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Managing Water in the West

Facilitating Fish Passage on the Klamath River through Large Dam Removals

Thomas E. Hepler, P.E.
Technical Service Center
Denver, Colorado

U.S. Department of the Interior
Bureau of Reclamation

Klamath Project Highlights

- Feasibility-level studies for removal of four hydroelectric dams on the Klamath River by 2020
- Public draft EIS/EIR and Detailed Plan Report (released Sept 22, 2011)
- Reclaims 68 miles of coho salmon habitat and 420 miles of steelhead habitat in upper basin
- Increases chinook salmon harvest by 80+ percent
- Increases reliability of water supplies for farms
- Results in loss of 169 MW generating capacity

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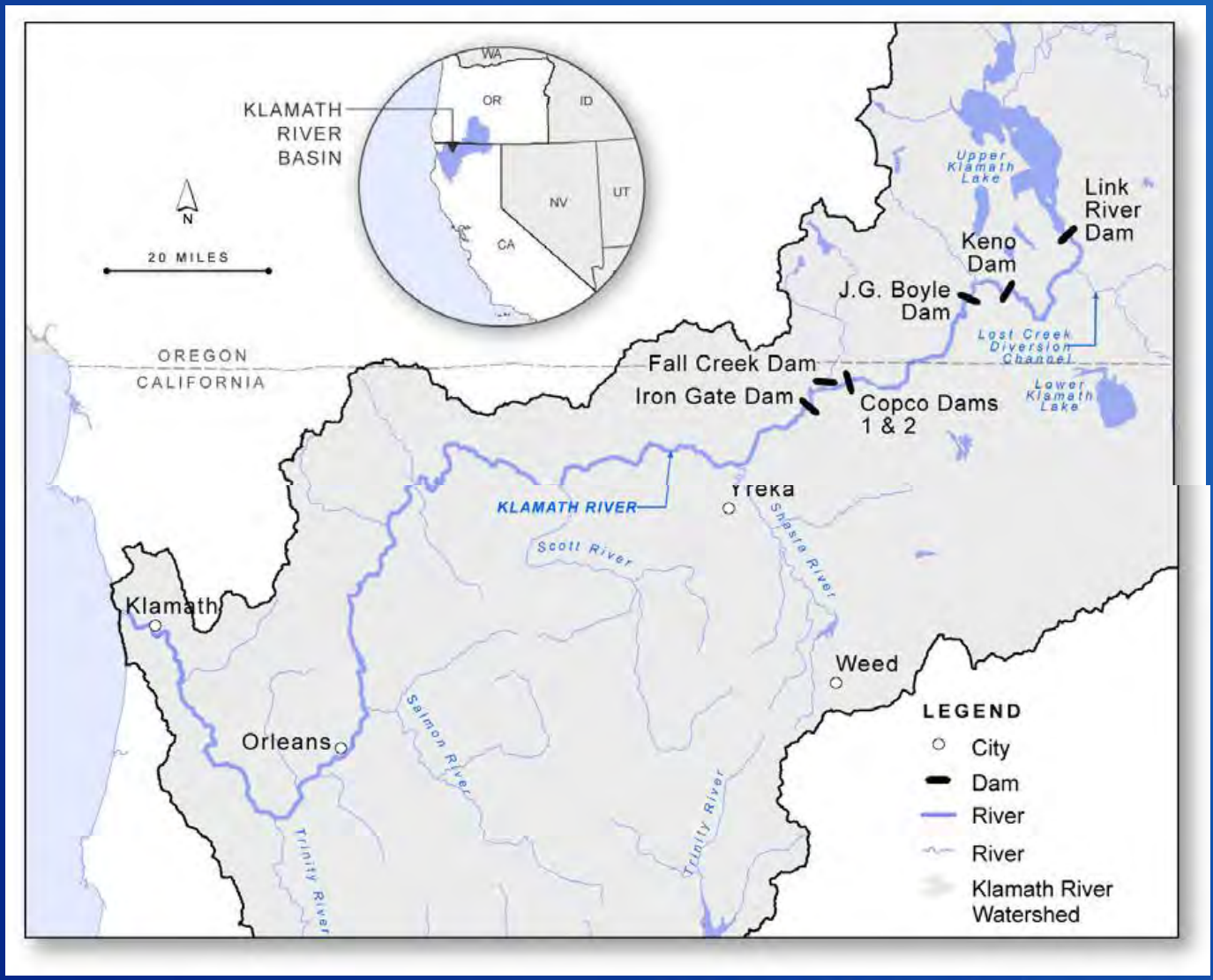
Klamath Project – Site Locations



