Columbia River Treaty 2014/2024 Review
Water Quality Workshop

Wednesday, August 31, 2011, 9am – 4:30pm
Location: CRITFC

Workshop Co-Chairs: Nancy Stephan, Bonneville Power Administration, and Matt Rea, U.S. Army Corps of Engineers, Treaty Review Program Managers

Workshop Facilitator: Terry Buchholz, Integrated Water Solutions

Workshop Summary

1. **Introductions, Workshop Overview and Objectives** *See Attachment One: Agenda*

   The Sovereign Technical Team (STT) held a public Water Quality Workshop on August 31, 2011 at Columbia River Inter Tribal Fish Commission in Portland, OR. The objectives of the meeting were to initiate the conversation concerning the scope of the water quality analyses for the Treaty Review Studies; to provide an overview of water quality models and tools that could be used for the Treaty Review Studies; to refine water quality evaluation criteria and critical locations; and to discuss the scope and schedule for the Water Quality Analyses in the Columbia River Treaty Review Studies (Treaty Review.)

2. **Columbia River Treaty Overview** *See Attachment Two: Columbia River Treaty Overview*

   The United States and Canada are engaged in the Columbia River Treaty, coordinating flood control and hydropower for the two nations sharing the Columbia River. The earliest termination date for the Treaty is September 2024 with ten years advance notice. The U.S. Entity is comprised of the Commanding General of the Northwest Region of the U.S. Army Corps of Engineers and the Administrator of Bonneville Power Administration. The Sovereign Review Team and Sovereign Technical Team are chaired by the U.S. Entity and are conducting technical studies to achieve a regional review of the Columbia River Treaty for a regional consensus recommendation regarding the Treaty to the U.S. Department of State by September 2013. The U.S. Entity is conducting studies to test the benefits and costs of the Treaty on the three primary driving purposes: Hydropower, Ecosystem-based Function and Flood Control. Impacts to other purposes of the Columbia River such as water quality, water supply, navigation, recreation and cultural resources are being evaluated as well.

3. **Review Treaty Objectives Related to Water Quality** *See Attachment Three: Columbia Basin Water Quality*

   The Sovereign Review Team (SRT) and Sovereign Technical Team (STT) have developed Treaty Review Objectives and sideboards to address the Primary Driving Purposes and Impact Assessments for the Treaty Review. The sideboard addressing Water Quality

states that impacts for other system uses (e.g. irrigation, navigation, Columbia River Water Management Program, and recreation) will be assessed qualitatively at a minimum, quantitatively where information and tools are available to support the analysis. There are two objectives addressing water quality, the Treaty Review will seek to provide streamflows with appropriate timing, quantity and water quality in the basin to promote productive populations of native fish and wildlife; and Minimize the impact of contaminated sediments.

4. **Columbia Basin Water Quality presented by USACE Districts** *See Attachment Three: Columbia Basin Water Quality*

   Representatives from the U.S. Army Corps of Engineers (USACE) districts in Seattle, Portland, Walla Walla and Northwest Division presented Columbia Basin Water Quality models at USACE projects. Detail on their presentation can be found on Attachment Three.

5. **Impact Assessment Areas – Contaminants of Concern in the Columbia River (Lake Roosevelt)** *See Attachment Four: Contaminants of Concern in the Columbia River*

   Greg Fuhrer, STT Member with U.S.G.S., gave a presentation on contaminants of concern in the Columbia River. The contaminants were classified into three tiers based on their effects and presence in the Columbia River. See Attachment Four for detail on the sediments and models used.

6. **Overview of Potential Water Quality Models and Tools** (90 minutes) *See Attachment Five: Overview of Potential Water Quality Models and Tools, Attachment Five-b: Overview of Potential Water Quality Models and Tools (description), Attachment Five-c: Overview of Potential Water Quality Models and Tools (maps), and See Attachment Six: Modeling Effects of Contaminants on Salmon in the Columbia Basin*

   The U.S. Army Corps of Engineers presented an inventory of potential water quality models and tools that are available in the Columbia River Basin. The inventory included a map showing the availability of CEQUAL-W2 and RBM-10 models available by reach of the river. See Attachment Five for detail.

   Ben Cope, STT member from EPA, presented the model RBM-10. This model is available on much of the river and has a resolution of every mile. The model outputs average daily temperature. NOAA also presented their research on Modeling Effects of Contaminants on Salmon in the Columbia Basin. Detail on their research is available on Attachment Six. Lake Roosevelt sediment models and Total Dissolved Gas modeling through CEQUAL-W2 was also discussed.

7. **Water Quality Evaluation Criteria and Identify Critical Locations** *See Attachment Seven: Evaluation Criteria and Identify Critical Locations*

   The group present discussed critical evaluation criteria and metrics and key locations in the basin. All was recorded on Attachment Seven.

Workshop Attendance

Name	Organization
Sovereign Technical Team Members Present:	
Rick Pendergrass	Bonneville Power Administration (BPA)
Matt Rea	U.S. Army Corps of Engineers (USACE)
Bob Heinith	Columbia River Inter-Tribal Fish Commission (CRITFC)
Lori Postlethwait	U.S. Bureau of Reclamation (USBR)
Rick Kruger	State of Oregon (OR)
Paul Wagner	National Marine Fisheries Service (NMFS)
Greg Fuhrer	U.S. Geological Service (USGS)
Keith Holliday	National Park Service
Ben Cope	EPA
Others Present:	
Jim Heffernan	CRTIFC
Rob Lothrop	CRTIFC
Stewart Rounds	USGS
Kim Johnson	USACE NWD
Steve Juul	USACE
Amy Reese	USACE
Clyde Lay	USBR
Rob Annear	Geosyntec (Consultant)
Lyndal Johnson	NOAA
Margie McGill	USACE
Dianne Borten	CRITFC
Elena Nilsen	USGS
Scott English	USACE
Mike Schneider	USACE
Agnes Lute	ODEQ
Mary Lou Soscia	EPA
Jim Britten	USACE
Bruce Duffe	USACE
Christine Golightly	CRITFC
Laura Gephart	CRITFC
Terry Buchholz	Integrated Water Solutions (Facilitator)
Lauren Buchholz	Integrated Water Solutions (Recorder)

Attachment One: Agenda

Columbia River Treaty 2014/2024 Review
Sovereign Technical Team Water Quality Workshop

Wednesday, August 31, 2011
Location: Columbia River Inter-Tribal Fish Commission
(729 NE Oregon Street) Columbia River Room, Portland, OR

August 31, 2011
9:00 am – 4:00 pm Sovereign Technical Team Water Quality Workshop

Workshop Co-Chairs: Rick Pendergrass, Bonneville Power Administration, Treaty Operating Chair, and Matt Rea, U.S. Army Corps of Engineers, Treaty Review Program Manager

Workshop Facilitator: Terry Buchholz, Integrated Water Solutions

Workshop Objectives:

1. To initiate the conversation concerning the scope of the water quality analyses for the Treaty Review studies
2. To provide an overview of water quality models and tools that could be used for the Treaty Review studies
3. To refine water quality evaluation criteria and critical locations
4. To discuss the scope and schedule for the water quality analyses

AGENDA

1. **Introductions, Workshop Overview and Objectives** (Buchholz, 15 minutes)
2. **Review Treaty Objectives Related to Water Quality** (10 minutes)
3. **Review Water Quality Evaluation Criteria (Metrics)** (50 minutes)

Break (15 minutes)

4. **Overview of Potential Water Quality Models and Tools** (90 minutes)

Lunch (60 minutes)

5. **Refine Water Quality Evaluation Criteria and Identify Critical Locations** (135 minutes with 15 minute break)
6. **Preliminary Discussion of the Scope and Schedule for of the Water Quality Analyses** (30 minutes)
7. **Path Forward, Action Items and Wrap-Up** (15 minutes)

Participating by Web Meeting

Toll-free phone bridge information for all meetings:

Number: 877-336-1828 Access code: 8468386 Security Password: 3669

Web Meeting login information for all meetings:

https://www.webmeeting.att.com Meeting number: 877-336-1828 Code: 8468386

2014/2024 Review

Columbia River Treaty

Treaty History and Overview

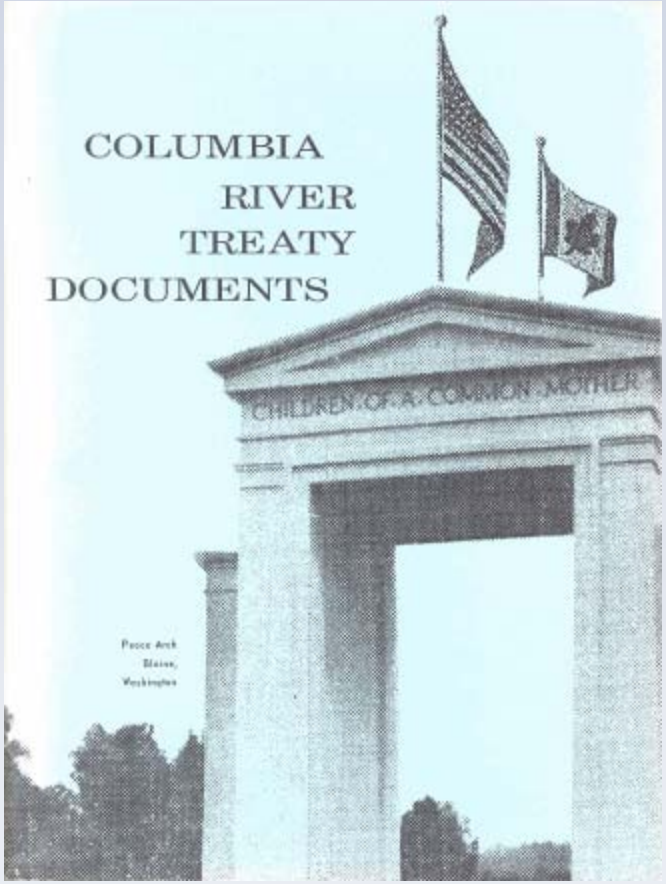
August 31, 2011

Columbia River Treaty Project Locations

Why conduct a Treaty 2014/2024 Review?

1. The Treaty has no specified end date; however, either nation can terminate most of the provisions of the Treaty as early as Sep 2024, with a minimum 10 years' written notice.

2. Current assured annual flood control operating procedures will end in 2024, independent of the Treaty termination decision.



Engagement Strategy

We have implemented an engagement plan to meet the needs of the region to identify and define sovereign and stakeholder interests regarding various Treaty future scenarios and evaluation. This process addresses the interests of key parties and general stakeholders.

Sovereign Review Team:

1. **Four States: OR, WA, ID, MT**
2. **15 NW Tribes (5 representatives)**
3. **Federal Agencies: NMFS, USFWS, BOR, USACE, BPA, BLM, EPA, USFS, USGS, BIA, NPS.**

NW Stakeholders:

Plan must take into consideration stakeholder concerns and input. This is being done through public Regional Listening Sessions (Two have been held to date: March 10 and June 10, 2011).

Congressional and Department of State:

The U.S. Entity has been working closely with the Department of State and briefing congressional staff over the last 2 years.

Purpose of the Treaty 2014/2024 Review

To enable the United States Entity and the regional sovereigns to make an informed recommendation to the U.S. Department of State by September 2013 as to whether or not it is in the best interest of the U.S. to continue the Treaty, terminate the Treaty, or seek to negotiate with Canada on amendment of the Treaty.

Primary Driving Purposes

- Ecosystem Based Function
- Flood Risk Management
- Hydropower

Primary Driving Purpose
Ecosystem Based Function Objectives

- Provide streamflows with appropriate timing, quantity and water quality in the basin to promote productive populations of native fish and wildlife.
- Provide reservoir conditions to promote productive[2] populations of fish and wildlife.

[2] *Productive* is defined as sustainable, healthy populations of fish and wildlife that provide treaty and trust harvest and other legal requirements.

Primary Driving Purpose
Ecosystem Based Function Objectives

- Provide for streamflow and reservoir conditions that protect and enhance cultural resources[3].
- Improve hydrology in the estuary to promote productive populations of native fish and wildlife.

[3] *Cultural Resources* includes culturally significant fish and wildlife.

Impact Assessment - Qualitative Environmental Issues or Concerns Objective

- Assess the impacts on the ability to minimize contaminated sediments.

Cli

Climate cha
evaluation.

Pertinent Water Quality Sideboards

- Ecosystem function alternatives and impact assessments will be defined by water flow and timing, reservoir levels, water quality, contaminant fate and transport, survival and recovery of important fish and wildlife populations and the long-term sustainability of functions and processes related to riparian, floodplain, and estuary habitat, including cultural resources.
- The Treaty Review will use tools, such as existing models or models under development that can be agreed upon by the STT and available for use within the limited timeframe of this Review.
- Current regulatory and statutory requirements will be the default, but will not necessarily constrain the development of alternatives.

Key Water Quality Question to be Answered…

What are water quality impacts and opportunities associated with the Treaty alternatives??

For more information:

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Nancy Stephan
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Bonneville Power Administration
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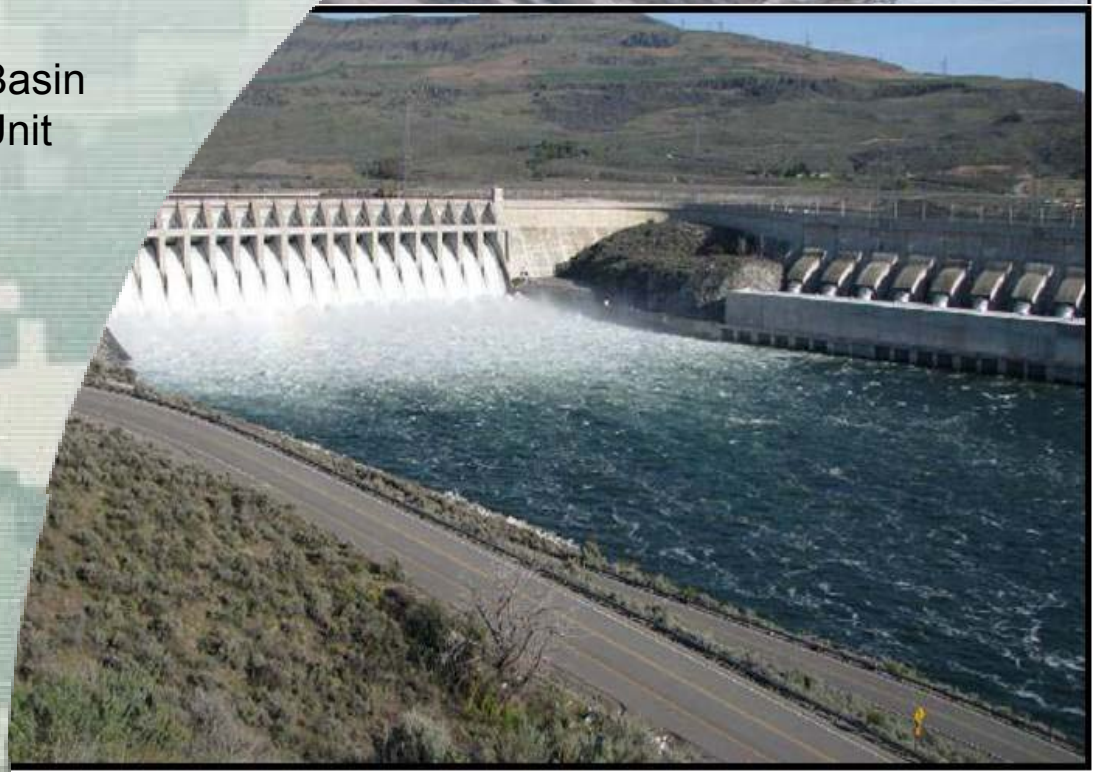
Columbia Basin Water Quality

Sovereign Technical Team Water Quality Workshop

Portland, Oregon
August 31, 2011



Scott English, Hydraulic Engineer
Northwestern Division - Columbia River Basin
Reservoir Control Center Water Quality Unit

Amy Reese, P.E.
Seattle District
Chief, Water Management Section

Steve Juul, Ph.D.
Walla Walla District
Water Quality Section

Overview

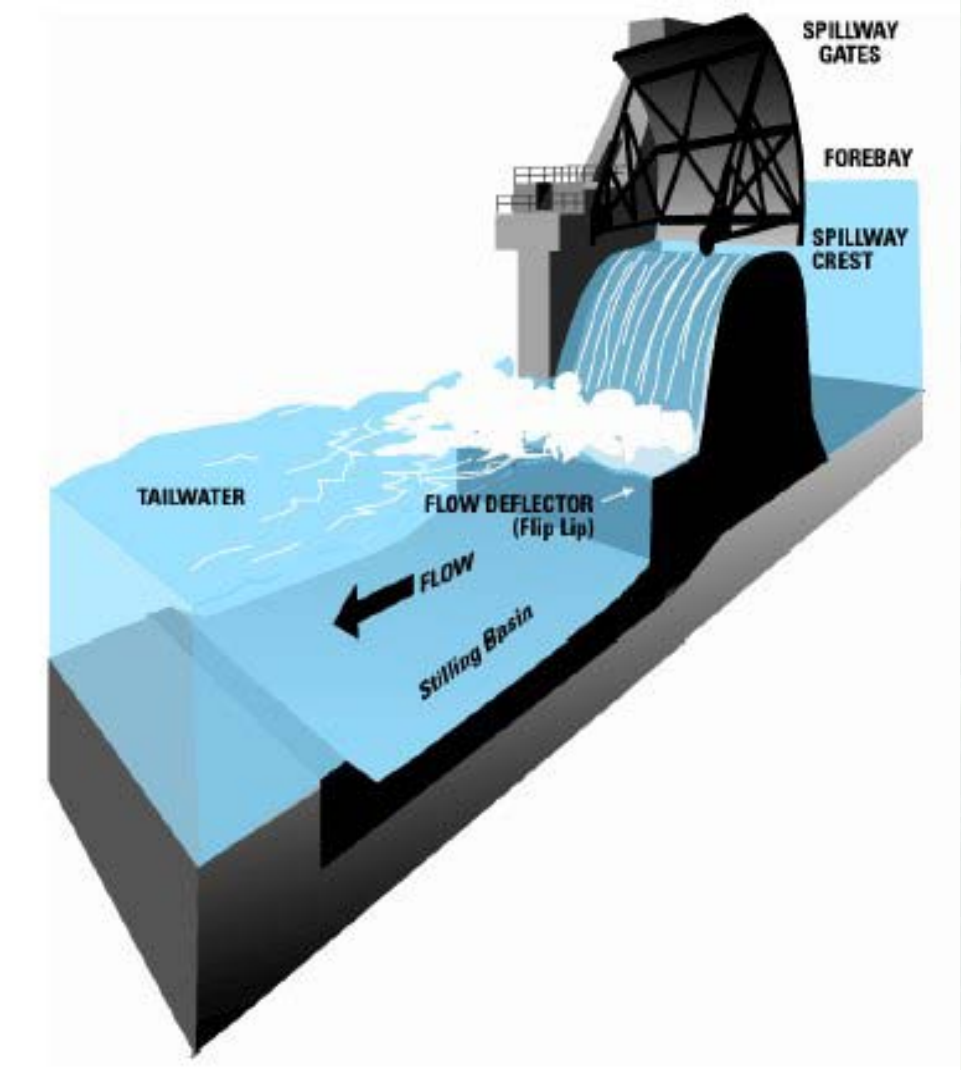
- Columbia Basin FCRPS Water Quality Introduction
- Water Quality Criteria & Compliance
- Structural & Operational Improvements
- Primary Water Quality Constituents
  - Total Dissolved Gas (TDG)
  - Water Temperature

The water quality standard for TDG relative to atmospheric pressure is 110%.

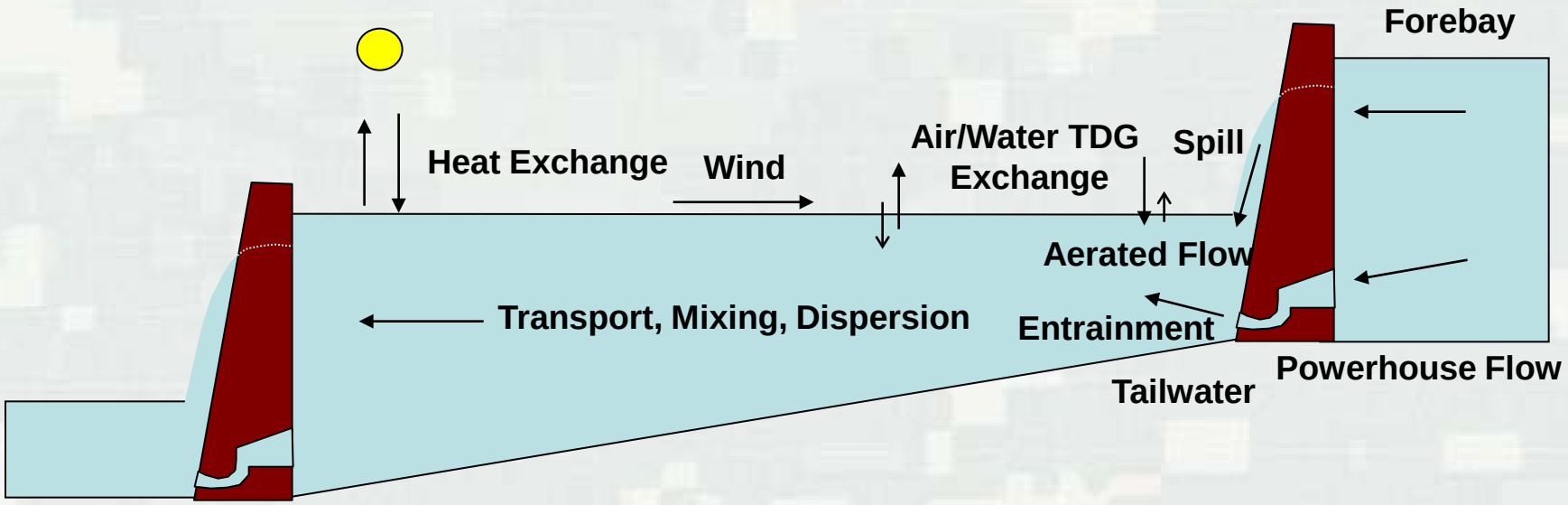
During the fish passage season, from April to August, the Corps is provided state waivers of 120% TDG saturation in the tailwater, and 115% TDG in the forebay of the next project downstream as the high 12-hour average.

The Corps has developed structural and operational measures for gas abatement including spillway flow deflectors installed just below the water surface on the spillway. This structure is designed to create a surface jet which reduces the TDG exchange by limiting the entrainment and transport of air bubbles to depth in the stilling basin.

Spillway flow deflectors have been installed on all the CE dams on the Columbia River (except The Dalles Dam) and all the lower Snake River Dams.



TDG & Water Temperature Exchange Process Overview



A system of Fixed Monitoring Stations (FMS) have been installed in the forebay & tailwater of each project.

Parameters

- **TDG pressure**
- **Water temperature**
- **Barometric pressure**
- **Depth**

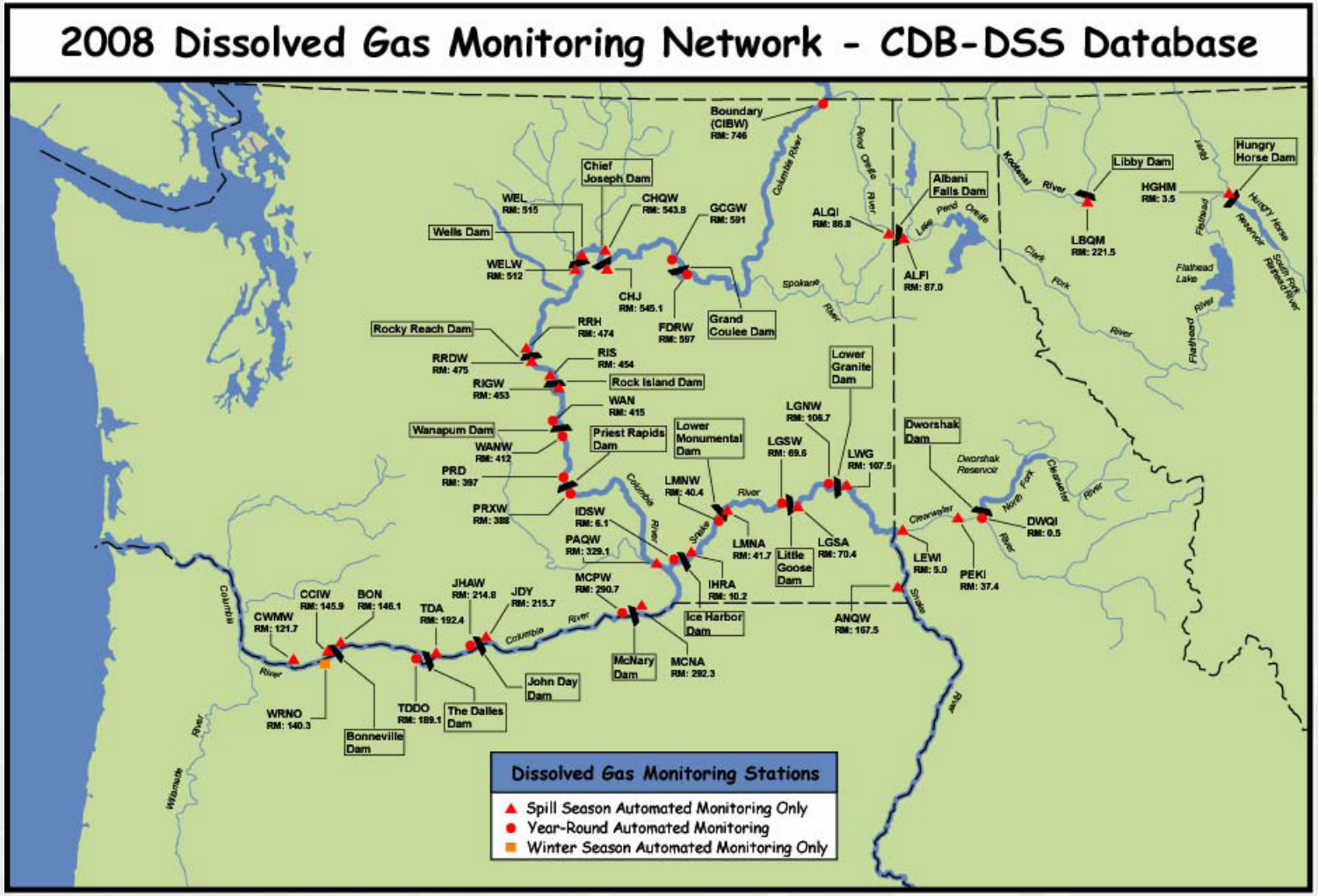
Sample Interval

- **Hourly**

Data Transmission

- **Satellite**
- **Radio**

Columbia Basin Water Quality Monitoring

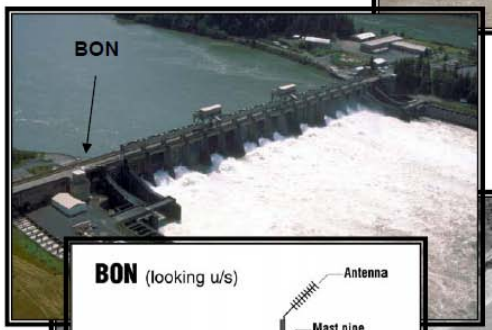


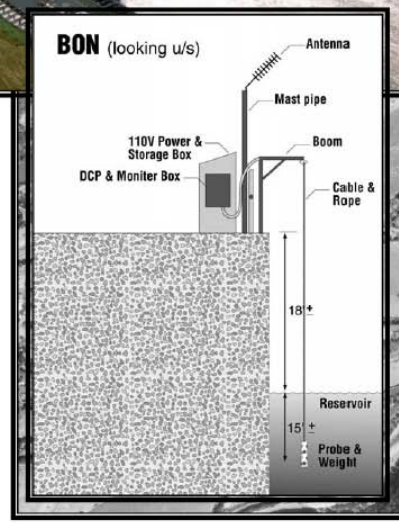
The FMS System:

- Provides decision makers with synthesized and relevant information needed to manage TDG supersaturation in the river system on a real-time basis.
- Ability to determine how project releases affect downstream water quality and aquatic habitat relative to ESA, CWA, BiOp, and related state and tribal TDG standards.
- Ability to identify long-term changes in basin-wide TDG saturation levels resulting from water management decisions and/or natural processes (trend monitoring).
- Ability to enhance analytical and predictive capability of existing models/tools used to evaluate management objectives.

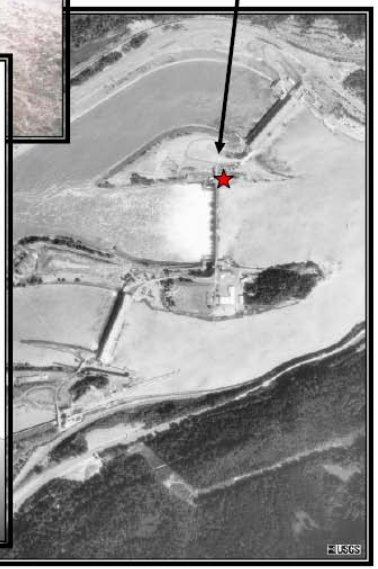
4. Bonneville Forebay TDG Monitoring Station (BON)

Gage Elevation: Fixed
Latitude: 45° 38′ 44.4″ N
Longitude: 121° 56′ 24.3″ W
Datum: NAD-83
River: Columbia
River Mile: 146.1
USGS-ID: 453845121562000
Owner: U.S. Army Corps of Engineers
Gauge Type: Hydrosonde
Data Transmission: GOES Satellite
Dates of Operation: Year-round
Years of Operation: 1986 – Present.
River Conditions: Forebay Monitor.
Location: This gauge is located in the forebay of Bonneville Dam on the northern side of the spillway channel on Cascade Island just upstream of spillbay #1.



