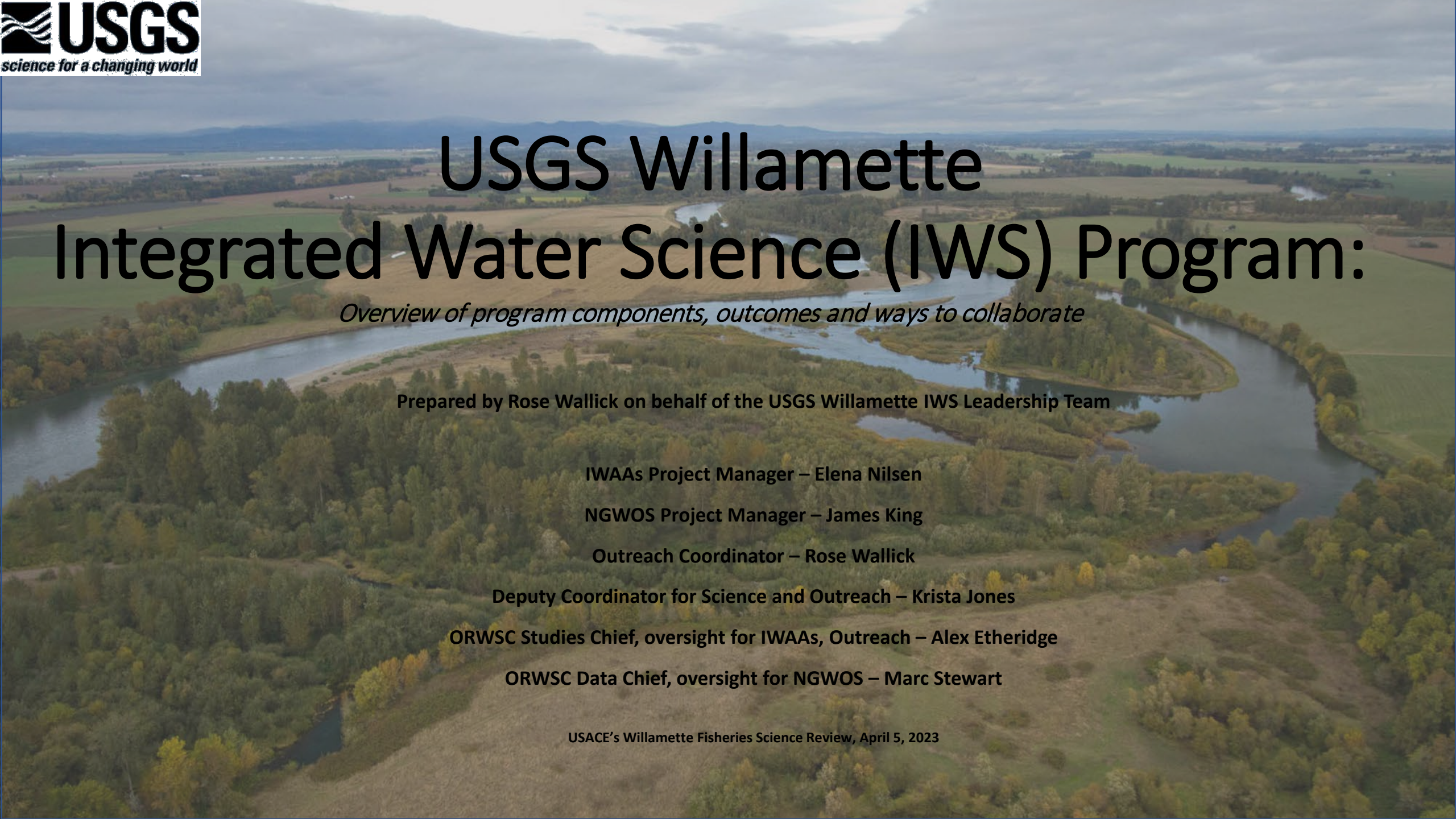


USGS Willamette Integrated Water Science (IWS) Program:

Overview of program components, outcomes and ways to collaborate

Prepared by Rose Wallick on behalf of the USGS Willamette IWS Leadership Team

IWAAs Project Manager – Elena Nilsen

NGWOS Project Manager – James King

Outreach Coordinator – Rose Wallick

Deputy Coordinator for Science and Outreach – Krista Jones

ORWSC Studies Chief, oversight for IWAAs, Outreach – Alex Etheridge

ORWSC Data Chief, oversight for NGWOS – Marc Stewart

USACE's Willamette Fisheries Science Review, April 5, 2023

Overview

Willamette Integrated Water Science (IWS)

- Background, program components, timelines
- Description of data collection and studies 2024-2026
- Opportunities for partnership and engagement

Acknowledgments

Numerous partners informed the IWS selection process; past research and collaborations provide the science foundation and inform new work

USACE: Salena Hart, Rich Piaskowski, Norm Buccola, Kathryn Tackley, Fenton Kahn, Greg Taylor, Paul Sclafani

NOAA: Anne Mullan, Aimee Fullerton, Morgan Bond, Jim Meyers

ODFW: Luke Whitman, Tom Friesen, Ben Clemens, Kelly Reis, Jeff Ziller, Elise Kelly, Jeremy Romer, Nik Zymonas, Elise Kelley, Mike Hogenson

OWRD: Alyssa Mucken

USFS: Gordon Grant, Becky Flitcroft, Sherri Johnson

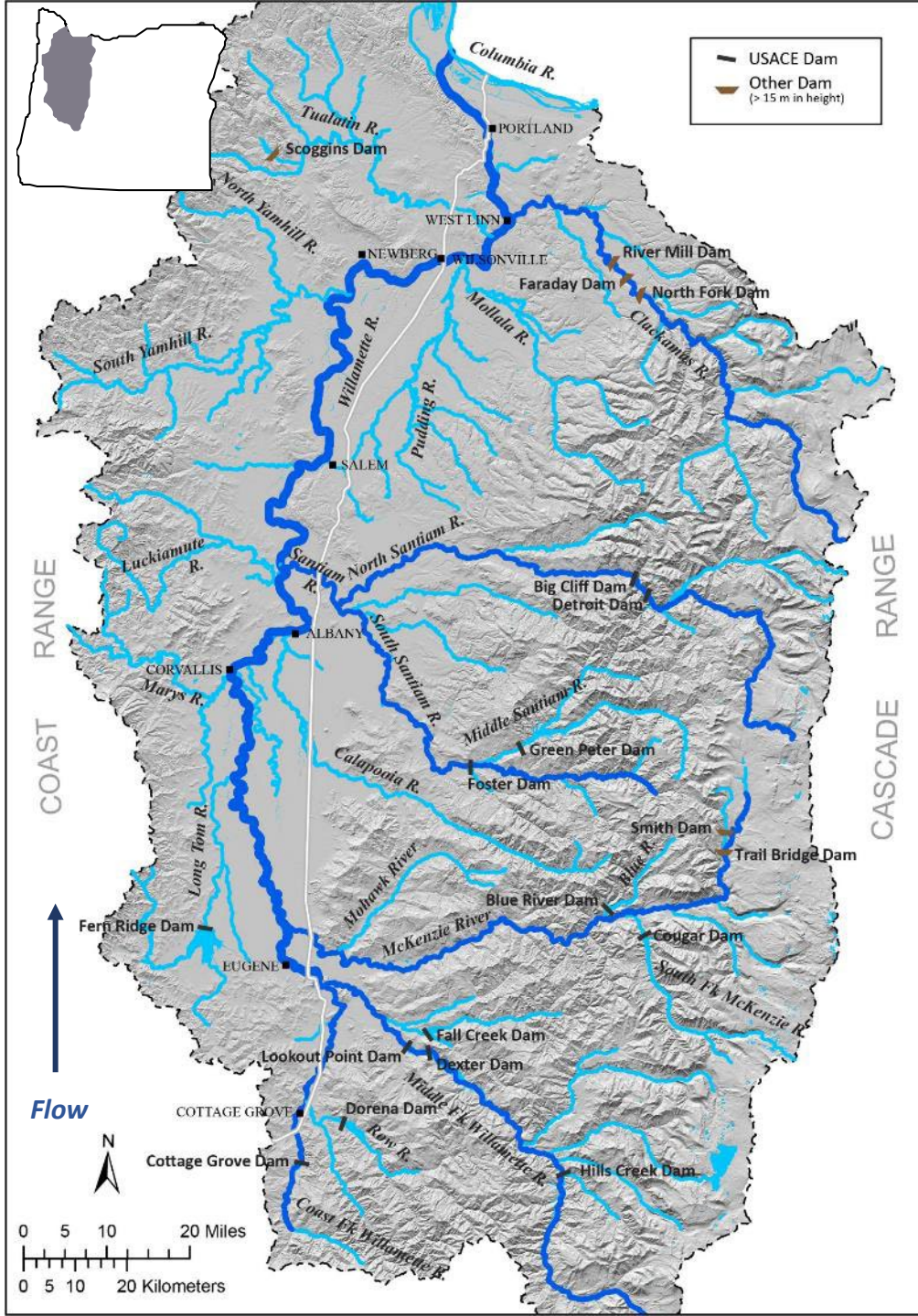
USGS: Laurel Stratton Garvin, James White, Brandon Overstreet, Jim Peterson, Toby Kock, Chrissy Murphy, Jason Dunham, Christian Torgersen, Gabriel Hansen

Universities: Matt Keefer, Stan Gregory, Chris Caudill, Jonny Armstrong, Desiree Tullos, Brooke Penaluna, Ivan Arismendi

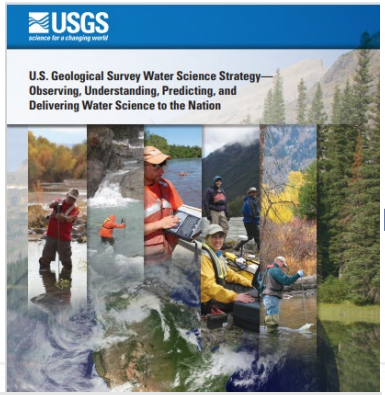
Others: PNNL, RDG, ESA

(and many more)

USGS



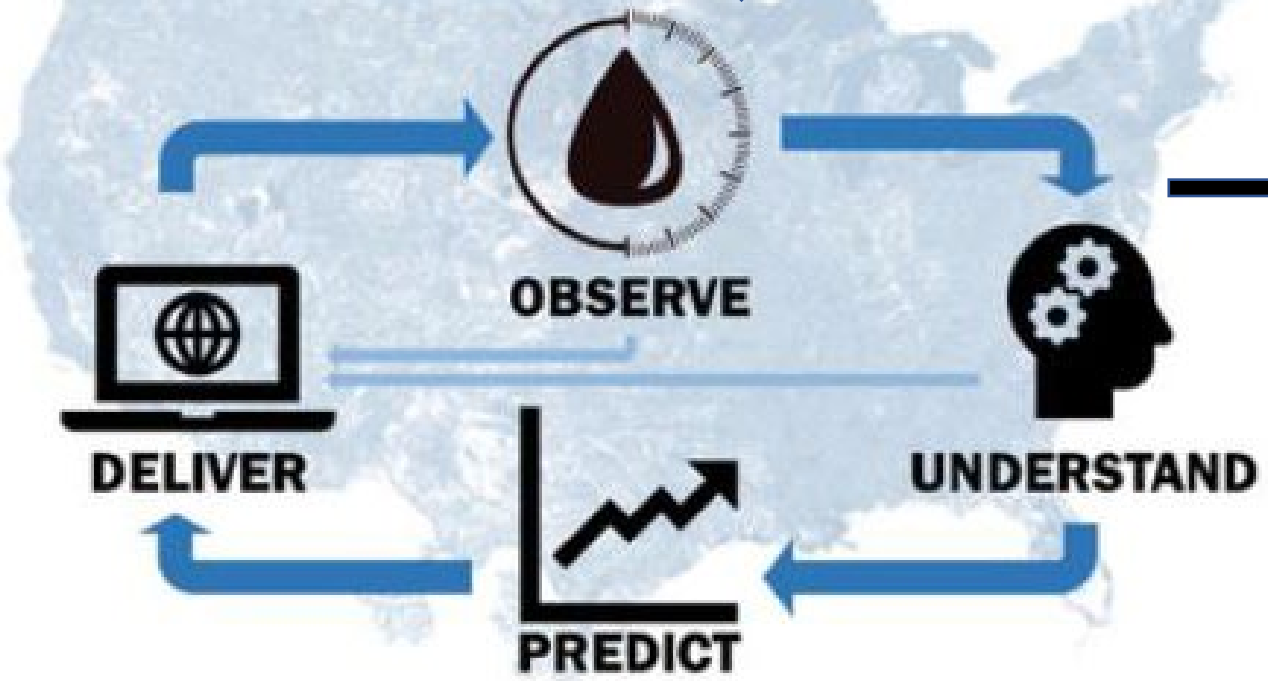
USGS Water Mission Area Science Strategy & IWS



USGS Water Mission Area Science Strategy

- Water quantity
- Timing of water delivery
- Water quality
- Human and ecological use

→ **Water availability**



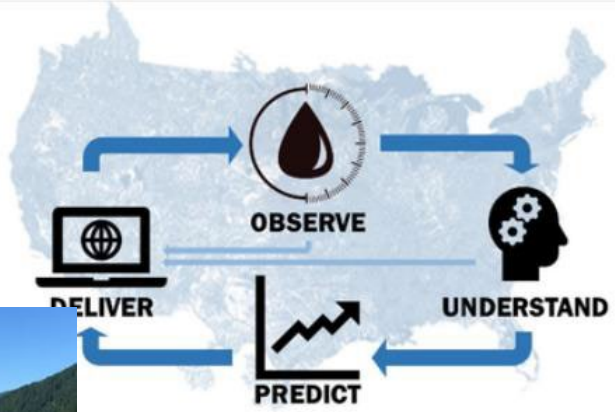
USGS Integrated Water Science (IWS) Basins; four of ten basins are underway

Evenson, E.J and others, 2013, U.S. Geological Survey water science strategy—Observing, understanding, predicting, and delivering water science to the Nation: U.S. Geological Survey Circular 1383–G, 49 p.

https://www.usgs.gov/mission-areas/water-resources/science/integrated-water-science-iws-basins

Integrated Water Science (IWS):

IWS is a large program with two components yielding near-term products to inform water management and fisheries decisions



Observe = *NGWOS*

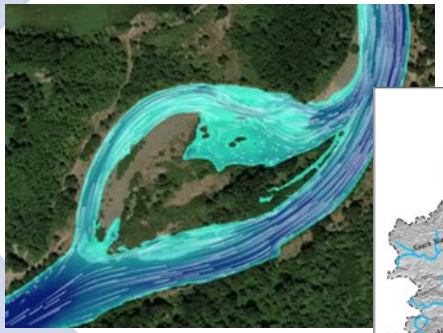
Water monitoring, mapping, R&D

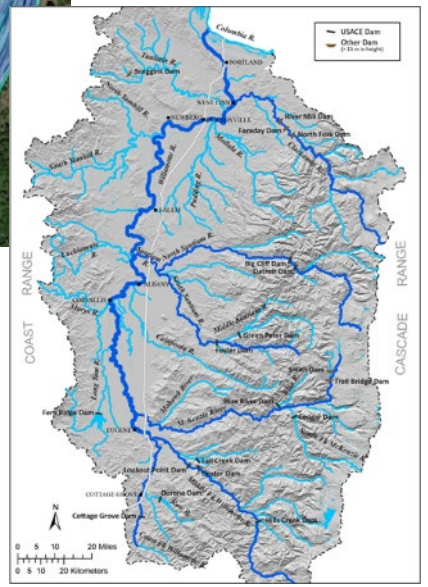
- **Next Generation Observing System (NGWOS)**
- *"Creating the water monitoring program of the future"*
- Includes gaging, mapping, monitoring, research & development
- Extends FY 2022-31

Understand = *IWAAs*

Analyses and research studies

- **Integrated Water Availability Assessments** (IWAAs)
- *"Understanding water availability, now and into the future"*
- Phase 1: FY 2024-26: Surface water for human uses & fish habitats
- Phase 2: FY 2027-31: Water for all human and ecosystem needs





USGS

The Willamette IWS focus is characterizing water availability, (quantity, quality) for humans and ecosystems now, and into the future. Hence, we will development tools to help us measure, map, understand and predict basin-wide patterns of water availability. Lessons learned in Willamette will advance national USGS models.