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Existing Project Features

J.C. Boyle Dam

- Built 1958 at RM 224.7
- 68 feet high
- 2,629 a-f storage
- 98 MW generation

Copco 2 Dam

- Built 1925 at RM 198.3
- 33 feet high
- 70 a-f storage
- 27 MW generation

Copco 1 Dam

- Built 1922 at RM 198.6
- 135 feet high
- 40,000 a-f storage
- 20 MW generation

Iron Gate Dam

- Built 1962 at RM 190.1
- 189 feet high
- 53,800 a-f storage
- 18 MW generation

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Klamath Project Issues

- Hydroelectric facilities owned/operated by PacifiCorp
- FERC relicensing began in 2000; EIS released in 2007 and established Mandatory Conditions for fish passage
- Agreement-in-Principle signed in 2009 to resolve relicensing issues and conflicts in Klamath Basin
- Final settlement agreement would specify steps for Facilities Removal; minimize adverse impacts; address stakeholder interests; and establish funding
- Potential benefits for fisheries and water quality were believed to outweigh potential costs, risks, and liabilities

Klamath Hydroelectric Settlement Agreement (KHSA) – Feb 2010

- Secretarial Determination on Klamath River Dams Removal
  - Enhance salmonid fisheries
  - Best interest of the public
  - Costs within State Cost Cap
- Requires environmental and technical studies to inform
- Established ratepayer and State funding sources (total $450 M)
- Separate agreement for other basin restoration efforts (KBRA) using Federal funding

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J.C. Boyle (Big Bend) Dam

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J. C. Boyle Embankment Section

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J.C. Boyle Intake and Gated Spillway

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J.C. Boyle Power Canal

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J. C. Boyle Penstocks and Powerhouse

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Copco 1 Dam and Gated Spillway

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Copco 1 Penstocks and Powerhouse

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Copco 2 Dam and Gated Spillway

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Copco 2 Wood-Stave Penstock

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Copco 2 Penstocks and Powerhouse

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Iron Gate Embankment Dam

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Iron Gate Side-Channel Spillway

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Iron Gate Powerhouse and Fish Collection Features

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Iron Gate Fish Hatchery

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Large Dam Removal Projects in U.S.

- Elwha Dam (WA) – 108’ high, 8,600 a-f
- Glines Canyon Dam (WA) – 210’ high, 25,800 a-f

- J.C. Boyle Dam (OR) – 68’ high, 2,629 a-f
- Copco 1 Dam (CA) – 135’ high, 40,000 a-f
- Iron Gate Dam (CA) – 189’ high, 53,800 a-f

- Condit Dam (WA) – 125’ high, >5,000 a-f
- San Clemente Dam (CA) – 106’ high, 1,700 a-f
- Matilija Dam (CA) – 190’ high, 7,000 a-f

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Project Goals for Dam Removal

- Identify means to safely remove J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams on Klamath River
- Provide for free flow and volitional fish passage
- Facilitate sediment management through controlled releases and construction work schedules
- Minimize downstream water quality impacts
- Protect existing infrastructure
- Establish reservoir restoration requirements
- Determine total construction costs for Full and Partial Removal alternatives

Establishment of Removal Limits

- Dam embankments (JC Boyle and Iron Gate) are too narrow and impractical to leave portions in place
- Concrete spillways at JC Boyle, Copco 1, and Copco 2 must be removed for diversion during construction; Iron Gate spillway will remain for both alternatives
- Hazardous materials to be removed – hydraulic fluids, batteries, treated wood, painted metalwork
- Transmission lines to be removed
- Tunnel portals and structure openings to be sealed

Copco 1 – Intake and Powerhouse

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Copco 2 – Powerhouse

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Key Dam Removal Activities

- Reservoir Drawdown
  - Identify existing release capacities at each site
- Streamflow Diversion
  - Develop diversion tunnels or notches
  - Limit drawdown rates (for slope stability, turbidity)
- Structure Demolition
  - Consider blasting or hoe-ramming; heavy earthwork
  - Compute quantities for all features to be removed
- Waste Disposal
  - Bury on-site, haul away, or salvage; address Haz/Mat
- Site Restoration
  - Restore natural-looking contours and revegetate

Criteria for Dam Removal Timing

- Provide maximum fisheries protection
  - Minimize sediment release during fish migration periods
  - Maximize drawdown between Jan 1 and Mar 15, 2020
- Ensure slope stability
  - Limit reservoir drawdown rates to preserve slopes
- Minimize dam overtopping (hydrologic) risk
  - Remove dam embankments during low flow season
  - Ensure minimum 100-year flood protection
- Minimize power generation impacts
  - KHSA assumes no power generation after Jan 1, 2020
  - Estimate effects of earlier and later shutdowns
- Consider environmental constraints

