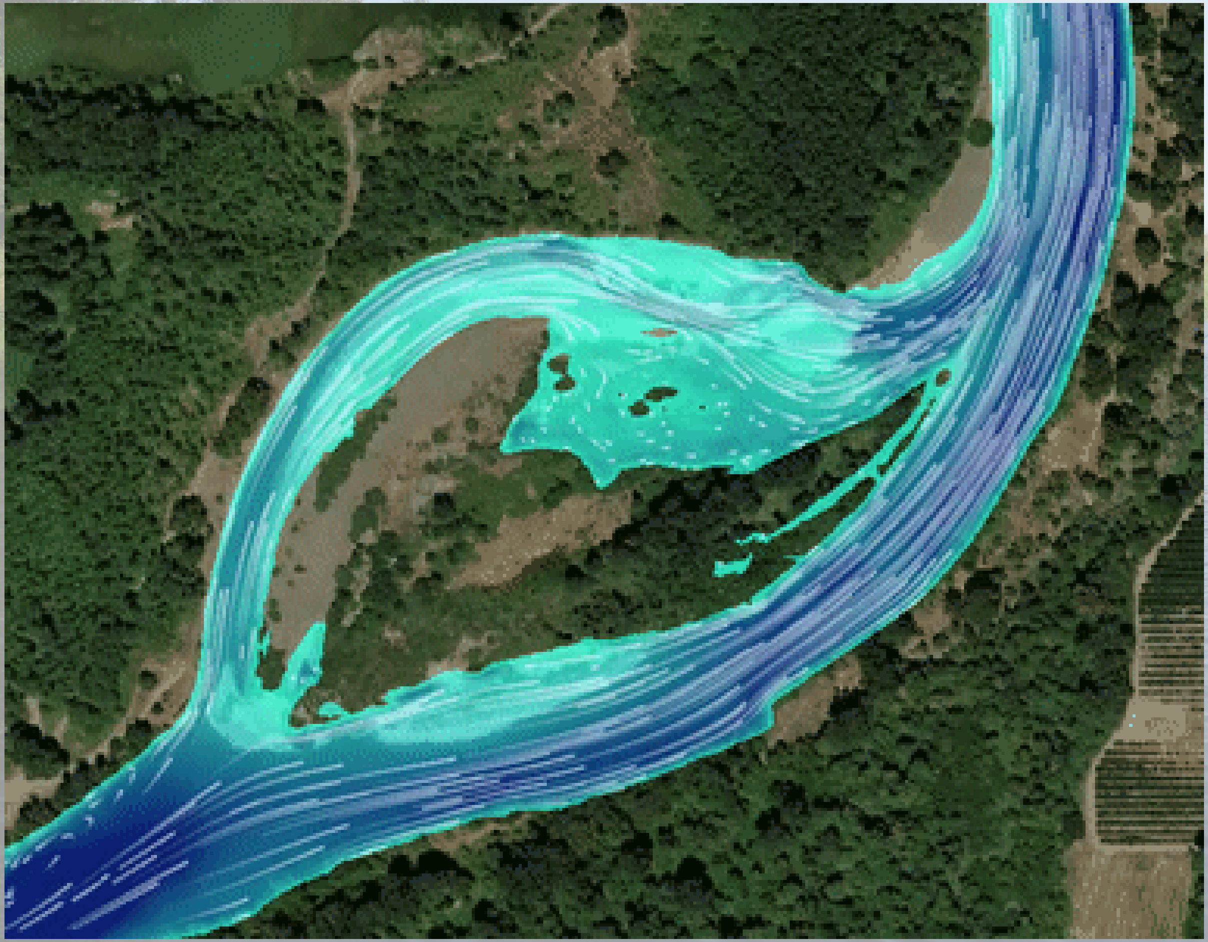
Where, When, and How Much Salmonid Habitat is Available on the Willamette River?

James White, Brandon Overstreet, Laurel Stratton, Rose Wallick, Gabriel Gordon

February 11, 2020



Many people involved and contributing to study

USGS ORWSC: Stewart Rounds, Adam Stonewall, Greg Lind, Mackenzie Keith, Krista Jones

USACE: Rich Piaskowski, Jacob Macdonald, Greg Taylor, Jeff Balantine, Norman Buccola, Paul Sclafani

Oregon State University: Jim Peterson, Jessica Pease, Tyrell DeWeber

USGS WFRC: Toby Kock, Gabriel Hansen, Russ Perry

NOAA Fisheries: Anne Mullan, Diana Dishman

ODFW: Luke Whitman, Brian Bangs

USGS

Funding provided by US Army Corps of Engineers

Overview

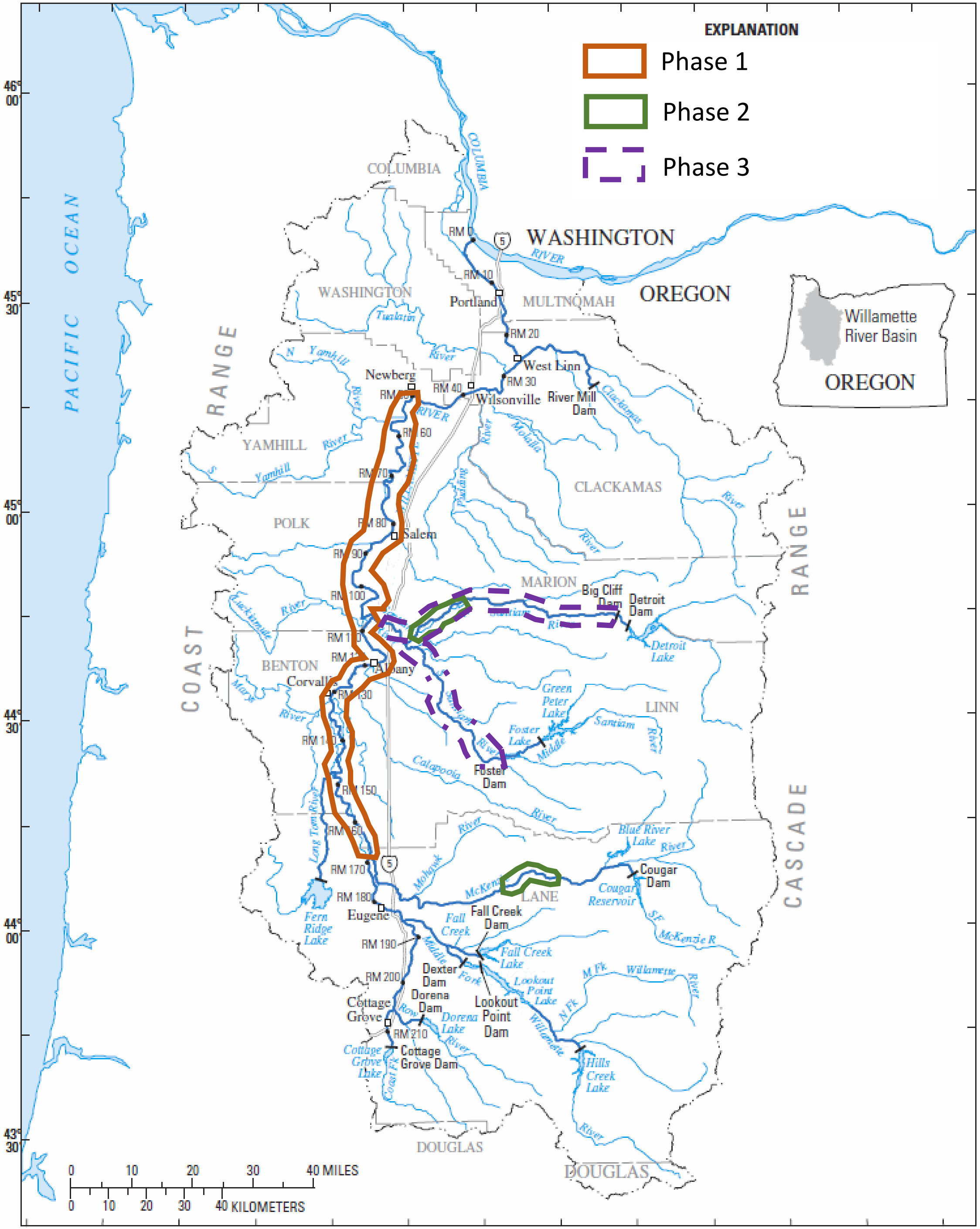
- Study Overview
  - Goals
  - Approaches
- Willamette River
  - Geomorphology, hydrology, and modern flow management
- Results
- Next Steps

Study Goals

1. Quantify available rearing Chinook and steelhead habitat as a function of streamflow and water temperature

2. Create models and datasets to facilitate similar analysis on key Willamette tributaries

3. Quantify physical habitat of additional species and potential overlap between rearing Chinook and Smallmouth bass to assess the extent to which flow management can limit predation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BENTON
LINN
LANE
DOUGLAS
Willamette River Basin
OREGON
Portland
West Linn
Wilsonville
Newberg
Salem
Albany
Corvallis
Eugene
Cottage Grove
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Cottage Grove Dam
Cottage Grove Lake
Hills Creek Lake
Fern Ridge Lake
Tualatin River
Yamhill River
Clackamas River
Molalla River
Pudding River
Santiam River
Calapooia River
McKenzie River
Mohawk River
Long Tom River
Row River
Luckiamute River
Marys River
0 10 20 30 40 MILES
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Willamette River Overview

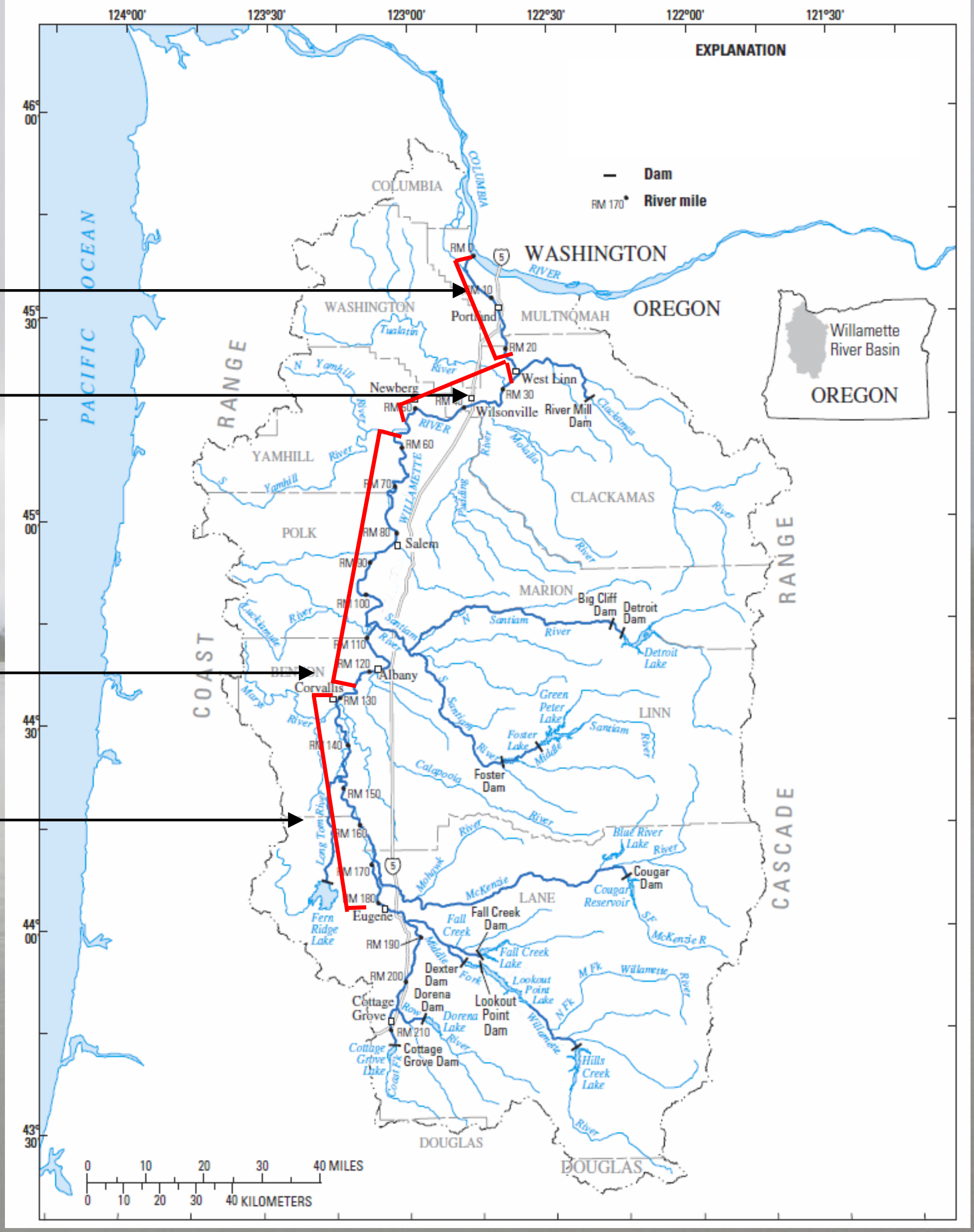
Four rivers in one valley

Lower Willamette

Newberg Pool

Middle Willamette

Upper Willamette



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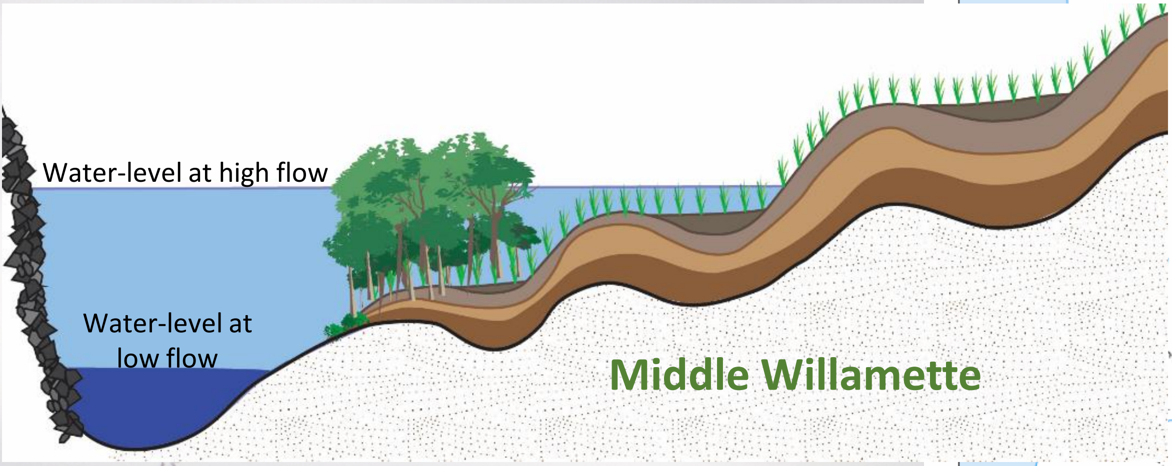
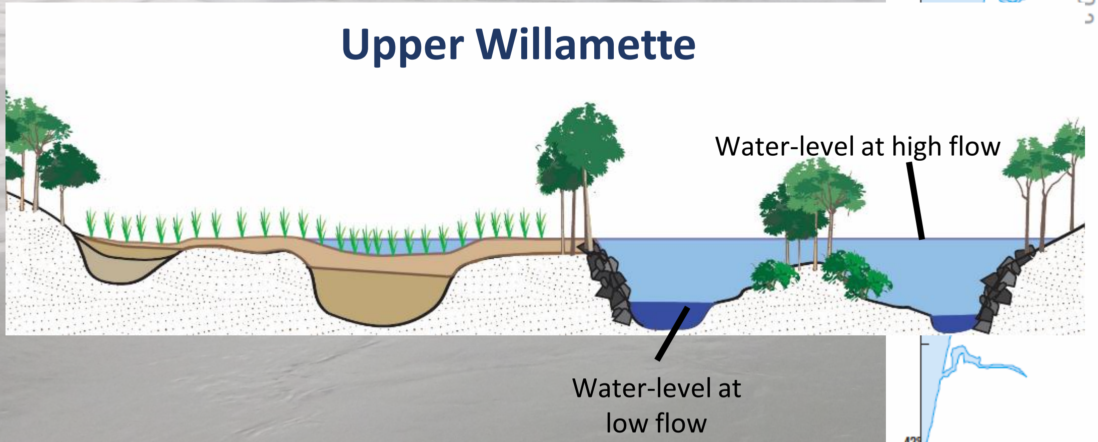
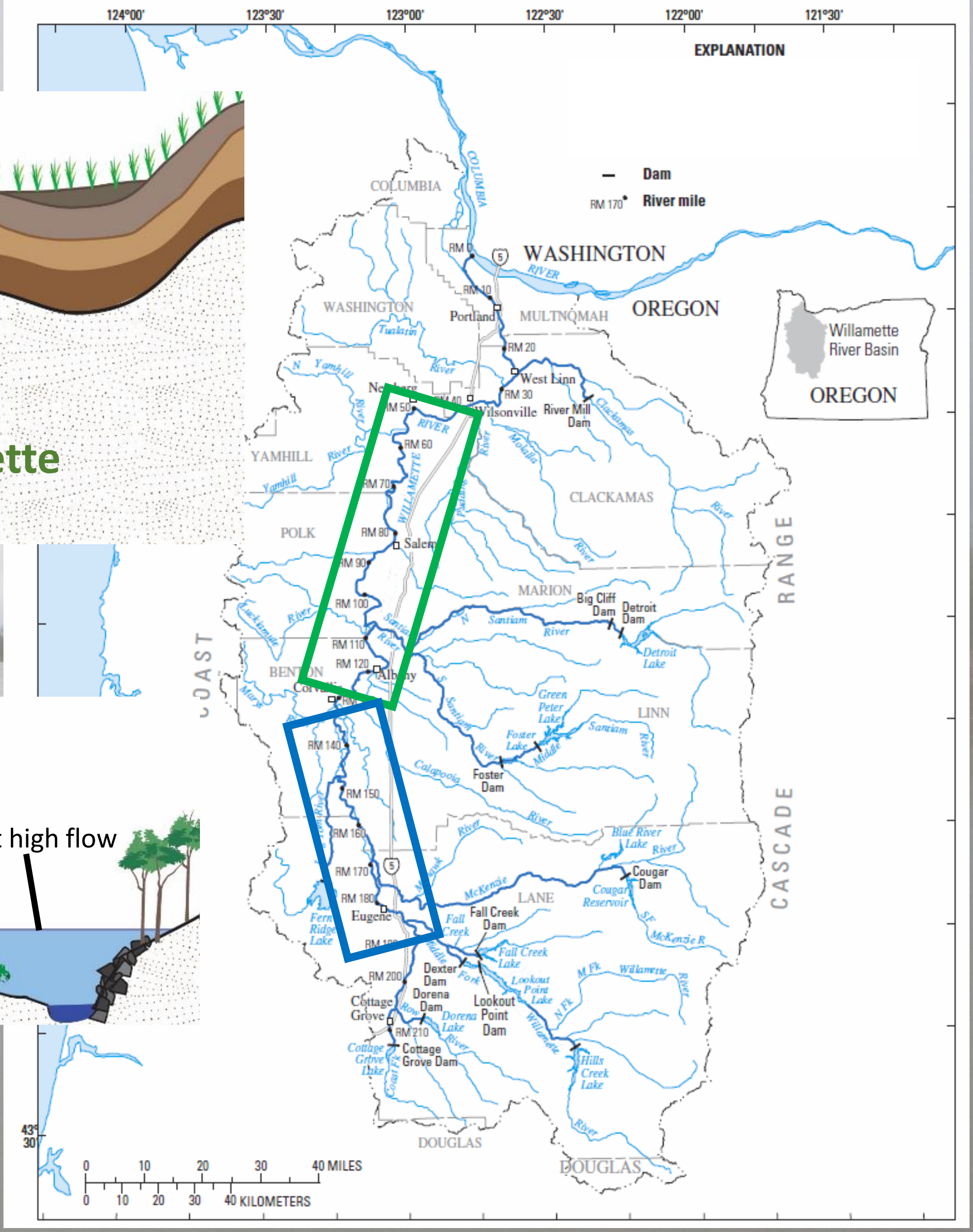
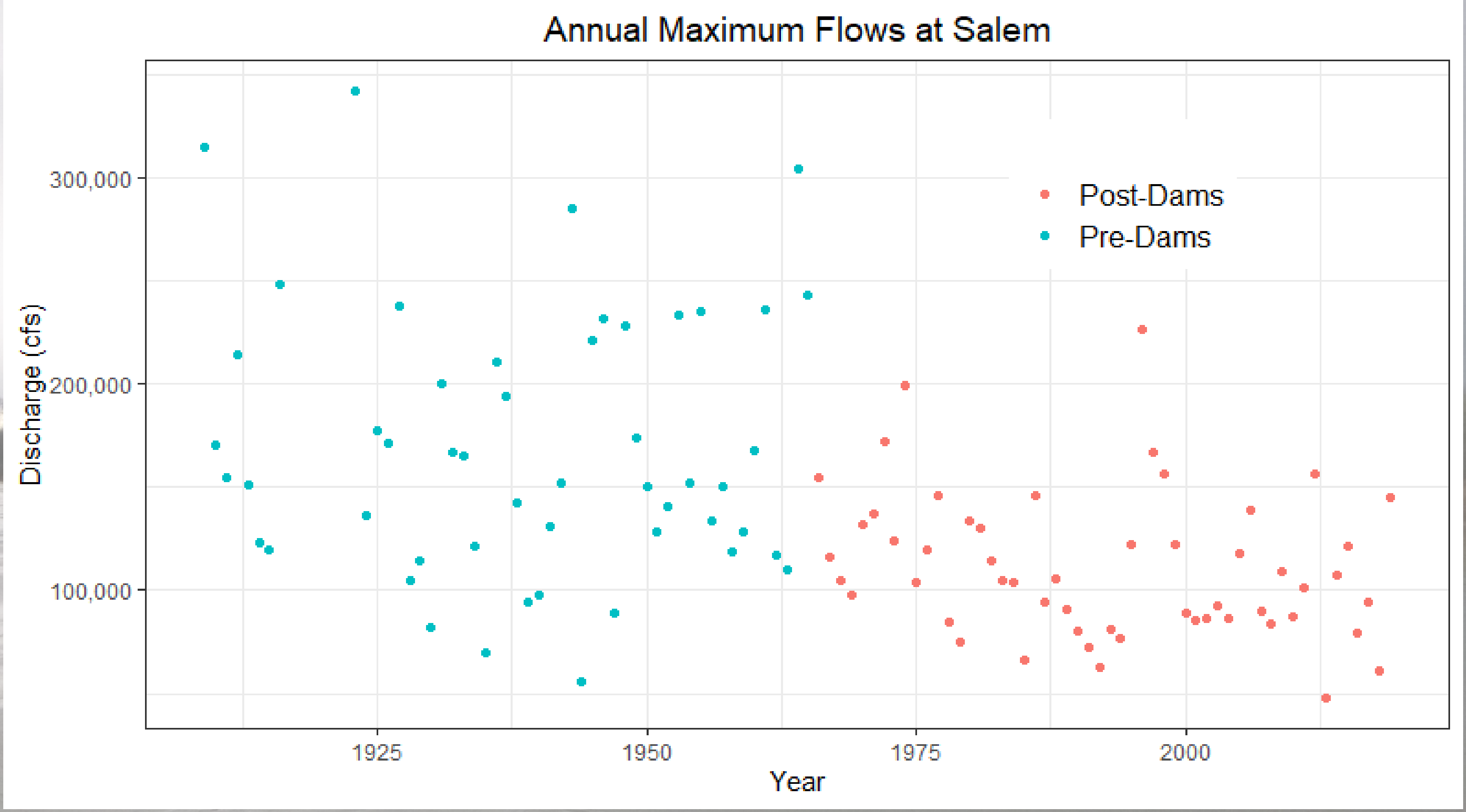
Willamette River Overview