Timelines for Willamette Integrated Water Science (IWS)

	Planning		Implementation						
	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
	Year 1	2	3	4	5	6	7	8	9	10
NGWOS: *Water observing systems (new gaging, remote sensing, monitoring, R&D)*										
	NGWOS Planning	*Fish habitat focused data collection*	*Broad-scale water observations: R&D, gaging and monitoring to characterize all aspects of hydrologic cycle, and to characterize water quantity and quality.*							
IWAAs Phase 1: *Focus study on surface water & fish habitats*						**IWAAs Phase 2:** *Comprehensive study of all water availability*				
	IWAAs Planning	***Surface water and fish habitat focus study:*** *Trends analysis, current and future conditions modeling*		***Finalize Phase 1*** ***Plan for Phase 2***		*Comprehensive evaluation of surface water, groundwater, water quality to assess water for all human and ecosystem needs. Basin assessment of past, current, and future water availability.*			*Publish capstone report* *Information transfer to National activities.*	
Outreach: *Multi-faceted partner engagement to inform IWS activities and ensure useful science products*										
	Outreach planning	*Implementation of multi-pronged internal and external engagement program*								

USGS

Future actions depend on annual appropriations

Water Monitoring and Mapping 2023-2031 (NGWOS)

The NGWOS (water observing) portion of the Willamette IWS has a broad mission to strategically collect data, expand our water monitoring network and carryout research and development to advance "next generation" monitoring approaches that will support the USGS's water monitoring program of the future. The goals and plans are in development but may include:

Expanding the USGS gaging network

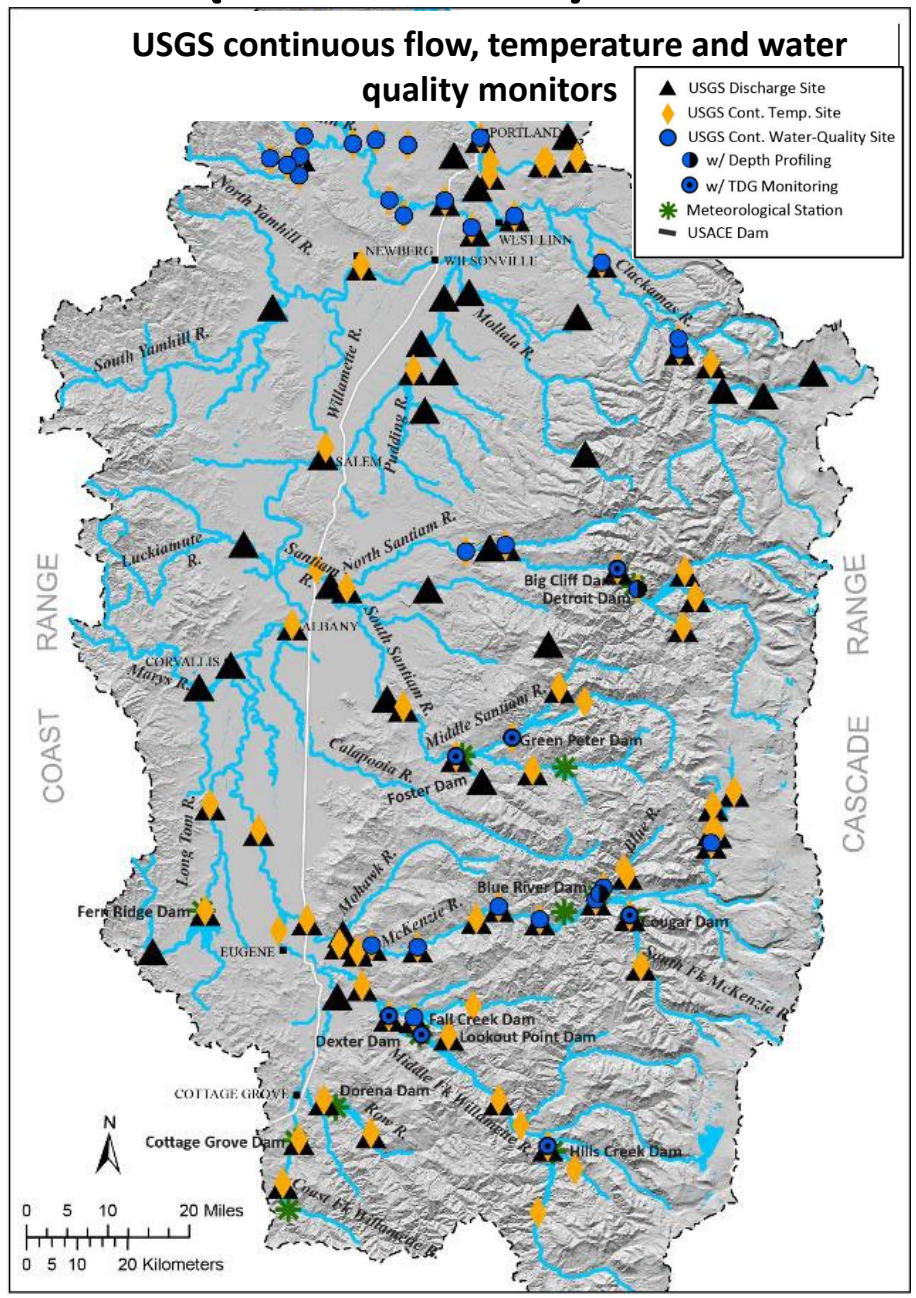
- *New and re-activated flow, temperature, water-quality gages*
- *"Tiered gaging" using traditional and lower-cost monitoring approaches*
- *Improved monitoring of the entire hydrologic cycle*

Expanding river, bathymetric and thermal mapping

- *Synthesizing and inventorying existing data (TIR, LiDAR, and more)*
- *New topo-bathymetric lidar surveys*
- *New field-based surveys*
- *New remote-sensing campaigns (UAS, piloted flights, and more)*

Building the "water monitoring network of the future"

Modernizing databases and creating data visualization applications

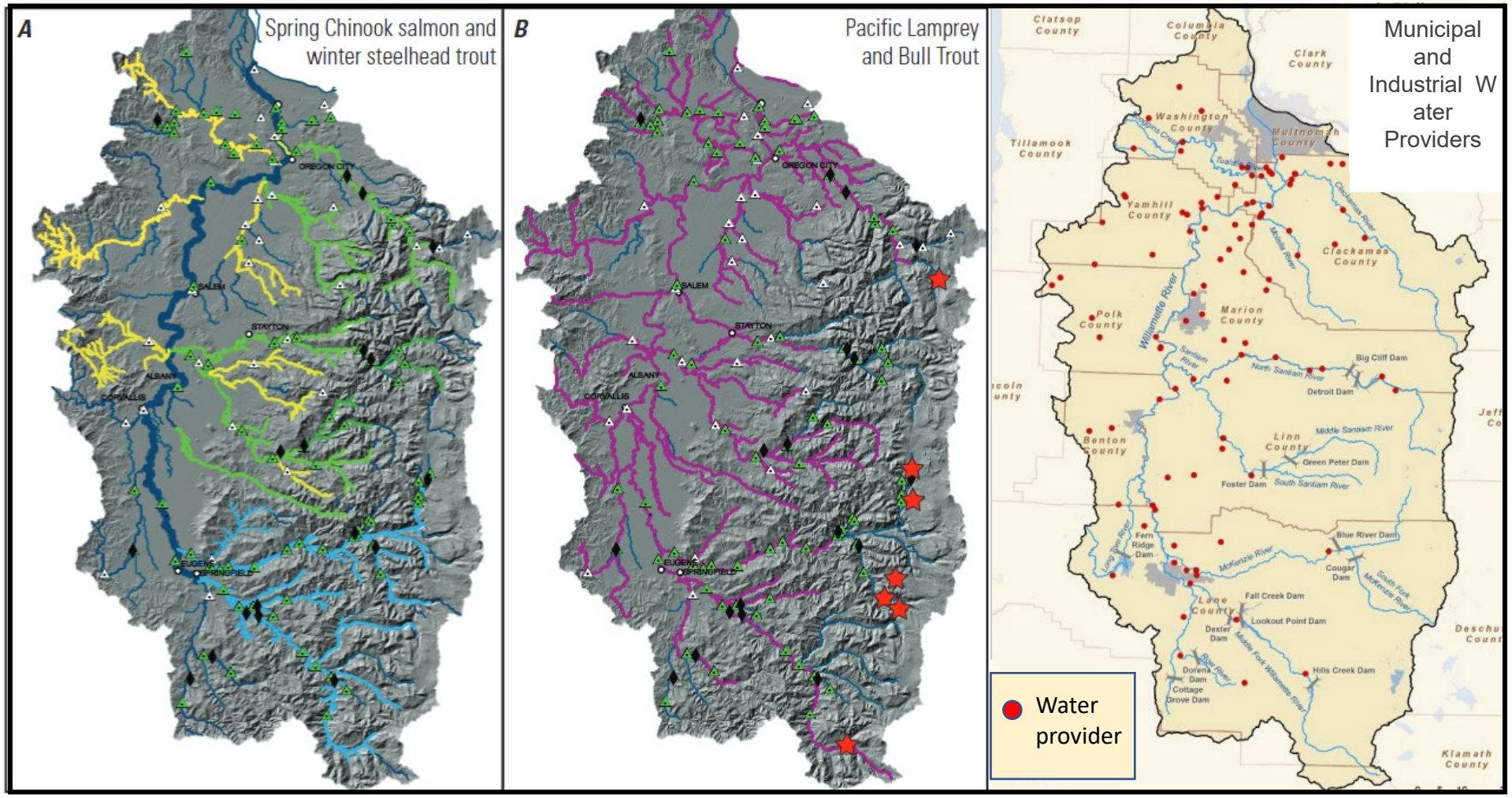


Surface Water and Fish Habitat Study 2024-2026 (IWAAs Phase 1)

Goal: Predict spatial and temporal patterns of surface water availability for humans and fish habitats, now and in the future.

Objectives:

- Understand landscape-level variation in flow and water temperature and underlying controls
- Predict hydrologic and thermal responses, to current and future hydroclimatic variability
- Examine "extreme events" and hydrologic/thermal responses
- Assess implications for human water needs and fish habitats



USGS

Source: NOAA Fisheries, 2008; USFWS, 2008; ODFW written communication. USACE, 2019.

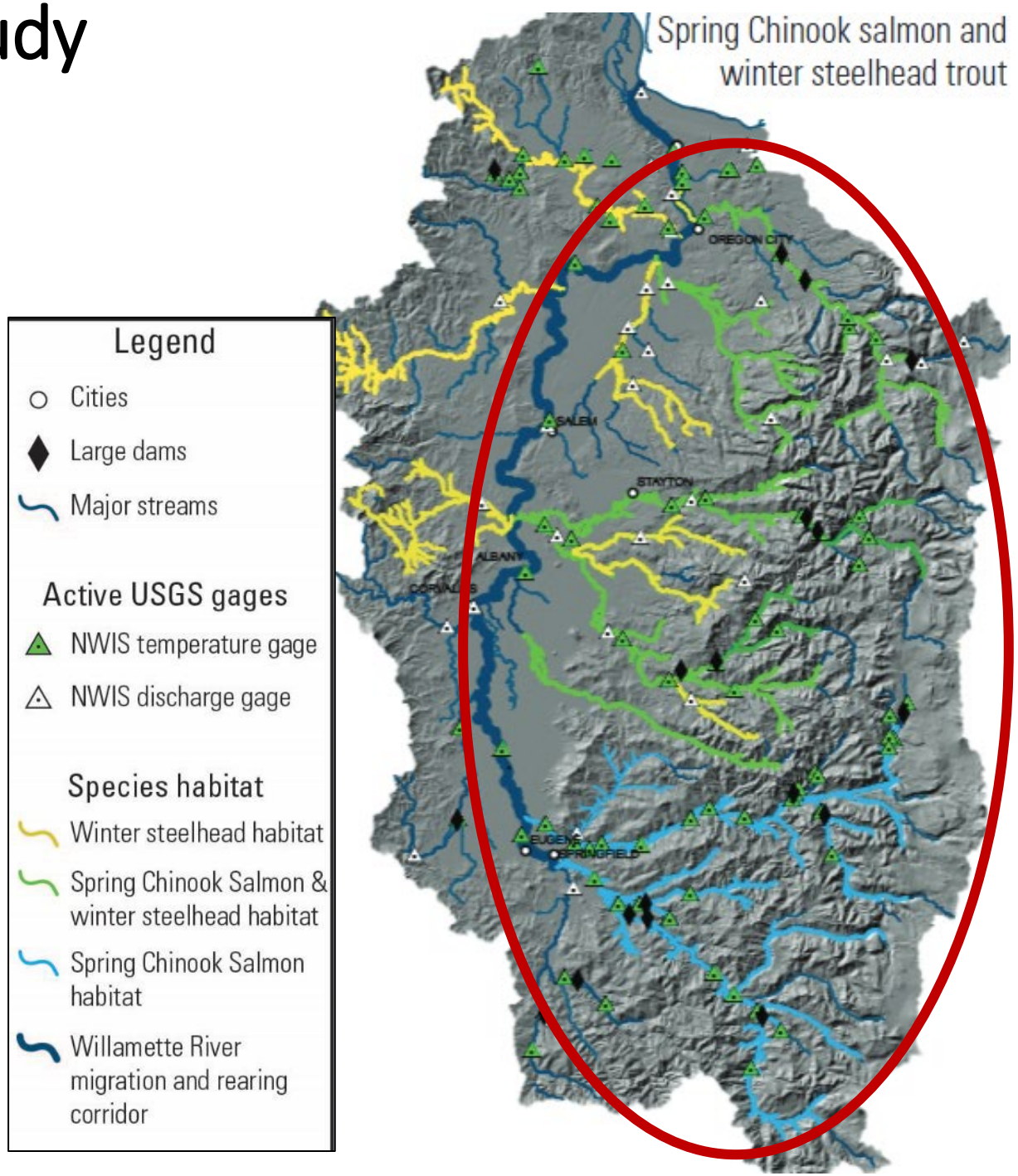
Surface Water and Fish Habitat Study 2024-2026 (IWAAs Phase 1)

Human water-needs focus:
Surface water needs for agriculture, municipal and industrial uses

Fisheries focus:
- spring Chinook Salmon
- winter steelhead
- Pacific Lamprey

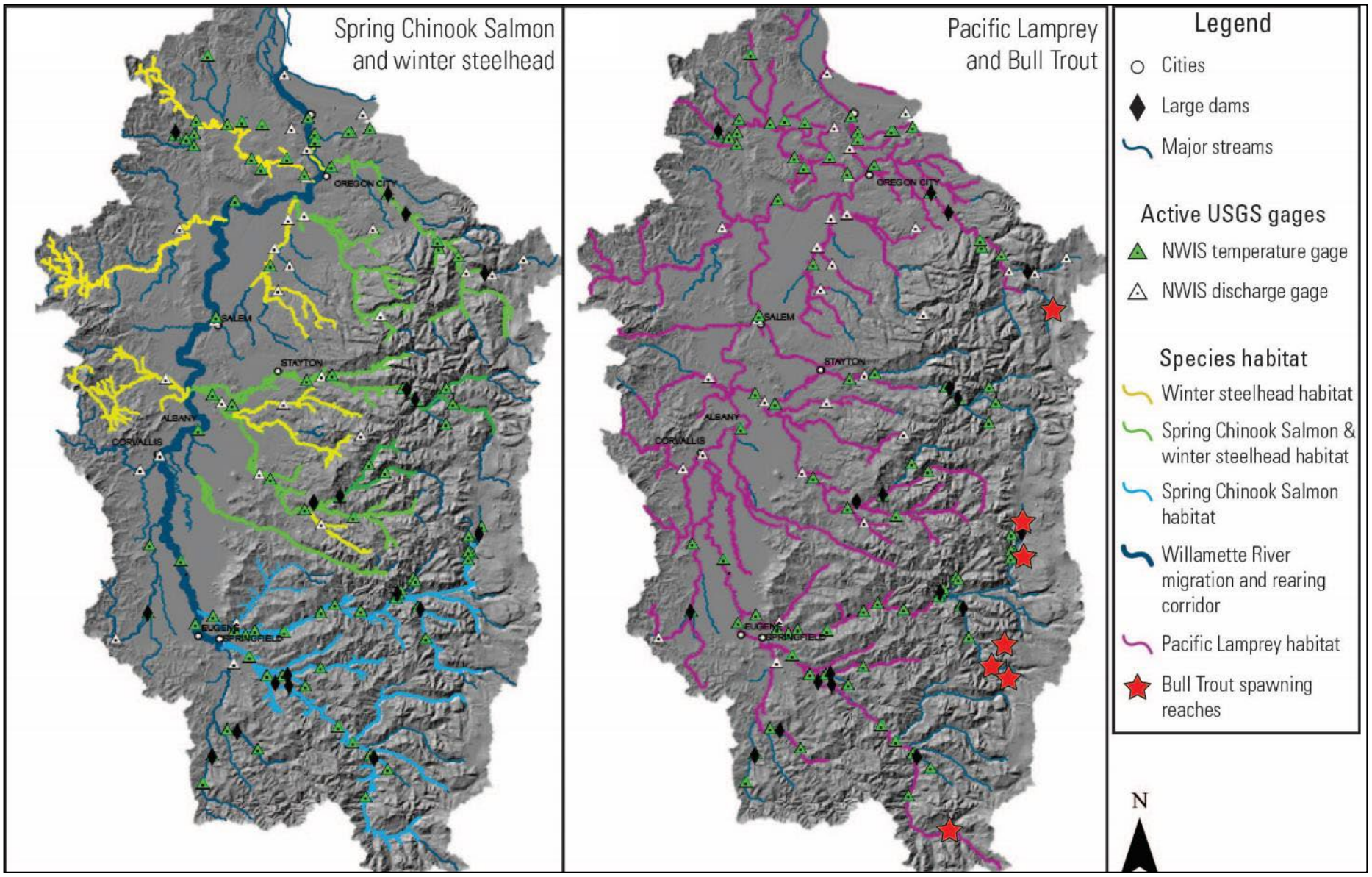
Spatial focus:
Cascade Range streams utilized by focal fish species and where water is diverted for human needs

Seasonal focus:
Spring, summer, fall, particularly in low-flow and extremely warm periods



USGS

Spring Chinook and Pacific Lamprey photos courtesy of Freshwaters Illustrated.
North Santiam irrigation pipe photo courtesy of Brandon Overstreet



Distributions of A) spring Chinook salmon and winter steelhead and b) Pacific Lamprey and Bull Trout in the Willamette River Basin based on NOAA (2008), USFWS (2008) and ODFW (written commun).

USGS

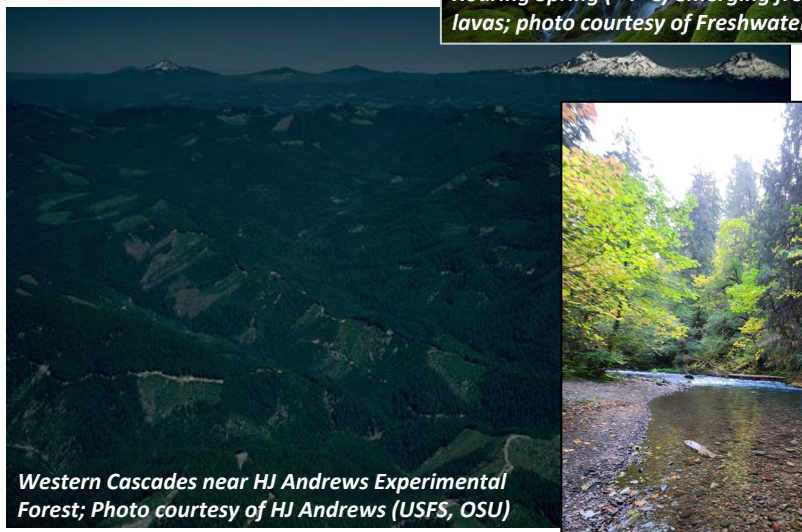
Willamette IWS focal fish species

Greater emphasis will be applied to spring Chinook Salmon and winter steelhead

Assessing Habitat Response to Hydroclimatic Variability Requires a Landscape-Level Approach and New Gages

High Cascades near McKenzie Pass; Photo by Jim O'Connor (USGS)