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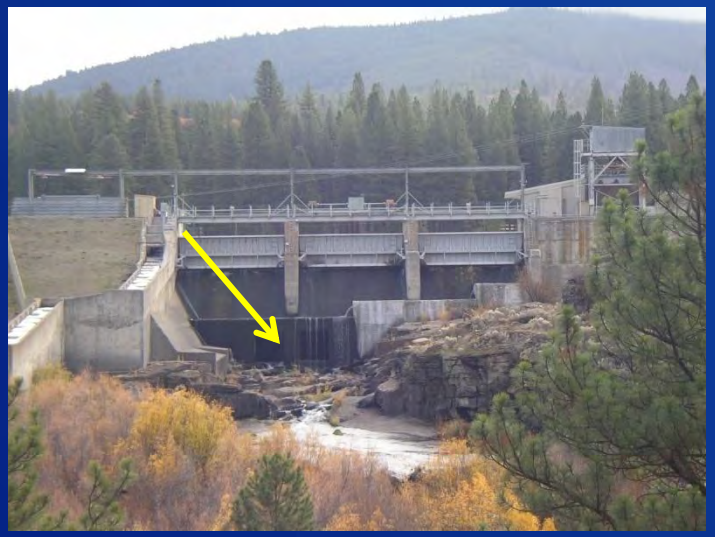
J.C. Boyle Dam – Diversion Plan

- Use gated spillway and penstock for drawdown up to 30 feet beginning Jan 1, 2020 (1 foot per day)
- Reopen low-level diversion conduits (one at a time)
- Remove additional concrete for overflow capacity
- Remove embankment after July 1, 2020 (low flow)
- Controlled breach by Sept 30, 2020 (after Iron Gate)



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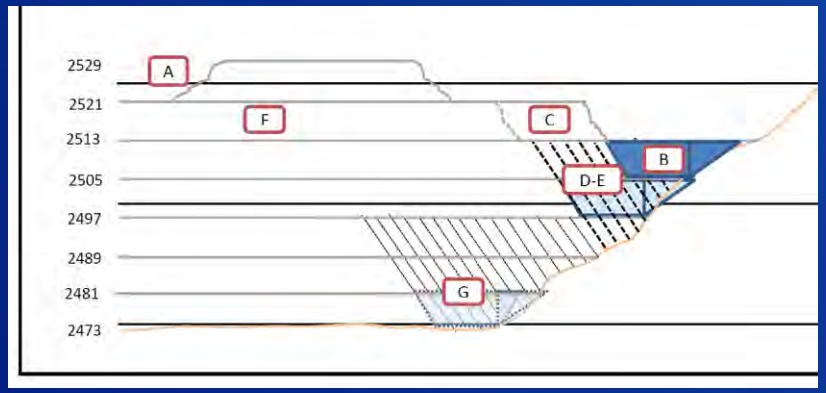
Copco 1 Dam – Diversion Plan

- Modify existing tunnel for diversion releases
- Use gated spillway and diversion tunnel for drawdown beginning Nov 1, 2019; remove spillway
- Remove dam concrete by blasting in 8-foot lifts after Jan 1, 2020, with releases through diversion tunnel
- Notch to d/s tailwater level by Mar 15, 2020
- Complete removal during low flow period, following removal of Copco 2 Dam



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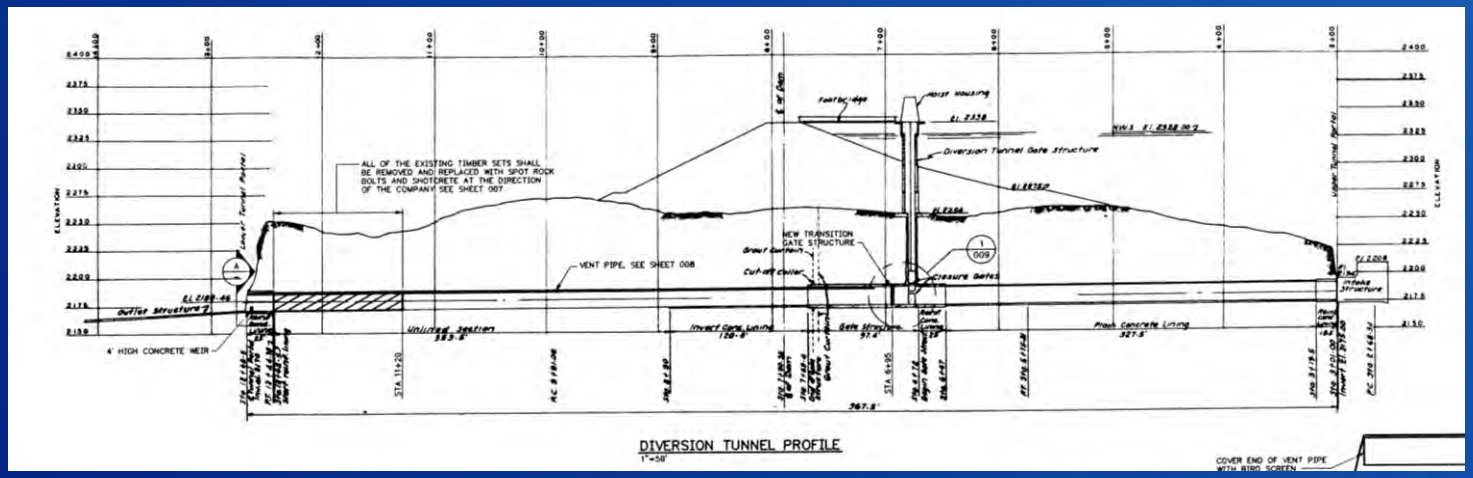
Copco 2 Dam – Diversion Plan

