow-water habitat area accessible to juvenile salmon (Kukulka and Jay 2003). With lower flows, opportunities to access to habitats would be further limited.

Manual 18

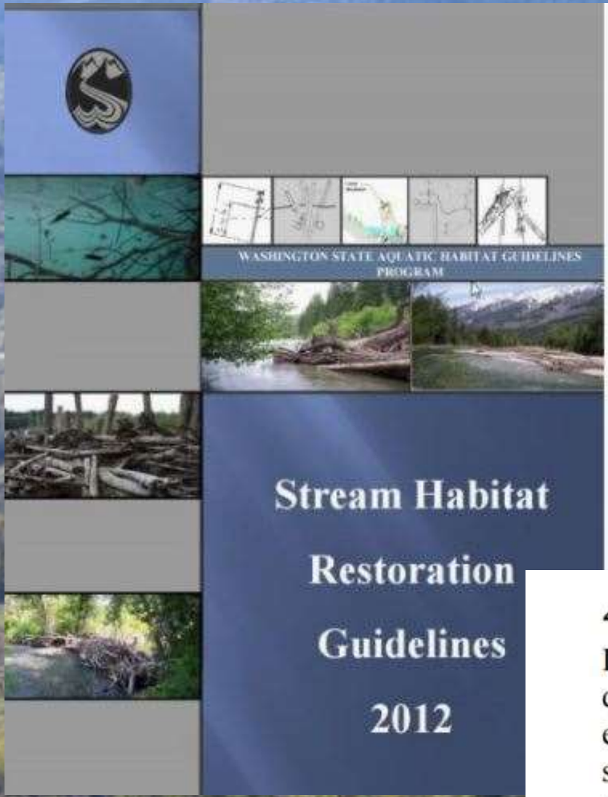
Salmon Recovery Grants

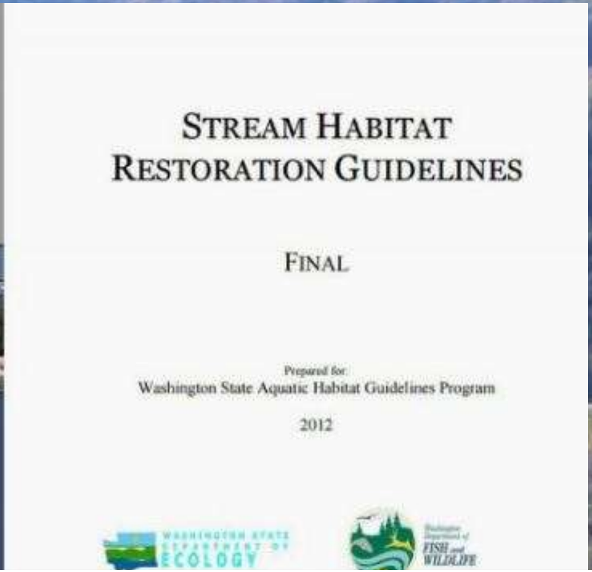
March 2018

- Project proposal sufficiently identified and considered how climate change will affect the project.

Salmon Recovery Funding Board

Kerry Island, OR, Photo: PC Trask





STREAM HABITAT RESTORATION GUIDELINES

FINAL

Prepared for:
Washington State Aquatic Habitat Guidelines Program

2012

4.1.1 Resilience

In the physical sciences and engineering, resiliency refers to the ability of a system to quickly and completely return to its original condition after being disturbed. In the ecological literature, resiliency carries the additional meaning of how much disturbance a system can "absorb" without crossing a threshold and entering an entirely different state of equilibrium (e.g. distinctly different physical habitat structure or conditions). In regard to recovery, habitat restoration, and conservation of at-risk aquatic species, resiliency also requires that certain key habitat characteristics or processes will change little, or not at all, in response to climate change. When it comes to aquatic fluvial habitat, the most important elements to remain steady are *temperature* and *disturbance regime*.

Kerry Island, OR, Photo: PC Trask

Conclusions

- Reduce effects of flow and temperature changes where possible
- Identify and advocate resilient restoration actions
- Develop simple tools to help Incorporate expected flow changes into restoration design

Beechie, 2014

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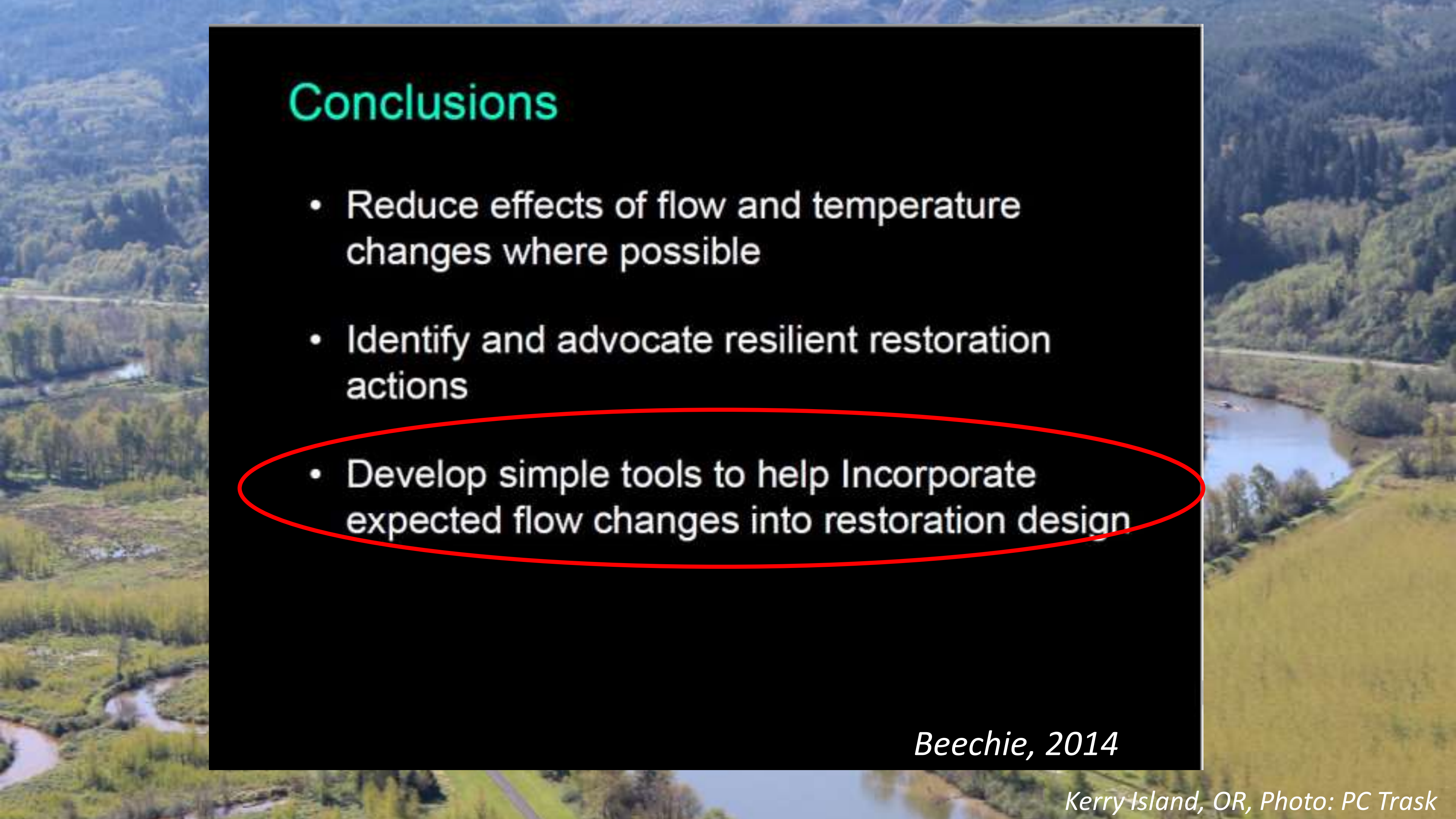

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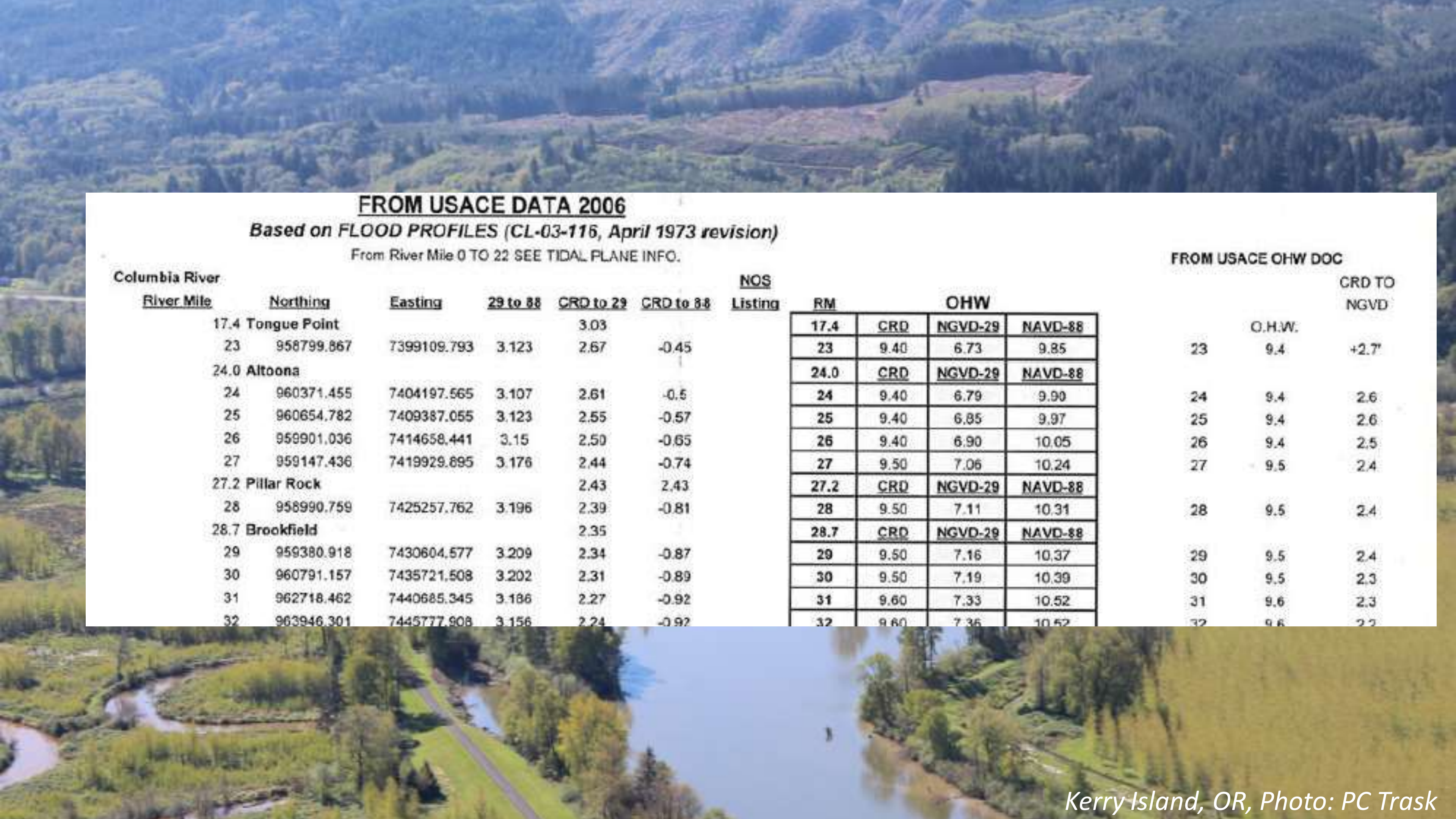

FROM USACE DATA 2006

Based on FLOOD PROFILES (CL-03-116, April 1973 revision)

From River Mile 0 TO 22 SEE TIDAL PLANE INFO.