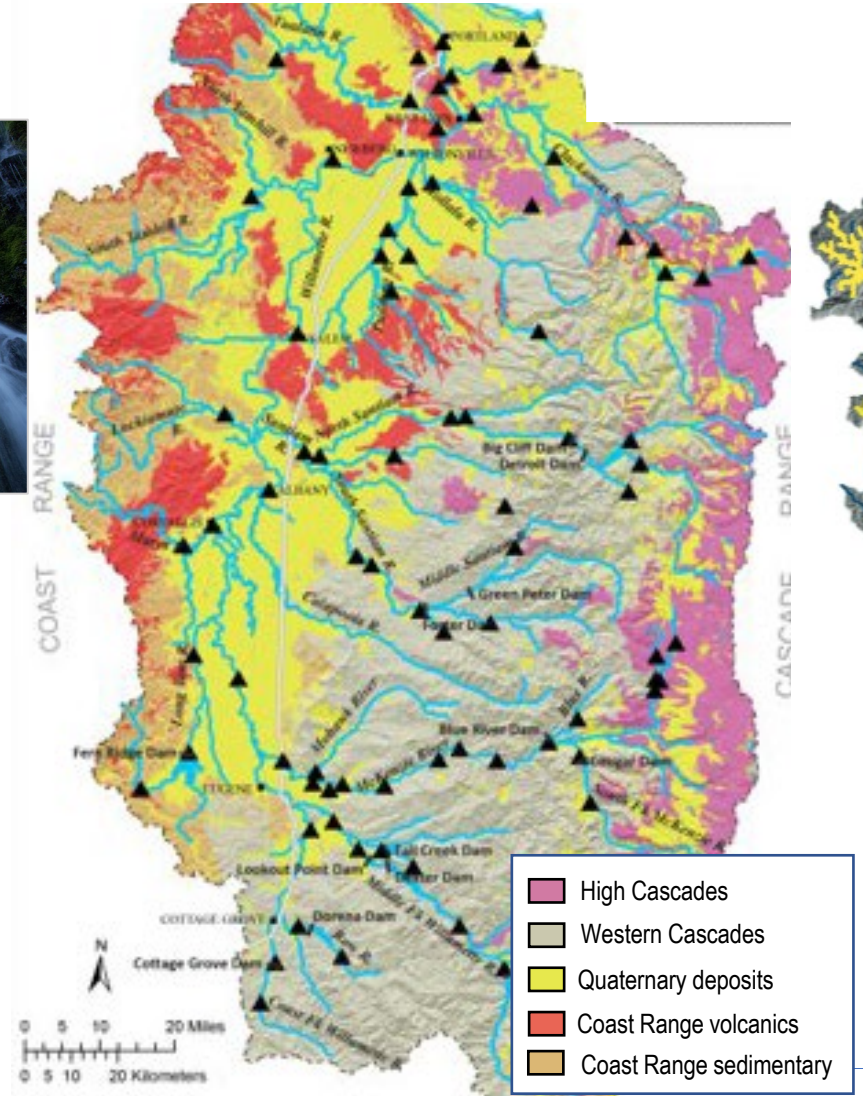
Roaring Spring (~4 °C) emerging from High Cascades lavas; photo courtesy of Freshwaters Illustrated



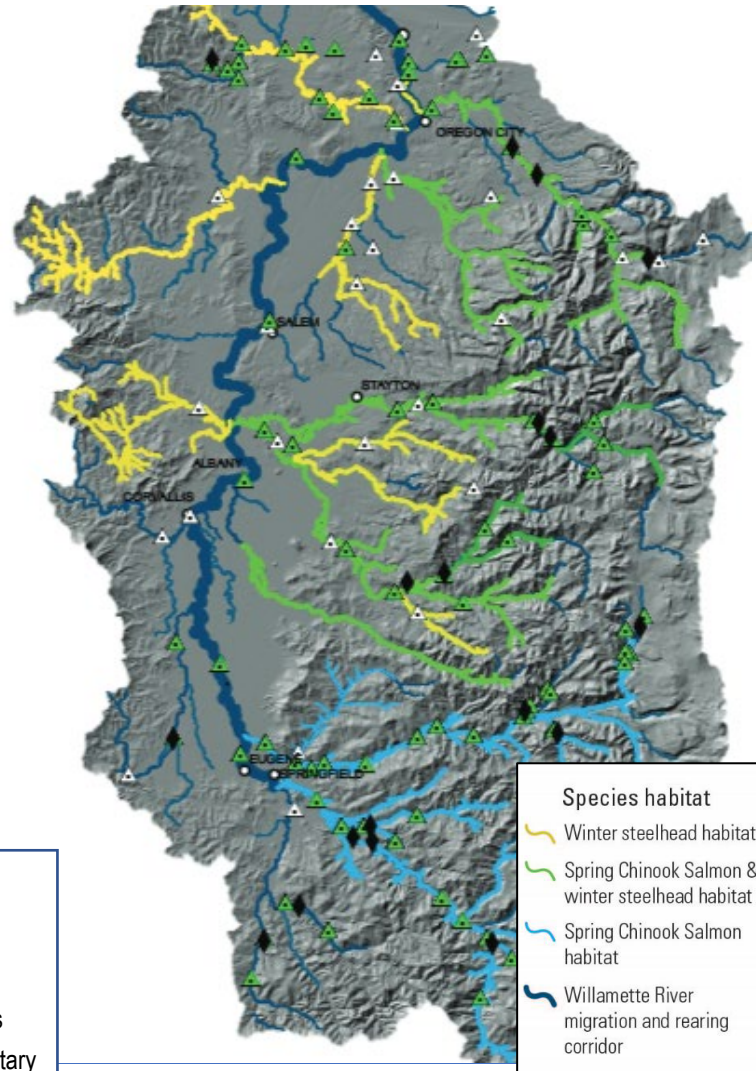
Western Cascades near HJ Andrews Experimental Forest; Photo courtesy of HJ Andrews (USFS, OSU)

South Fork McKenzie above Cougar Dam

Willamette Basin Geological Provinces
(modified from O'Connor and others, 2015)



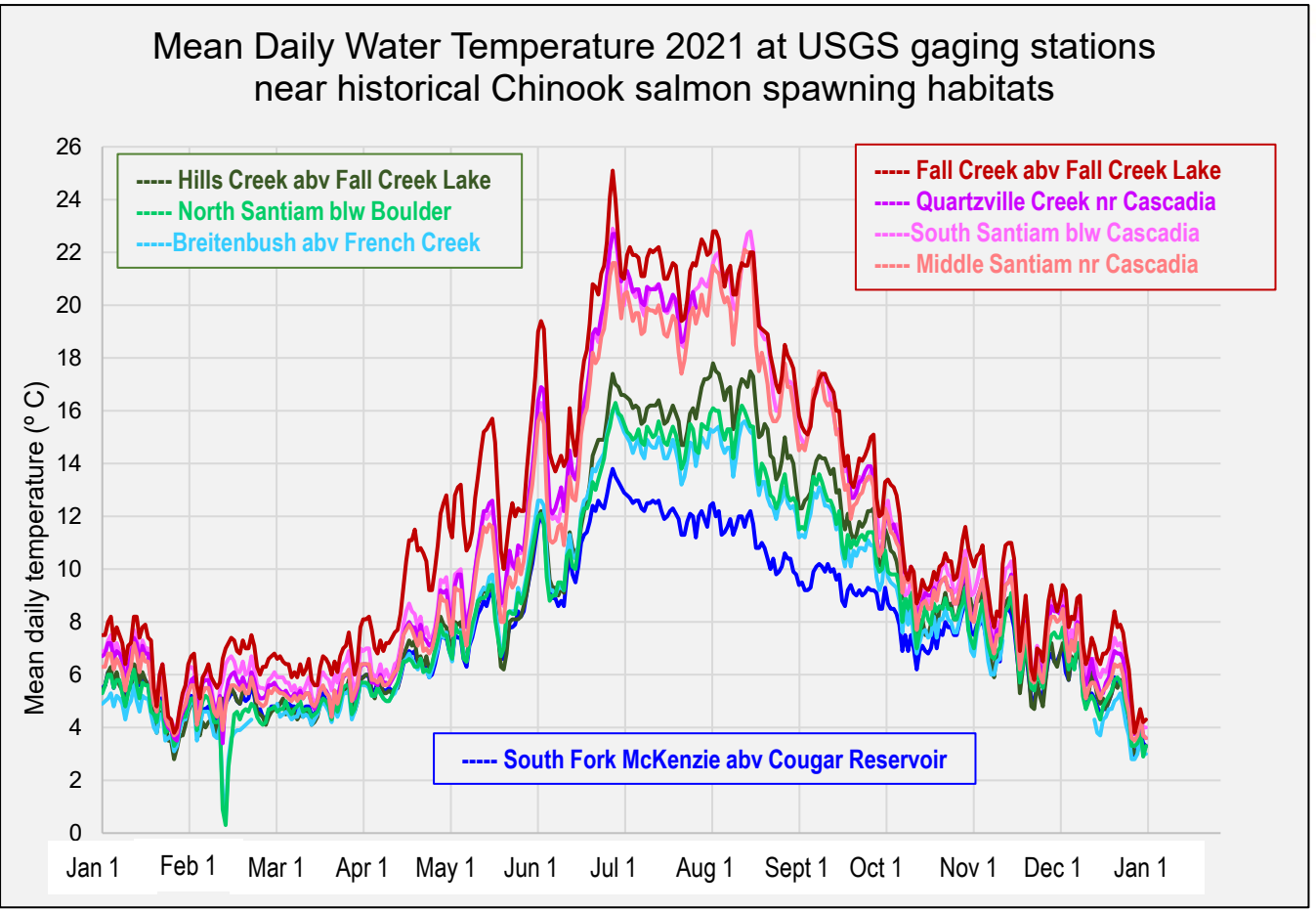
Willamette Basin Salmon and Steelhead Distributions ***(source: NOAA Critical Habitat)***



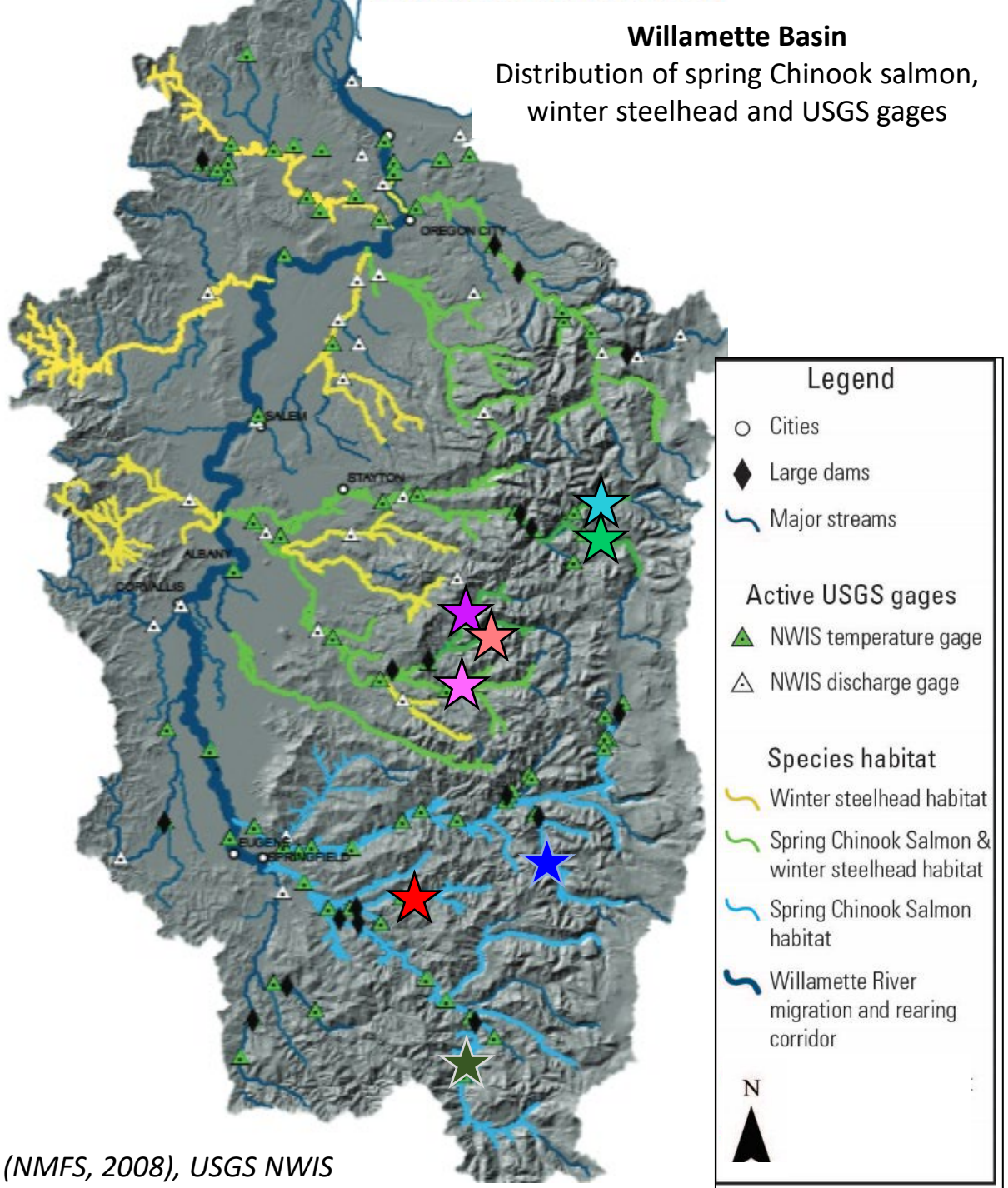
USGS

Examples of Thermal Variability between Spawning Reaches: 2021

Above dam spawning reaches



Willamette Basin
Distribution of spring Chinook salmon, winter steelhead and USGS gages



USGS

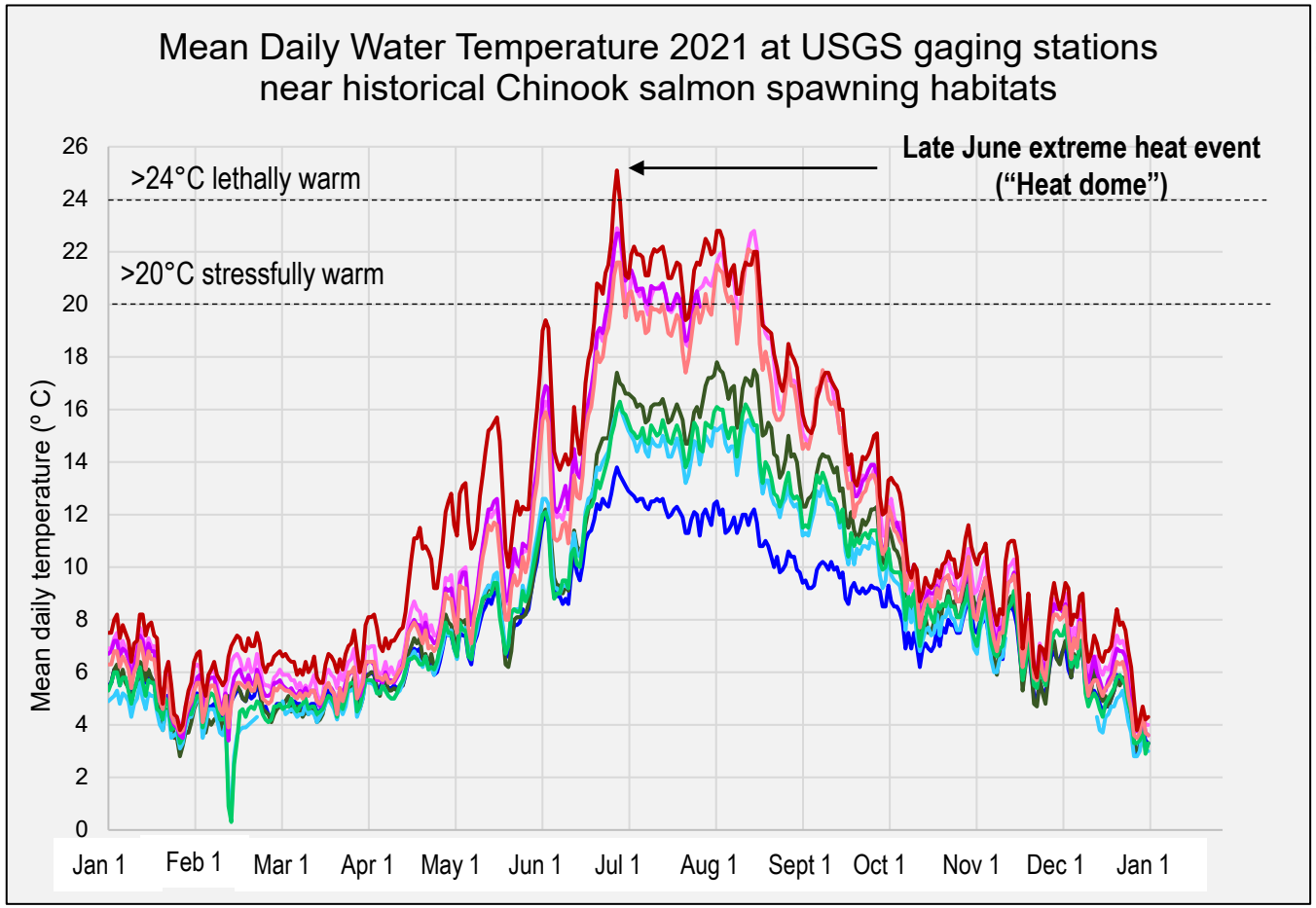
Source: NOAA Critical Habitat (NMFS, 2008), USGS NWIS

Examples of Thermal Variability between Spawning Reaches: 2021

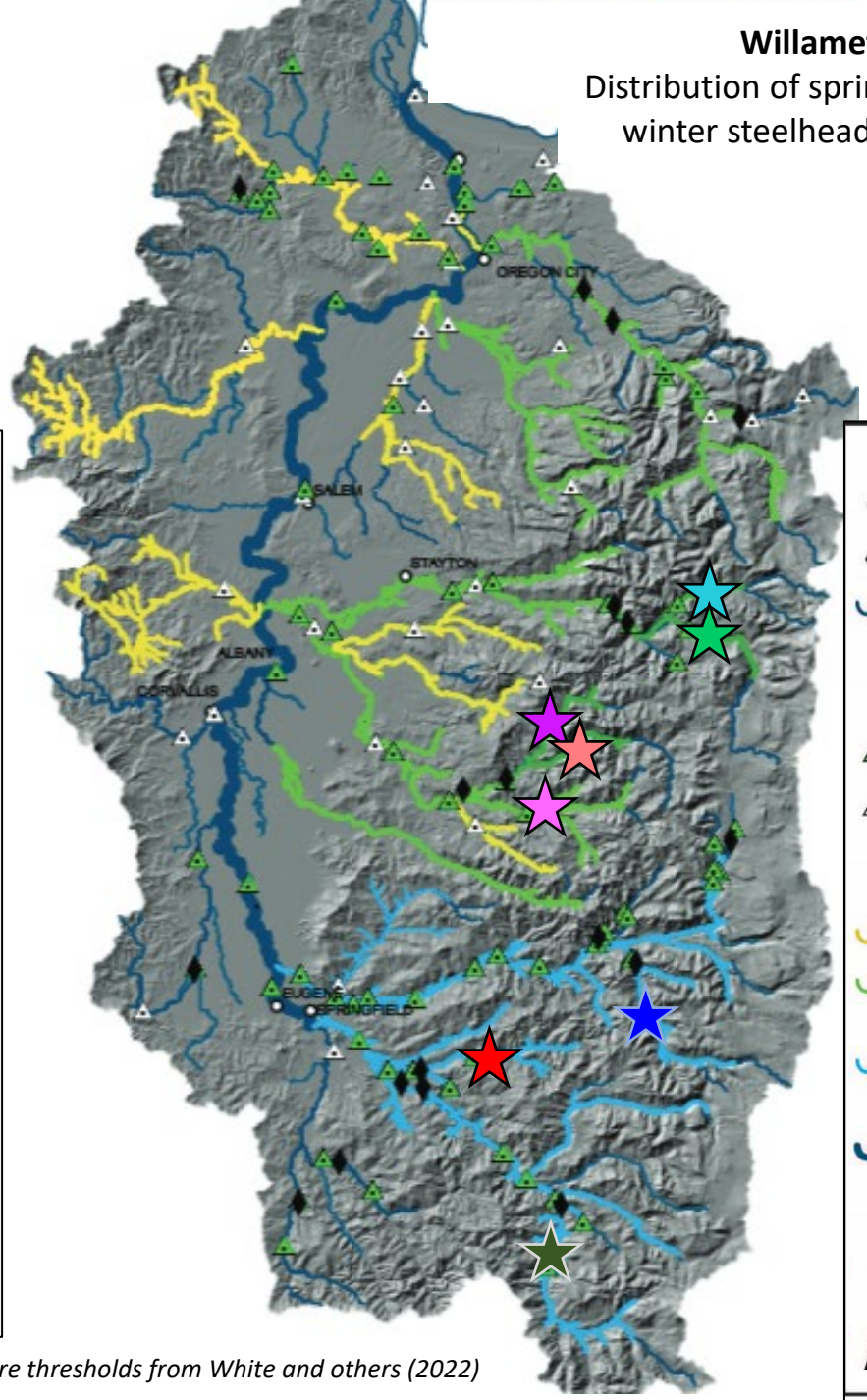
----- Fall Creek abv Fall Creek Lake
----- Quartzville Creek nr Cascadia
-----South Santiam blw Cascadia
----- Middle Santiam nr Cascadia