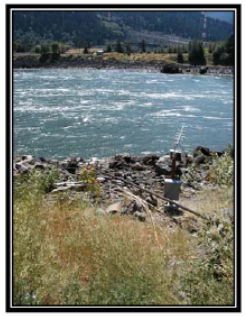


Bonneville Spillway

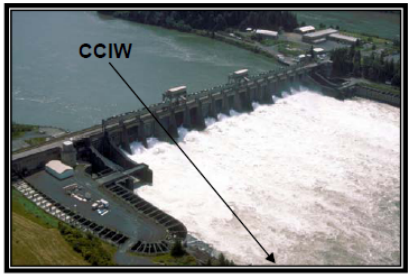


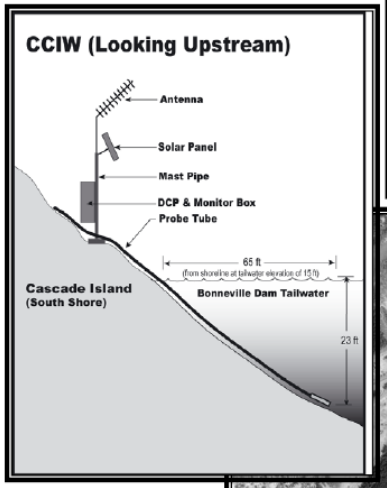
6. Cascades Island TDG Monitoring Station (CCIW)

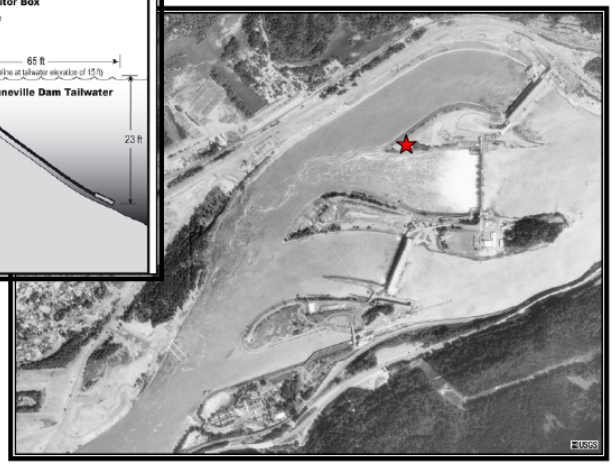
Gage Elevation: Fixed
Latitude: 45° 38' 44.4" N
Longitude: 121° 56' 44.3" W
Datum: NAD-83
River: Columbia
River Mile: 145.9
USGS-ID: 453845121564001
Owner: U.S. Army Corps of Engineers
Gauge Type: Hydrosonde
Data Transmission: GOES Satellite
Dates of Operation: April 1 – Sept. 31
Years of Operation: 2004 – Present
River Conditions: Spillway Monitor
Location: This gauge is located within the Bonneville Dam spillway channel on Cascade Island approximately 1400 feet downstream of the spillway gates.



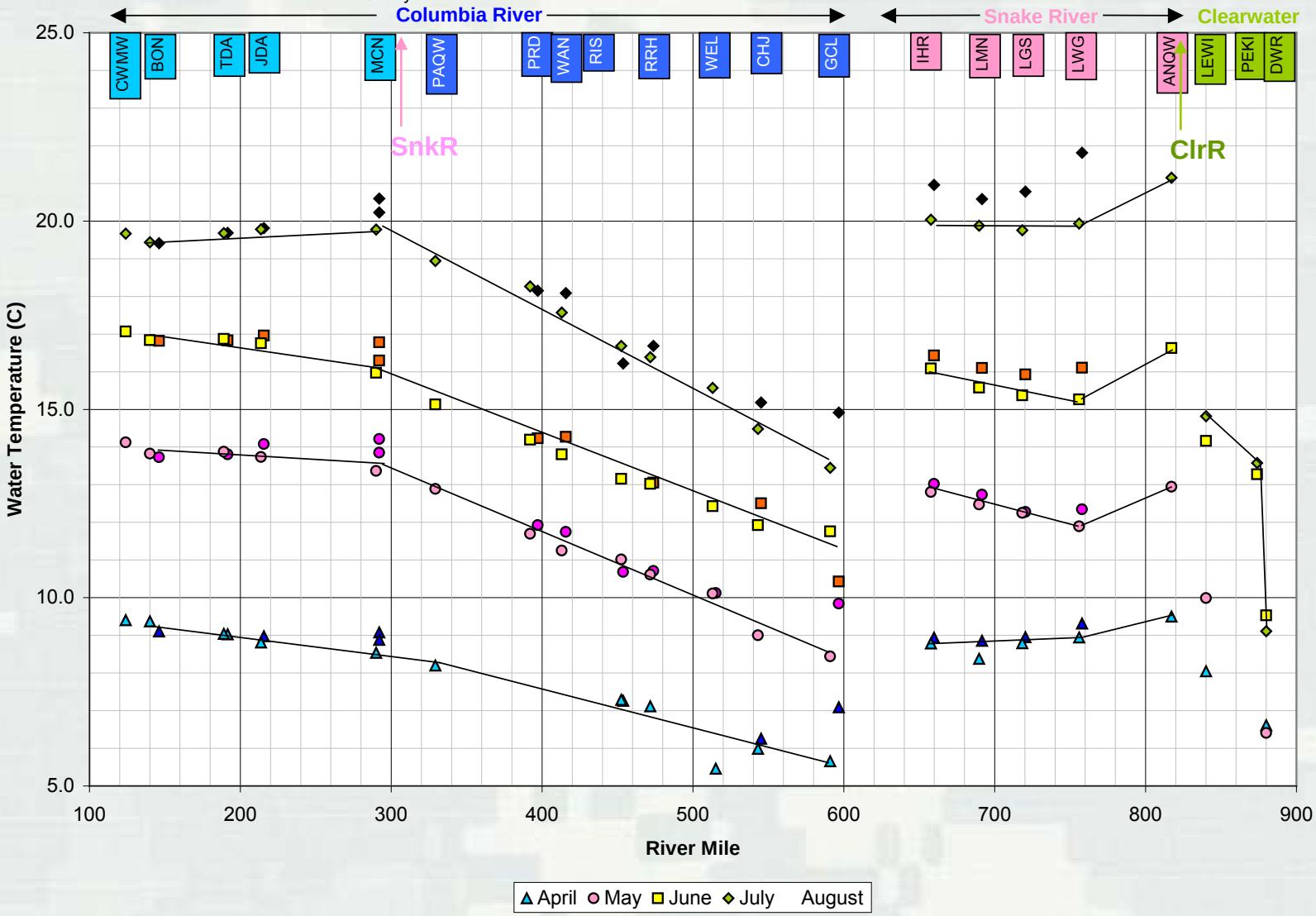
Comment: This gauge is currently used as the spillway tailrace gauge for management of spill at Bonneville Dam.



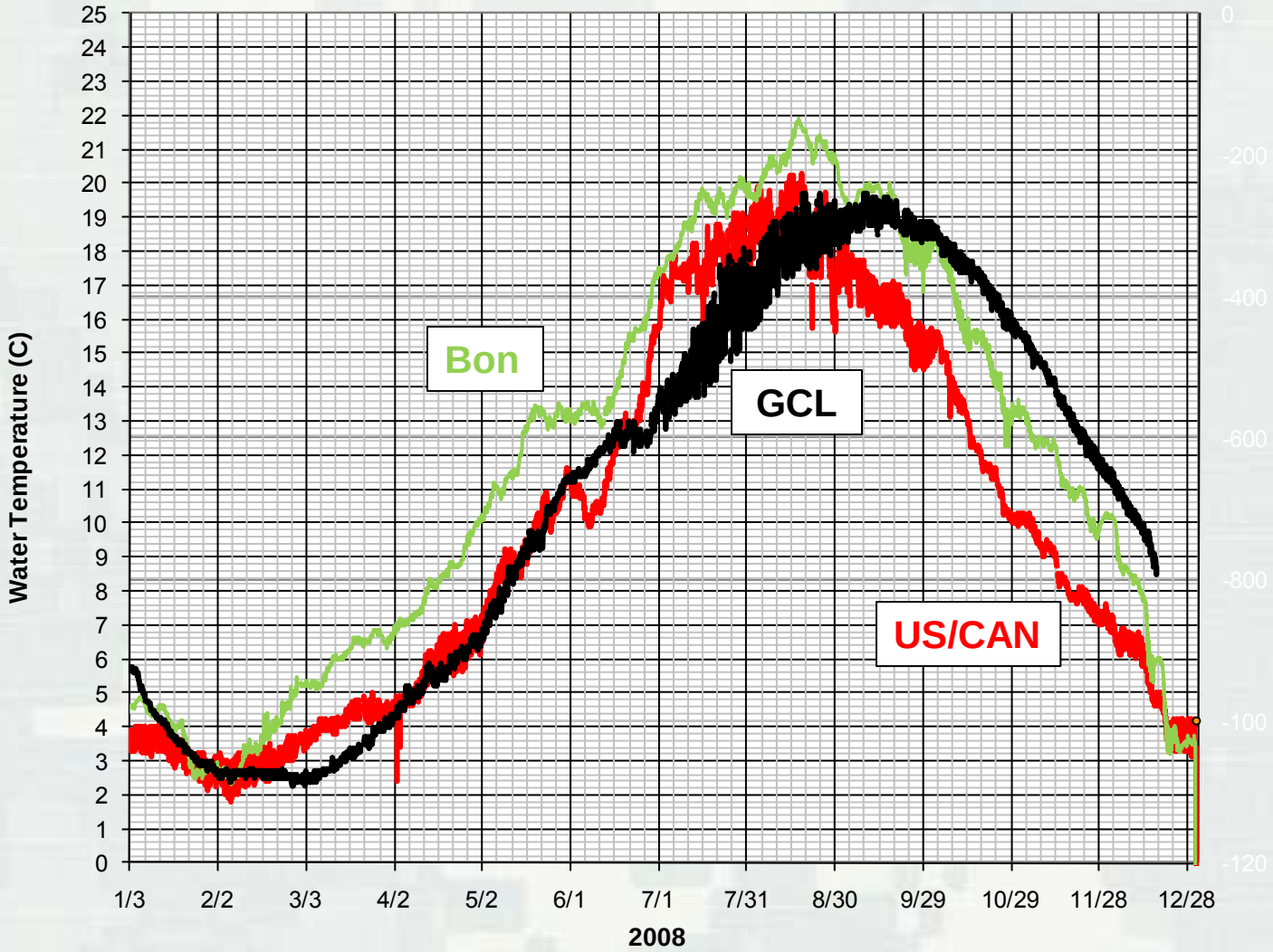




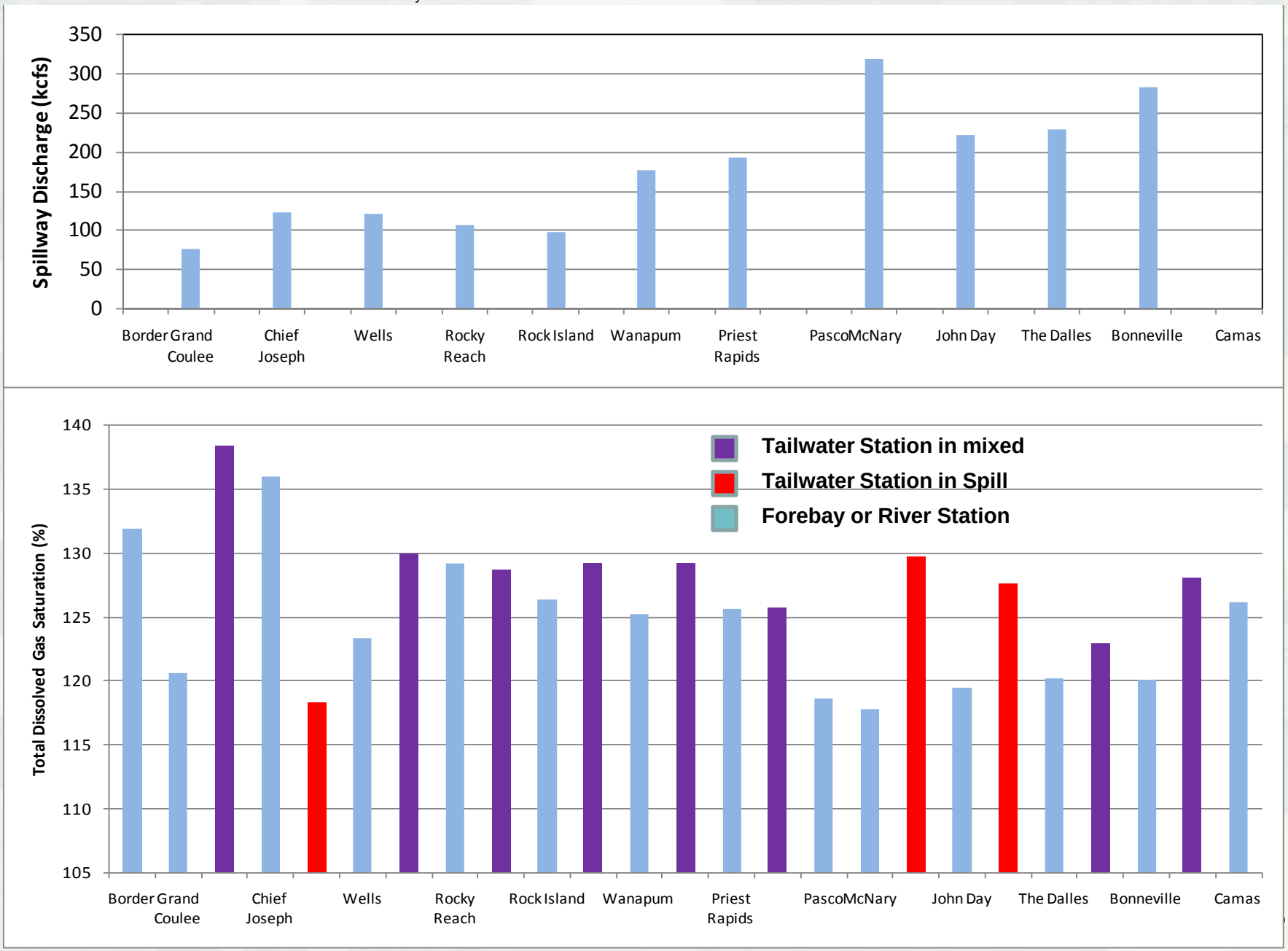
Typical Forebay & Tailwater FMS



Average Monthly Water Temperatures as Measured at the Fixed Monitoring Stations in the Columbia River Basin for 2001 (Forebay Stations are Denoted by Darker Colors)



Hourly Columbia River Water Temperatures at US/Canada Border, Grand Coulee Dam, and Bonneville Dam for 2008



Average Total Dissolved Gas Saturation and Project Spill in the Columbia River at fixed monitoring stations, June 1-24, 2011

Libby Dam Water Quality

TDG: High head project

Conducted TDG exchange study in 2002

Limited spill at Libby Dam

TDG saturation in spillway releases increases as an exponential function of spillway discharge

Strong lateral gradients in TDG saturations are present in Kootenai River downstream of Libby

TDG loading reset at Kootenai Falls

Temperature: Current monitoring program collects hourly data at fixed monitoring stations in the forebay (temperature string) and tailwater

Conducted temperature study from 2003 through 2008

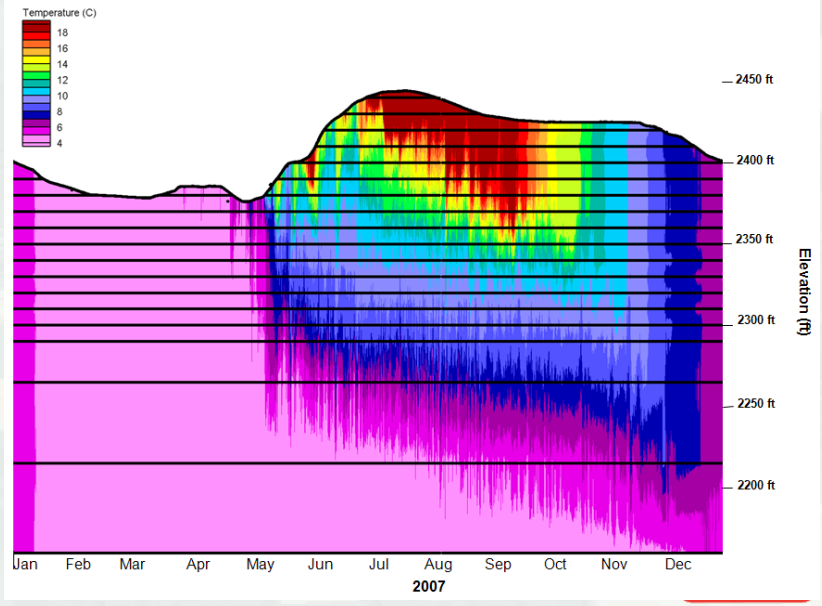
CE-QUAL-W2 temperature models

Lake Koocanusa, Kootenai River in development

Lake Koocanusa thermally stratifies

Selective withdrawal system used to meet downstream temperatures

BiOp Sturgeon temperatures and Temperature rule curve



Albeni Falls Dam Water Quality

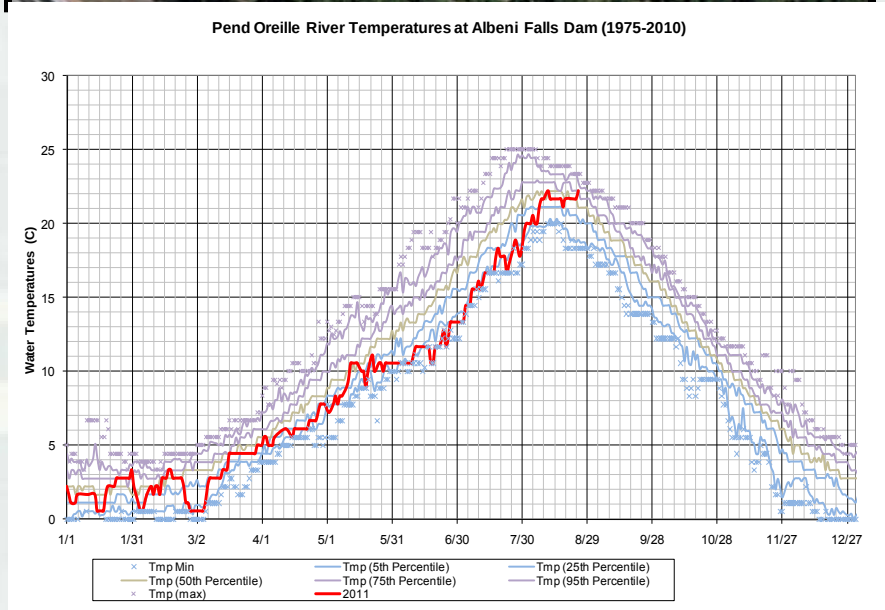
TDG: complicated relationship: forebay elevation, tailwater elevation, background TDG, spill gate setting

Albeni Falls Dam is a low head dam with a shallow stilling basin that does not contribute much TDG to the Pend Oreille River system

Non-uniform spill pattern can increase TDG saturations by about 5 to 8 percent over background saturations

Conducted TDG exchange study in 2003

Pend Oreille River TDG TMDL: Washington Final/Idaho Draft



Temperature: Lake Pend Oreille thermally stratifies in summer with temperatures exceeding 20C (forebay does not)

Cold subsurface temperatures retained

Higher lake elevation favors a larger contribution of cooler sub-surface waters

Conducted temperature study in 2004, 2005 and 2006

CE-QUAL-W2 models of POR developed for Water Temperature TMDLs

Pend Oreille River TMDL: Washington Final/Idaho Draft

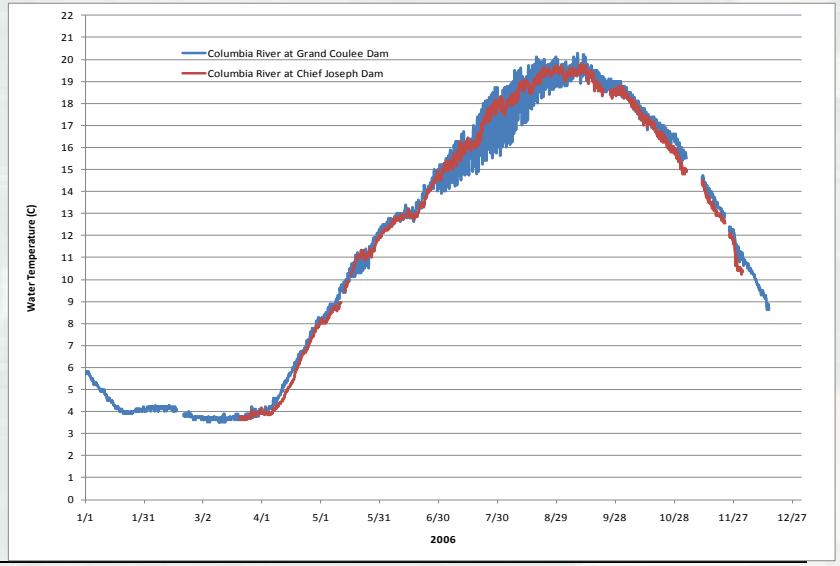
Chief Joseph Dam Water Quality

TDG: High head project comparatively
Spill through 19 spillway bays with flow deflectors since 2009
Deflectors result in substantial reduction in TDG generation
Can actually strip gas (2011 data)
TDG management opportunities involves joint operation with Grand Coulee Dam
CE-QUAL temperature model for Lake Rufus Woods in development.

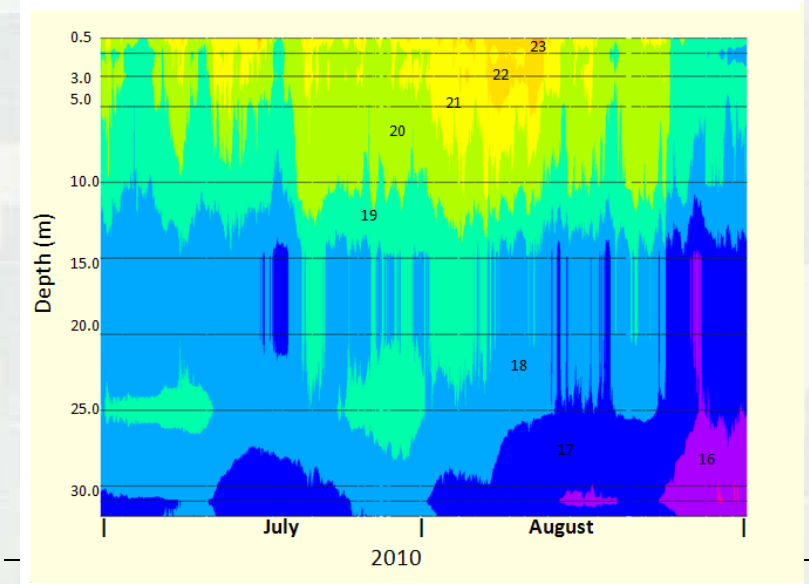
Temperature: Run-of-river project — Short residence time (about 3 to 8 days)
Powerhouse releases sub-surface waters

- Seasonal temperature patterns largely controlled by Grand Coulee Dam releases (2006). Very weak thermal gradient

Conducted temperature study in 2003 and 2004

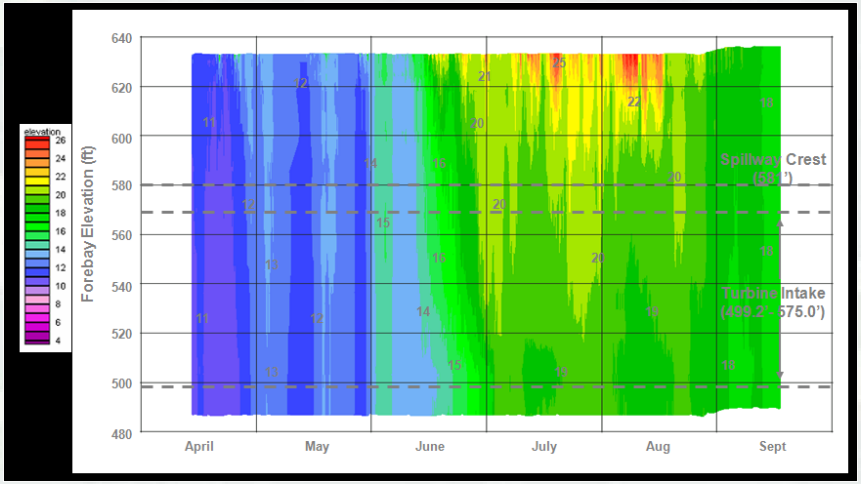


Lower Granite Dam



- Moderate TDG Production
- Non-Uniform Spill Pattern
- Spillway Flow Deflectors on all 8 Bays
- Strong Entrainment of Powerhouse Flows
  - Short training wall between spillway and powerhouse
- RSW Operational
- BGC Operational
- Low Initial TDG Saturation
- Tailwater FMS in Spillway Water
- Moderate Thermal Stratification
- Powerhouse Capacity 108 kcfs
  - Hydraulic Head 99 ft
- Lower Granite Lake 39.3 miles
  - Time of Travel 65 hrs

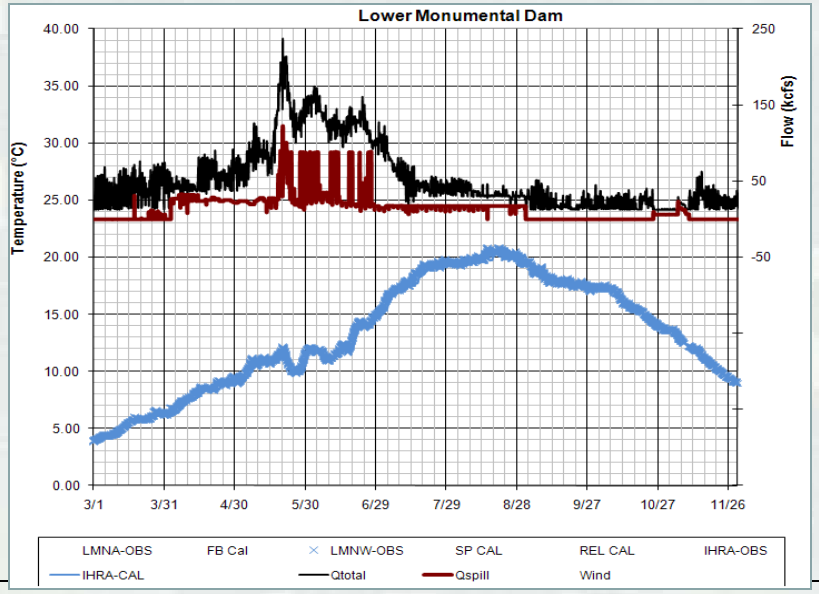
Little Goose Dam



- Moderate TDG Production
- Spillway Flow Deflectors on all 8 Bays
- TSW operational
- Strong Entrainment of Powerhouse Flows
- Roller Bucket Stilling Basin
- Tailwater FMS in Spillway Water
- Weak thermal stratification
- Powerhouse Capacity 111 kcfs
  - Hydraulic Head 96
- Lake Bryan 37.2 miles
  - Time of Travel 80 hrs

BUILDING STRONG®

Lower Monumental Dam



- Moderate TDG Production
- TSW Operational
- Short Powerhouse/Spillway Training Wall
- Spillway Flow Deflectors on all 8 Bays
- Shallow Tailwater Channel
- Tailwater FMS in Spillway Water
- Thermal Stratification weak
- Powerhouse Capacity 98 kcfs
  - Hydraulic Head 97 ft
- Lake Herbert West 28.7 miles
  - Time of Travel 54 hrs

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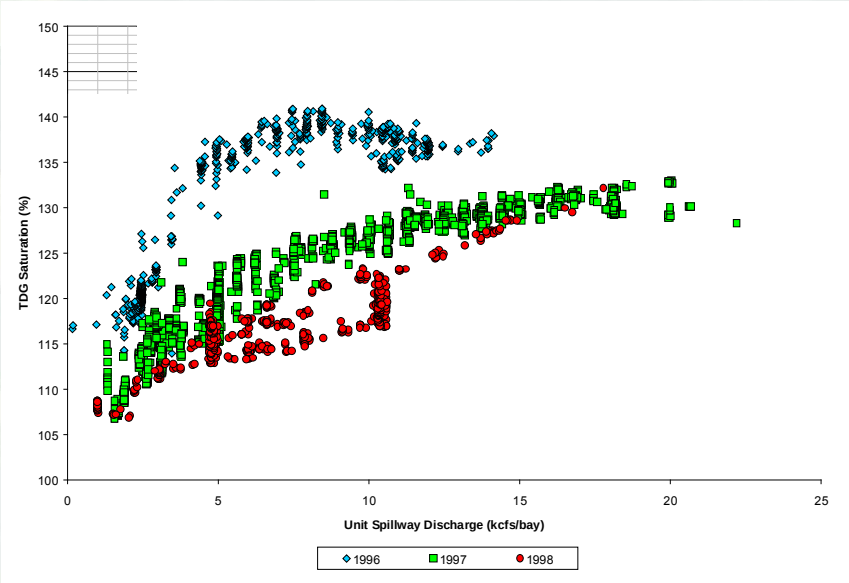
Ice Harbor Dam

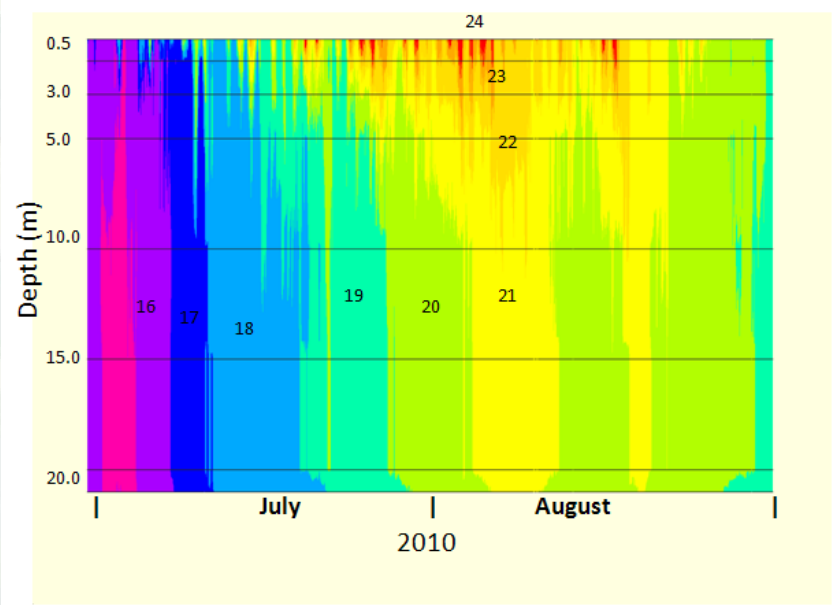


TDG Exchange before and after Spillway Flow Deflectors
(blue – before, red – after)