Columbia River River Mile	Northing	Easting	29 to 88	CRD to 29	CRD to 88	NOS Listing
17.4 Tongue Point				3.03		
23	958799.867	7399109.793	3.123	2.67	-0.45	
24.0 Altoona						
24	960371.455	7404197.565	3.107	2.61	-0.5	
25	960654.782	7409387.055	3.123	2.55	-0.57	
26	959901.036	7414658.441	3.15	2.50	-0.65	
27	959147.436	7419929.895	3.176	2.44	-0.74	
27.2 Pillar Rock				2.43	2.43	
28	958990.759	7425257.762	3.196	2.39	-0.81	
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RM	OHW		
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23	9.40	6.73	9.85
24.0	CRD	NGVD-29	NAVD-88
24	9.40	6.79	9.90
25	9.40	6.85	9.97
26	9.40	6.90	10.05
27	9.50	7.06	10.24
27.2	CRD	NGVD-29	NAVD-88
28	9.50	7.11	10.31
28.7	CRD	NGVD-29	NAVD-88
29	9.50	7.16	10.37
30	9.50	7.19	10.39
31	9.60	7.33	10.52
32	9.60	7.36	10.52

FROM USACE OHW DOC

	O.H.W.	CRD TO NGVD
23	9.4	+2.7'
24	9.4	2.6
25	9.4	2.6
26	9.4	2.5
27	9.5	2.4
28	9.5	2.4
29	9.5	2.4
30	9.5	2.3
31	9.6	2.3
32	9.6	2.2

Kerry Island, OR, Photo: PC Trask

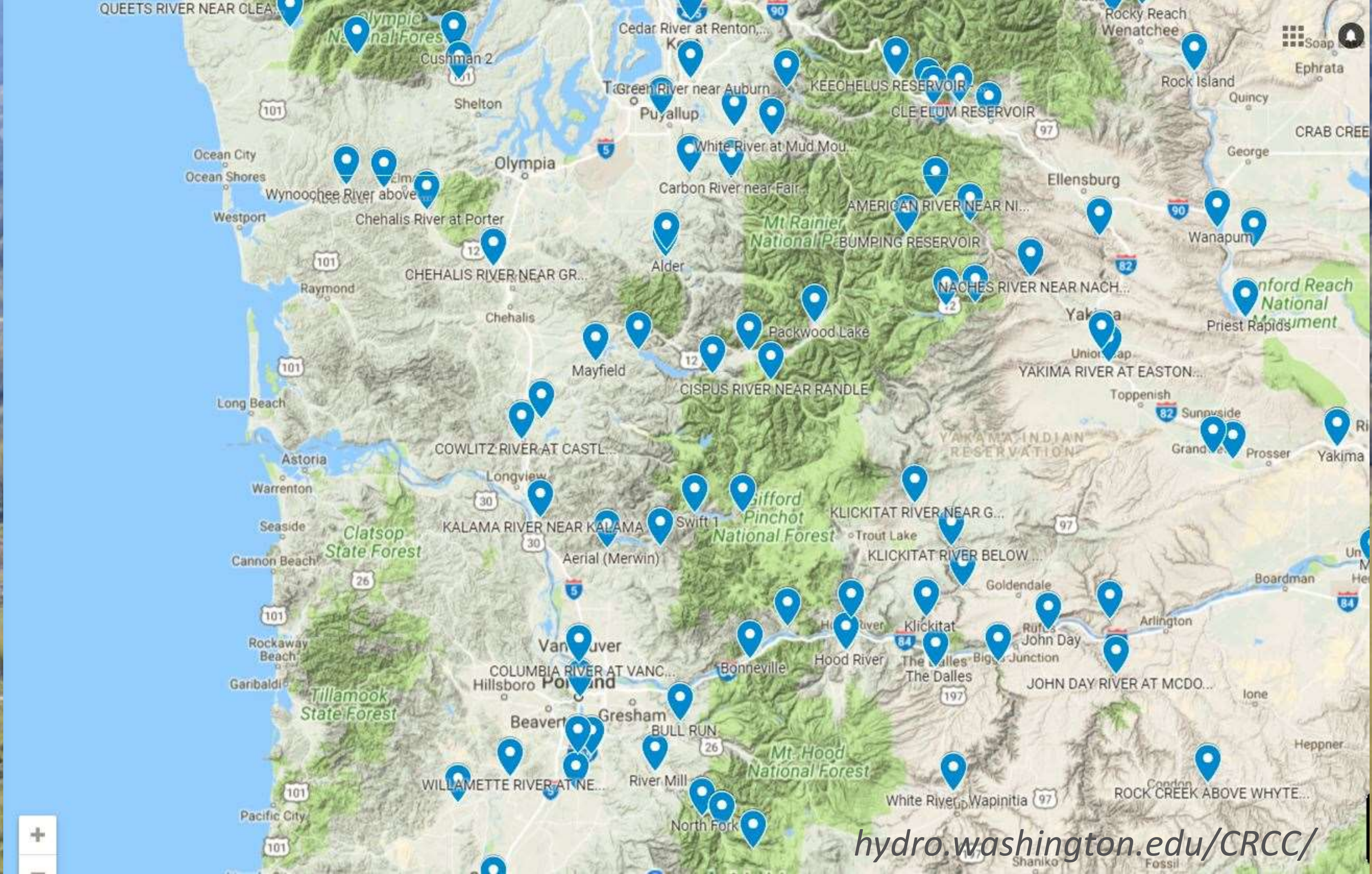
UW Hydro | Columbia River Climate Change

HOME DOCUMENTATION DATA TEAM

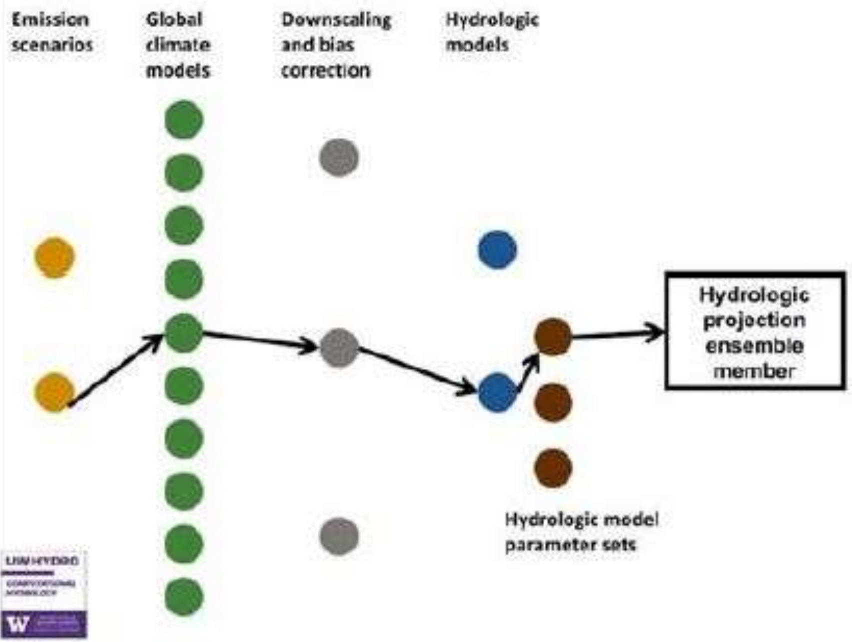
Hydrologic Response of the Columbia River Basin to Climate Change