----- Hills Creek abv Fall Creek Lake
----- North Santiam blw Boulder
-----Breitenbush abv French Creek

----- South Fork McKenzie abv Cougar Reservoir



Willamette Basin
Distribution of spring Chinook salmon, winter steelhead and USGS gages



Legend
Cities
Large dams
Major streams
Active USGS gages
NWIS temperature gage
NWIS discharge gage
Species habitat
Winter steelhead habitat
Spring Chinook Salmon & winter steelhead habitat
Spring Chinook Salmon habitat
Willamette River migration and rearing corridor
N

USGS

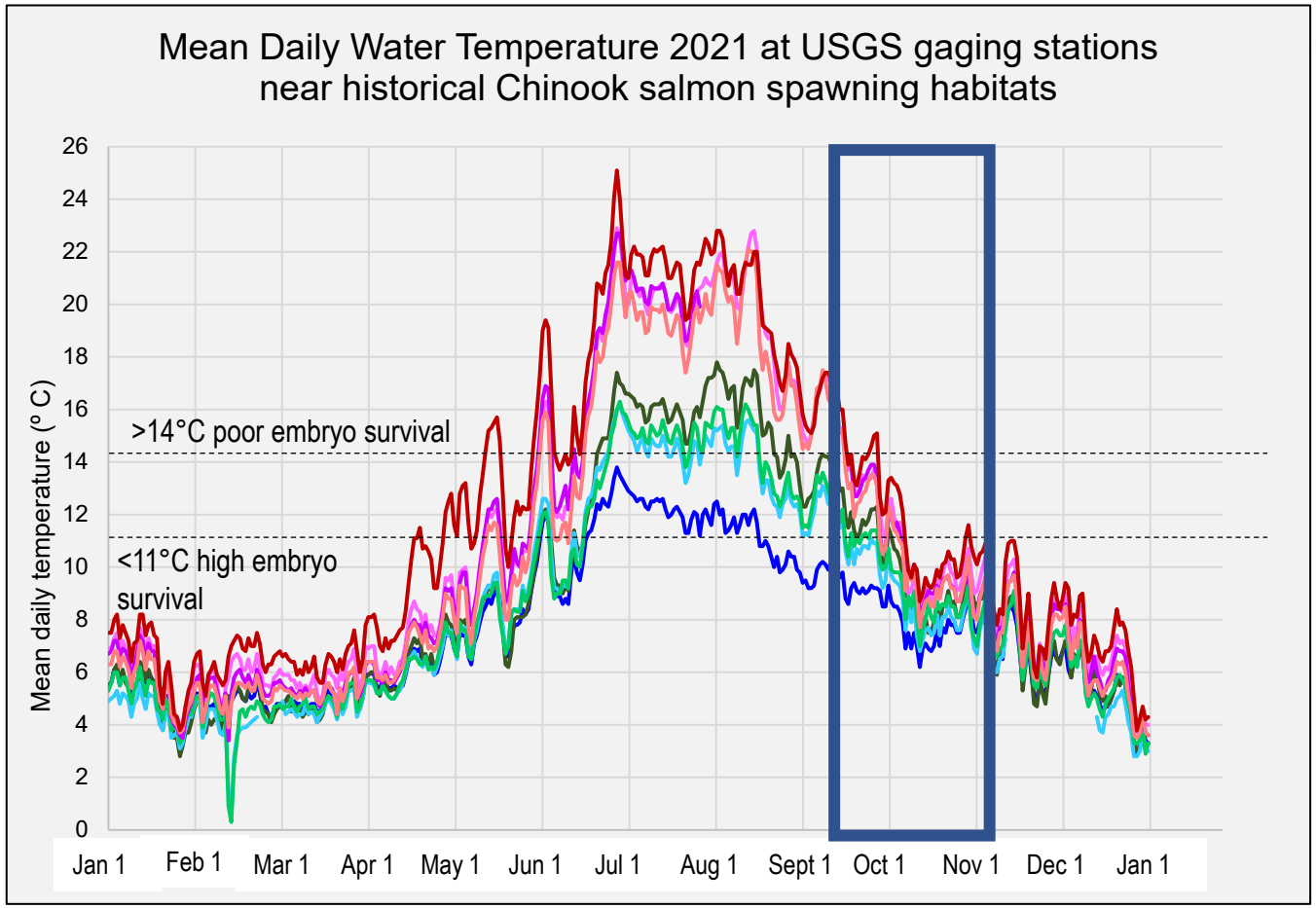
Data sources: NOAA Critical Habitat (NMFS, 2008), USGS NWIS; Temperature thresholds from White and others (2022)

Examples of Thermal Variability between Spawning Reaches: 2021

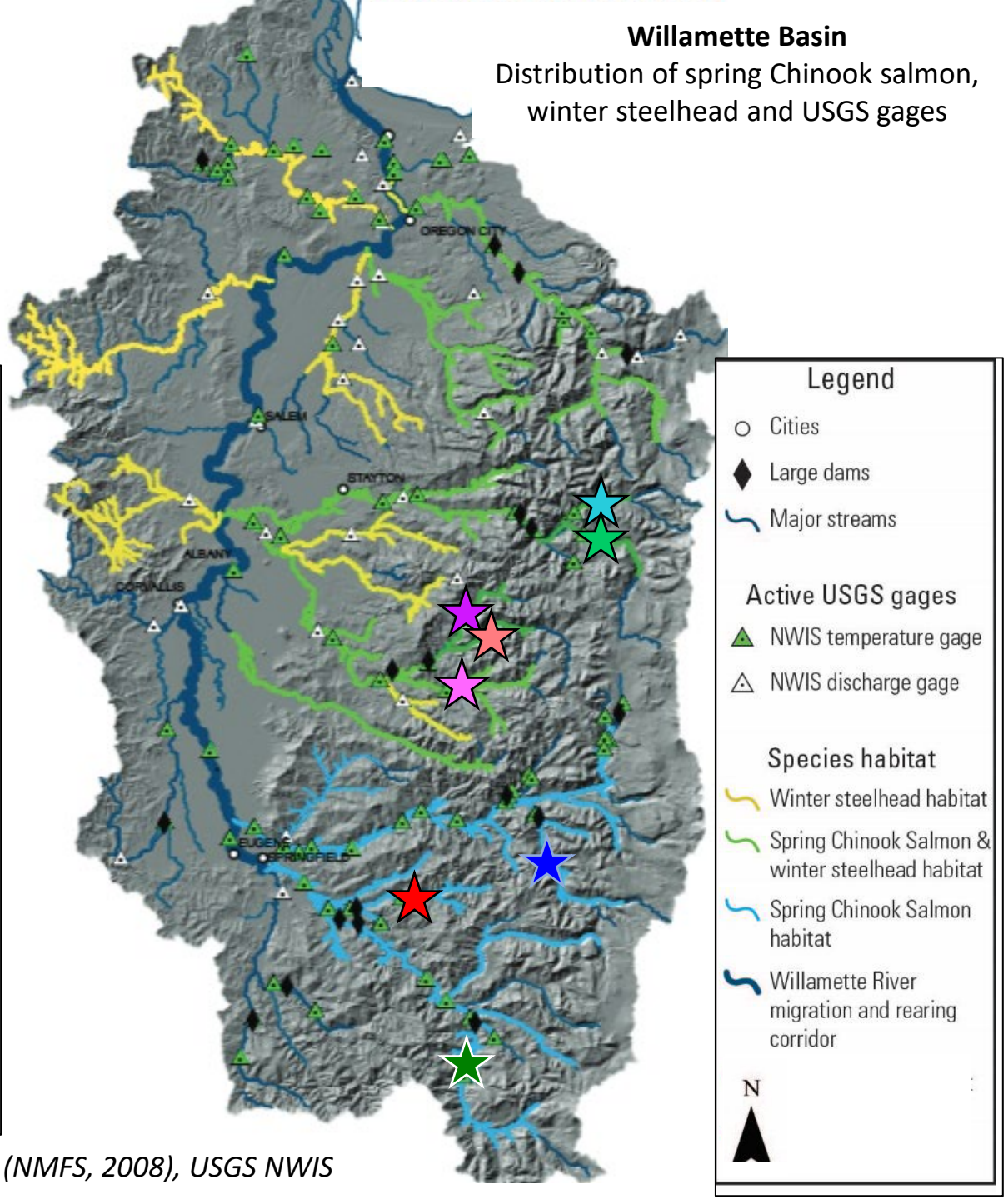
----- Fall Creek abv Fall Creek Lake
----- Quartzville Creek nr Cascadia
-----South Santiam blw Cascadia
----- Middle Santiam nr Cascadia

----- Hills Creek abv Fall Creek Lake
----- North Santiam blw Boulder
-----Breitenbush abv French Creek

----- South Fork McKenzie abv Cougar Reservoir



Willamette Basin
Distribution of spring Chinook salmon, winter steelhead and USGS gages



USGS

Source: NOAA Critical Habitat (NMFS, 2008), USGS NWIS

New Data Collection 2023-2025 (NGWOS)

Data collection will target ungaged, unmapped smaller streams used by salmon and steelhead, including above-dam reaches and unregulated streams. Data will support upcoming analyses and modeling.

Flow and Temperature Monitoring

- Continuous monitoring in key spawning areas
- New and re-activated USGS gaging stations in select salmon and steelhead streams
- Synoptic surveys to characterize heterogeneity

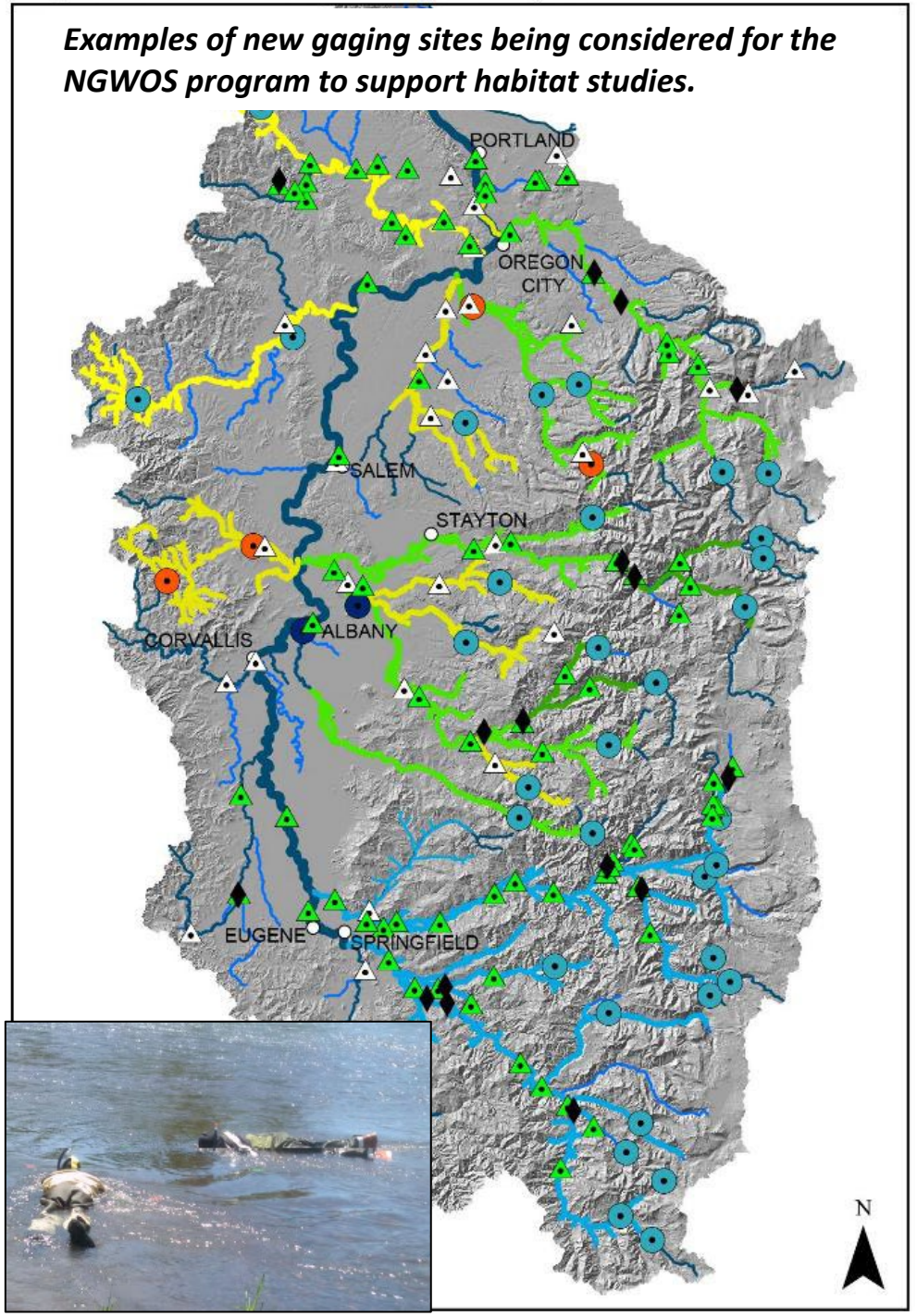
Integrated River Mapping

- Remote sensing and field surveys in key habitat reaches to map bathymetry, temperature, substrates, vegetation and more

Fish Sampling

- Strategic sampling to confirm fish distributions and habitat criteria

Examples of new gaging sites being considered for the NGWOS program to support habitat studies.



Snorkel survey of micro-habitats to refine Willamette River habitat modeling. Photo by Toby Kock (USGS)

USGS

New Research 2024-2026 (IWAAs Phase 1 Study)

Study area

- Cascade-range streams to mouth of Willamette

Trends analysis with existing data

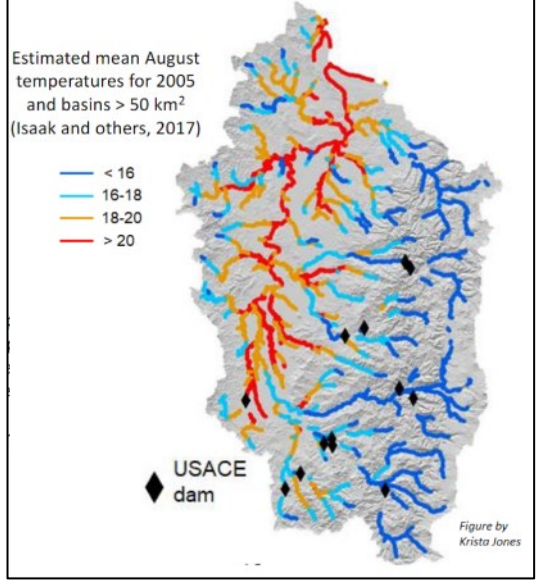
- Assess spatial and temporal variation in streamflow and water temperature
- Define and evaluate extreme events

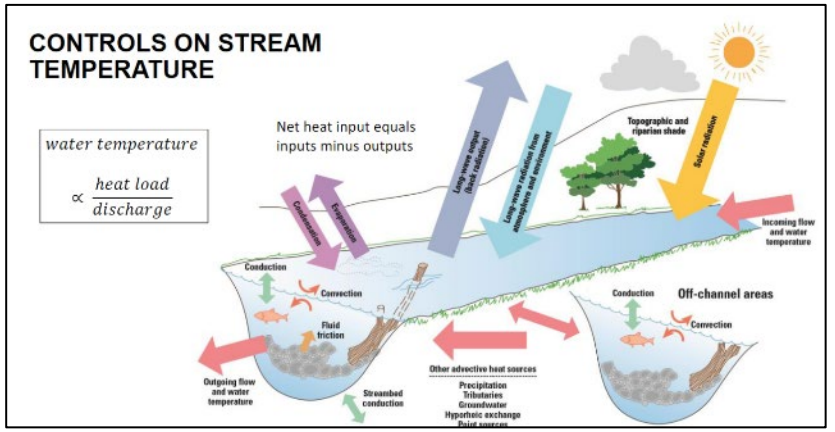
Regional modeling of current & future conditions

- Modeling hydrologic, thermal conditions
- Evaluate how flow, stream temperature may vary in future

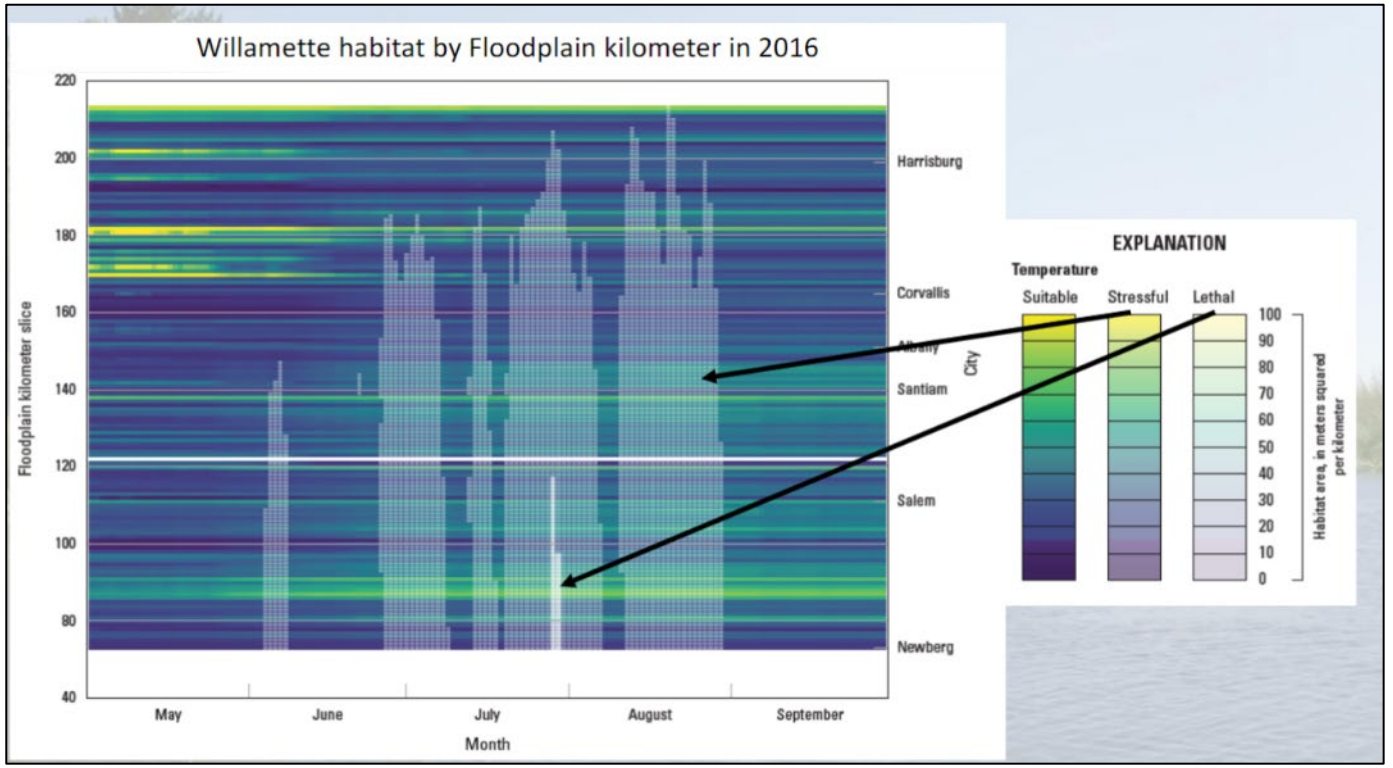
Evaluate

- Human and natural influences on flow, temperature and responses to hydroclimatic variability
- Implications for human water use and fish habitats
- Conditions when water may be limiting for human water needs and/or fish habitats





Source: Stratton Garvin and Rounds, 2022.