Willamette River Overview
Peak Flows 1895 - 2019



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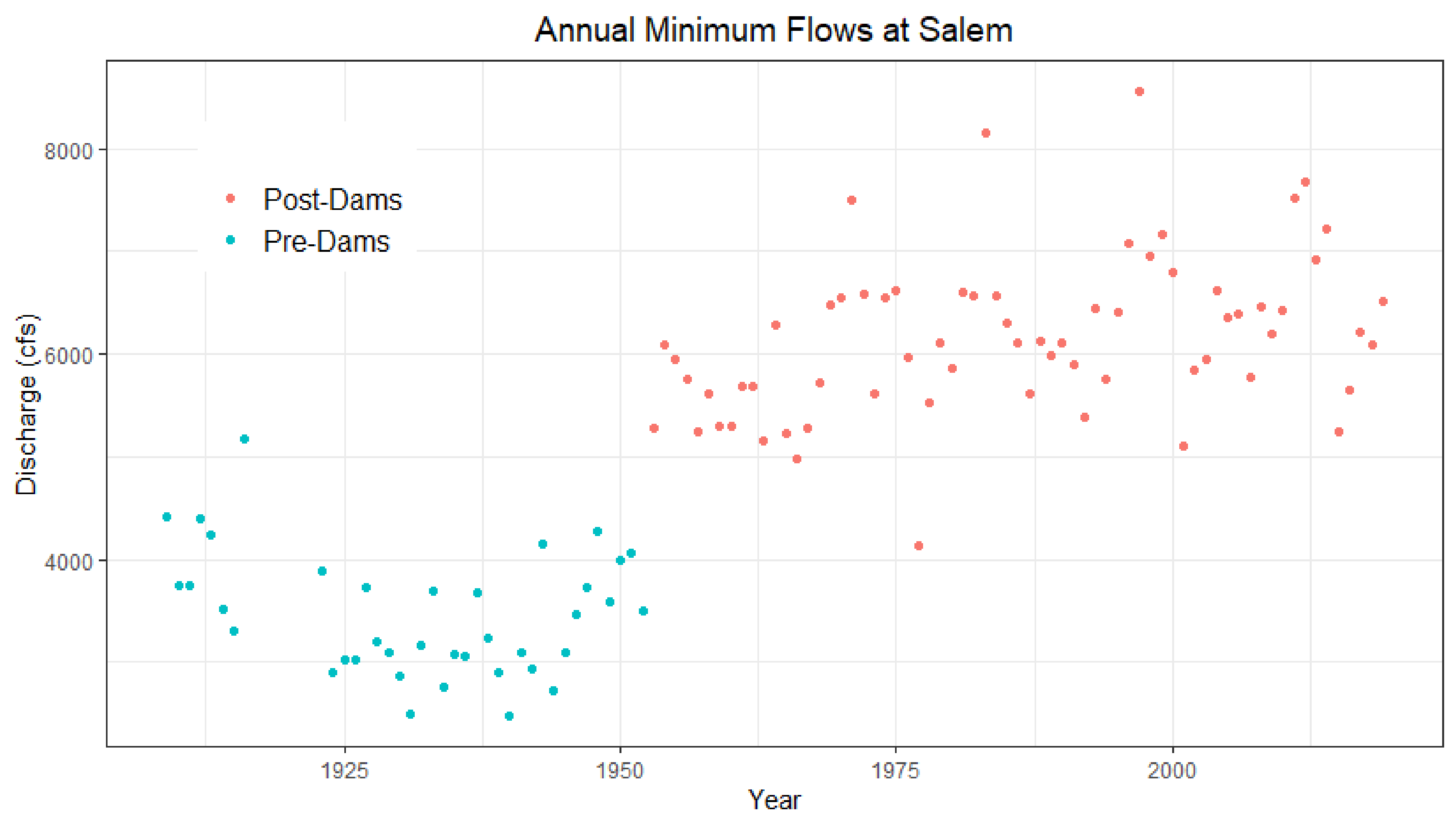
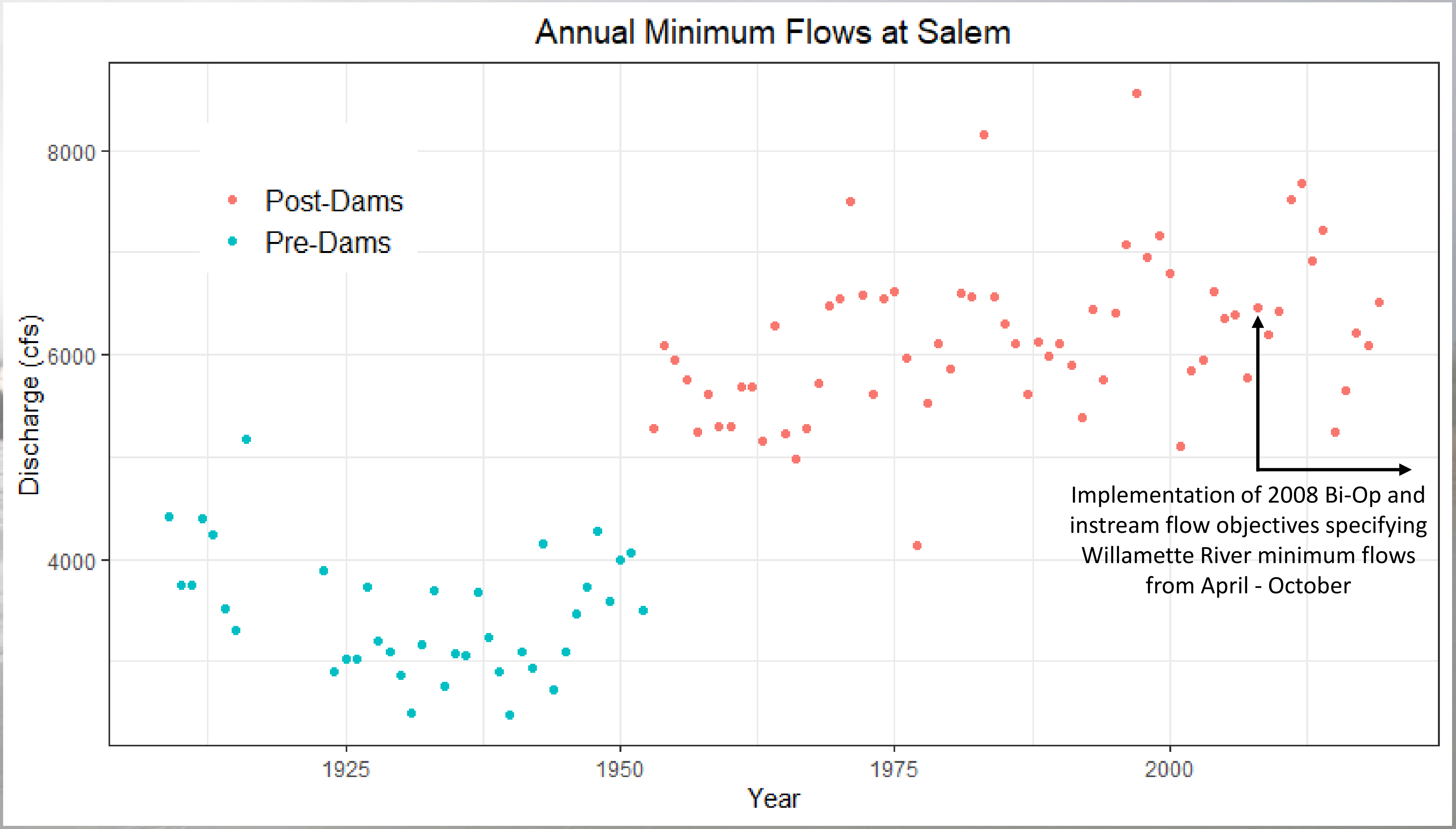
Willamette River Overview
Annual Minimum Flows 1895 - 2019



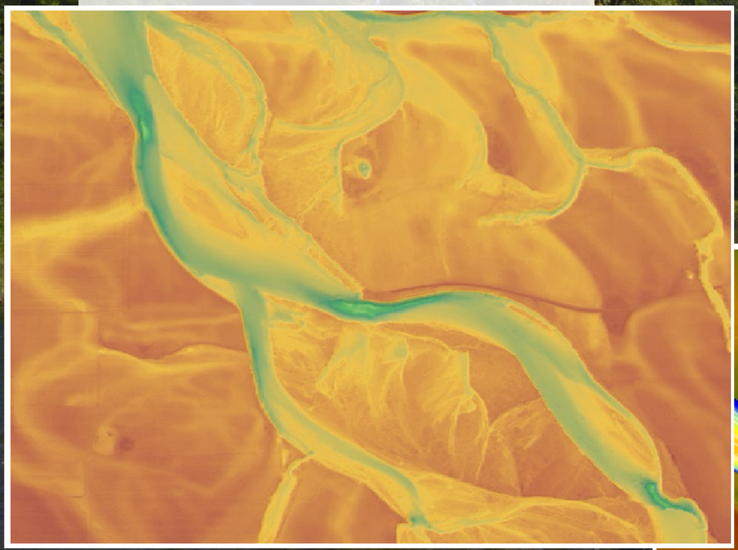
Willamette River Overview
Annual Minimum Flows 1895 - 2019



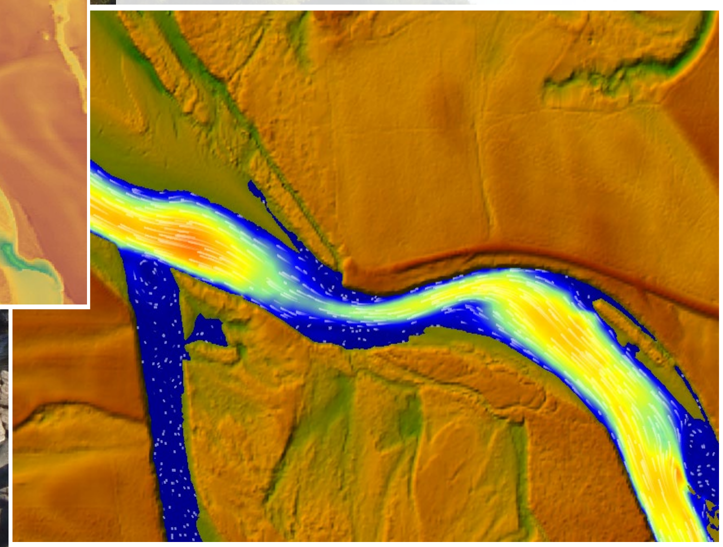
Goal 1: Quantify useable rearing habitat

Aquatic habitat evaluated using three datasets

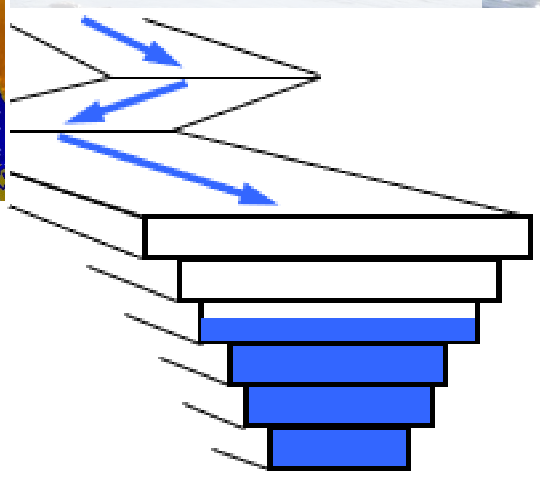
Bathymetry



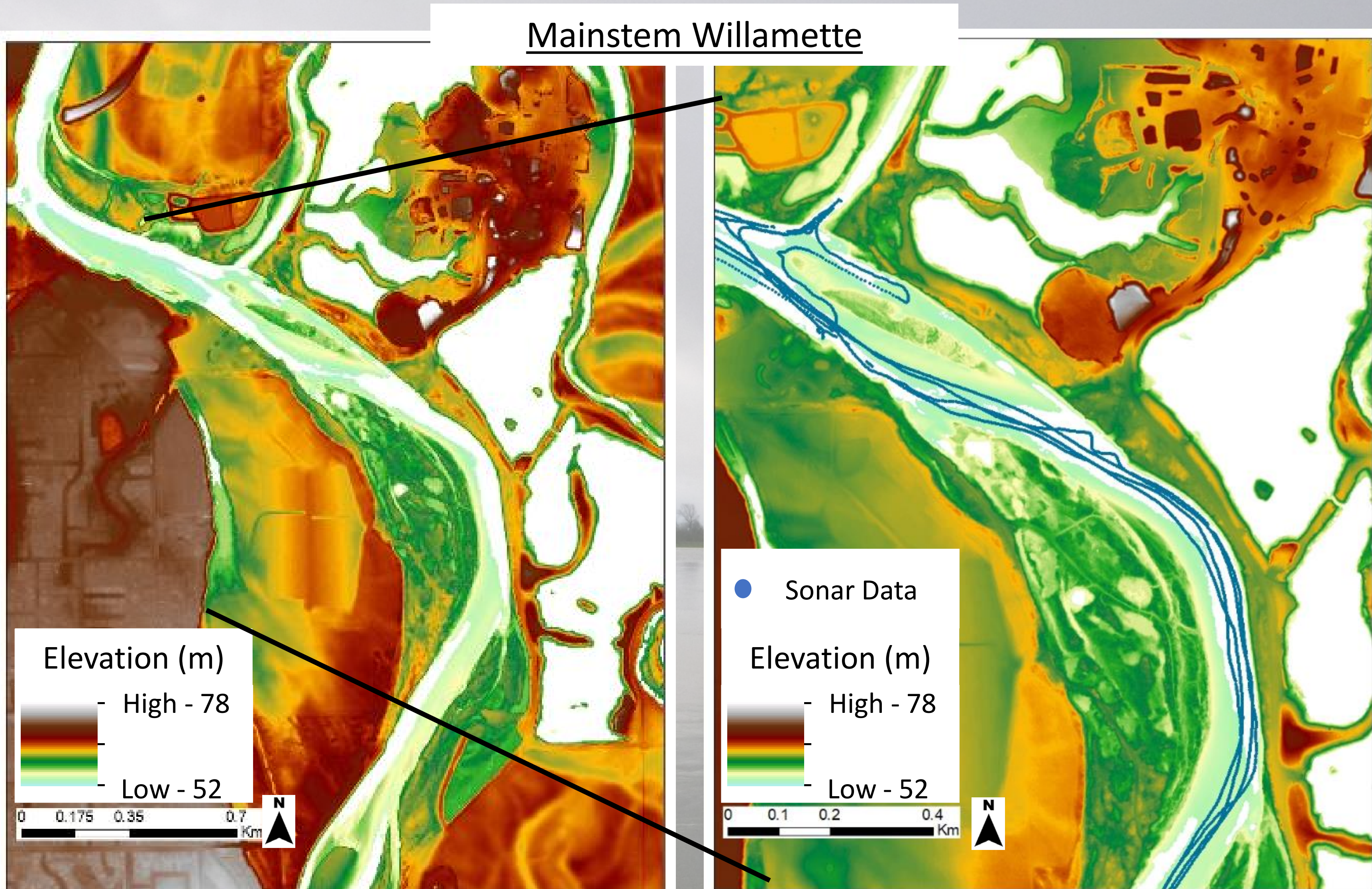
2D Hydraulic Model



Temperature Model



Bathymetry



2017 topo-bathymetric lidar

2015-2018 sonar

Data source: QSI, 2017

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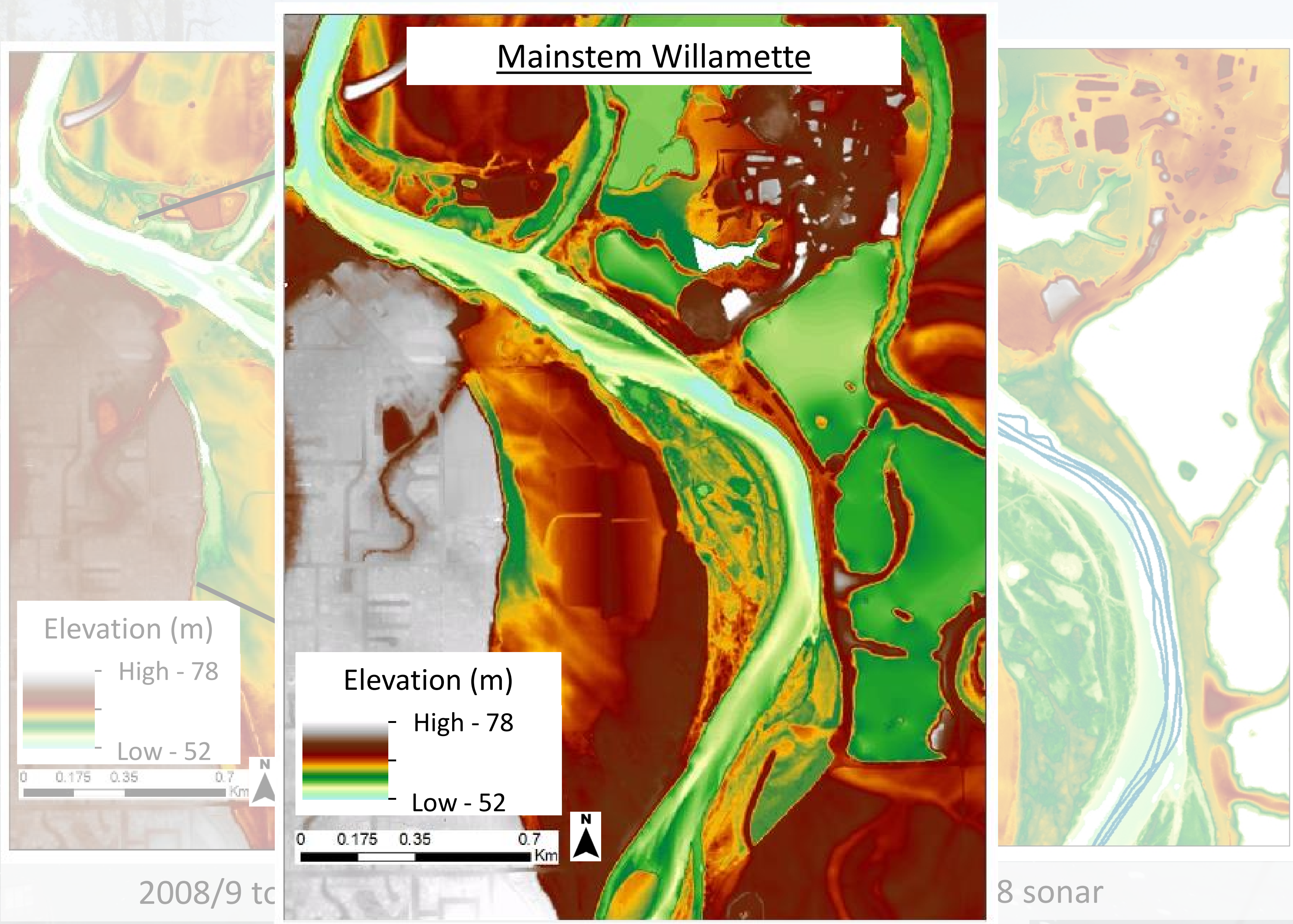
Preliminary Results – subject to revision

Bathymetry



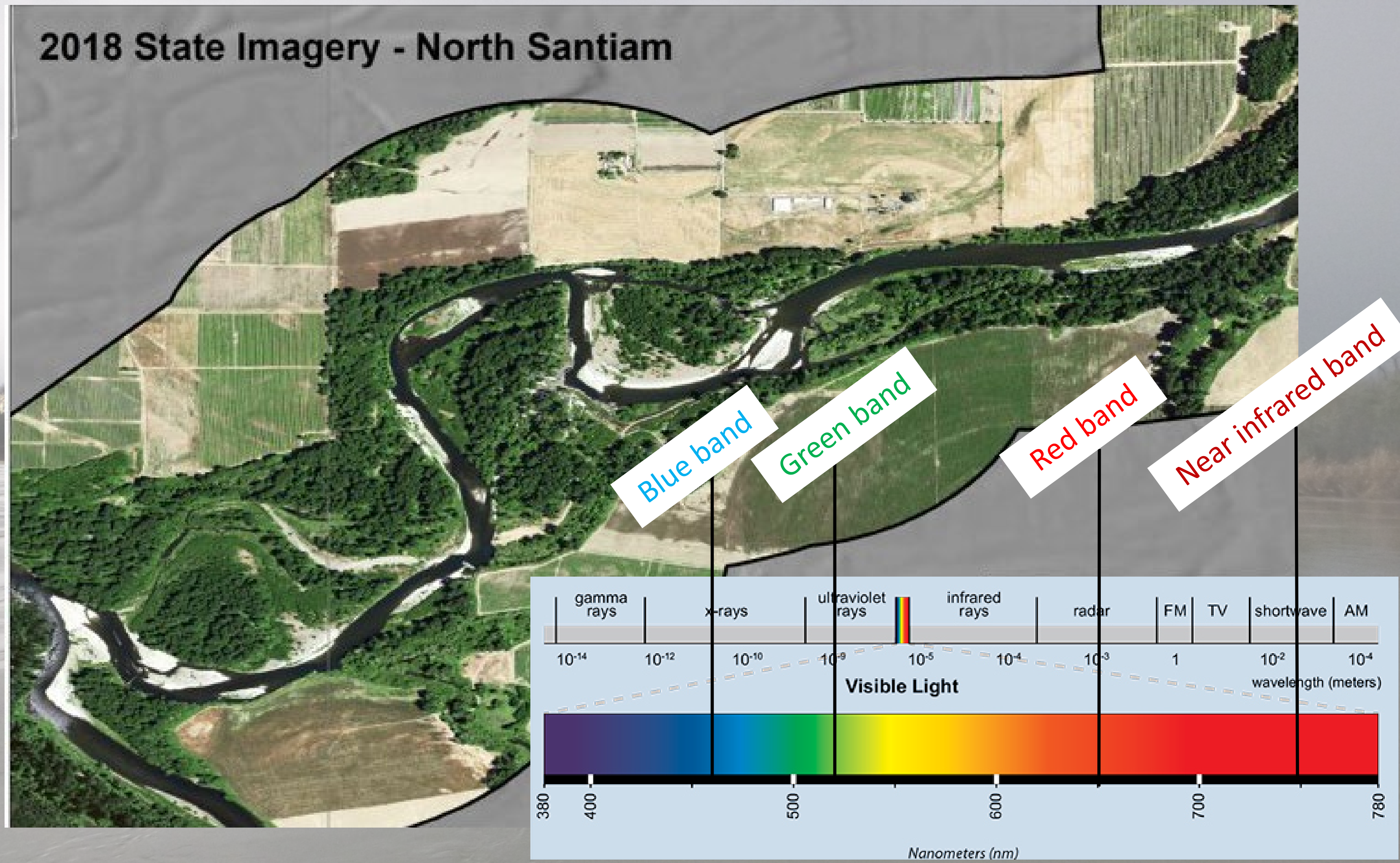
Seamless bathymetry/topography

Data source: QSI, 2017

Preliminary Results – subject to revision

Bathymetry

Topo-bathymetric lidar not available on most tributaries



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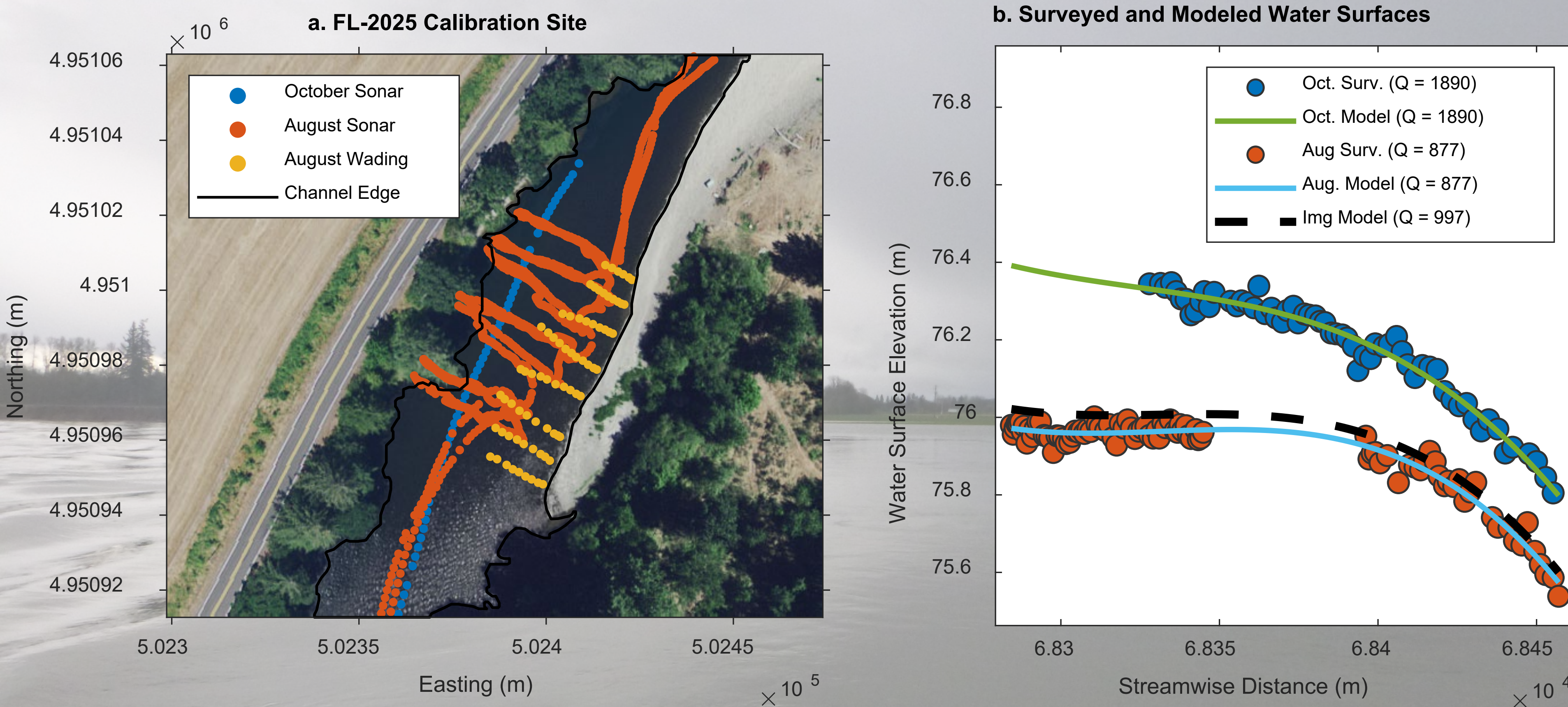
Bathymetry