- Low TDG Production
- RSW Operational
- Spillway Flow Deflectors on all 10 Bays
- Coffer cells added to lower lock approach
- Shallow Tailwater Channel
- Tailwater FMS in Spillway Water
- TDG Exchange dependent on both tailwater stage and spillway discharge
- Thermal Stratification weak
- Powerhouse Capacity 92 kcfs
- Lake Sacajawea 32 miles
  - Time of Travel 58 hrs

BUILDING STRONG®

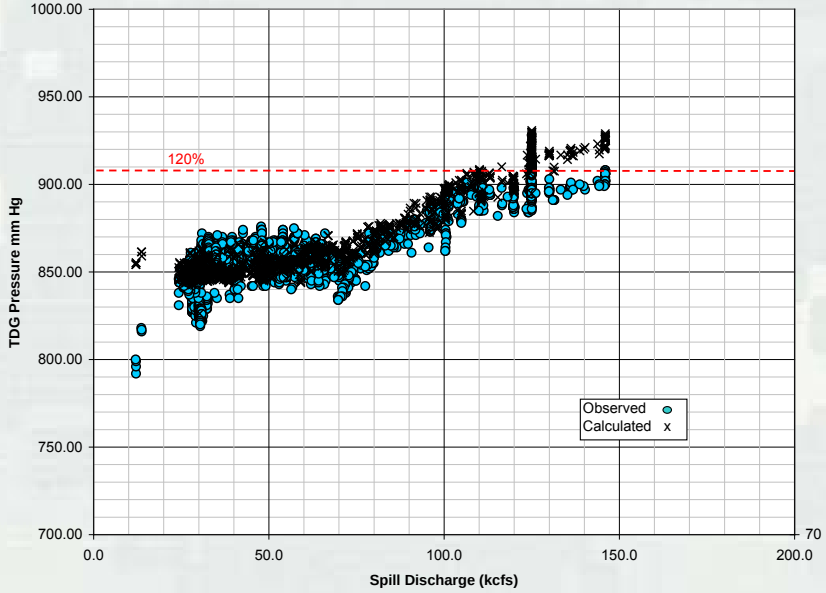
McNary Dam



- Moderate TDG Production
- TSW Operational
- Split Leaf Gate Operation
- Spillway Flow Deflectors all 22 Bays
- Irregular Tailwater Channel
- Lake Umatilla 76 miles/ 4 days Travel Time
- Tailwater FMS in Spillway Water
- Thermal Stratification Moderate
- Warm surface waters drawn into Juvenile bypass system
- Small Powerhouse Hydraulic Capacity 174 kcfs
  - Hydraulic Head 72 ft
- Lake Wallula 64 miles
  - Time of Travel 68 hrs

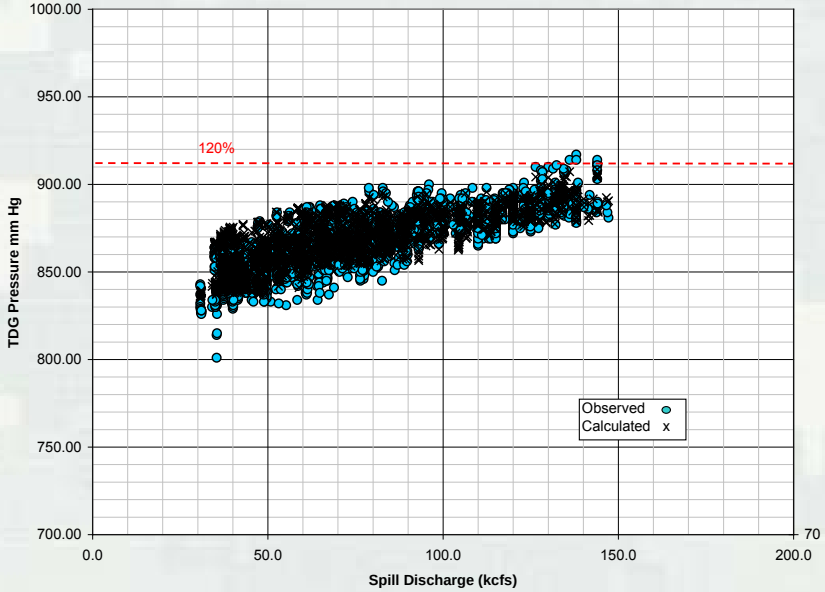
BUILDING STRONG®

John Day Dam



- **Moderate TDG Production**
- **Non-uniform Spill Pattern**
- **Deep Spillway Flow Deflectors on 18 of 20 Bays**
- **New Spillway Flow Deflector bay 20 (50 ft length)**
- **TSW Operational Bays 18-19**
- **Deep Stilling Basin and Irregular Tailwater Channel**
- **Tailwater FMS in Spillway Water**
- **Thermal Stratification weak**
- **Powerhouse Capacity 329 kcfs**
  - **Hydraulic Head 72 ft**
- **Lake Umatilla 64 miles**
  - **Time of Travel 96 hrs**

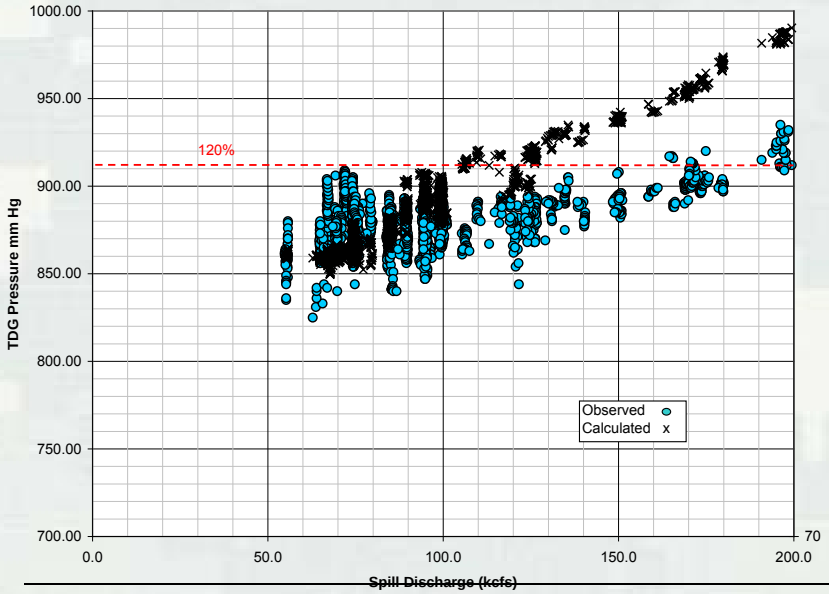
The Dalles Dam



- High TDG Production
- Spill Pattern Peaked to North Side of Spillway
- Spillway Training Wall
- Ice/Trash Sluiceway passage
- No Spillway Flow Deflectors
- Shallow Stilling Basin and Tailwater Channel
- Rapid Mixing of Project Releases
- Tailwater FMS in Mixed Water
- No thermal stratification
- Powerhouse Capacity 284 kcfs
  - Hydraulic Head 78 ft
- Lake Celilo 24.1 Miles
  - Time of Travel 14 hrs

BUILDING STRONG®

Bonneville Dam



- Moderate TDG Production
- Deflectors on all 18 spill bays
- B2CC Surface bypass can be source of elevated TDG pressures
- Wide range of Tailwater Elevation
- Deep Tailwater Channel
- Islands Partition Hydropower flows from Spillway
- Last dam on Columbia River
- No thermal stratification
- Powerhouse Capacity 252 kcfs
  - Hydraulic Head 54 ft
- Bonneville Lake 45.4 miles
  - Time of Travel 33.4 hrs

BUILDING STRONG®

Dworshak Reservoir - Lower Snake River, and McNary Project Temperature Operations

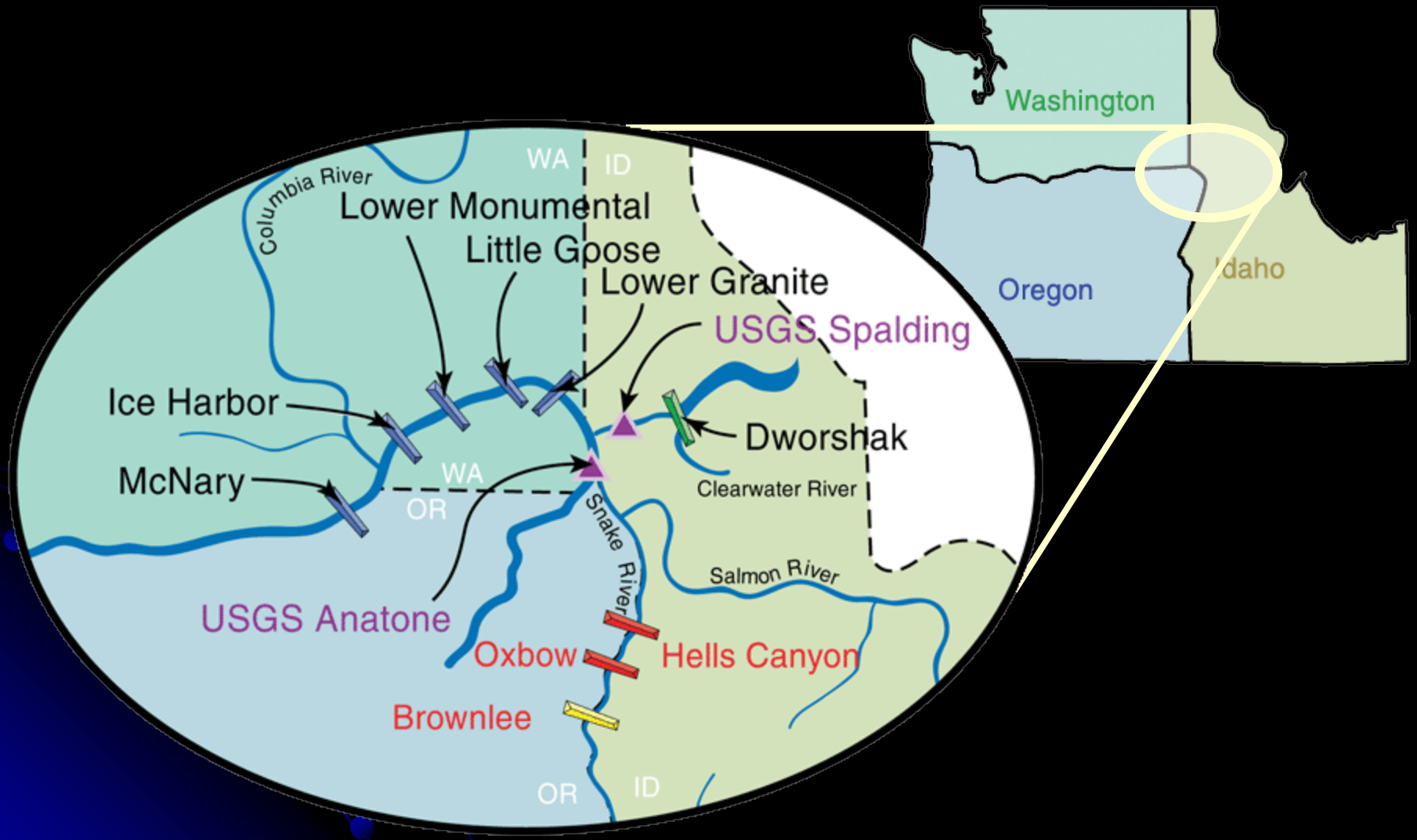
Steve Juul, Ph.D.

US Army Corps of Engineers

Walla Walla District

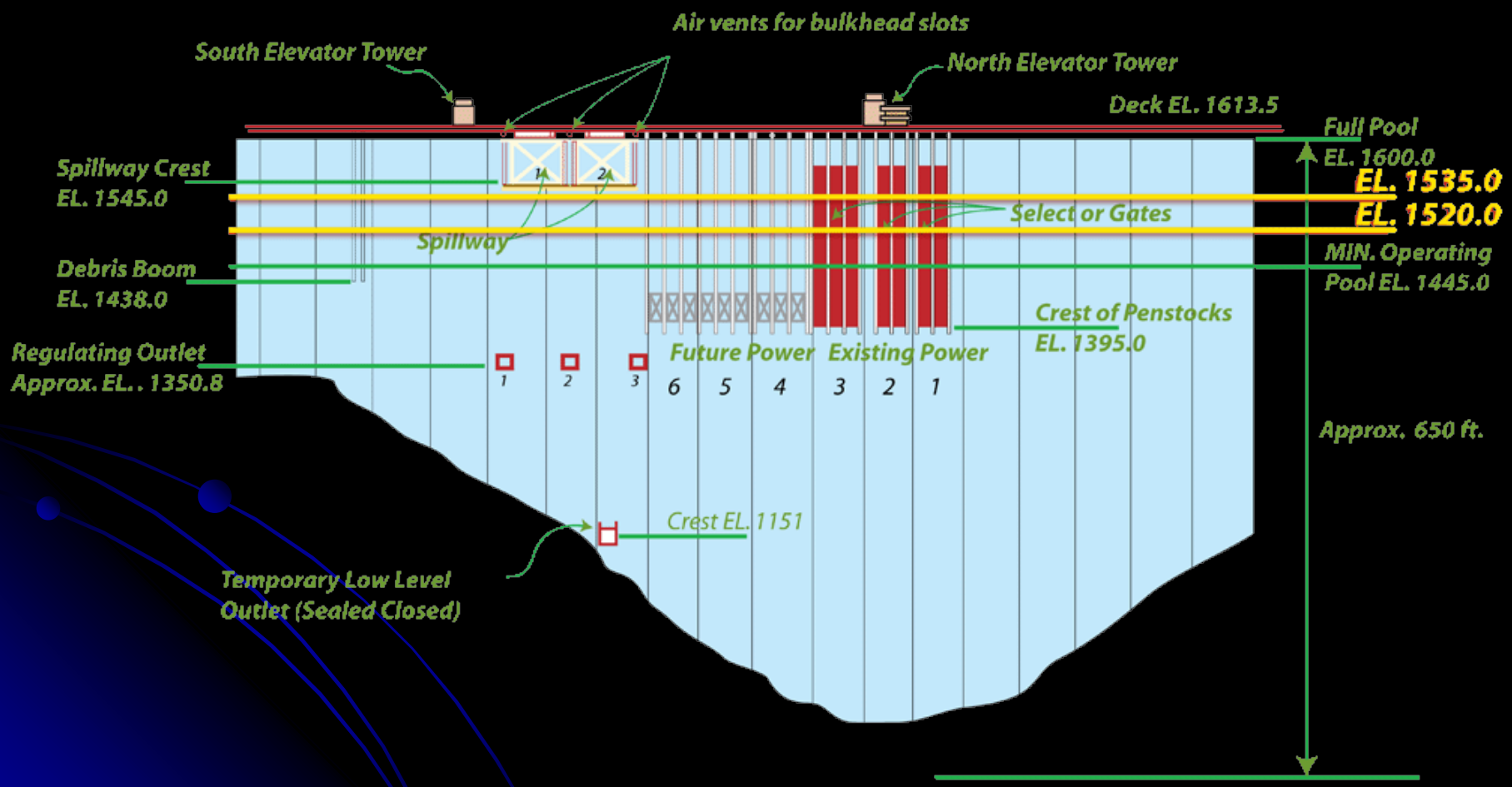
Water Quality Section

Dworshak Reservoir, Lower Snake River Projects, and McNary Dam

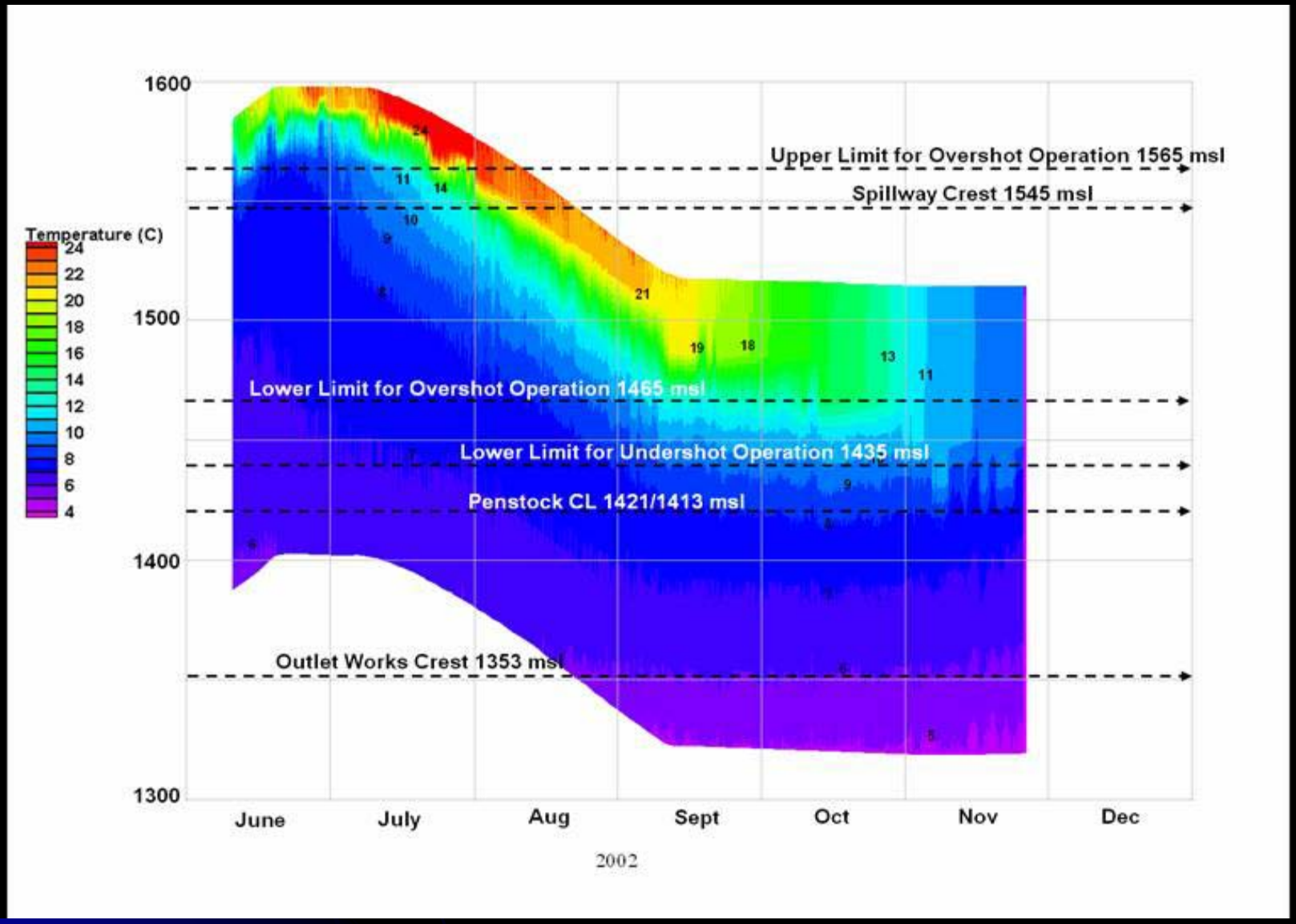


Dworshak Dam, Idaho

Upstream Face of Dworshak Dam

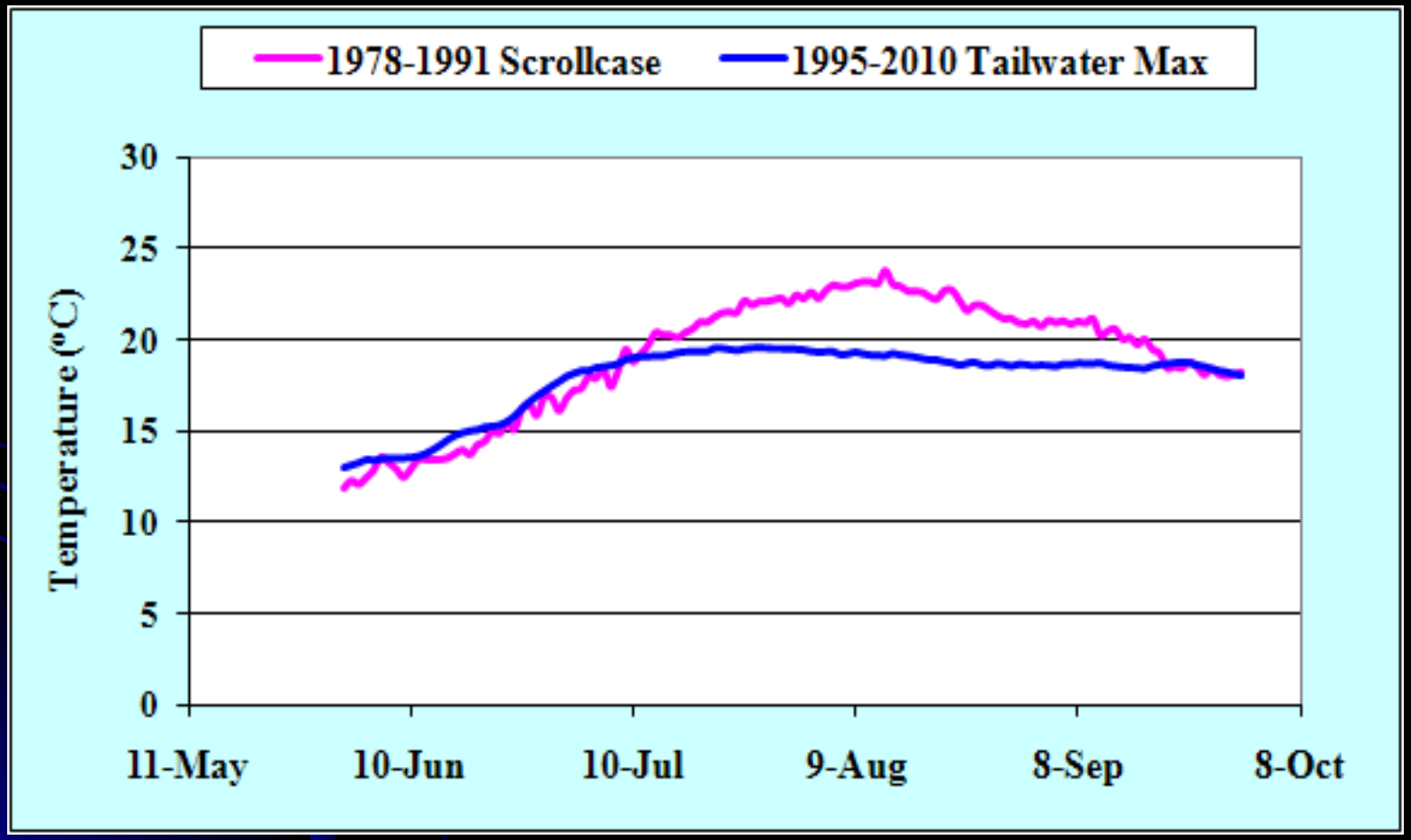


Dworshak Forebay Cross Section



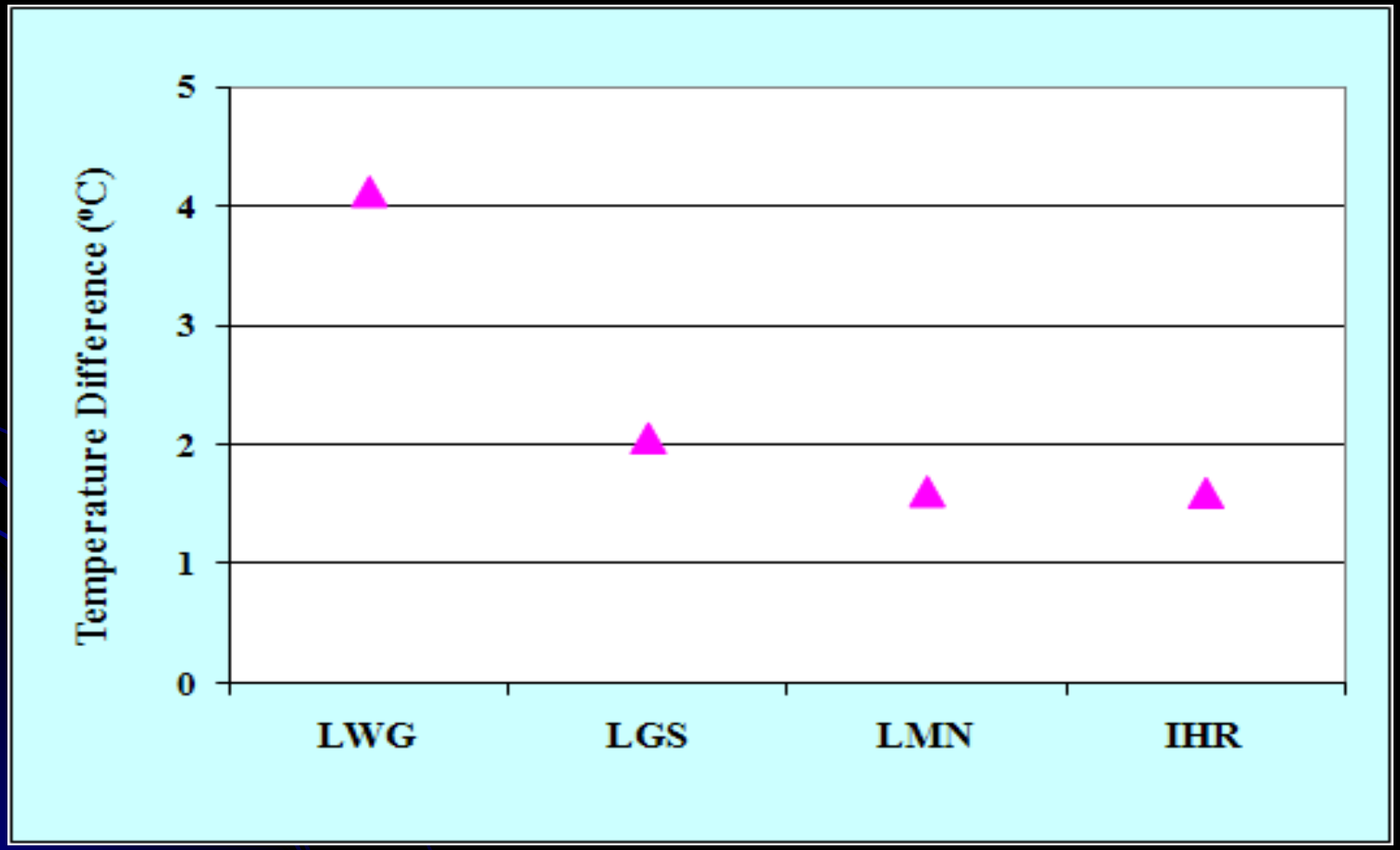
Lower Granite Dam, Washington

Lower Granite Dam Scrollcase Versus Tailwater Temperatures

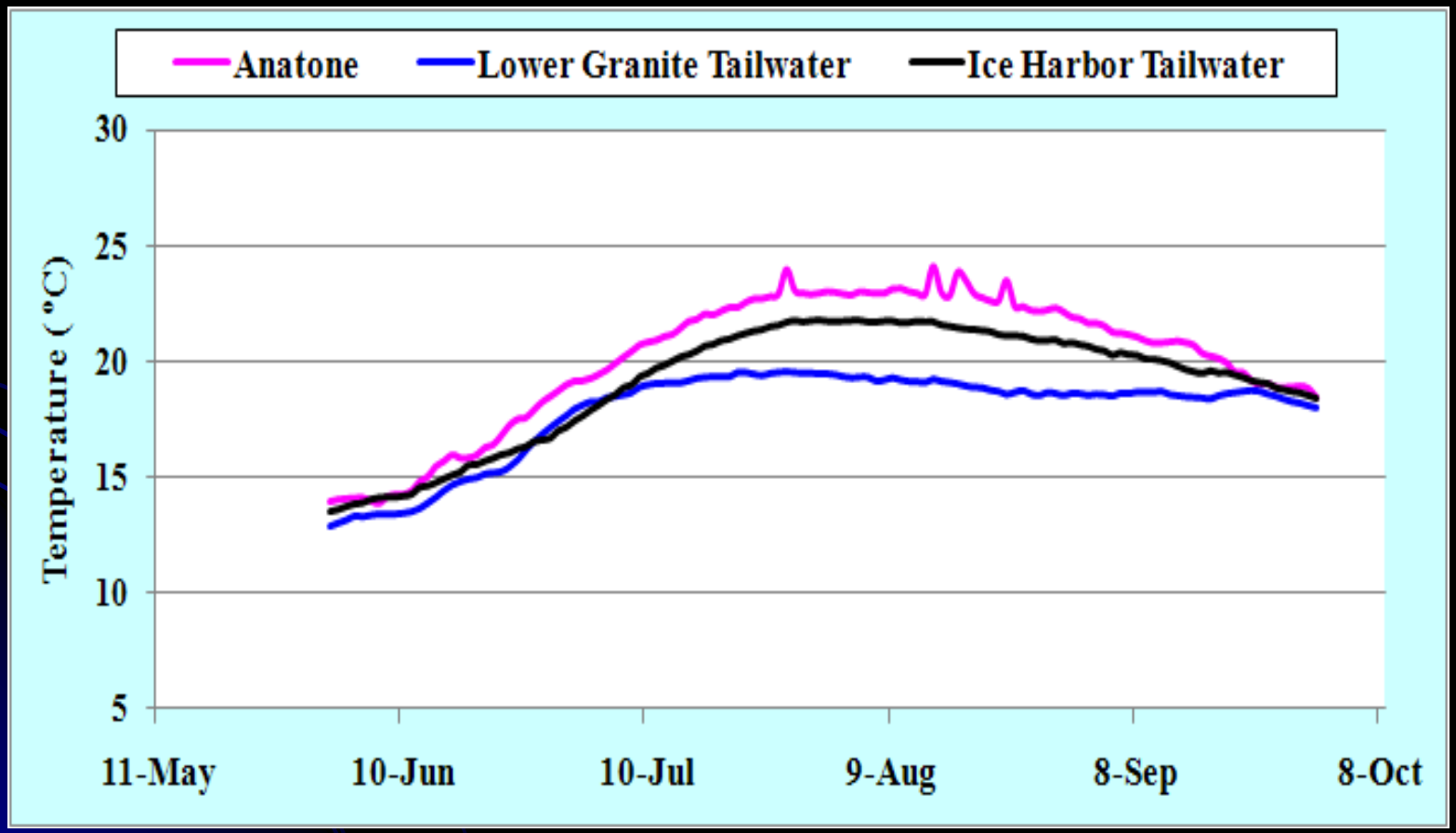


Typical Forebay Water Quality Float

15 July - 31 August 2005-2010 Mean Water Column Temperature Differences

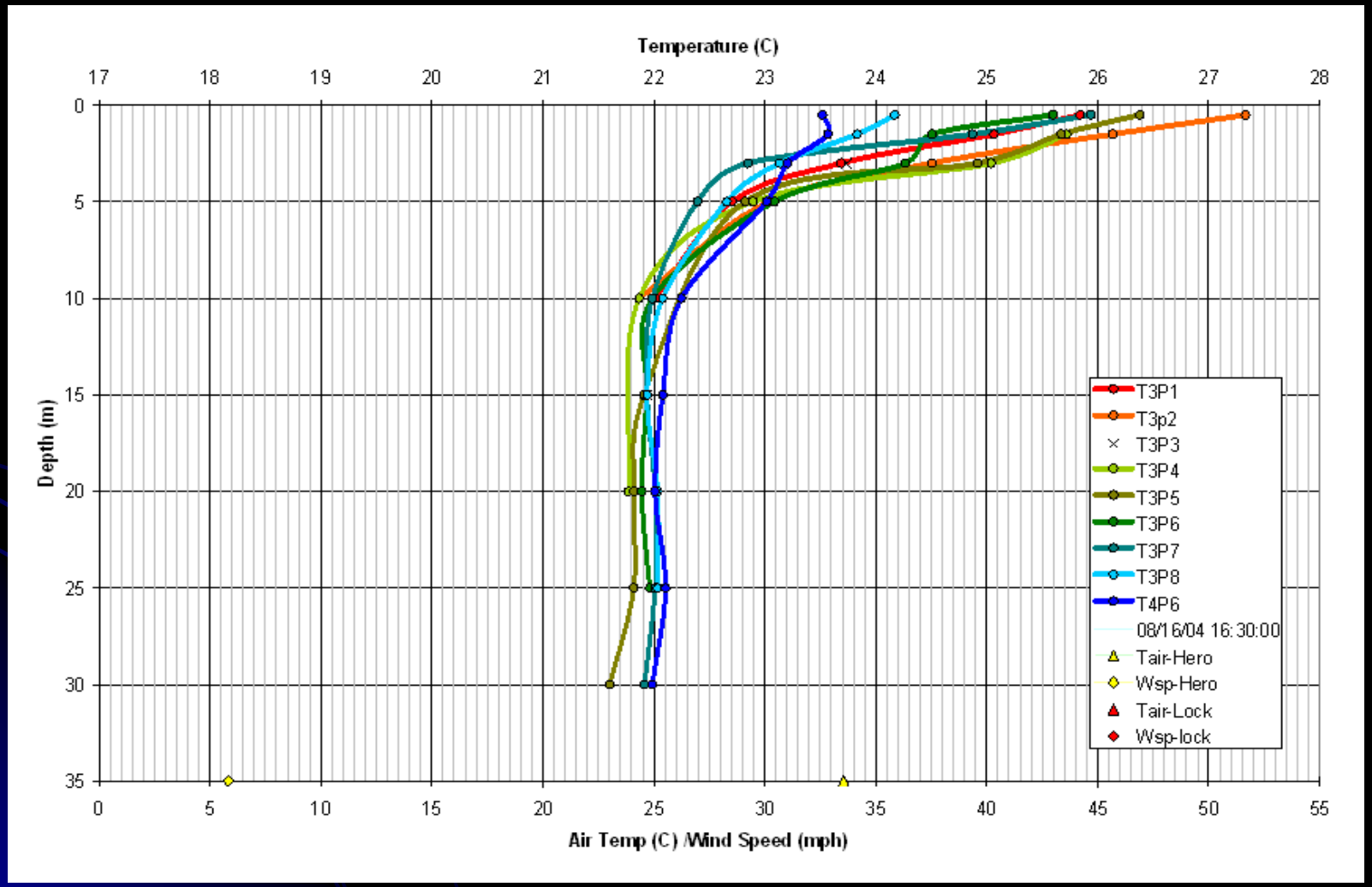


1995-2010 Mean Daily Max Temperatures for Anatone and Ice Harbor/ L. Granite Tailwater