Source: White and others, 2022b.

Willamette IWS Outreach and Communications

Stakeholder input will inform all aspects of the IWS:

- Understanding of key ‘water-related issues’ and science priorities
- Decisions regarding hydrologic monitoring and mapping
- Science syntheses, publications and websites

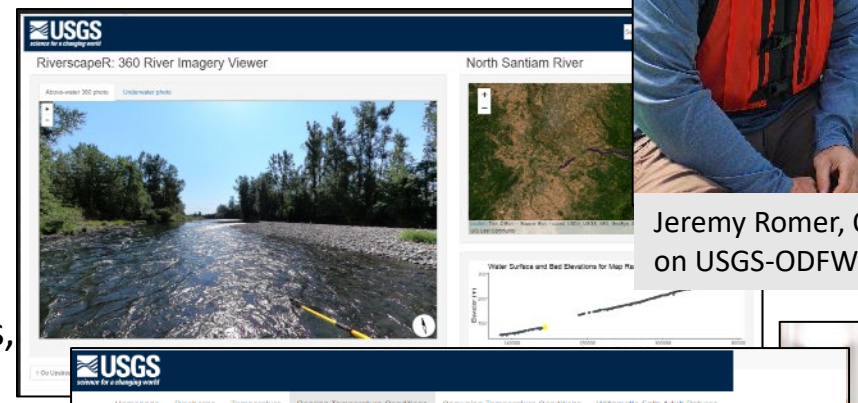
Multi-faceted communication platforms in development:

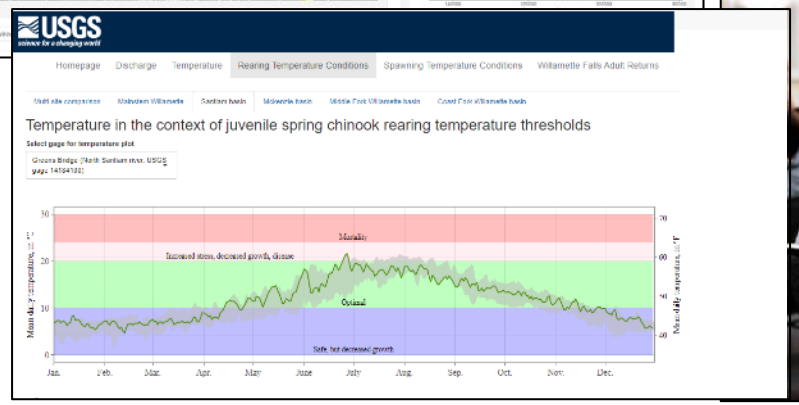
- Websites
- Email-list serves and newsletters
- Data visualizations and web-applications

Two-way dialogue and outreach will include:

- Web-based surveys
- One-on-one conversations with agencies, stakeholders, researchers, NGOs and others
- Ongoing dialogue with 'focus groups' and expert panels
- Larger meetings and workshops
- Future science convening (2025?)
- Ongoing progress updates
- Future science updates

Jeremy Romer, ODFW (right) and Toby Kock, USGS WFRC (left), on USGS-ODFW spawning trip, McKenzie River 2022





Willamette Basin Web Applications in development: River viewer (top) and synthesis of flow, temperature and salmon habitat conditions (bottom)

Within Our Reach Workshop, 2018

USGS

Timelines for Willamette Integrated Water Science (IWS)

	Planning		Implementation						
	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
	Year 1	2	3	4	5	6	7	8	9	10
NGWOS: *Water observing systems (new gaging, remote sensing, monitoring, R&D)*										
	NGWOS Planning	*Fish habitat focused data collection*	*Broad-scale water observations: R&D, gaging and monitoring to characterize all aspects of hydrologic cycle, and to characterize water quantity and quality.*							
IWAAs Phase 1: *Focus study on surface water & fish habitats*						**IWAAs Phase 2:** *Comprehensive study of all water availability*				
	IWAAs Planning	***Surface water and fish habitat focus study:*** *Trends analysis, current and future conditions modeling*		***Finalize Phase 1*** ***Plan for Phase 2***		*Comprehensive evaluation of surface water, groundwater, water quality to assess water for all human and ecosystem needs. Basin assessment of past, current, and future water availability.*			*Publish capstone report* *Information transfer to National activities.*	
Outreach: *Multi-faceted partner engagement to inform IWS activities and ensure useful science products*										
	Outreach planning	*Implementation of multi-pronged internal and external engagement program*								

USGS

Future actions depend on annual appropriations

Summary of Willamette Integrated Water Science (IWS)

Extends 10 years (2022-2031)

Encompasses two complementary programs:

- Next Generation Water Observing Systems (NGWOS)
- Integrated Water Availability Assessments (IWAAs)

Data collection and studies (2024-2026)

- Surface water for humans and focal fish habitats (IWAAs Phase 1)

Data collection and studies (2026-2031)

- Broader basin-wide water availability (IWAAs Phase 2)

Past research, collaborations and stakeholder input provide the foundation for Willamette IWS

Stakeholder engagement will kickoff late spring 2023 to inform science activities

USGS

Unparalleled Opportunity to mark 100+ years of River & Fisheries Science in the Willamette Basin

USGS Oregon Mounted Topographer R.H. McKee, 1899

PROFILE SURVEYS IN WILLAMETTE RIVER BASIN, OREGON.

Prepared under the direction of R. B. MARSHALL, Chief Geographer.

GENERAL FEATURES OF WILLAMETTE RIVER BASIN.

Willamette River drains a trough-shaped area extending north and south between the Coast and Cascade ranges in Oregon. The

GEOLOGY AND WATER RESOURCES OF THE UPPER McKENZIE VALLEY, OREGON

By HAROLD T. STEARNS

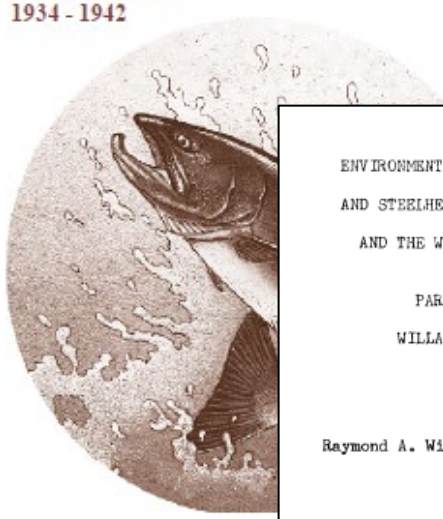
INTRODUCTION

good fortune in the summer of 1926 to be
gation of numerous dam and reservoir sites in
ng this investigation trips were made to many
One of these was a trip by pack train up
source, made in the company of B. E. Jones,
vision, conservation branch, United States
h Arthur Belknap as packer. The writer is

Bureau of Fisheries Stream Habitat Surveys

Willamette River Basin

Summary Report
1934 - 1942

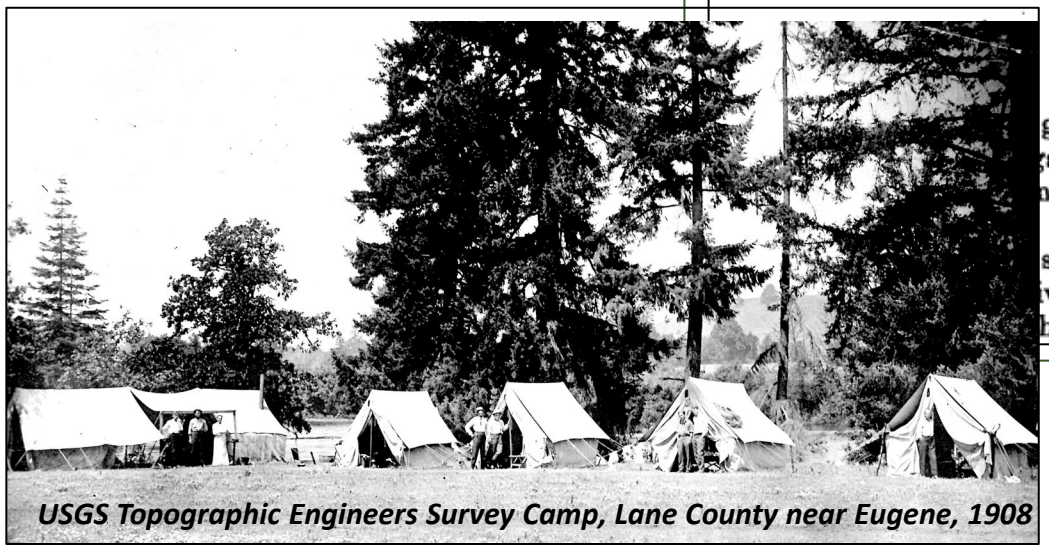


ENVIRONMENTAL SURVEY REPORT PERTAINING TO SALMON AND STEELHEAD IN CERTAIN RIVERS OF EASTERN OREGON AND THE WILLAMETTE RIVER AND ITS TRIBUTARIES

PART II. SURVEY REPORTS OF THE WILLAMETTE RIVER AND ITS TRIBUTARIES

By
Raymond A. Willis, Melvin D. Collins, and Roy E. Sams

Fish Commission of Oregon
Research Division, Clackamas, Oregon
June 1960



USGS Topographic Engineers Survey Camp, Lane County near Eugene, 1908

Questions?

Rose Wallick, Willamette IWS Outreach Coordinator: rosewall@usgs.gov

General inquiries: WillametteIWS@usgs.gov **Survey:** https://forms.office.com/g/HfFzvCUUZm

North Santiam River, Photograph courtesy of NOAA Fisheries

Extras

Examples of Questions we seek to Address

What are temperature and flow conditions in ungaged historical spawning reaches?

How has stream temperature in the spawning and rearing reaches varied over time?

Has the magnitude, frequency and timing of heat waves increased over time?

How do different stream reaches respond to hydroclimatic variability and heat waves?

What are the implications for different species and life stages?

North Santiam River near Wiseman Island, courtesy of NOAA Fisheries

USGS

USGS Mission and Mission Areas

Mission Statement:

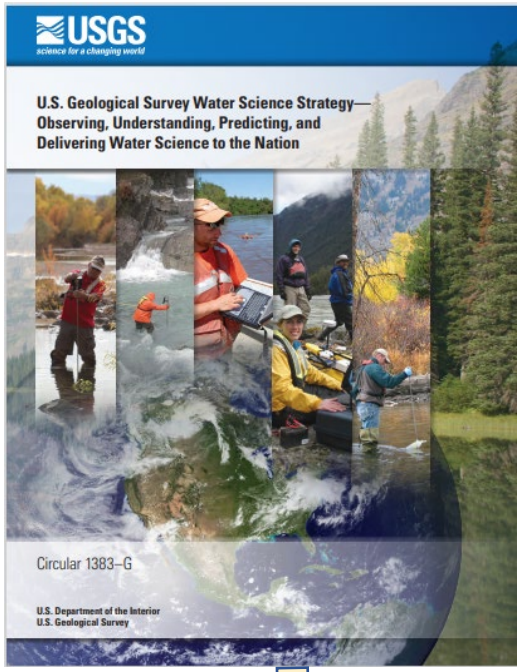
The USGS monitors, analyzes, and predicts current and evolving Earth-system interactions and delivers actionable information at scales and timeframes relevant to decision makers. The USGS provides science about natural hazards, natural resources, ecosystems and environmental health, and the effects of climate and land-use change.

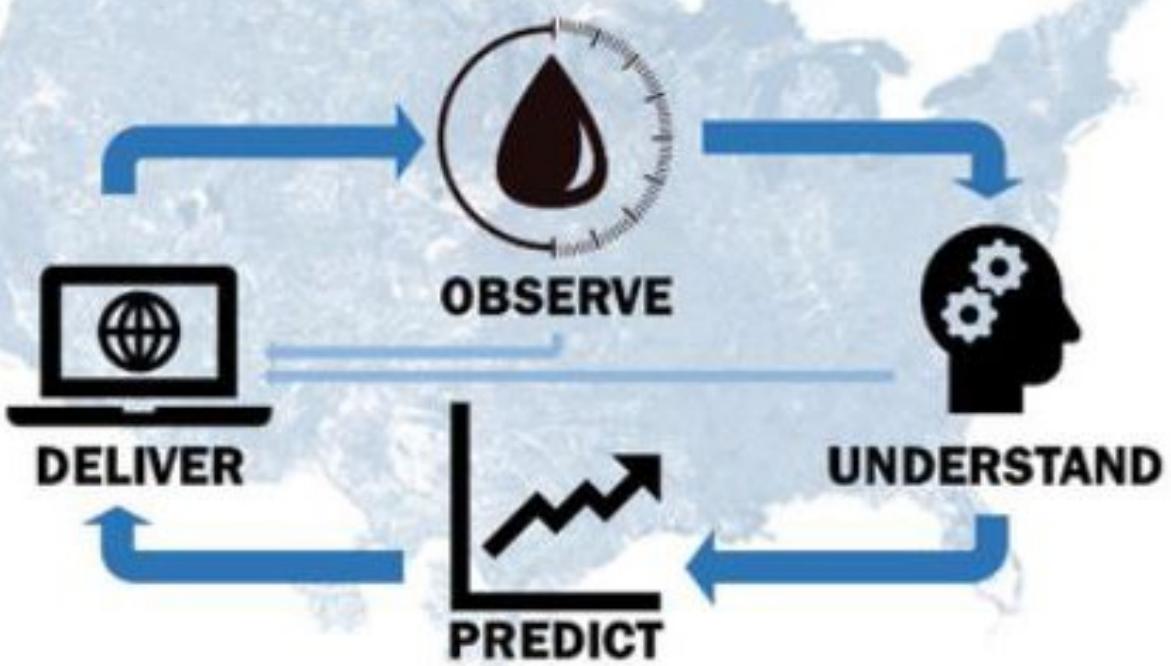
USGS Mission Areas

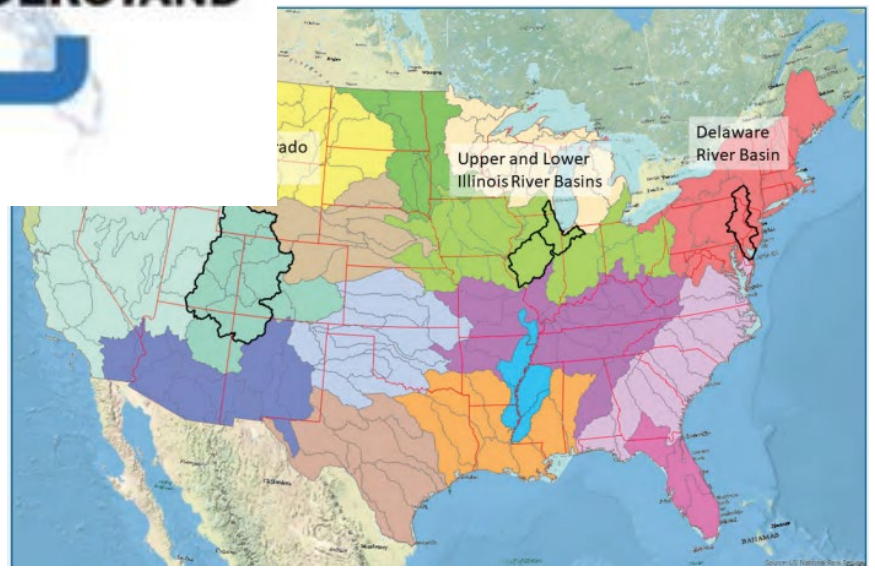
- Climate and Land Use Change
- Core Science Systems
- Ecosystems
- Energy and Minerals
- Environmental Health
- Natural Hazards
- Water

https://www.usgs.gov/about/about-us/who-we-are

USGS Water Mission Area Science Strategy





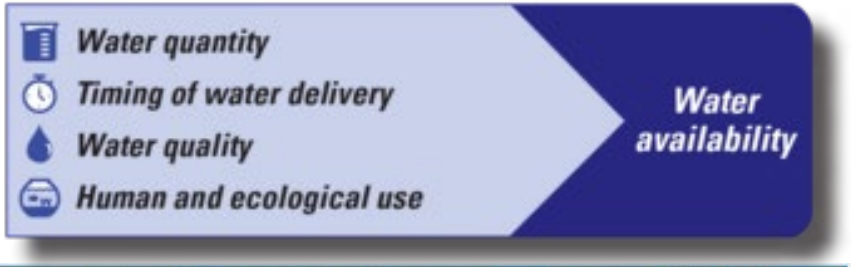


Evenson, E.J and others, 2013, U.S. Geological Survey water science strategy—Observing, understanding, predicting, and delivering water science to the Nation: U.S. Geological Survey Circular 1383–G, 49 p.

https://www.usgs.gov/mission-areas/water-resources/science/integrated-water-science-iws-basins

Integrated Water Science (IWS)