Field data collection



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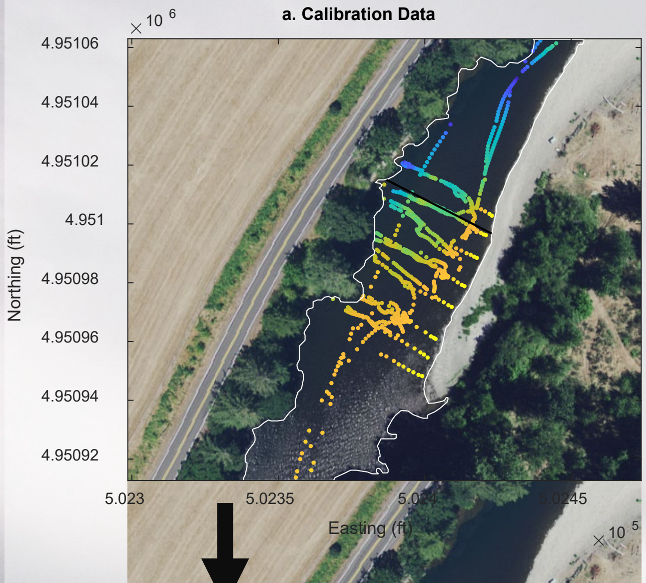
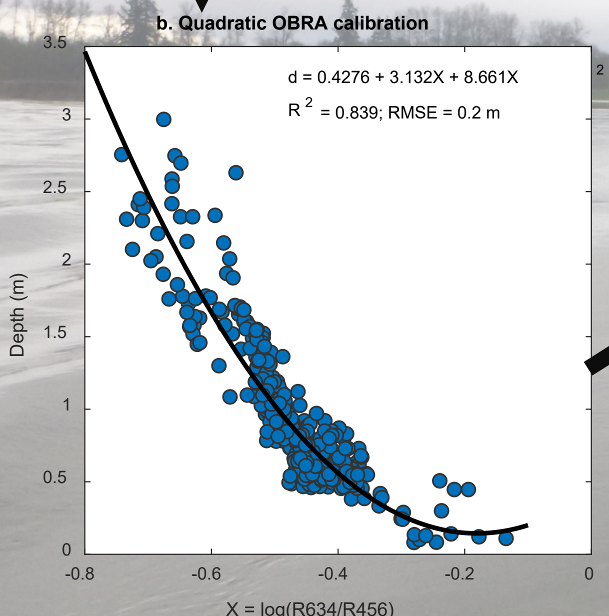
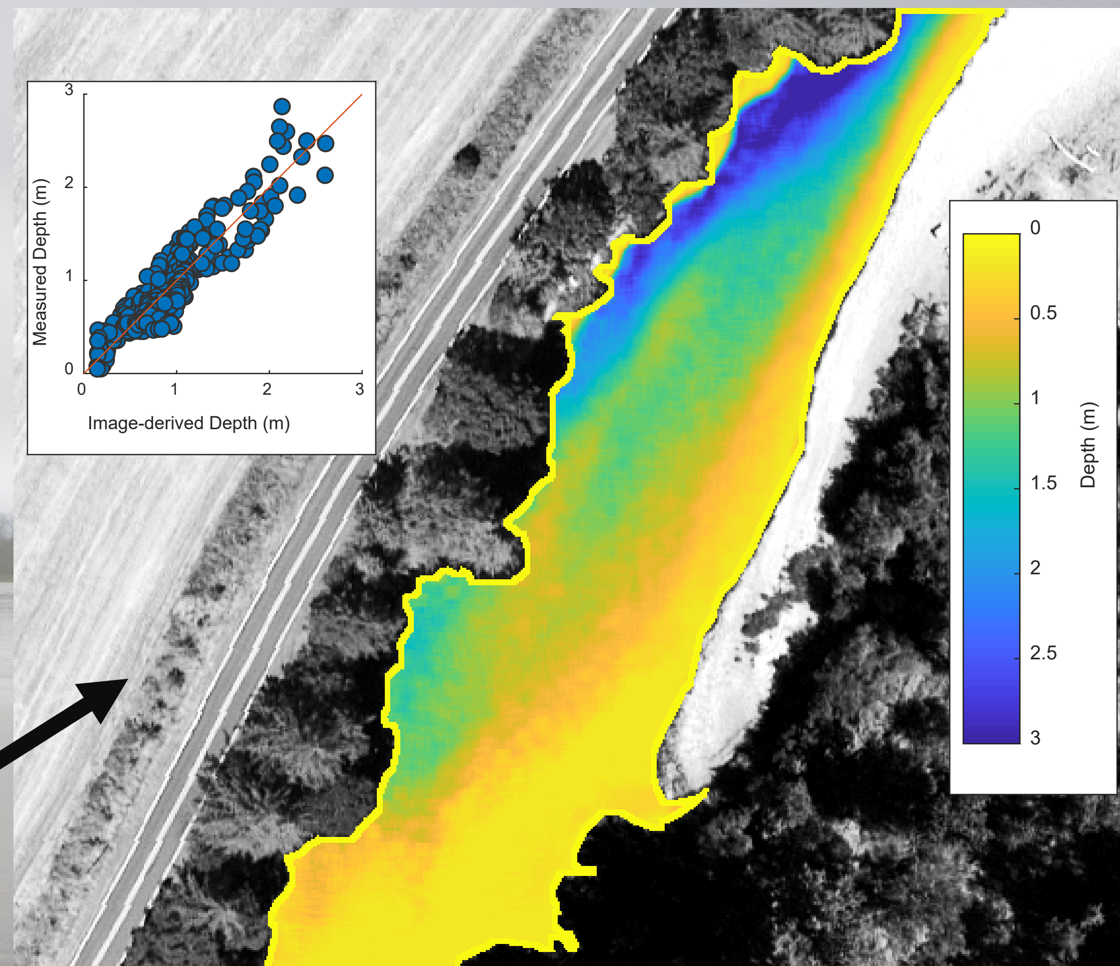


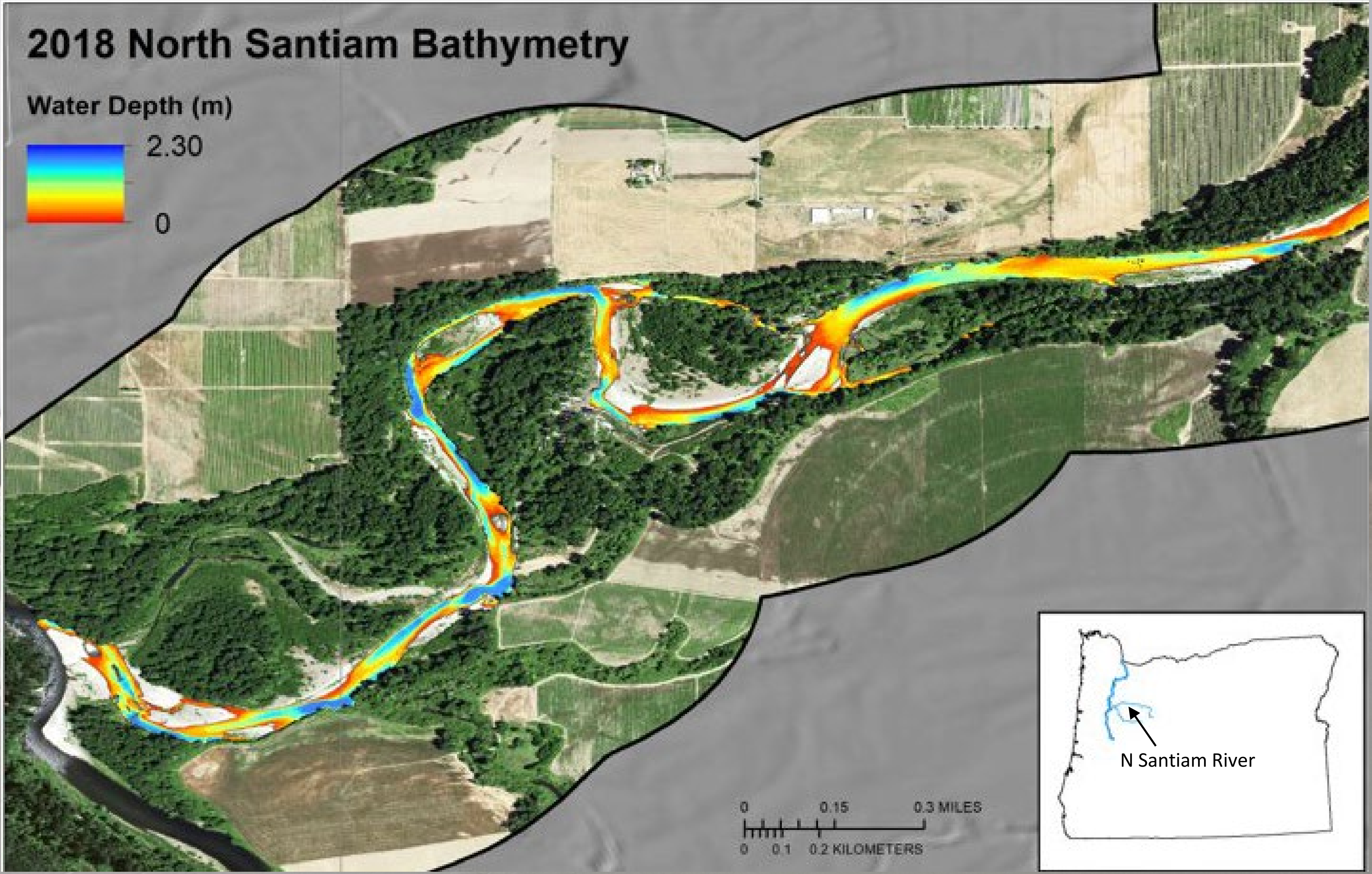




Red/blue band ratio

Preliminary Results – subject to revision

Bathymetry



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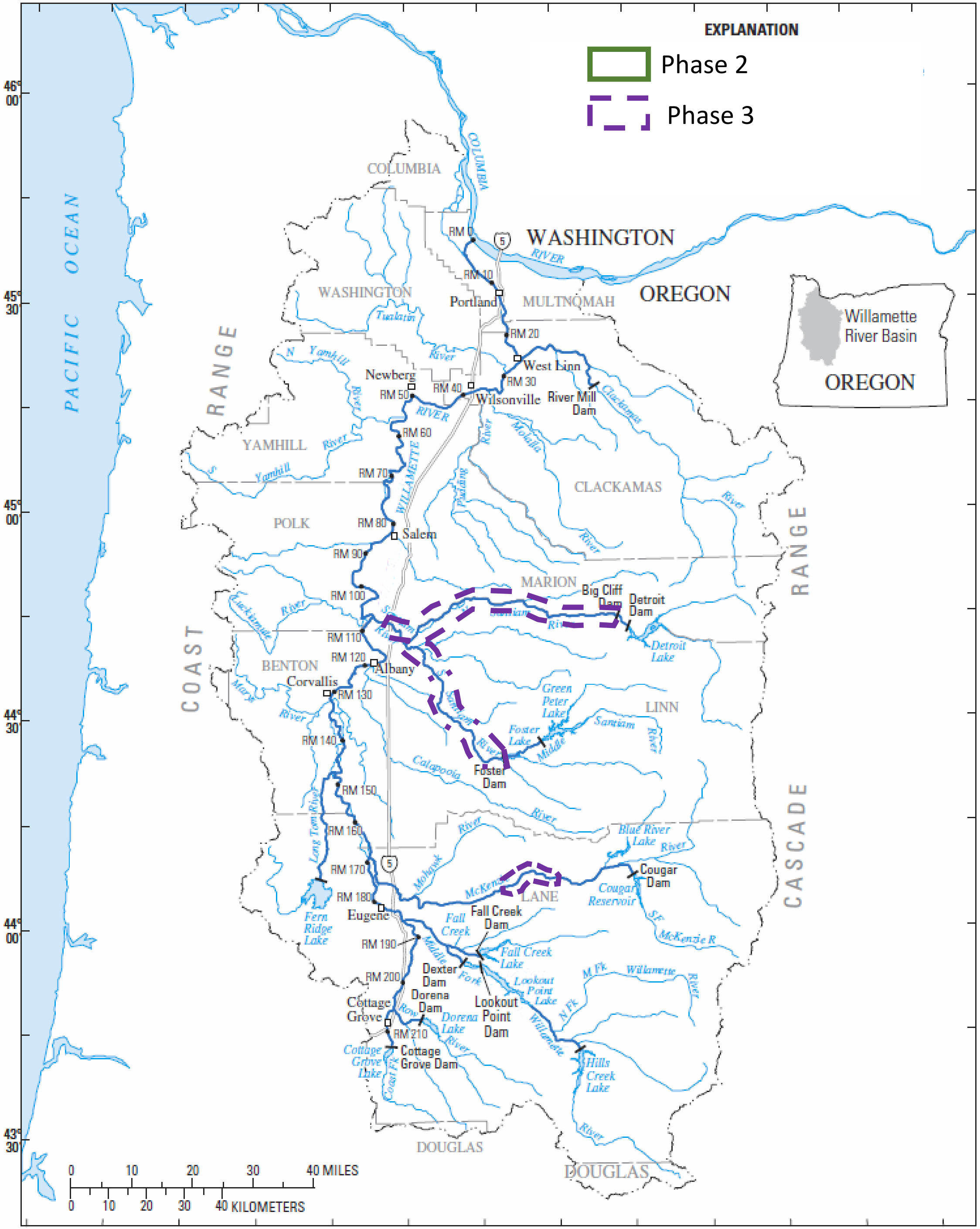

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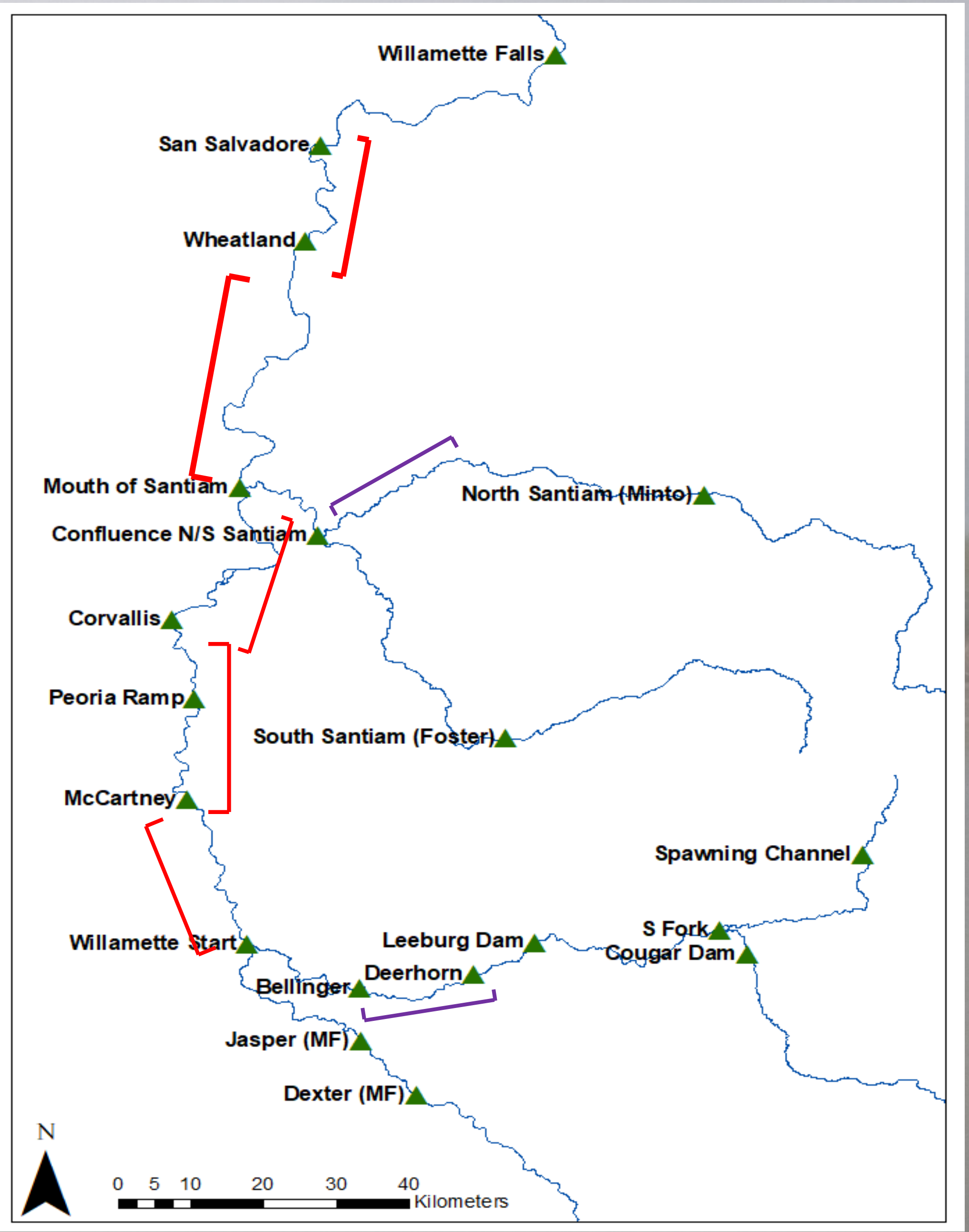
Hydraulic Model

Hydraulic Model Reaches



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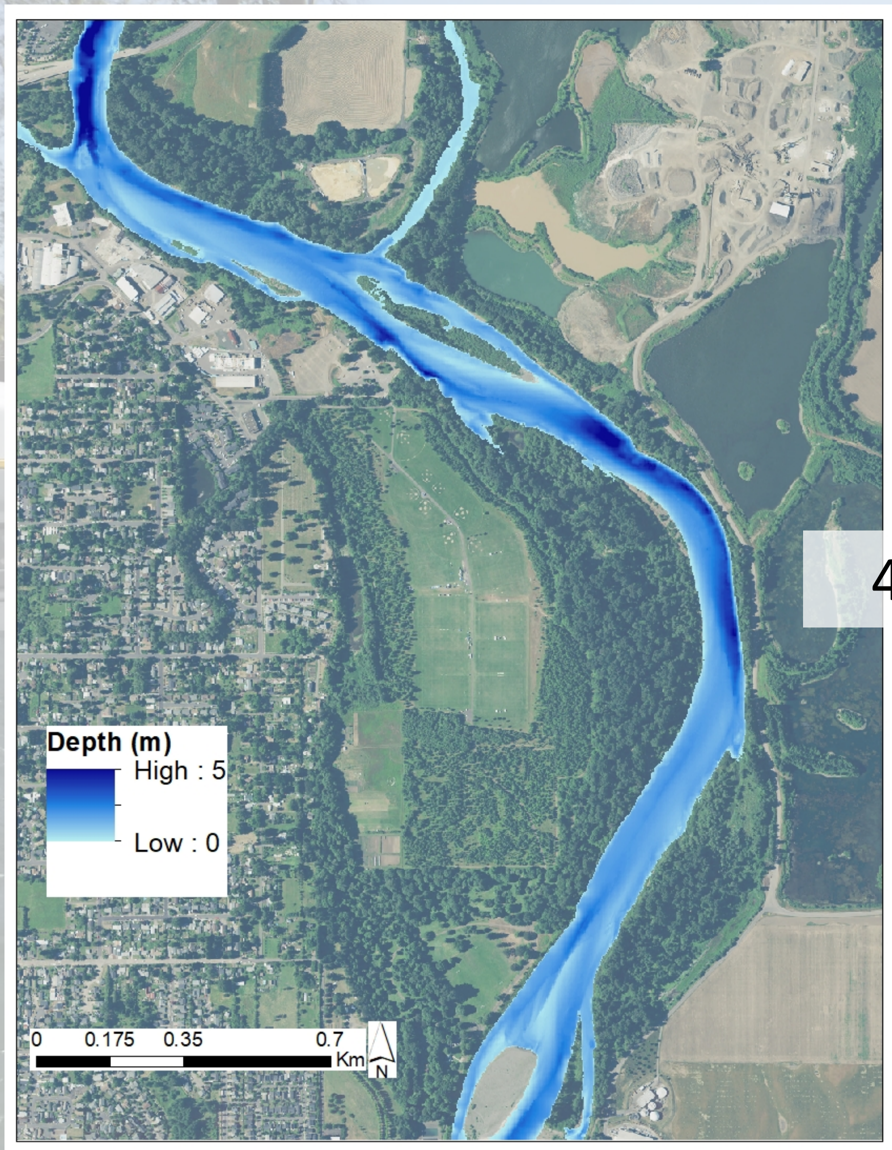
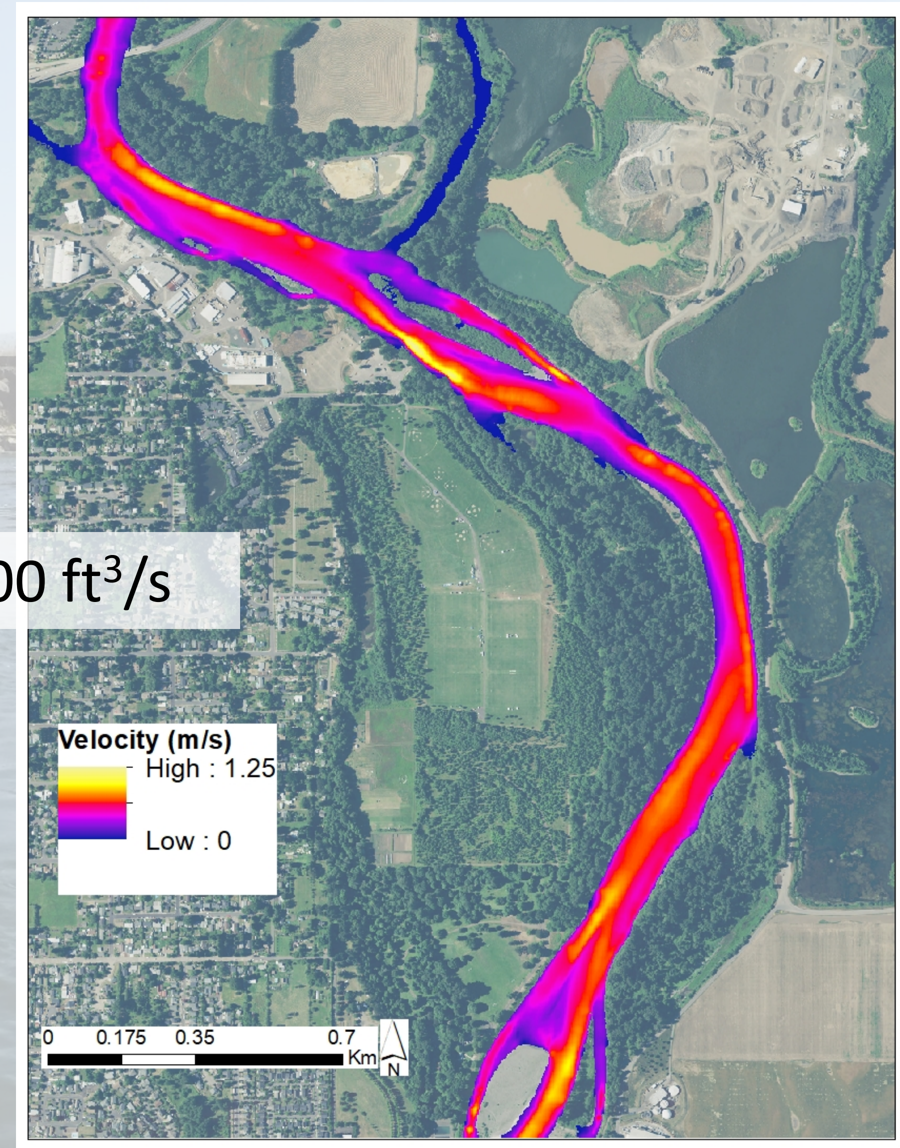
Hydraulic Model



4,000 ft^3/s



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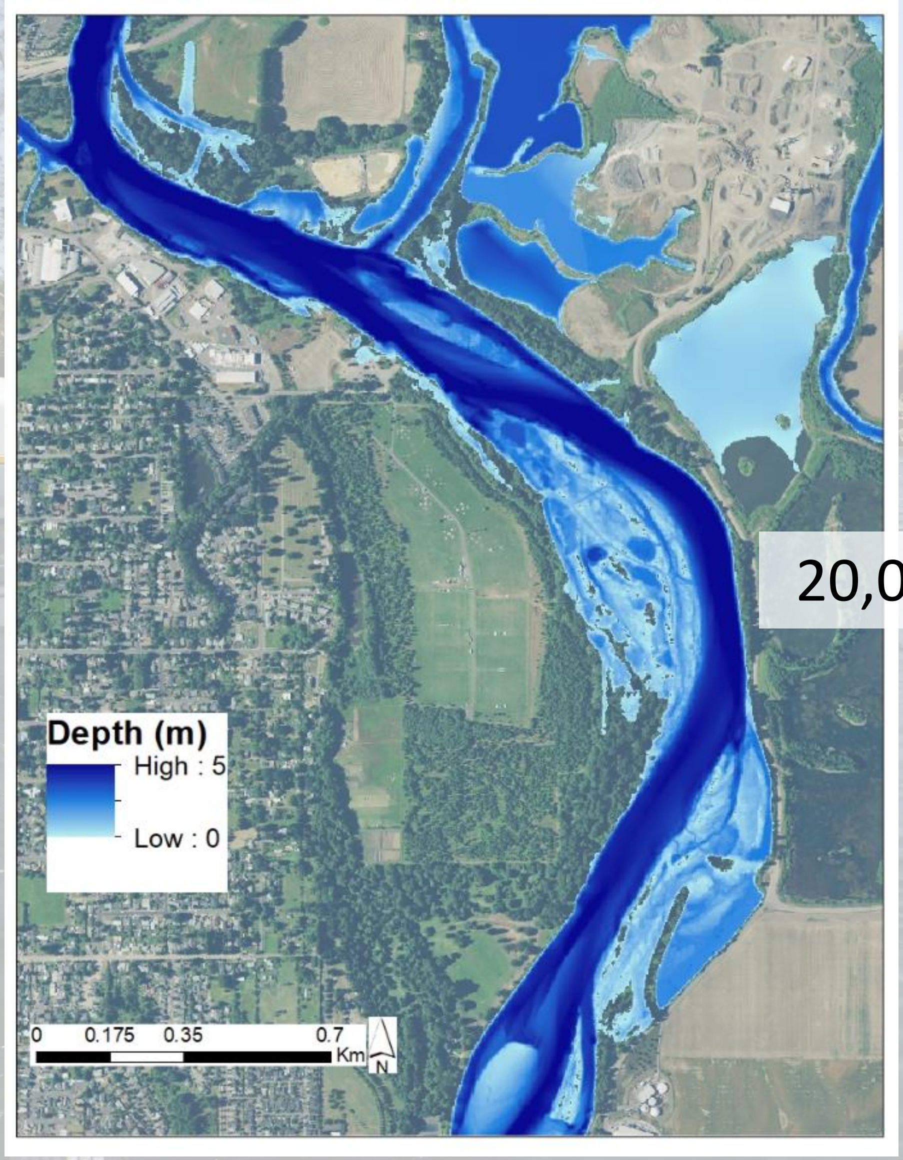
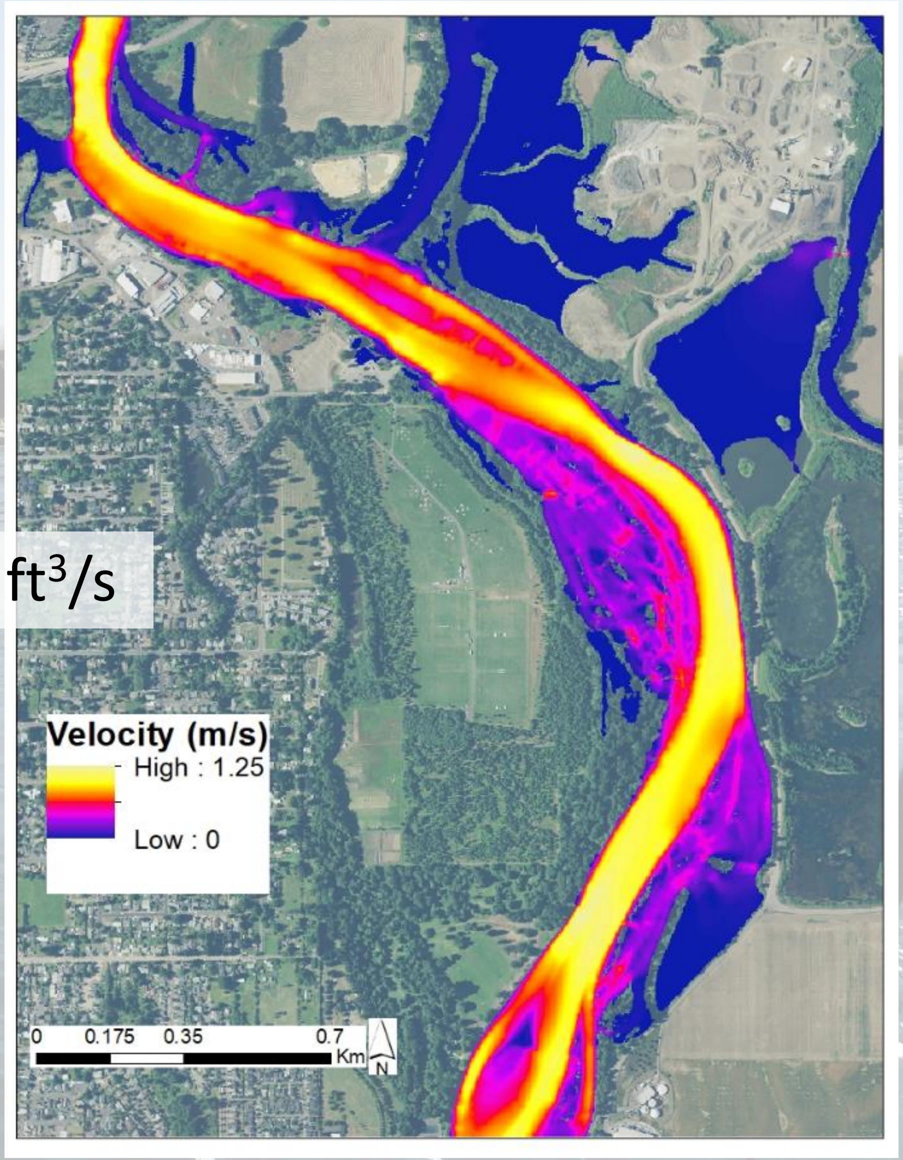
Preliminary Results – subject to revision

