Restoration of Cold Water Refugia in the Columbia River Estuary

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Lower Columbia Estuary Partnership

Restoration of Cold Water Refugia

Presentation Outline:

- Thermal conditions during outmigration
- Pros/cons of thermal refugia
- Assessment & design criteria
- Case study
  - Example restoration actions
  - Monitoring results

Mainstem thermal regime during adult returns

- ~50% of steelhead used thermal refugia when temperatures were 19-21°C.
- *>70% used tributaries when temperatures were > 21°C.*
- Duration of use e*xtended to weeks during the warmest times*.

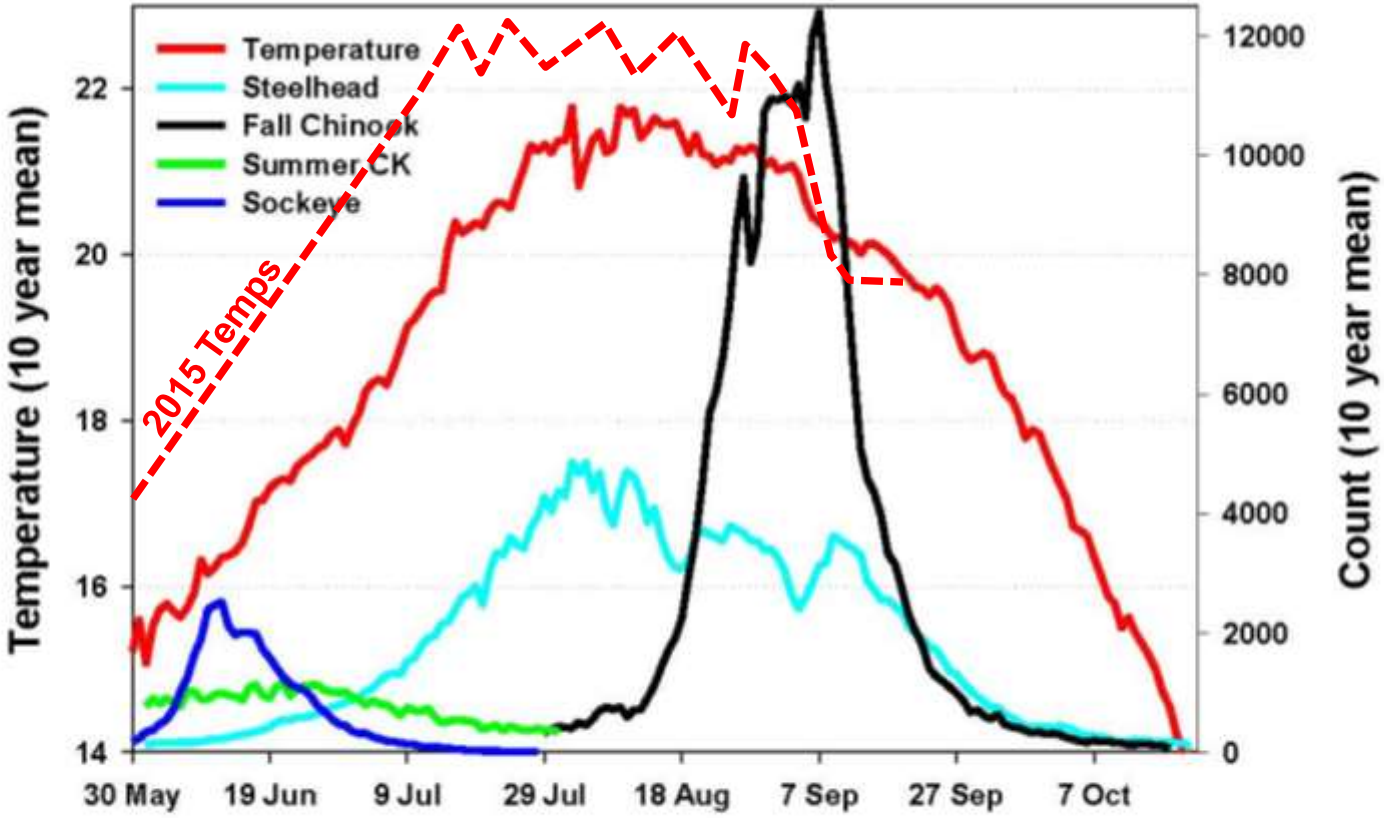
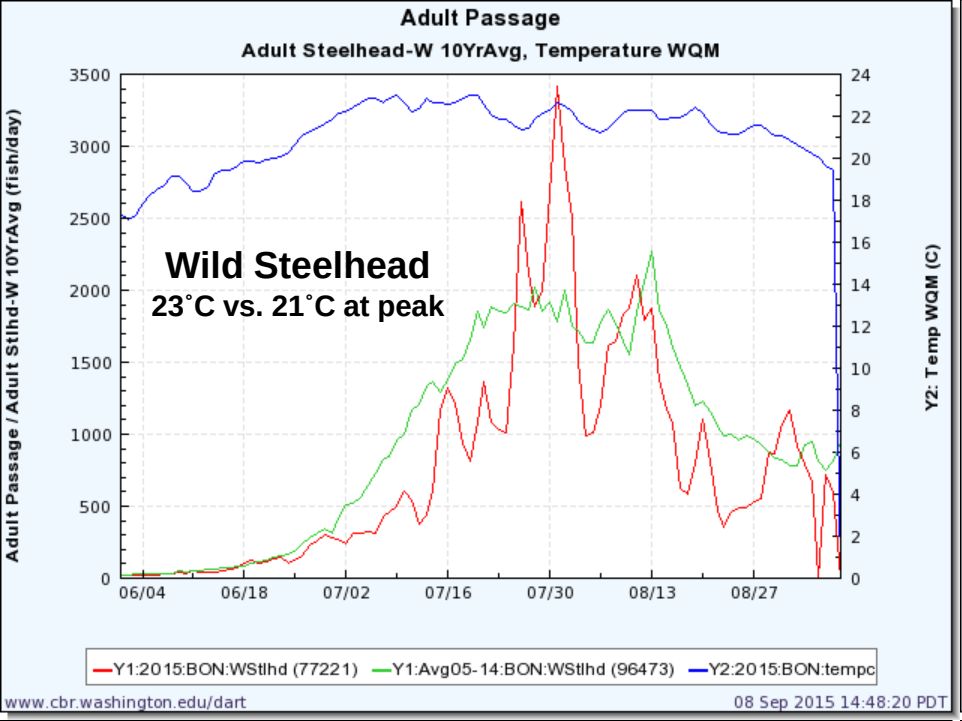


Figure 2. Ten-year (1996-2005) mean lower Columbia River water temperature (°C) and mean run size and timing of adult summer Chinook salmon, fall Chinook salmon, sockeye salmon, and summer steelhead at Bonneville Dam. Thermal refugia use by many adult populations has been associated with

Graph and text copied from Keefer et al. 2011.