- Continue power generation until dam removal begins
- Use gated spillway for drawdown after May 1, 2020; construct cofferdam to remove left side of dam
- Breach and relocate cofferdam to remove right side of dam by Sept 2020

Iron Gate Dam – Diversion Plan

- Modify existing tunnel for diversion releases
- Use diversion tunnel for drawdown up to 126 feet beginning Jan 1, 2020 (3 feet per day)
- Remove embankment after Jun 1, 2020 (1.1 million cubic yards) during low flow
- Controlled breach by Sept 15, 2020



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Risk and Uncertainty of Dam Removal

- Fishery Effects
  - Suspended sediments
  - Increased bedload
- Water Quality
  - Temperature changes
  - Dissolved oxygen
- Local Communities
  - 70 homes at Copco
  - Groundwater impacts
  - Higher d/s flood levels
- Effects on Tribal Interests
  - Cultural resources

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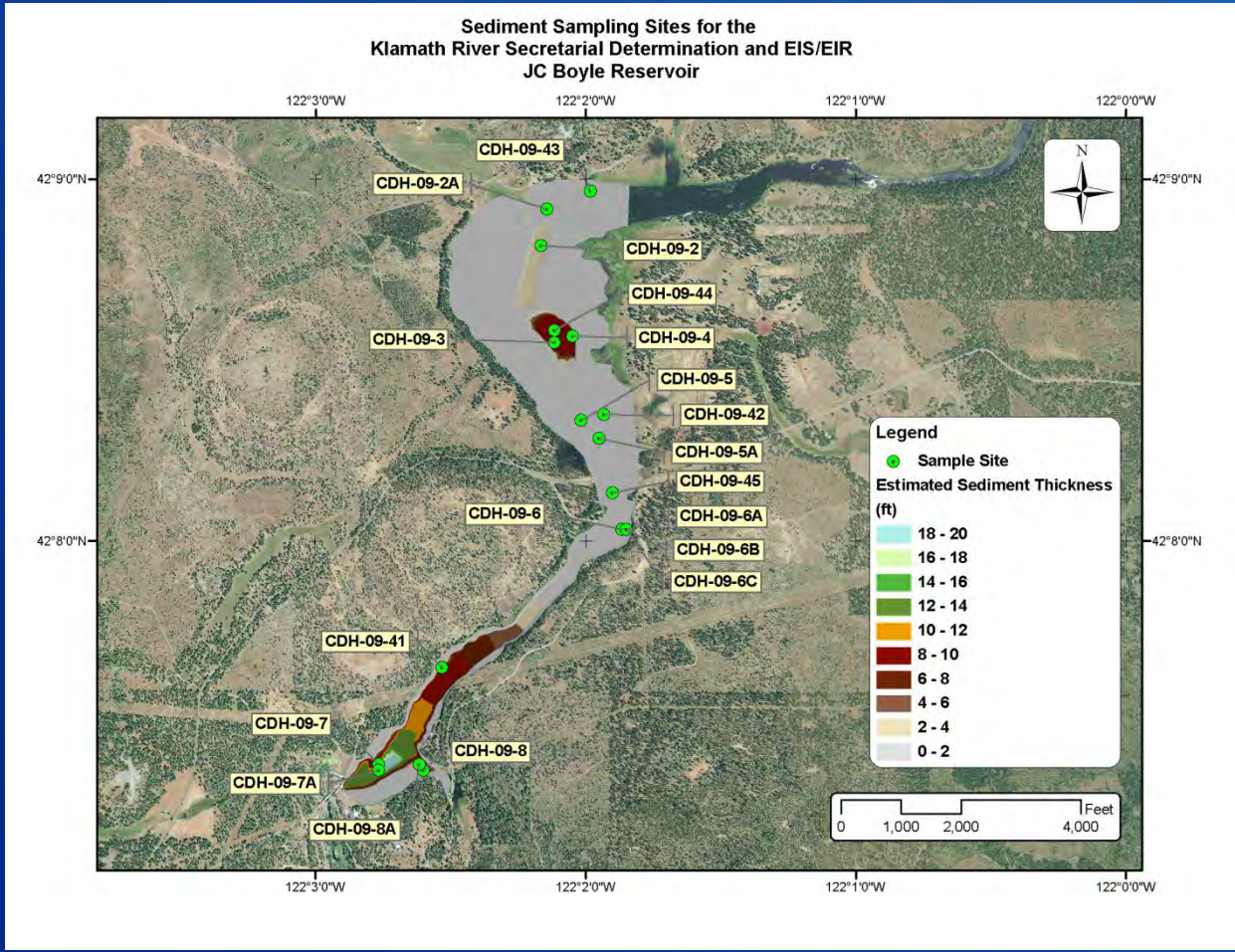
Sediment Sampling – J.C. Boyle