Hydraulic Model



20,000 ft^3/s



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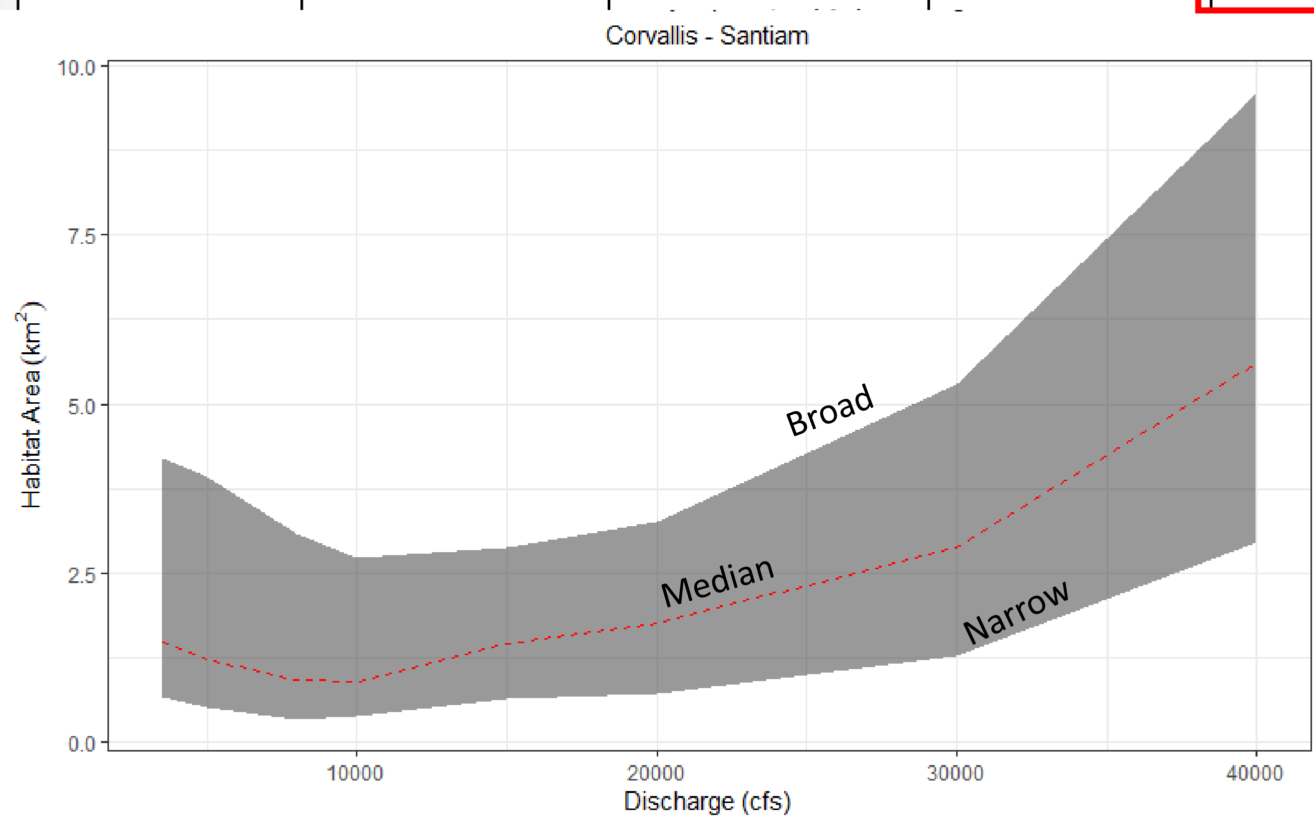
Preliminary Results – subject to revision

Goal 1: Quantify useable rearing habitat

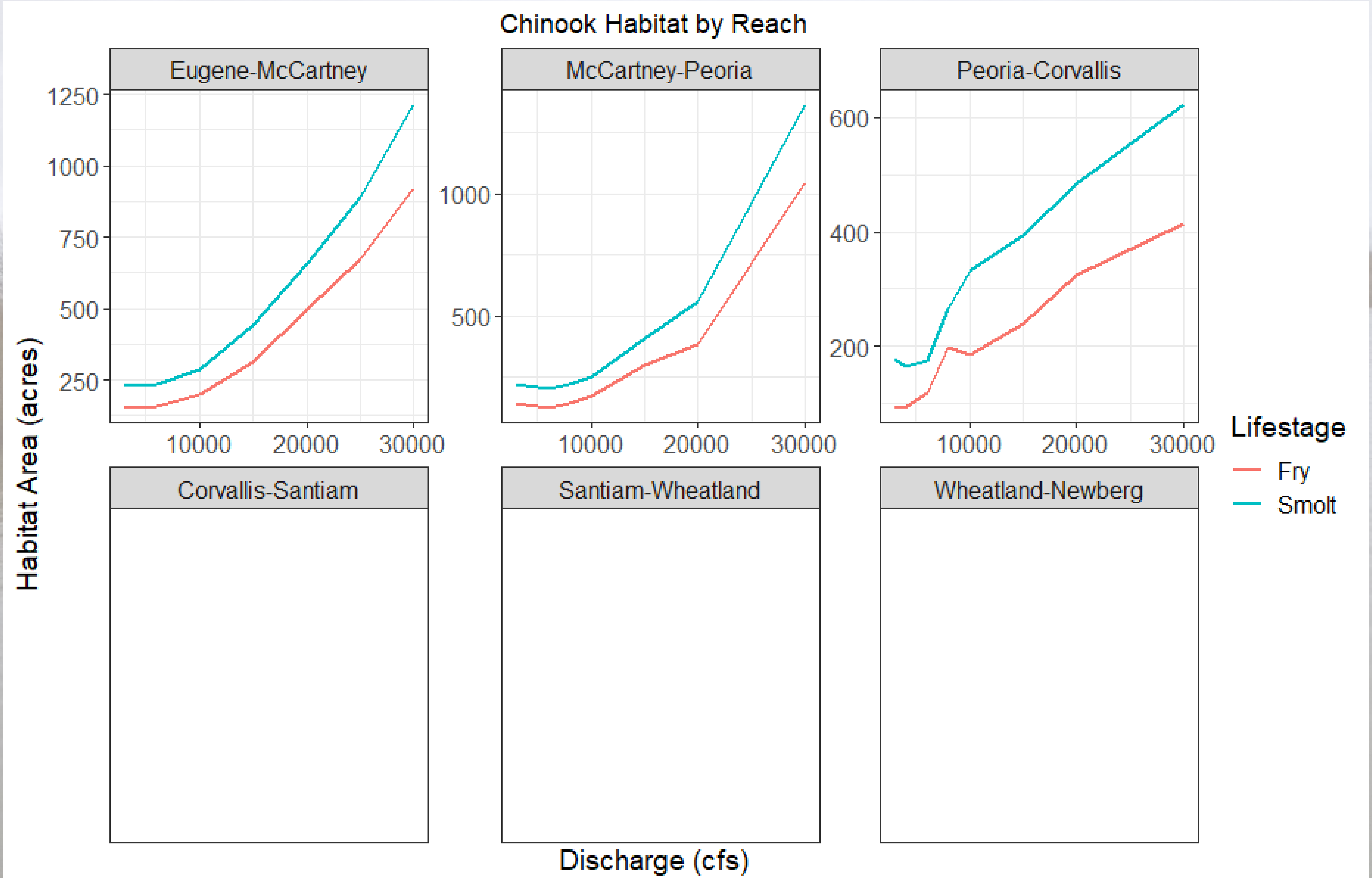
Useable habitat = f(depth[1], velocity[1], bed-slope[2], temperature[3])

1 – Hydraulic Model
2 – Bathymetry
3 – Temperature Model

Species	Size Class	Criteria	Narrow	Median	Broad
Chinook salmon	Pre-smolt (>60mm)	Depth (ft)	0.15-2.25	0.15-3.5	0.15-Inf
		Velocity (ft/s)	0-1.25	0-1.63	0-3
		Bed Slope	<0.4	<0.55	Any
				.15-3.5	0.15-5
				)-1.25	0-1.5
				<0.55	Any
				).15-1	0.15-Inf
				)-3.25	0-3.5
				NA	NA
				).25-2	0.25-5
				)-1.25	0-2
				NA	NA



Habitat Model Results



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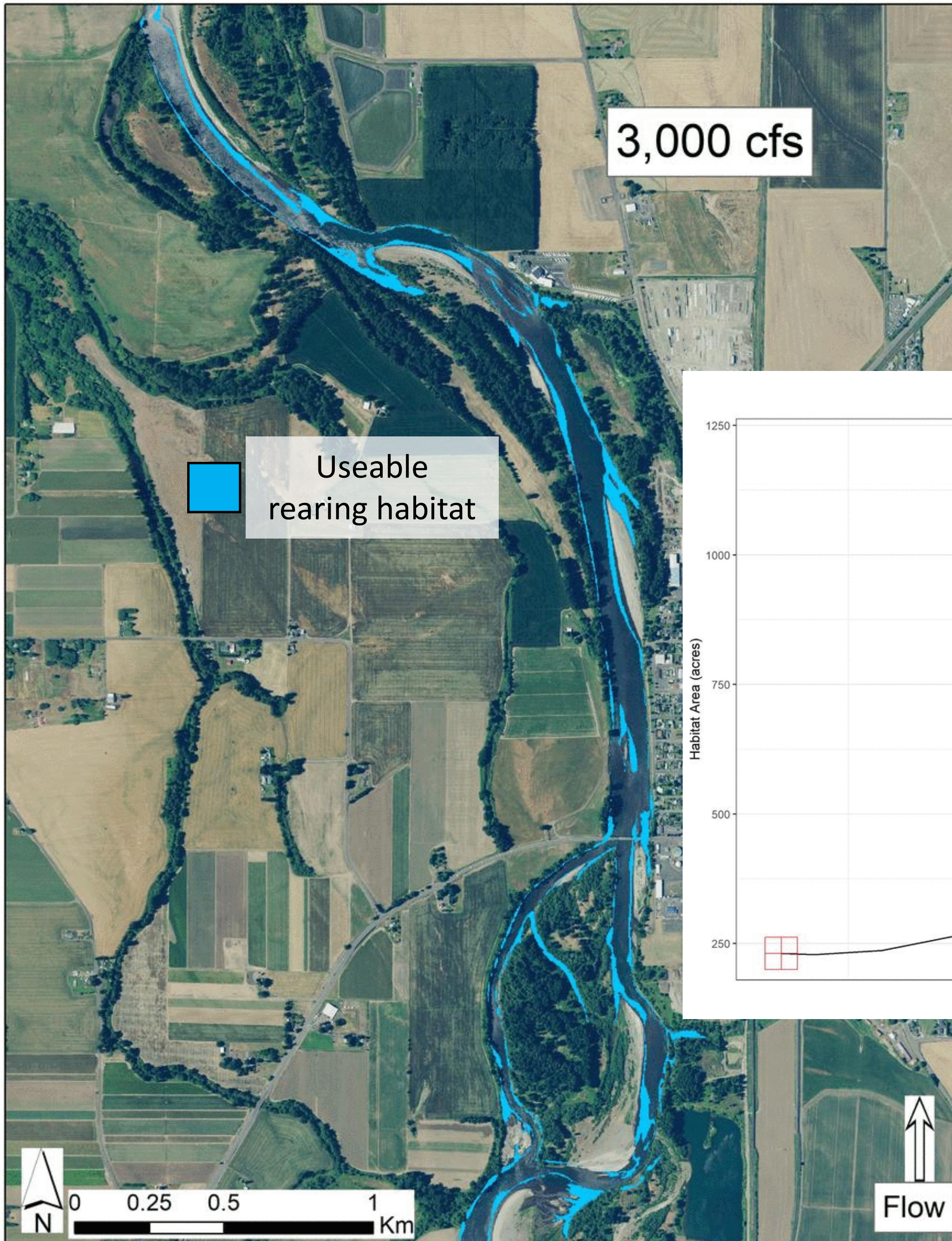
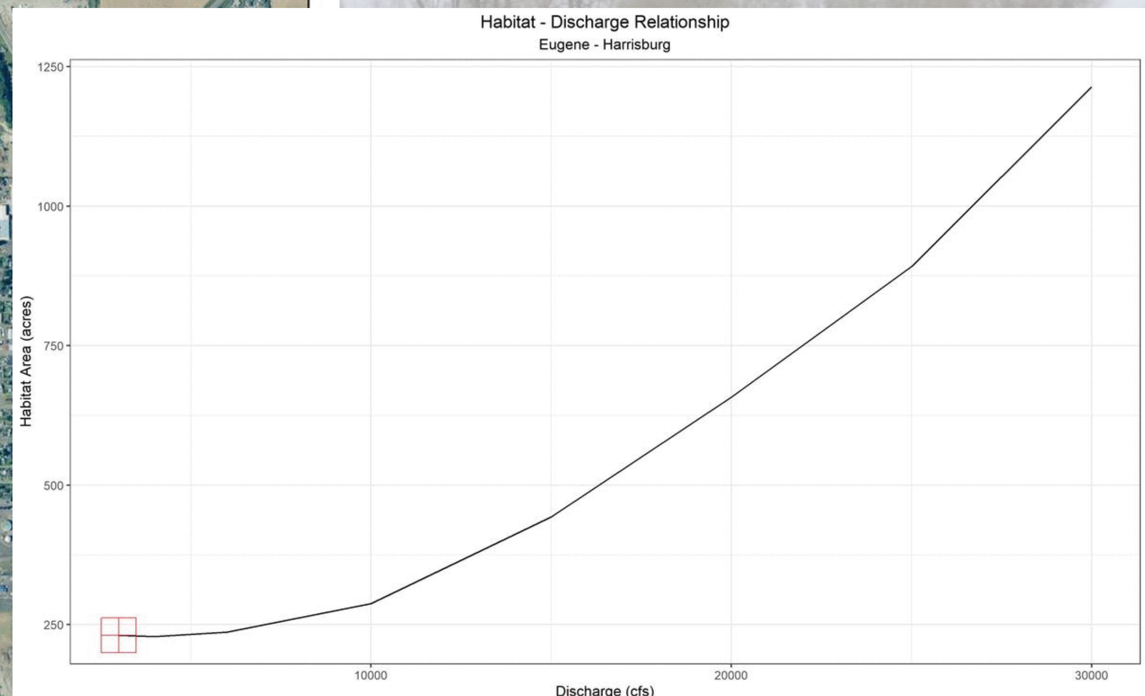
Preliminary Results – subject to revision

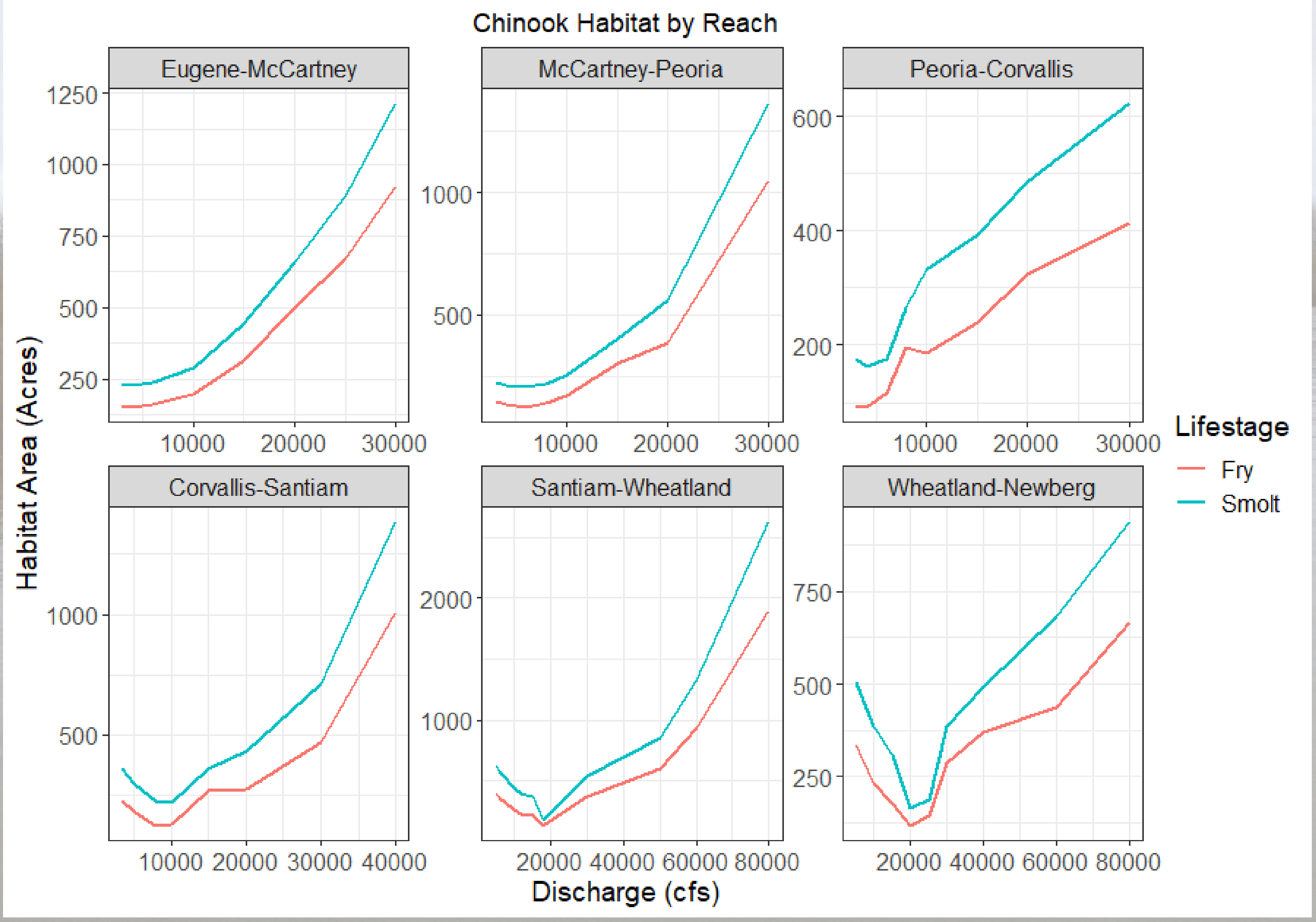
Upper Willamette: multi-channel, low elevation floodplain, lots of active gravel bars





Preliminary Results – subject to revision

Habitat Model Results



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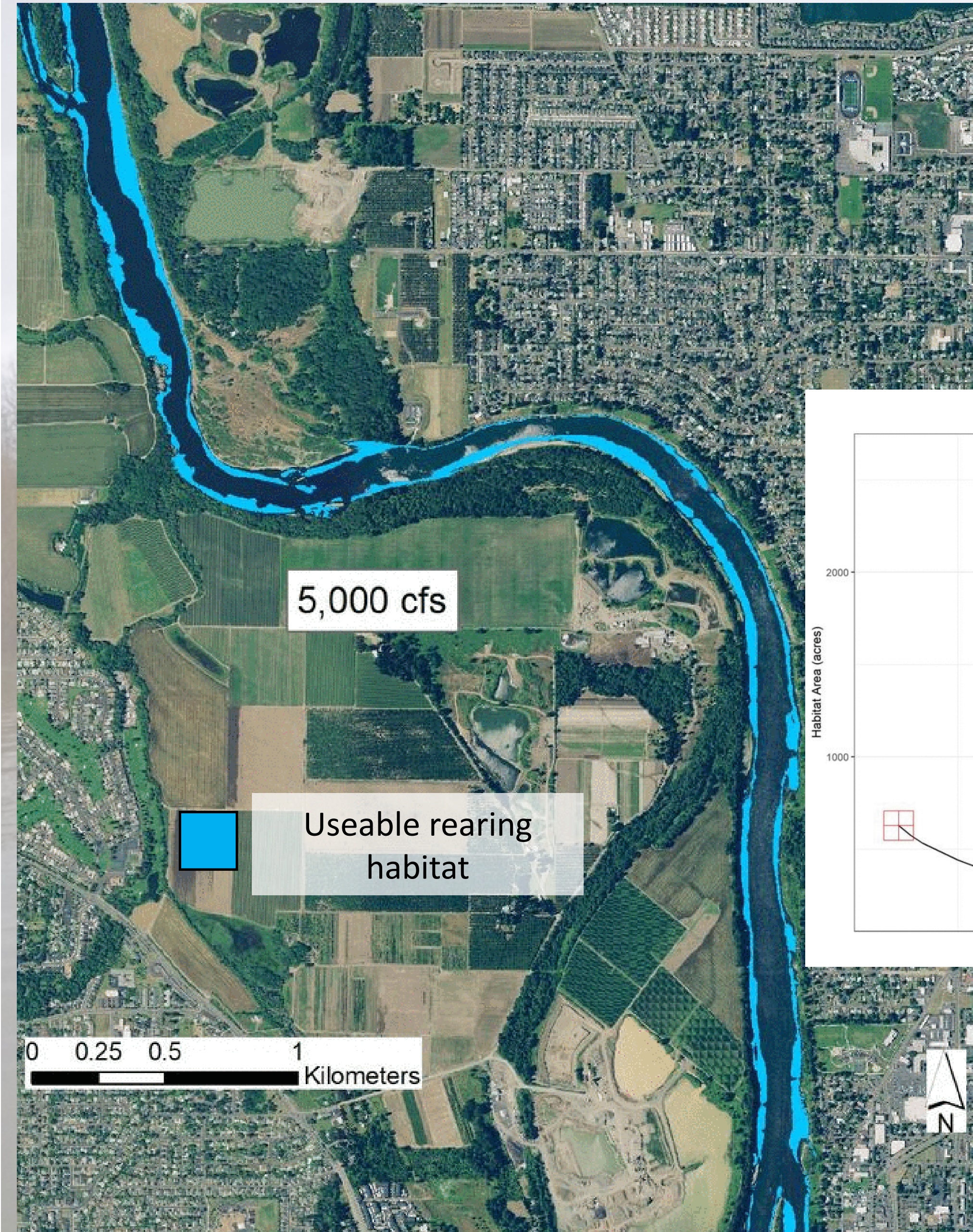
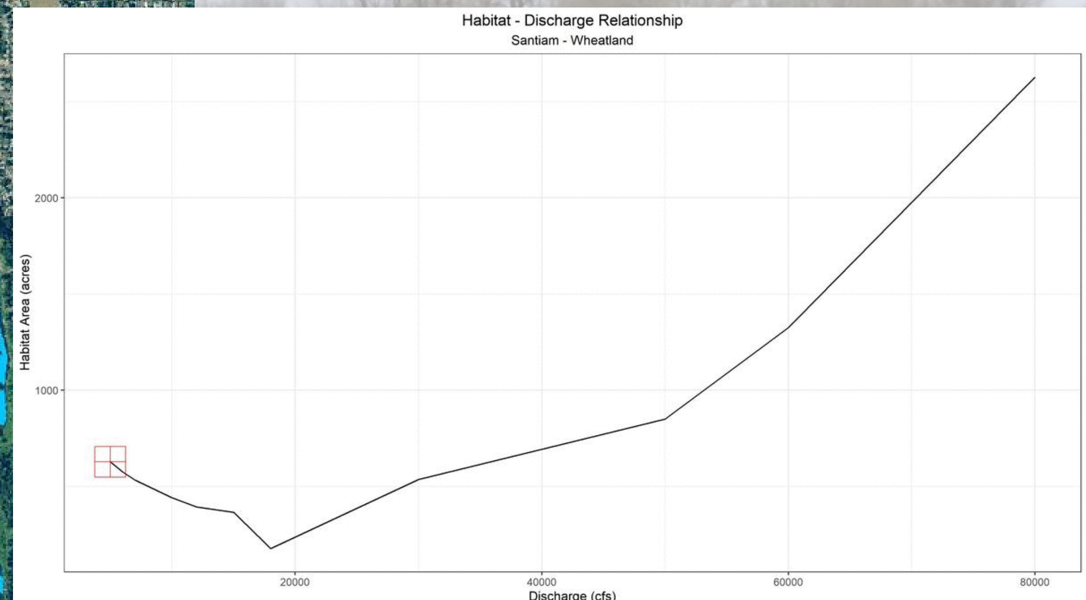
Preliminary Results – subject to revision

Middle Willamette:
Single thread channel,
high elevation floodplains,
few gravel bars