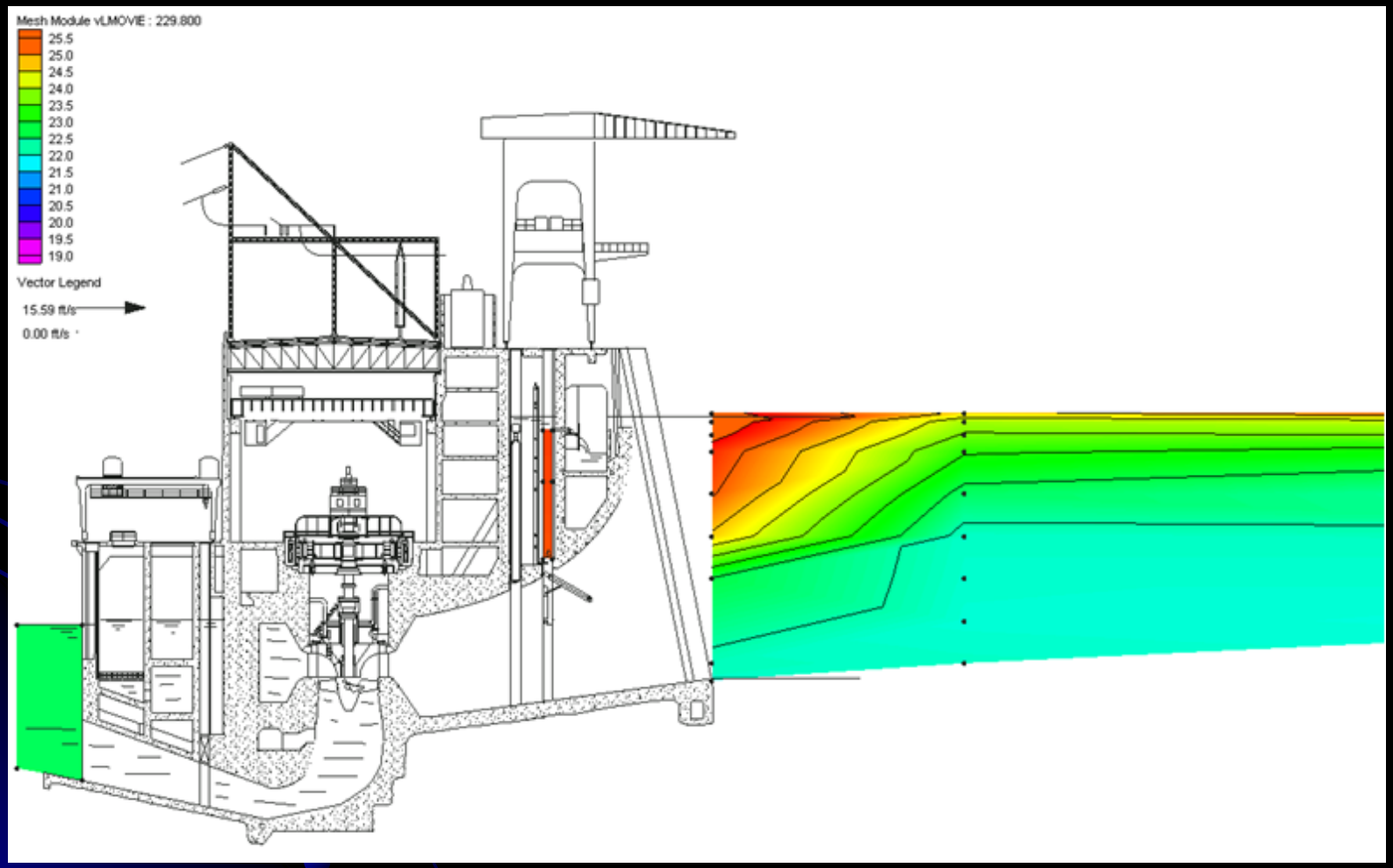


McNary Lock and Dam

McNary Forebay Thermoclines 16 August 2004 @16:30 hrs



McNary Powerhouse Cross Section



QUESTIONS?

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Columbia River Treaty--
Water Quality Workshop

Contaminants of Concern in the Columbia?

U.S. Department of the Interior
U.S. Geological Survey

Where Does Water Quality Fit in the Columbia River Treaty?

- Primary Operational Driving Purposes
  - Ecosystem Based Functions
    - WATER QUALITY
      - Temperature
      - Turbidity
      - Total Dissolved Gas
      - Suspended Sediment

Run Models

- Impact Assessment Areas
  - Water Quality
    - Contaminants
      - Water, Sediment, and Biota

Outputs

USGS

How did we arrive at this listing of "Contaminants of Concern"?

- Columbia River Toxic Reduction Strategy
  - Contaminants of Concern Matrix
    - Tier-I (DDT, PCBs, Mercury, PBDEs)
    - Tier –II (PAHs, As, Dioxins/Furans, OPs, Estrogenic)
    - Tier –III
      - Trace Elements
      - Current Use & Legacy Pesticides
      - Pharmaceuticals
      - Waste Water Compounds
      - Hormones
      - Pyrethroids
- Reservoir Operations & Flow Management

USGS

Contaminants of Concern –Tier I

Contaminant Name	Tier	Evidence of the Problem	Biological Effects	Reduction Strategies	Methods and Criteria	Sampling Media	Rationale (for media)	Media with detects in Columbia River or tributaries
DDT (and metabolites)	1	• widespread • 303(d) listed in OR and WA • WA fish consumption advisories for Lake Chelan and the Yakima River • evidence in water and sediment • exceeds regulatory criteria • evidence in fish and wildlife	• PBT • endocrine disruptor • probable carcinogen	• TMDLs in Yakima, Okanogan, Walla Walla and in Snake Rivers, Lake Chelan and Johnson Creek • TMDL in Columbia Slough • EPA Strategic Plan for Columbia • EPA National PBT Action Plan	• methods exist • regulatory criteria exist	1.passive sampling (SPMD) & fish 2. sediment 3. water	hydrophobic bioaccumulative	SPMD fish tissue sediment water
PCBs	1	• widespread • 303(d) listed in OR and WA • exceeds criteria • OR fish consumption advisory from above Bonneville Dam to the mouth • WA fish consumption advisories for the Spokane and Walla Walla Rivers • evidence in fish and wildlife • evidence in water and sediment	• PBTs • endocrine disruptors • probable carcinogens	• TMDLs in Walla Walla and Okanogan Rivers and Lake Chelan • TMDL in Columbia Slough • EPA Strategic Plan for Columbia • EPA National PBT Action Plan • CERCLA cleanups, Portland Harbor, Bradford Island	• methods exist • analytical costs for congeners rel. high • regulatory criteria exist	1. passive sampling (SPMD) & fish 2. sediment 3. Water	hydrophobic bioaccumulative	SPMD fish tissue sediment
Mercury (including methylmercury)	1	• widespread • WA 303(d) list • OR fish consumption advisories in Willamette and Snake Rivers • WA fish consumption advisories in Lake Roosevelt • evidence in fish, wildlife, and water	• PBT • endocrine disruptor • possible carcinogen (methyl) • noncancer effects	• WA PBT Action Plan • Willamette and Snake River TMDLs • EPA National PBT Action Plan • ODEQ Hg Reduction Strategy	• methods exist • regulatory criteria exist	1. water & fish 2. sediment	hydrophobic bioaccumulative methylates	water fish tissue sediment
PBDEs	1	• widespread • emerging problem, possibly increasing • evidence in fish and wildlife	• PBT • endocrine disruptor • suspected carcinogen (not EPA-classified) • noncancer effects	• WA PBT Action Plan • National EPA Project Plan	• methods exist • analytical costs rel. high • no regulatory criteria	1. passive sampling (SPMD) & fish 2. sediment 3. water	hydrophobic bioaccumulative	SPMD fish tissue suspended sediment

USGS

Contaminants of Concern --Tier I

Contaminant Name	Tier	Notes on spatial patterns	References for Columbia River Basin detections	Other notes	Seasonal considerations	Seasonal recommendation
DDT (and metabolites)	1	based on SPMDs, Yakima is major agricultural source, Willamette R., Johnson Cr., Wenatchee R, and Snake R are moderate sources Columbia Slough, Willamette R and Multnomah Ch. are sources affecting mainstem	USGS 1999, Ecology 2005, and LCREP 2007 for SPMDs CRITFC, EMAP, LCREP 2007, NOAA/COE 2007 , Bi-State, Yakima R, CCPT, and Willamette NAWQAs for fish EMAP, LCREP 2007, Bi-State, Yakima R, CCPT, and Willamette NAWQAs, various COE reports for bed sediment		Detection probable year round, No seasonality expected for inputs, but may get more detects in high flow with greater suspended sediment loads and resuspension	high flow
PCBs	1	SPMD conc. highest in tribs--Johnson Cr., Willamette R., Multnoman Ch., Columbia Slough (urban influences), Lake R., and Wenatchee R. sources in lower Willamette appear to be local, urban	Ecology 2005 and LCREP 2007 for SPMDs CRITFC, EMAP, NOAA/COE 2007, LCREP 2007, Bi-State, Willamette and CCPT NAWQAs for fish tissue EMAP, Willamette and CCPT NAWQAs, and various COE reports for bed sediment USGS 2006 for suspended sediment	EMAP congener method not high res GC/MS and Neither is NOAA method	Fewer detections on suspended sediments during low flow	high flow
Mercury (including methylmercury)	1		CRITFC and EMAP for fish tissue EMAP for bed sediment USGS 2006 for suspended sediment		Hg higher winter and spring (runoff and resuspension) meHg higher in summer and spring recommend 4 times/year for Hg and methylated Hg to get both seasonal flux and capture exposure periods (spring and fall)	multiple flows/seasons
PBDEs	1	LCREP and USGS data from Lower Columbia only Ecology data extends up to Spokane R.	Ecology and LCREP 2007 for SPMDs and fish tissue USGS 2006 for suspended sediment	detected at all sites on suspended sed, in SPMDs 10 of 11 sites	Detection probable year round, No seasonality expected for inputs, but may get more detects in high flow with greater suspended sediment loads and resuspension	high flow

USGS

Contaminants of Concern –Tier I

Contaminant Name	Tier	Evidence of the Problem	Biological Effects	Reduction Strategies	Methods and Criteria	Sampling Media	Rationale (for media)	Media with detects in Columbia River or tributaries
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PCBs	1	• widespread • 303(d) listed in OR and WA • exceeds criteria • OR fish consumption advisory from above Bonneville Dam to the mouth • WA fish consumption advisories for the Spokane and Walla Walla Rivers • evidence in fish and wildlife • evidence in water and sediment	• PBTs • endocrine disruptors • probable carcinogens	• TMDLs in Walla Walla and Okanogan Rivers and Lake Chelan • TMDL in Columbia Slough • EPA Strategic Plan for Columbia • EPA National PBT Action Plan • CERCLA cleanups, Portland Harbor, Bradford Island	• methods exist • analytical costs for congeners rel. high • regulatory criteria exist	1. passive sampling (SPMD) & fish 2. sediment 3. Water	hydrophobic bioaccumulative	SPMD fish tissue sediment
Mercury (including methylmercury)	1	• widespread • WA 303(d) list • OR fish consumption advisories in Willamette and Snake Rivers • WA fish consumption advisories in Lake Roosevelt • evidence in fish, wildlife, and water	• PBT • endocrine disruptor • possible carcinogen (methyl) • noncancer effects	• WA PBT Action Plan • Willamette and Snake River TMDLs • EPA National PBT Action Plan • ODEQ Hg Reduction Strategy	• methods exist • regulatory criteria exist	1. water & fish 2. sediment	hydrophobic bioaccumulative methylates	water fish tissue sediment
PBDEs	1	• widespread • emerging problem, possibly increasing • evidence in fish and wildlife	• PBT • endocrine disruptor • suspected carcinogen (not EPA-classified) • noncancer effects	• WA PBT Action Plan • National EPA Project Plan	• methods exist • analytical costs rel. high • no regulatory criteria	1. passive sampling (SPMD) & fish 2. sediment 3. water	hydrophobic bioaccumulative	SPMD fish tissue suspended sediment

USGS

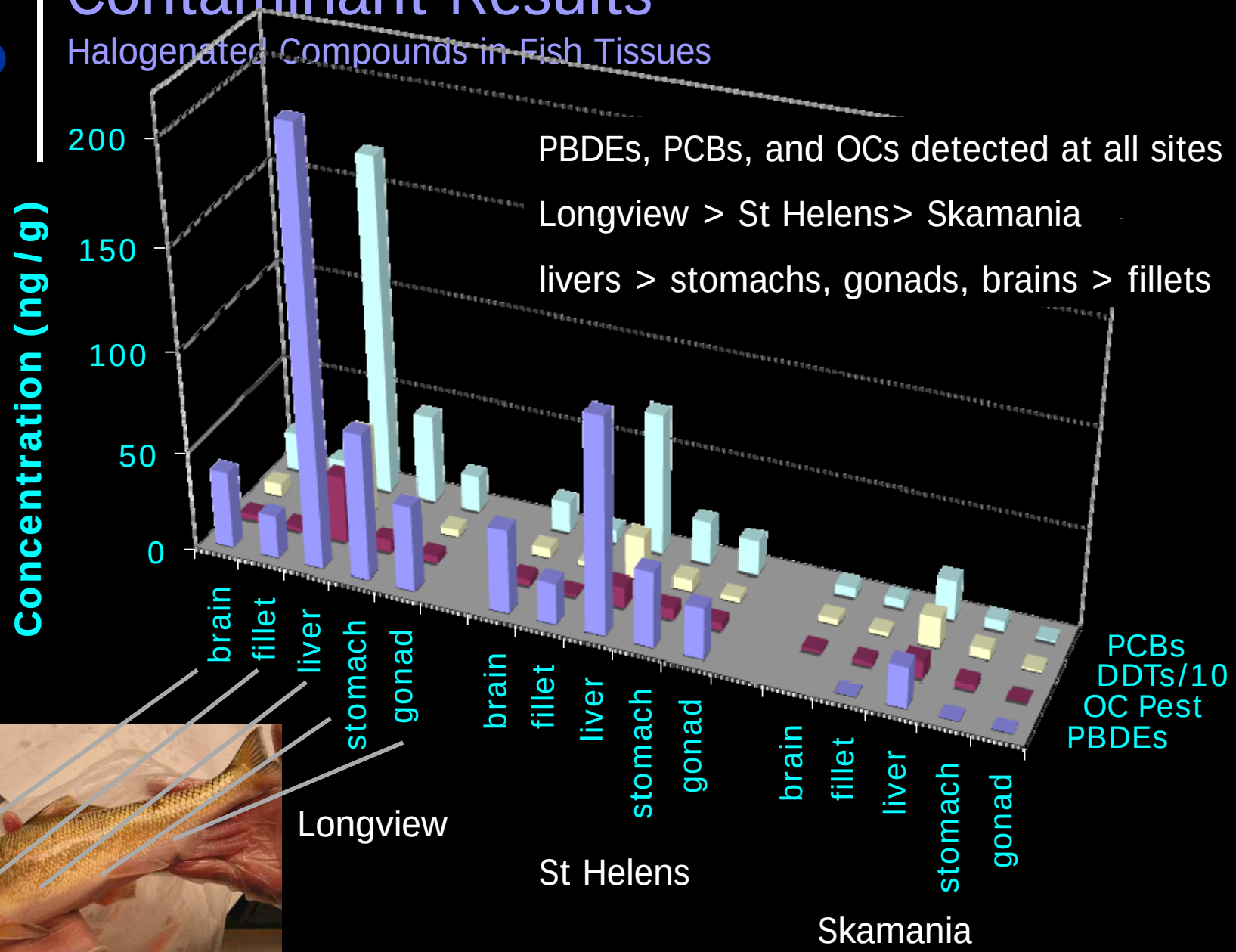
Contaminants of Concern --Tier I

Contaminant Name	Tier	Notes on spatial patterns	References for Columbia River Basin detections	Other notes	Seasonal considerations	Seasonal recommendation
DDT (and metabolites)	1	based on SPMDs, Yakima is major agricultural source, Willamette R., Johnson Cr., Wenatchee R, and Snake R are moderate sources Columbia Slough, Willamette R and Multnomah Ch. are sources affecting mainstem	USGS 1999, Ecology 2005, and LCREP 2007 for SPMDs CRITFC, EMAP, LCREP 2007, NOAA/COE 2007 , Bi-State, Yakima R, CCPT, and Willamette NAWQAs for fish EMAP, LCREP 2007, Bi-State, Yakima R, CCPT, and Willamette NAWQAs, various COE reports for bed sediment		Detection probable year round, No seasonality expected for inputs, but may get more detects in high flow with greater suspended sediment loads and resuspension	high flow
PCBs	1	SPMD conc. highest in tribs--Johnson Cr., Willamette R., Multnoman Ch., Columbia Slough (urban influences), Lake R., and Wenatchee R. sources in lower Willamette appear to be local, urban	Ecology 2005 and LCREP 2007 for SPMDs CRITFC, EMAP, NOAA/COE 2007, LCREP 2007, Bi-State, Willamette and CCPT NAWQAs for fish tissue EMAP, Willamette and CCPT NAWQAs, and various COE reports for bed sediment USGS 2006 for suspended sediment	EMAP congener method not high res GC/MS and Neither is NOAA method	Fewer detections on suspended sediments during low flow	high flow
Mercury (including methylmercury)	1		CRITFC and EMAP for fish tissue EMAP for bed sediment USGS 2006 for suspended sediment		Hg higher winter and spring (runoff and resuspension) meHg higher in summer and spring recommend 4 times/year for Hg and methylated Hg to get both seasonal flux and capture exposure periods (spring and fall)	multiple flows/seasons
PBDEs	1	LCREP and USGS data from Lower Columbia only Ecology data extends up to Spokane R.	Ecology and LCREP 2007 for SPMDs and fish tissue USGS 2006 for suspended sediment	detected at all sites on suspended sed, in SPMDs 10 of 11 sites	Detection probable year round, No seasonality expected for inputs, but may get more detects in high flow with greater suspended sediment loads and resuspension	high flow

USGS

Contaminant Results

Halogenated Compounds in Fish Tissues



PBDEs, PCBs, and OCs detected at all sites

Longview > St Helens> Skamania

livers > stomachs, gonads, brains > fillets

Contaminants of Concern—Tier II

Contaminant Name	Tier	Evidence of the Problem	Biological Effects	Reduction Strategies	Methods and Criteria	Sampling Media	Rationale (for media)	Media with detects in Columbia River or tributaries
PAHs	2	• widespread, plus hot spots in urban/industrial areas; also in stormwater • OR 303(d) list • exceeds regulatory criteria • evidence in water and sediment • evidence in fish and wildlife	• PBTs • possible/probable carcinogens • noncancer effects	• WA PBT Strategy • Sediment Clean up sites	• methods exist • regulatory criteria exist	1. passive sampling (SPMD), fish (bile and stomach contents), & sediment 2. water	hydrophobic sediment assists with source identification, metabolized in fish	SPMD fish stomach contents fish bile bed sediment
Arsenic	2	• widespread • OR 303(d) list • exceeds regulatory criteria • evidence in water and/or sediments	• human carcinogen (inorganic As) • noncancer effects	• OR TMDL to be scheduled • Similkameen TMDL	• methods exist • regulatory criteria exist • analytical costs low	1. water 2. fish 3. sediment	most transport in dissolved phase	water fish tissue sediment
Dioxins/furans	2	• widespread • 303(d) list in OR, WA, ID • exceeds regulatory criteria • evidence in fish and wildlife • OR fish consumption advisory	• PBT • endocrine disruptors • probable carcinogens	• TMDL, 1991 for main stem, Snake, and Willamette • TMDL in Columbia Slough	• methods exist • regulatory criteria exist • analytical costs rel. high	1. passive sampling (SPMD), fish & sediment	sediment assists with hot spot/source identification	SPMD fish tissue bed sediment
Lead	2	• local or regional, mining.smelter sites • WA fish consumption advisory in Spokane River • evidence in fish	• PBT • reasonably anticipated carcinogen (not EPA-classified) • noncancer effects	• TMDLs in Columbia Slough and the Spokane River • WA PBT Strategy • CERCLA--Upper Columbia	• methods exist • analytical costs low • regulatory criteria exist	1. water	adequate to determine spatial pattern	water fish tissue sediment
Organophospate Insecticides (azinphos methyl, chlorpyrifos, diazinon)	2	• 303(d) listings in the Yakima, Hood and Yamhill subbasins for endosulfan, azinphos methyl and chlorpyrifos • widespread in agricultural basins • evidence in water	• noncancer effects • sublethal effects on fish	• EPA Strategic Plan for Columbia • ODEQ Pesticide Stewardship Partnership	• methods exist • regulatory criteria exist	1. passive sampling (POCIS) 2. water	expect presence in dissolved and colloidal phase criteria based on water concentrations	water
Copper	2	•probably widespread, associated in part with stormwater • evidence in water and/or sediments	• sub-lethal effects on fish		• methods exist • analytical costs low • regulatory criteria exist	1. water	most transport in dissolved phase criteria based on water concentrations	water fish tissue sediment
Estrogenic compounds (Bisphenol A, AHTN, natural and synthetic estrogens [e.g., estradiol, estrone], Nonylphenol)	2	• extent unknown, but probably local, urban sites, outfalls • emerging problem, possibly increasing • detects with presumed effects on fish and aquatic biota	• endocrine disruptors	• ACWA "Don't Flush" program • OR Drug Take Back program	• methods not standardized for sed/biota for all compounds • no regulatory criteria	1. water 2. passive sampling (POCIS), fish, & sediment	analytical methods available for water and sediments (some compounds), being developed for tissues sediment assists with source identification	water fish blood

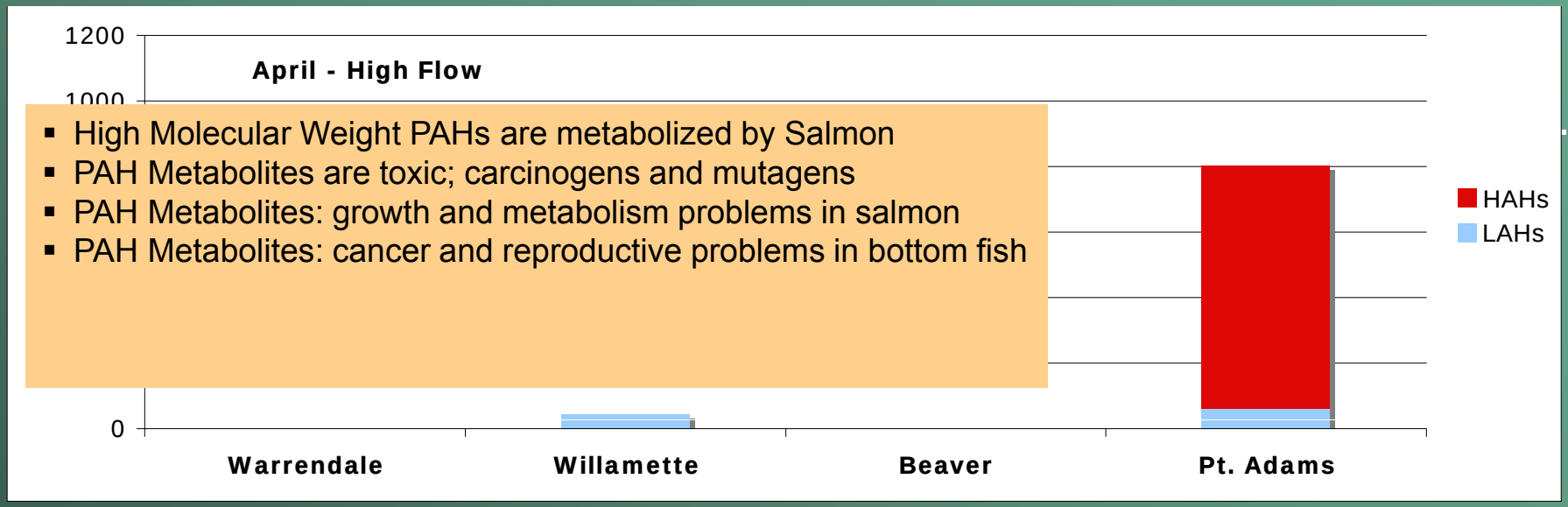
USGS

Contaminants of Concern --Tier II

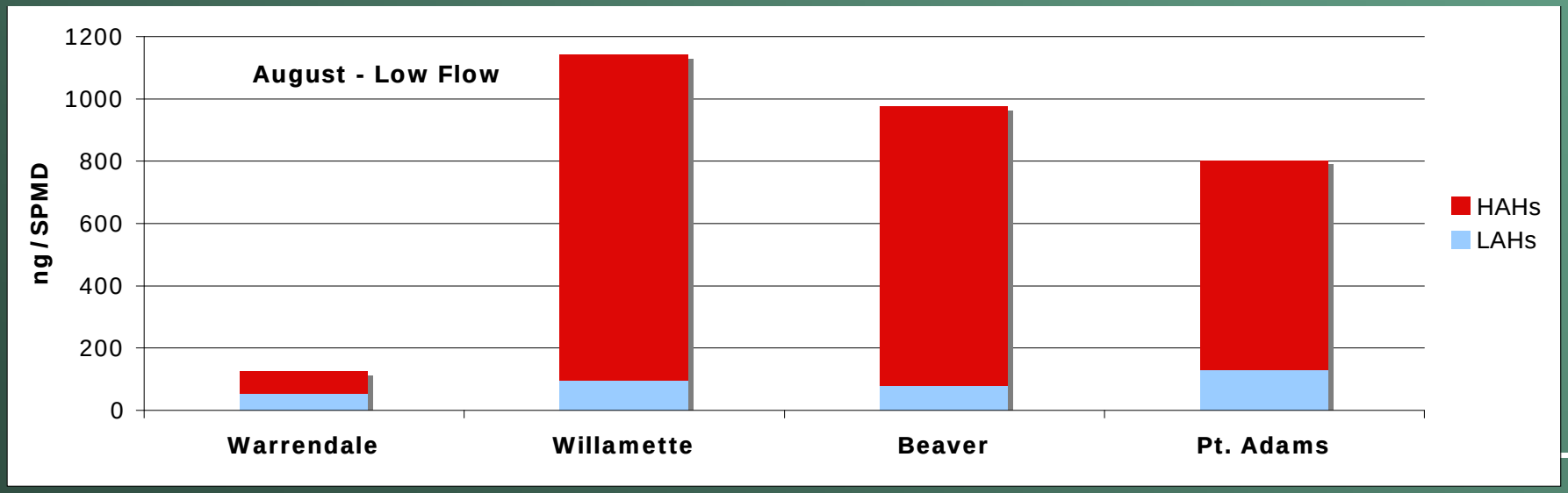
Contaminant Name	Tier	Notes on spatial patterns	References for Columbia River Basin detections	Other notes	Seasonal considerations	Seasonal recommendation
PAHs	2	Salmon stomach contents and bile data show highest levels in Portland/Vancouver area tribs (Willamette R), around Columbia City	USGS 1999 and LCREP 2007 for SPMDs CRITFC for fish tissue LCREP 2007 for stomach contents and fish bile NOAA/COE 2007 for salmon stomach contents EMAP, Bi-State, Willamette and CCPT NAWQAs, and various COE reports for bed sediment	Metabolized in fish, so may be easier to detect in bile or stomach contents than tissues	Detection probable year round, No seasonality expected for inputs, but may get more detects in high flow with greater suspended sediment loads and resuspension. Possible increased levels at tmes of high/first season road runoff	high flow
Arsenic	2	detected at main stem sites, not in tribs below Bonneville (water) Hanford data (sediment) indicate upstream source high in Yakima due to agricultural runoff	many datasets for water and sediment Bi-State, USGS 1994, and USGS 2006 for water, EMAP and Bi-State? for sediment CRITFC and EMAP for fish tissue (not speciated)	for fish consumption risk, need inorganic As	Detection probable year round	any time
Dioxins/furans	2	SPMD conc. highest in Portland/Vancouver tribs (Willamette R. and Johnson Cr) plus Yakima R.	USGS 1999, Ecology 2005 for SPMDs Bi-State and Willamette NAWQA for bed sediment CRITFC,Bi-State, and Willamette NAWQA for fish tissue	SPMDs did not detect 2,3,,7,8 TCDD (USGS and Ecology studies)		inadequate information
Lead	2	Willamette and CR detects sporadic, no clear spatial/temporal trends	USGS 2006 for water CRITFC and EMAP for fish tissue EMAP for bed sediment			any time
Organophospate Insecticides (azinphos methyl, chlorpyrifos, diazinon)	2	Detections in tributaries not mainstem, dependent on peak runoff and application from contributing tributaries	Willamette, CCPT, and Yakima NAWQAs for water		Dependent on peak runoff and application from contributing tributaries, but are usually sampled in late spring and early summer	pesticide- and location-specific
Copper	2	detected in water at all main stem sites and most tribs	many datasets for water and sediment USGS 2006 for water CRITFC and EMAP for fish tissue EMAP for bed sediment		Possible increased levels at times of high/first season road runoff	any time
Estrogenic compounds (Bisphenol A, AHTN, natural and synthetic estrogens [e.g., estradiol, estrone], Nonylphenol)	2	detects in Columbia but extent unknown	USGS 2006 for water, LCREP 2007 for fish blood		Detection probable year round, no seasonality expected for inputs but may see more during low flow because of less dilution	low flow