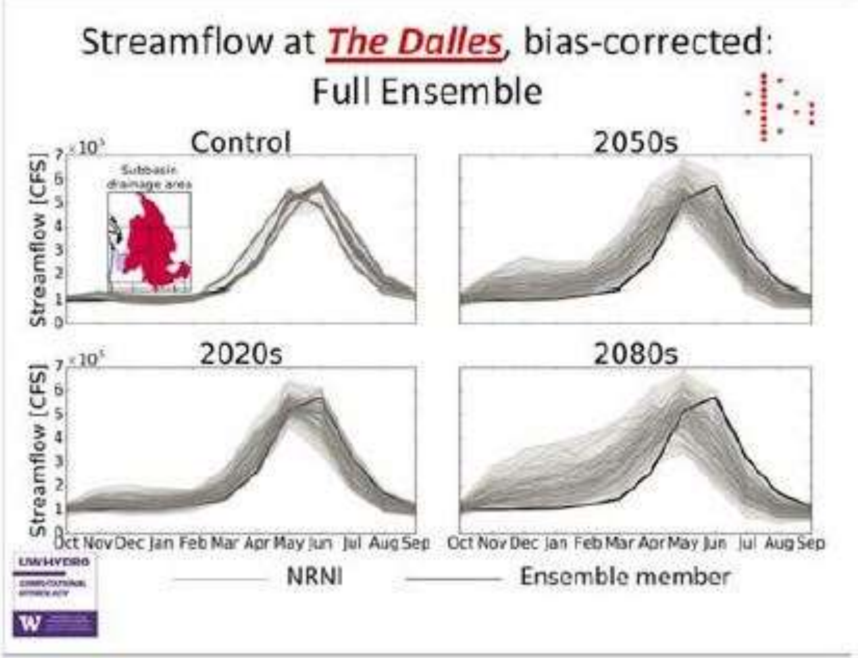
hydro.washington.edu/CRCC/

Kerry Island, OR, Photo: PC Trask



hydro.washington.edu/CRCC/

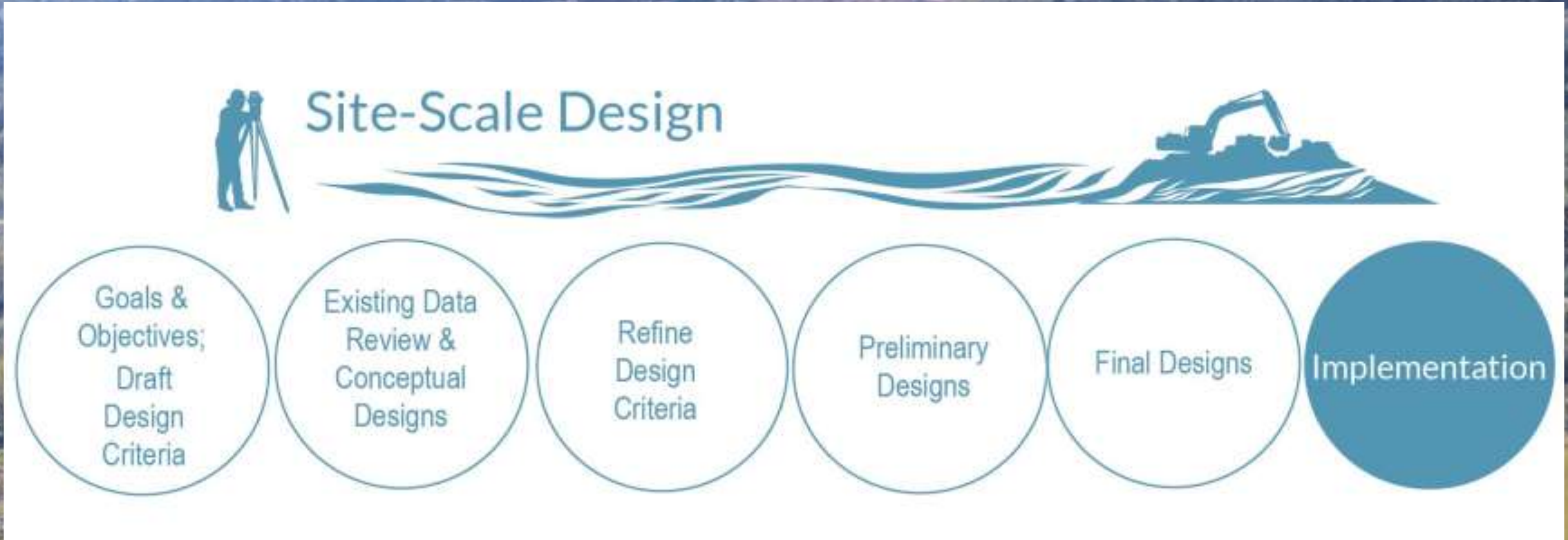




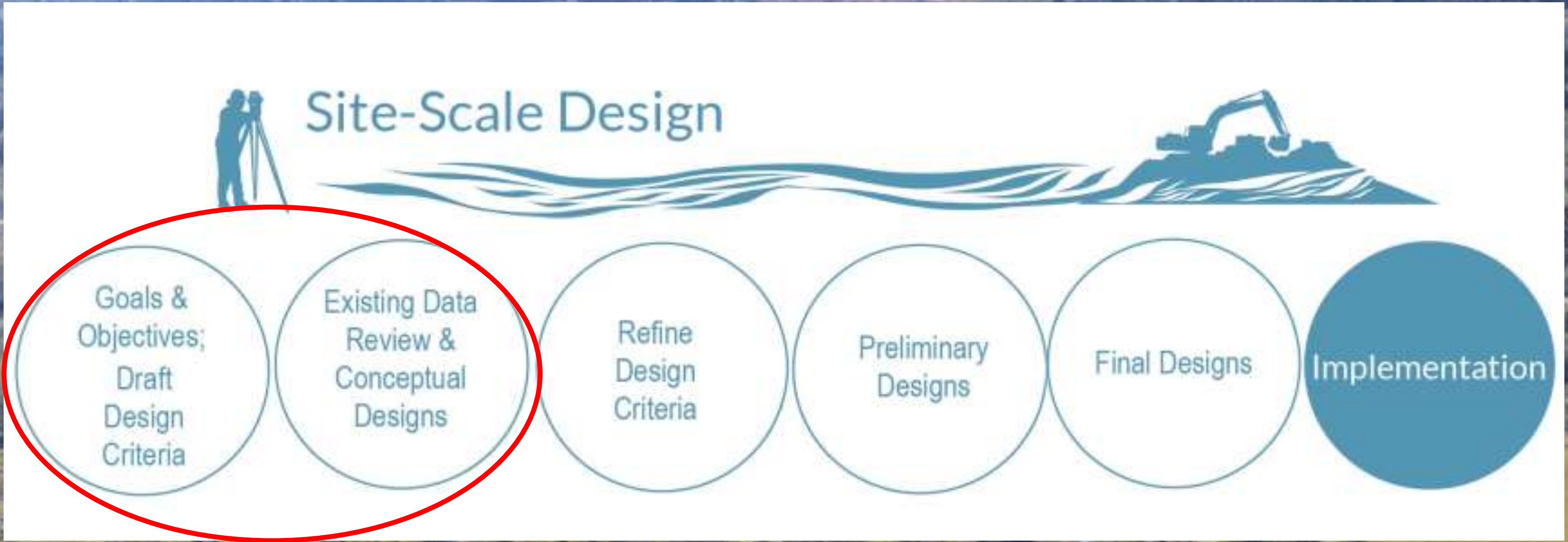

Nijssen 2017

Kerry Island, OR, Photo: PC Trask

Typical Design Process



Kerry Island, OR, Photo: PC Trask



Typical Design Process

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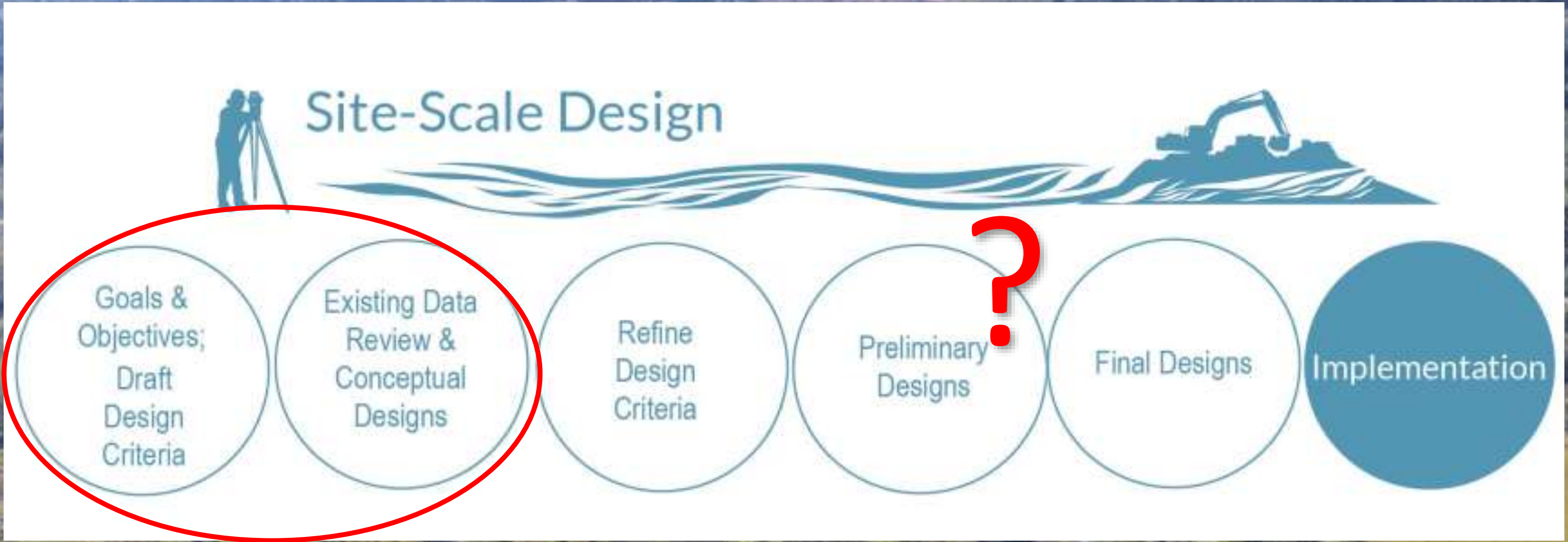
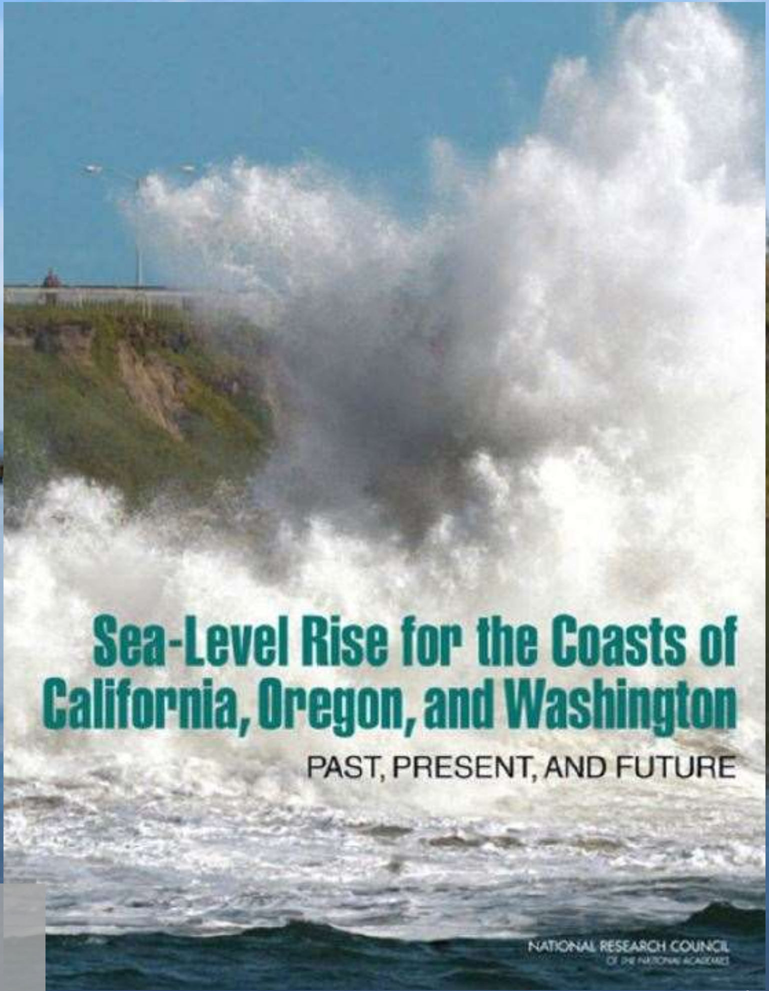


