Gold Country — Legacy Mining Impacts and Restoration Strategies

A Concurrent Session at the 34th Annual Salmonid Restoration Conference held in Fortuna, CA from April 6-9, 2016.

Session Overview

- Session Coordinator:
  - Jay Stallman, Stillwater Sciences

Large scale surface gold mining in the Klamath-Siskiyou region and western slope of the Sierra Nevada profoundly altered landscape form and process: streams were dammed, diverted or drained; soil and vegetation was stripped over large areas; piles of coarse mine tailings reduced floodplain inundation; and excessive sediment loading massively aggraded and armored stream channels. Many of these impacts persist today, with severe and enduring effects on critical habitat for salmon species. Effective recovery of at risk salmon populations in river ecosystems extensively impacted by mining requires careful assessment and planning. This session will feature presentations exploring the persistent impacts of legacy gold mining on thermal regimes, fluvial processes and channel morphology, and channel and floodplain habitats; as well as restoration strategies being implemented to address these legacy effects.

Presentations

(Slide 4) Assessing Legacy Impacts of Hydraulic Mining in the Sierra Nevada - a 20-year Perspective
Jennifer A. Curtis, U.S. Geological Survey, California Water Science Center

(Slide 32) Gravel, Gold, and Fish: Reclaiming California's Gold Fields
Rocko Brown, Ph.D., Environmental Science Associates

(Slide 59) Restoration Progress and Opportunities for the Yuba River Goldfields
Gary Reedy, South Yuba River Citizens League

(Slide 96) Gold Mining, Extreme Floods, and Geomorphic Context of the Trinity River, CA
Andreas Krause, Yurok Tribe

(Slide 128) Riparian Area Rehabilitation after Gold Mining
John H. Bair, McBain Associates

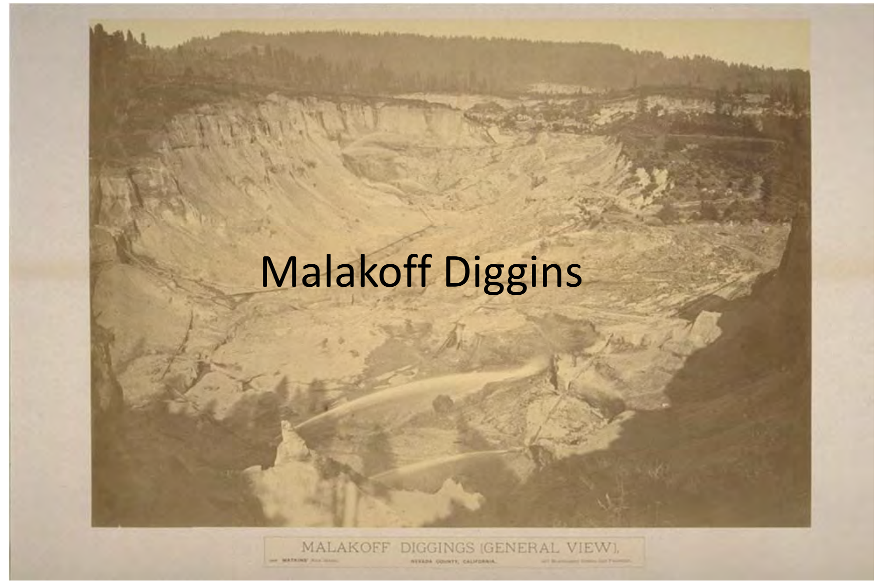
(Slide 158) Quantifying Legacy Impacts on Summer Stream Temperatures and Potential Riparian Reforestation Strategies
Rosealea M. Bond, Department of Forestry and Wildland Resources, Humboldt State University

Assessing Legacy Impacts of Hydraulic Mining in the Sierra Nevada ~ a 20-yr Perspective

Jenny Curtis USGS California Water Science Center, Eureka, CA
Allen James, Charlie Alpers, Noah Snyder, Carrie Monahan,