Adult Passage
Adult Steelhead-W 10YrAvg, Temperature WQM
Wild Steelhead
23˚C vs. 21˚C at peak
Adult Passage / Adult Stlhd-W 10YrAvg (fish/day)
Y2: Temp WQM (C)
Y1:2015:BON:WStlhd (77221)
Y1:Avg05-14:BON:WStlhd (96473)
Y2:2015:BON:tempc
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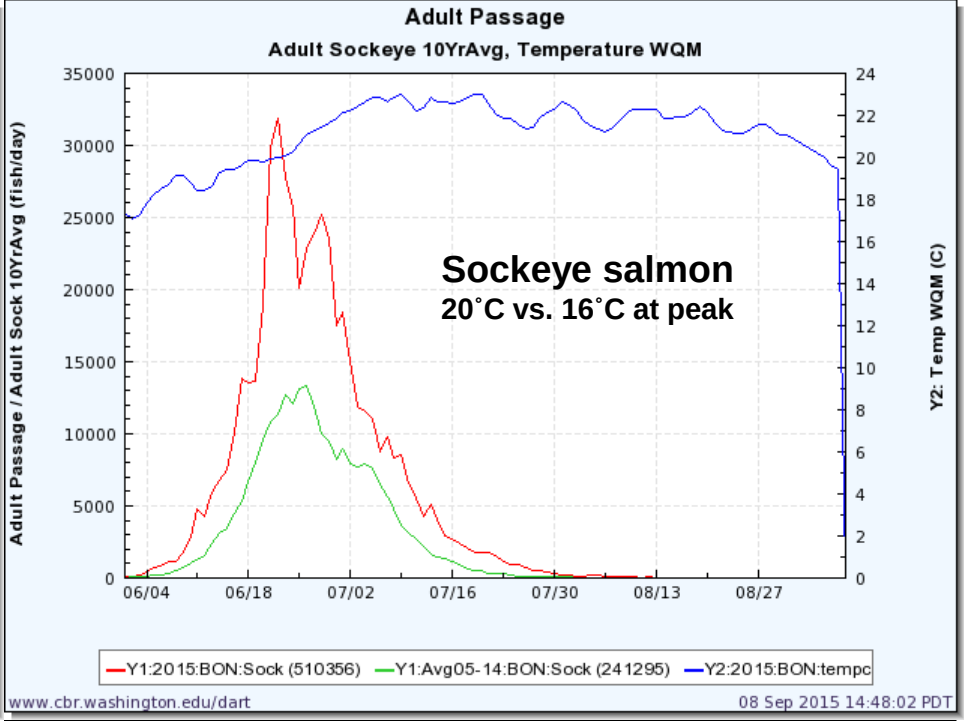
Adult Passage
Adult Sockeye 10YrAvg, Temperature WQM
Sockeye salmon
20˚C vs. 16˚C at peak
Adult Passage / Adult Sock 10YrAvg (fish/day)
Y2: Temp WQM (C)
Y1:2015:BON:Sock (510356)
Y1:Avg05-14:BON:Sock (241295)
Y2:2015:BON:tempc
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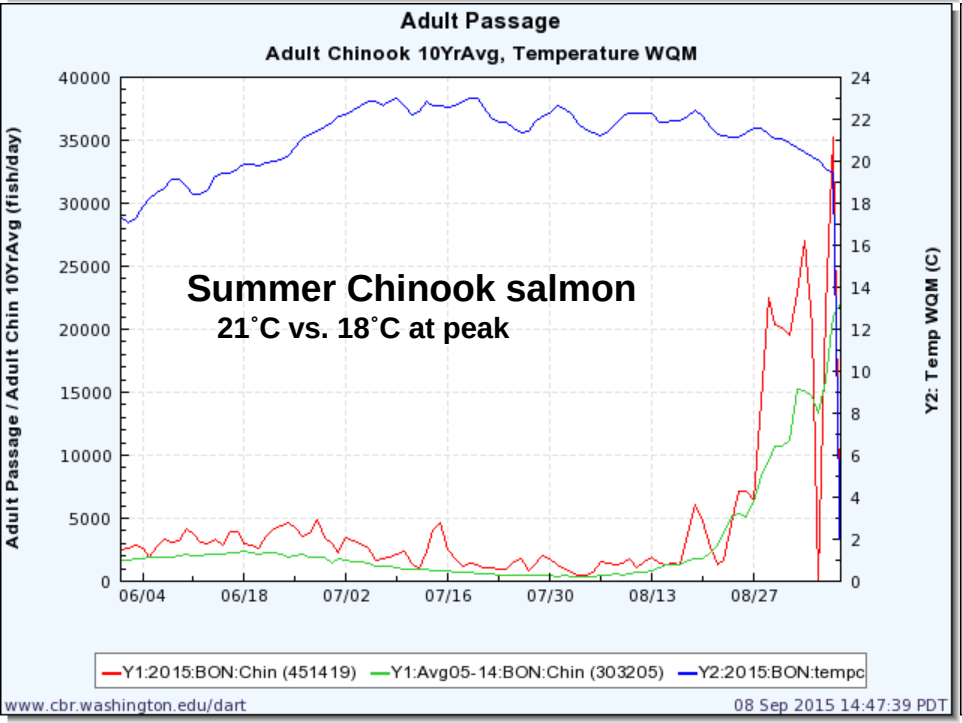
Adult Passage
Adult Chinook 10YrAvg, Temperature WQM
Summer Chinook salmon
21˚C vs. 18˚C at peak
Adult Passage / Adult Chin 10YrAvg (fish/day)
Y2: Temp WQM (C)
Y1:2015:BON:Chin (451419)
Y1:Avg05-14:BON:Chin (303205)
Y2:2015:BON:tempc
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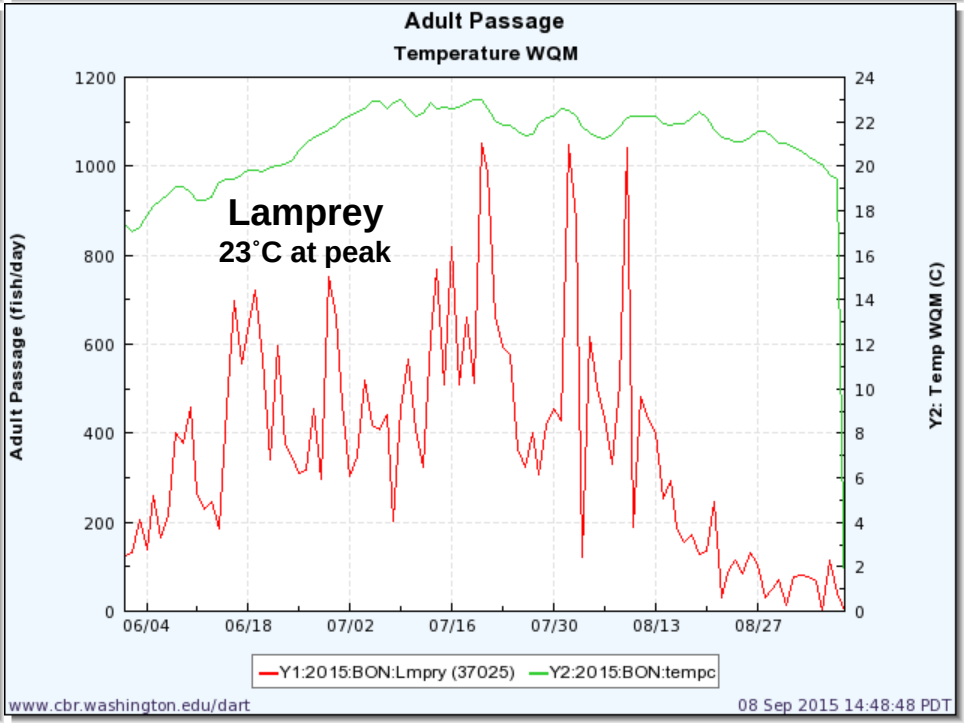
Adult Passage
Temperature WQM
Lamprey
23˚C at peak
Adult Passage (fish/day)
Y2: Temp WQM (C)
Y1:2015:BON:Lmpry (37025)
Y2:2015:BON:tempc
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Mainstem thermal regime during adult returns

Steelhead returns – run timing by population

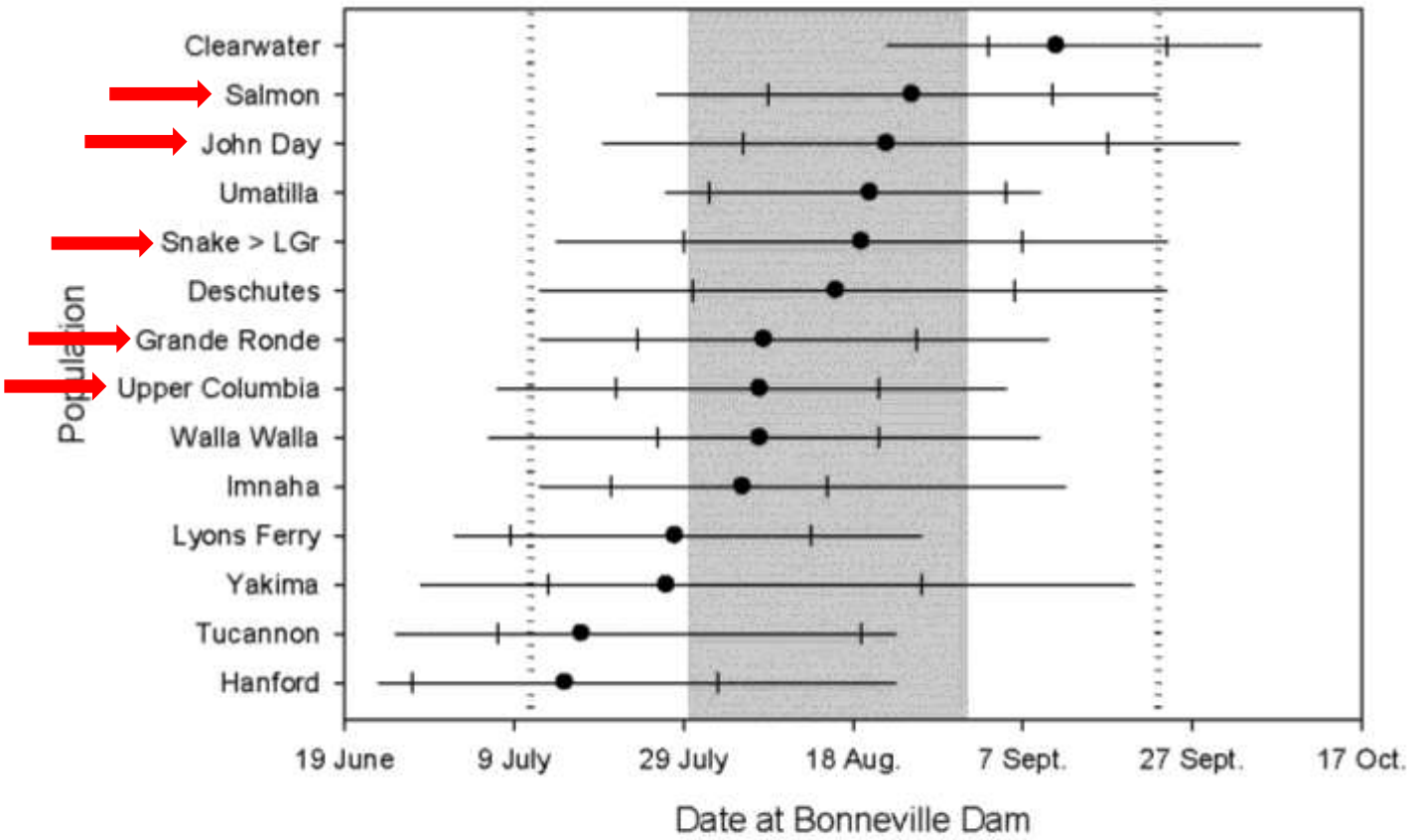
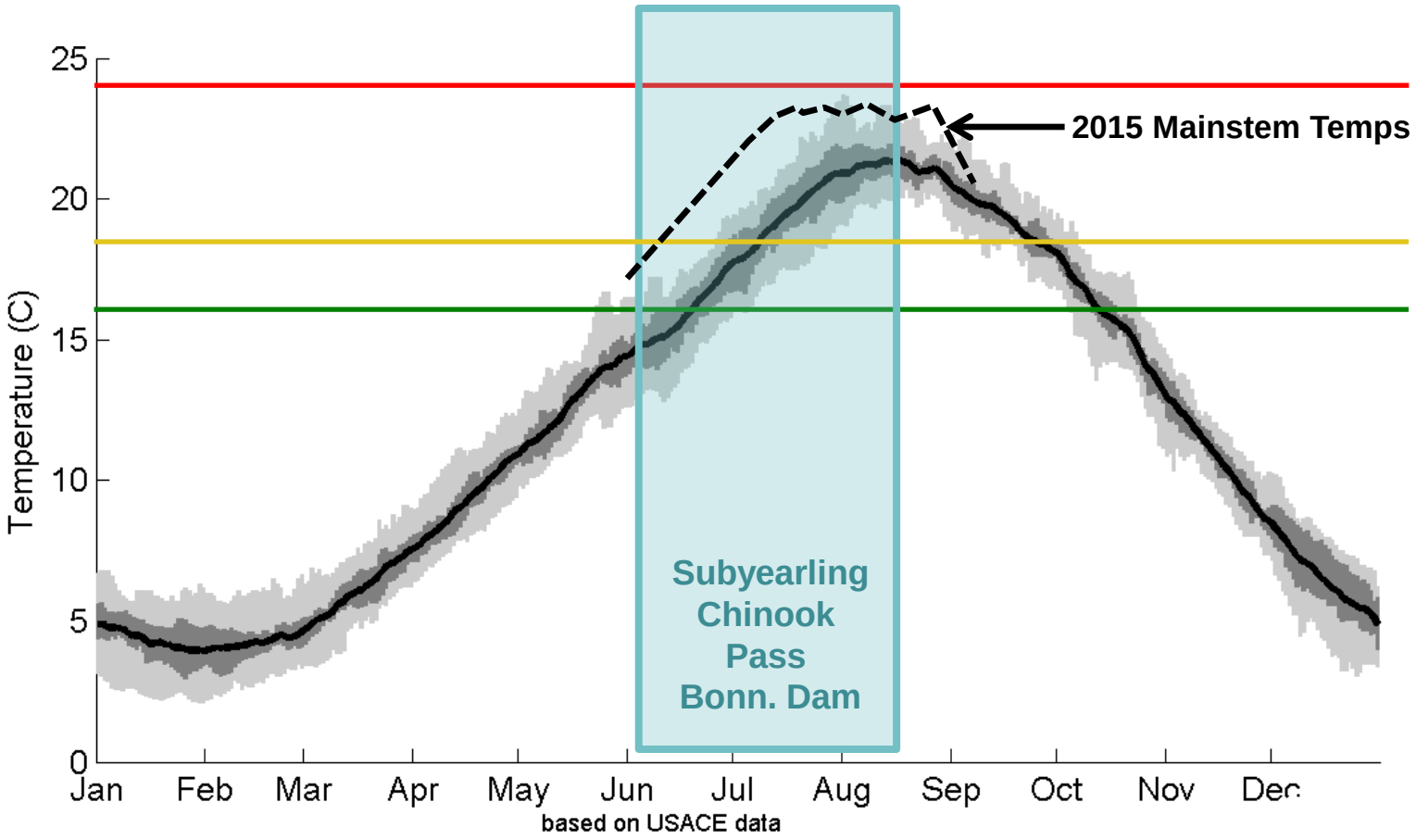