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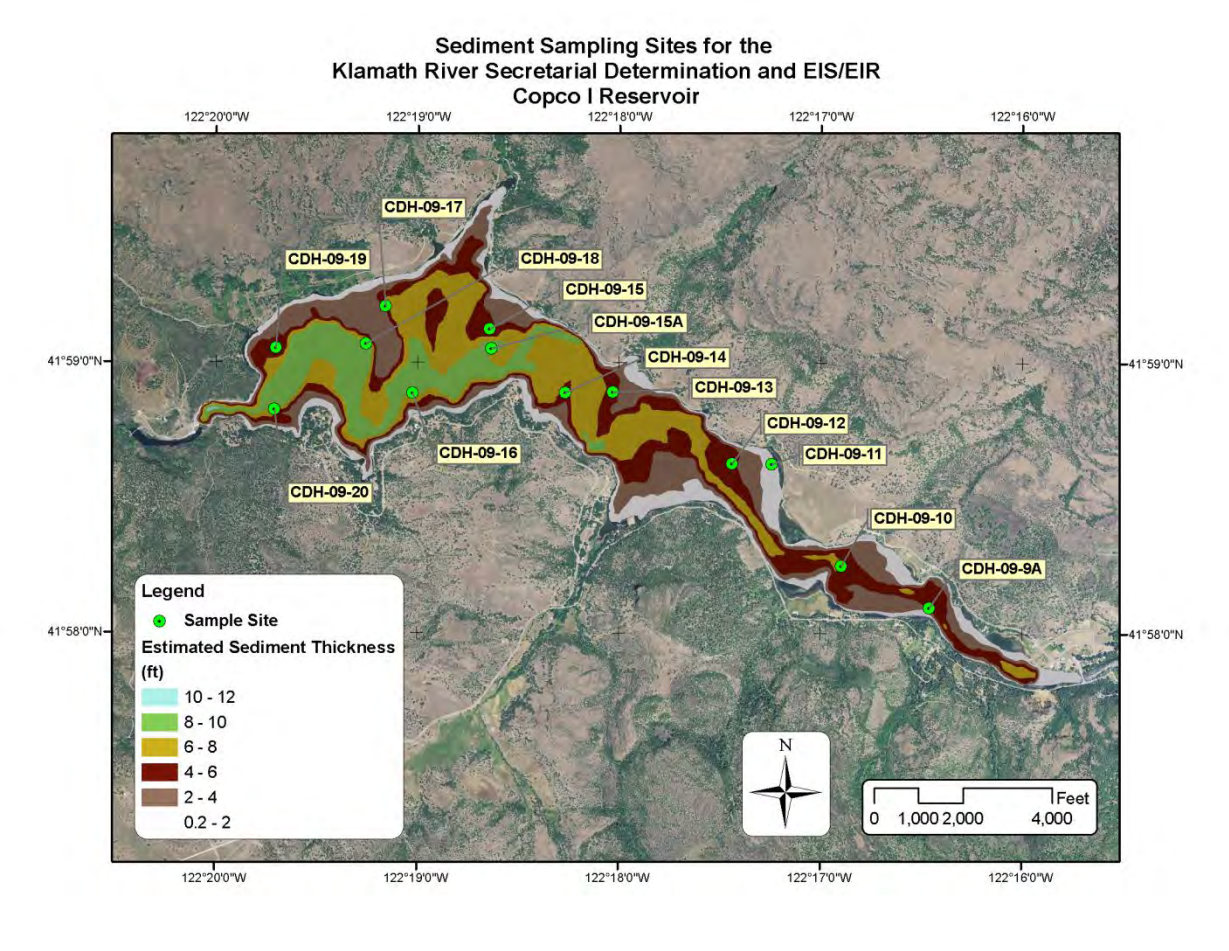
Sediment Sampling – Copco 1