USGS

PAHs in the Lower Columbia River



- High Molecular Weight PAHs are metabolized by Salmon
- PAH Metabolites are toxic; carcinogens and mutagens
- PAH Metabolites: growth and metabolism problems in salmon
- PAH Metabolites: cancer and reproductive problems in bottom fish



USGS

Contaminants of Concern— Tier III

Contaminant Name	Tier	Evidence of the Problem	Biological Effects	Reduction Strategies	Methods and Criteria	Sampling Media	Rationale (for media)	Media with detects in Columbia River or tributaries
Organochlorines (alpha BHC, aldrin, dieldrin, chlordane, lindane)	3	• widespread at low levels; higher concentrations in agricultural areas • some are on the 303(d) list in WA	• PBTs • carcinogens	• Dieldrin TMDL in Snake, Walla Walla, and Yakima Rivers; Columbia Slough, and Johnson Creek • Walla Walla TMDL also addresses chlordane, toxaphene, heptachlor, heptachlor epoxide, hexachlorobenzene • some in EPA National PBT Action Plan	• methods exist • regulatory criteria exist for some	1. fish & passive sampling (SPMD) 2. sediment 3. water	hydrophobic bioaccumulative	SPMD fish tissue sediment water
Trace elements	3	• some are on the 303(d) lists in WA	• some have sublethal effects on fish	• Dissolved metals TMDL for lead, cadmium and zinc in Spokane River • CERCLA--Upper Columbia	• methods exist • analytical costs low • regulatory criteria exist	1. water	adequate to determine spatial pattern many transported in dissolved phase	water fish tissue sediment
Wastewater compounds 1	3	• extent unknown • emerging problem, possibly increasing large group of toxics of concern • evidence in water and/or sediments for some compounds	• some are endocrine disruptors		• methods exist for water and sediments • no (or few) regulatory criteria	1. water 2. fish 3. sediments	analytical methods available for water and sediments being developed for tissues	water
Pharmaceuticals	3	• extent unknown • emerging problem, possibly increasing	• some are endocrine disruptors	• ACWA "Don't Flush" program • OR Drug Take Back program	• methods exist for water and sediments • no regulatory criteria	1. water 2. passive sampling (POCIS) & fish 3. sediments	analytical methods available for water and sediments being developed for tissues	water
Hormones	3	• extent unknown • emerging problem, possibly increasing many included above under estrogenic compounds	• endocrine disruptors • some are suspected carcinogens (not EPA-classified)	• ACWA "Don't Flush" program • OR Drug Take Back program	• methods under development • no regulatory criteria	1. water 2. passive sampling (POCIS) & fish	analytical methods due to be released for water, being developed for tissues and sediments	
Current use pesticides (carbamates, triazine herbicides, fipronil)	3	• widespread in agricultural basins • emerging problem, use may be increasing • evidence in fish and wildlife and water and/or sediment for some	• effects on olfaction (carbamates) • endocrine disruptors, reproducive toxicants (triazine herbicides) • some with high toxicity to aquatic invertebrates in short-term exposures		• methods exist for water • methods exist for sediments, not widely available (some don't accumulate in sediments) • regulatory criteria exist	1. water & passive sampling (POCIS)	expect presence in dissolved and colloidal phase criteria based on water concentrations	water
synthetic pyrethroids	3	• extent unknown • emerging problem, use may be increasing	• potential to bioaccumulate (persistent in sediments) • effects on olfaction • endocrine disruptors • highly toxic to aquatic invertebrates and fish.		• methods exist, not widely available • some regulatory criteria exist	1. sediment 2. water	sediment assists with source identification, hydrophobic	
Phthalates	3	• extent unknown, probably regional, urban/industrial areas	• potential endocrine disruptors • possible/probable carcinogens		• methods exist, not widely available • some regulatory criteria exist but not for sediments	1. sediment	sediment assists with source identification, hydrophobic bioaccumulation somewhat limited because of metabolism	sediment

USGS

Contaminants of Concern— Tier III

Contaminant Name	Tier	Evidence of the Problem	Biological Effects	Reduction Strategies	Methods and Criteria	Sampling Media	Rationale (for media)	Media with detects in Columbia River or tributaries
Organochlorines (alpha BHC, aldrin, dieldrin, chlordane, lindane)	3	• widespread at low levels; higher concentrations in agricultural areas • some are on the 303(d) list in WA	• PBTs • carcinogens	• Dieldrin TMDL in Snake, Walla Walla, and Yakima Rivers; Columbia Slough, and Johnson Creek • Walla Walla TMDL also addresses chlordane, toxaphene, heptachlor, heptachlor epoxide, hexachlorobenzene • some in EPA National PBT Action Plan	• methods exist • regulatory criteria exist for some	1. fish & passive sampling (SPMD) 2. sediment 3. water	hydrophobic bioaccumulative	SPMD fish tissue sediment water
Trace elements	3	• some are on the 303(d) lists in WA	• some have sublethal effects on fish	• Dissolved metals TMDL for lead, cadmium and zinc in Spokane River • CERCLA--Upper Columbia	• methods exist • analytical costs low • regulatory criteria exist	1. water	adequate to determine spatial pattern many transported in dissolved phase	water fish tissue sediment
Wastewater compounds 1	3	• extent unknown • emerging problem, possibly increasing large group of toxics of concern • evidence in water and/or sediments for some compounds	• some are endocrine disruptors		• methods exist for water and sediments • no (or few) regulatory criteria	1. water 2. fish 3. sediments	analytical methods available for water and sediments being developed for tissues	water
Pharmaceuticals	3	• extent unknown • emerging problem, possibly increasing	• some are endocrine disruptors	• ACWA "Don't Flush" program • OR Drug Take Back program	• methods exist for water and sediments • no regulatory criteria	1. water 2. passive sampling (POCIS) & fish 3. sediments	analytical methods available for water and sediments being developed for tissues	water
Hormones	3	• extent unknown • emerging problem, possibly increasing many included above under estrogenic compounds	• endocrine disruptors • some are suspected carcinogens (not EPA-classified)	• ACWA "Don't Flush" program • OR Drug Take Back program	• methods under development • no regulatory criteria	1. water 2. passive sampling (POCIS) & fish	analytical methods due to be released for water, being developed for tissues and sediments	
Current use pesticides (carbamates, triazine herbicides, fipronil)	3	• widespread in agricultural basins • emerging problem, use may be increasing • evidence in fish and wildlife and water and/or sediment for some	• effects on olfaction (carbamates) • endocrine disruptors, reproducive toxicants (triazine herbicides) • some with high toxicity to aquatic invertebrates in short-term exposures		• methods exist for water • methods exist for sediments, not widely available (some don't accumulate in sediments) • regulatory criteria exist	1. water & passive sampling (POCIS)	expect presence in dissolved and colloidal phase criteria based on water concentrations	water
synthetic pyrethroids	3	• extent unknown • emerging problem, use may be increasing	• potential to bioaccumulate (persistent in sediments) • effects on olfaction • endocrine disruptors • highly toxic to aquatic invertebrates and fish.		• methods exist, not widely available • some regulatory criteria exist	1. sediment 2. water	sediment assists with source identification, hydrophobic	
Phthalates	3	• extent unknown, probably regional, urban/industrial areas	• potential endocrine disruptors • possible/probable carcinogens		• methods exist, not widely available • some regulatory criteria exist but not for sediments	1. sediment	sediment assists with source identification, hydrophobic bioaccumulation somewhat limited because of metabolism	sediment

USGS

Contaminants of Concern—Tier III

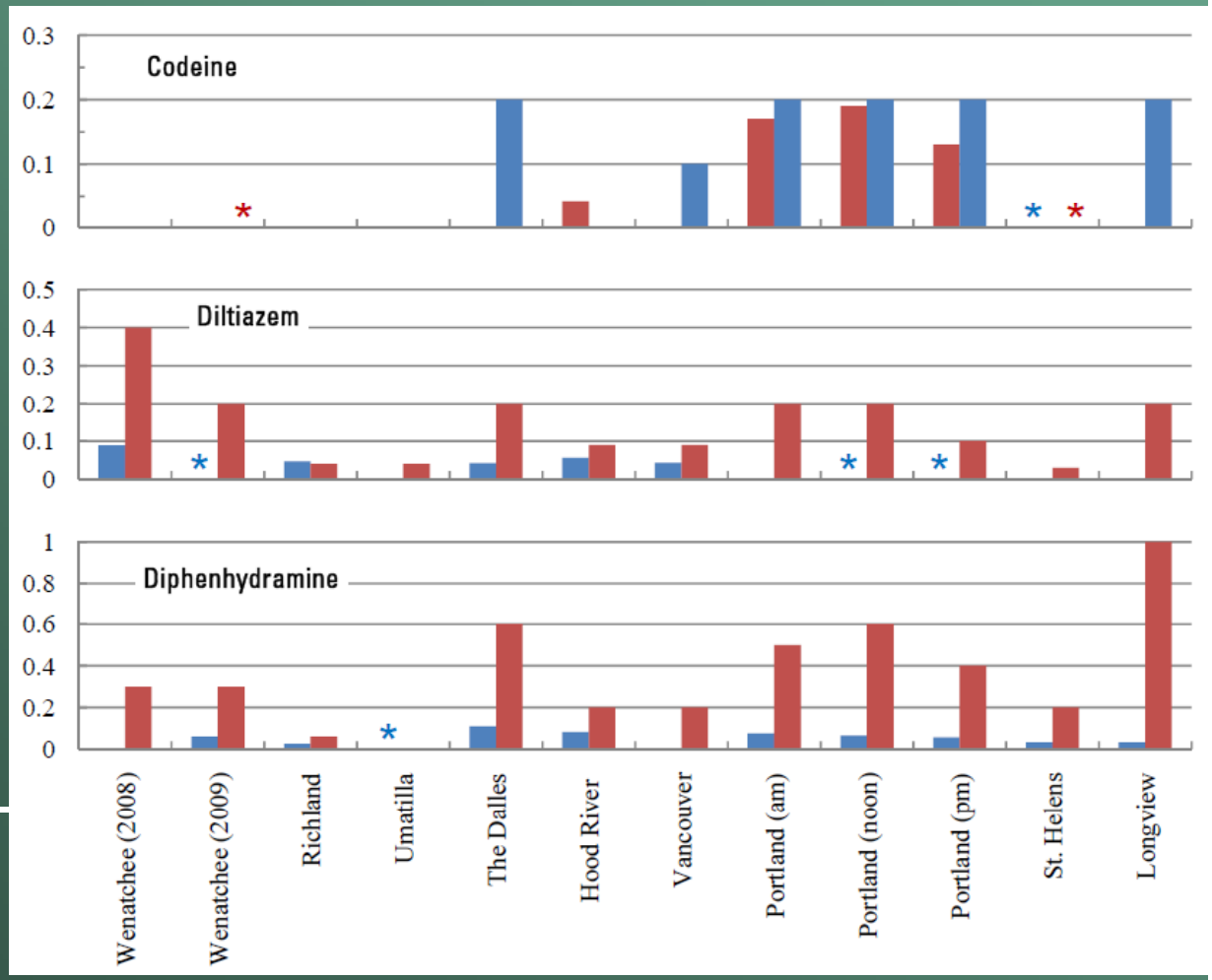
Contaminant Name	Tier	Notes on spatial patterns	References for Columbia River Basin detections	Other notes	Seasonal considerations	Seasonal recommendation
Organochlorines (alpha BHC, aldrin, dieldrin, chlordane, lindane)	3	based on SPMDs, Dieldrin and Lindane sources are from agr. activities above Bonneville, concentrations decrease downstream Willamette detects	Ecology 2005 and LCREP 2007 for SPMDs CRITFC, EMAP, LCREP 2007, Willamette and CCPT NAWQAs for fish tissue Yakima NAWQA for unfiltered water Bi-State, Willamette and CCPT NAWQAs for sediment		Dependent on peak runoff and application from contributing tributaries	pesticide- and location-specific
Trace elements	3	natural and anthropogenic sources, widely detected	Bi-State, USGS 1994, USGS 2006, Willamette, CCPT, and Yakima NAWQAs for water CRITFC, Bi-State and EMAP for fish tissue Various COE reports on dredged materials for bed sediments		Detection probable year round	any time
Wastewater compounds 1	3	detects in Columbia but extent unknown	USGS 2006 for water		Detection probable year round, no seasonality expected for inputs but may see more during low flow because of less dilution May also see incrased inputs during CSO events	low flow
Pharmaceuticals	3	detects in Columbia but extent unknown	USGS 2006 for water		Detection probable year round, no seasonality expected for inputs but may see more during low flow because of less dilution May also see incrased inputs during CSO events	low flow
Hormones	3	extent unknown			Detection probable year round, no seasonality expected for inputs but may see more during low flow because of less dilution May also see incrased inputs during CSO events	low flow
Current use pesticides (carbamates, triazine herbicides, fipronil)	3	Data from tribs plus mainstem below Bonneville found in 85-90% Willamette samples--lower conc. and fewer detects in mainstem below mouth of Willamette	Bi-State, USGS 1994, USGS 2006, Willamette, CCPT, and Yakima NAWQAs for water	atrazine, metochlor and simazine detected most frequently	Dependent on peak runoff and application from contributing tributaries	pesticide- and location-specific
synthetic pyrethroids	3			beginning to be reported in tissue, suspected bioaccumulative existing USGS analytical schedules include permethrin, cyfluthrin, cypermethrin, Kuivila method for sediments	Dependent on seasonality of home garden application	pesticide- and location-specific
Phthalates	3		Various COE reports on dredged materials for bed sediments	Seen in insects, but bioaccumulation in fish somewhat limited because of metabolism, may be higher in prey than in fish. Detected in water, sediments, and tissue.		

USGS

Tier –III Pharmaceuticals

Contaminants of Concern

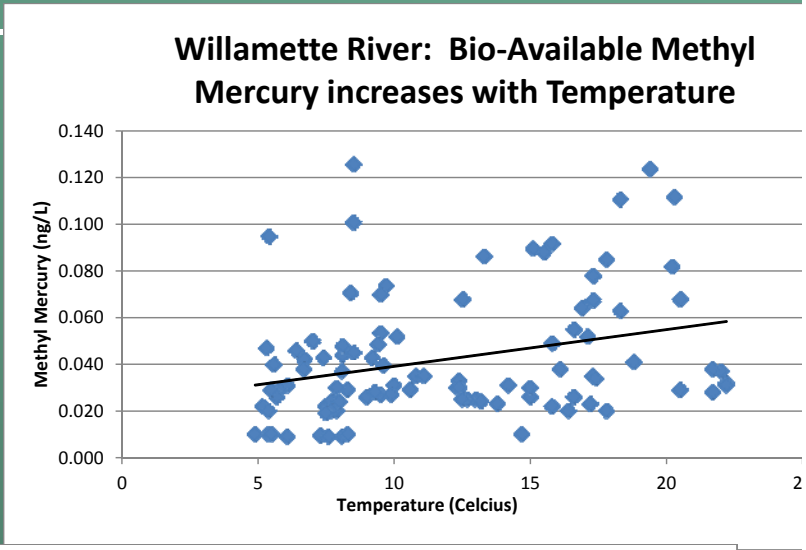
- Columbia River Inputs Study
- Management Implications
  - Mixing zones
  - Sediment
  - Resuspension
  - Aquatic Life

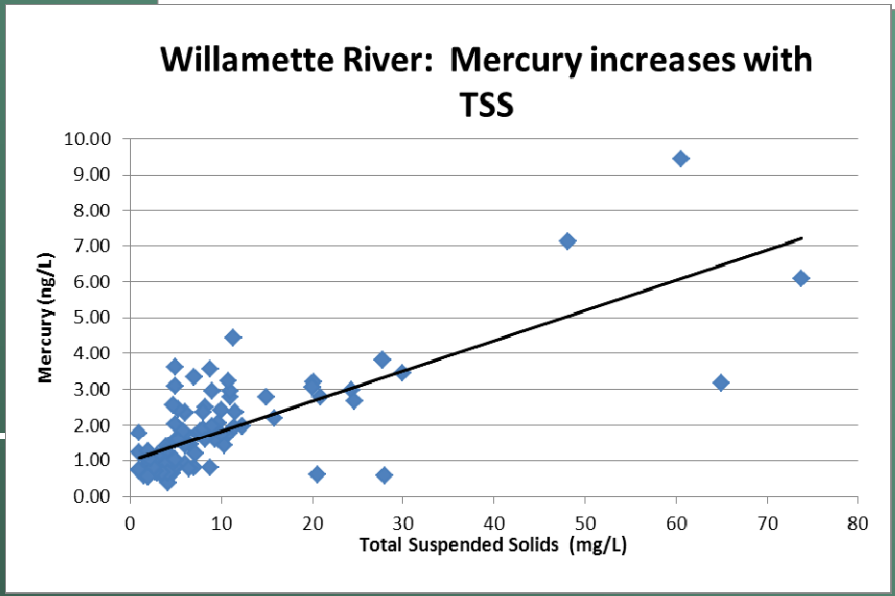


USGS

Where Do We go from Here?

- Will the physical models have utility for addressing "impact Assessments" related to contaminants?
- What other tools should we be considering to address contaminants?





USGS

Thank You!

USGS

BASIN	DAM /RIVER REACH	PROJ TYPE STORAGE/ RUN OF R.	PROJECT OWNER	WATER QUALITY MODEL CE-QUAL-W2 2-D	MASS1 1-D	MASS2 2-D	RBM-10 1-D	SYSTDG EMPIRICAL	WQRRS 1-D	EFDC 3-D	HEC-RAS* 1-D	CORIE	WHO DEVELOPED MODEL?	COST	IS CALIBRATION DATA AVAILABLE ? RIVER TEMPS	FB TEMPS	VERTICAL PROFILES	TW TEMPS	TDG FB/TW	TDG STUDY	FLOWS	WEATHER
											*(Currently RAS models do not include T OR TDG But RAS has those capabilities)											
KOOTENAI																						
	LIBBY	**STR**	COE, NWS	T							STEADY		NWS, COE			YES	YES	YES	YES	YES	YES	YES
	LIBBY DAM TW TO BORDER		COE, NWS	T									NWS		YES					YES	YES	YES
	BONNERS FERRY TO BORDER										UNSTEADY		COE								YES	YES
FLATHEAD																						
	HUNGRY HORSE	**STR**	BOR													YES	YES	YES	YES		YES	YES
	KERR (FLATHEAD LAKE)	**STR**	PPL MONTANA								UNSTEADY		COE								YES	YES
CLARK FORK																						
	THOMPSON FALLS	**ROR**	PPL MONTANA								STEADY		COE								YES	YES
	NOXON	**STR**	AVISTA								STEADY		COE								YES	YES
	CABINET GORGE	**ROR**	AVISTA								STEADY		COE				YES	YES	YES		YES	YES
PEND OREILLE																						
	PRIEST LAKE	**STR**	WA WATER PWR								UNSTEADY		COE			YES	YES	YES			YES	YES
	ALBENI FALLS	**ROR**	COE, NWS	T, WQ							UNSTEADY		PSU, NWS. IDEQ/COE		YES	YES	YES	YES	YES	YES	YES	YES
	BOX CANYON TW TO ALBENI FALLS TW		PEND OREILLE PUD	T							STEADY		PSU/WDOE/COE		YES	YES	YES	YES	YES	YES	YES	YES
	BOX CANYON DAM TO BOUNDARY DAM		SEATTLE CITY LIGHT	T							STEADY		PNNL/COE/CITY LIGHT	$150,000	YES	YES	YES	YES			YES	YES
	BOUNDARY DAM TO CANADIAN BORDER			T							STEADY		BATTELLE-WDOE/COE/CITY LIGHT		YES	YES	YES	YES	YES	YES	YES	YES
	SEVEN MILE (CANADA)	**ROR**	BC HYDRO																YES		YES	YES
	WANETA (CANADA)	**ROR**	TECK RESOURCES																YES		YES	YES
SPOKANE R																						
	LONG LAKE DAM TO COL R	**STR**		T, WQ									PSU, Spokane Tribes		YES	YES	YES	YES			YES	YES
COLUMBIA R																						
	BORDER TO GRAND COULEE										STEADY		COE		YES				YES		YES	YES
	GRAND COULEE TO RICHLAND										STEADY		COE		YES				YES		YES	YES
	RICHLAND TO MCNARY DAM										UNSTEADY		COE		YES				YES		YES	YES
	MCNARY TO BONNEVILLE DAM										STEADY		COE		YES				YES		YES	YES
	BONNEVILLE DAM TO OCEAN										UNSTEADY		COE		YES				YES		YES	YES
	COL R. GRAND COULEE TO BON		COE, PUDS					TDG					ERDC									
	PRIEST RADIDS DAM TO COL RM 110		COE, PUD		T,TDG	T, TDG					UNSTEADY		PNNL/COE		YES	YES		YES	YES		YES	YES
	GRAND COULEE	**STR**	BOR	T	T		T	TDG								YES	YES	YES	YES	YES	YES	YES
	BANKS LAKE	**STR**	BOR										PSU?									
	CHIEF JOSEPH	**ROR**	COE	T	T		T	TDG					MIKE S.	$20,000	YES	YES	YES	YES	YES	YES	YES	YES
	WELLS	**ROR**	DOUGLAS CO PUD	T	T		T	TDG					WEST		YES	YES	YES	YES	YES	YES	YES	YES
	CHELAN	**ROR**	CHELAN CO PUD	T									WEST		YES	YES	YES	YES			YES	YES
	ROCKY REACH	**ROR**	CHELAN CO PUD	T	T		T	TDG					WEST		YES	YES	YES	YES	YES		YES	YES
	ROCK ISLAND	**ROR**	CHELAN CO PUD	T	T		T	TDG							YES	YES	YES	YES	YES	YES	YES	YES
	WANAPUM	**ROR**	GRANT CO PUD		T		T	TDG					PNNL		YES	YES	YES	YES	YES	YES	YES	YES
	PRIEST RAPIDS	**ROR**	GRANT CO PUD		T	T, TDG	T	TDG					PNNL		YES	YES	YES	YES	YES		YES	YES
	MCNARY	**ROR**	COE		T	T, TDG	T	TDG					PNNL		YES	YES	YES	YES	YES	YES	YES	YES
	JOHN DAY	**ROR**	COE		T	T, TDG	T	TDG							YES	YES	YES	YES	YES	YES	YES	YES
	THE DALLES	**ROR**	COE		T	T, TDG	T	TDG							YES	YES	YES	YES	YES	YES	YES	YES
	BONNEVILLE	**ROR**	COE		T	T, TDG		TDG							YES	YES	YES	YES	YES	YES	YES	YES
	BONNEVILLE TO BEAVER ARMY TERMINAL			T, WQ									PSU, ODEQ, CLACKAMAS COUNTY		YES	YES		YES	YES	YES	YES	YES
	Last 20 miles+ of Columbia River											T, WQ	OHSU/OGI-Antonio Baptista and NOAA									
	CAMUS-WASHOUGAL							TDG												YES		
	COL R - ESTUARY TO CANADIAN BORDER				T		T						PNNL/EPA		YES	YES		YES			YES	YES
	COL R GRAND COULEE TO CAMAS							TDG					COE/ERDC						YES	YES	YES	YES

BASIN	DAM /RIVER REACH	PROJ TYPE STORAGE/ RUN OF R.	PROJECT OWNER	WATER QUALITY MODEL CE-QUAL-W2 2-D	MASS1 1-D	MASS2 2-D	RBM-10 1-D	SYSTDG EMPIRICAL	WQRRS 1-D	EFDC 3-D	HEC-RAS* 1-D	CORIE	WHO DEVELOPED MODEL?	COST	IS CALIBRATION DATA AVAILABLE ? RIVER TEMPS	FB TEMPS	VERTICAL PROFILES	TW TEMPS	TDG FB/TW	TDG STUDY	FLOWS	WEATHER
SNAKE RIVER																						
	BROWNLEE	**STR**	Idaho Power	T									Scott Wells, PSU			YES	YES	YES			YES	YES
	OXBOW	**ROR**	Idaho Power	T									Scott Wells, PSU			YES	YES	YES			YES	YES
	HELLS CANYON	**ROR**	Idaho Power	T									Scott Wells, PSU			YES	YES	YES			YES	YES
	HELLS CANYON TO LEWISTON								T,TDG,DO	(MIKE 11)			IDAHO POWER		YES					YES	YES	YES
	HELLS CANYON TO LOWER GRANITE				T								PNNL		YES						YES	YES
	SNAKE R MOUTH OF SALMON TO COL R						T						EPA		YES	YES	YES	YES			YES	YES
	ANATONE TO CLEARWATER CONFLUENCE			T									ERDC		yes						yes	yes
	SNAKE R DWORSHAK TO MCNARY							TDG					COE/ERDC						YES	YES	YES	YES
	LEWISTON TO LOWER GRANITE					T, TDG					UNSTEADY										YES	YES
	MOUTH CLEARWATER TO MCNARY DAM					T, TDG				T			PNNL		YES	YES	YES	YES	YES		YES	YES
	LOWER GRANITE	**ROR**	COE	T	T, TDG	T, TDG	T	TDG	T, WQ				ERDC/PNNL/EPA/FTN ASSOC.	$283,000	YES	YES	YES	YES	YES		YES	YES
	LITTLE GOOSE	**ROR**	COE	T	T, TDG	T, TDG	T	TDG	T, WQ				ERDC/PNNL/EPA/FTN ASSOC.	$133,000	YES		YES	YES	YES		YES	YES
	LOWER MONUMENTAL	**ROR**	COE	T, TDG	T, TDG	T, TDG	T	TDG	T, WQ				ERDC/PNNL/EPA/FTN ASSOC.	$199,000	YES	YES	YES	YES	YES		YES	YES
	ICE HARBOR	**ROR**	COE	T	T, TDG	T, TDG	T	TDG	T, WQ				ERDC/PNNL/EPA/FTN ASSOC.	$151,000	YES	YES	YES	YES	YES		YES	YES
																	YES	YES			YES	YES
CLEARWATER																						
	DWORSHAK	**STR**	COE	T				TDG					ERDC	$166,000		YES	YES	YES	YES		YES	YES
	DWORSHAK TO SNAKE			T	T			TDG					ERDC		YES	YES	YES	YES	YES		YES	YES
	DWORSHAK TO COL R			T				TDG					ERDC				YES	YES	YES		YES	YES
	CLEARWATER R OROFINO TO LEWISTON			T			T						ERDC/ EPA		YES						YES	YES
WILLAMETTE																						
	WILLAMETTE FALLS TO COL R			T, WQ									PSU, ODEQ, CLACKAMAS COUNTY		YES						YES	YES

MODEL ATTRIBUTES & ADVANTAGES

MODELS DIVIDE EACH REACH OR DAM POOL INTO NUMBERED SEGMENTS STARTING FROM THE UPSTREAM TO DOWNSTREAM END.