Typical Design Process

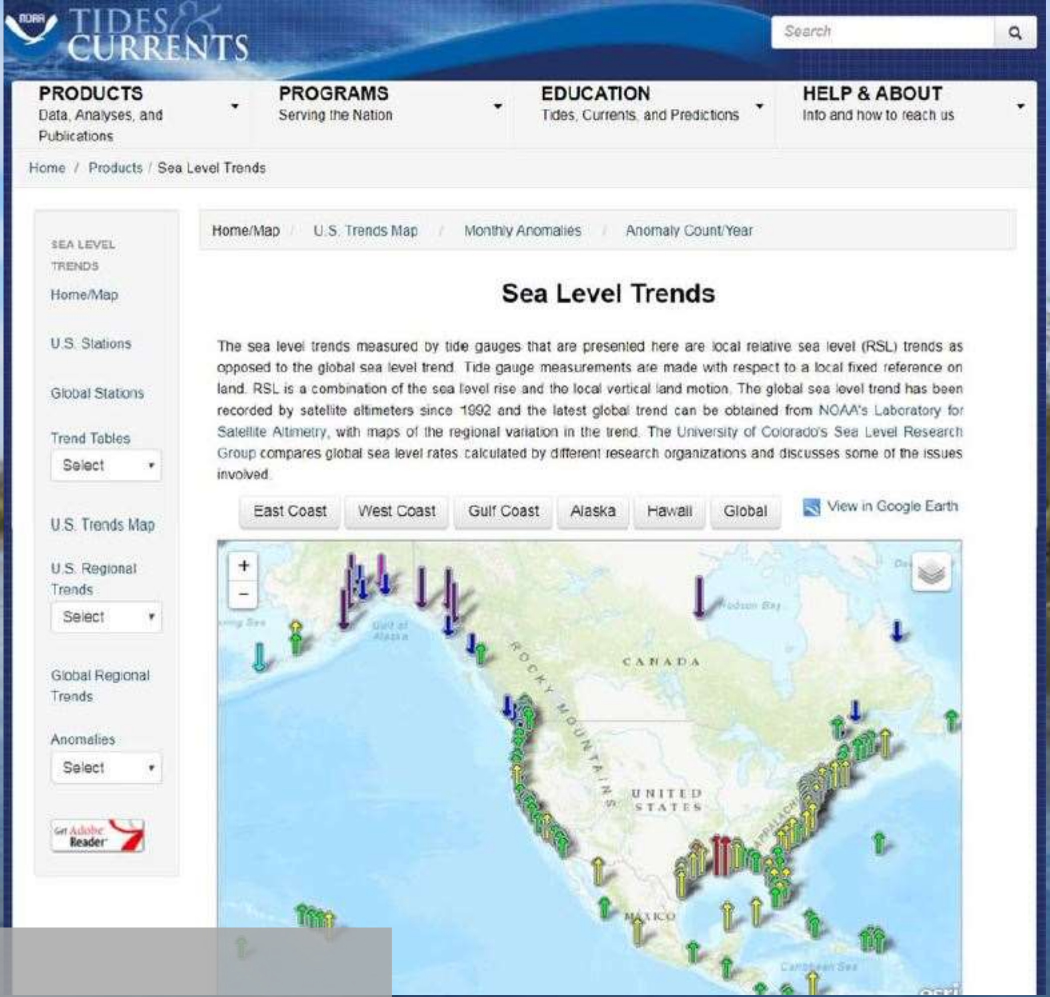
Kerry Island, OR, Photo: PC Trask

2. The current applied-design toolbox

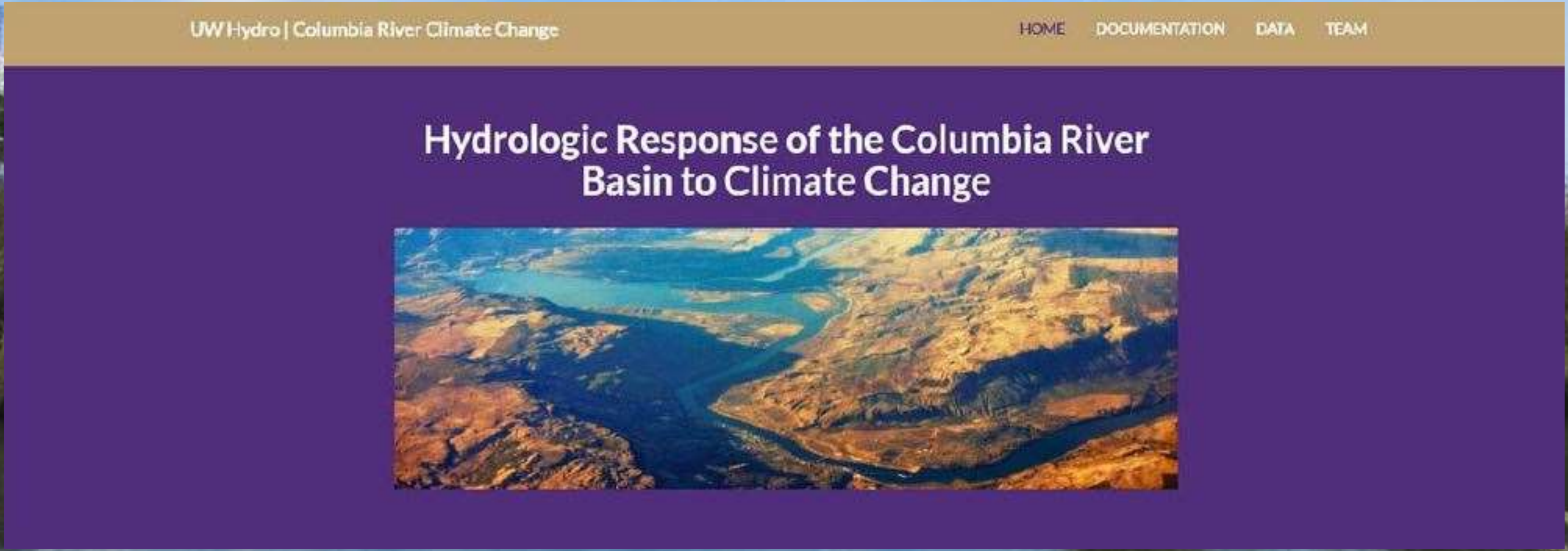


National Research Council

Guiding Documents



Large Data Sets



UW CRCC

Large Data Sets

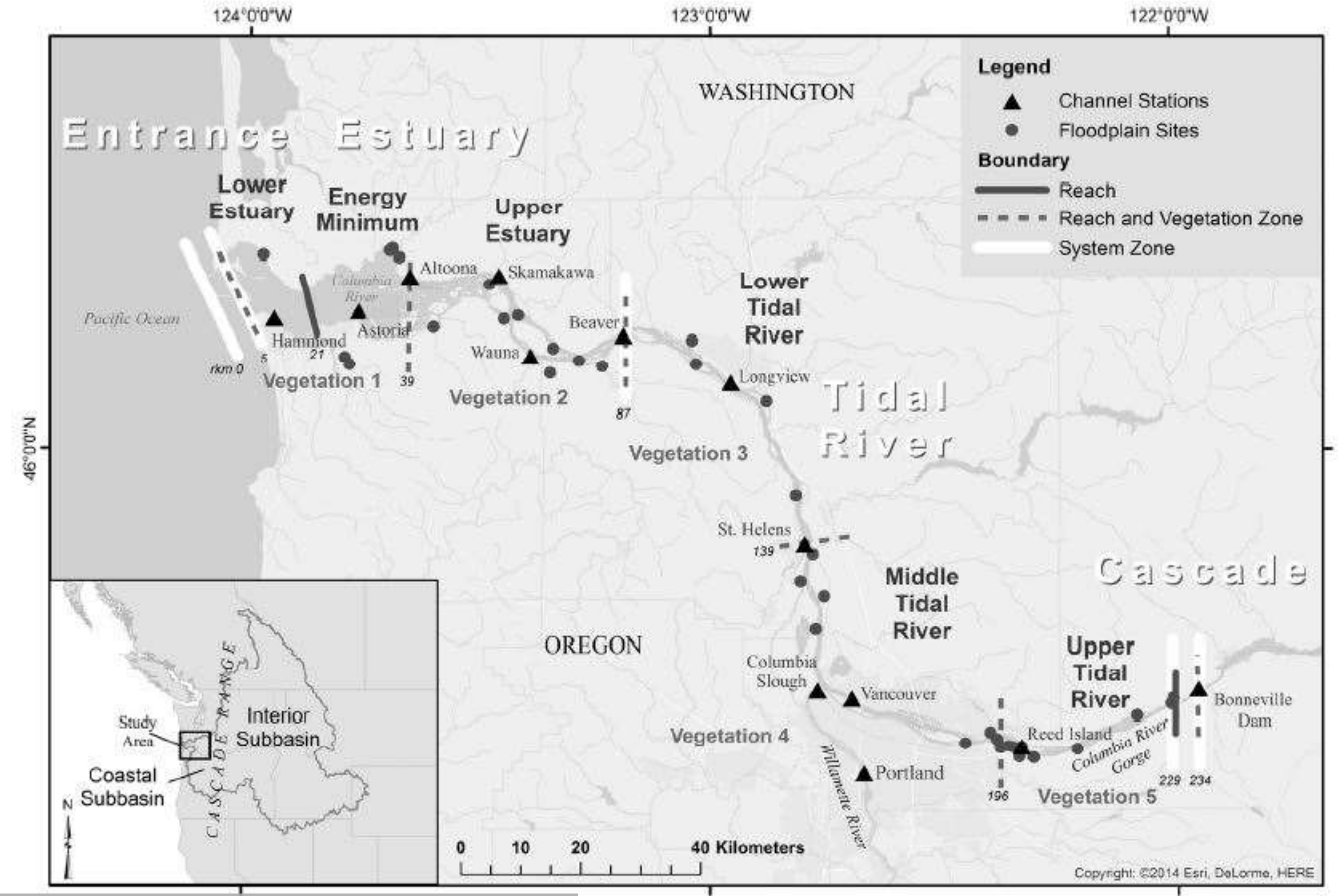
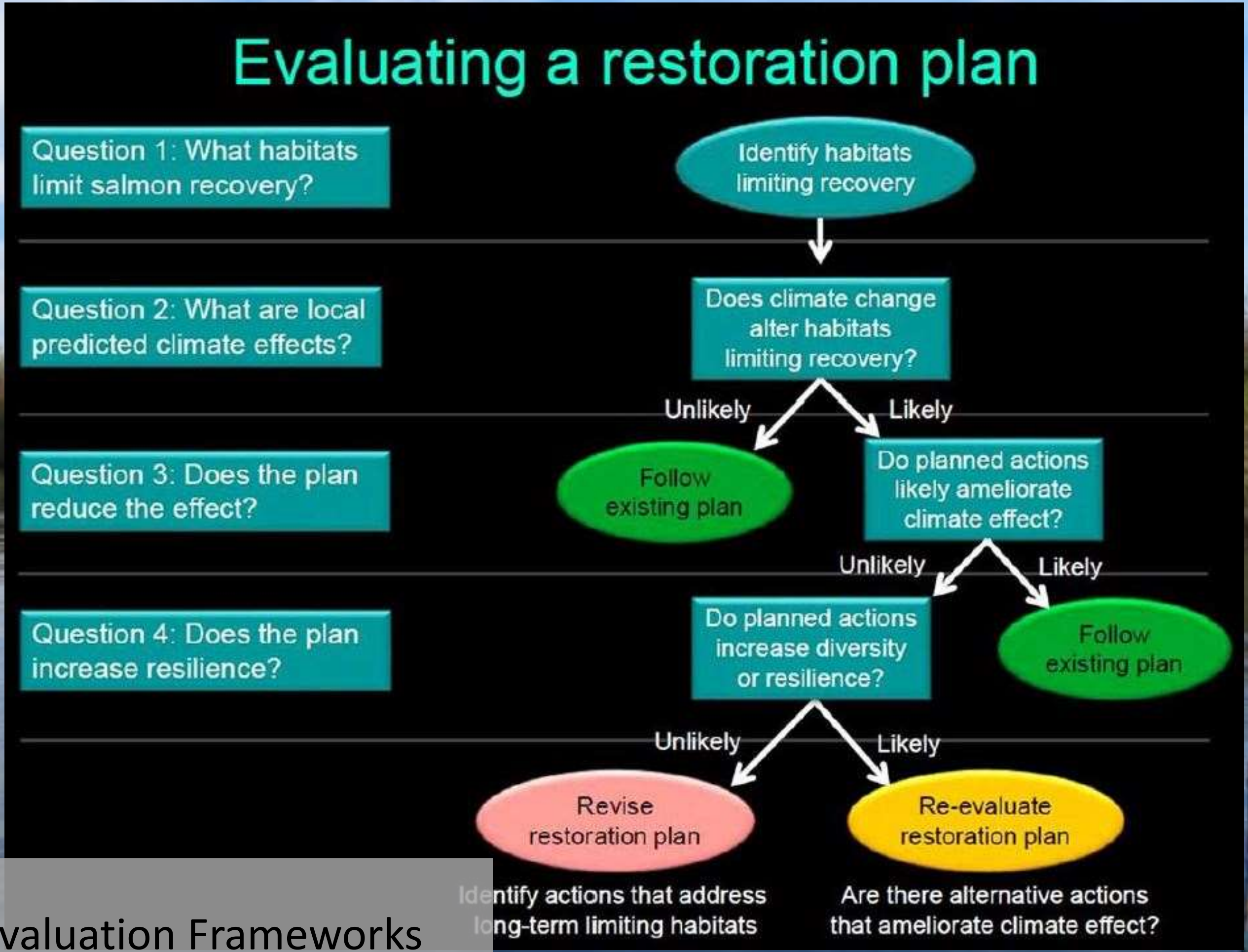