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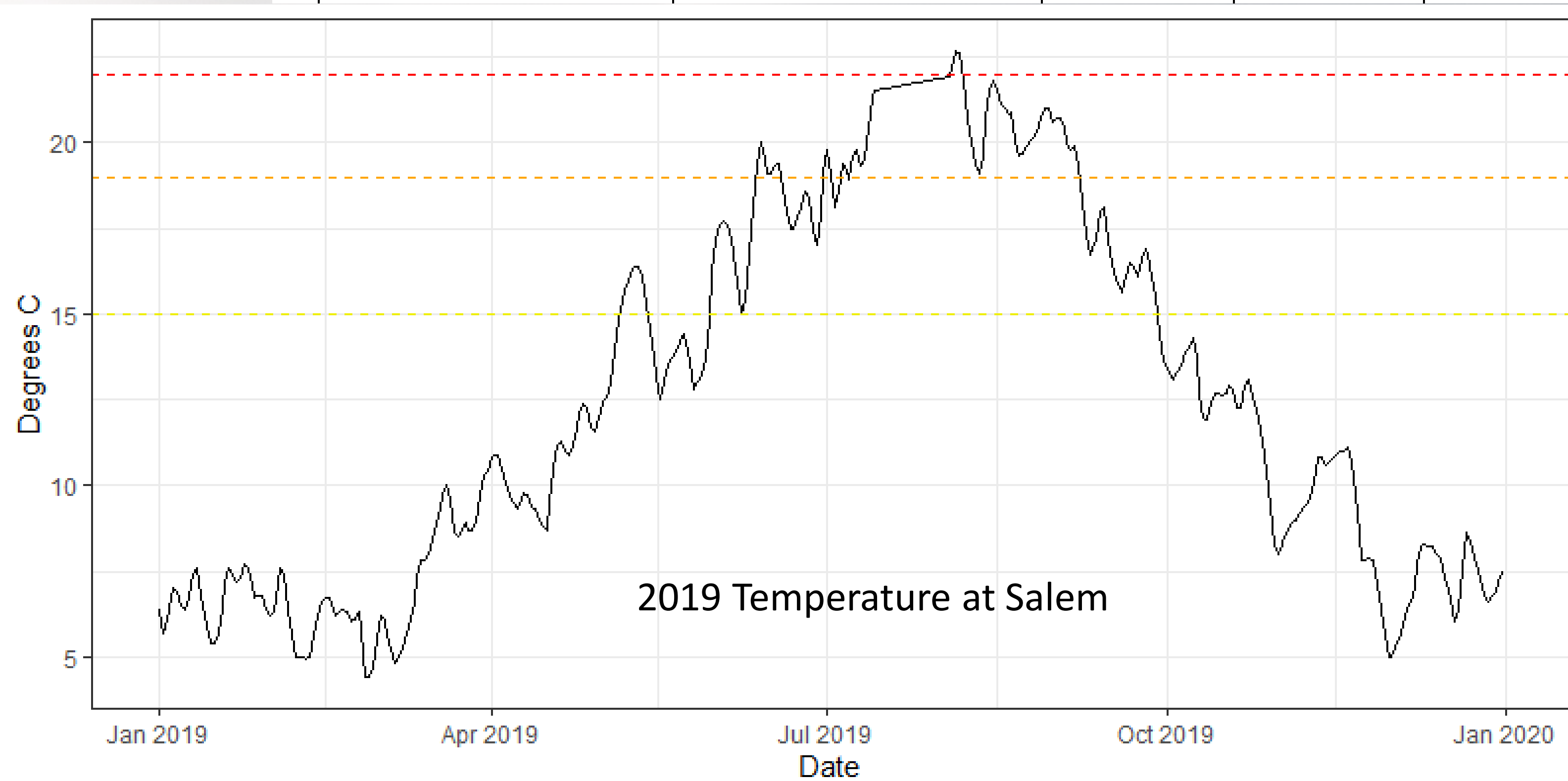
Preliminary Results – subject to revision

Goal 1: Quantify useable rearing habitat

Useable habitat = f(depth[1], velocity[1], bed-slope[2], temperature[3])

1 – Hydraulic Model
2 – Bathymetry
3 – Temperature Model

		Water temperature, °C		
Species	**Life-stage**	**Narrow**	**Median**	**Broad**
Spring Chinook salmon	**Adult migration/holding**	8–12	3–17	3–20
	Spawning	6–13	4–14	4–16
	Incubation	6–10	4–12	2–14
	Rearing	10–15	4–19	4–22
Literature sources – McCullough 1999; U.S. EPA 2003; Carter 2005, 2008; Kubo 2017				



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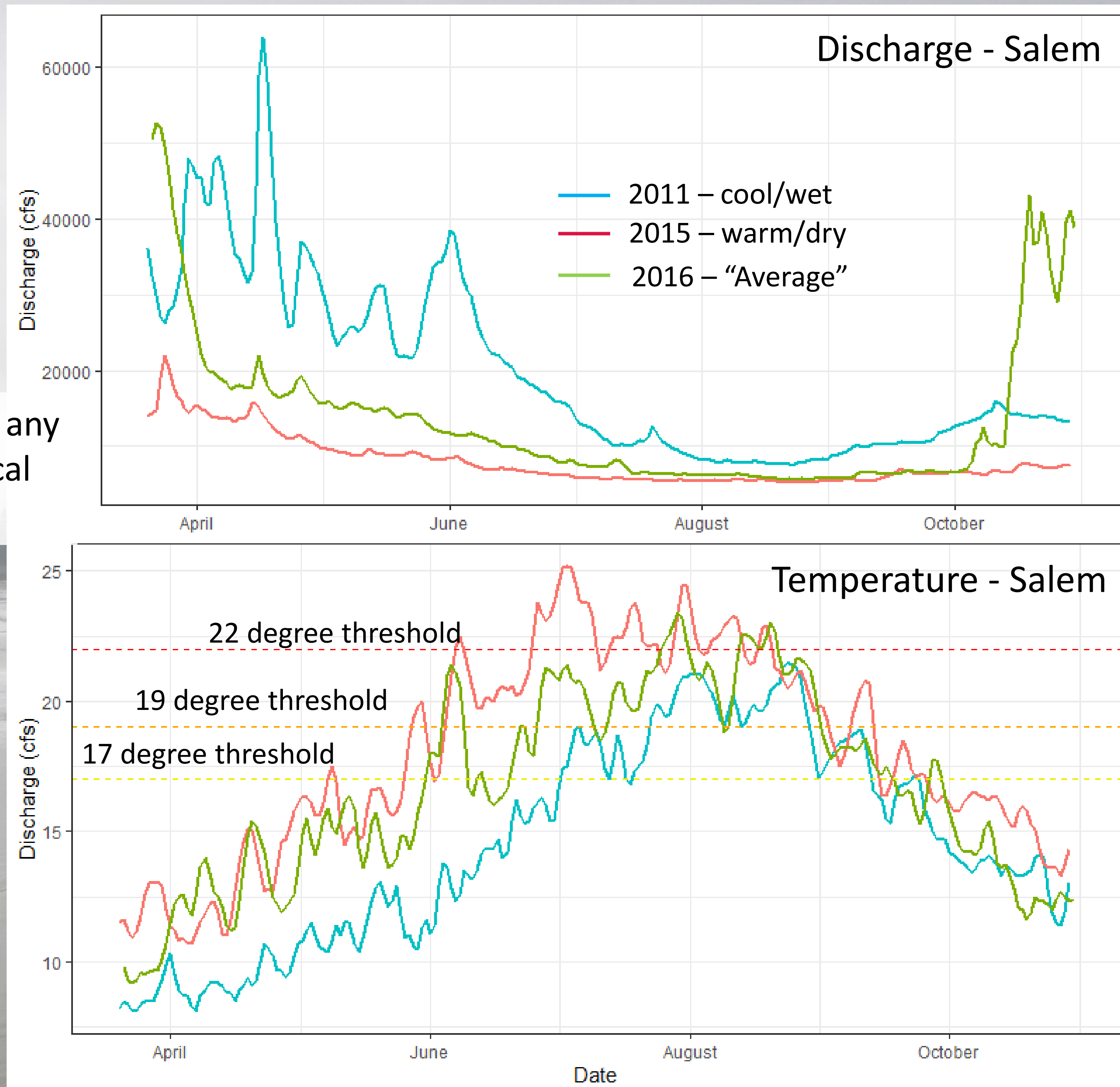
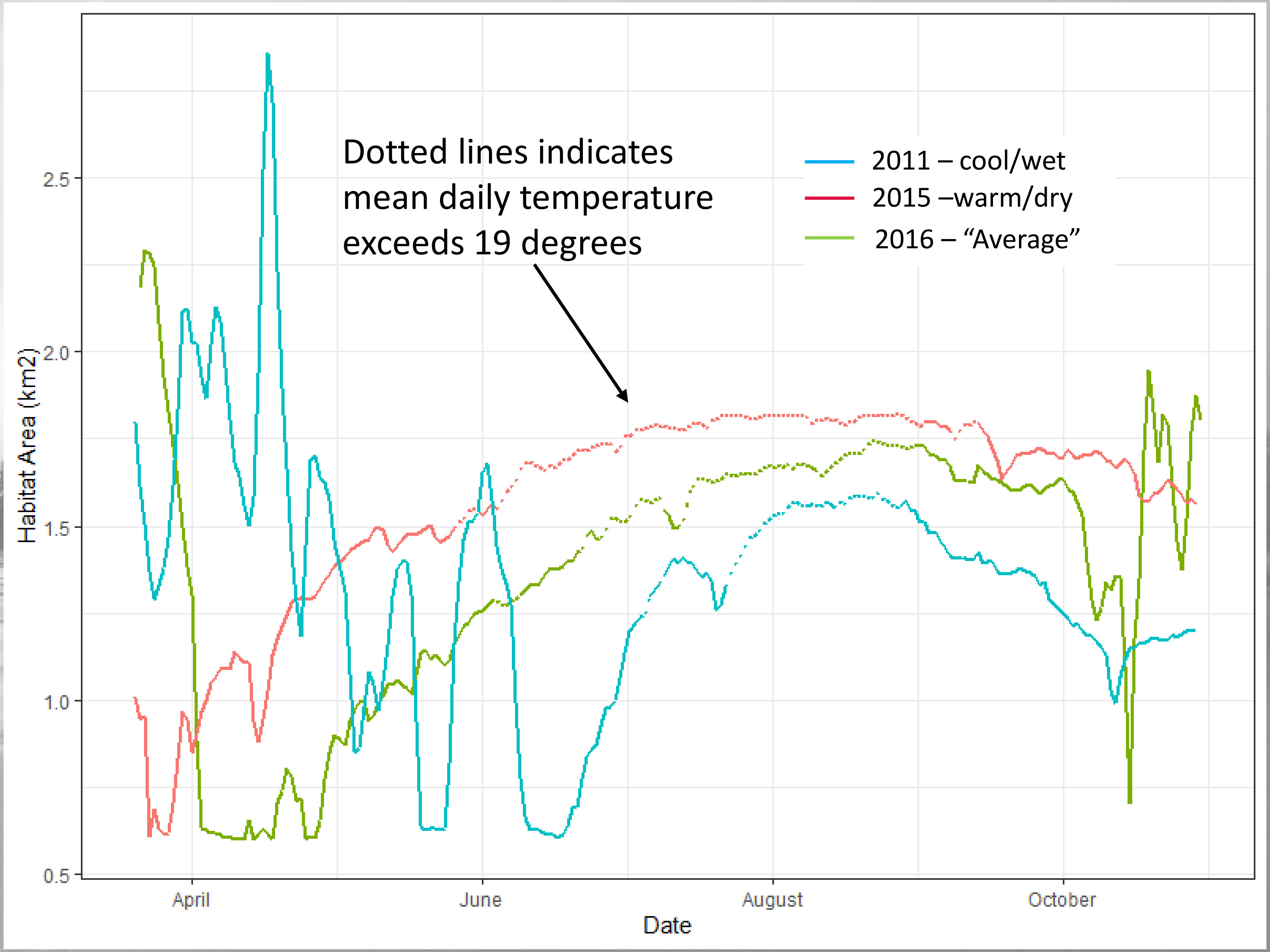
Habitat criteria source: Hansen and others, in prep

Conditions on “Representative” Years

Models can simulate any historical/theoretical hydrograph

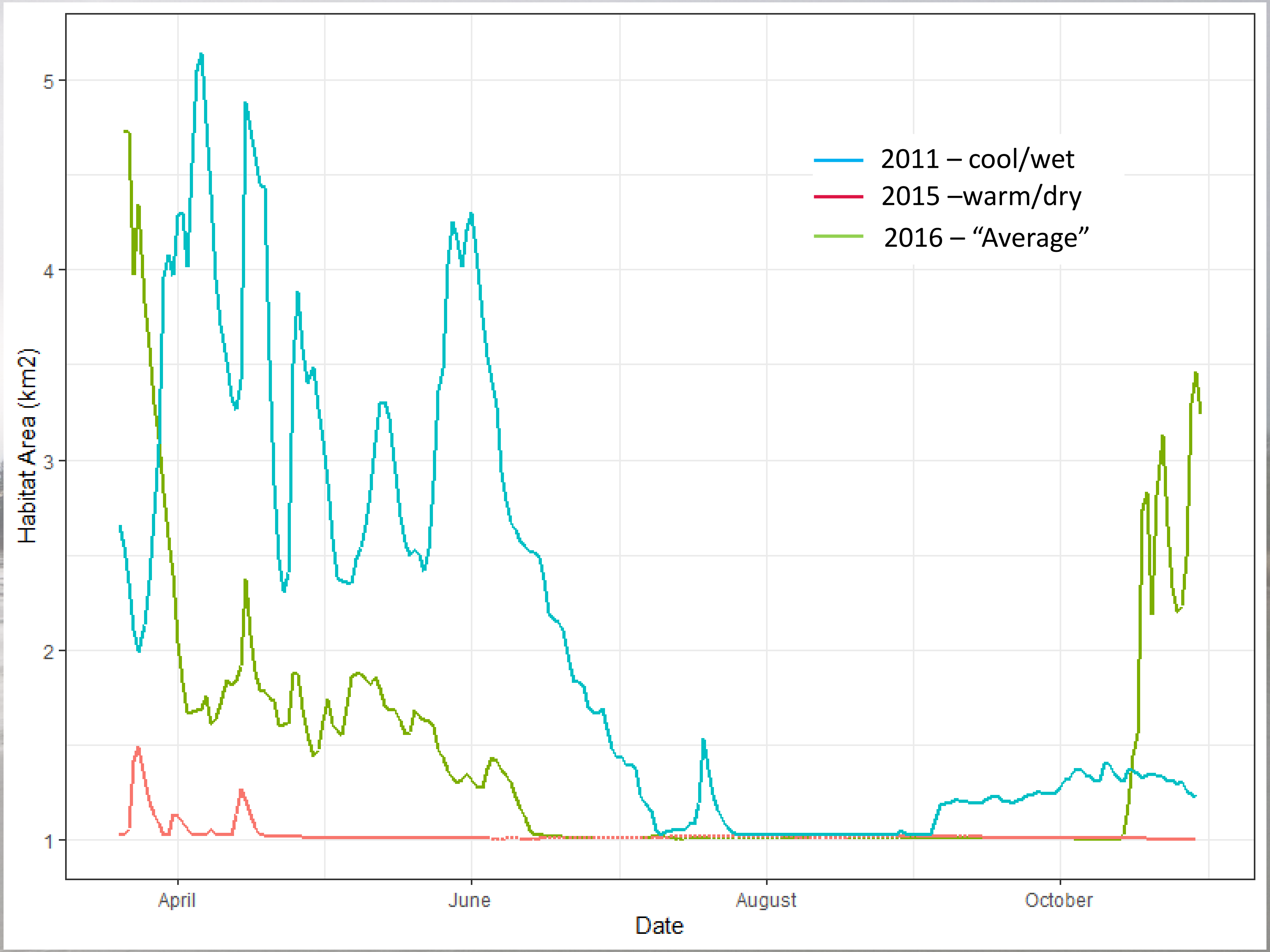


Wheatland - Newberg



Preliminary Results – subject to revision

Eugene - Peoria



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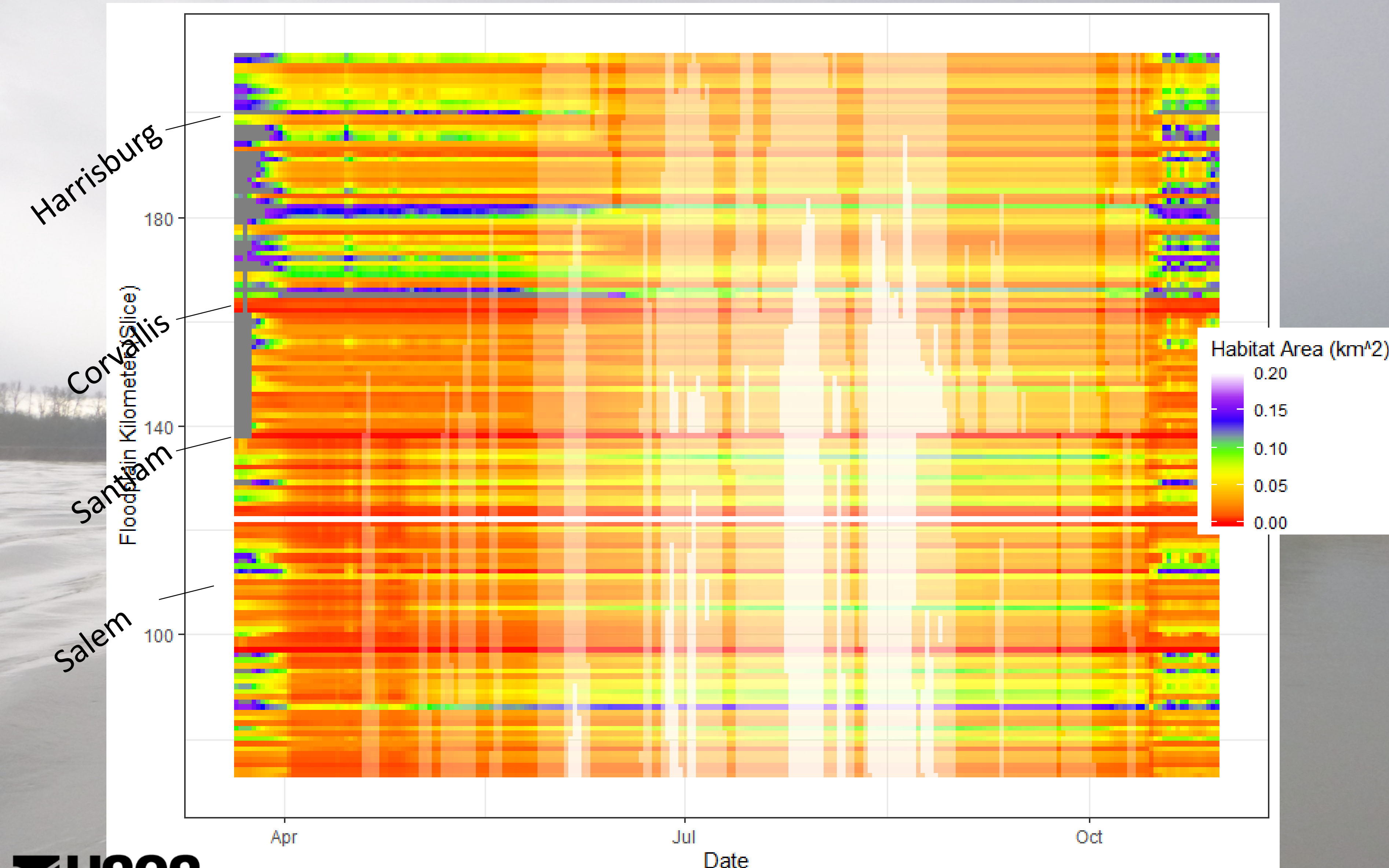
Preliminary Results – subject to revision

Daily Habitat and Temperature by River Kilometer

2016 – “Normal”



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2. Create models and datasets to facilitate similar analysis on key Willamette tributaries

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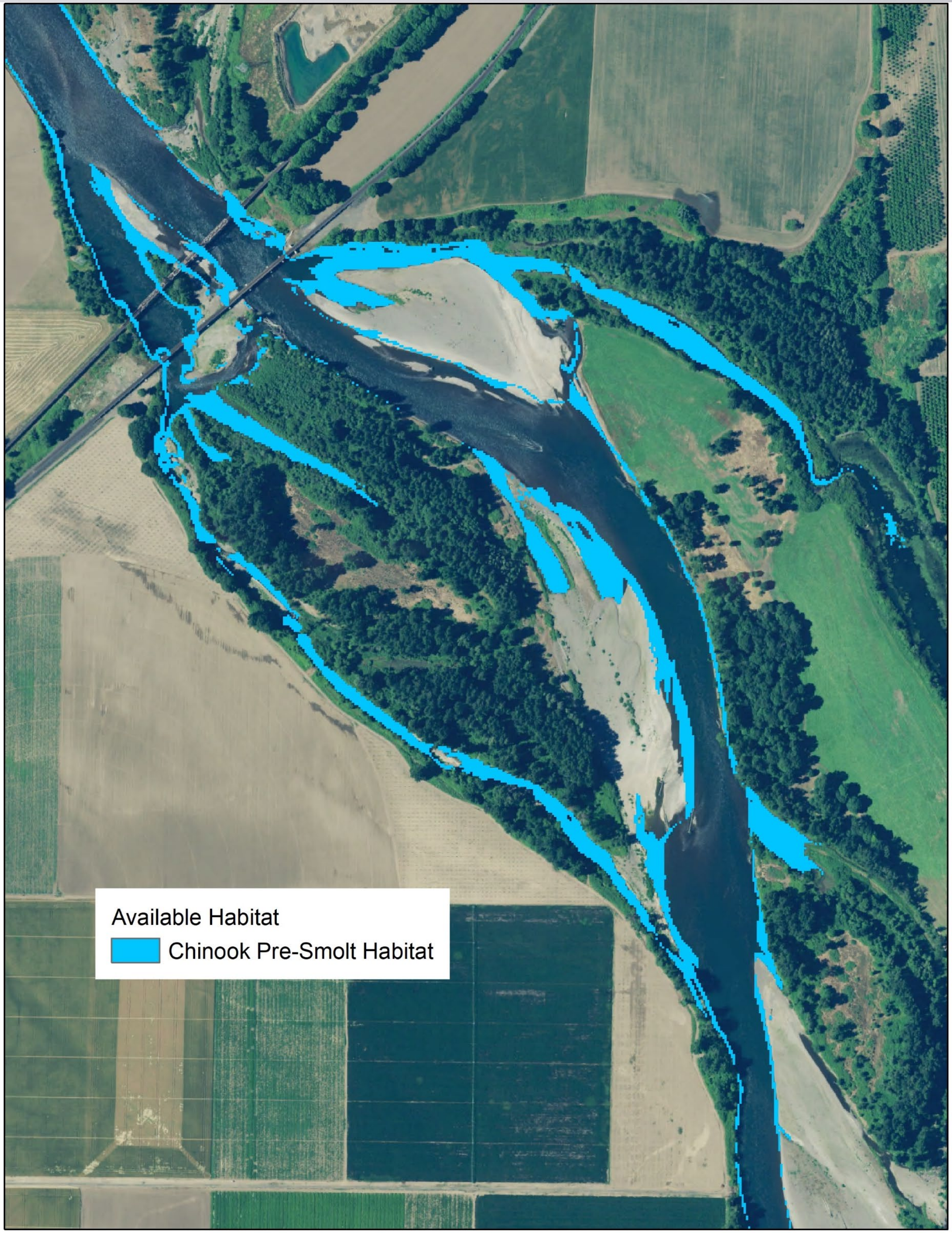
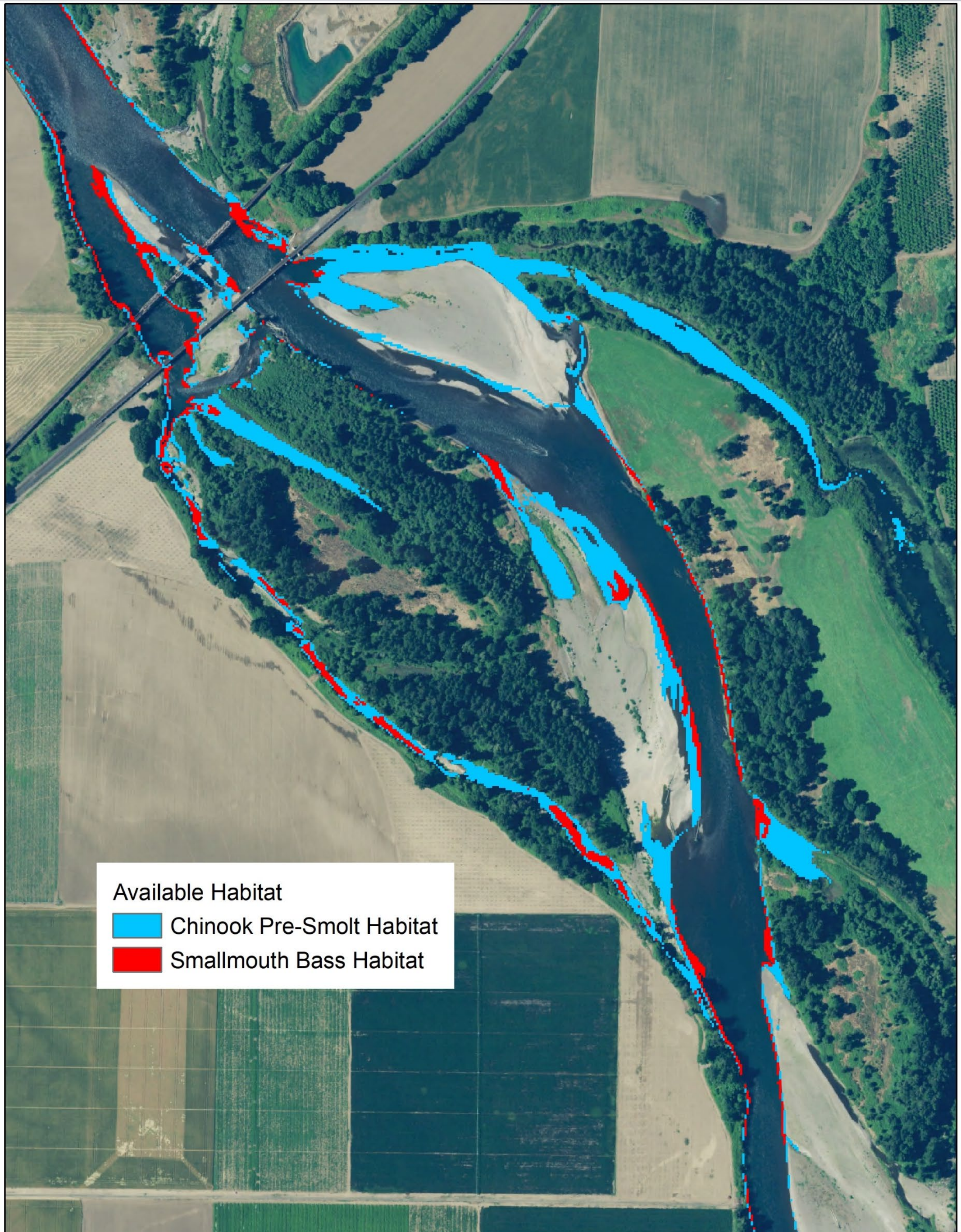
Juvenile Chinook habitat near Harrisburg