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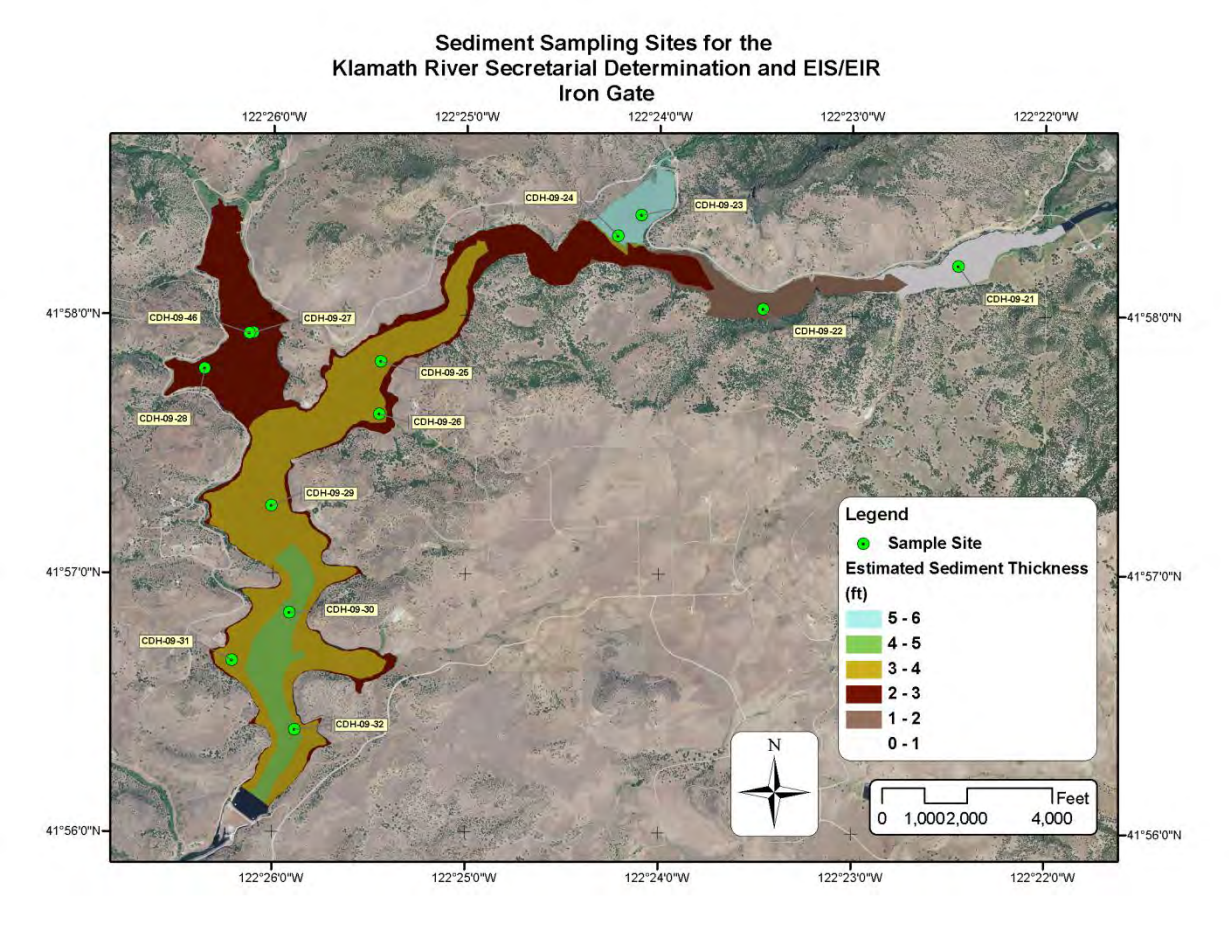
Sediment Sampling – Iron Gate



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Sediment Volumes and Type Based on Sampling and Testing Results

Sediment depths determined by regression of drill hole depth (compared to previous estimates)

Reservoir	# holes	Volume (yd^3)	silt and clay (%)
JC Boyle	5 + 26 = 31	1,000,000 (640,000)	44 (upper) 88 (lower)
Copco I	12 + 17 = 29	7,400,000 (10,900,000)	73 (upper) 88 (lower)
Copco II		0	0
Iron Gate	9 + 19 = 28	4,700,000 (8,900,000)	73 (upper) 85 (lower)
TOTAL		13,100,000 (20,440,000)	