Fig. 1 Lower Columbia River and estuary (LCRE) place names and system zonation

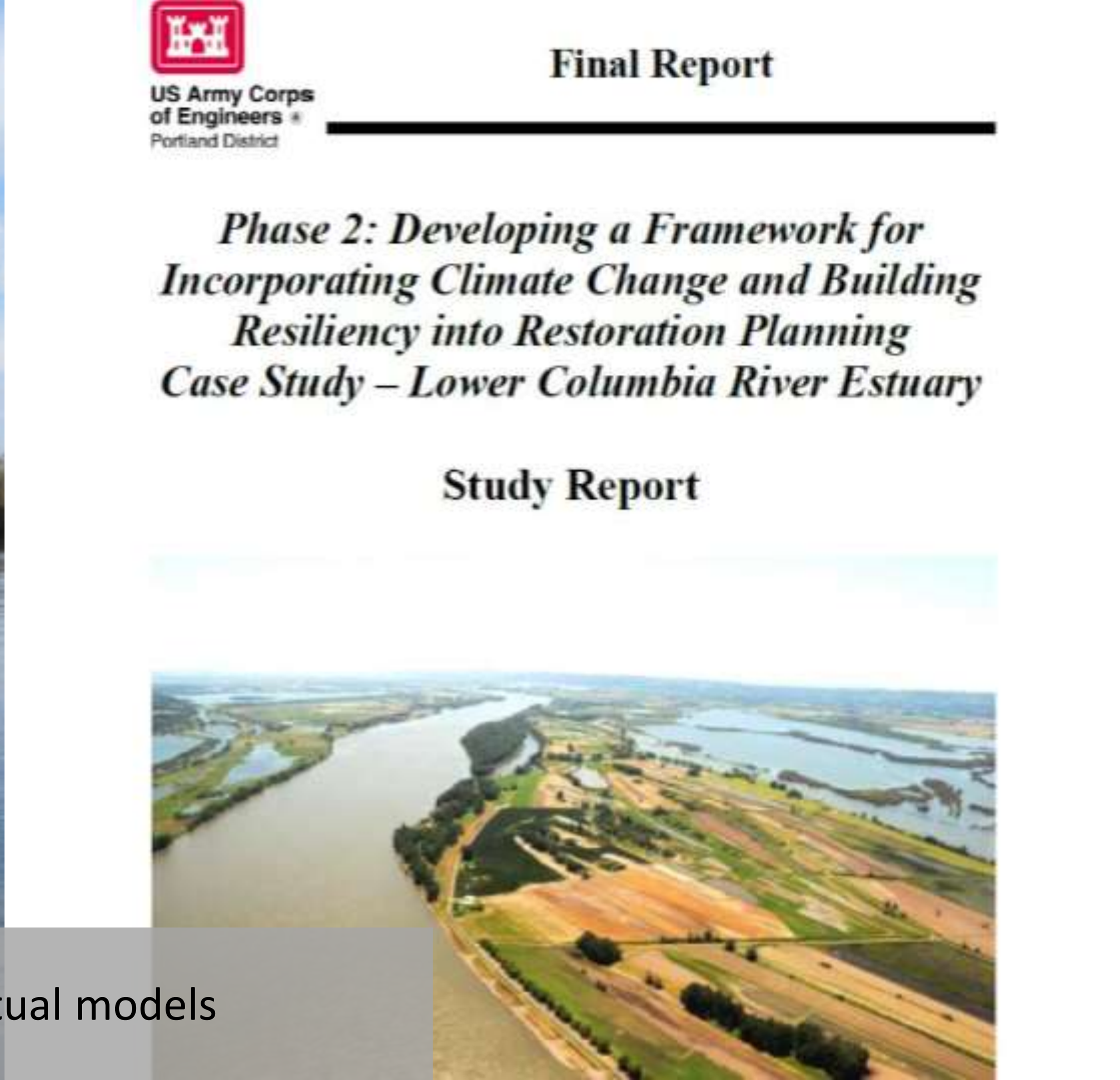
Jay et al. 2016

Long term trends



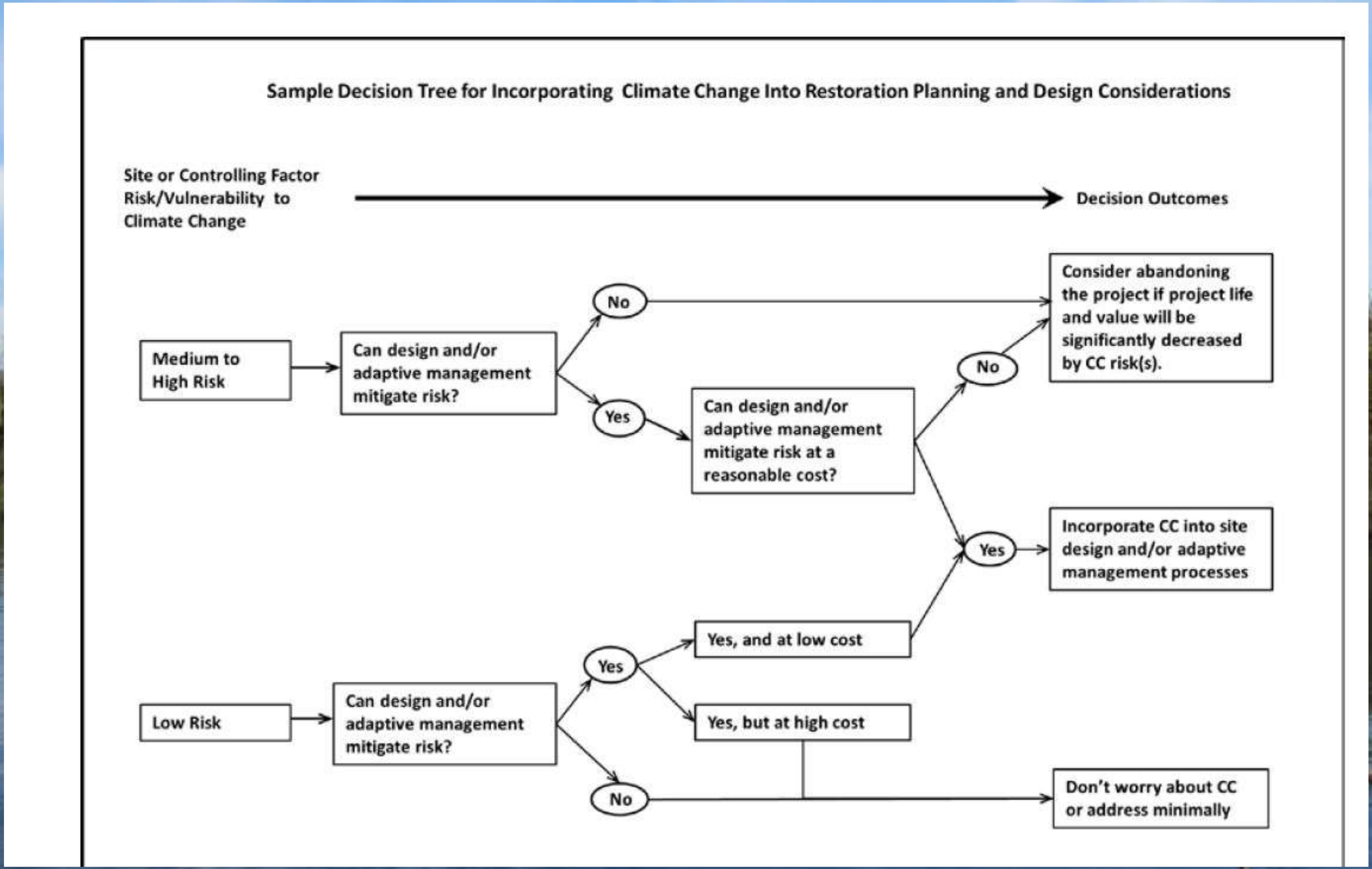
Restoration Evaluation Frameworks

Beechie, 2014



Detailed conceptual models

ACOE 2015


Sample Decision Tree for Incorporating Climate Change Into Restoration Planning and Design Considerations
Site or Controlling Factor Risk/Vulnerability to Climate Change
Decision Outcomes
Medium to High Risk
Can design and/or adaptive management mitigate risk?
No
Yes
Can design and/or adaptive management mitigate risk at a reasonable cost?
No
Yes
Consider abandoning the project if project life and value will be significantly decreased by CC risk(s).
Incorporate CC into site design and/or adaptive management processes
Low Risk
Can design and/or adaptive management mitigate risk?
Yes
No
Yes, and at low cost
Yes, but at high cost
Don't worry about CC or address minimally

ACOE 2015

Table 4: Example of Potential Stressors, Sensitivities, and Adaptation Measures for the LCRE

Stressor	Impacts/Sensitivities	Adaptation Management Measure
Sea Level Rise	• Effects to habitat sensitive to water levels; elevation bands. • Impacts to food web/prey resource. • Alterations to marshes from inundation depth changes. • Increased erosion due to higher and more extreme waves/fetch. • Reduced flood protection due to higher water elevations. • Effect on salinity, subsidence issues, infrastructure/land use habitat to be protected.	• Re-grading site for anticipated future conditions. • Design for higher elevation targets, provide sloping gradients and some benching to help provide for long-term succession if possible, thereby increasing site resilience. Gradual transitions could provide additional value to the current approach. • Need to identify water elevation thresholds in adaptive management plans, etc. • Adjust design of channels with future climate change sea level rise as it affects the tidal levels etc.

Adaptation Management Measure

- Re-grading site for anticipated future conditions.
- Design for higher elevation targets, provide sloping gradients and some benching to help provide for long-term succession if possible, thereby increasing site resilience. Gradual transitions could provide additional value to the current approach.
- Need to identify water elevation thresholds in adaptive management plans, etc.
- Adjust design of channels with future climate change sea level rise as it affects the tidal levels etc.
- Provide increased (riparian) canopy and shading

ACOE 2015

Conceptual Models

Case study examples

Lessons Learned: Dike Design, Construction, and Settlement

- Level of Protection/Storm surge/climate change
- Constructability
- Settlement

Jenna Friebel

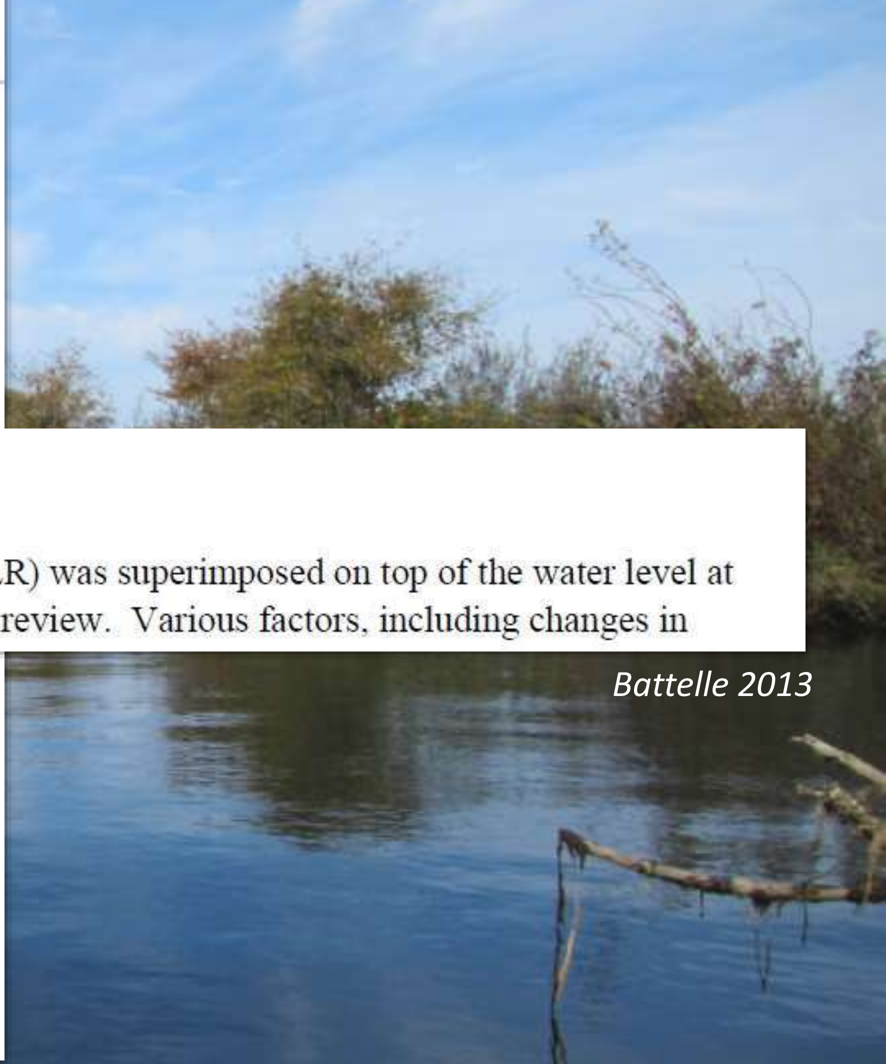
Battelle
The Business of Innovation

PNWD-4398

Hydrodynamic Modeling Analysis for the Fir Island Farm Restoration Project in Skagit Bay, Washington

4.1.4 Long-Term Sea Level Rise (η_{slr})

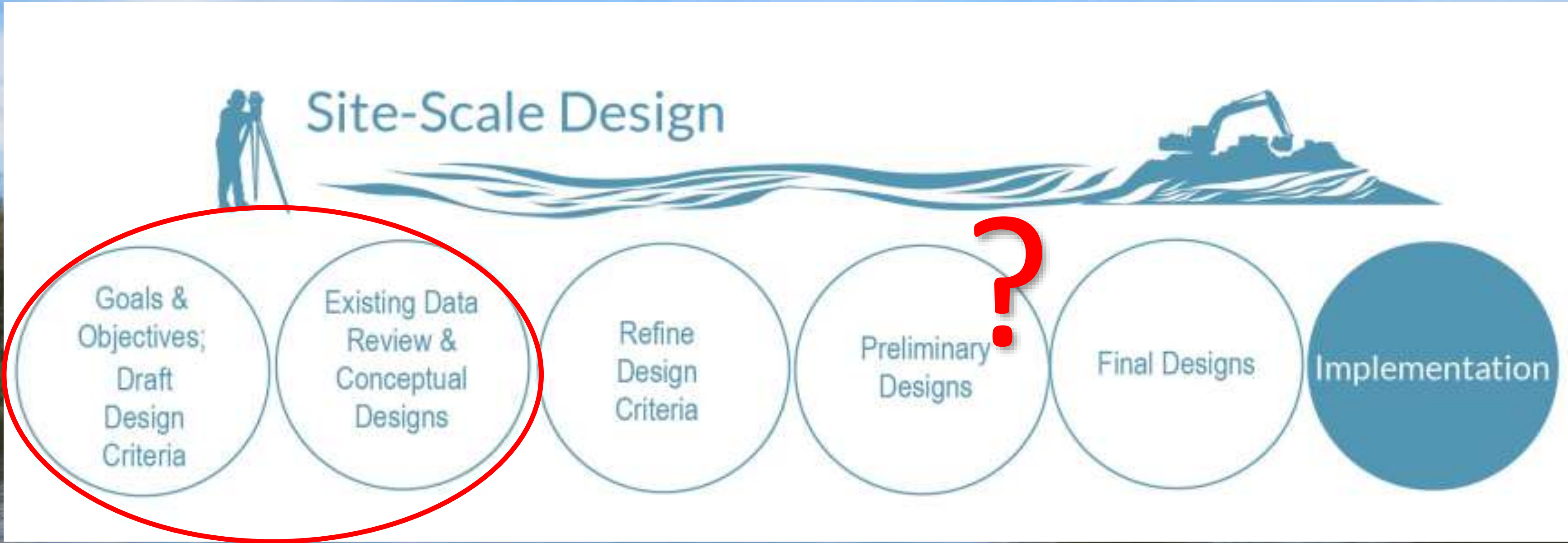
In this study, the effect of relative sea-level rise (SLR) was superimposed on top of the water level at the project site based on values reported from literature review. Various factors, including changes in