Preliminary Results – subject to revision



Juvenile Chinook habitat overlaid by smallmouth bass habitat, near Harrisburg

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Modeling other species and interactions

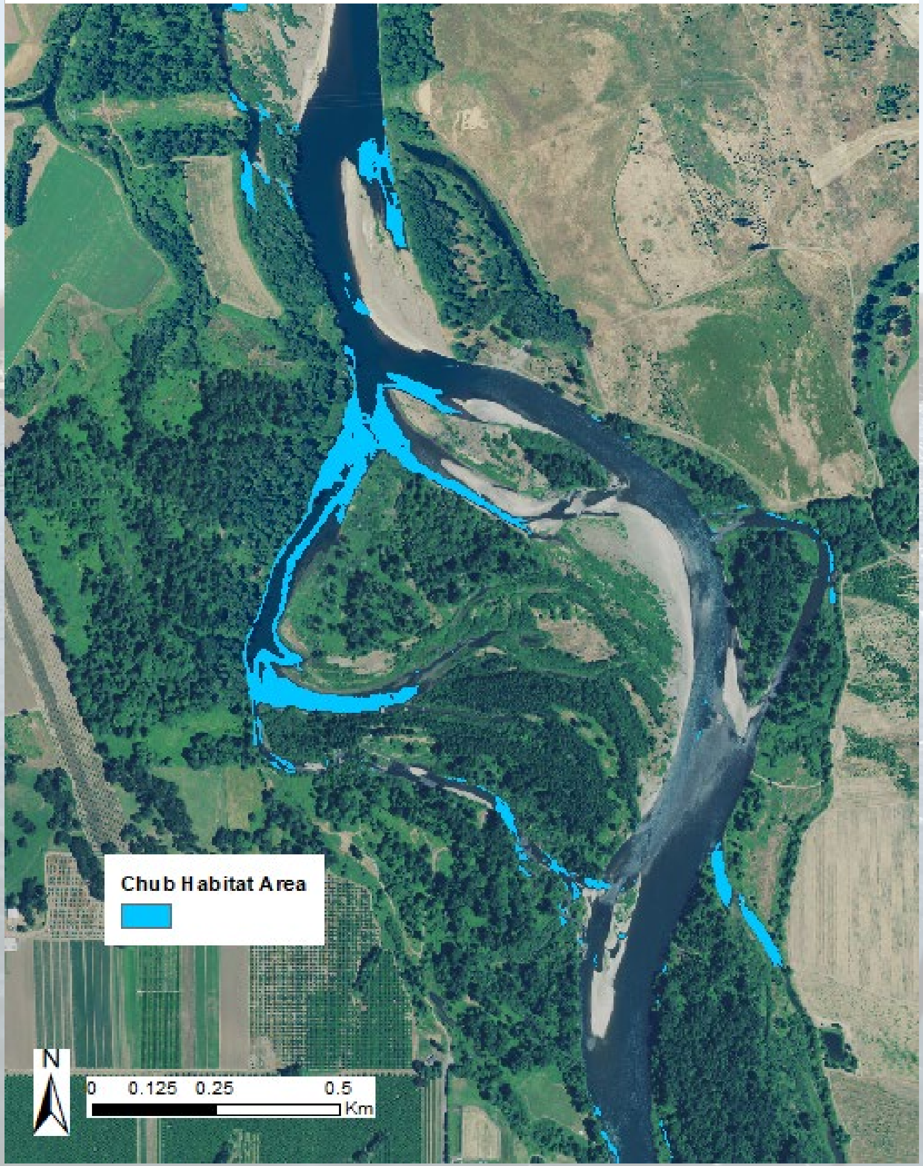
Photo: Jeremy Monroe, Freshwater Illustrated

Oregon Chub habitat preferences:

- Depth: 0.5 m – 2.0 m
- Velocity: <0.1 m/s
- Reaches with upstream connections in winter

Habitat criteria provided by Brian Bangs, ODFW

Upper Willamette River near Green Island



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Preliminary Results – subject to revision

Take home points

- Hydraulic and temperature models provide a foundation to evaluate instream flow on rearing salmon
    - Remote sensing offers promising approach to cost-effective high-resolution bathymetry along North and South Santiam and McKenzie Rivers

- Physical rearing habitat response to changing streamflow varies along the Willamette
    - Downstream reaches see reduced physical habitat with moderate flows
    - Habitat in upstream reaches responds accordingly with flow

- Temperature is generally more sensitive to changes in streamflow than physical habitat

- Smallmouth bass habitat has considerable overlap with juvenile Chinook
    - Sensitivity to temperature and streamflow not yet evaluated

Timelines and Next Steps

- Publish Willamette topo-bathymetric DEM and Hydraulic models – Spring/Summer 2020
- Interactive flow-management tool – Spring/Summer 2020
- Publish Habitat Models – Fall 2020
    - Juvenile Chinook
    - Juvenile Steelhead
    - Oregon Chub
    - Juvenile Chinook/small mouth overlay
- Publish North & South Santiam topo-bathymetric DEM – Winter 2020

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Questions

jameswhite@usgs.gov

EXTRA SLIDES

2015 – “Warm/Dry”

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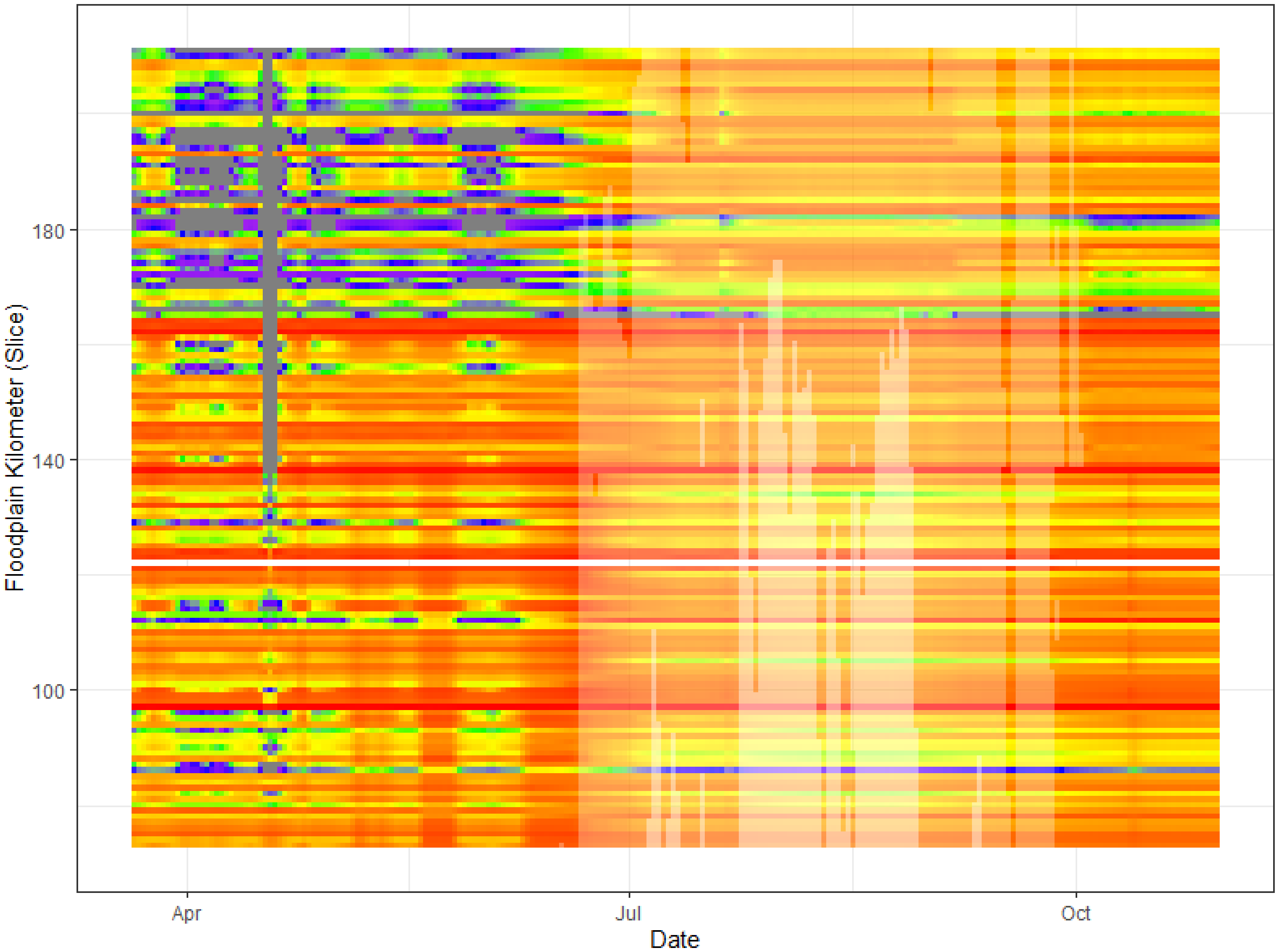
2011 – “Cool/Wet”



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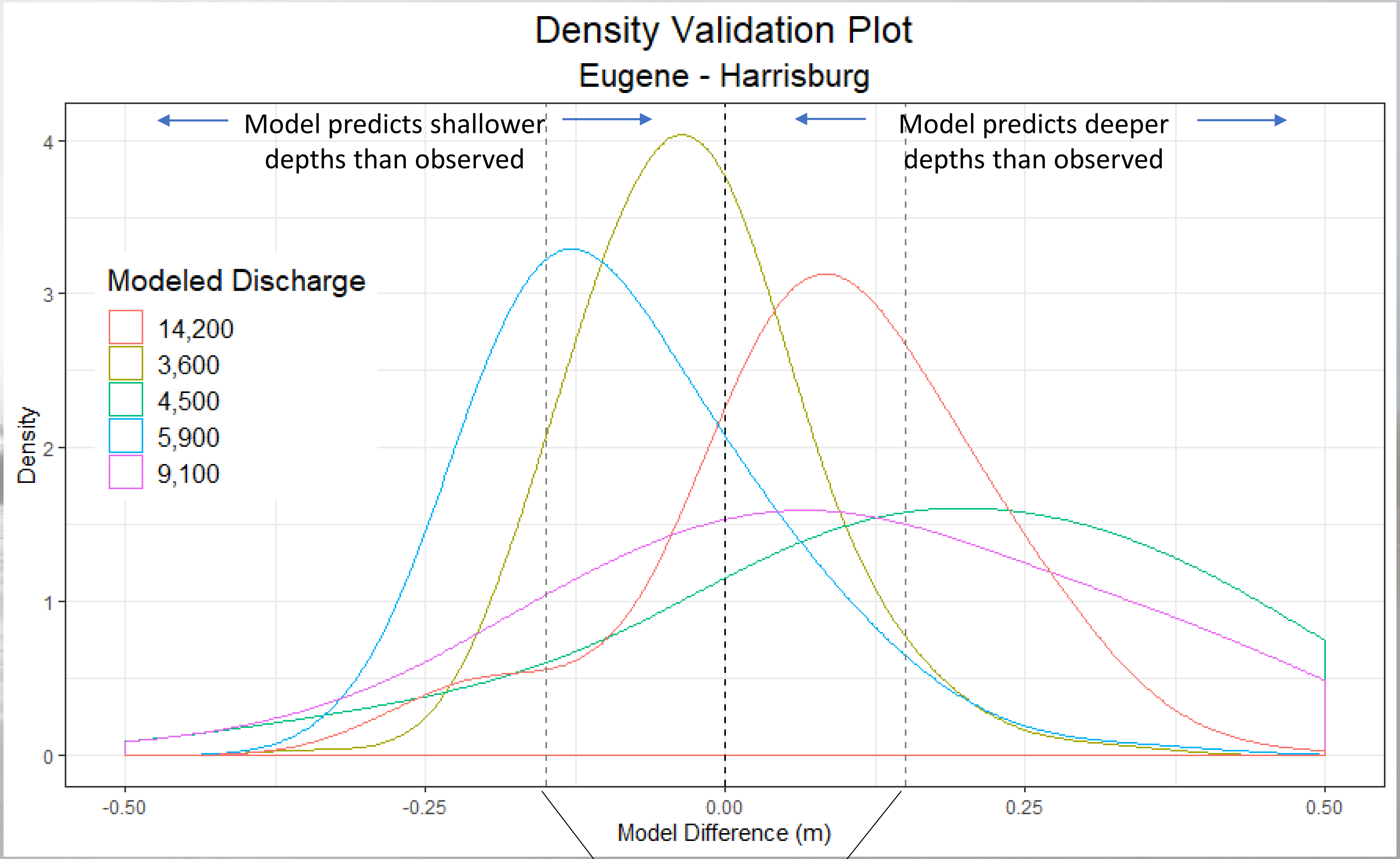
Hydraulic Model



Calibration data uncertainty

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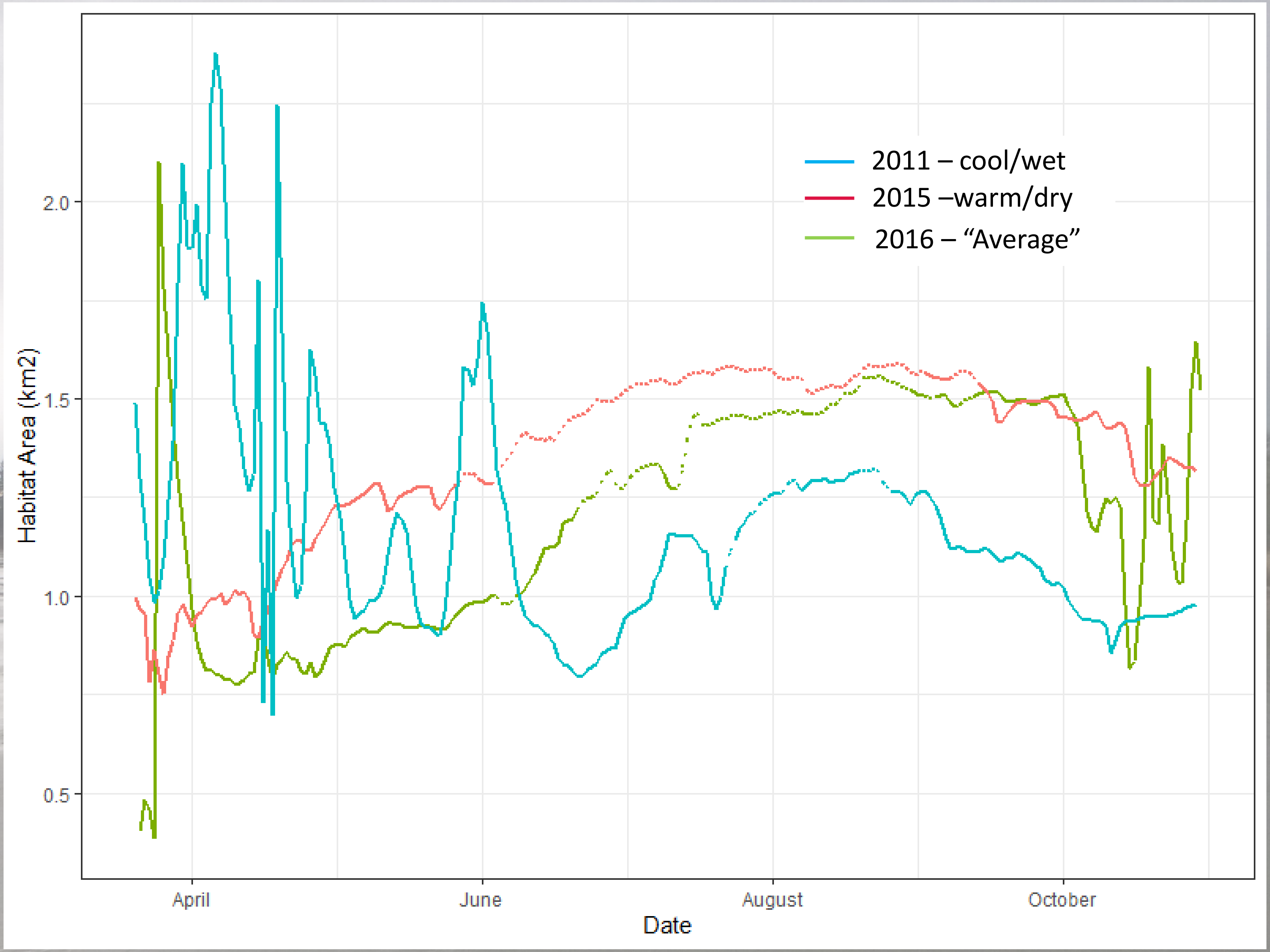
Preliminary Results – subject to revision

Independence - Albany



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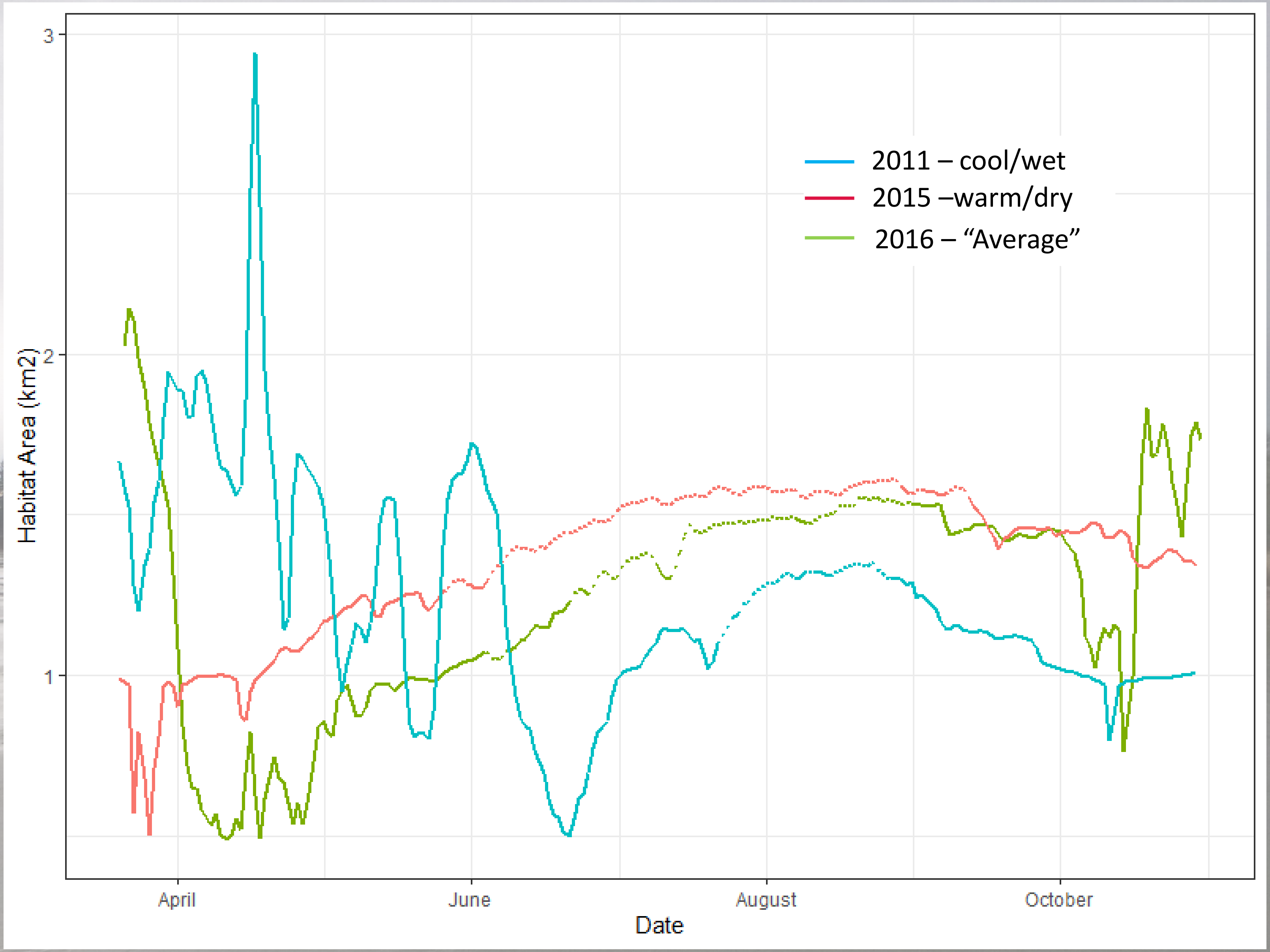
Preliminary Results – subject to revision

Independence - Wheatland



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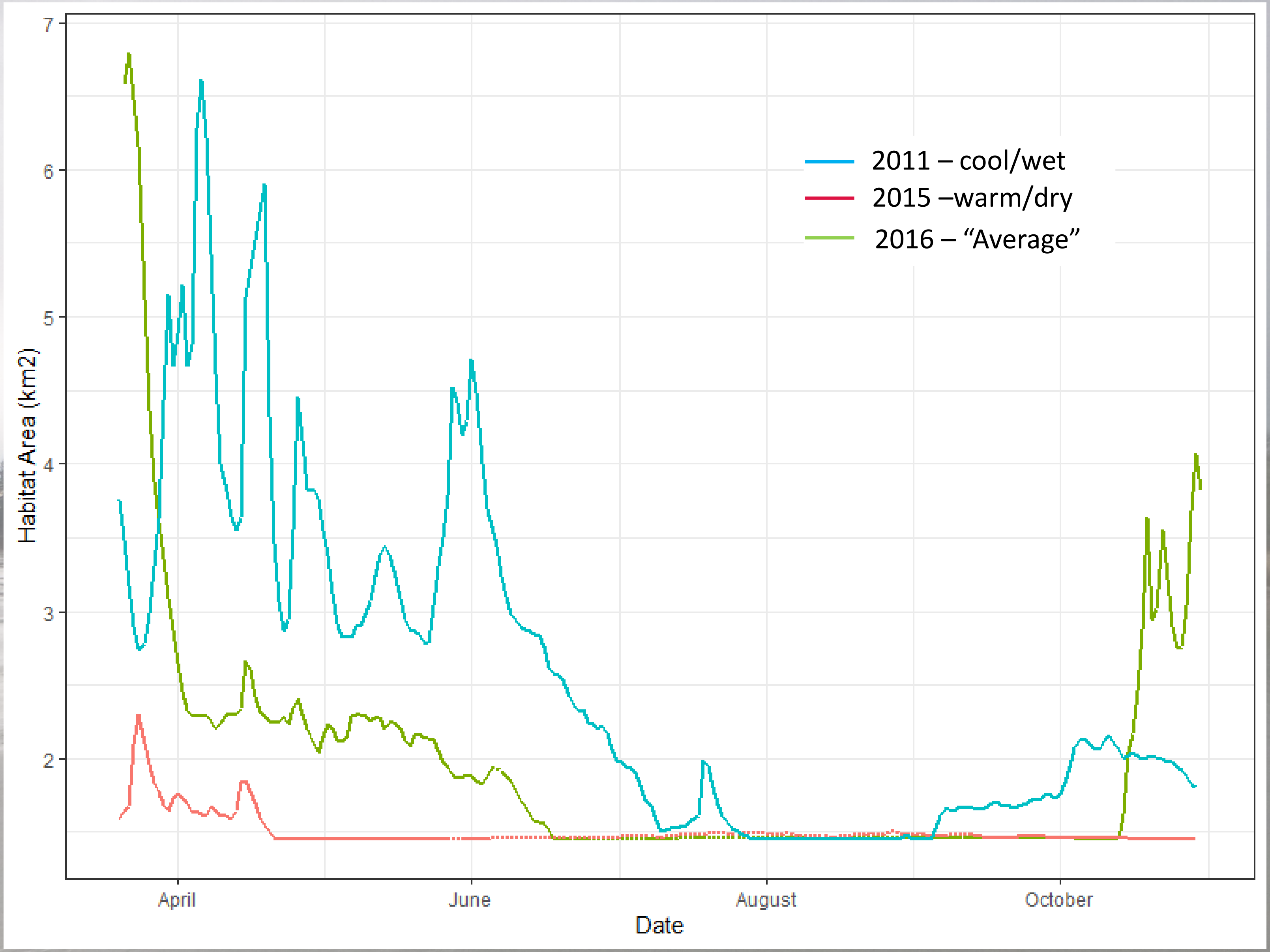
Albany - Peoria



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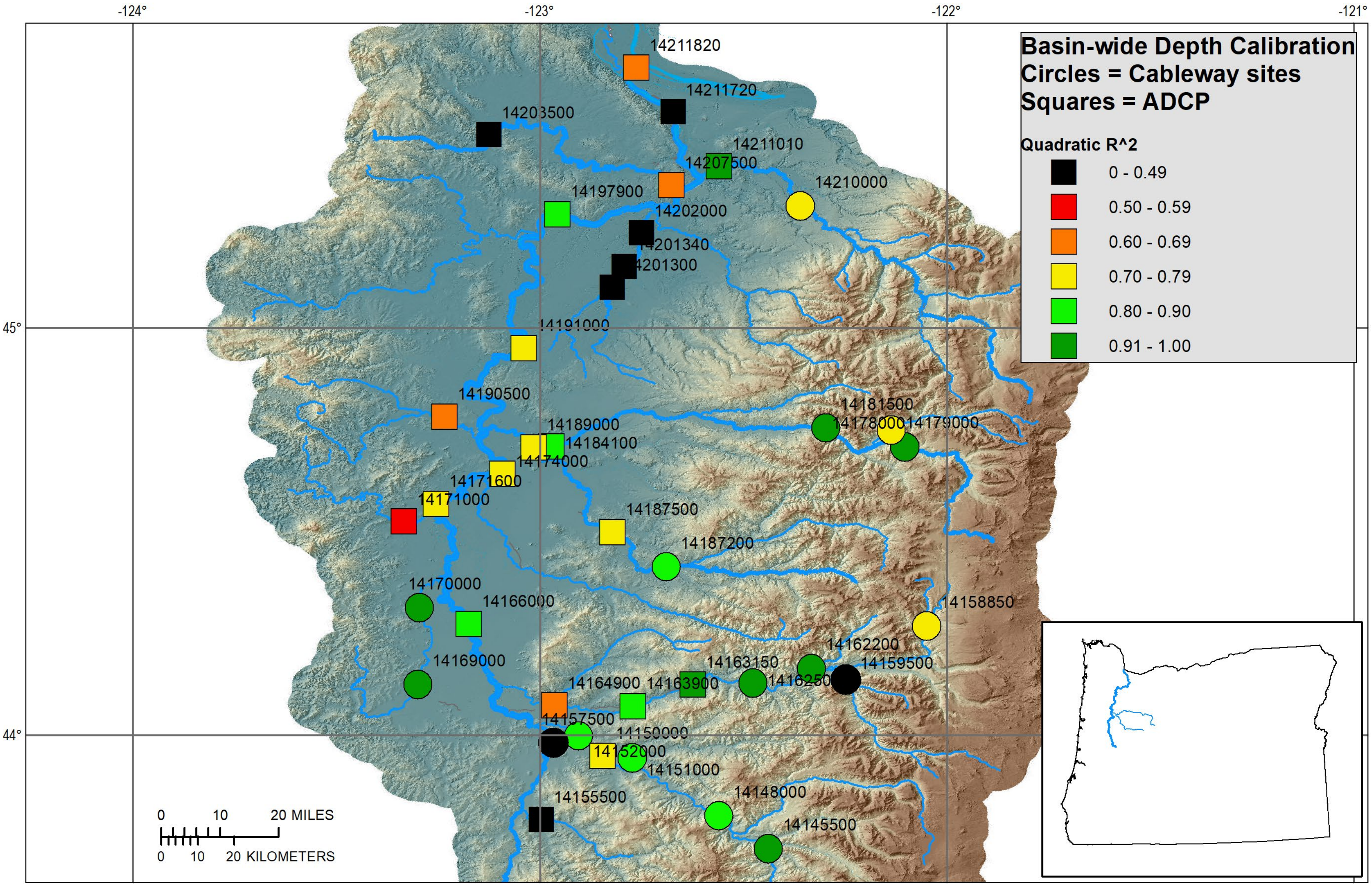
Preliminary Results – subject to revision