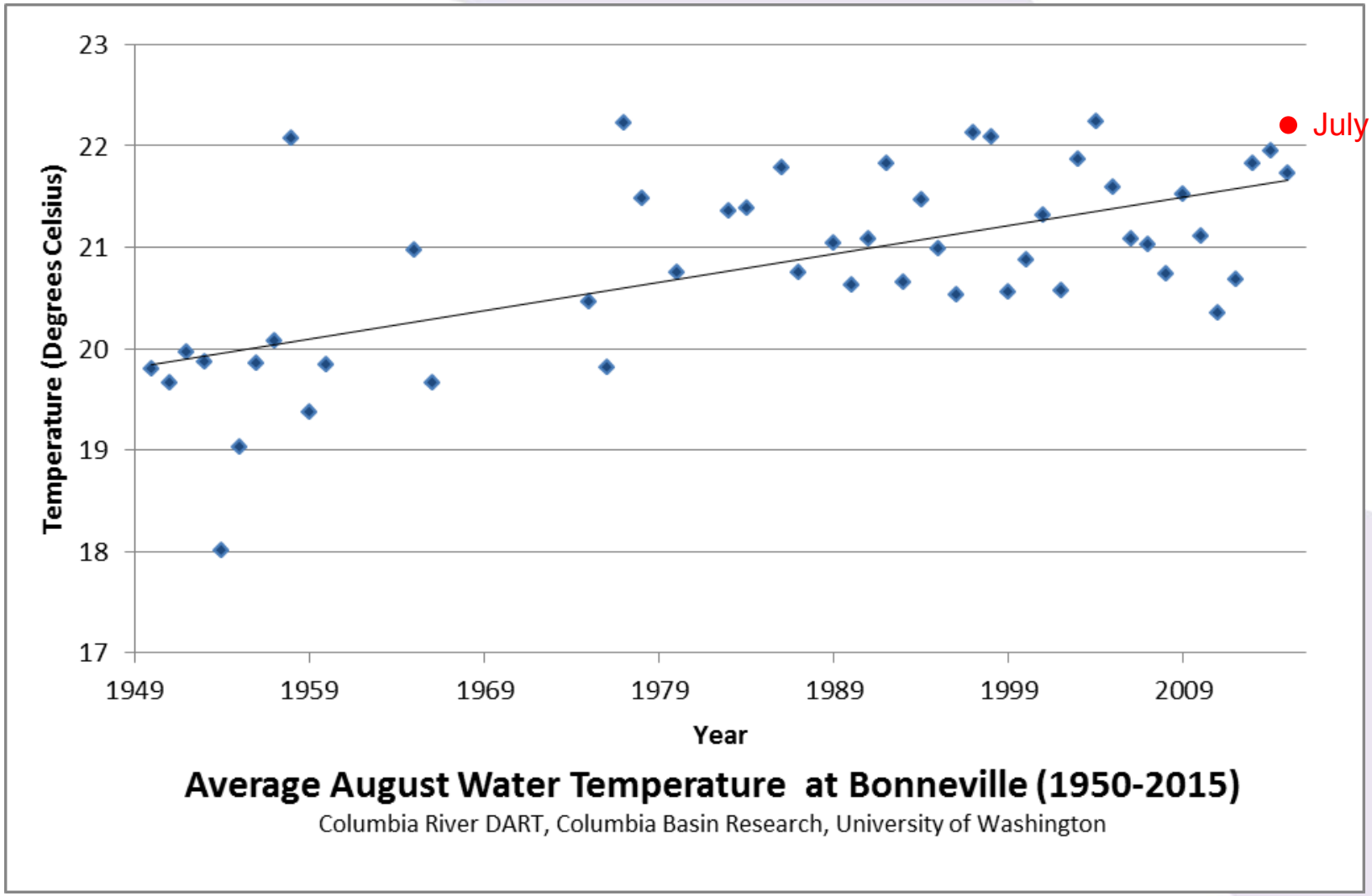
Figure 9. Migration timing distributions (median, quartiles, and 10th and 90th percentiles) at Bonneville Dam for steelhead that successfully returned to tributaries or hatcheries across study years. Vertical dotted lines show mean first and last dates that Columbia River water temperature was 19 °C; the shaded area shows dates with mean temperature ≥21 °C. From Keefer et al. (2009).

Graph and text copied from Keefer et al. 2011

Mainstem thermal regime during outmigration

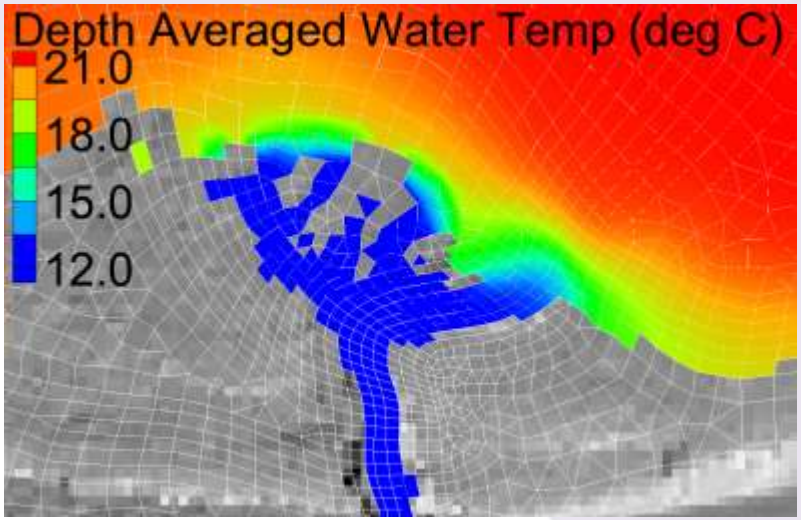


Mainstem thermal regime during outmigration



Potential benefits and impacts of thermal refugia

- Numerous potential benefits and impacts associated with thermal refugia, e.g. disease and predation.
- *Diversity & Resilience*:
  - Species: *Five life history strategies* documented in single populations of Chinook and coho (Reimers 1973; Craig 2010).
  - Habitats: A diversity of habitats (including varied thermal conditions), supports a variety of life history strategies, which is important for population resilience.
- Most natural systems have spatially variable thermal profiles, i.e., not homogenous and not linear…"more homogenized thermal landscapes may not provide sufficient variety of conditions for organisms to adapt" (Fullerton et al. 2015).