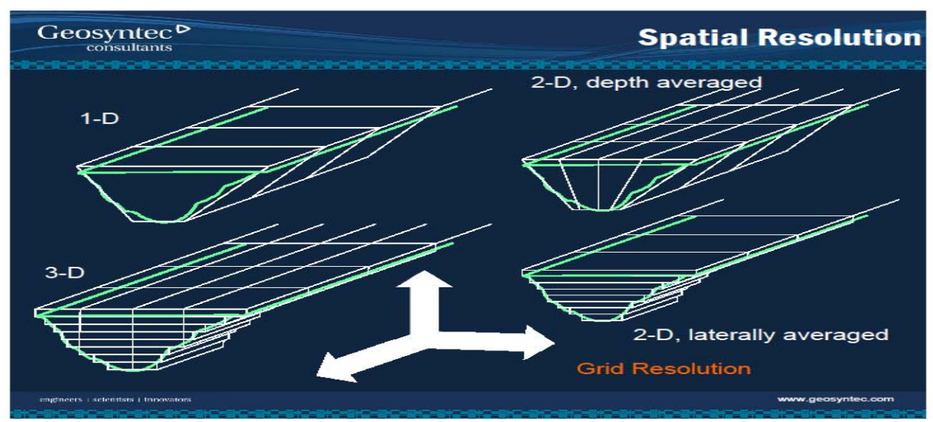
CE-QUAL-W2	2-DIMENSIONAL. COMPUTES TEMPERATURE IN EACH LONGITUDUNAL SEGMENT AT EACH HORIZONTAL LAYER **(LATERALLY AVERAGED)**. MODELS TDG, NUTRIENTS, DO, ALGAE, ZOOPLANK, HABITAT, SEDIMENT, CARBON FORMS.
RBM-10	1-DIMENSIONAL. COMPUTES TEMPERATURE IN EACH LONGITUDUNAL SEGMENT.
MASS1	1-DIMENSIONAL. COMPUTES TEMPERATURE IN EACH LONGITUDUNAL SEGMENT.
MASS2	2-DIMENSIONAL. COMPUTES TEMPERATURE IN EACH LONGITUDINAL SEGMENT IN VERTICAL LAYERS **(DEPTH AVERAGED)** .
WQRRS	1-DIMENSIONAL. COMPUTES TEMPERATURE IN EACH LONGITUDUNAL SEGMENT.
SYSTDG	COMPUTES FOREBAY AND TAILWATER TDG BASED ON EMPIRICAL OBSERVATIONS OF TDG IN RELATTION TO SPILL AND SPILL PATTERN
RAS STEADY/UNSTEADY	RAS STEADY COMPUTES WATER ELEVATIONS IN REACHES BASED ON A STEADY FLOW. UNSTEADY MODELS REACH ELEVATIONS BASED ON HYRDOGRAPH. RAS CAN MODEL SOME WQ PARAMETRES - T, DO AND OTHERS. No vegetative or topographic shade (may not matter r
MIKE11	1-DIMENSIONAL. COMPUTES TEMPERATURE IN EACH LONGITUDUNAL SEGMENT. USES ADDITIONAL MODEL TO CALCULATE TDG AND TEMPERATURE (ECOLAB)
EFDC	3-DIMENSIONAL. COMPUTES TEMPERATURE IN EACH HORIZONTAL AND VERTICAL LAYER IN EACN LONGITUDINAL SEGMENT.

SOURCES FOR MODEL APPLICATIONS

MIKE SCHNEIDER, ERDC 541-298-6872, W2, SYSTDG
STEVE JUUL, NWW 509-527-7281, W2
KENT EASTHOUSE, NWS 206-764-6926, W2
ROB ANNEAR, GEOSYNTEC, 503-222-9518, W2
MARSHALL RICHMOND, BATTELLE 509-373-6241, MASS1 &2, EFDC
TARANG KHANGOANKAR, BATTELLE, 206-528-3053, W2
SHAUN PARKINSON, IDAHO POWER 208-388-2495 W2, MIKE 11
KEITH DUFFY, NWP, 503-808-4969, HEC-RAS

RBM-10
MASS1
MIKE 11

EFDC



MASS2

CE-QUAL-W2

OVERVIEW OF WATER QUALITY MODELS USED IN THE COLUMBIA RIVER BASIN

The attached spreadsheet contains a list of projects and river reaches where water quality models have been developed in the Columbia River Basin. The area covered includes projects and river reaches in the Flathead, Kootenai, Clark Fork, Pond Oreille, Spokane, Columbia, Snake and Clearwater rivers. The effort to find models was limited in the Columbia to the reach from the estuary to the Canadian border and in the Snake up to Brownlee Dam (river mile 285). Information in the spreadsheet was gathered by interviewing several individuals with knowledge of modeling efforts. The list of individuals and contact phone numbers is included in the spreadsheet. The water quality models applied include CE- QUAL-W2, MASS1, MASS2, RBM-10, SYSTDG, WQRRS, MIKE 11, EFDC and RAS. The models were developed by public and private entities primarily for temperature and total dissolved gas (TDG) applications.

CE-QUAL-W2 is a Corps of engineers model used worldwide to model numerous water bodies. It is a hydrodynamic, 2-D laterally averaged water quality model capable of modeling physical, chemical and biological characteristics of rivers, lakes, reservoirs and estuaries. It has been used in the Columbia River Basin to primarily model water temperatures. As mentioned, CE-QUAL-W2, W2 for short, is a laterally averaged model. This means it predicts temperatures along the length of a water body and in layers from top to bottom. A Drawing of what this means is included in the spreadsheet. W2 can also model TDG and has been used to model TDG in one Snake River Project – Lower Monumental (Schneider, personal communication). An advantage of W2 is that, should the need arise later, other water quality parameters such as dissolved oxygen, nutrients, algae, zooplankton, and habitat can also be modeled.

MASS1 is a 1-D model developed by Battelle that models temperature along the length of a water body with the temperature in each segment computed as an average from top to bottom. It has been used to predict temperature and TDG in Columbia River projects from the estuary to Grand Coulee and in the Snake River up to Brownlee.

MASS2 is a 2-D model that has been used to model temperature and TDG in Columbia and Snake River Projects. It models these parameters along the length of a water body but unlike most 2-D models it computes a depth averaged temperature in each segment, for example, instead of predicting temperature in each segment in horizontal layers. It predicts them in vertical layers that extend from top to bottom. In this way it can give an idea of near shore temperatures compared to mid water body temperatures thus providing estimates of habitat conditions (see figure in spreadsheet).

RBM-10 is a 1-D model that computes temperatures along the length of a water body. It has been used by EPA in an effort to develop temperature targets for a Columbia and Snake River temperature Total Daily Maximum Load (TMDL). The TMDL effort for these rivers has been put on hold.

SYSTDG is an empirically based model that requires forebay and tailwater TDG measurements as well as flow and operations data to derive equations that predict TDG at a project.

WQRSS is a 1-D precursor to W2 that is rarely used.

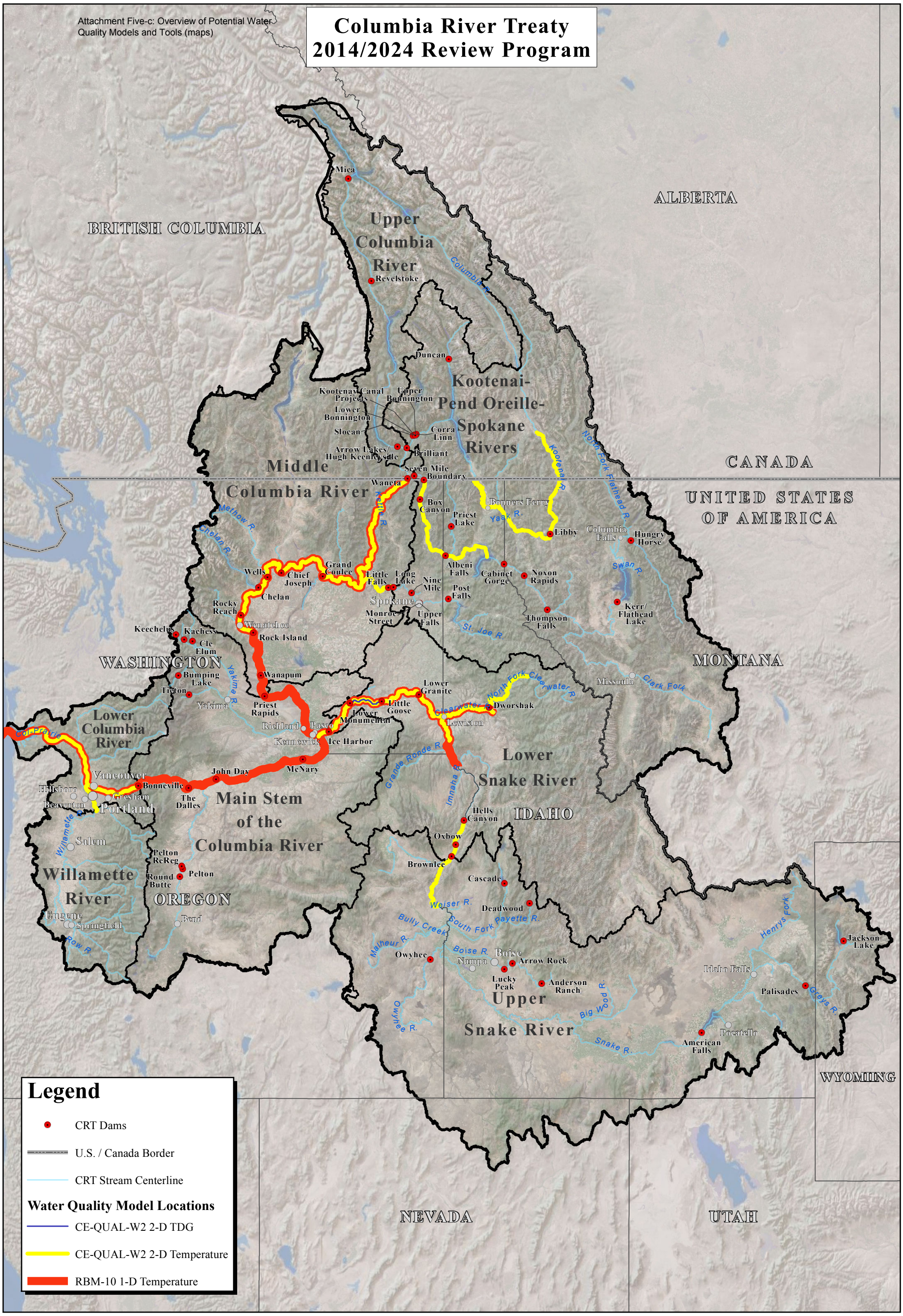
EFDC is a W2 like model that predicts temperatures in 3 dimensions. It is primarily used to model forebay temperatures but has also been used to track water temperatures between the confluence of the Snake and Clearwater to McNary dam.

Mike 11 is a 1-D model used by Idaho Power to model temperature, TDG and DO from Hells Canyon dam to Lewiston Idaho.

RAS is a 1-D hydraulics model that is used to compute water elevations under steady and unsteady (hydrograph) flows in a river system. It can also model certain water quality parameters such as temperature, TDG, DO and nutrients (HEC, personal communication). The unsteady form would be best for water quality applications.

Attachment Five-c: Overview of Potential Water Quality Models and Tools (maps)

Columbia River Treaty 2014/2024 Review Program



0 60 120
Miles

Map Created: 25 AUG 2011
Imagery: © 2010 MDA Information Systems, USGS, NASA

Columbia River Watershed - Water Quality Model Extents

N

SHEET 1 OF 5

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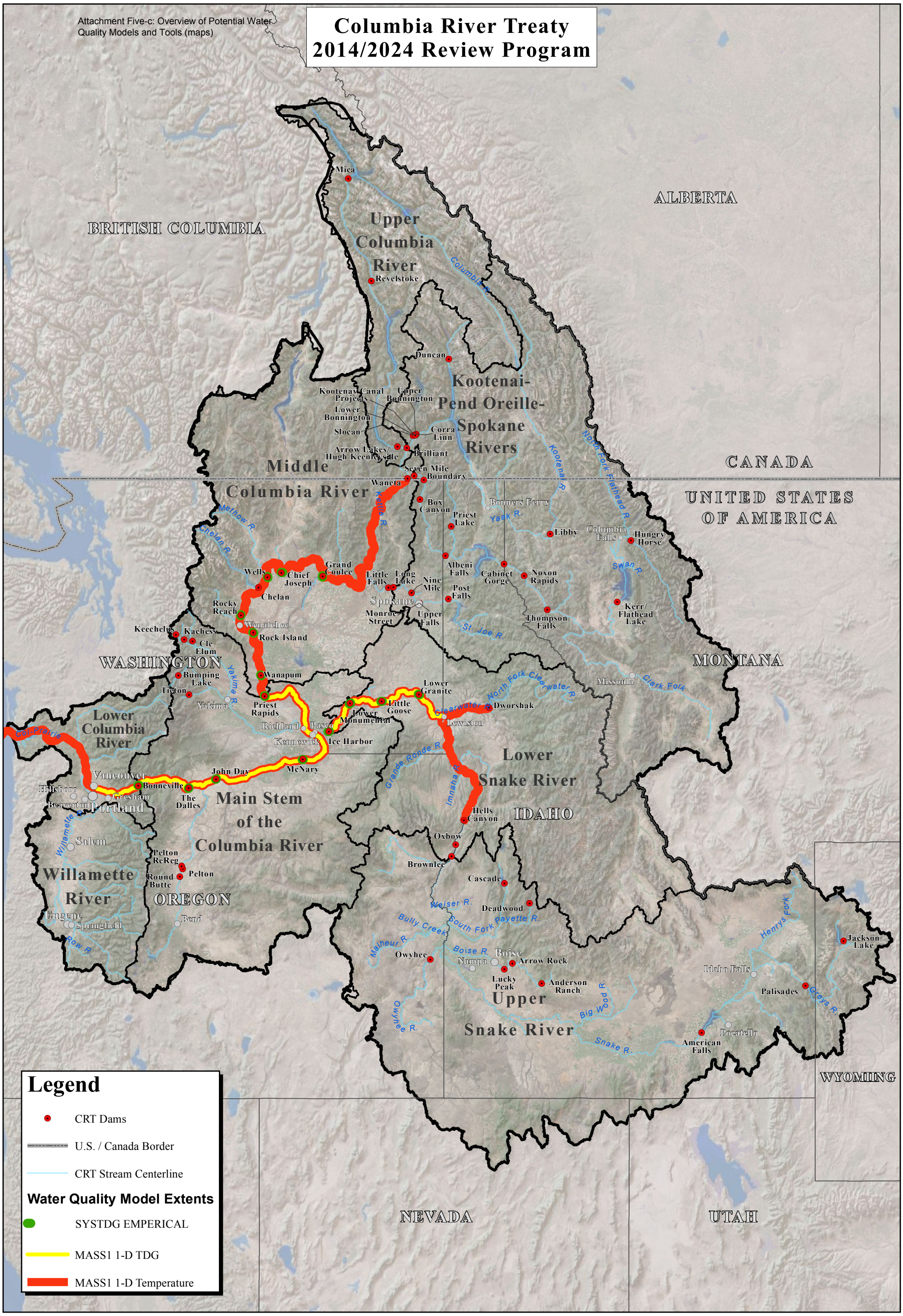
Attachment Five-c: Overview of Potential Water Quality Models and Tools (maps)

Columbia River Treaty 2014/2024 Review Program



Map Created: 25 AUG 2011
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0 60 120
Miles

Columbia River Watershed - Water Quality Model Extents

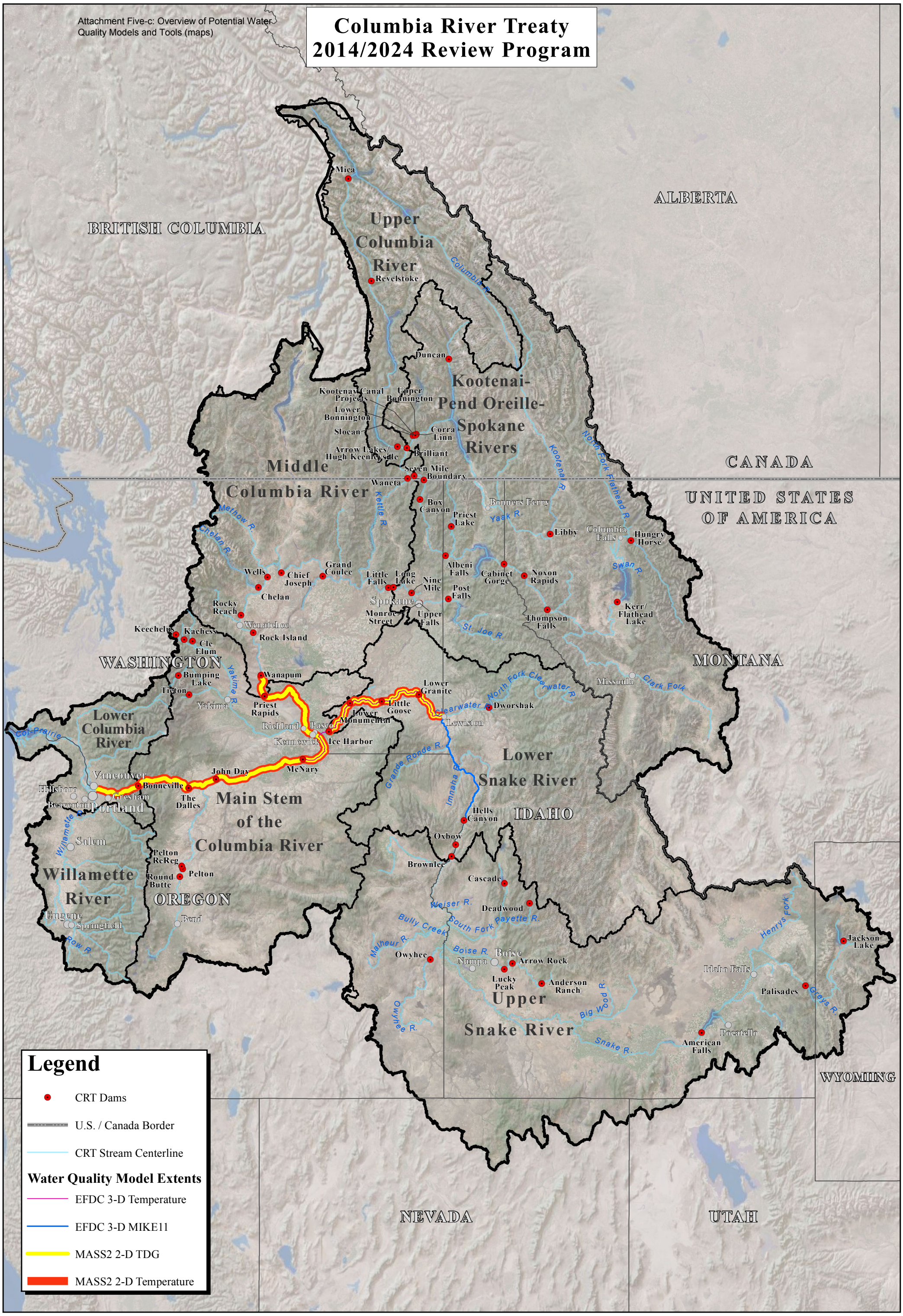
N

SHEET 2 OF 5

US Army Corps of Engineers®

Attachment Five-c: Overview of Potential Water Quality Models and Tools (maps)

Columbia River Treaty 2014/2024 Review Program



Map Created: 25 AUG 2011
Imagery: © 2010 MDA Information Systems, USGS, NASA

0 60 120
Miles

Columbia River Watershed - Water Quality Model Extents

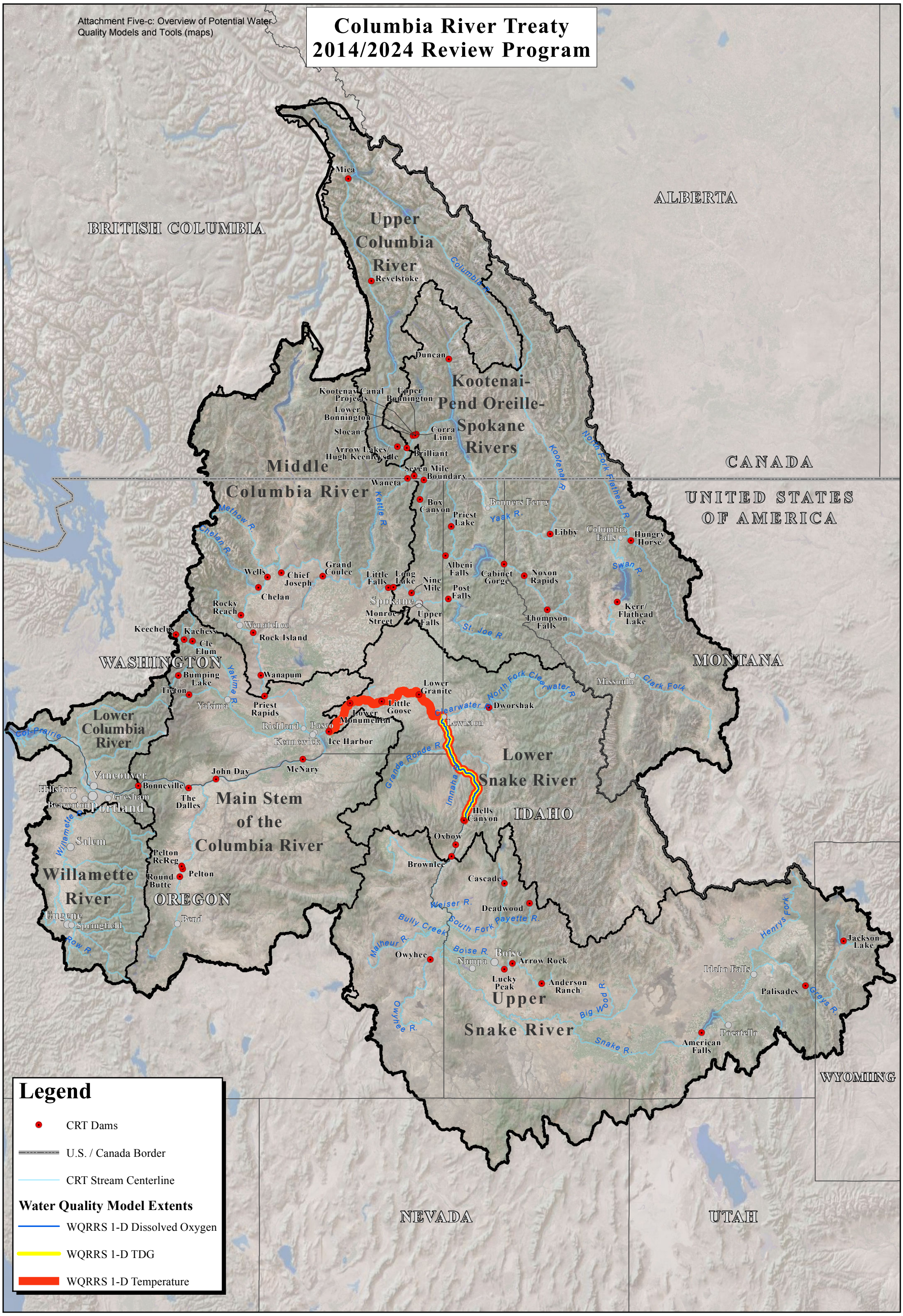
N

SHEET 3 OF 5

US Army Corps of Engineers®

Attachment Five-c: Overview of Potential Water Quality Models and Tools (maps)

Columbia River Treaty 2014/2024 Review Program



Map Created: 25 AUG 2011
Imagery: © 2010 MDA Information Systems, USGS, NASA

0 60 120
Miles

Columbia River Watershed - Water Quality Model Extents

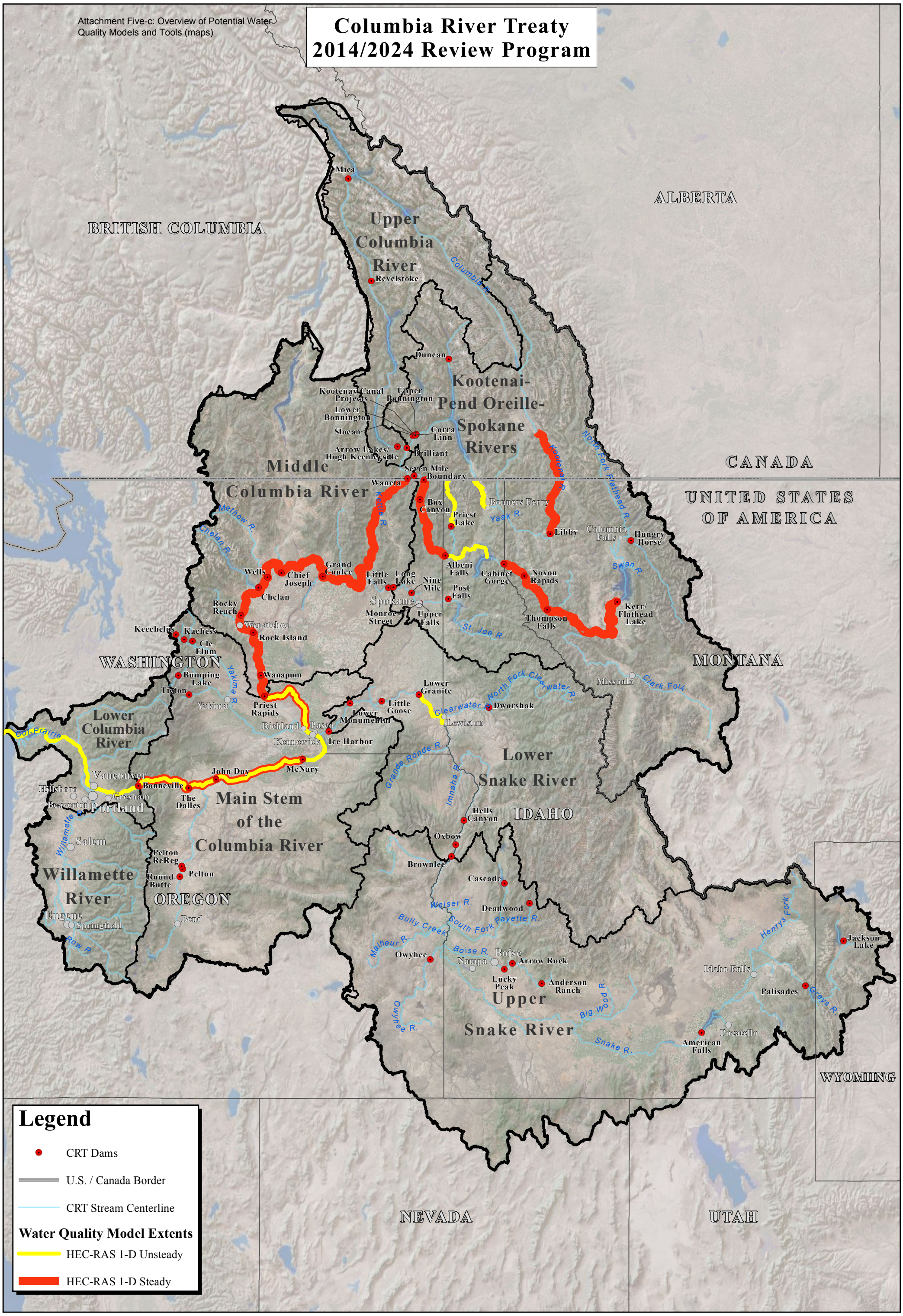
N

SHEET 4 OF 5

US Army Corps of Engineers®

Attachment Five-c: Overview of Potential Water Quality Models and Tools (maps)

Columbia River Treaty 2014/2024 Review Program



Map Created: 25 AUG 2011
Imagery: © 2010 MDA Information Systems, USGS, NASA

0 60 120
Miles

Columbia River Watershed - Water Quality Model Extents

N

SHEET 5 OF 5

US Army Corps of Engineers®

Modeling Effects of Contaminants on Salmon in the Columbia Basin

Lyndal L. Johnson
NOAA Fisheries Northwest Fisheries Science Center
Seattle, WA

Columbia River Treaty 2014/2024 Review
Sovereign Technical Team Water Quality Workshop

Wednesday, August 31, 2011

Twenty-seven salmon and steelhead population segments, or Evolutionarily Significant Units (ESUs), are currently listed as either threatened or endangered under the U.S. Endangered Species Act (ESA)

This include 13 stocks in the Columbia Basin

- Snake River Spring/Summer Chinook
- Snake River Fall Chinook
- Lower Columbia River Chinook
- Upper Willamette River Chinook
- Upper Columbia River Spring Chinook
- Lower Columbia River Coho
- Columbia River Chum
- Snake River Sockeye
- Upper Willamette Steelhead
- Snake River Steelhead
- Lower Columbia River Steelhead
- Upper Columbia River Steelhead
- Middle Columbia River Steelhead

Factors Contributing to Salmon Population Declines

- Harvest
- Hydropower
- Hatchery practices
- Habitat loss
- Toxic chemicals
- Predation
- Climate change
- Disease

Contaminants That Pose Risks to Salmon

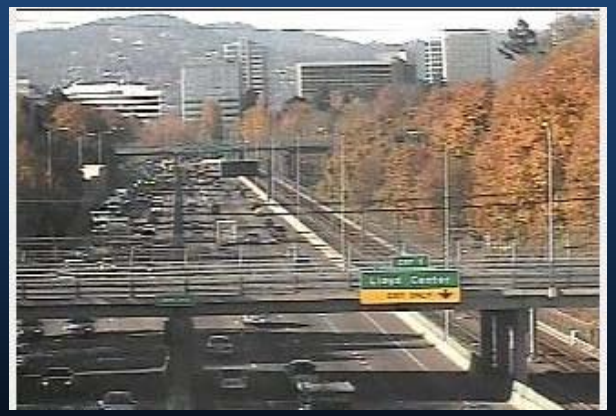
Persistent and bioaccumulative organic pollutants (e.g., PCBs, DDTs, PBDEs)