Willamette River Flow Objectives

Source: Table 2-8 from Biological Opinion for USACE's Willamette Valley Project, NOAA Fisheries, 2008

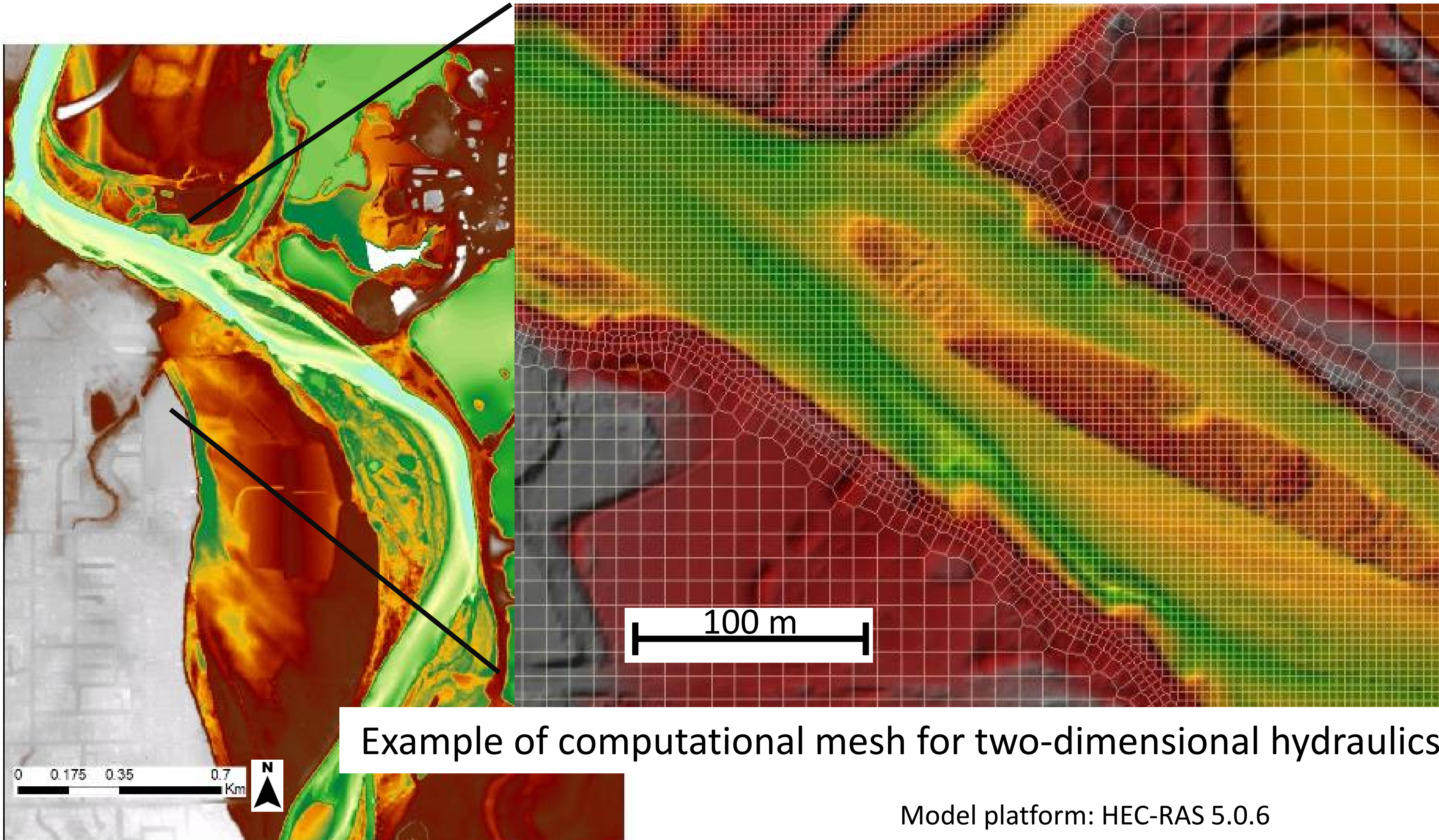
Time Period	7-Day Moving Average[1] Minimum Flow at Salem (cfs)	Instantaneous Minimum Flow at Salem (cfs)	Minimum Flow at Albany (cfs) [2]
April 1 - 30	17,800	14,300	---
May 1 - 31	15,000	12,000	---
June 1 - 15	13,000	10,500	4,500
June 16 - 30	8,700	7,000	4,500
July 1 - 31	---	6,000	4,500
August 1 - 15	---	6,000	5,000
August 16 - 31	---	6,500	5,000
September 1 - 30	---	7,000	5,000
October 1 - 31	---	7,000	5,000



Map Source Data: USGS NHD

Willamette Basin Depth Calibration Sites

Building blocks of hydraulic model

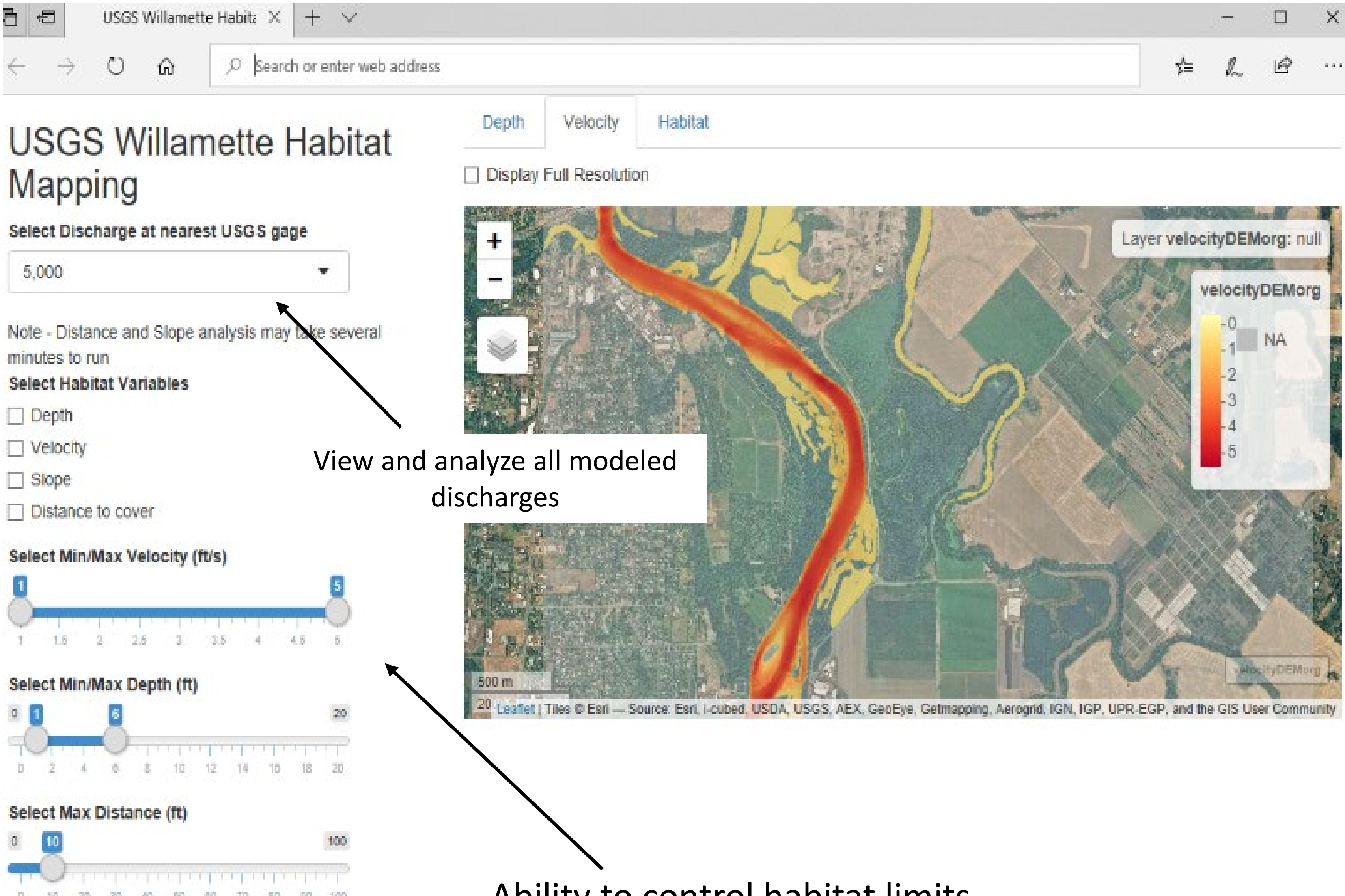


Example of computational mesh for two-dimensional hydraulics

Model platform: HEC-RAS 5.0.6

Potential tools to support flow management and habitat restoration

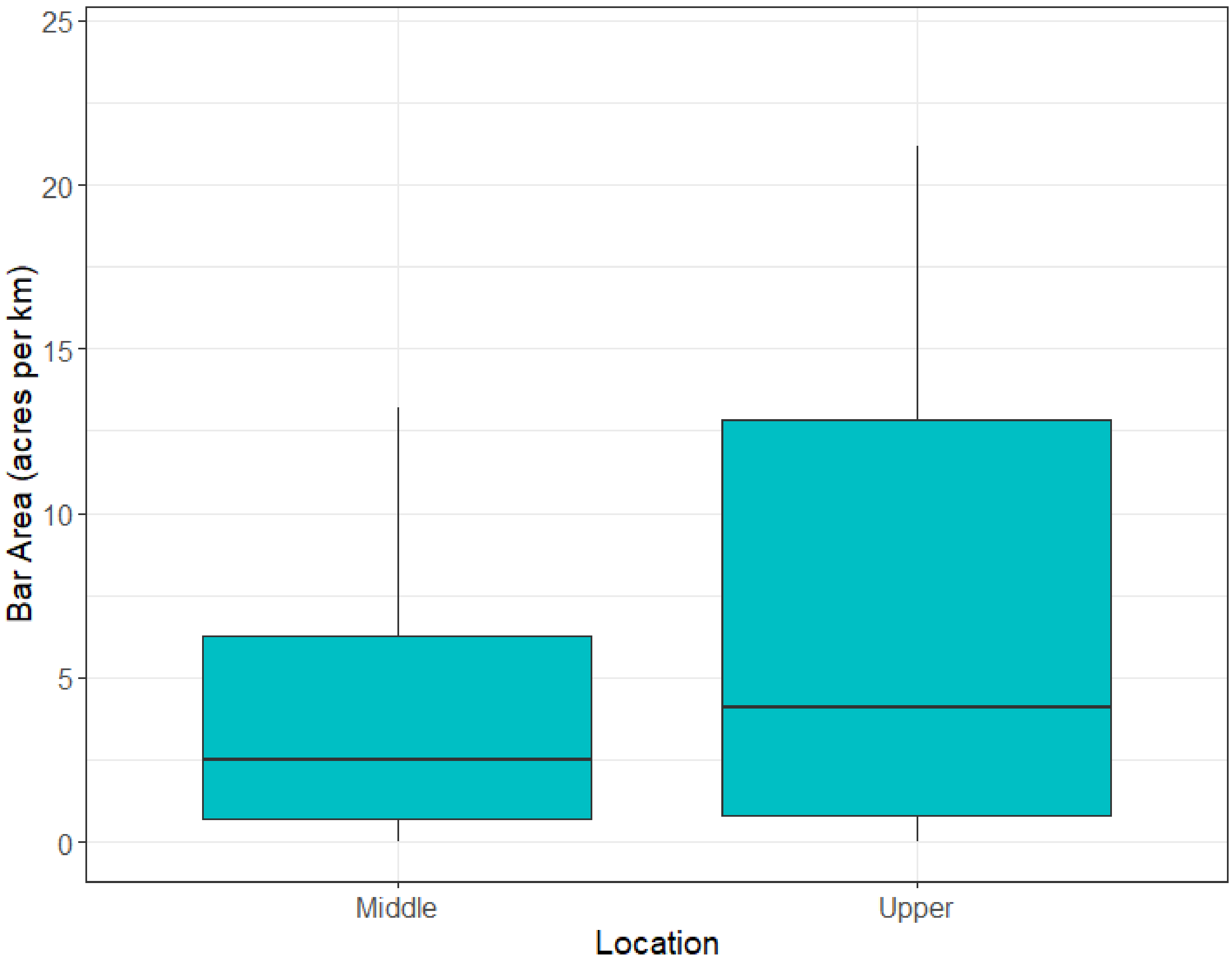
Example Shiny Application where user can define habitat criteria and view maps of habitat availability



View and analyze all modeled discharges

Ability to control habitat limits

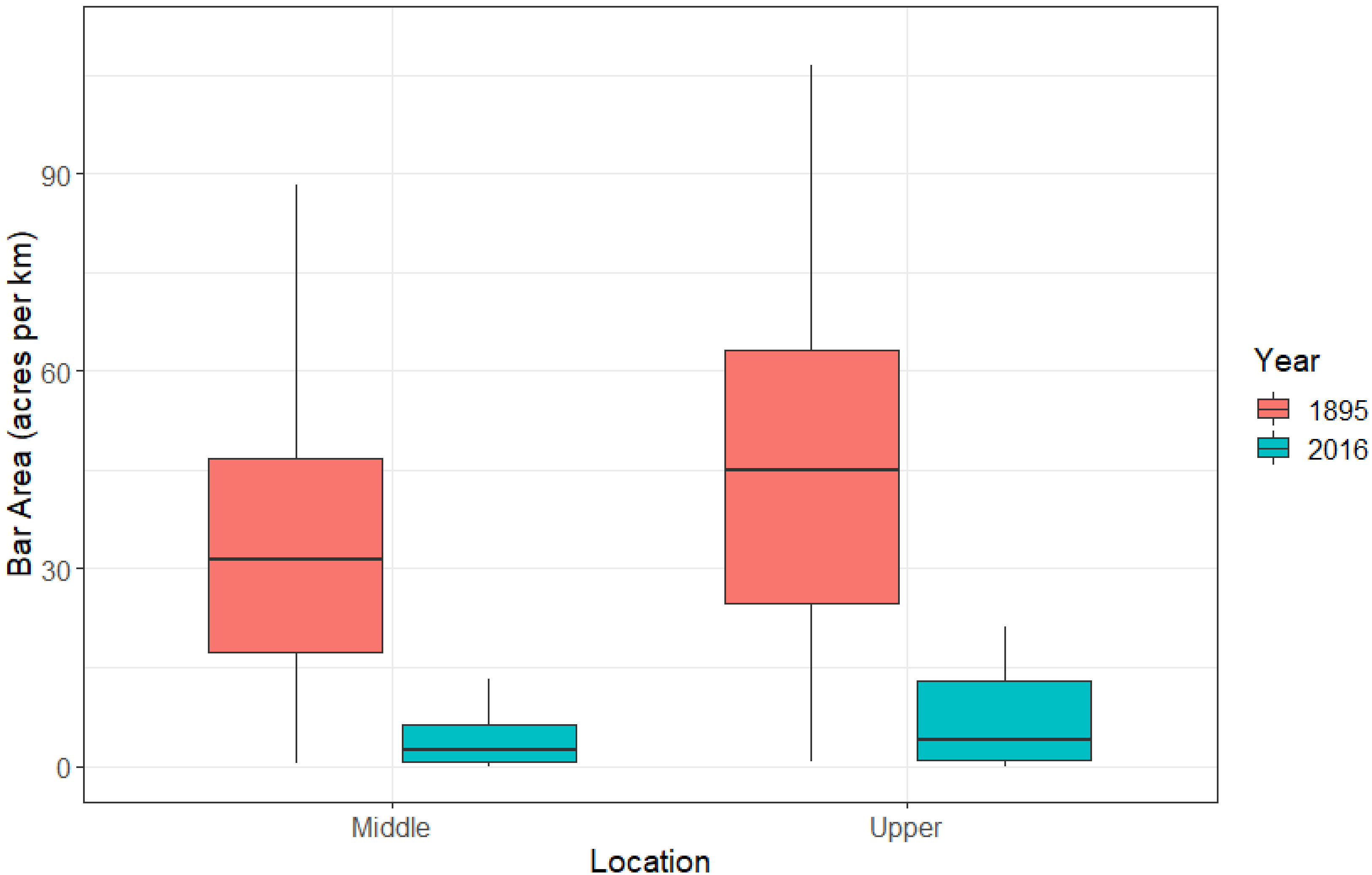
Bar Distribution 2016



Preliminary Results – subject to revision

Change in gravel bars 1895-2016

~85% reduction in bare bars in Willamette River above Newberg



USGS

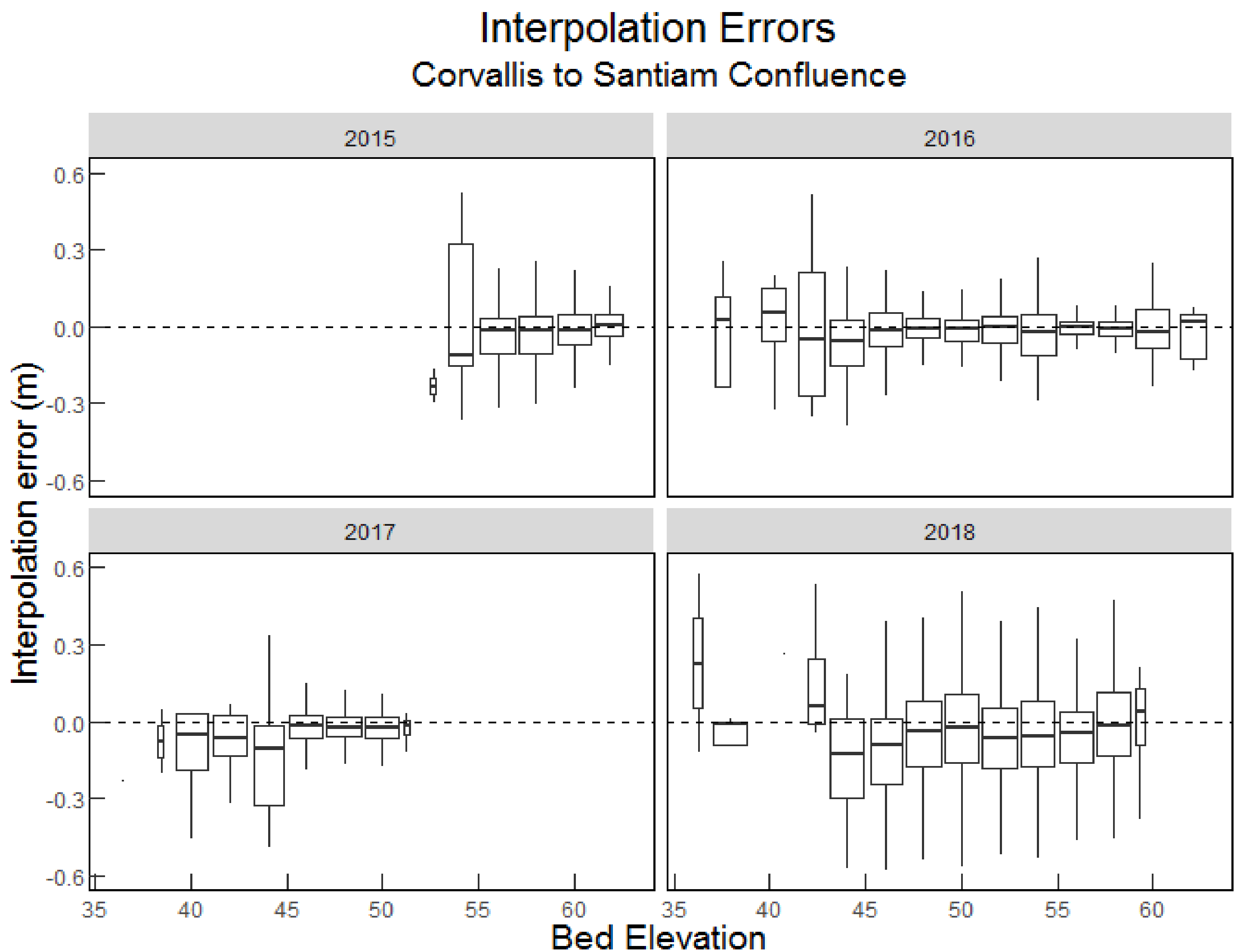
Preliminary Results – subject to revision

Hydraulic model outputs

Percentile	Salem	Albany	Harrisburg
(%)	(ft^3/s)		
1	5,517	3,875	3,457
5	6,369	4,427	4,010
10	6,811	4,777	4,495
90	49,031	27,951	21,374
95	64,610	36,995	28,570
99	93,355	54,281	41,470

Source: Peterson and others, 2018

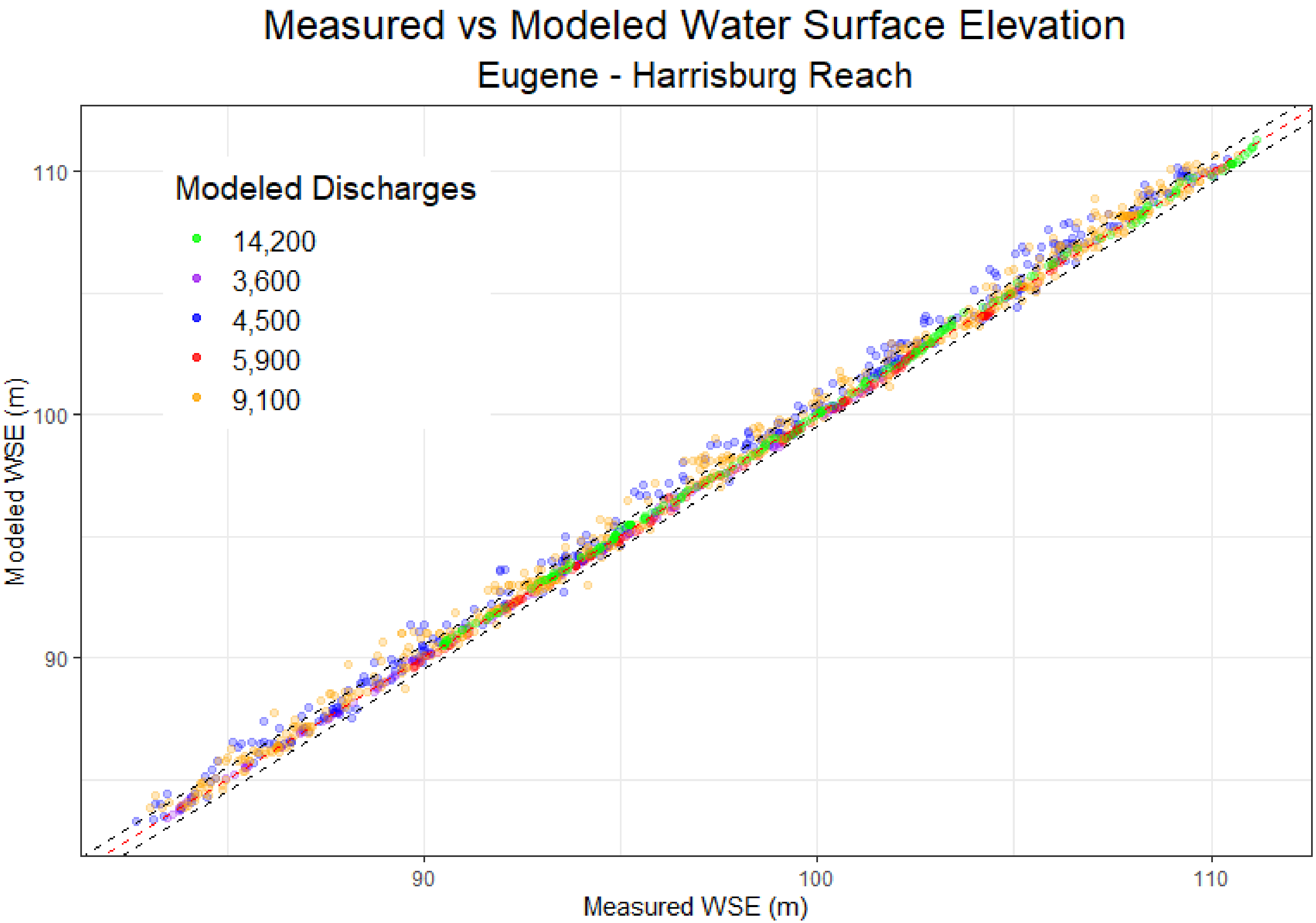
Fusing lidar and sonar data



USGS

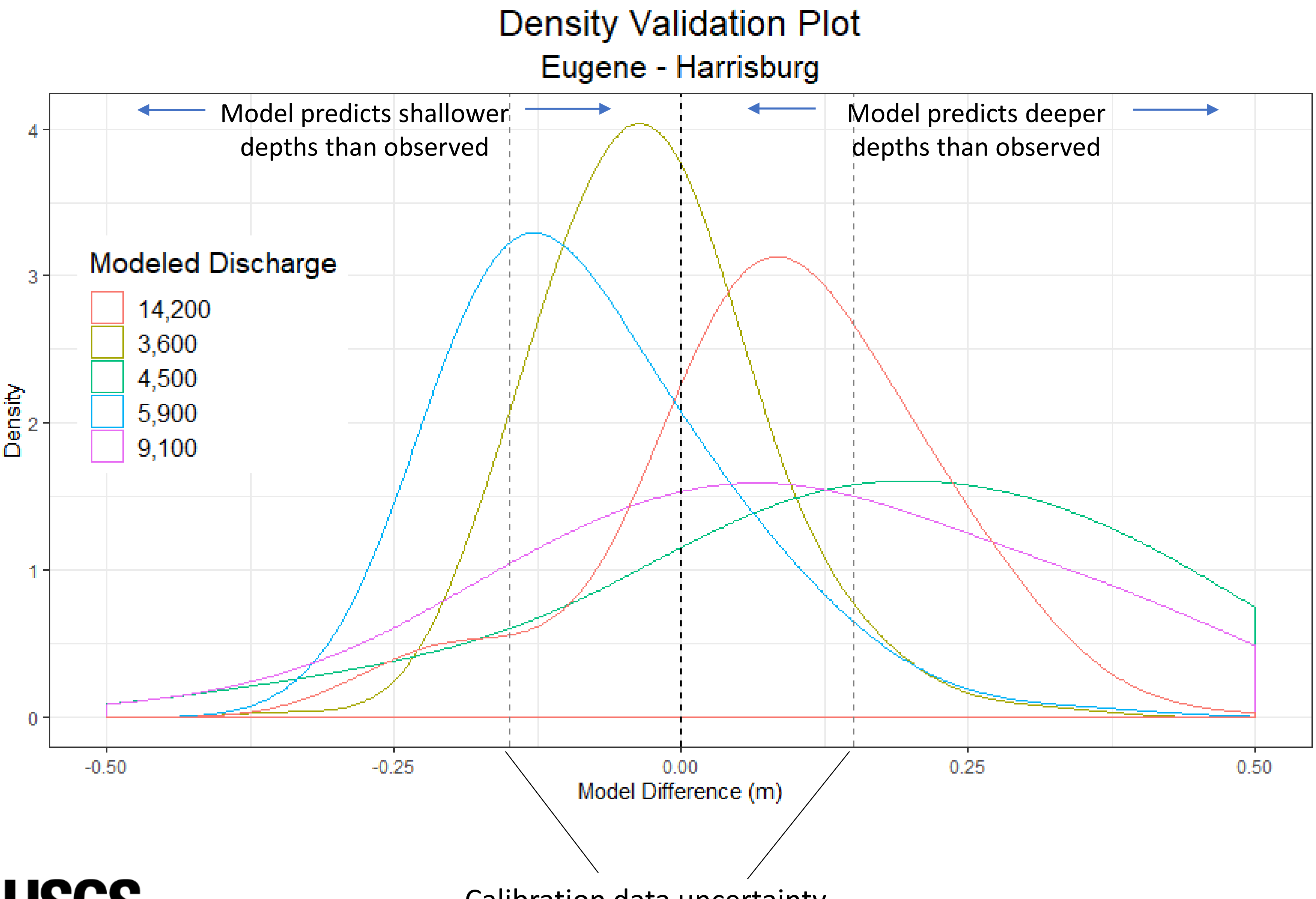
Preliminary Results – subject to revision