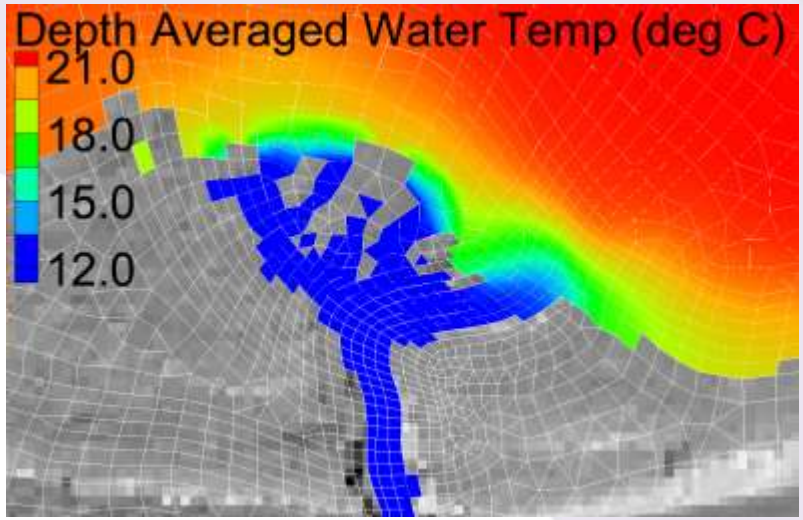


Characteristics of thermal refugia

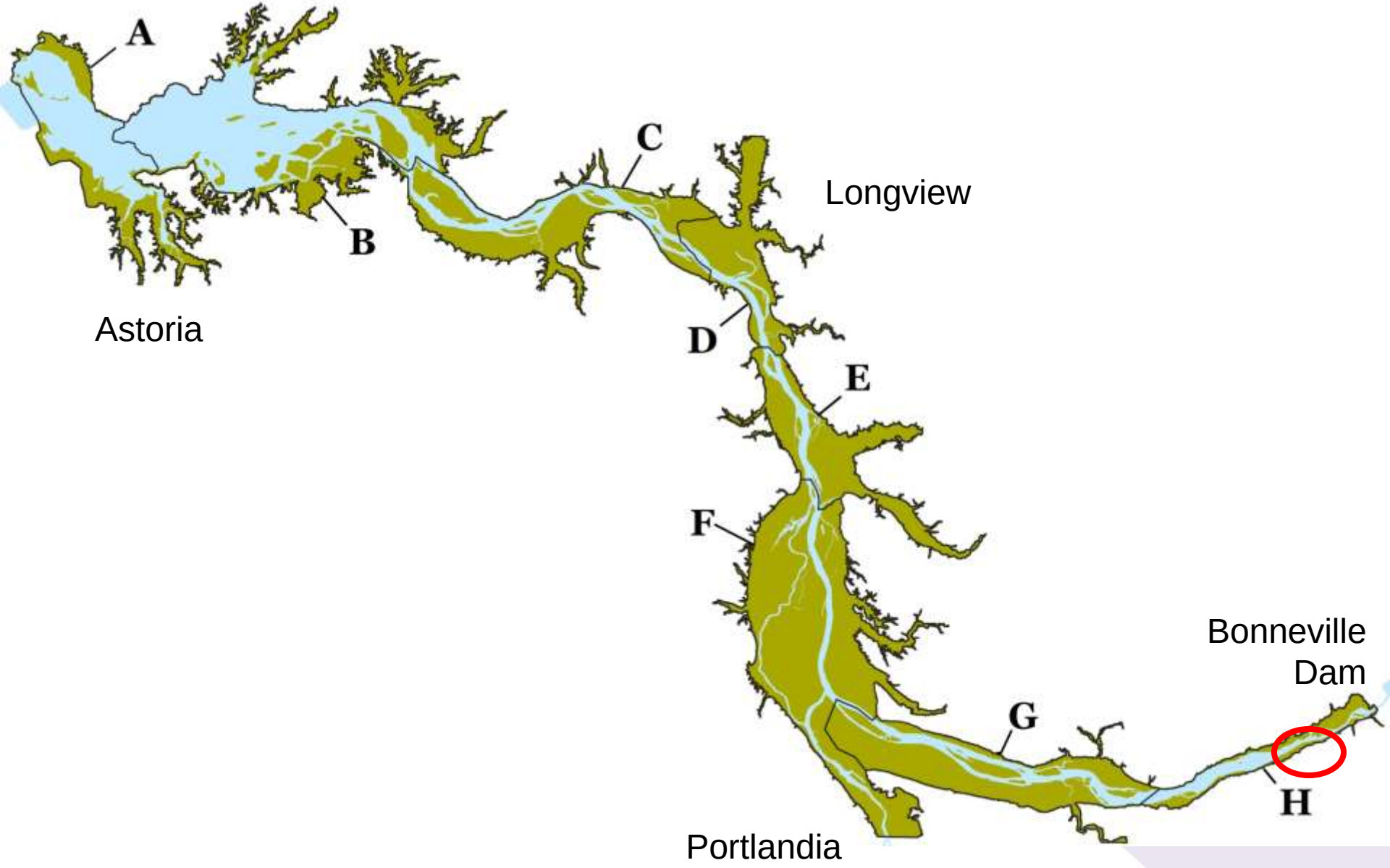
Organized by attributes presented in *Ecological Assessment Criteria for Restoring Anadromous Salmonid Habitat in Pacific Northwest Estuaries* (Simenstad and Cordell, 2000)

- **Opportunity/Access**:
  - Adjacent to mainstem
  - Detection: - Plume must extend into the migratory corridor
    - Temp. differential (2-7˚C cued adults above Bonneville) (Keefer et al. 2011)
- **Capacity**:
  - Temperature: - physiological: <19˚C (Bottom et al. 2011)
    - protection from predators: <19˚C (Moyle 2002)
  - Depth: minimum of ~0.5m for juveniles (Bottom et al. 2005)
  - Horizontal extent: uncertain

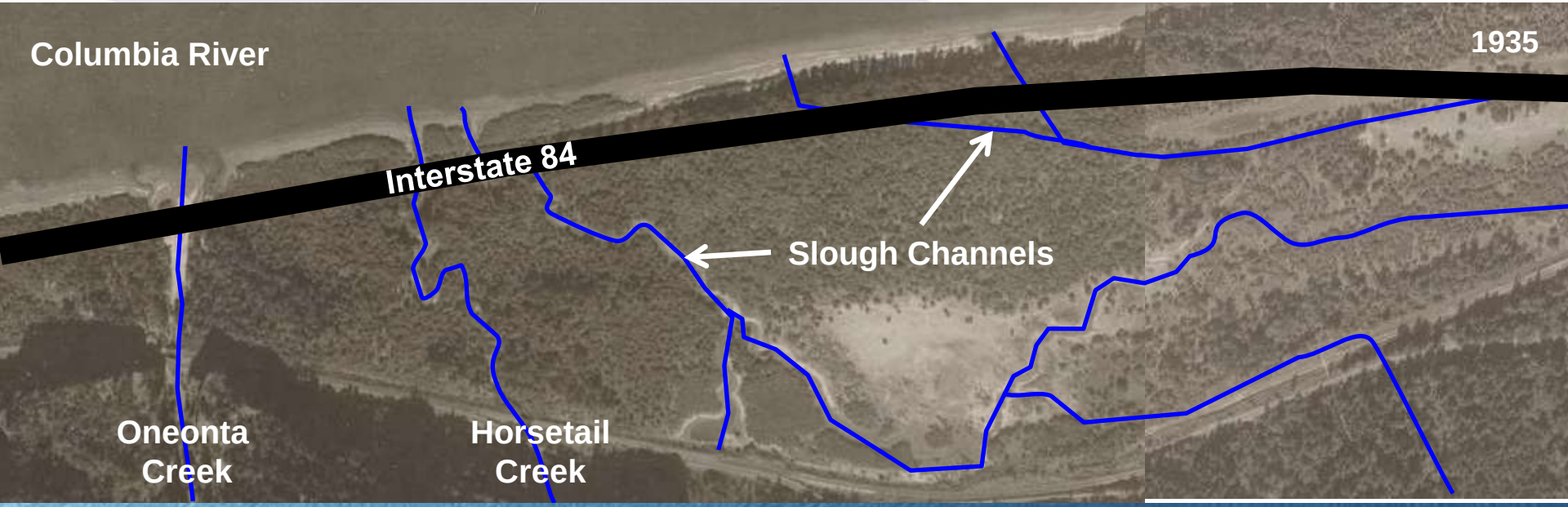
Design Criteria: - 2°C temperature difference
- 19°C max. tributary temp.
- >0.5m depth
- max. spatial extent practical



Example Project

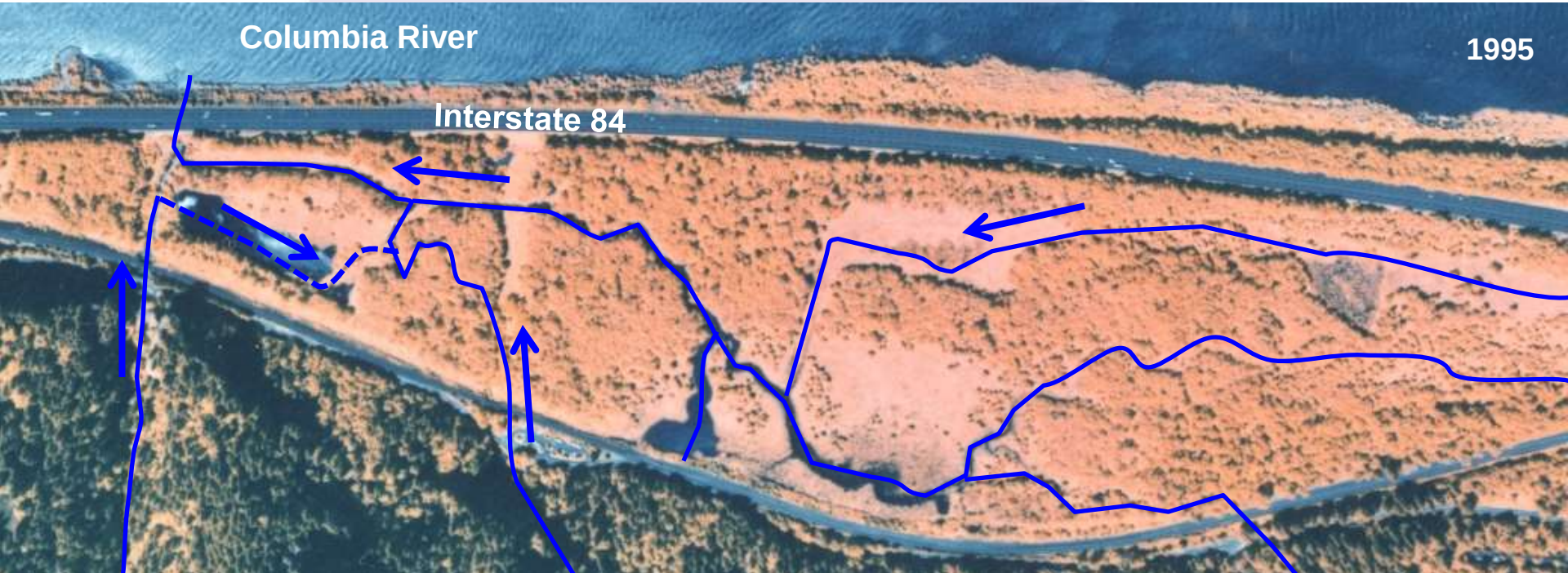


Example Project



Restoration Actions – Example 1: restore instream flow (eliminate stream diversions)