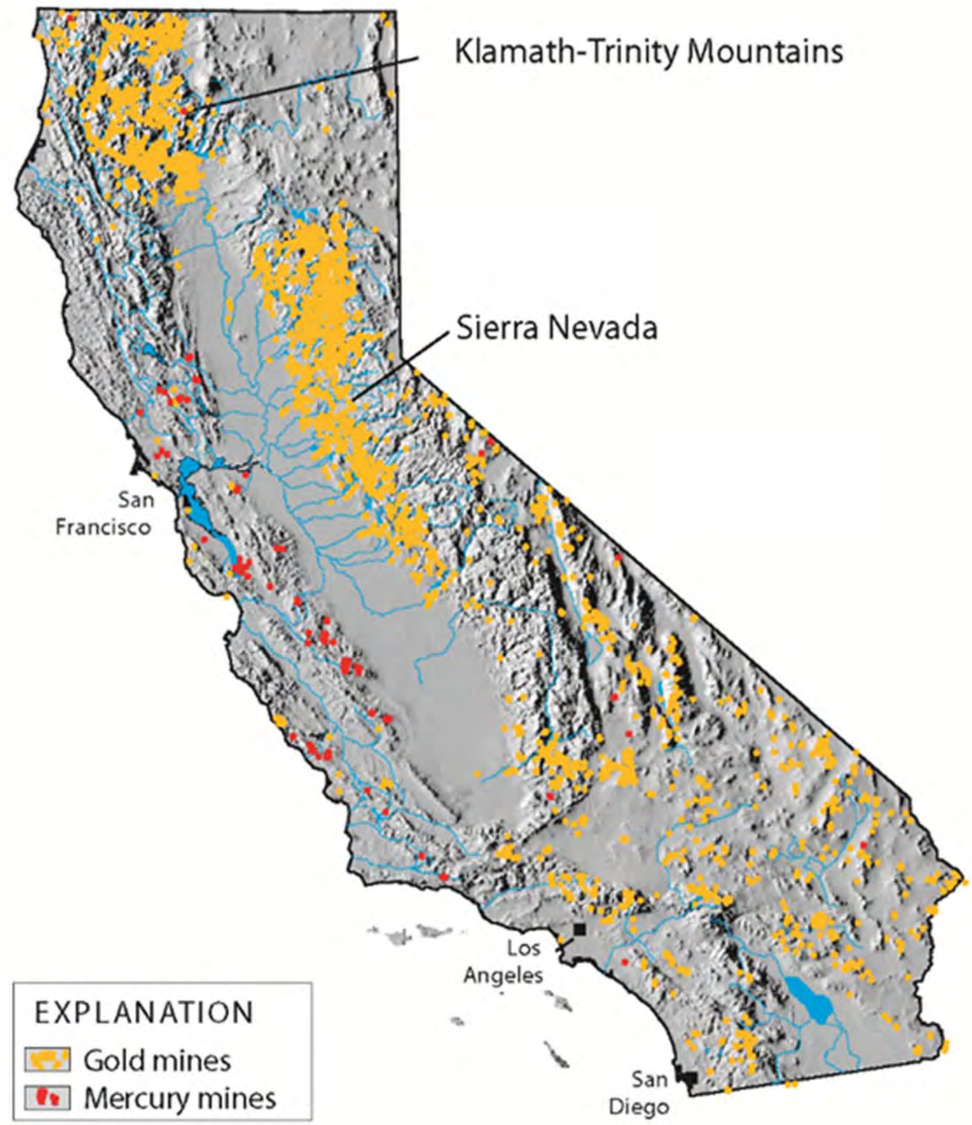
Outline …

- Spatial and temporal scale of impacts
- Origin of “public trust” and mandates for sediment and water management
- **Fate and transport of sediment and Hg in the western Sierra Nevada**
  - **Bear and Yuba Rivers**



After the Gold Rush….

- 47,000 abandoned mines (CA Dept of Conservation, 2003)
- 46 m of coarse valley fill in headwater tributaries (Curtis, 1999)
- 1 m of silt in SF Bay (Capiella et al, 1999)