The United States faces growing challenges to its water supply, infrastructure, and aquatic ecosystems ...*To help address these challenges, the USGS Water Resources Mission Area (WMA) is integrating recent advances in monitoring, research, and modeling to improve assessments of water availability throughout the United States.* ***A key part of this effort is the intensive study of 10 Integrated Water Science (IWS) basins across the Nation between 2019 and 2028.***

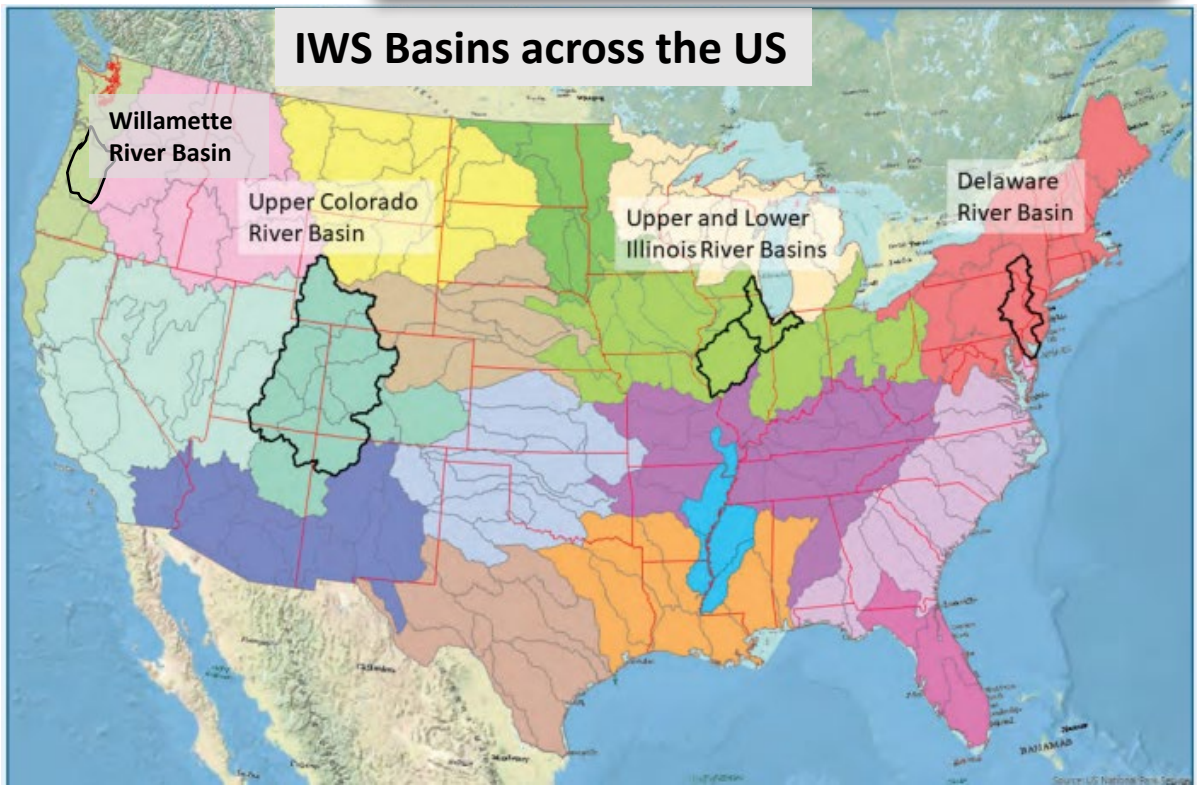


IWS Goals and Outcomes:

1. Study 10 IWS basins that are:
   - representative of large geographic regions
   - encompass a variety of threats to water availability

2. IWS basins has a specific theme and collectively, will help quantify and forecast water availability in larger regions and for the US

3. Each IWS basin will evaluate water availability utilizing multi-pronged approach (observing, understanding, predicting water availability)



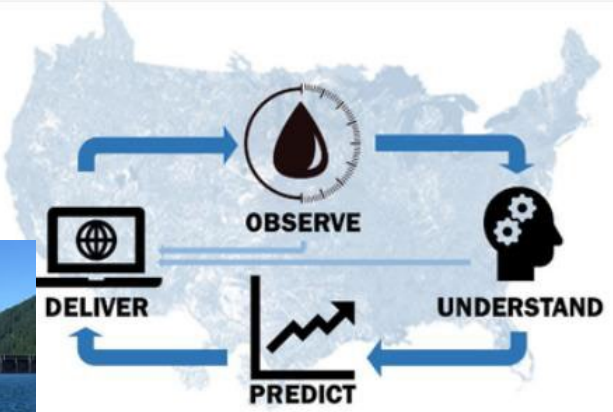
https://pubs.usgs.gov/fs/2021/3041/fs20213041.pdf; NASEM, 2018

Integrated Water Science (IWS)

Observe = *NGWOS*

Water monitoring, mapping, R&D

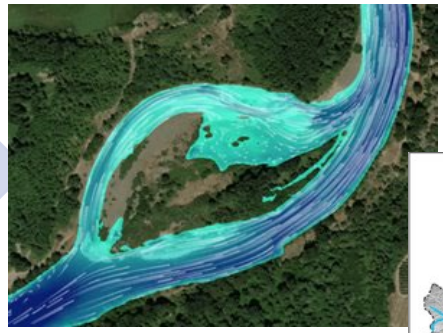
- Next Generation Observing System (NGWOS)
- Gaging, mapping, monitoring, Research & Development
- **FY** 2022-31

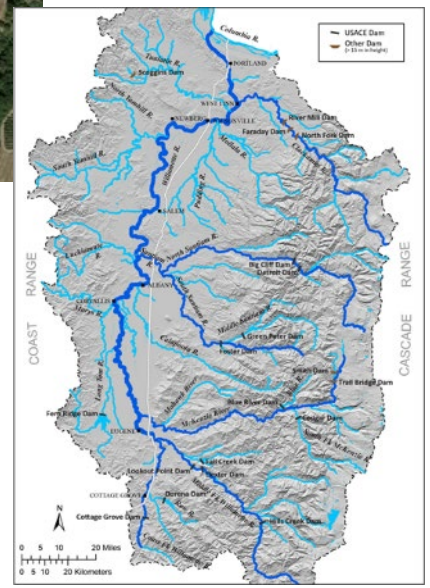


Understand = *IWAAs*

Analyses and research studies

- **Integrated Water Availability Assessments** (IWAAs)
- Phase 1: FY 2022-26: Water for salmon & surface water withdrawals
- Phase 2: FY 2027-31: Water for all human and ecosystem needs





Predict = *IWP*

Modeling to predict future water availability

- Integrated Water Prediction (IWP)
- Knowledge gained in Willamette used to refine and fill gaps in national water prediction models

USGS

The Willamette IWS focus is characterizing water availability, (quantity, quality) for humans and ecosystems now, and into the future. Hence, we will development tools to help us measure, map, understand and predict basin-wide patterns of water availability. Lessons learned in Willamette will advance national USGS models.

Examples of Questions for Stakeholders

From your organization's perspective, what are some of the biggest questions/challenges facing river corridors in the Willamette River Basin? Where are those challenges most pressing?

What are key science questions, that if answered, could provide actionable information to inform decision making? What types of information would be most useful, how would it be used, and by whom?

What types of new continuous monitors (streamflow, temperature, groundwater) would be most useful? Where should these monitors be located?

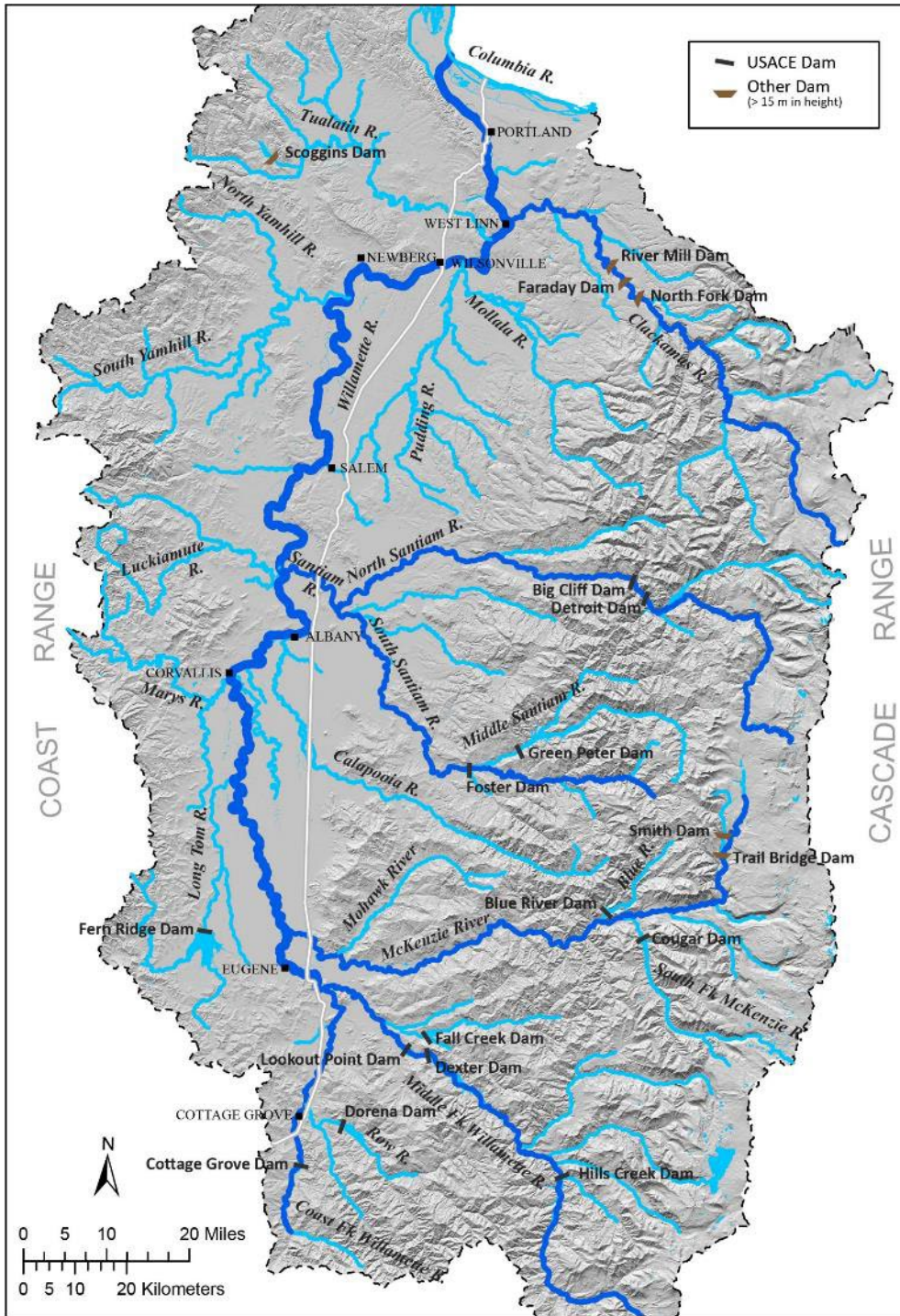
What types of new geospatial information would be most useful? Where should these products be prioritized? What types of temporal, spatial resolution are needed?

What research studies might provide most useful/actionable information?

What is the best path forward for partnering on IWS?

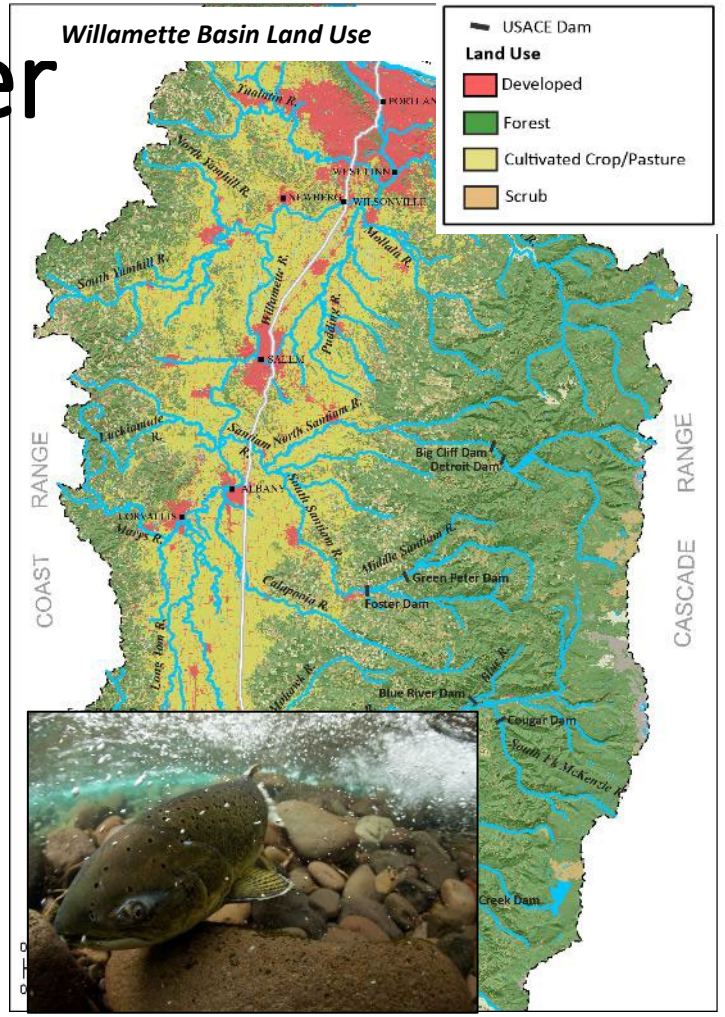
USGS

Which crucial questions are missing from this list?

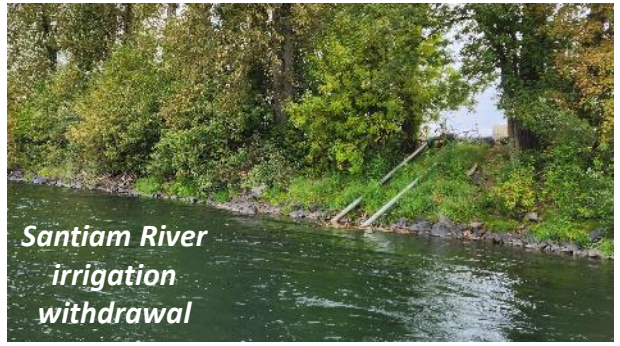


2023-2031 Willamette Integrated Water Availability Assessments (IWAAs)

Willamette IWS "Theme"	***Water availability for humans and ecosystems***	
Program Phase	***IWAAs Basin Specific Study (2023-26, Phase 1)***	***IWAAs Comprehensive Study (National transferability, 2027-31, Phase 2)***
Science Focus	*Two-year focus study on surface water availability for authorized withdrawals and fish habitats*	*Five-year, comprehensive portrait of entire water cycle, including water quantity, quality for all human and ecosystem needs*
Study Area	*TBD Salmon-bearing rivers of the Cascades*	*Entire Willamette River Basin*
Scientific Approach	*Targeted methods* *1. Trends analyses* *2. River-channel modeling of current and future conditions*	*Comprehensive basin-scale modeling:* • *Groundwater* • *Surface water* • *Water quality*



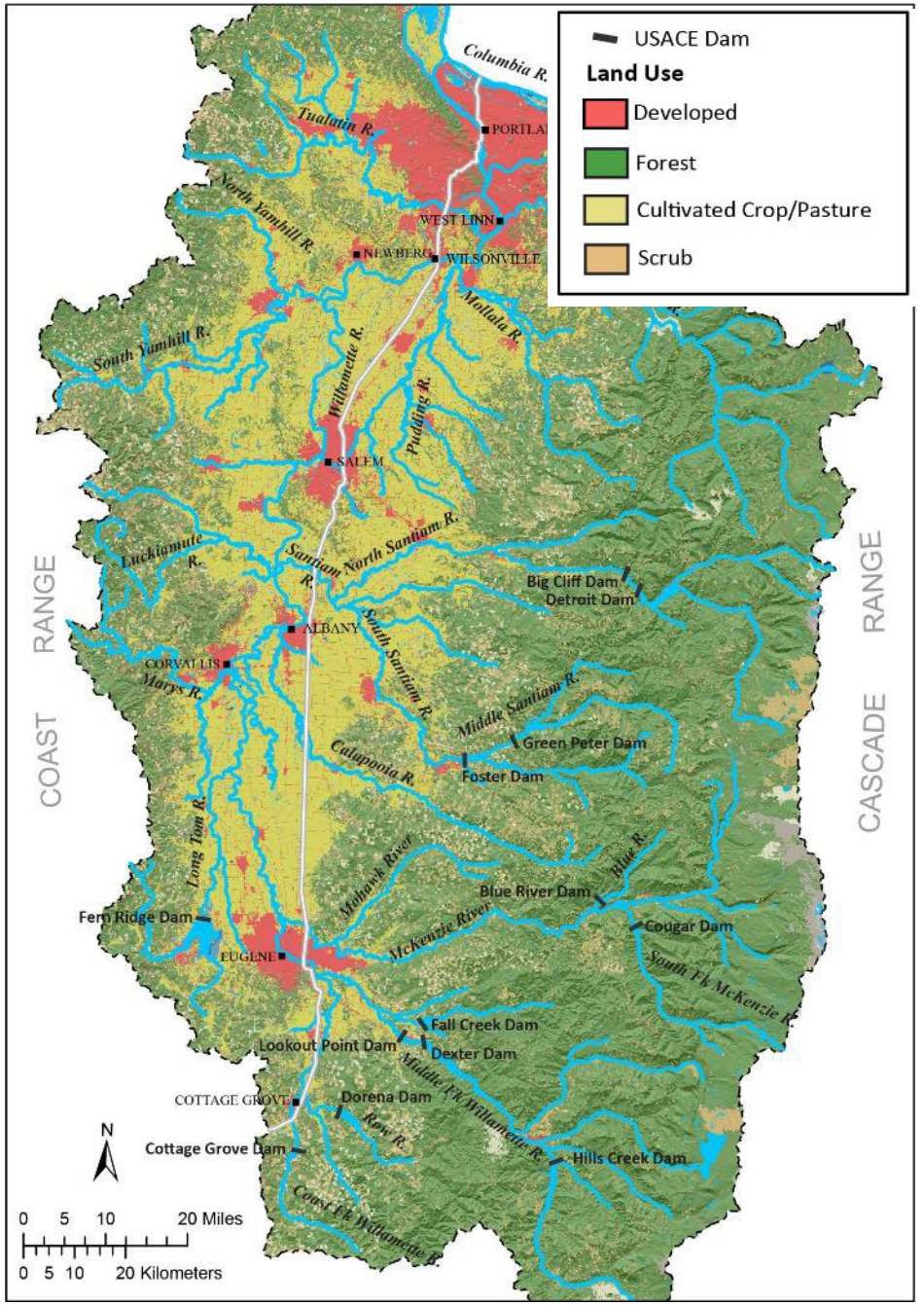
Spring Chinook salmon above Cougar Reservoir, SFK McKenzie