Oneonta Cr. Diversion - 2012



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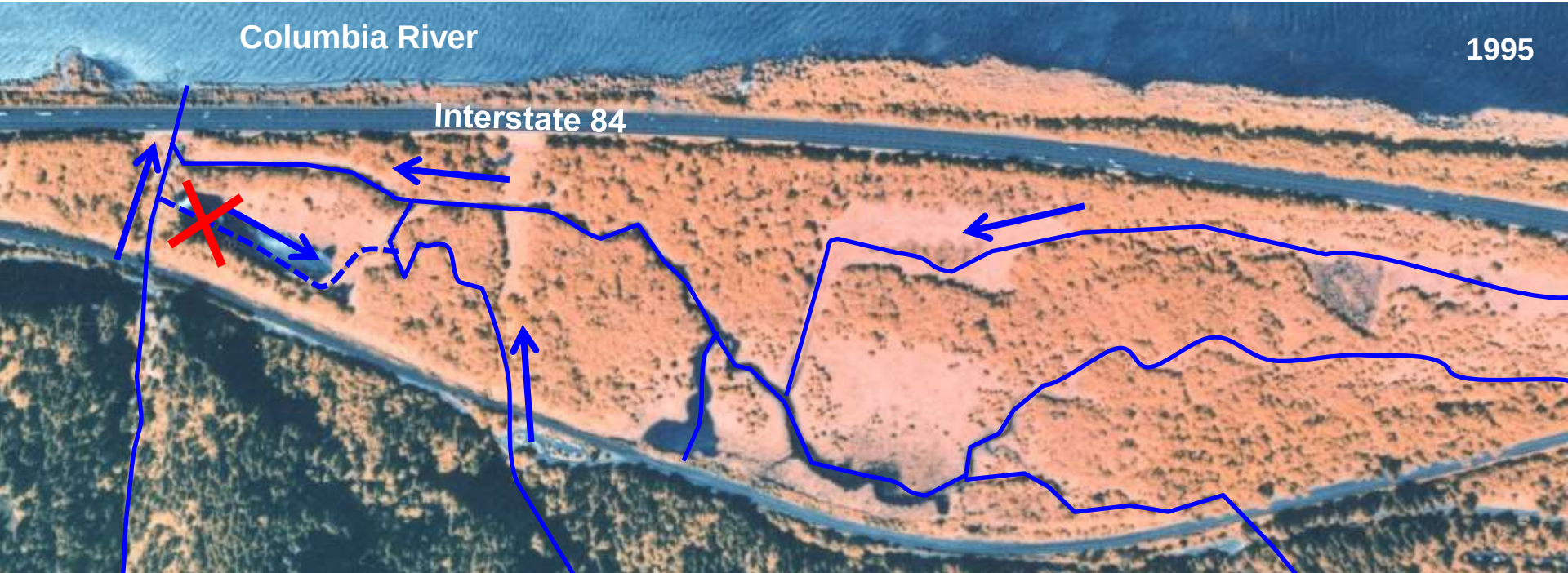
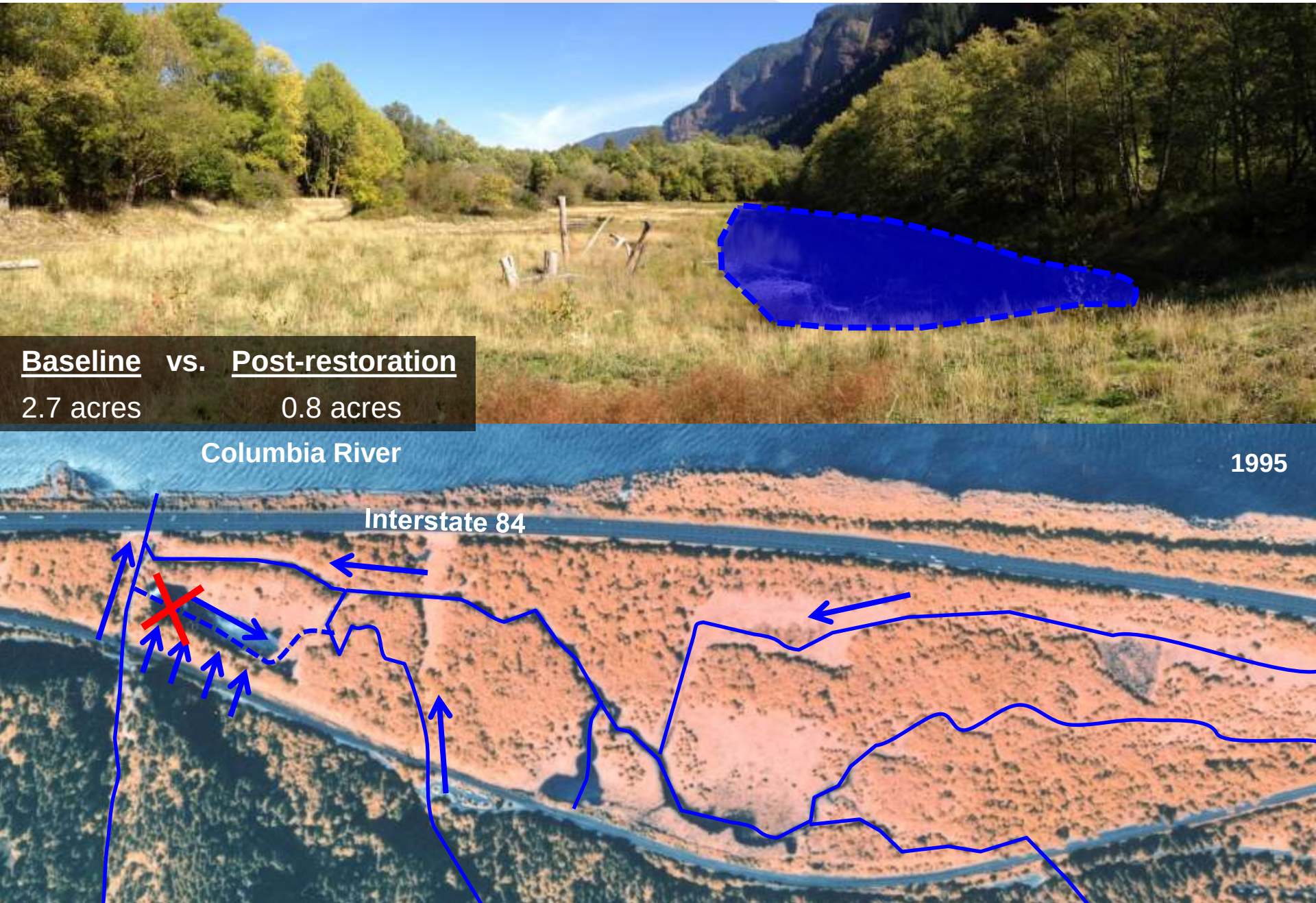
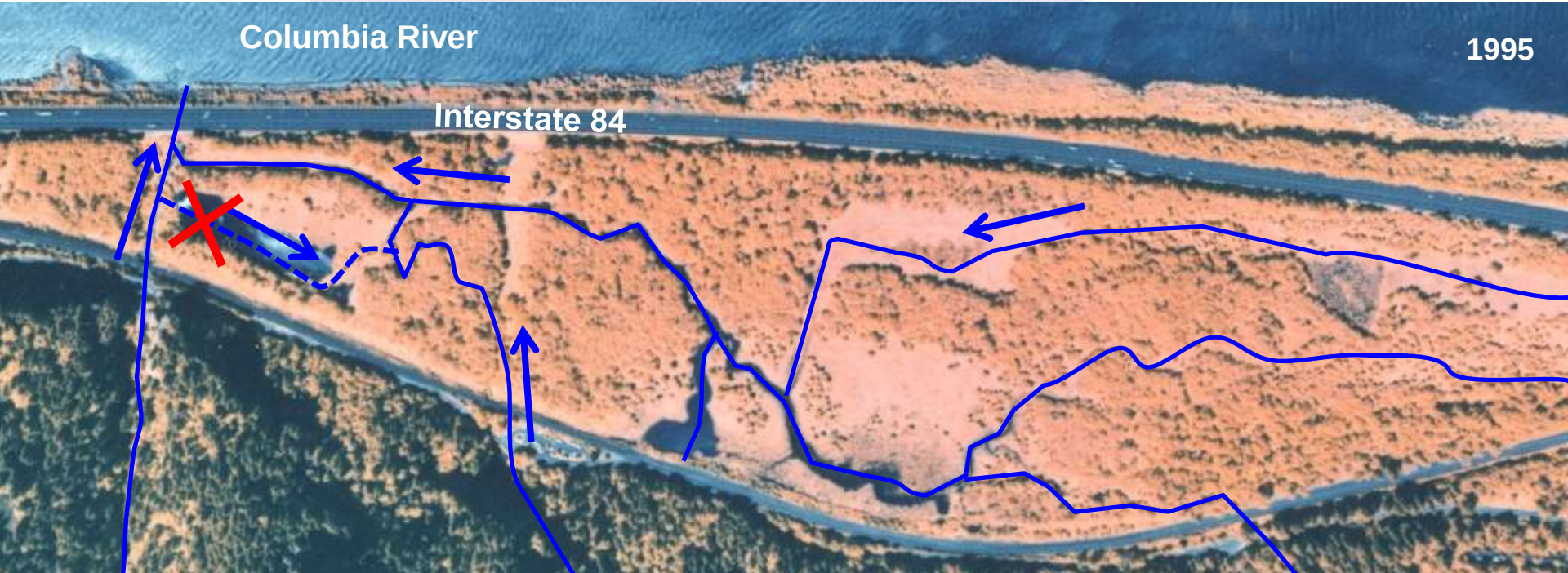