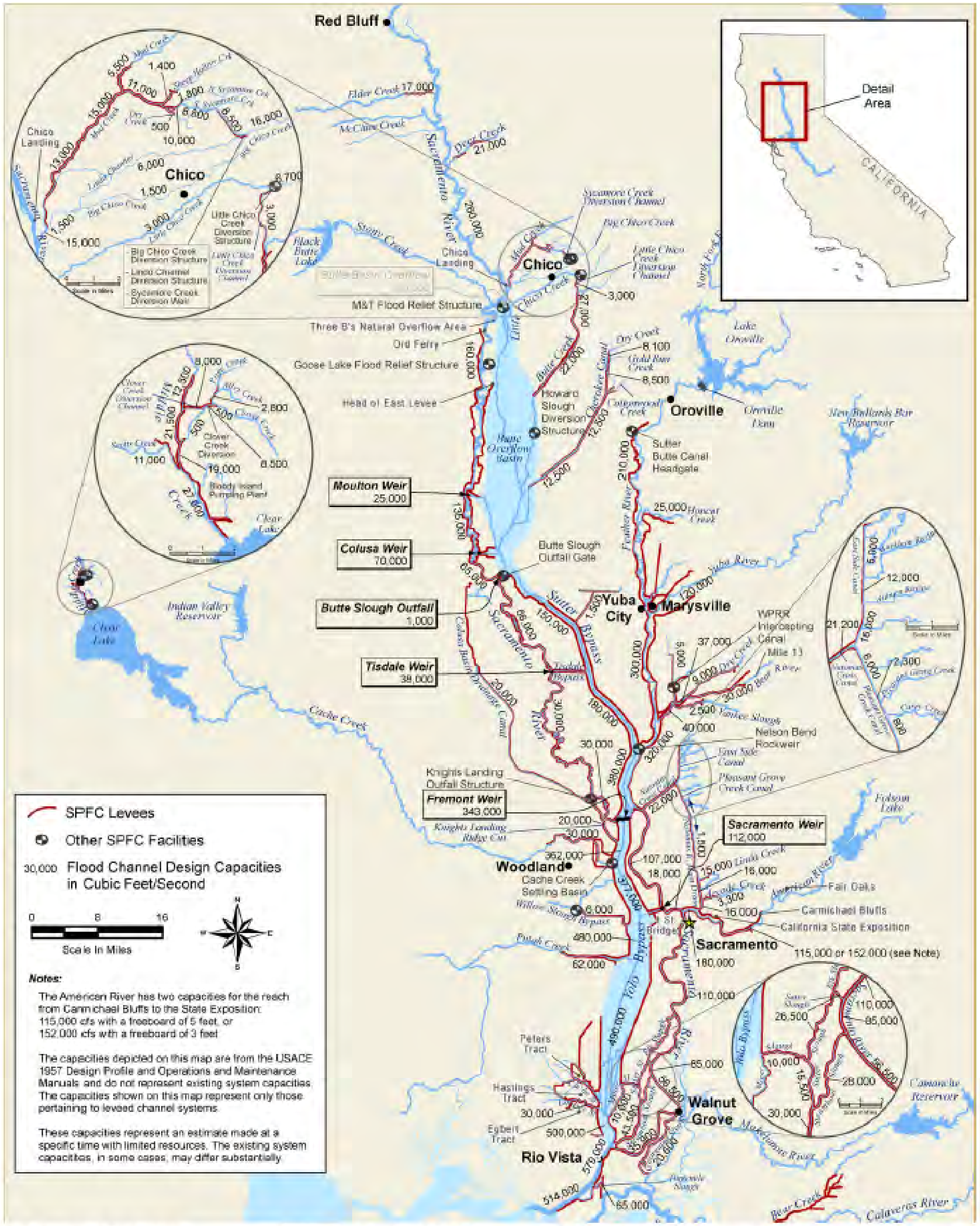
The sediment problem…

Hydraulic mining
- 850 million m^3

Seattle, WA regrades
- 24.3 million m^3

Panama Canal
- 205 million m^3