USGS

Willamette River near Albany at flood stage, January 2012.
Photographs courtesy Freshwaters Illustrated

Spring Chinook salmon



Willamette Basin Land use

IWAAs Phase 1 Study

Trends analysis

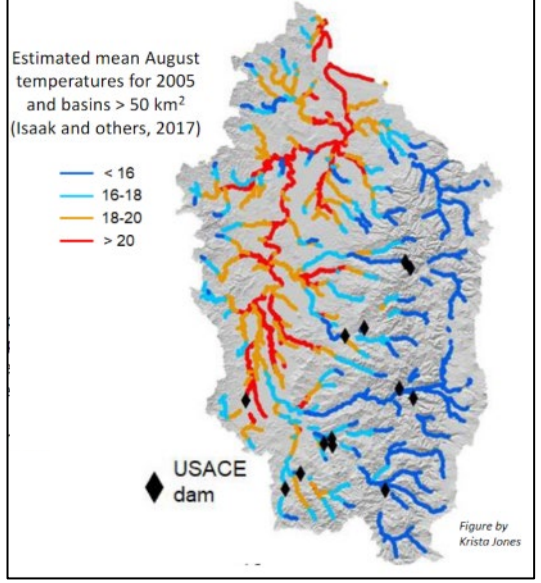
- Assess spatial and temporal variation in streamflow, temperature;
- Define and evaluate conditions such as “heat waves” and changes over time
- Evaluate human and natural controls on flow and thermal regimes
- Implications for surface water withdrawals and habitats for focal fish species

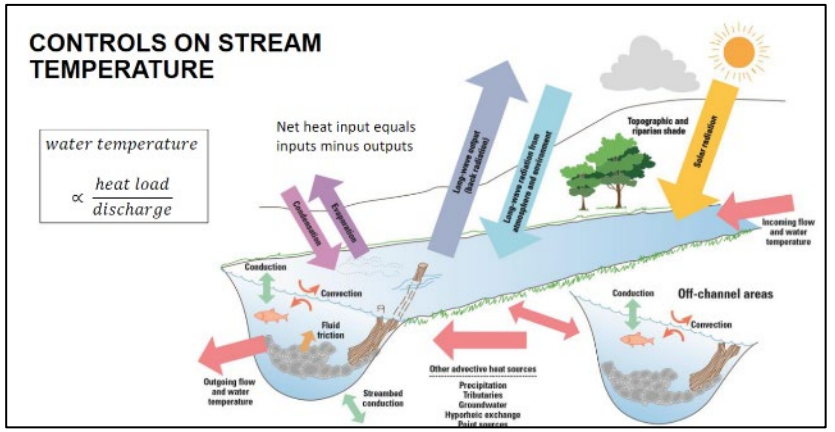
Modeling of current conditions

- Modeling the hydrologic, thermal landscape
- Assessing where, when water may be limiting for authorized withdrawals or key habitats for key species, life stages

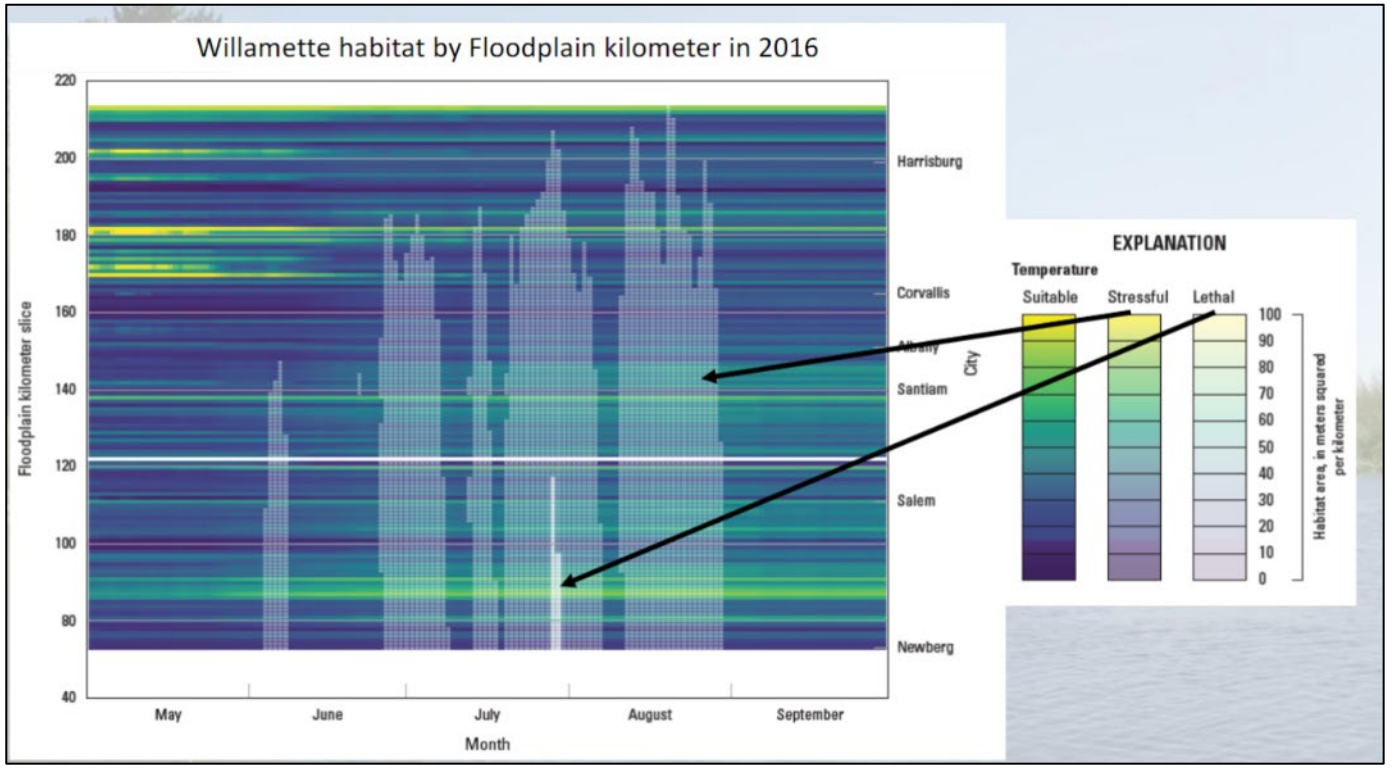
Modeling of future conditions

- How might flow, stream temperature vary in the future?
- What are the likely future trajectories and how might this vary seasonally, spatially?
- What are implications for humans and habitats?





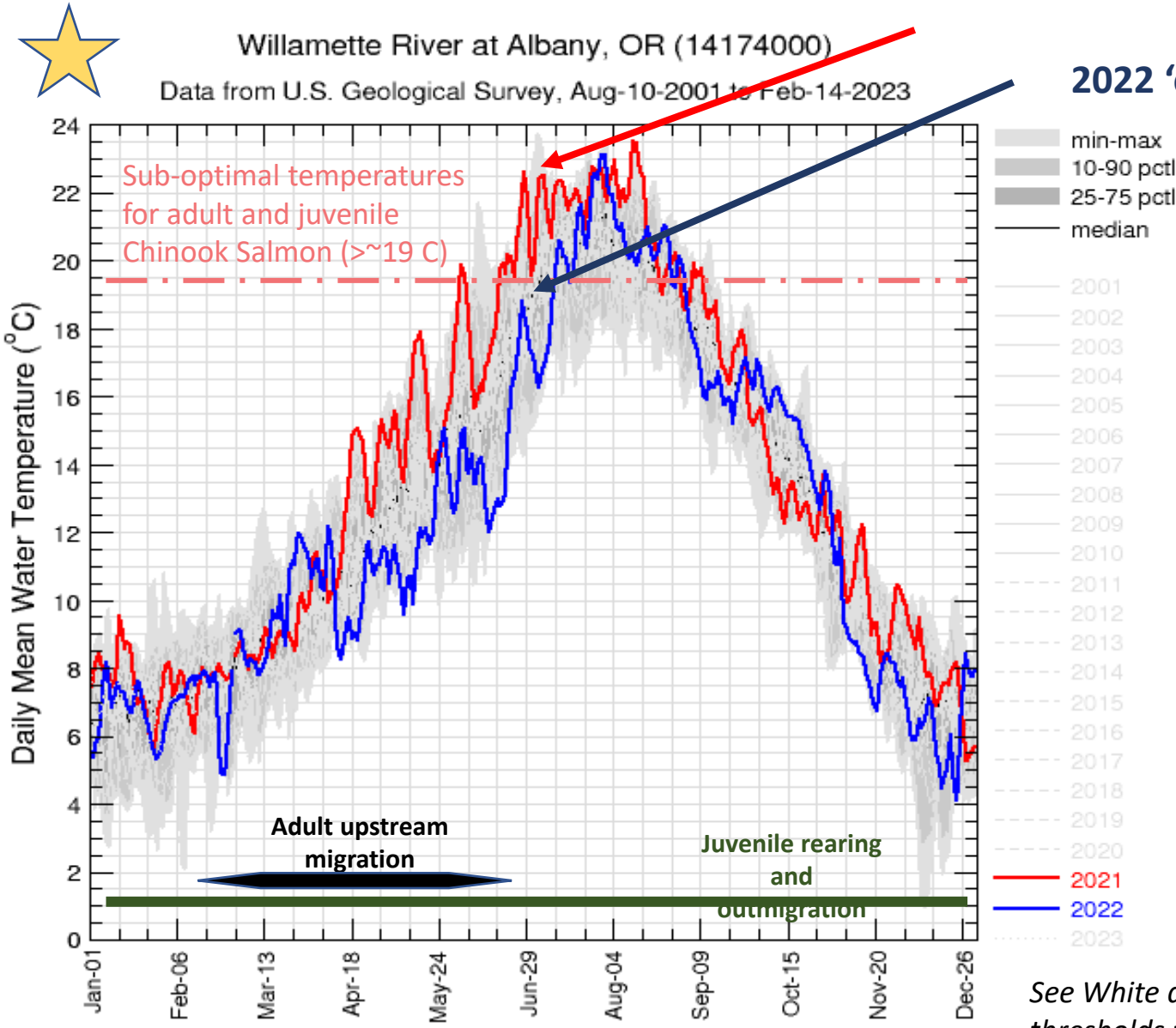
Excerpt from Laurel Stratton Garvin’s November 2, 2022 Willamette Science Symposium presentation on Willamette River Thermal Regimes. See Stratton Garvin and Rounds, 2022.



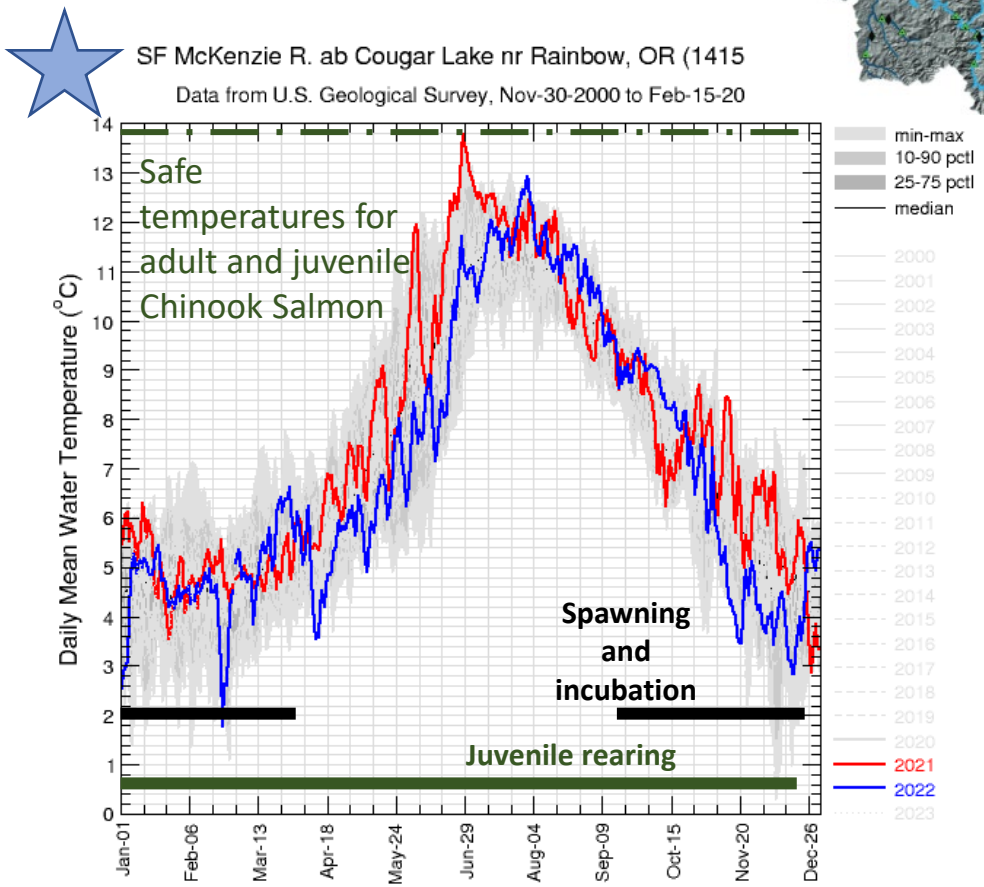
Excerpt from James White’s November 3, 2022 Willamette Science Symposium presentation on Willamette River juvenile salmon habitat modeling. See White and others, 2022b.

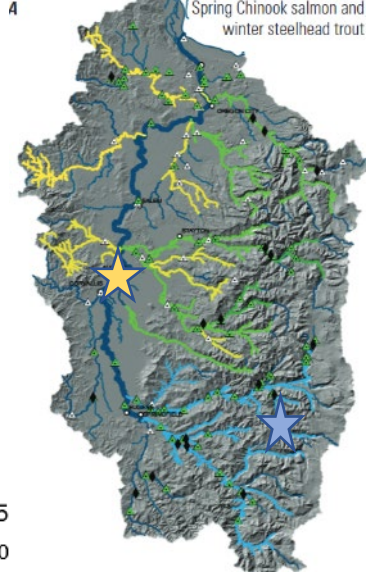
Examples of McKenzie Basin Thermal Variability that will be explored in IWAAs Phase 1

2021 'Heat Dome' (air temperature >110° F!)



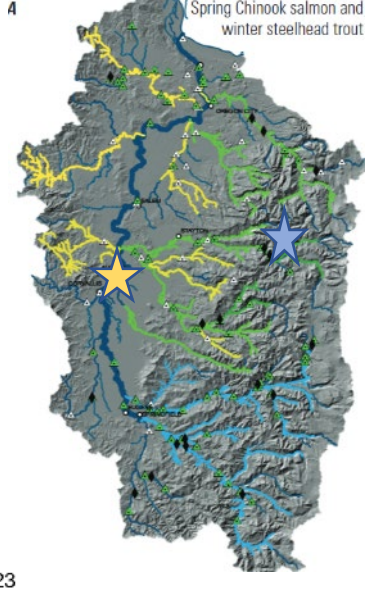
2022 'cool, wet spring'

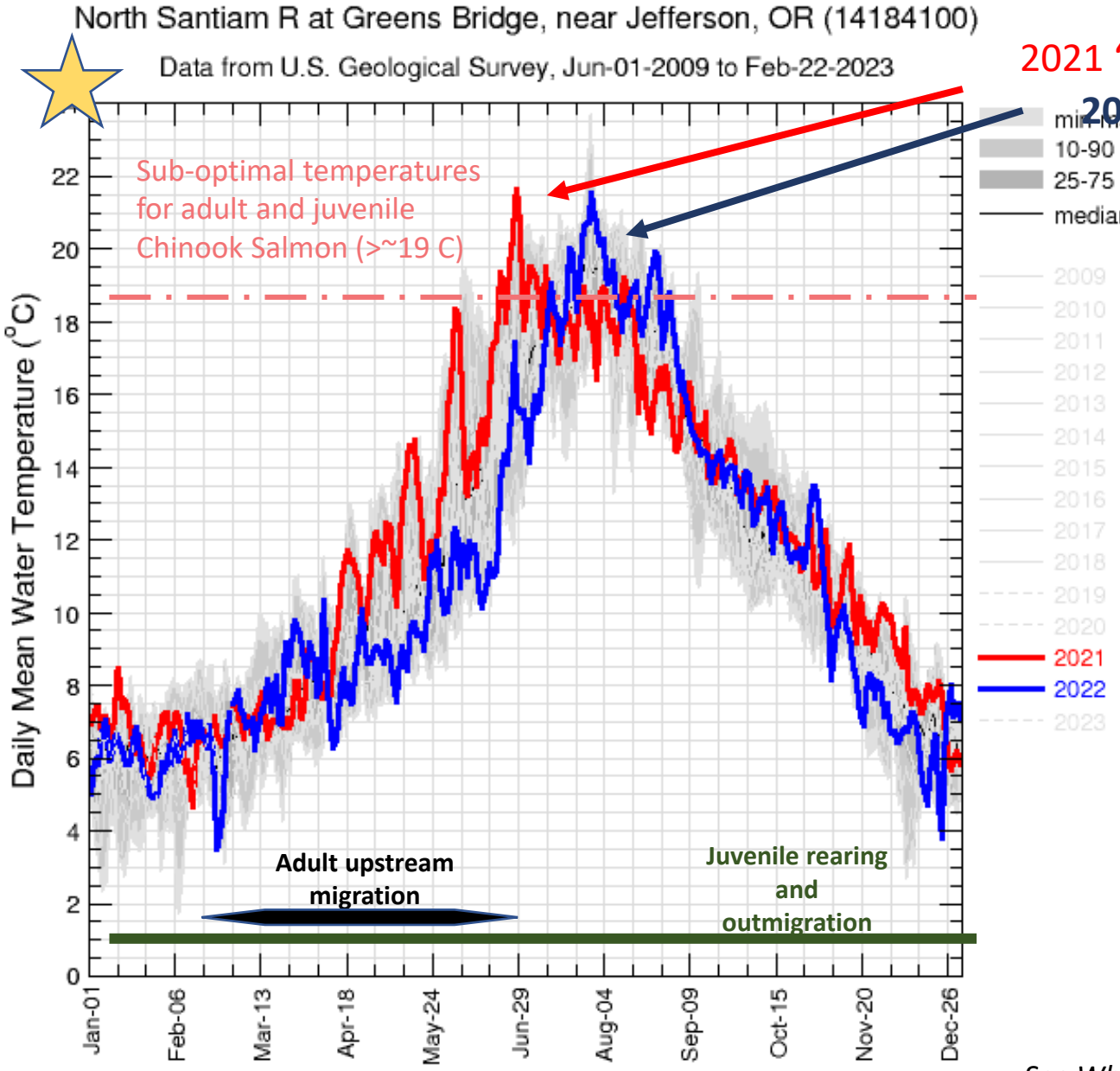




See White and others, 2022 appendix 2 for complete description of thermal thresholds for juvenile and adult Chinook Salmon