Battelle 2013

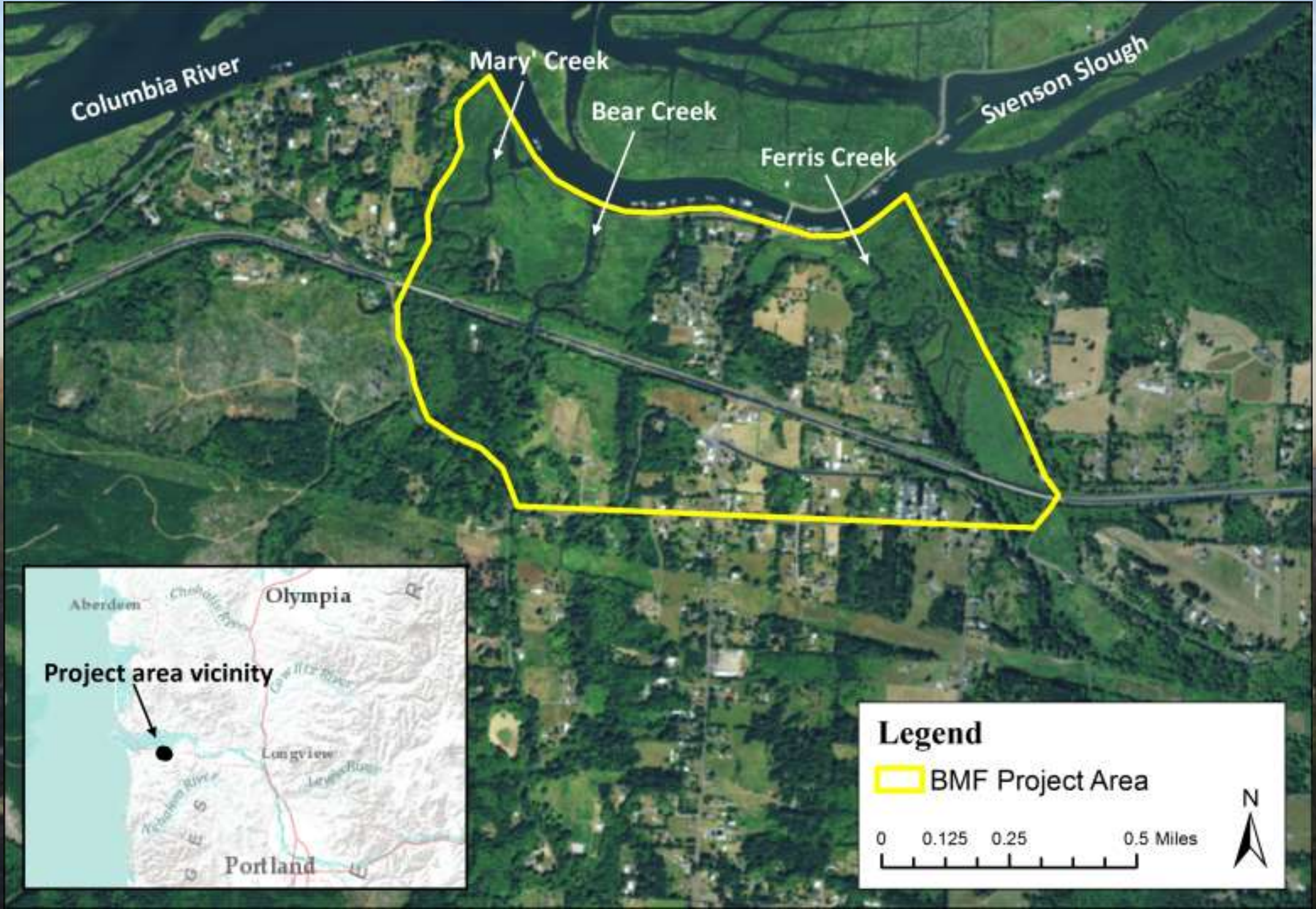
Battelle
Pacific Northwest Division
Richland, Washington 99352

Prepared for
Shannon & Wilson, Inc.
400 North 34th Street, Suite 100
Seattle, Washington 98103
under Contract No. 63526



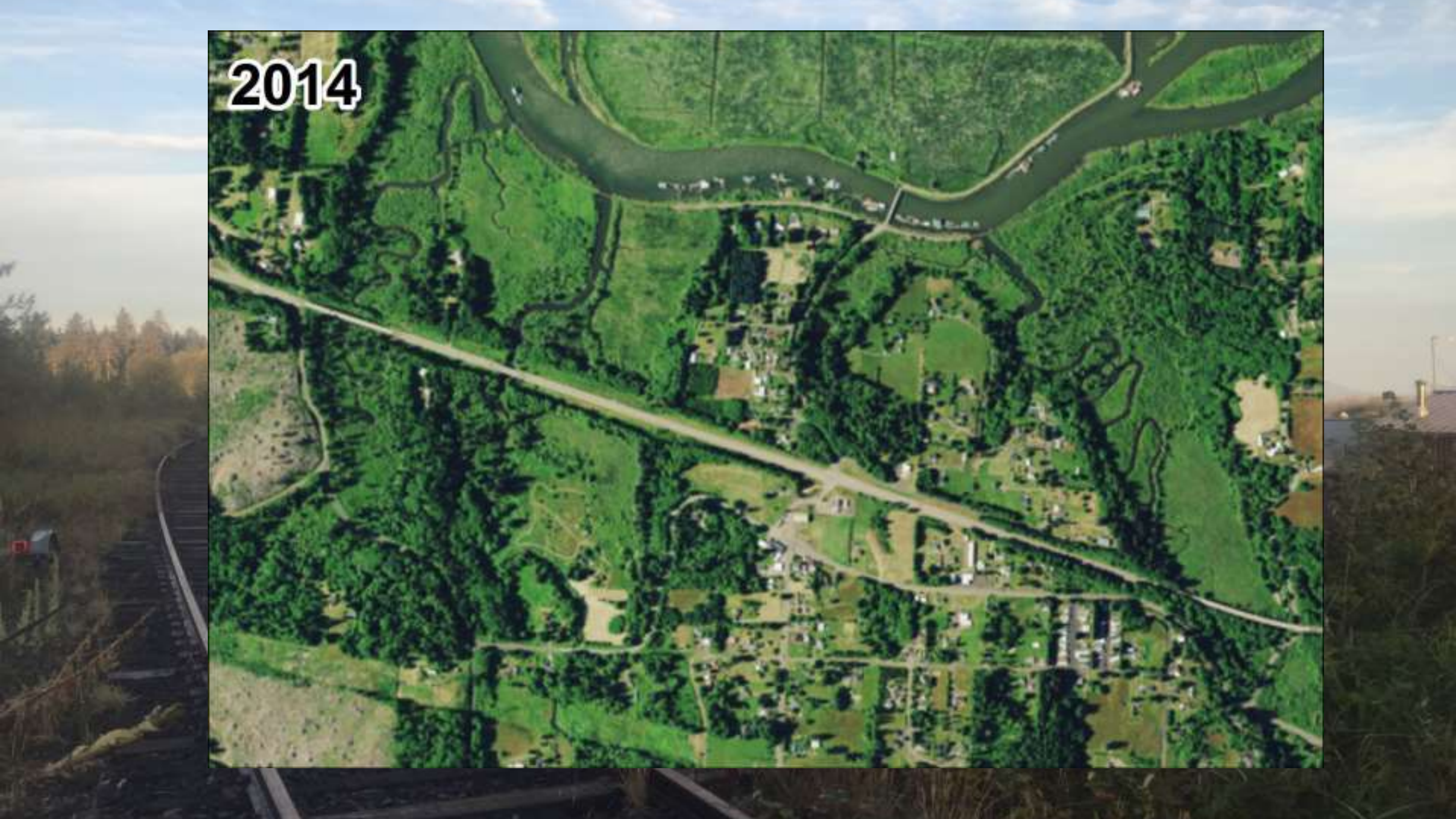
Typical Design Process

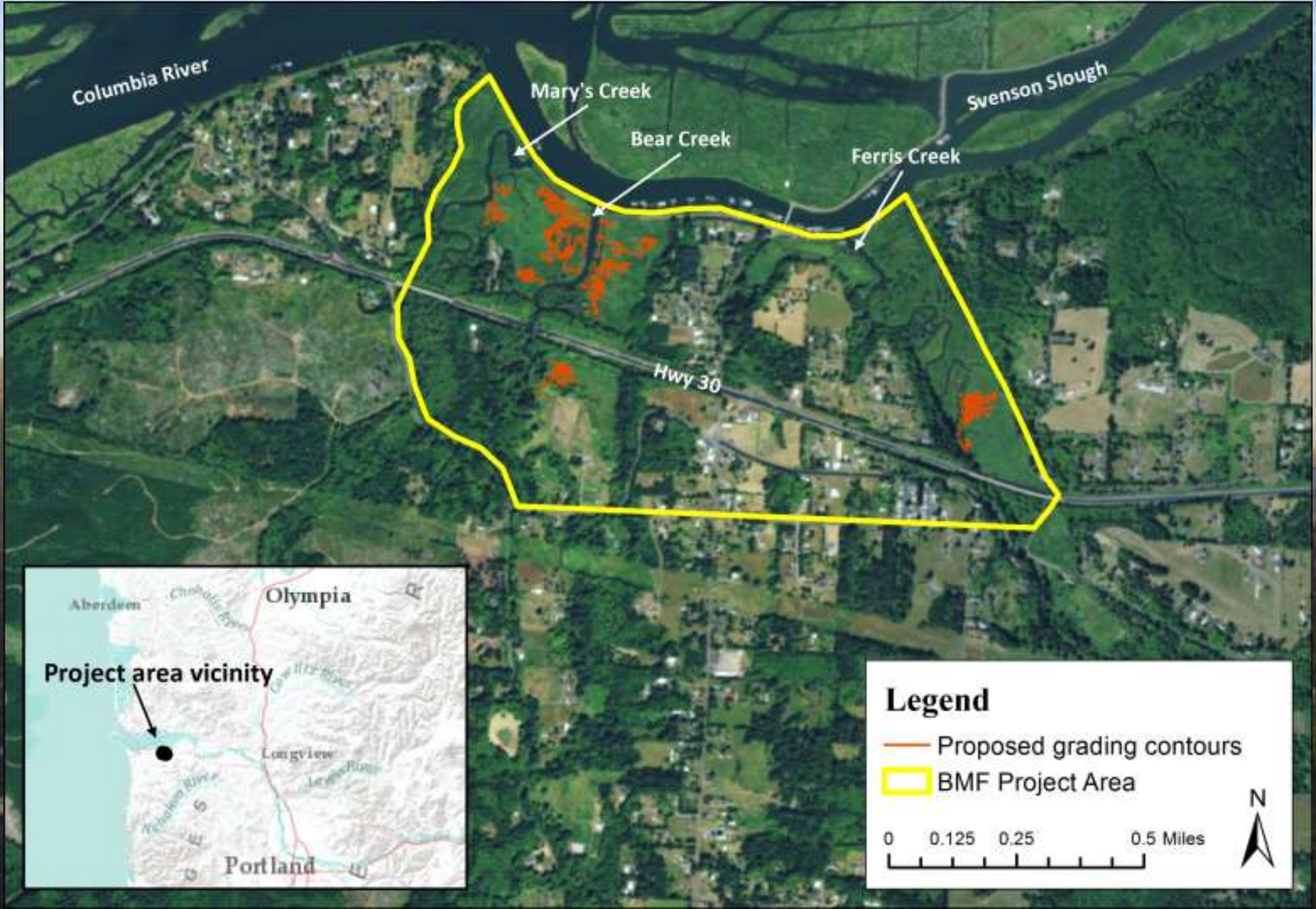
3. Case study: Bear Mary Ferris



Columbia River
Mary' Creek
Bear Creek
Svenson Slough
Ferris Creek
Aberdeen
Olympia
Project area vicinity
Longview
Portland
Legend
BMF Project Area
0
0.125
0.25
0.5 Miles
N