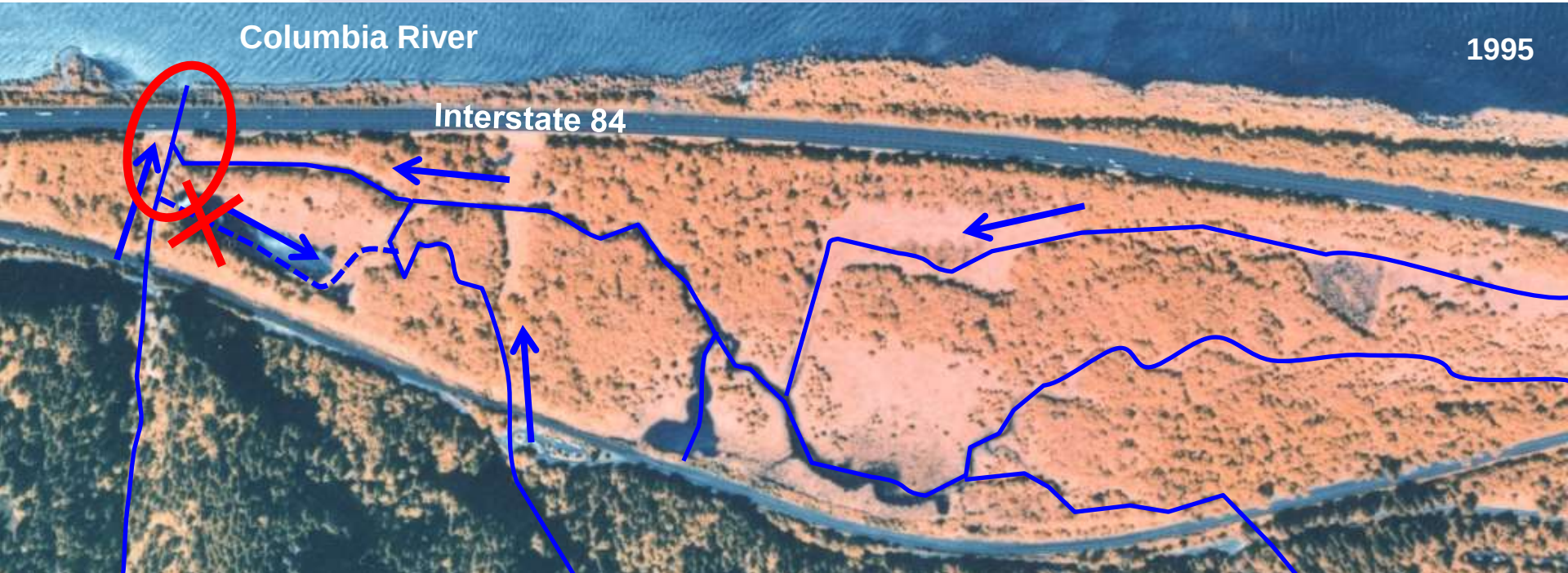
Restoration Actions – Example 2: restore floodplain hydrology



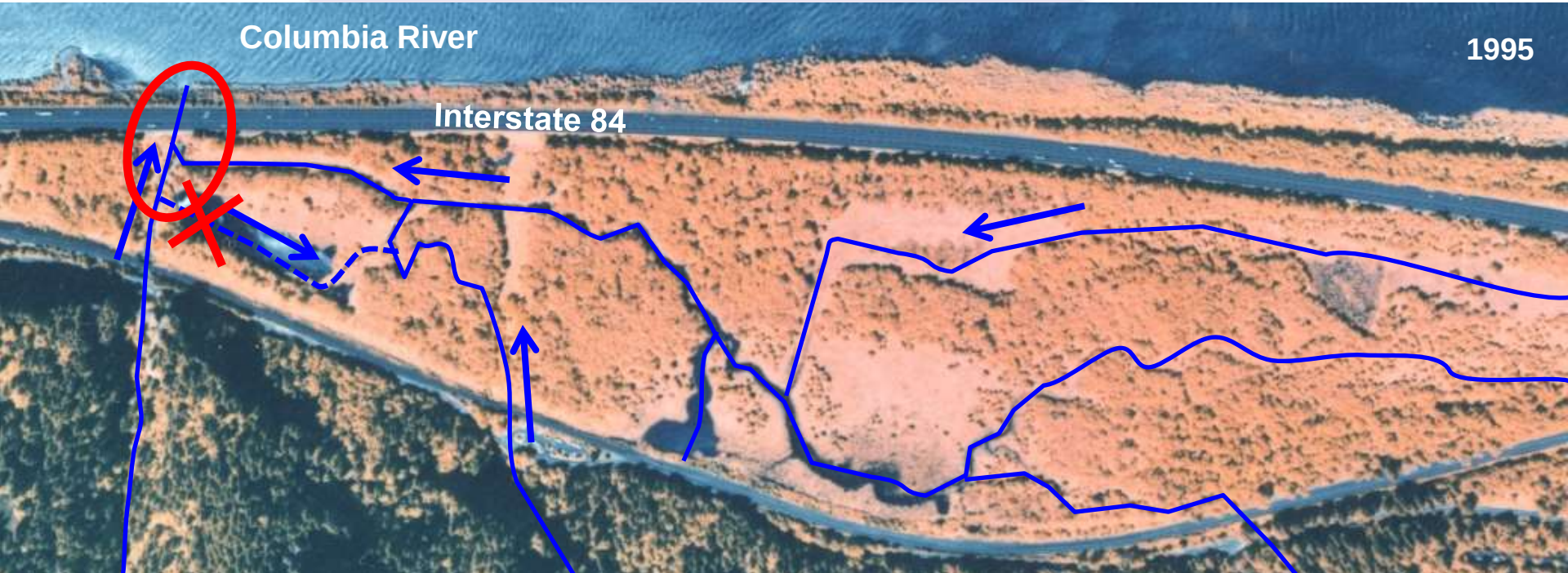
Restoration Actions – Example 3: reduce site temperatures by improving riparian vegetation



Restoration Actions – Example 4: provide access (longitudinal connectivity)