Wastewater Compounds—Pharmaceuticals, personal care products, caffeine, nicotine

Current use pesticides--common as mixtures in fish habitats

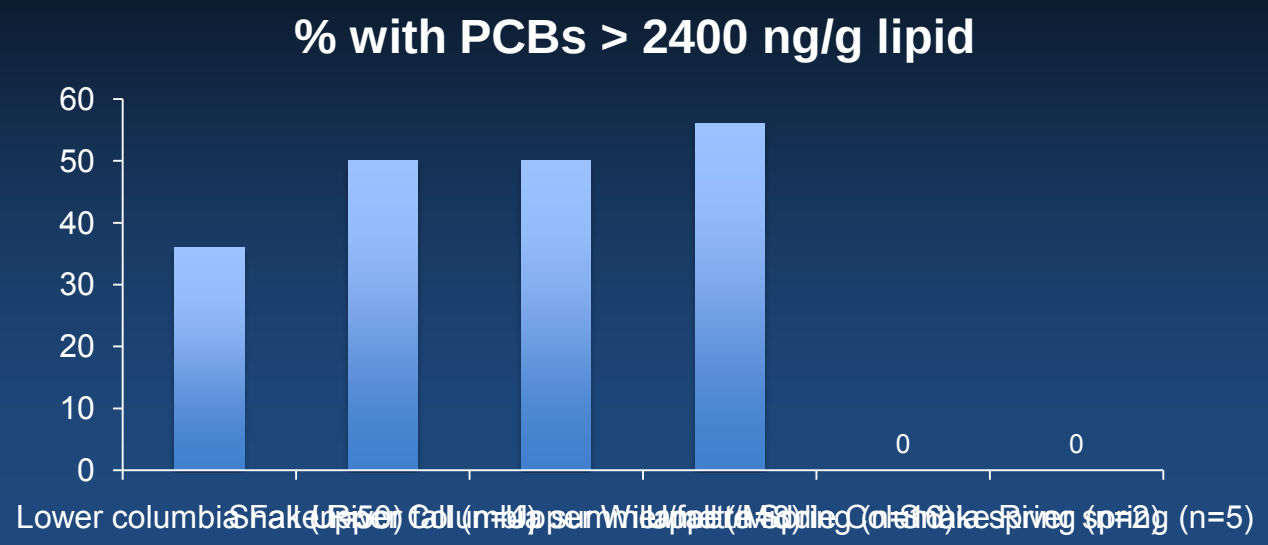
- organophosphate insecticides (diazanon, chlorpyrifos)
- carbamate insecticides (carbaryl, carbofuran)
- pyrethroid insecticides (cypermethrin, esfenvalerate)
- Herbicides (2,4-D, atrazine)

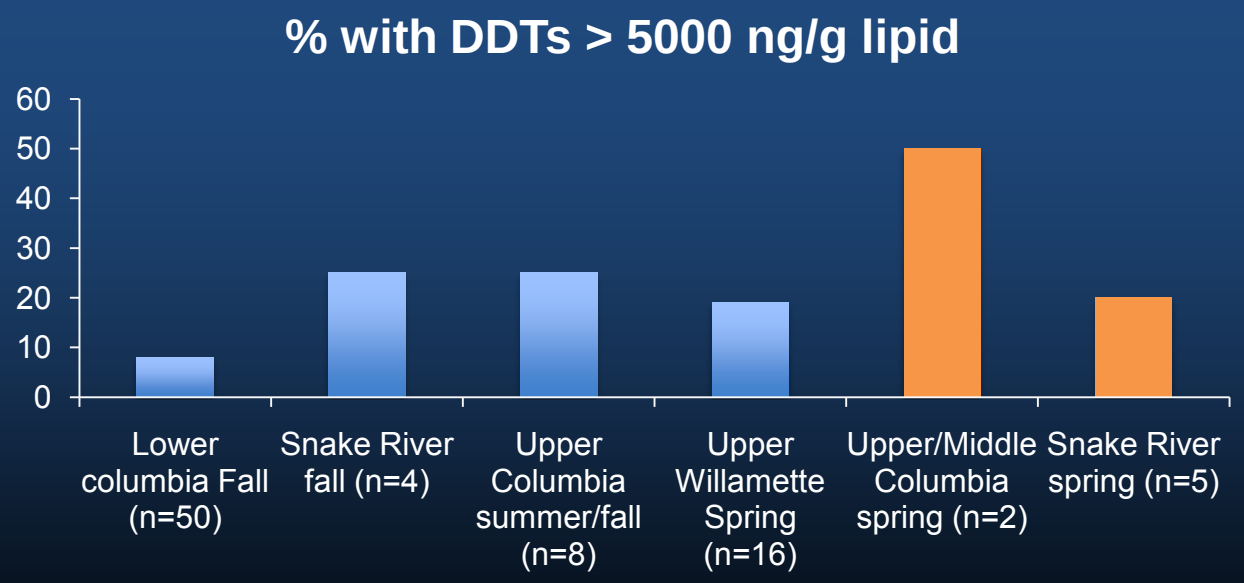
Trace metals (e.g., copper, found in road runoff, storm water, as pesticide)



Polycyclic aromatic hydrocarbons (e.g., fossil fuels, car exhaust, creosote)

PCBs and DDTs in salmon above fish health effect thresholds

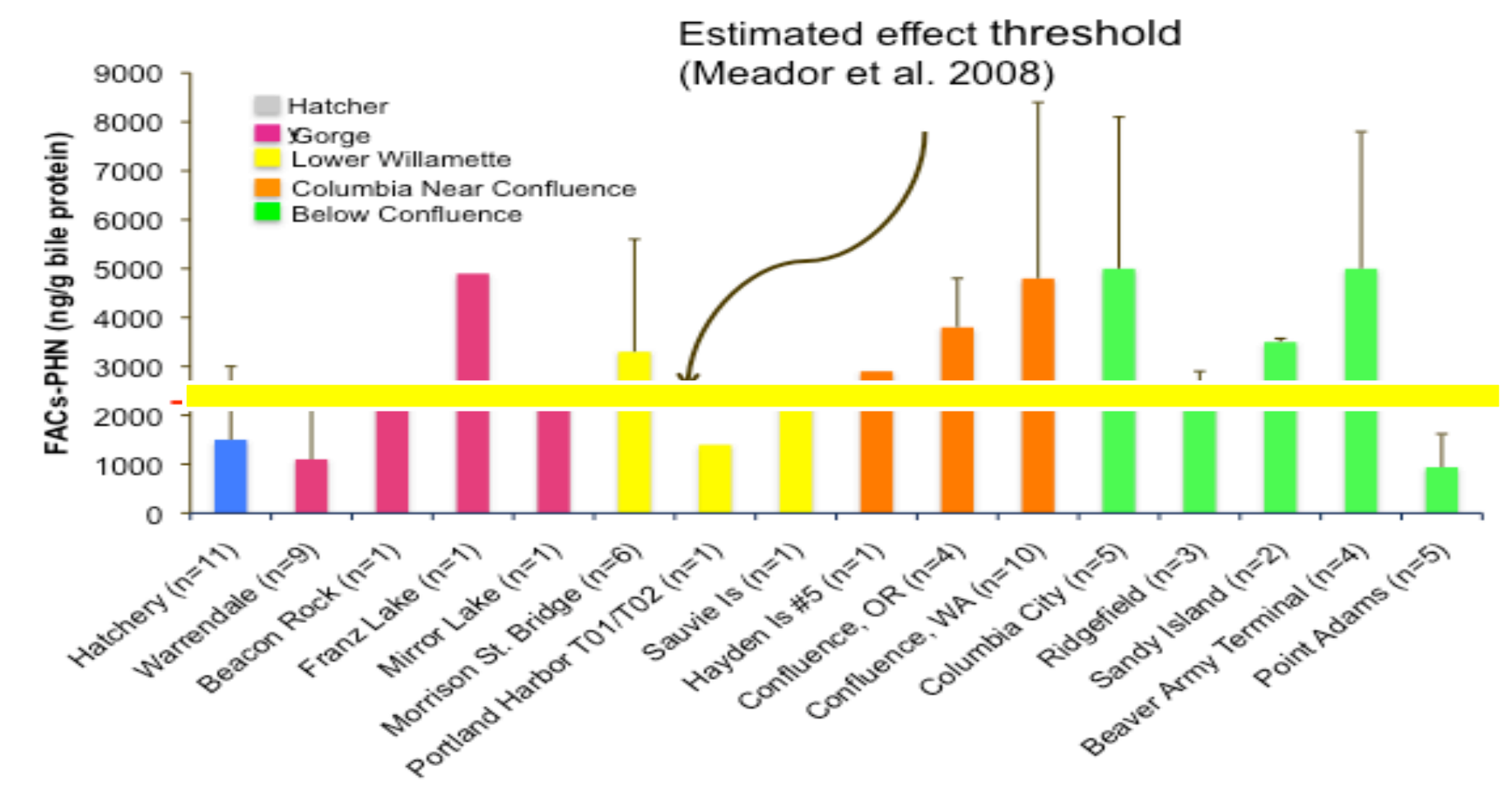




Industrial/urban contaminants (e.g., PCBs) are a greater threat to fall and Upper Willamette spring stocks that feed and rear in the lower river and estuary

Agricultural pesticides (e.g., DDTs) are a greater risk for Interior Columbia spring Chinook stocks that feed and rear primarily upriver

PAH Concentrations above Effect Thresholds



Toxics-Focused Salmon Population Models

- Designed to estimate the likely effects on salmon population growth rates of exposure to toxicants at environmentally relevant levels
- Based on effects data from laboratory exposure studies and contaminant concentrations measured in the field
- Effects on prey base, growth, reproduction and survival of individual salmon
- Will not predict contaminant levels in water and sediment, but evaluate how changes in levels predicted using other models might affect salmon productivity

Sample Population Models

- Spromberg and Meador 2006—non-specific toxicant effects on salmon of different life history types
- Spromberg and Johnson 2008—non-specific toxicant effects in linked populations with different/effect exposure levels
- Loge et al. 2005—effects of PCBs on disease-induced mortality and impact on population growth rate
- Baldwin et al. 2009—effects of organophosphate pesticides on salmon feeding behavior, growth, survival, and population growth rate
- NMFS 2009--effects of organophosphate pesticides on prey availability, salmon feeding behavior, growth, survival, and population growth rate

Spromberg and Meador 2006

•Objective was to gauge the relative magnitude of response to toxic effects among salmon species with different life history strategies

•Used life history matrix models

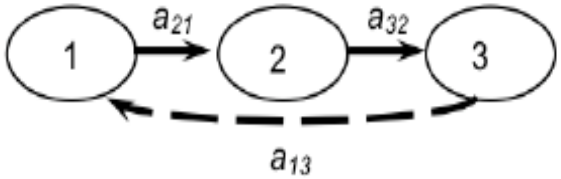
•Separate matrix models for coho salmon (*Oncorhynchus kisutch*), sockeye salmon (*Oncorhynchus nerka*) and Chinook salmon (*Oncorhynchus tshawytscha*).

•Toxic impacts were modeled as 10% reductions in the affected population demographic parameters (growth, survival, reproductive output)..

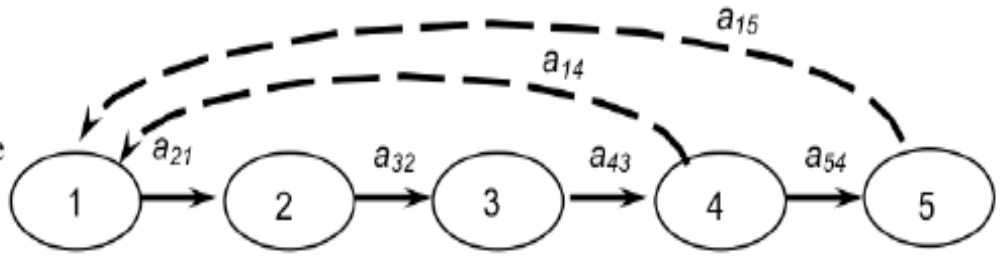
•Results suggested that changes in growth survival, and reproductive rates of this magnitude could have substantial effects on fish abundance and rates of population increase.

•Of the three life history strategies presented here, the Chinook life history strategy appears to be the most resilient, and coho the least robust.

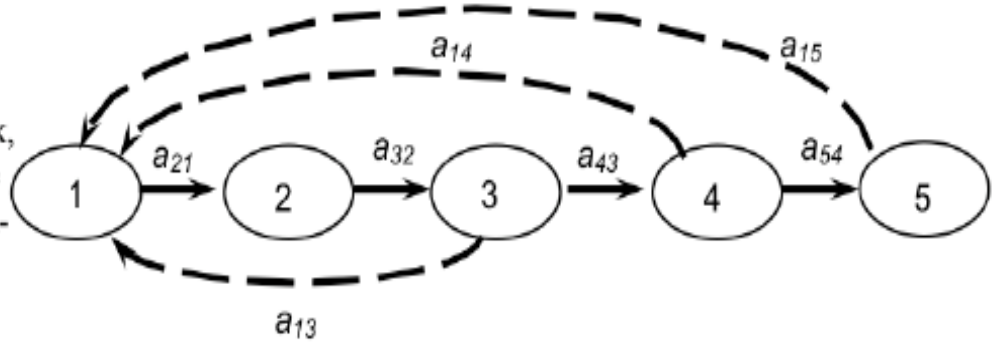
A. Coho



B. Sockeye



C. Chinook, ocean-type and stream-type



D. Transition Matrix

$$A = \begin{bmatrix} 0 & 0 & R3=a_{13} & R4=a_{14} & R5=a_{15} \\ S1=a_{21} & 0 & 0 & 0 & 0 \\ 0 & S2=a_{32} & 0 & 0 & 0 \\ 0 & 0 & S3=a_{43} & 0 & 0 \\ 0 & 0 & 0 & S4=a_{54} & 0 \end{bmatrix}$$

Spromberg and Johnson 2008

- Objective was to investigate population levels impacts of toxicant injury in juvenile fall Chinook salmon - 22 populations from the Lower Columbia River ESU

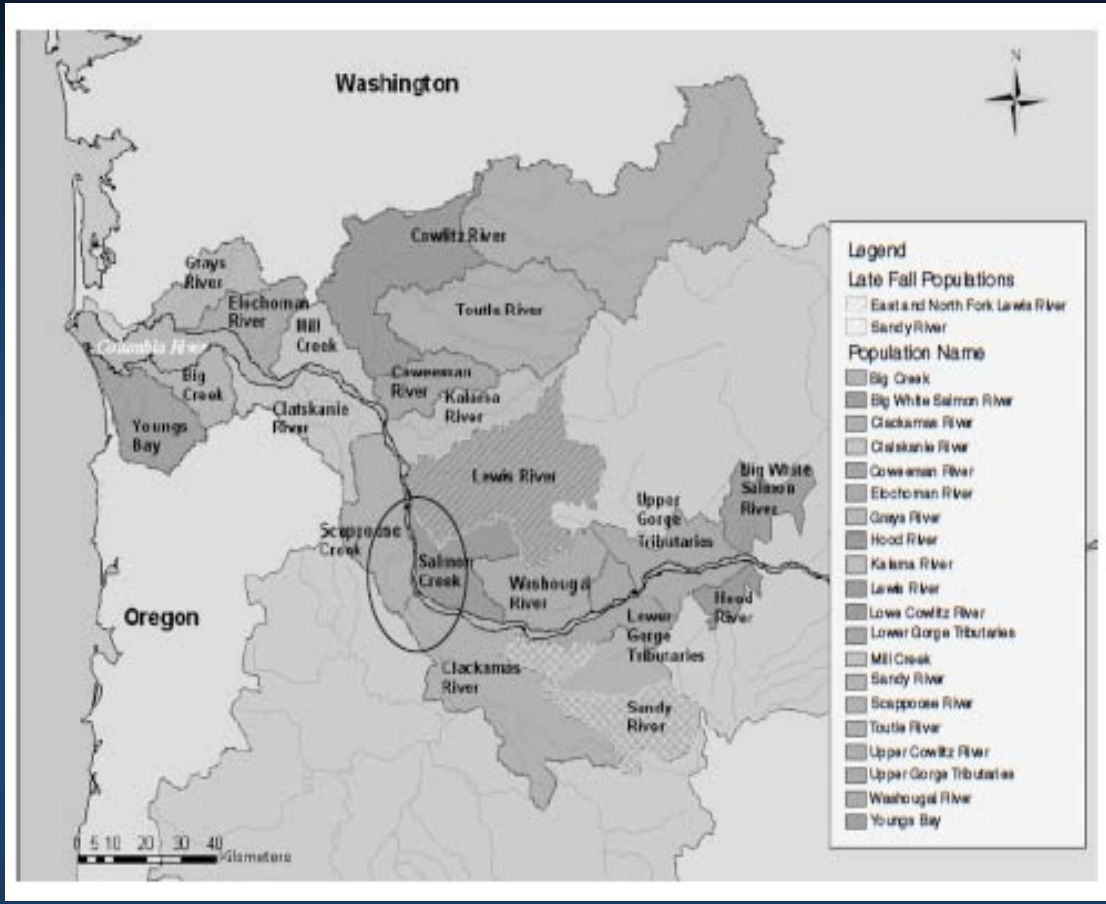
- Used life history matrix model for Chinook salmon (Spromberg and Meador 2006)

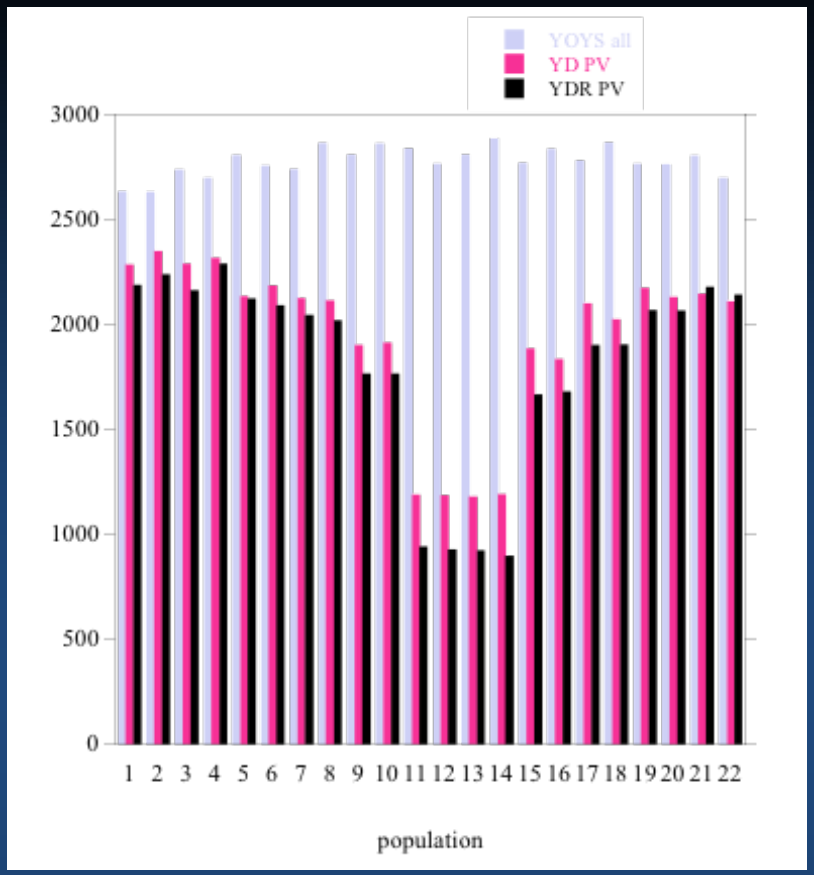
- Toxic impacts were modeled as up to 20% 10% reduction in young of year survival, 10% reduction in ocean survival and reproductive output

- Included scenarios where toxicant-related declines in survival and reproductive rates were restricted to populations originating in the Portland/Vancouver area, or to all populations downstream of this area

- Meta-population model that incorporated straying between different Lower Columbia River populations

Lower Columbia River fall Chinook populations





Estimated abundance compared to control with toxic effects only on PV populations

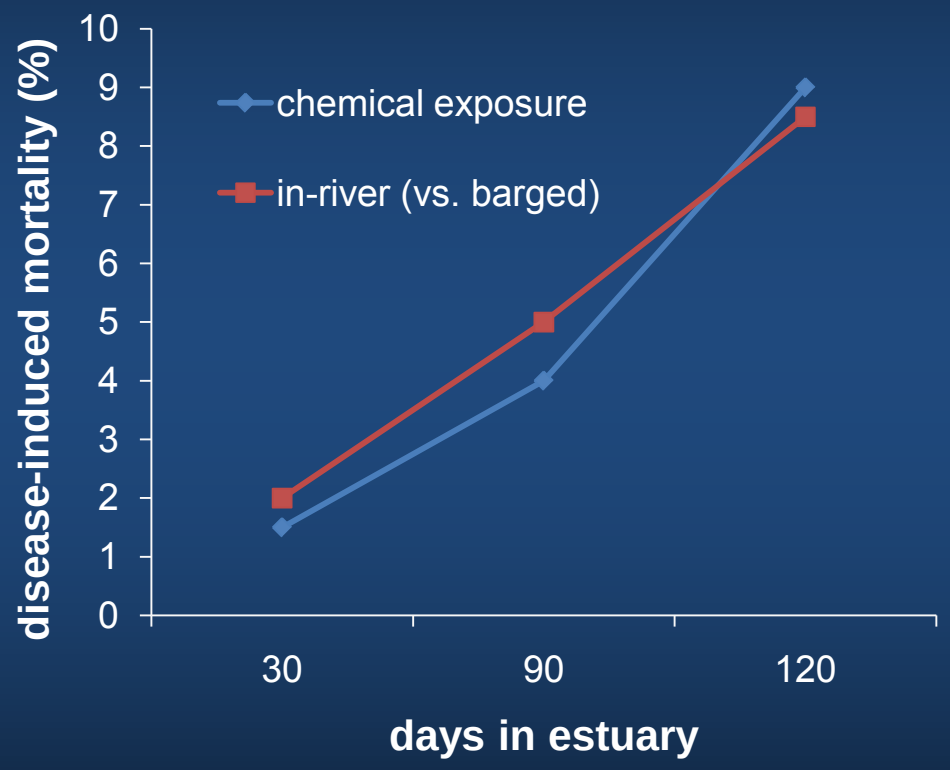
•Major finding were that even where effects were restricted only to populations from urban areas, the depression in these populations could lead to depression in other populations because of straying.

- **10% reduction in ocean survival leads to extinction in 74 yrs**
- **10% reduction in ocean survival and 10% reduction in fecundity leads to extinction in 50 yrs**

Loge et al. 2005

- Examines the population level impacts of disease-induced mortality in Chinook salmon occurring as a result of PCB-related immunosuppression, but could be modified for other contaminants and endpoints
- Individually-based, dose-structured population model
- Range of PCB body concentrations in individual fish was determined from the distribution of PCB concentrations from juvenile Chinook salmon in the Lower Columbia Estuary (Johnson et al. 2007).
- The dose-related risk of disease-induced mortality was based laboratory dose-response data from disease challenge experiments with Chinook salmon (Arkoosh et al 2001).
- Compared to risk of delayed disease induced mortality associated with stress of damage passage, based on disease –challenge studies by Arkoosh et al. (2008).

Projected Contaminant-Related Disease-Induced Mortality



Disease-related mortality from contaminant-associated immunosuppression estimated at 1.5-9%; same range for disease-induced mortality associated with stress of dam passage

Projected increase in survival needed to mitigate declines is 3-11% (Kareiva et al 2000)

Loge, F. J., M. R. Arkoosh, T. R. Ginn, L. L. Johnson, and T. K. Collier. 2005. Impacts of environmental stressors on the dynamics of disease transmission. ES&T 39:7329-7336.

Baldwin et al. 2009

•**Fo**cus on current-use organophosphate and carbamate pesticides that inhibit the activity of the acetylcholinesterase (AChE), an enzyme involved with nervous system function, and disrupt several fish behaviors, including swimming and feeding.

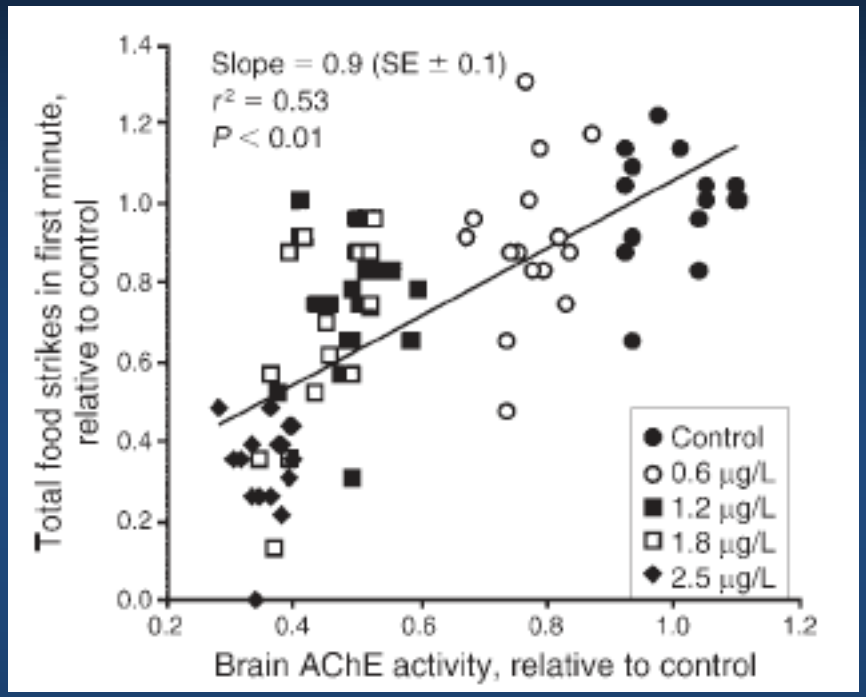
•Model uses experimental data linking pesticide exposure to AChE inhibition, which in turn was correlated with reductions in swimming speed and prey consumption rate (Sandahl et al. 2005; Beauvais et al. 2000).

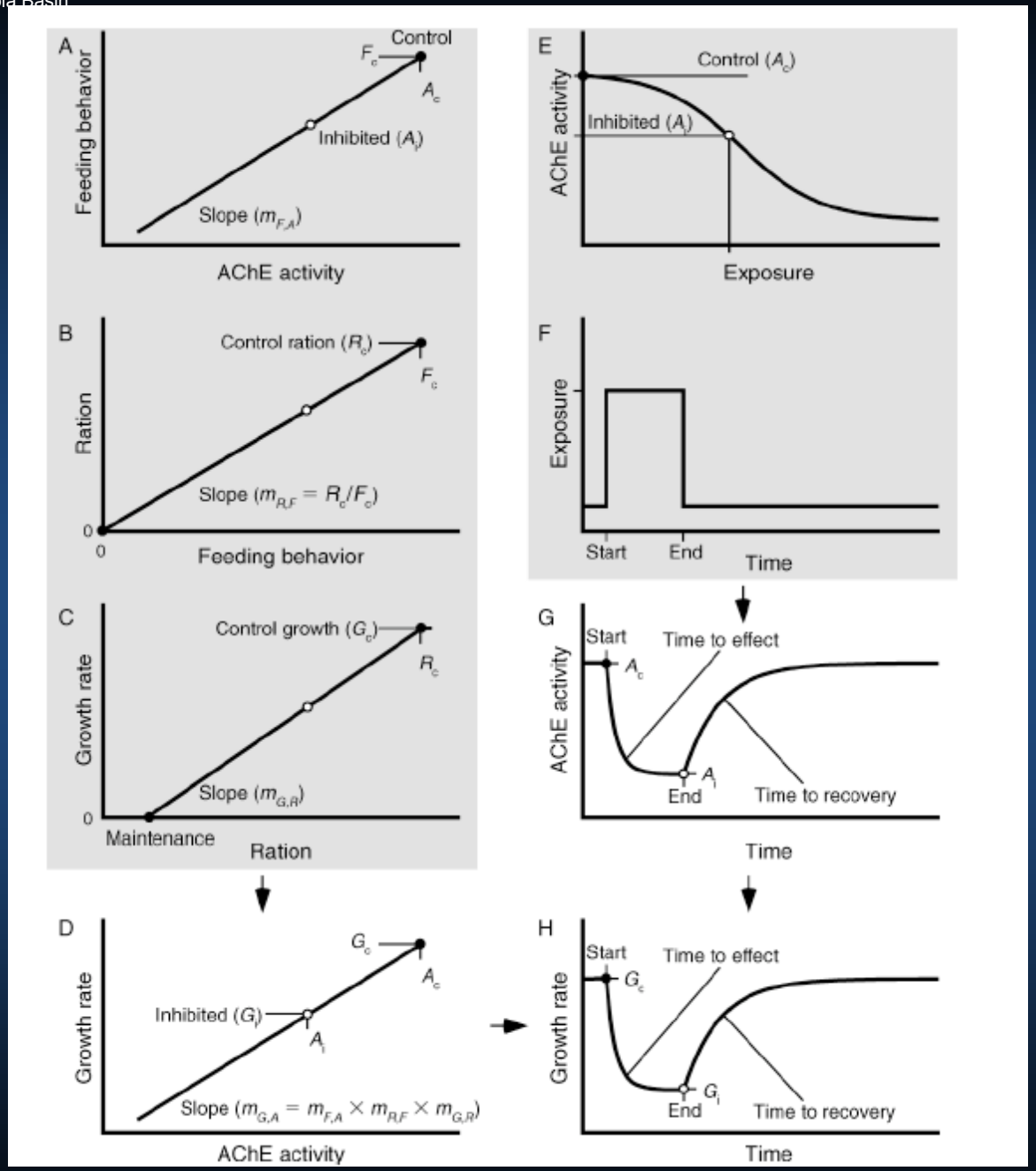
•The reductions in food intake is used to model changes in fish growth rate and size at time of ocean entry.