Quantifying Uncertainty in Model Results

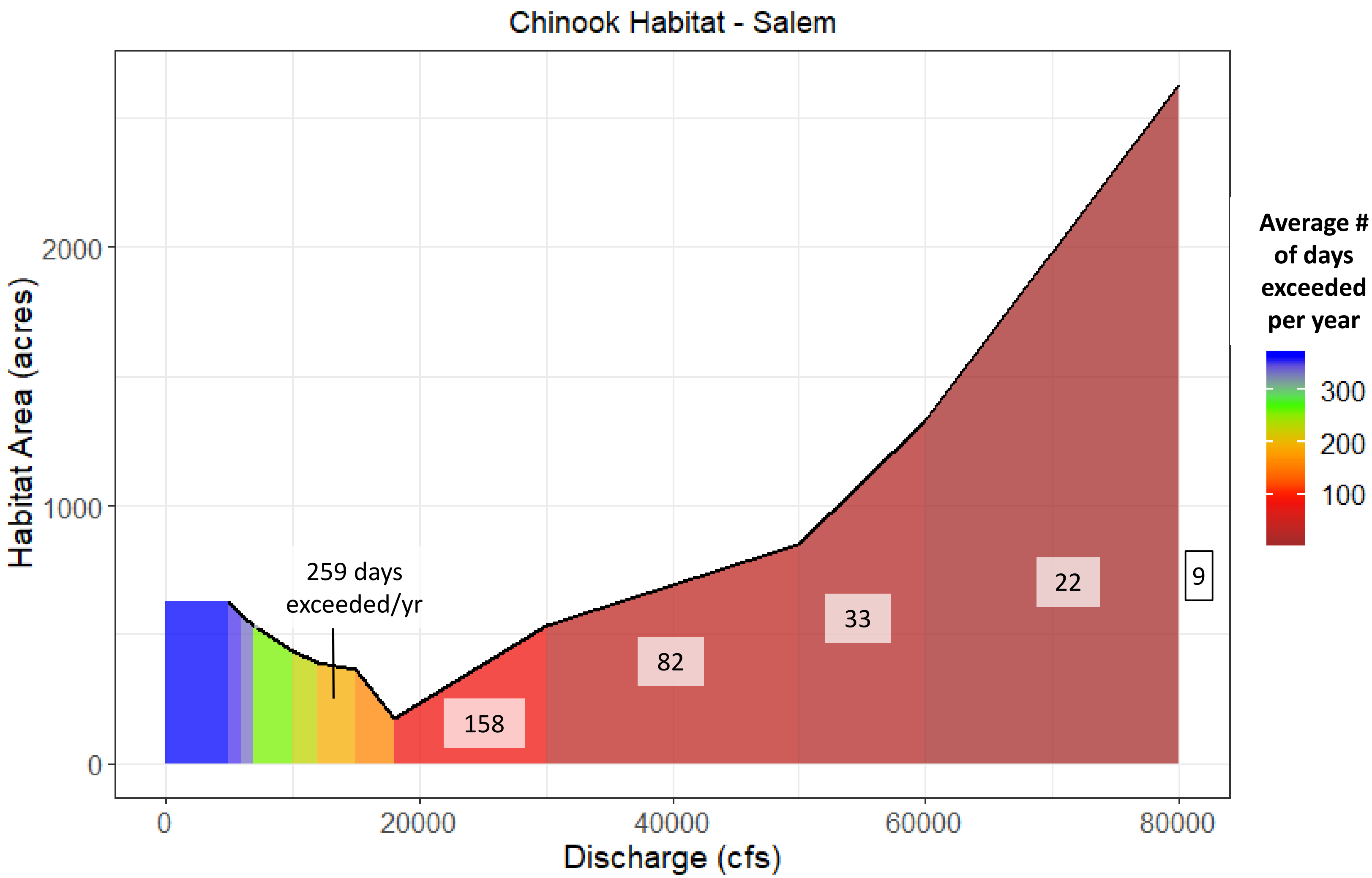


USGS

Quantifying Uncertainty in Model Results

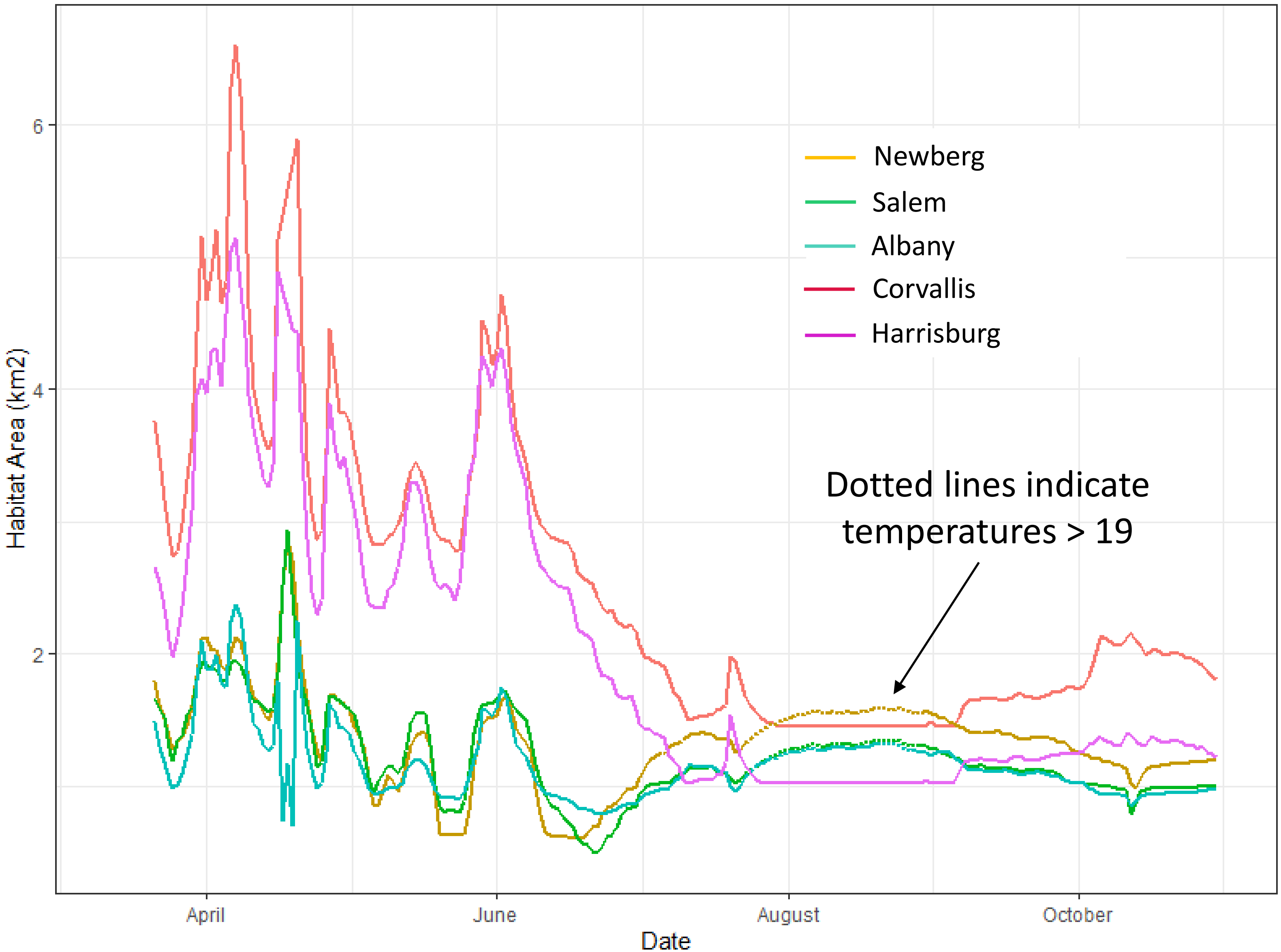


Preliminary Results – subject to revision

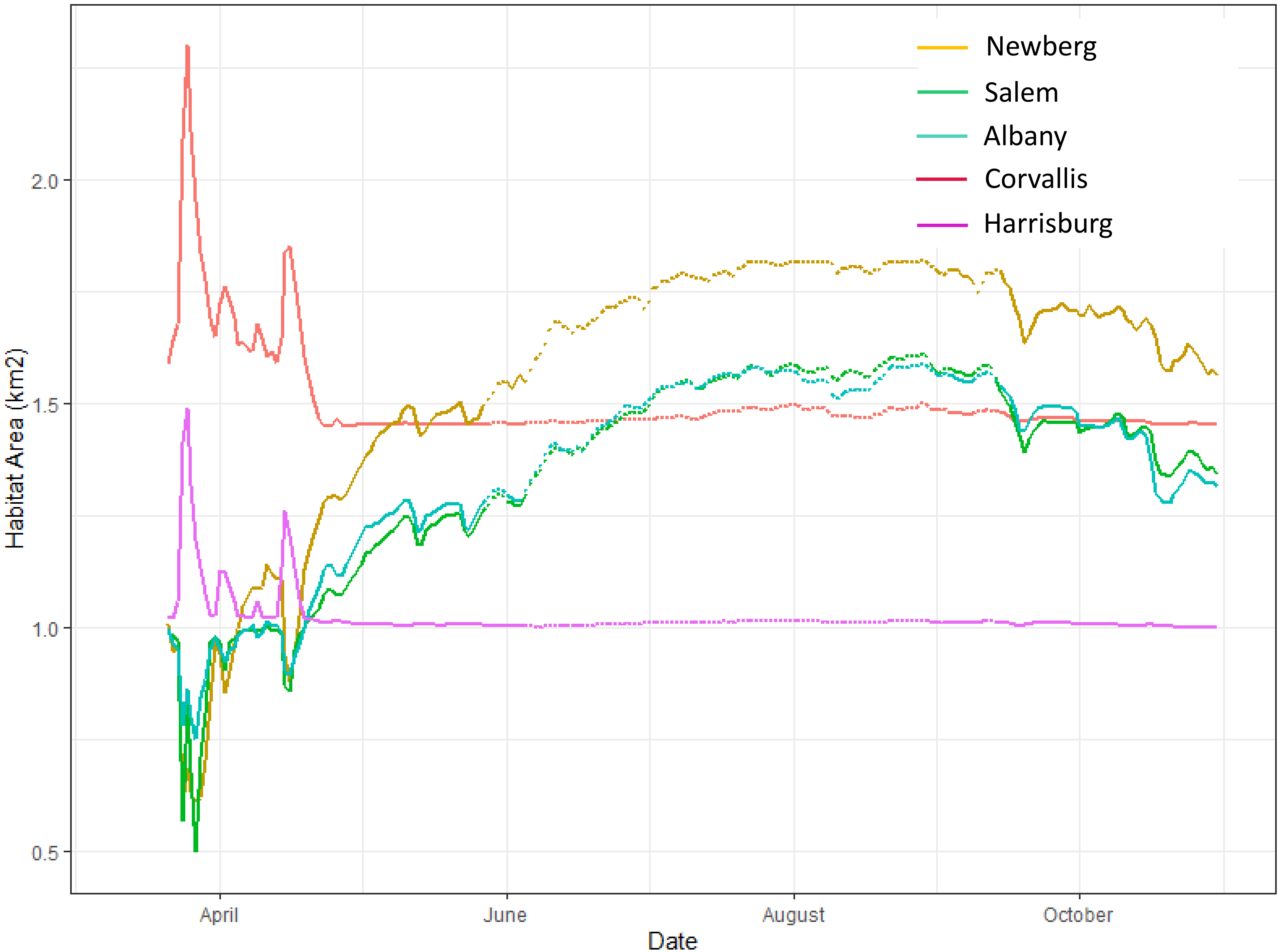


Preliminary Results – subject to revision

2011 – Cool Wet

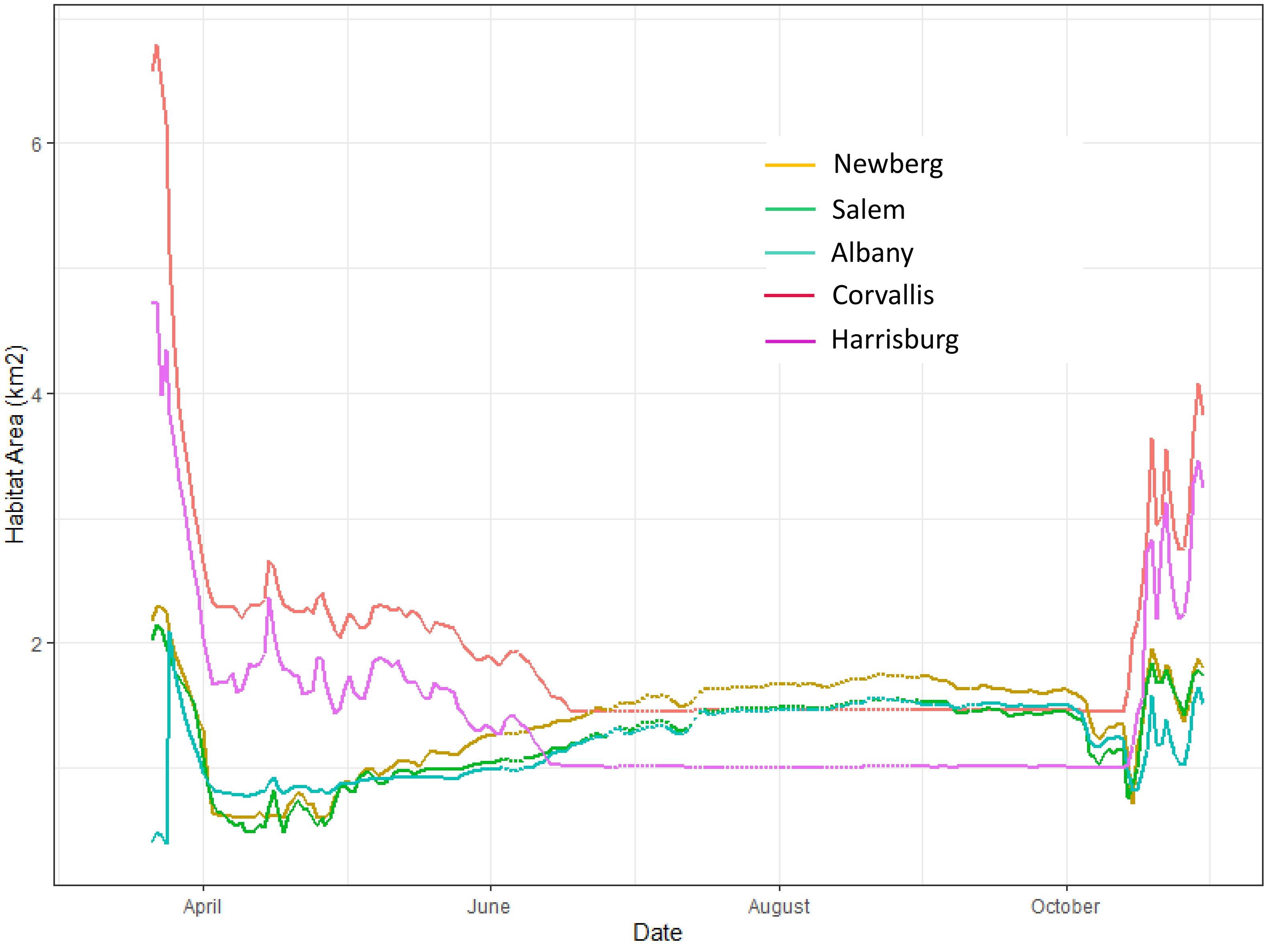


2015 – Warm Dry



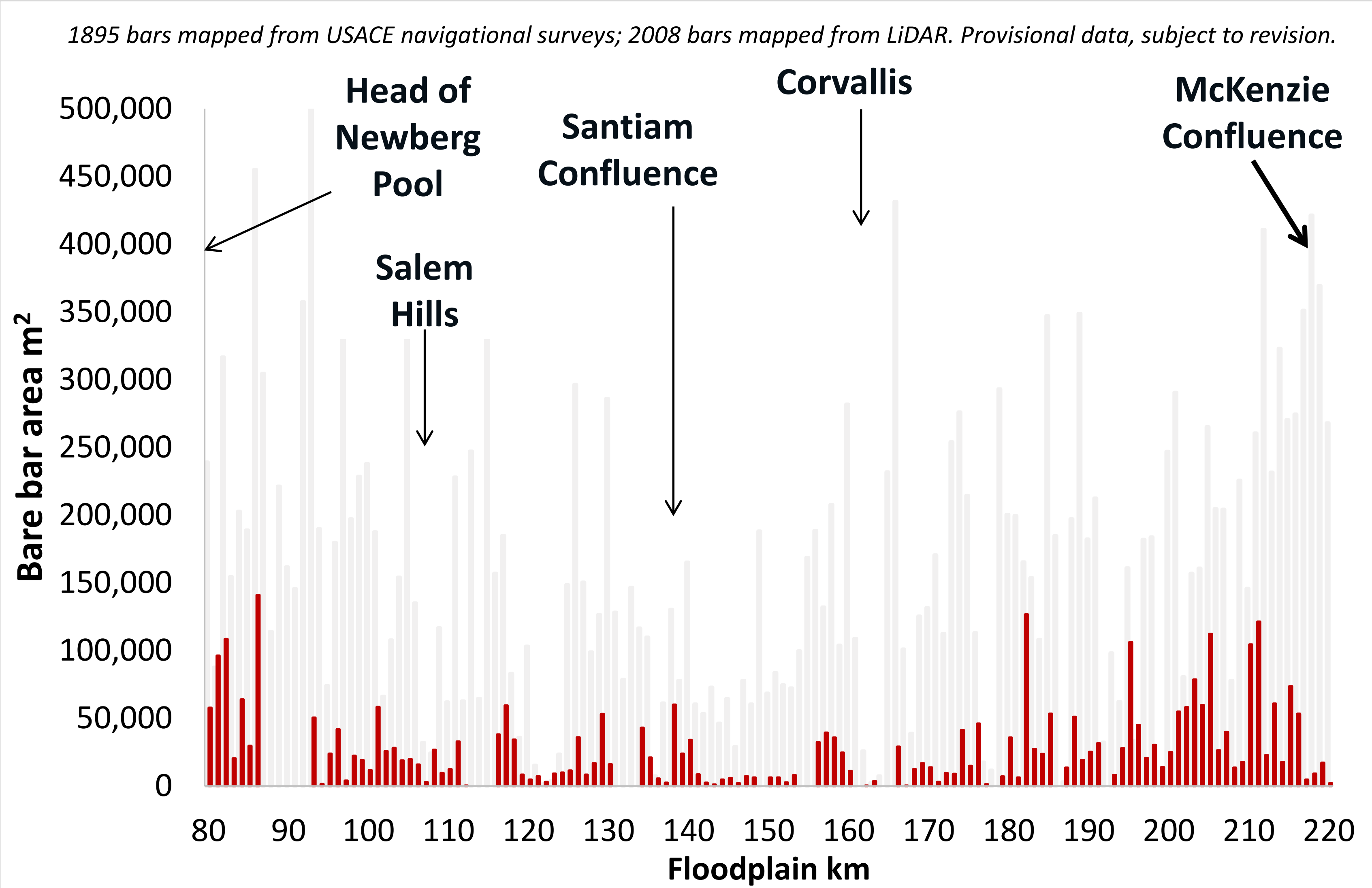
USGS

2016 – “Average”

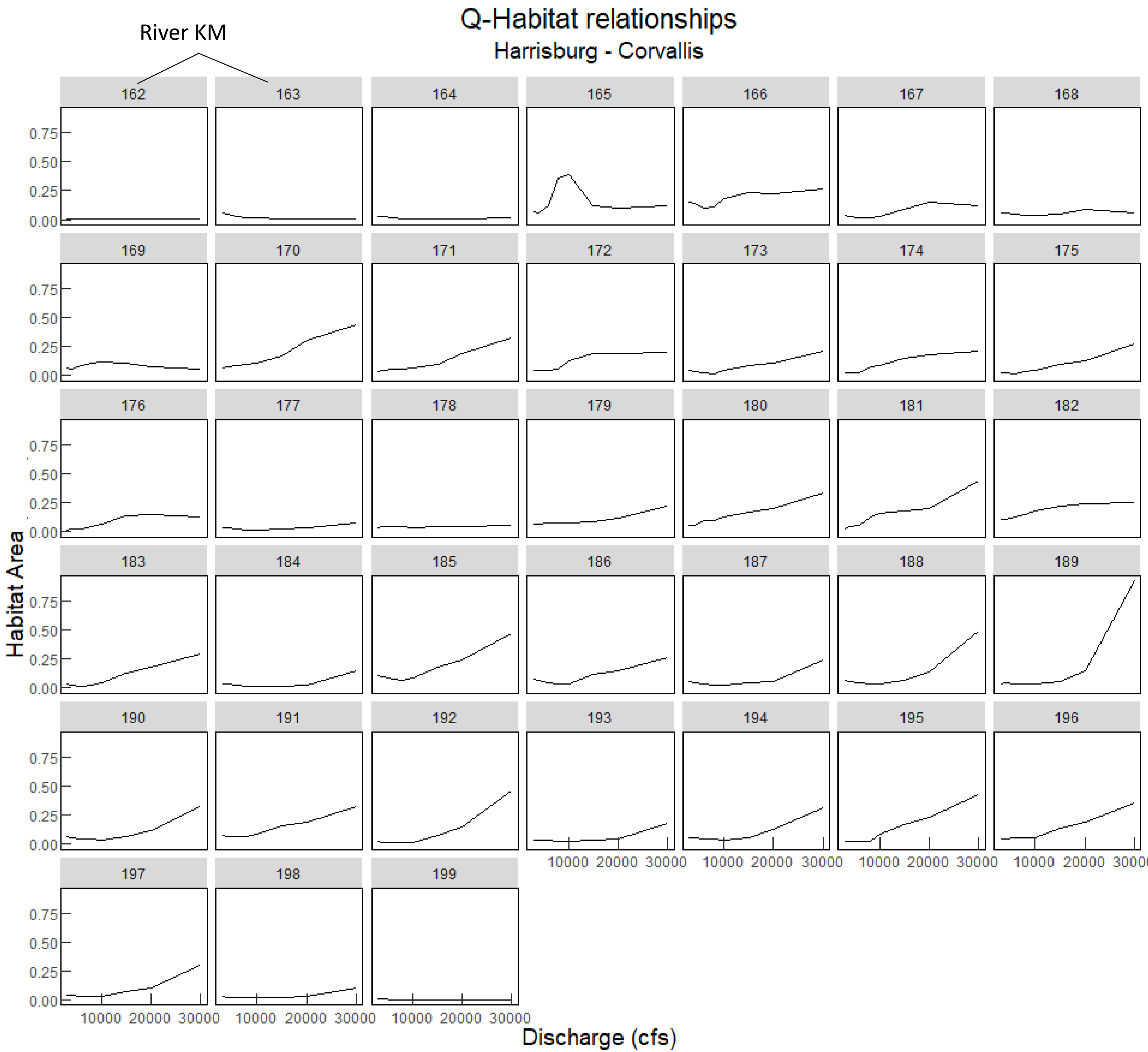


Change in gravel bars 1895-2008

~85% reduction in bare bars in Willamette River above Newberg



USGS


Q-Habitat relationships
Harrisburg - Corvallis
River KM
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0.25
0.00
10000 20000 30000
Habitat Area
Discharge (cfs)

:o revision