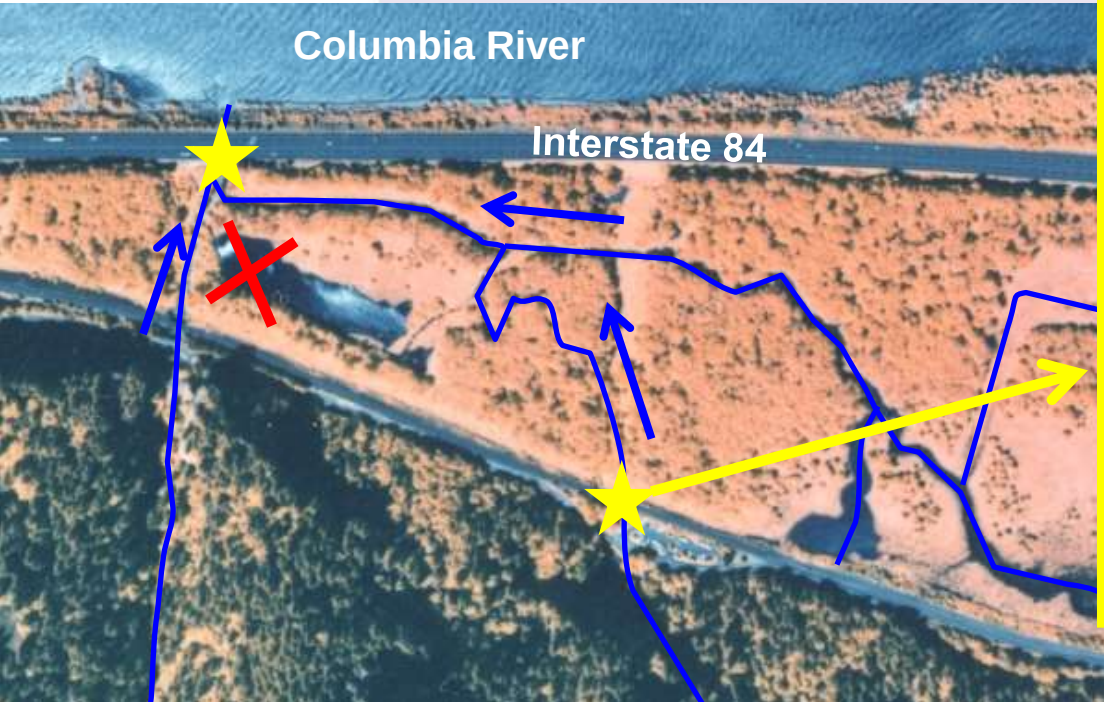


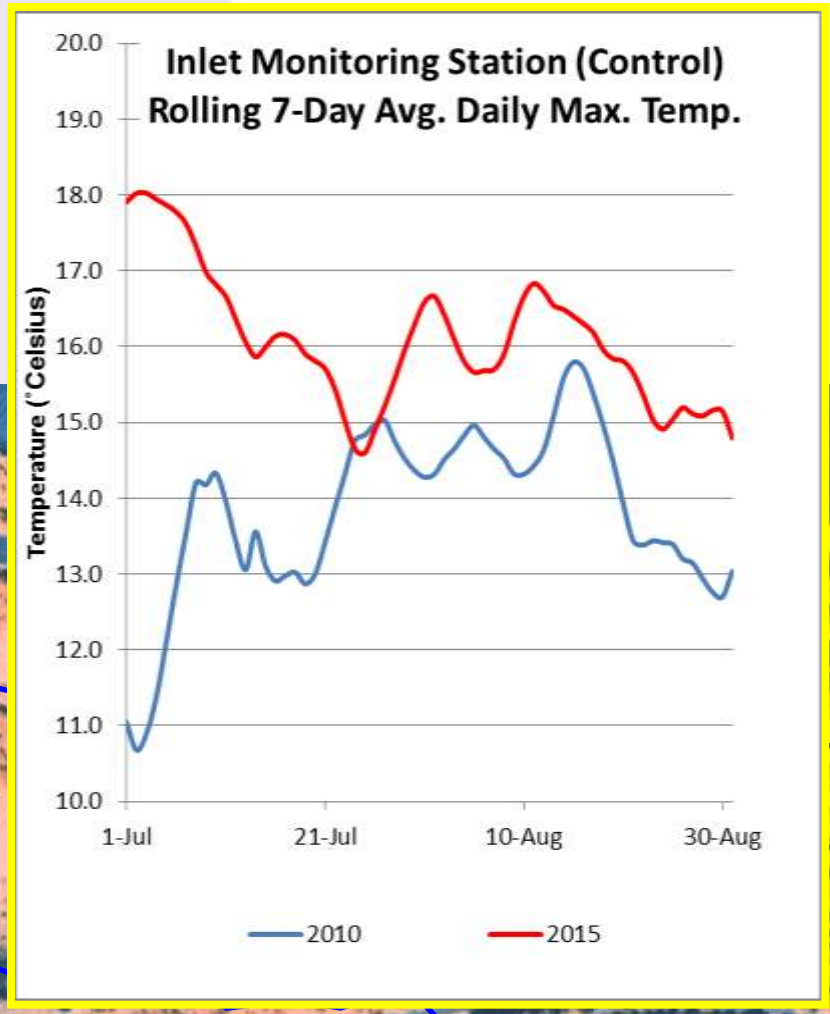
Restoration Actions – Example 4: provide access (longitudinal connectivity)



Preliminary Monitoring Results – thermal loading within the site

- As compared to historic data:
  - Baseline (2010) monitoring period was cool and wet.
  - Post-restoration (2015) monitoring period was hot and dry.
  - 2015 monitoring period was 2.8˚C warmer than 2010 and had 5.8 inches less rain.
- Mean increase in temperature between inlet (reference) and outlet monitoring stations was constant between years (2.7˚C vs. 2.9˚C).
- Peak temperatures in the restored gravel pond decreased by 5˚C (from 23.6˚C to 18.5˚C).

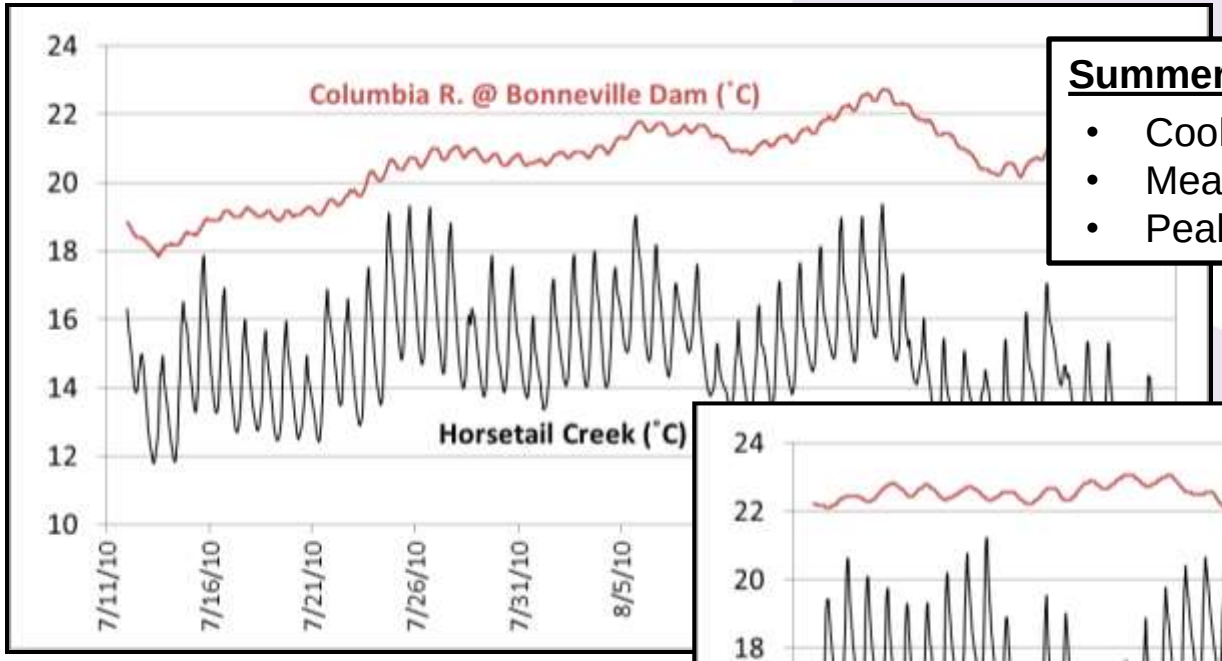




Preliminary Monitoring Results – thermal refugia in the mainstem

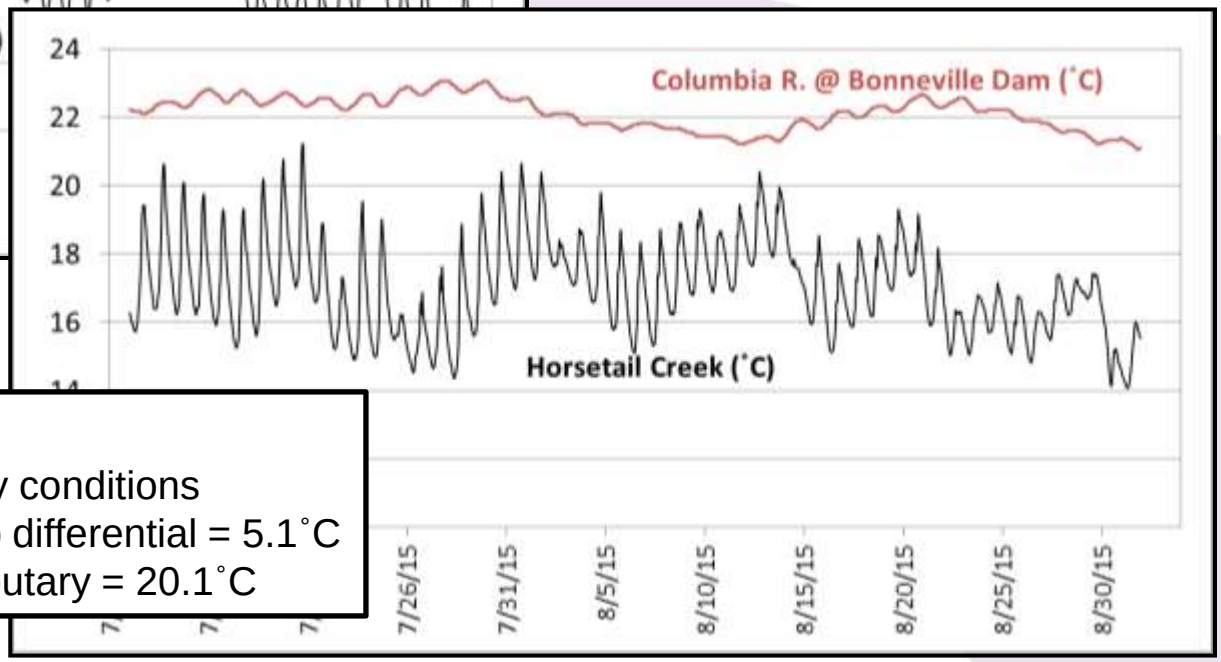
***Preliminary* Temperature Criteria:**

- Temperature differential b/t mainstem and tributary = >2˚C (Keefer et al., 2011)
- Peak tributary temperature = 19˚C (Bottom et al., 2011; Moyle 2002)



Summer 2010:

- Cool and wet conditions
- Mean temp differential = 5.8˚C
- Peak in tributary = 18.3˚C