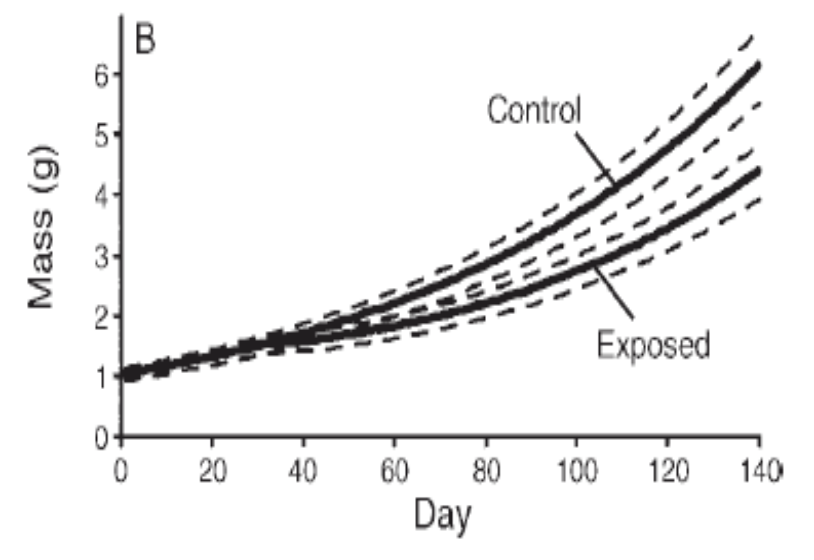
•Fish size is then linked to survival, using a relationship previously established by Zabel and Achord (2004).

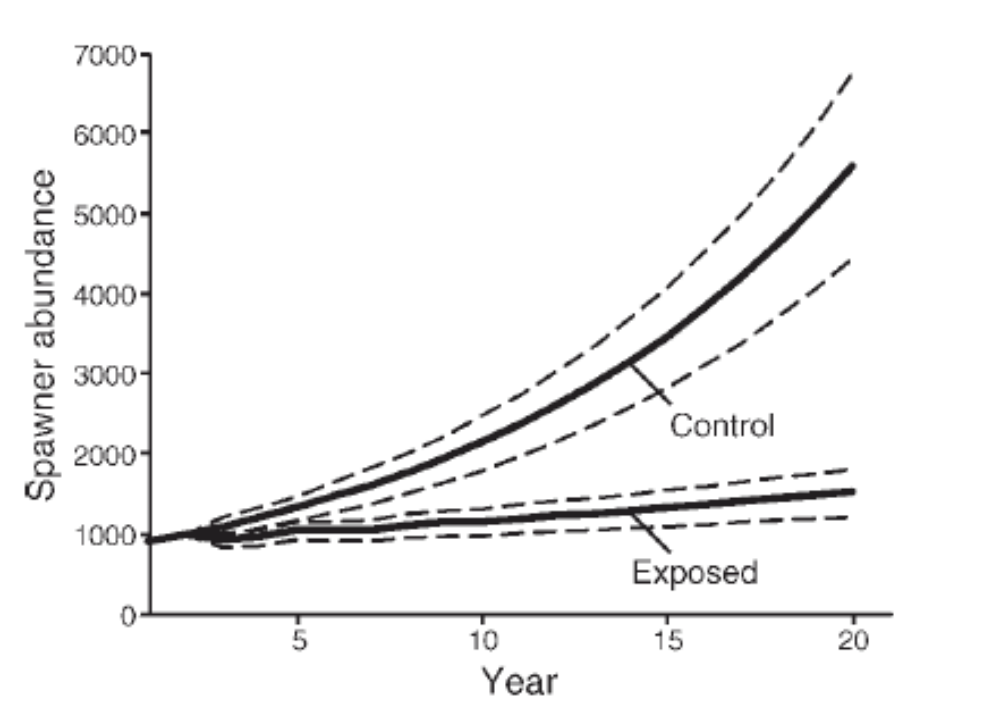
•Exposure scenarios involve continuous vs. single to multiple pose exposure at doses causing 10-50% AChE inhibition

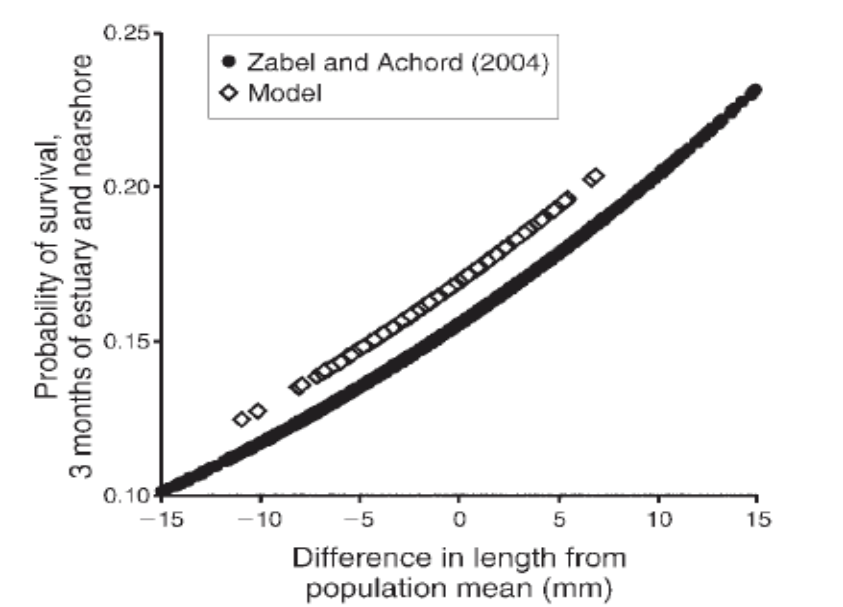
•Survival estimates incorporated into a matrix population model.


Slope = 0.9 (SE ± 0.1)
r^2 = 0.53
P < 0.01
Total food strikes in first minute, relative to control
Brain AChE activity, relative to control
Control
0.6 µg/L
1.2 µg/L
1.8 µg/L
2.5 µg/L


A
Feeding behavior
AChE activity
Control
Inhibited (A_i)
Slope ($m_{F,A}$)
B
Ration
Feeding behavior
Control ration (R_c)
Slope ($m_{R,F} = R_c/F_c$)
C
Growth rate
Ration
Control growth (G_c)
Slope ($m_{G,R}$)
Maintenance
D
Growth rate
AChE activity
Inhibited (G_i)
Slope ($m_{G,A} = m_{F,A} \times m_{R,F} \times m_{G,R}$)
E
AChE activity
Exposure
Control (A_c)
Inhibited (A_i)
F
Exposure
Time
Start
End
G
AChE activity
Time
Start
Time to effect
End
Time to recovery
H
Growth rate
Time
Start
Time to effect
End
Time to recovery







The results indicated that, over a period of 20 years, pesticide exposure could reduce spawner abundance to from 27 to 86% of control numbers.

NMFS 2009

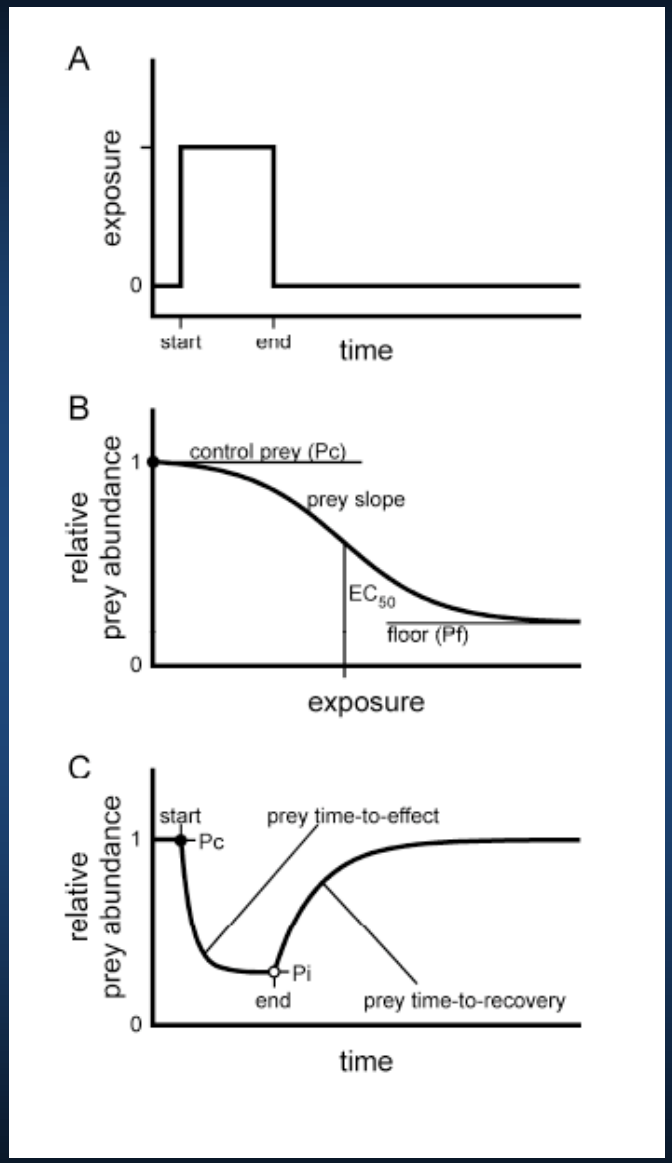
•Revised version of the Baldwin et al. (2009) model used in Section 7 national pesticides consultations

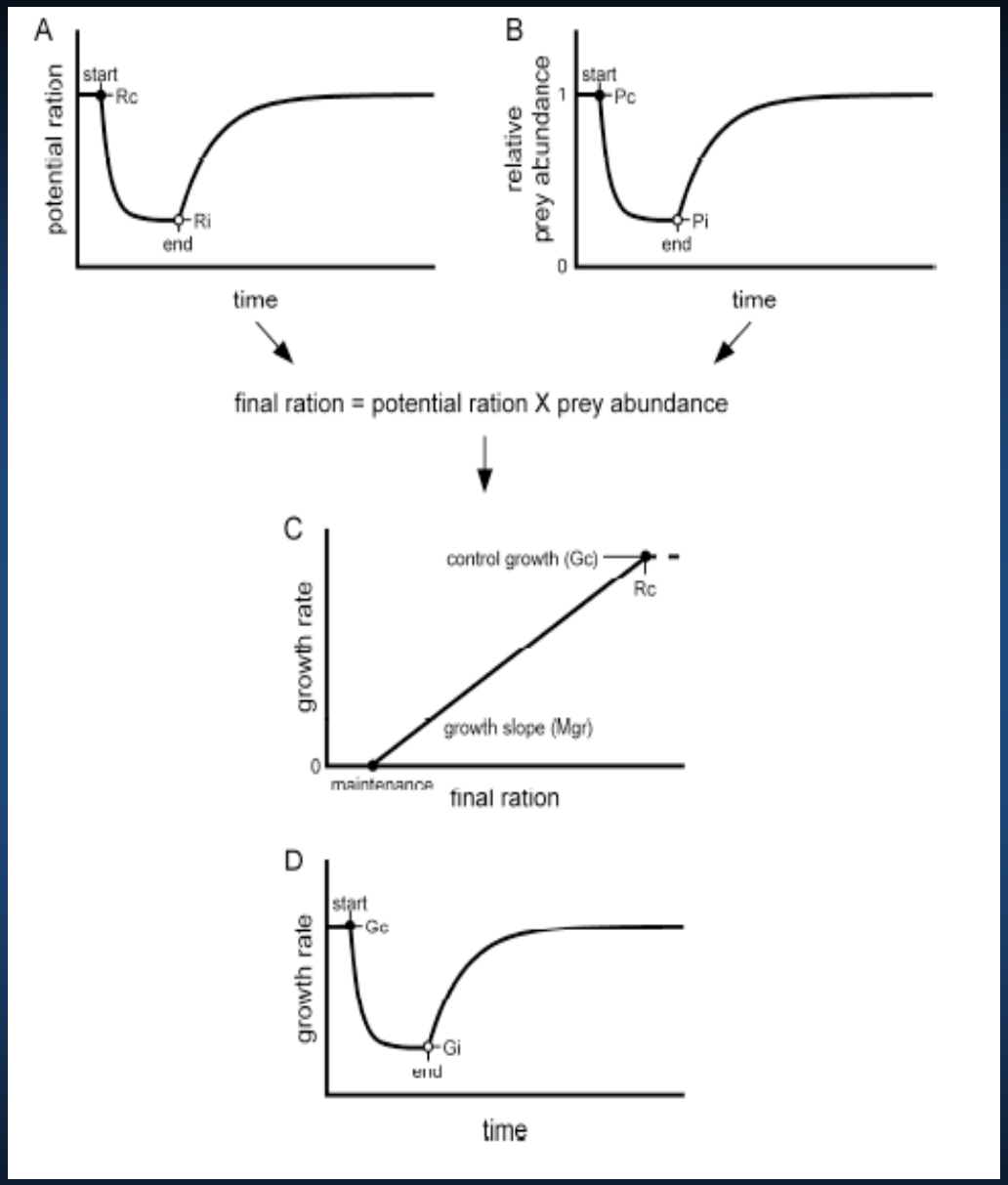
•Salmon growth rate is a function not only of the fish's ability to capture food, which can be directly affected by pesticide exposure, but also by the availability of food to capture, which is determined by the toxicity of the pesticide to the salmon prey base.

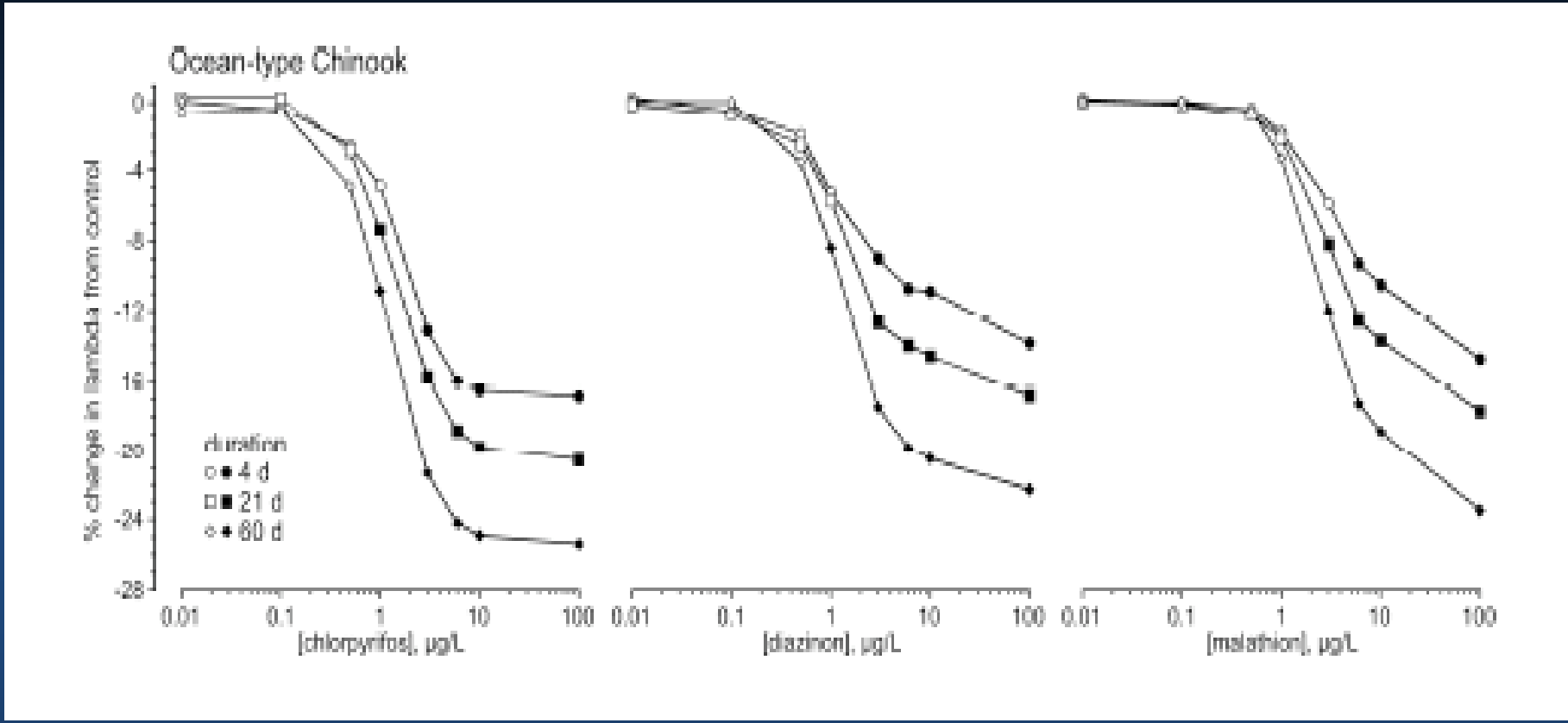
•Pesticide concentrations for the model were set at the EC50 concentration that would protect 90% of salmon prey.

• Prey ration linked to growth rate and final size to survival using species specific information for stream-type Chinook, ocean-type Chinook, coho, and sockeye salmon,

•The population models are also modified to fit the specific life history pattern (e.g., life span, age-specific survival, age-specific reproduction) for each species.


A
exposure
1
0
start
end
time
B
relative prey abundance
1
control prey (Pc)
prey slope
EC50
floor (Pf)
0
exposure
C
relative prey abundance
1
start
Pc
prey time-to-effect
Pi
end
prey time-to-recovery
0
time


A
potential ration
start
Rc
Ri
end
time
B
relative prey abundance
1
start
Pc
Pi
end
0
time
final ration = potential ration X prey abundance
C
growth rate
control growth (Gc)
Rc
growth slope (Mgr)
0
maintenance
final ration
D
growth rate
start
Gc
Gi
end
time



% change in population growth rate for ocean –type Chinook exposed to chlorpyriphos, diazonon, or malathion

Results suggest that all populations of threatened and endangered salmonids covered by the consultation would likely show reductions in viability associated with pesticide exposures

Mixtures of Contaminants, Multiple Stressors

In their natural environment, salmon are exposed to a complex mixture of chemical contaminants,

Generally it is assumed that multiple contaminants will have additive effects., but effects can be synergistic (e.g., recent research on enhanced toxicity of certain mixtures of current use pesticides)

Contaminant also interact with other environmental stressors to reduce fitness and survival of salmon.

Lipid loss—can lead to mobilization and increased toxicity of bioaccumulative contaminants such as PCBs, DDTs, and PBDEs, which are stored in body fat. This means that any stressors that reduce the energy stores of outmigrant juveniles could put them at greater risk for toxic injury.

•Contaminant toxicity can also be affected by physical environmental conditions, particularly water temperature. Generally, at elevated temperatures, toxic effects are increased for a number of chemicals.

References

Baldwin, D. H., J. A. Spromberg, T. K. Collier, N. L. Scholz. 2009. A fish of many scales: extrapolating sublethal pesticide exposures to the productivity of wild salmon populations. Ecological Applications, 19(8):2004-2015.

Loge, F., M. R. Arkoosh, T. R. Ginn, L. L. Johnson, T. K. Collier. 2005. Impact of environmental stressors on the dynamics of disease transmission. Environmental Science & Technology, 39:7329-7336

NMFS 2008. National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion. Environmental Protection Agency Registration of Pesticides Containing Chlorpyrifos, Diazinon, and Malathion. November 2008.

Spromberg, J. A., L. L. Johnson. 2008. Potential effects of freshwater and estuarine contaminant exposure on Lower Columbia River Chinook Salmon (Oncorhynchus tshawytscha) populations. Page 288 *in* Akcakaya, H. R., J. D. Stark, T. S. Bridges. (Eds.) Demographic Toxicity Methods in Ecological Risk Assessment. Oxford University Press, Oxford, United Kingdom.

Spromberg, J. A., J. P. Meador. 2006. Relating chronic toxicity responses to population-level effects: A comparison of population-level parameters for three salmon species as a function of low-level toxicity. Ecological Modeling, 199(2006):240-252.

Contact Information

NOAA Fisheries Websites

http://www.nwfsc.noaa.gov/publications

http://www.nmfs.noaa.gov/pr/consultation/pesticides.htm

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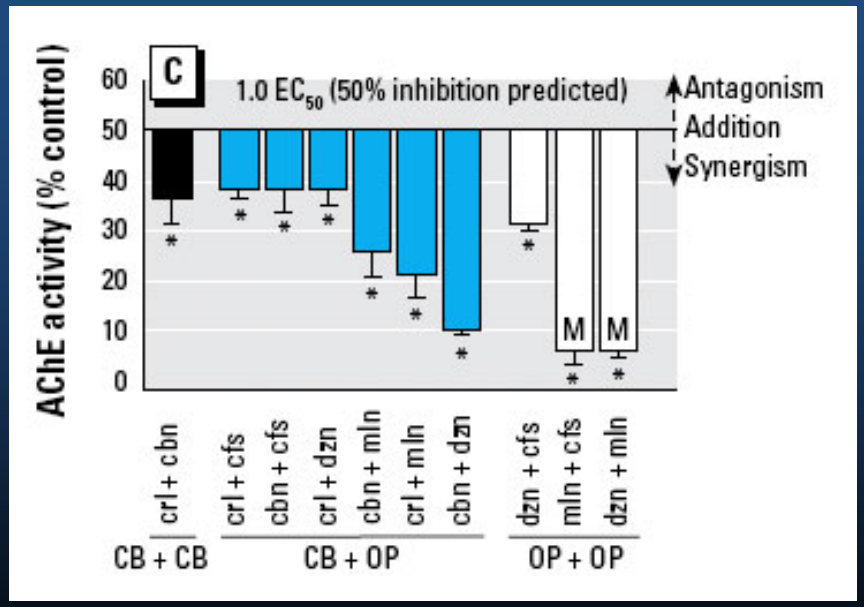
Current use pesticides are common as mixtures in fish habitats

Common pesticides include
- organophosphate insecticides (diazanon, chlorpyrifos)
- carbamate insecticides (carbaryl, carbofuran)
- pyrethroid insecticides (cypermethrin, esfenvalerate)
- Herbicides (2,4-D, atrazine)

More than 90% of urban, agricultural, and mixed-use streams contain 2 or more pesticides.
(Gilliom et al., 2006, *USGS Circular 1291*)



Organophosphate pesticides disrupt olfaction in salmon, interfere with prey capture and predator avoidance (Labenia et al. 2007. Mar. Ecol. Prog. Ser. 329:1-11; Scholz and Hopkins. 2006. Environ. Toxicol. Chem. 25:1185-1186)

Some pesticides combinations can have lethal synergistic effects
(Laetz et al.2009. *Environ Health Perspect 117:348–353*).

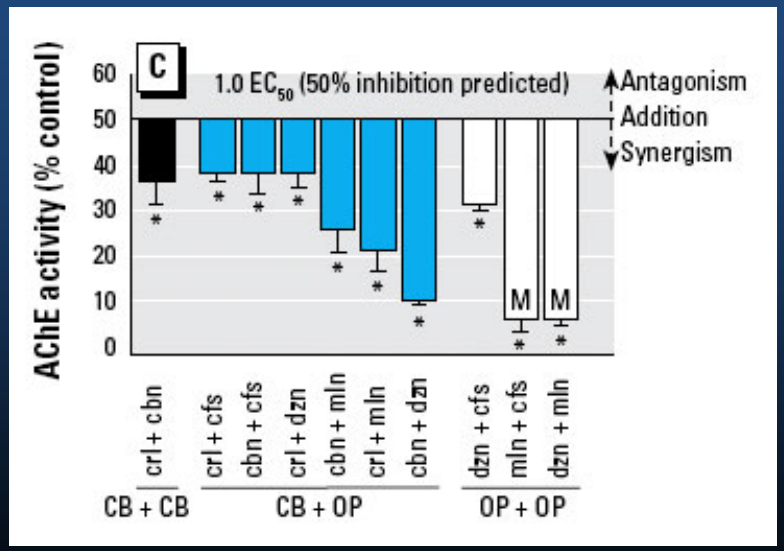
Current use pesticides and dissolved copper are toxic to fish sensory systems

Problems with olfaction and related behaviors (prey capture, predator avoidance) at concentrations as low as 0.2 ug/L.

The U.S. Geological Survey of 811 United States stream sites detected a median copper concentration of 1.2 ugL.

Impairment of sensory functions important to survival of juvenile salmonids is likely to be widespread.

(See Hecht et al. 2007. NOAA Tech Memo NMFS-NWFSC-83).



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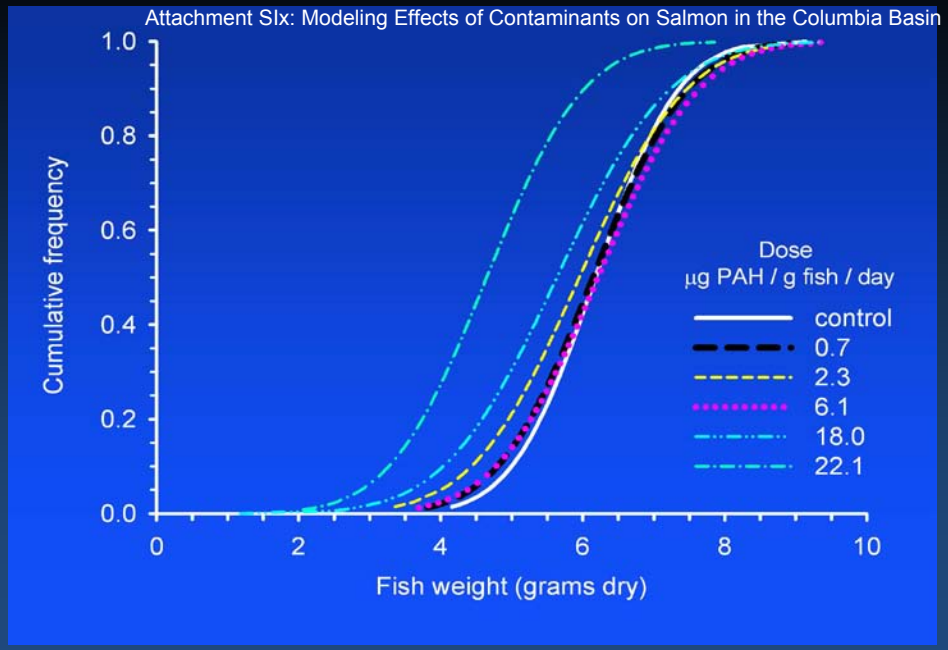
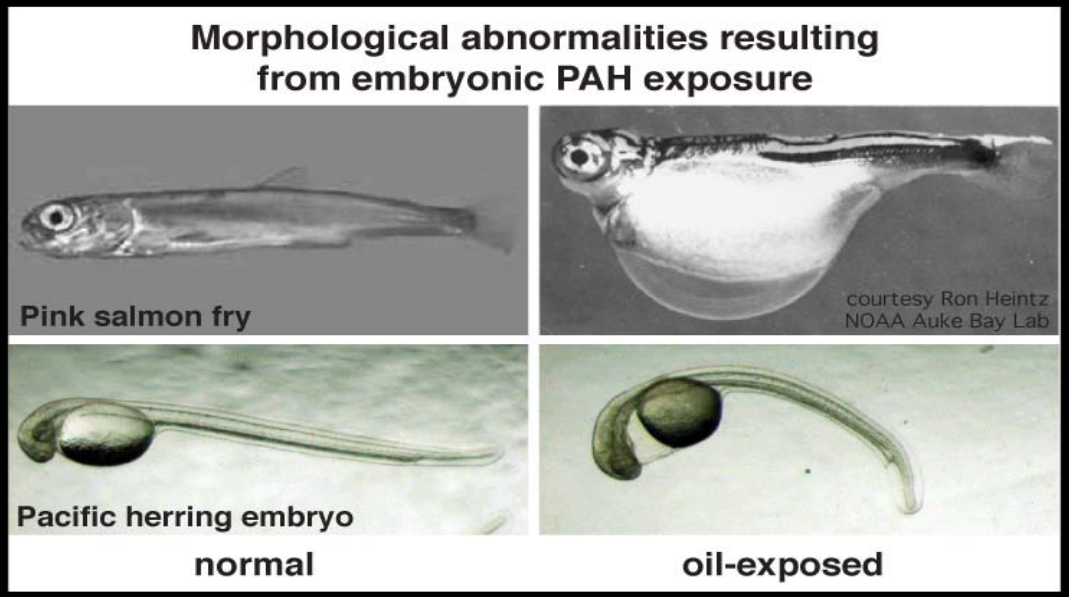


Polycyclic aromatic hydrocarbons (PAHs) affect juvenile salmon growth and lipid content, and are toxic to embryos



Poor growth and low lipid levels in juvenile salmon associated with increased risk of mortality.

Even low PAH concentrations that cause no obvious developmental problems can cause heart defects that reduce fitness and increase risk of mortality

(See Meador et al. 2006. Can J. Fish. Aquat. Sci. 63:2364-2376 and Incardona et al. 2009. ES&T 43:201-207.)

Dissolved copper is toxic to fish sensory systems

Problems with olfaction and related behaviors (prey capture, predator avoidance) at concentrations as low as 0.2 ug/L.

The U.S. Geological Survey of 811 United States stream sites detected a median copper concentration of 1.2 ugL.

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Treaty Review
Preliminary Draft Iteration #1 Evaluation Criteria

Location or Control Point	Temperature			TDG	Turbidity % Change (NTU)	Sediment Concentration	Salinity % Change PPT
	Average Daily	Maximum Daily	Seasonal Change				
Canada - Columbia River							
Mica							
Arrow							
Duncan							
Brilliant							
Kootenay Lake							
Pend Oreille (Waneta)							
Canadian Border	x			x		x	
U.S. Upper Columbia							
Libby				x			
Bonners Ferry							
Hungry Horse				xx			
Columbia Falls							
Kerr							
Thompson Falls							
Noxon Falls							
Cabinet Gorge							
Albeni Falls							
Grand Coulee	x	x		xxxx		x	
Chief Joseph				x			
U.S. Clearwater/Snake River							
Brownlee		x					
Dworshak							
Lower Granite		x					
Little Goose							
Lower Monumental							
Ice Harbor		x		x			
U.S. Mid-Columbia River							
Wells							
Rock Island							
Wanapum							
Priest Rapids		x		x			
Vernita Bar							
Richland/Kennwick							
U.S. Lower Columbia River							
McNary	x	xxxx		xxxx	x	xx	
John Day							
The Dalles				x			
Bonneville		x		x		xx	
Portland/Vancouver						x	
Estuaries		x					
US System							
Federal							
Mid-Cs							
Canadian							

Columbia River Inter-Tribal Fish Commission

Sign-In Sheet Columbia River Treaty 2014/2024 Re

Date 8/31

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Columbia River Inter-Tribal Fish Commission
Sign-In Sheet Columbia River treaty 2014/2024 Reme

Date 8/31 Meeting Title Water Quality Workshop

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