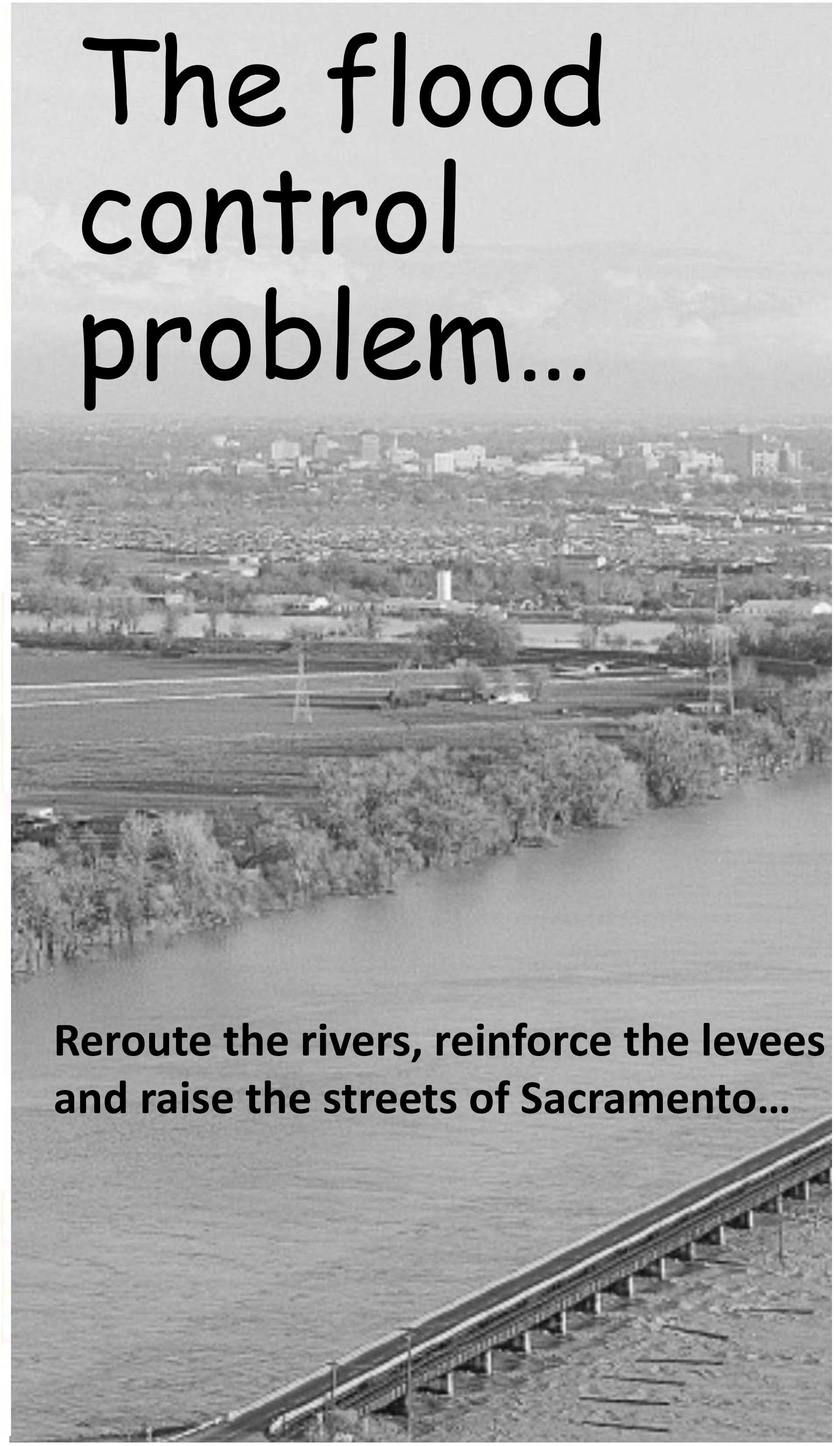
Mt St Helens 1980
- 2.8 billion m^3



Key: cfs = cubic feet per second SPFC = State Plan of Flood Control USACE = U.S. Army Corps of Engineers