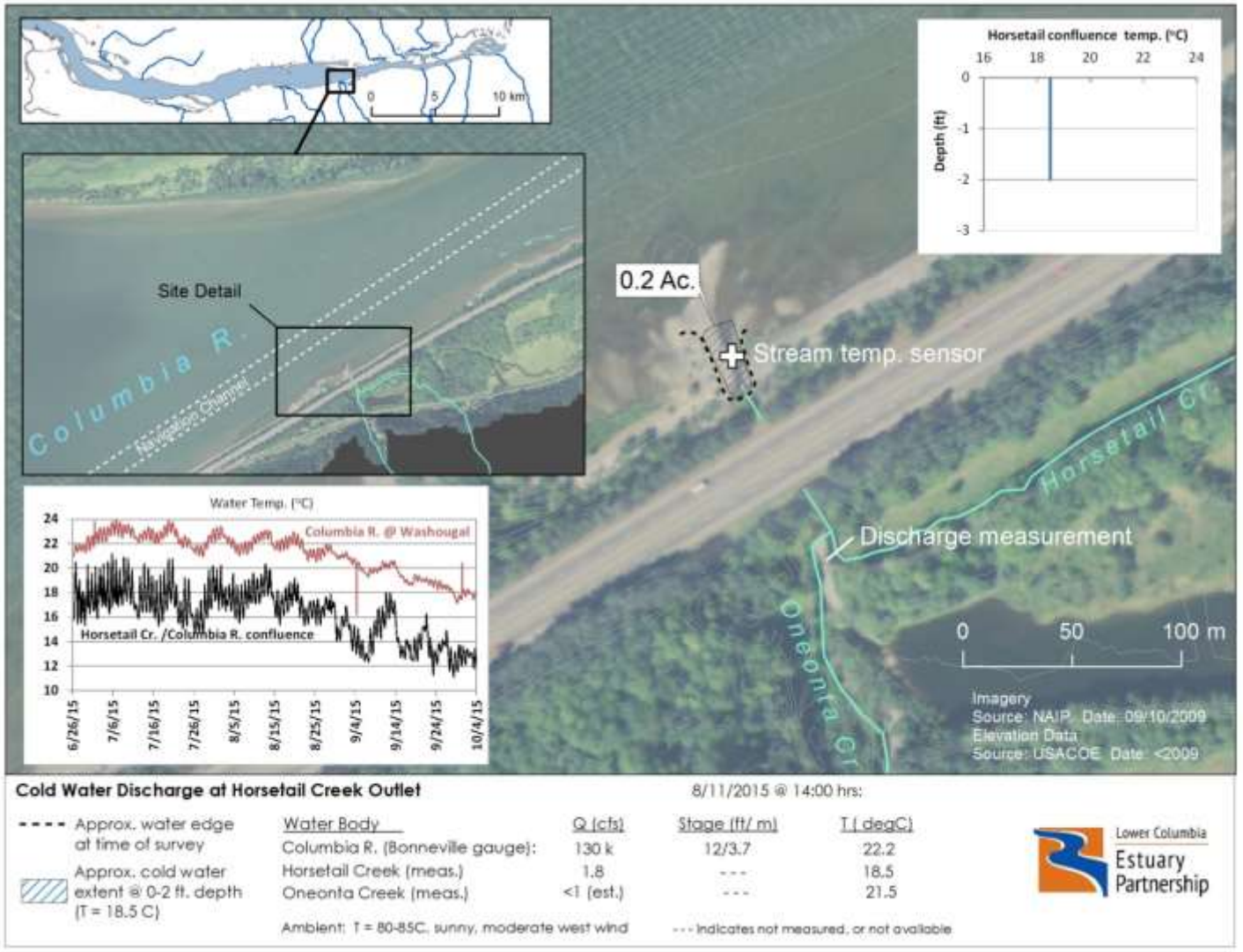


Summer 2015:

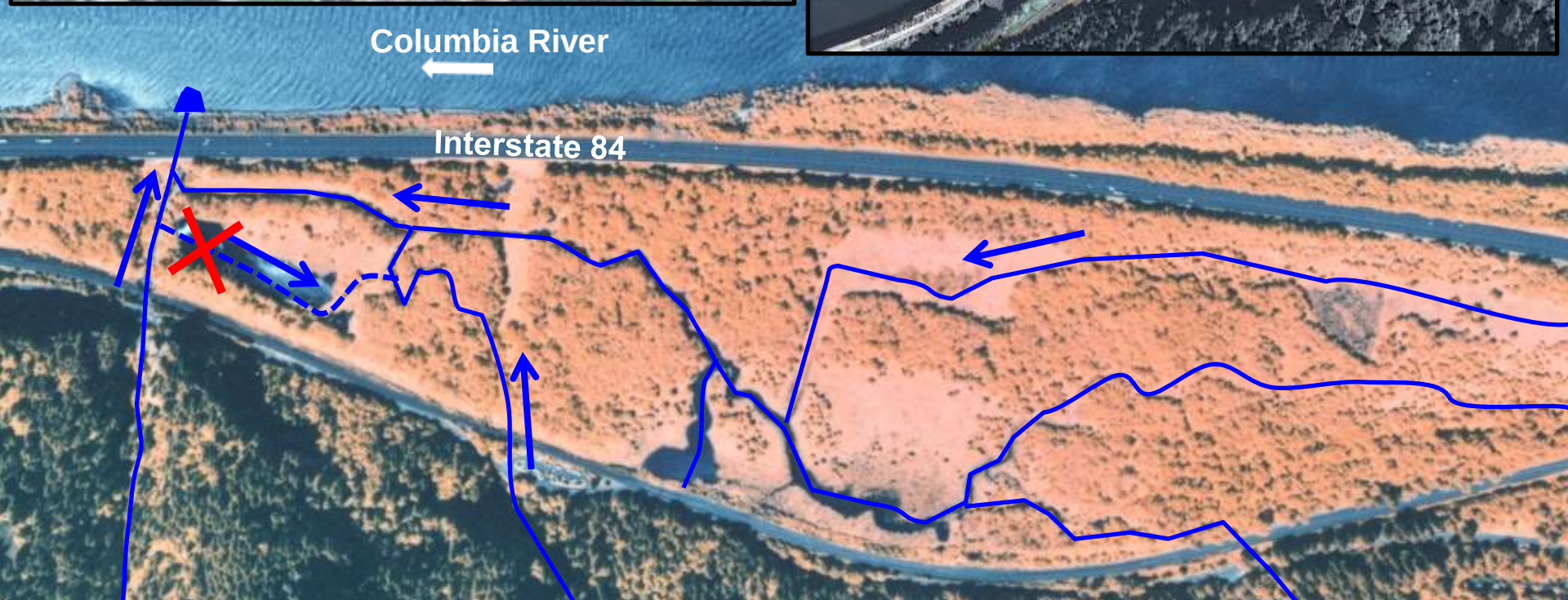
- Hot and dry conditions
- Mean temp differential = 5.1˚C
- Peak in tributary = 20.1˚C

Preliminary Monitoring Results – thermal refugia in the mainstem

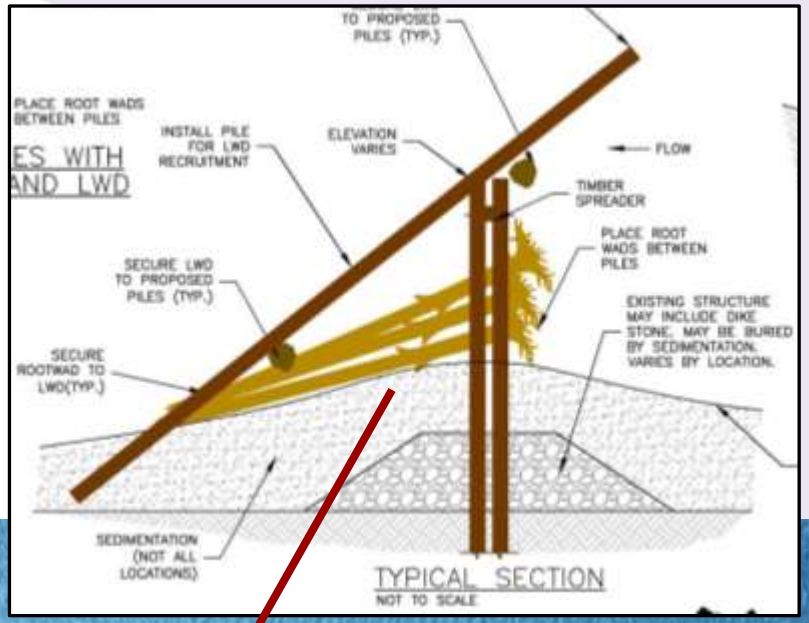
- Thus far, restoration has focused on the site (decreasing temps, increasing flow).
- Questions:
  - What are the conditions in the mainstem?
  - Are there more direct actions we could take to improve conditions there?



Preliminary Monitoring Results – thermal refugia in the mainstem



Preliminary Monitoring Results – thermal refugia in the mainstem



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Columbia River

Interstate 84

Preliminary Monitoring Results – thermal refugia in the mainstem

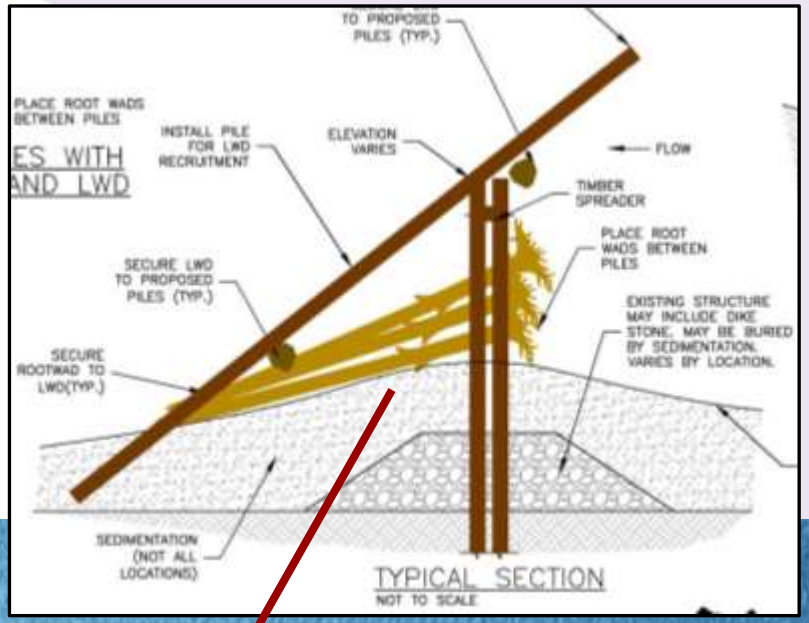

Photo courtesy of Tony Meyer, LCFEG

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Columbia River

Interstate 84

Thanks… Funders: BPA, USFS, OWEB, E. Multnomah SWCD, OCF, and ODOT
Mike Burke and Deb Stewart, InterFluve
Mark Kreiter, USFS (retired)
Matt Keefer, U. of Idaho
Tim Beechie, NMFS

Questions… Chris Collins
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Preliminary Monitoring Results – thermal refugia in the mainstem

Design Criteria: *how do we compare?*

	Criteria	2010	2015	Comments
Temperature differential	>2˚C	Mean = 5.8˚C Min. = 1.0˚C	Mean = 5.1˚C Min. = 1.0˚C	Keefer et al. 2011
Tributary temperature (peak 7-DADM)	<19˚C	18.3˚C	20.1˚C	Bottom et al. 2011 Moyle 2002 Keefer et al. 2011
Size of plume	TBD	Unknown	0.1 acres	
Depth	>0.5m	Unknown	Mean = 0.3m	Bottom et al. 2005