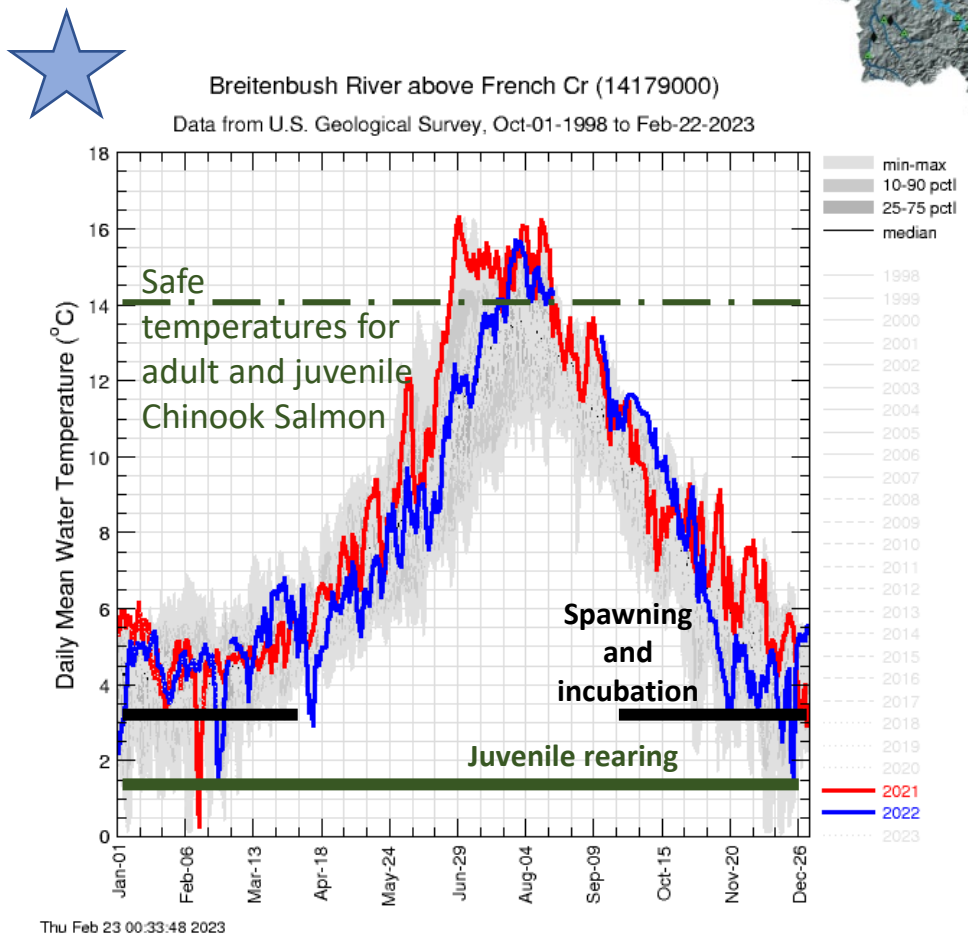
Examples of North Santiam Thermal Variability that will be explored in IWAAs Phase 1





2021 'Heat Dome' (air temperature >110° F!)

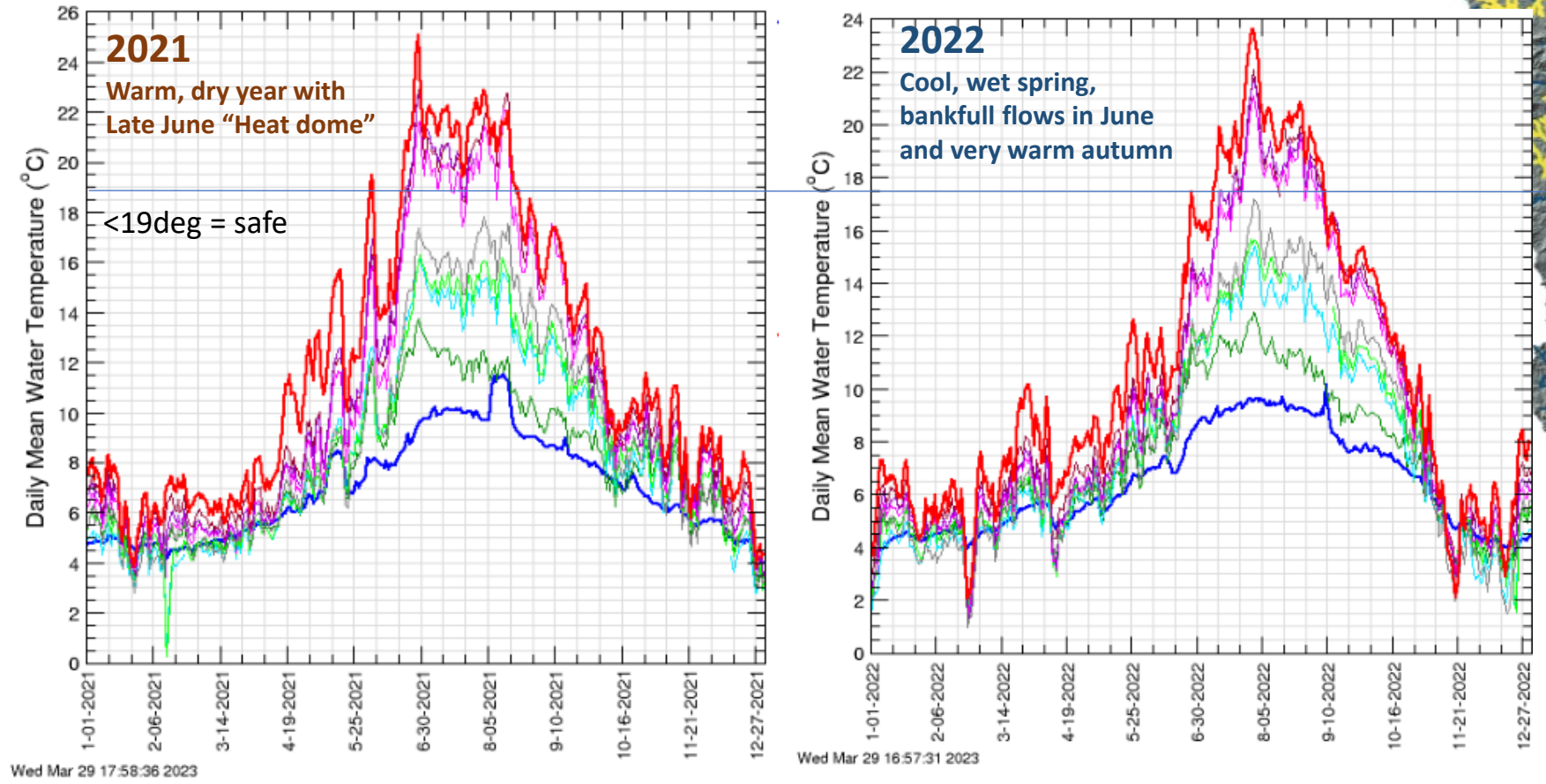
2022 'cool, wet spring'



See White and others, 2022 appendix 2 for complete description of thermal

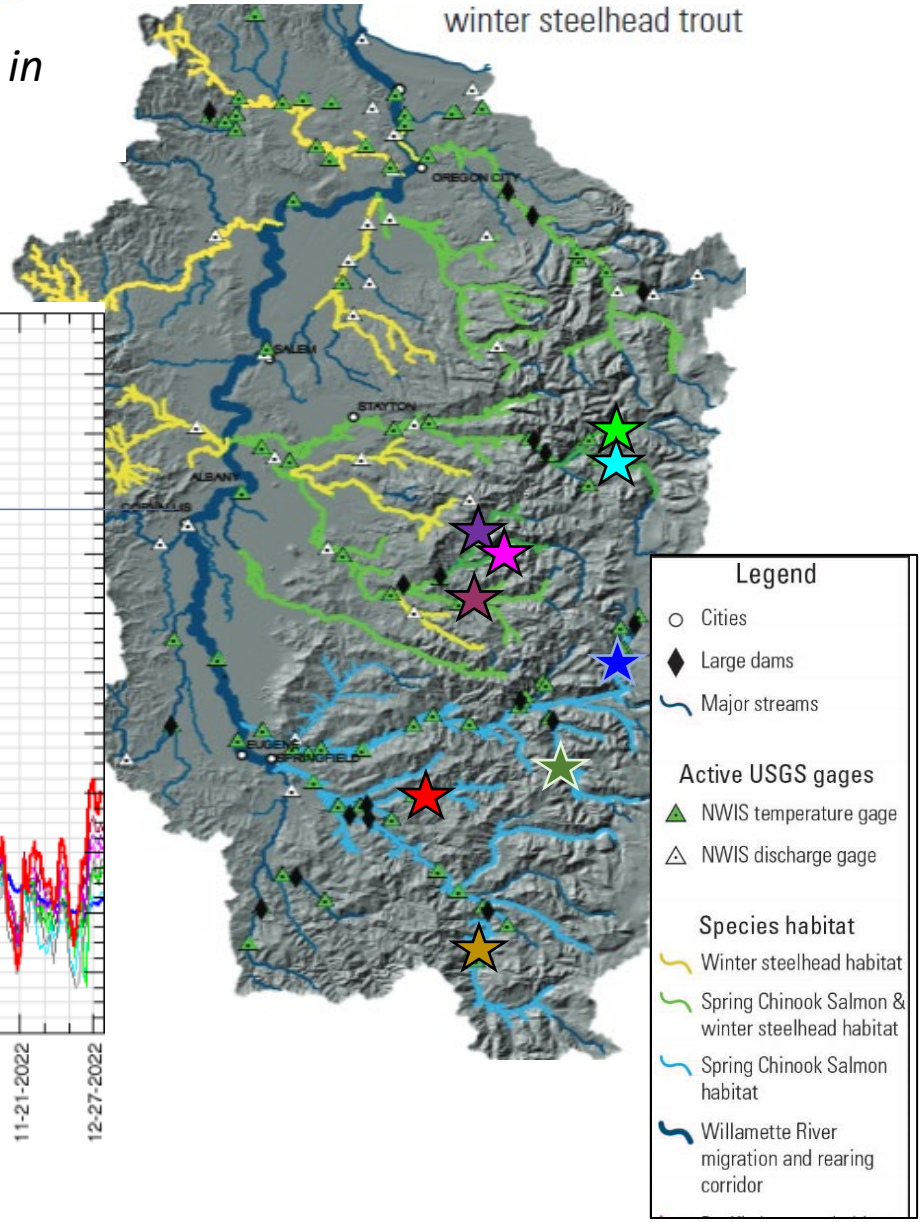
Examples of Variation in Thermal Responses to Hydroclimatic Conditions of 2021 vs 2022

Comparison of mean daily temperatures in above dam historical spawning reaches in the North Santiam, South Santiam, Fall Creek and Middle Fork Basins 2021-2022



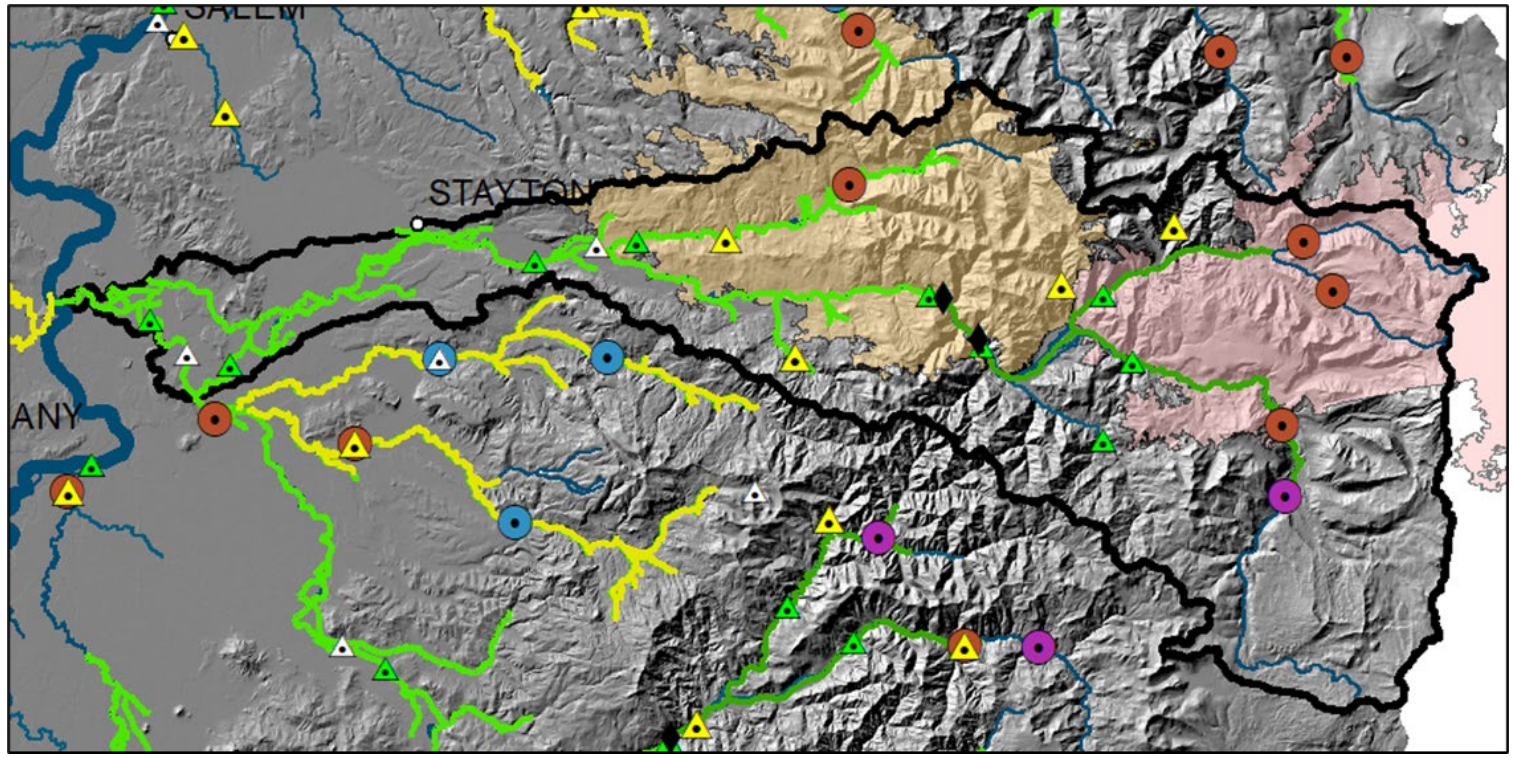
Willamette Basin

Distribution of spring Chinook salmon, winter steelhead and USGS gages



Gaging Opportunities

Proposed new gaging in North Santiam Basin in unregulated spawning reaches



Legend

Protential new gage (target species)

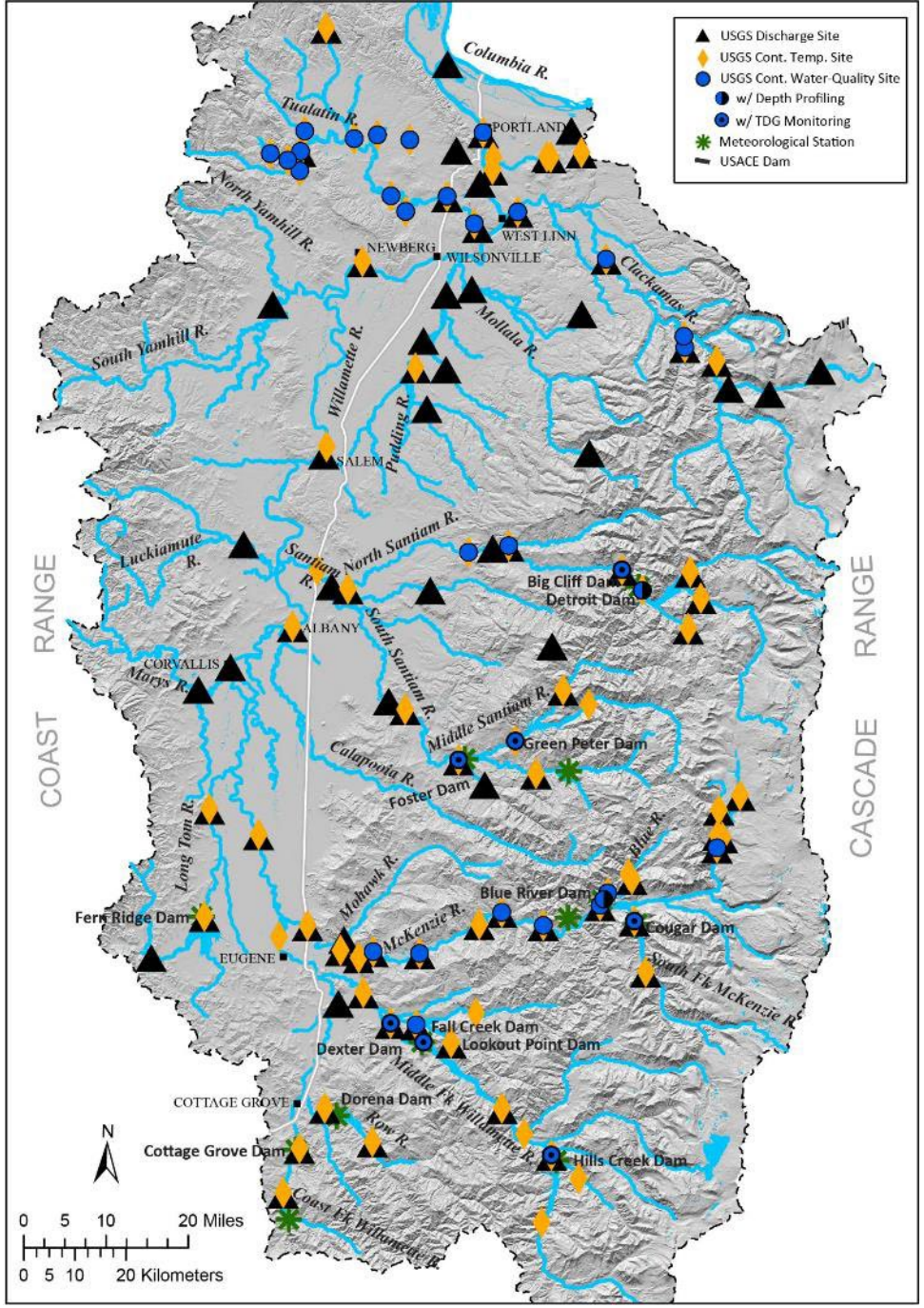
- Bull Trout
- Chinook & Steelhead
- Chinook
- Steelhead

NOAA Critical Habitat

- Chinook and Steelhead
- Steelhead

USGS gages

- Inactive USGS gage
- Active discharge USGS gage
- Active discharge, temperature USGS gage



Willamette Basin USGS gaging network