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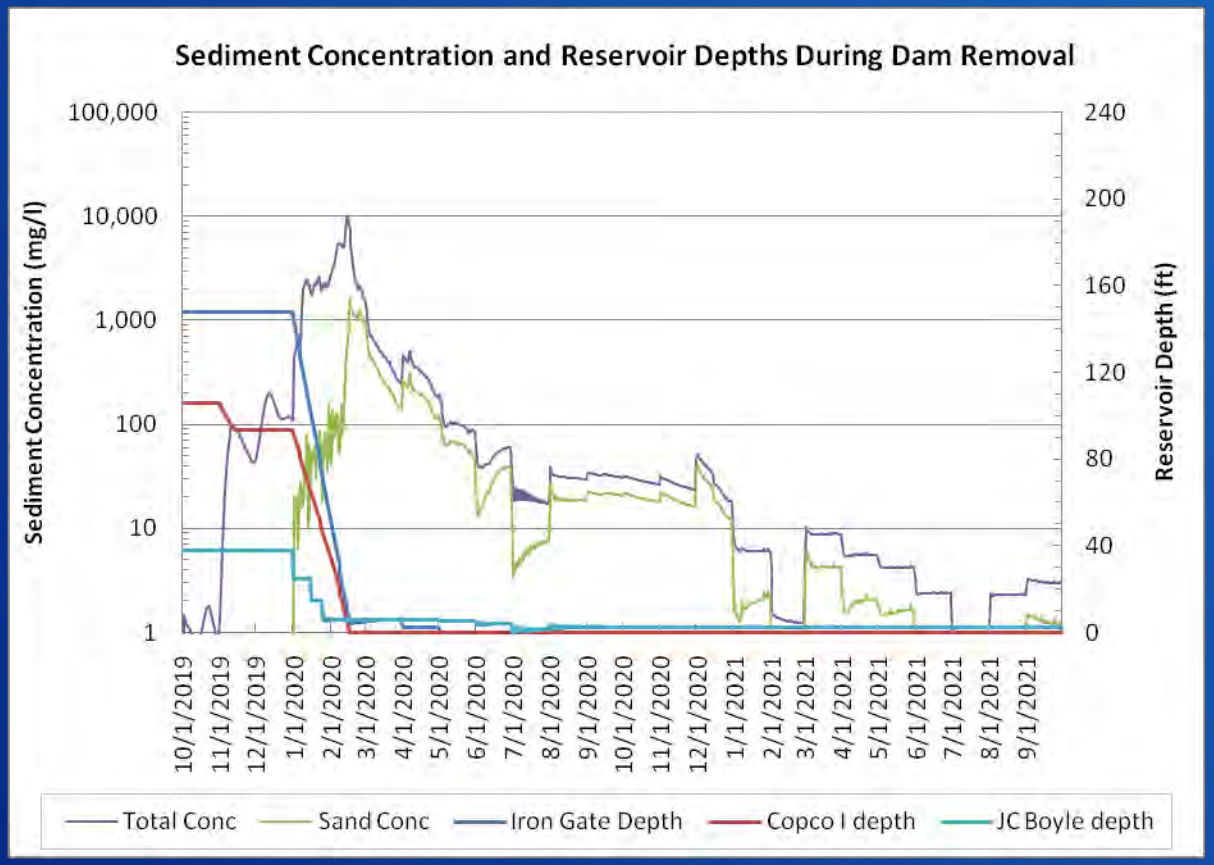
Iron Gate Concentrations (Avg. Year)



Concentration Definitions:

High > 1,000 mg/l
Medium = 100 to 1,000 mg/l
Low < 100 mg/l

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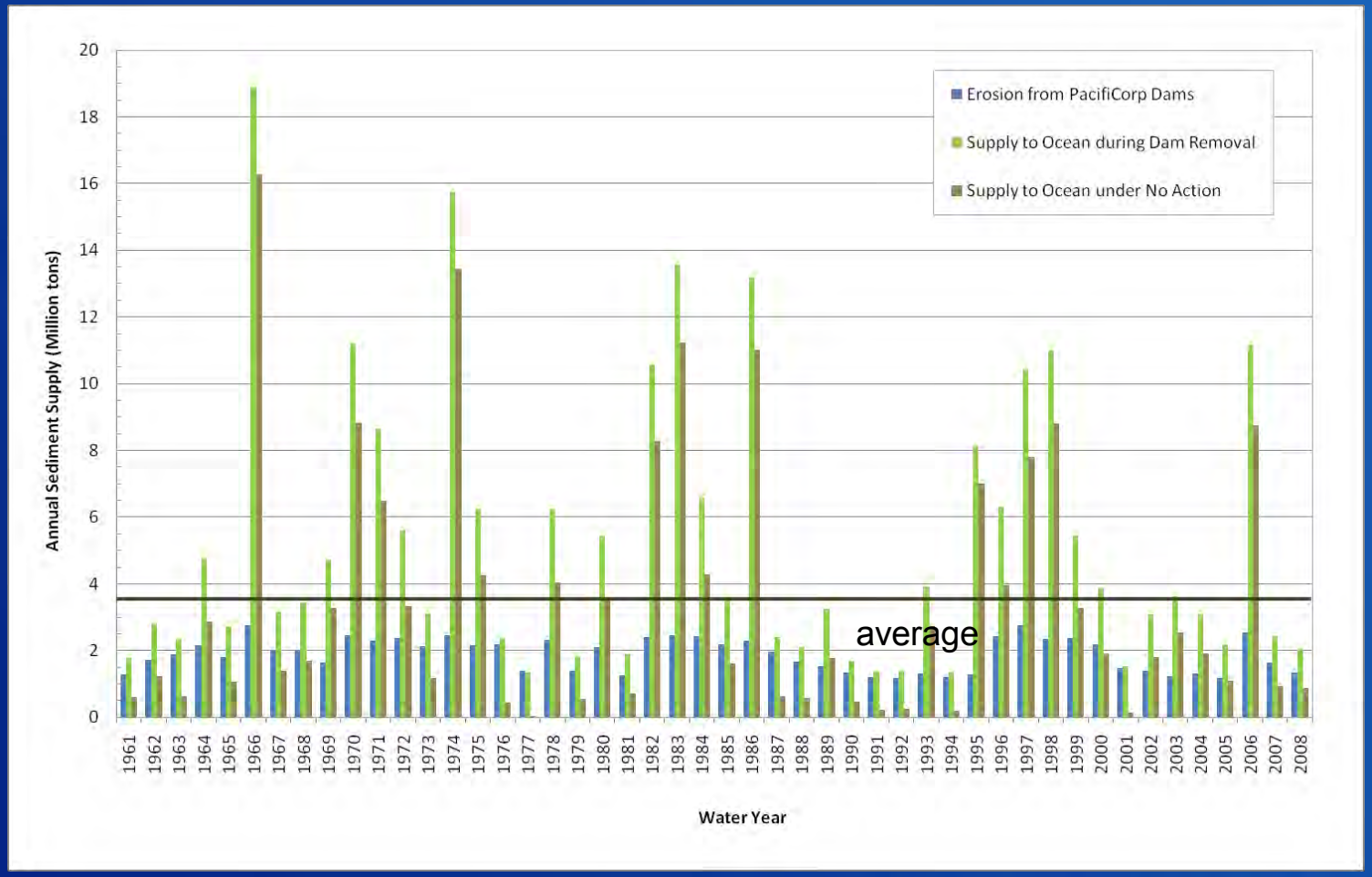
Sediment Delivery to Ocean (All Water Years)



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Elements of Cost Estimates

Full Removal Alt.

- Removals
  - Dams
  - All Structures
  - Rec. Facilities
  - Powerhouses
- Reservoir Restoration
- Contingencies
- Non-contract Costs
  - Engineering
  - Mitigation

Partial Removal Alt.

- Removals
  - Dams
  - Some Structures
  - Rec. Facilities
- Life Cycle Costs
- Reservoir Restoration
- Contingencies
- Non-contract Costs
  - Engineering
  - Mitigation

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Mitigation and Monitoring Costs

Based on proposed mitigation measures – EIS/EIR

- Aquatic Resources (fish impacts)
- Terrestrial Resources (wildlife impacts)
- Surface Water Hydrology (d/s flood impacts)
- Groundwater (u/s well impacts)
- Water Supply/Water Rights (d/s intake impacts)
- Cultural and Historic Resources (submerged sites)
- Recreation (replacement of facilities)
- Transportation (protection of bridges and culverts)
- Monitoring Plans – sediment, water quality, fish

Summary of Project Costs (2020)

Full Removal Alternative

- **Most Probable Construction Cost – $291.6 million**
- **Forecast Range – $238 to $493.1 million**

Partial Removal Alternative

- **Most Probable Construction Cost – $234.6 million**
- **Life Cycle (O&M) Cost – $12.4 million**
- **Forecast Range – $194.1 to $430.4 million**

State Cost Cap

- **PacifiCorp Ratepayers – $200 million**
- **California State Funds – up to $250 million**

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For More Information:

KlamathRestoration.gov

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