1880
III 26.00
15
II 38.30
I 47.75
14
IV 39.50
II 17.66
I 24.62
III 30.84
I 35.30
I 98
21
22 320
23 320
South
8050
Creek
Ferris
Creek
50 80.00
80.25
S.89°51'W.
S.89°49'W.
25
20
35


2014


Columbia River
Mary's Creek
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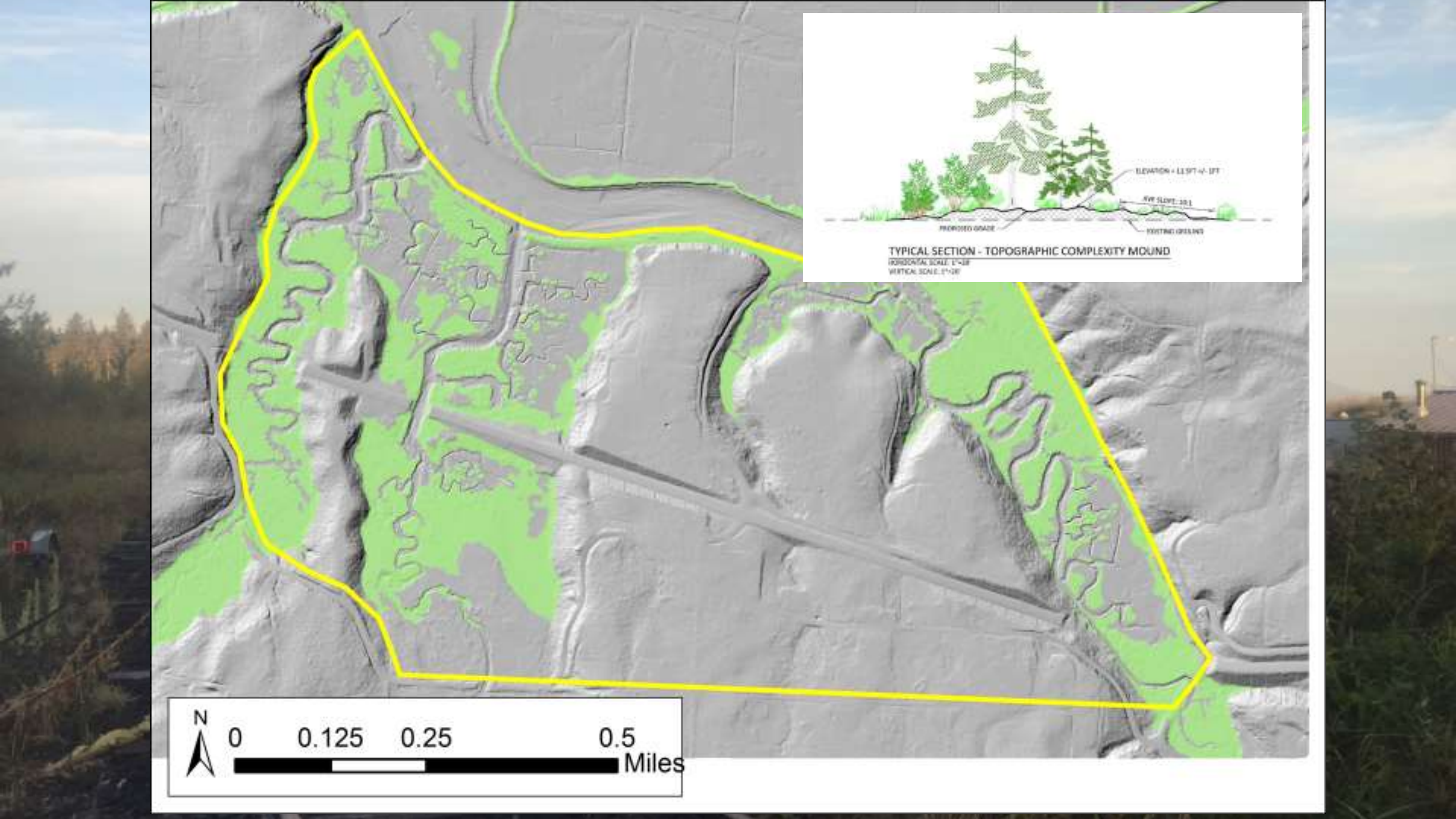
Svenson Slough
Ferris Creek
Hwy 30
Aberdeen
Olympia
Project area vicinity
Longview
Portland
Legend
Proposed grading contours
BMF Project Area
N
0
0.125
0.25
0.5 Miles


TYPICAL SECTION - TOPOGRAPHIC COMPLEXITY MOUND
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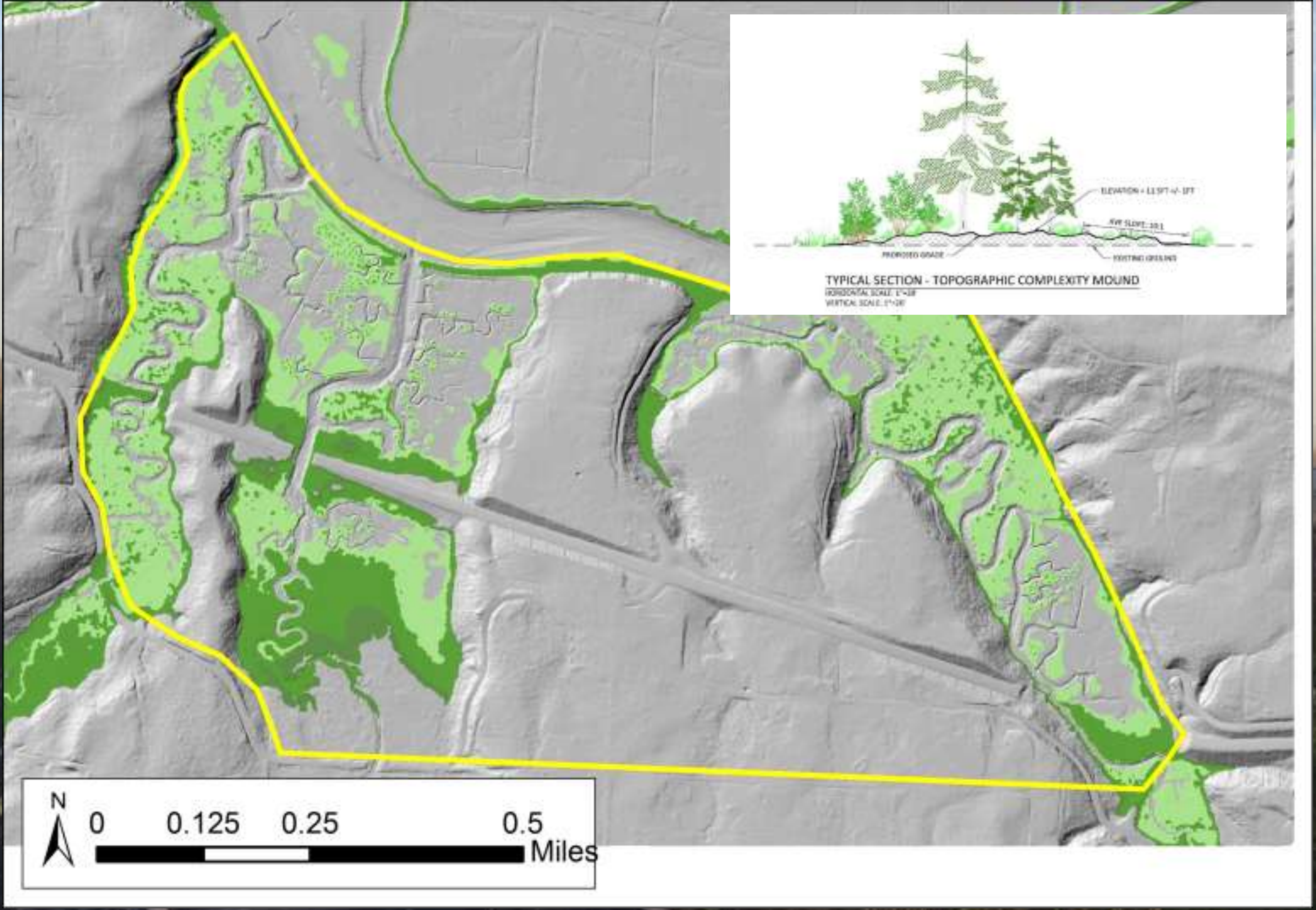
0
0.125
0.25
0.5
Miles


TYPICAL SECTION - TOPOGRAPHIC COMPLEXITY MOUND
PROPOSED GRADE
EXISTING GROUND
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0.125
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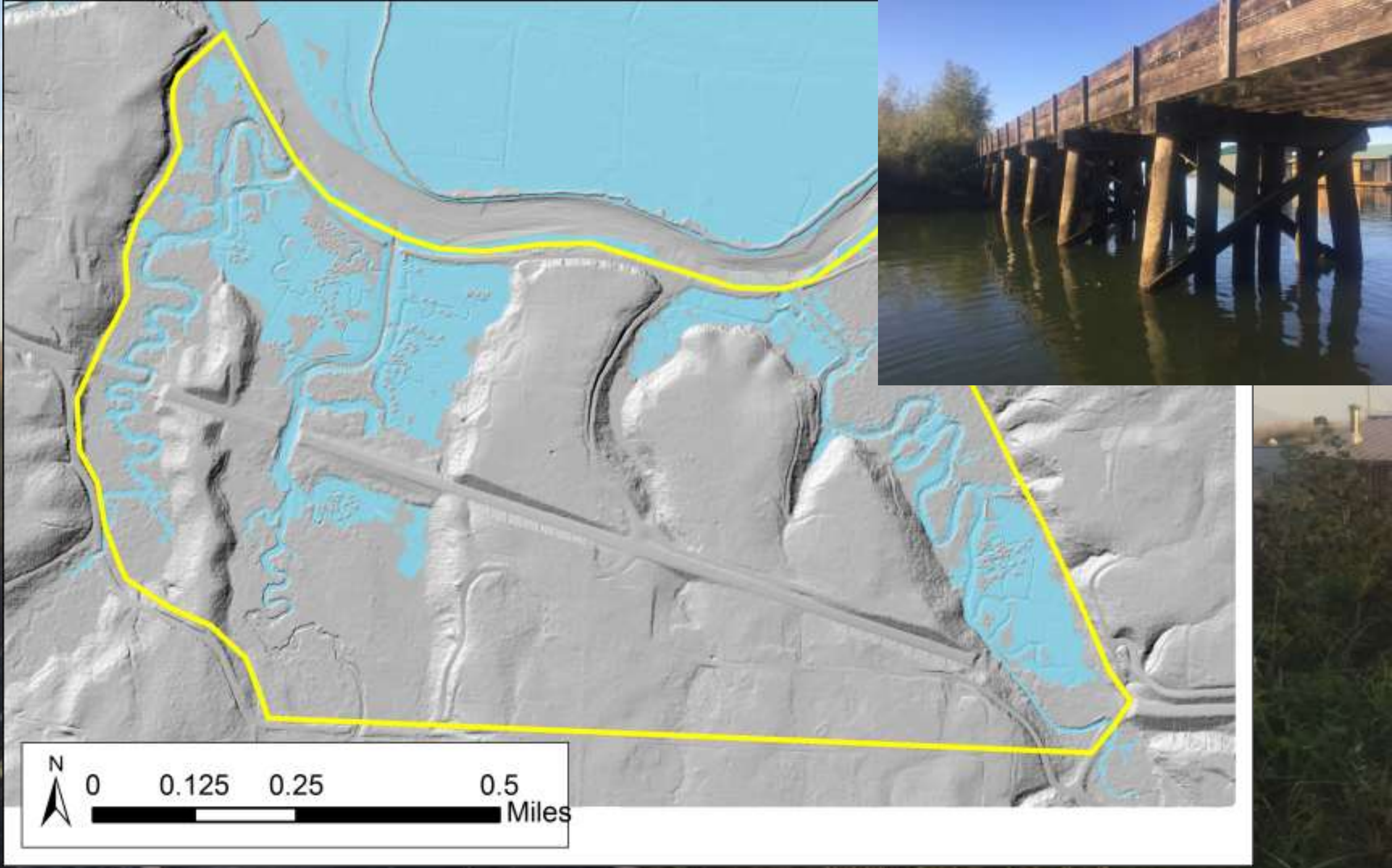
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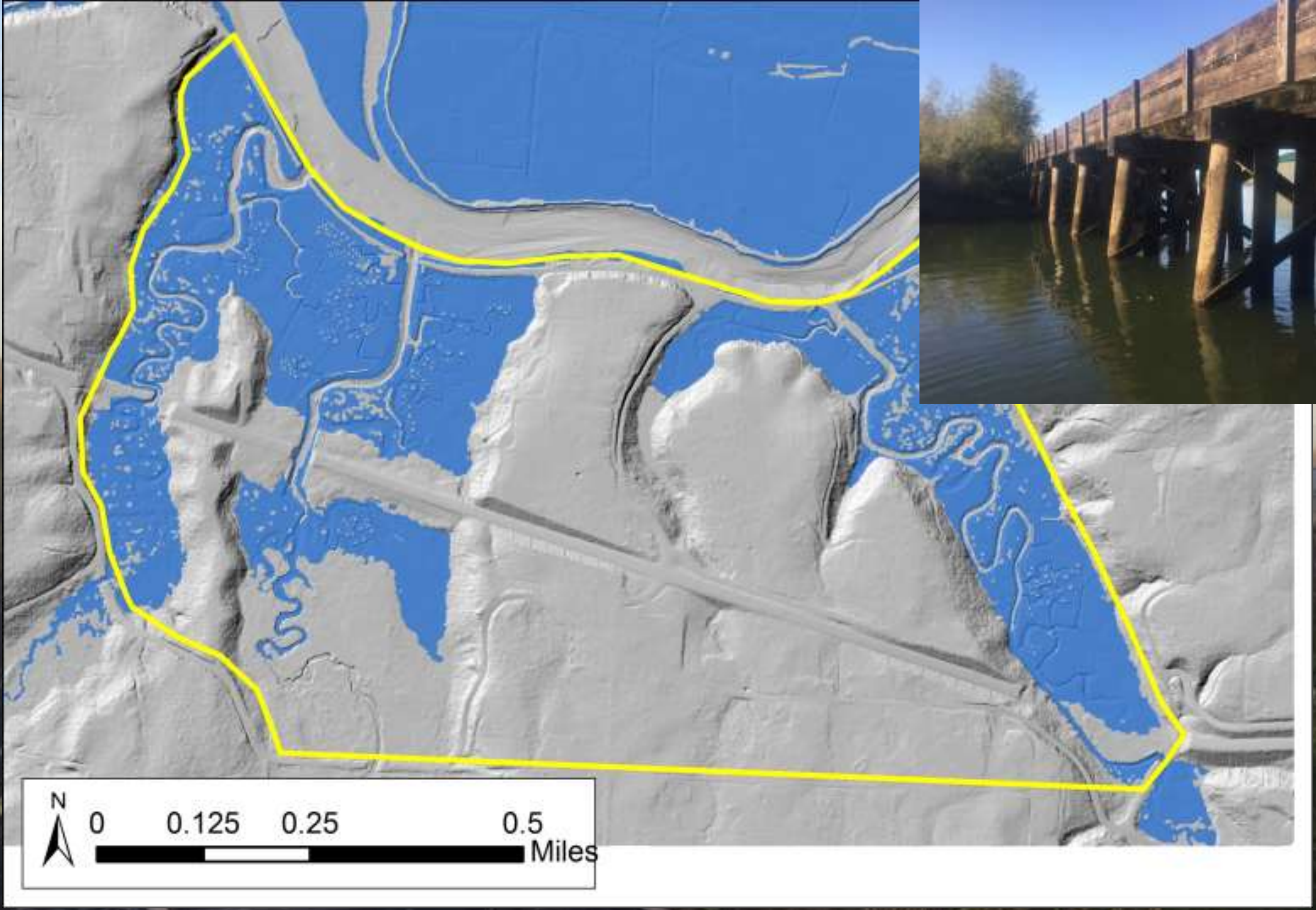
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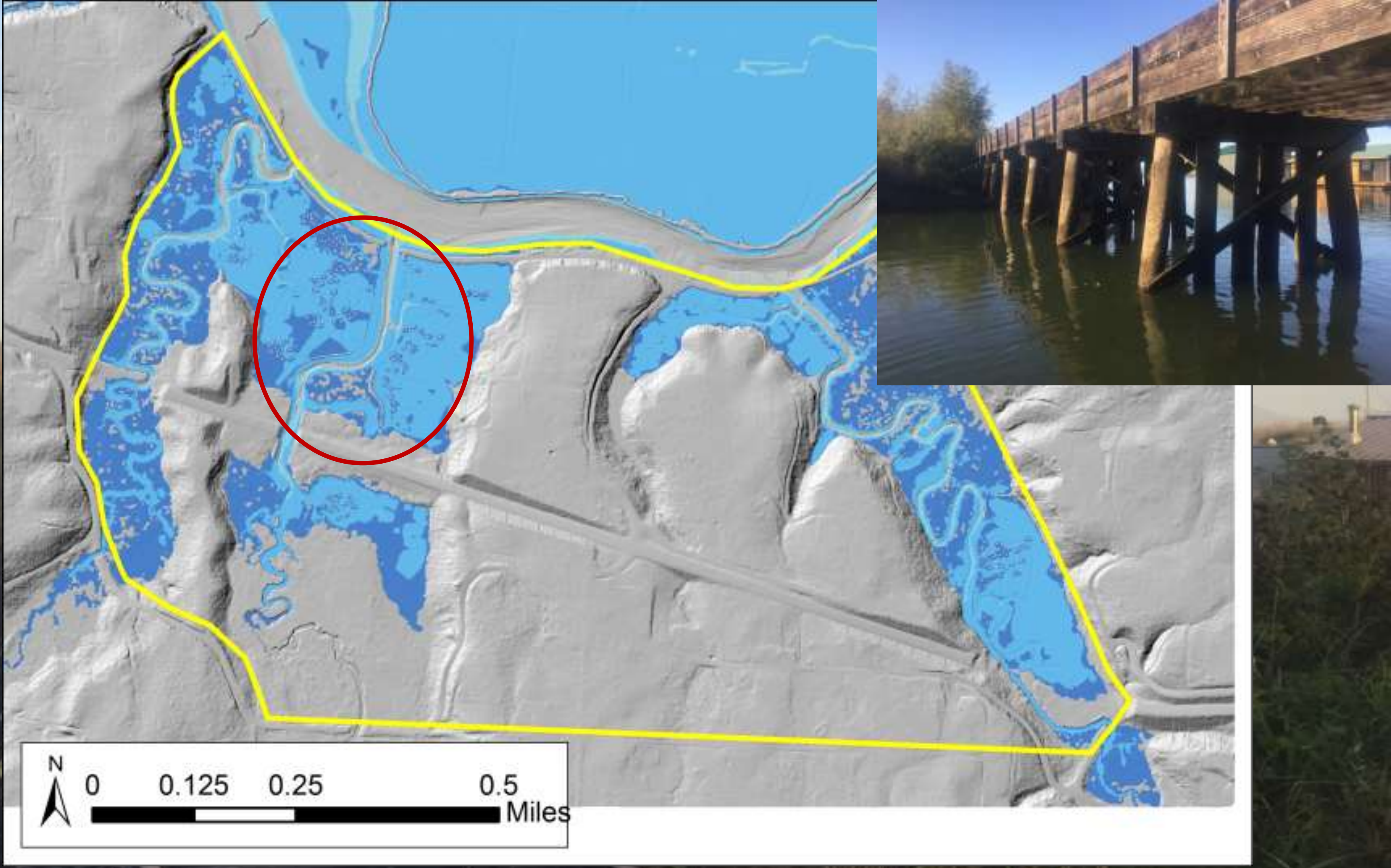
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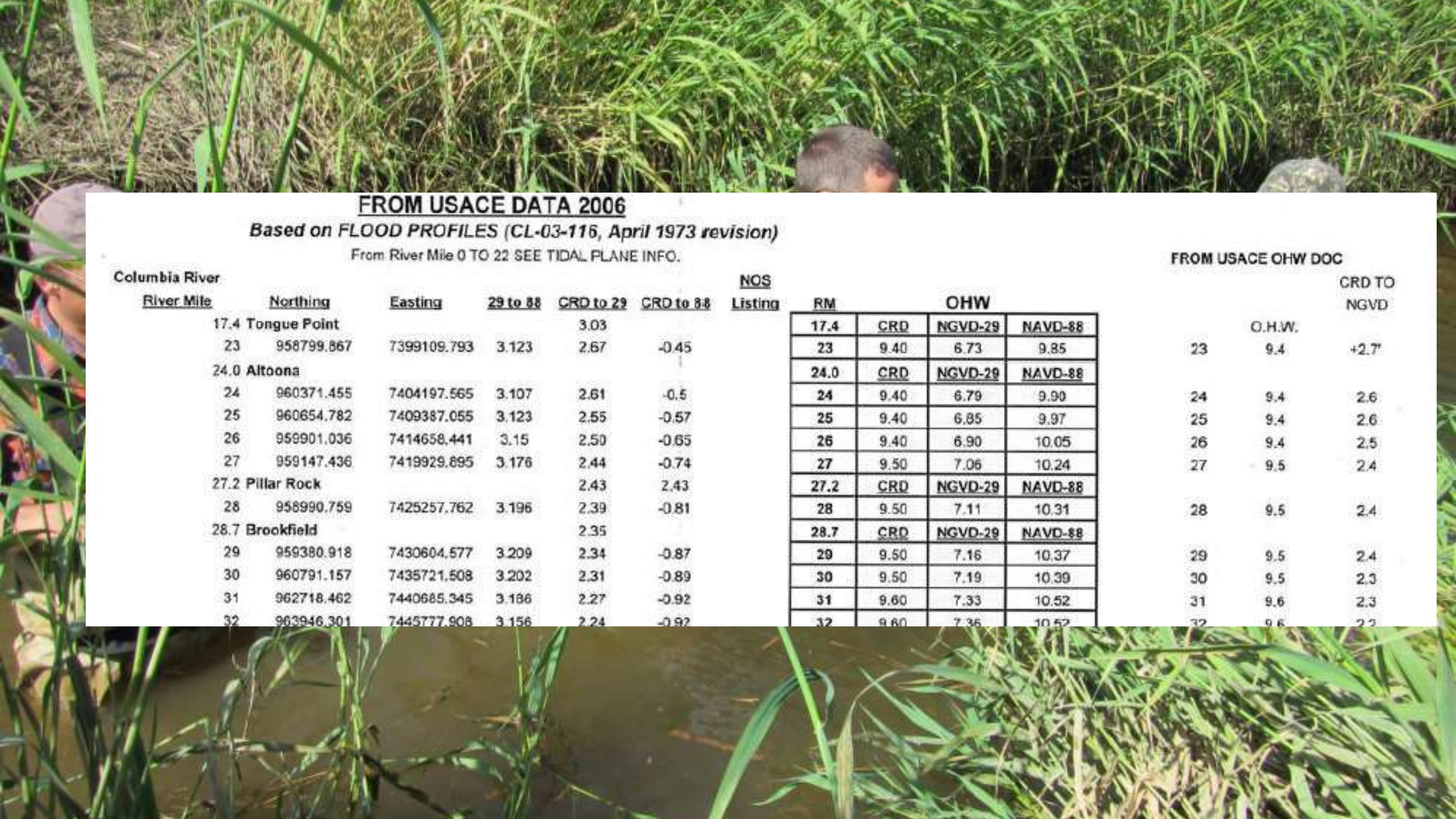
0
0.125
0.25
0.5
Miles

4. Next steps, thoughts

As designers and practitioners we want to contribute to development of tools and guidance for nuanced hydrology…

- Sea level rise
- Columbia River runoff timing
    - Guidance/discussion for selecting climate model outputs
- Hydro regulation
- Tidal dynamics, propagation throughout the estuary
    - Floods/storms
    - channel forming tidal datums
- Ungaged tributaries
- And more



FROM USACE DATA 2006

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30	9.5	2.3
31	9.6	2.3
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Thank you.

calcott@interfluve.com
mcox@interfluve.com