http://www.water.ca.gov/cvfmp/docs/2012%20CVFPP_June.pdf

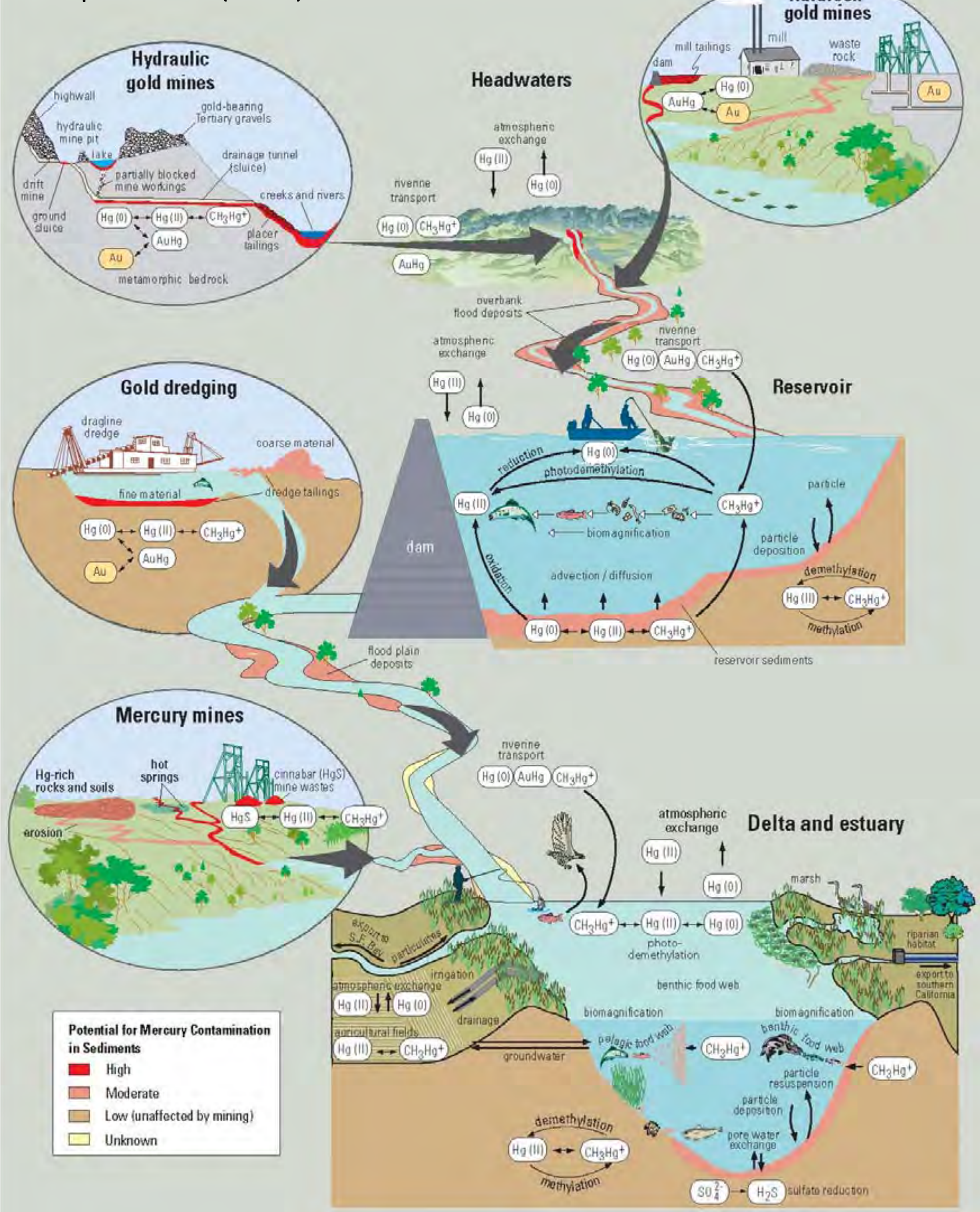
The flood control problem…

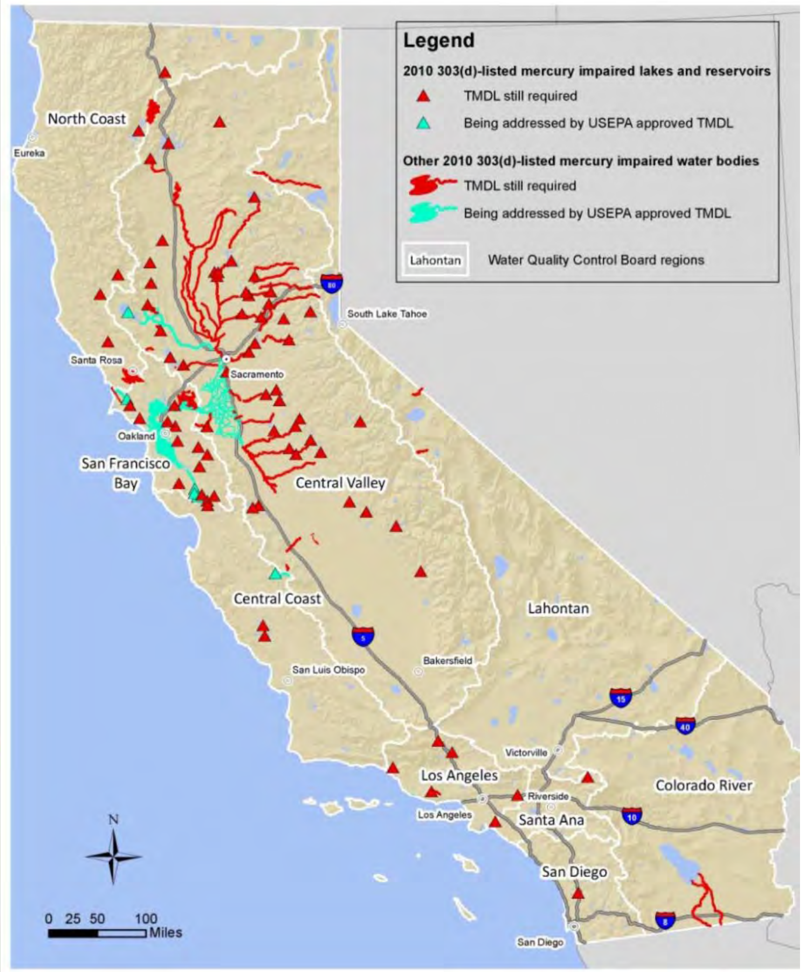


Reroute the rivers, reinforce the levees and raise the streets of Sacramento…

The Hg problem…

Alpers et al. (2005) USGS Fact Sheet 2005-3014





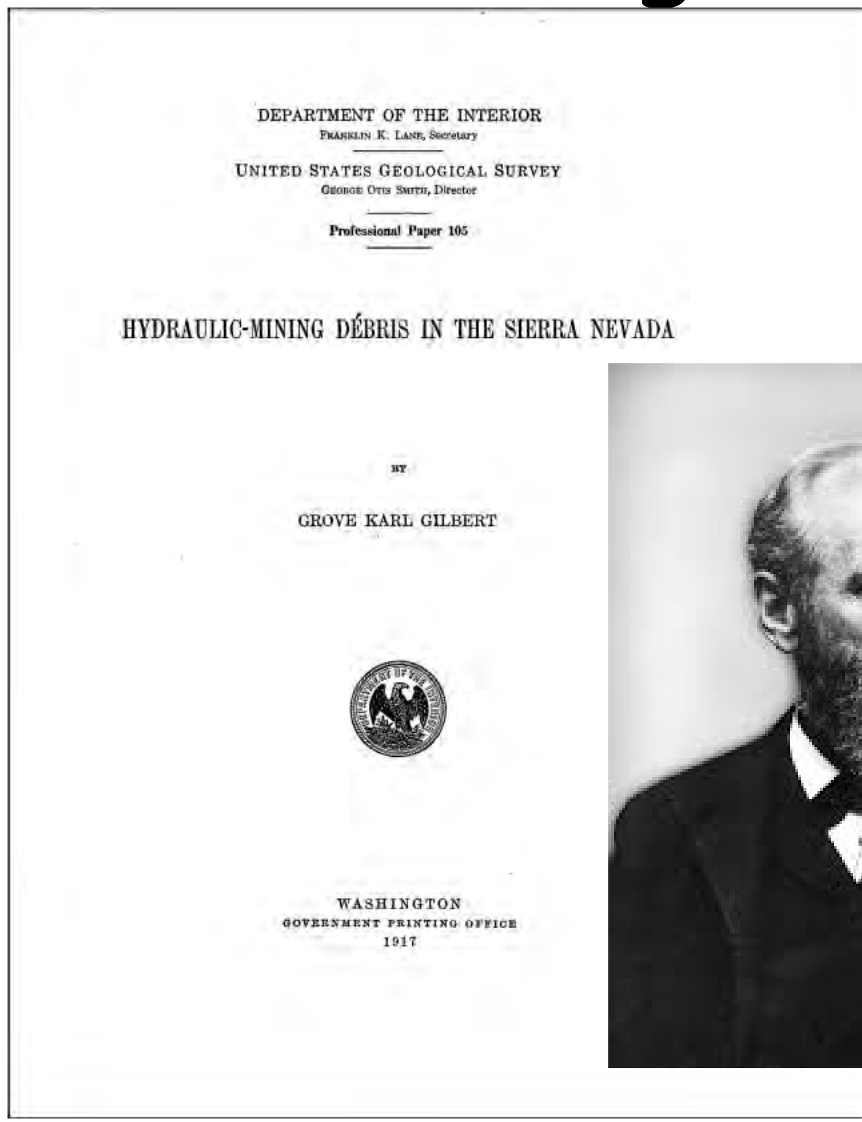
SWRCB Mercury Policy (SWRCB 2012)
http://cabyregion.org/caby-irwmp-sections/Ch6%20Water%20Quality%2010-1-13.docx/view

The concept of "Public Trust" …

- 1884 – Sawyer Decision
  - U.S. Supreme Court issues 1st federal environmental decision
  - Edwards Woodruff v. North Bloomfield Gravel Mining Co.
- Judicial Precedence
  - Hydraulic mining constituted a public nuisance and violated the "***collective public interest***"
  - The state holds water ways "***in trust***" for use by the public
    - Navigation, recreation, fishing, and ecological values

Fate and transport of mine-related sediment and Hg …

- G.K. Gilbert (1917) the problem of aggradation and flooding could only be resolved by <u>sediment retention and regulation of mine tailing disposal</u>
- Predicted recovery of tributary channel bed elevations by 1960



DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

Professional Paper 105

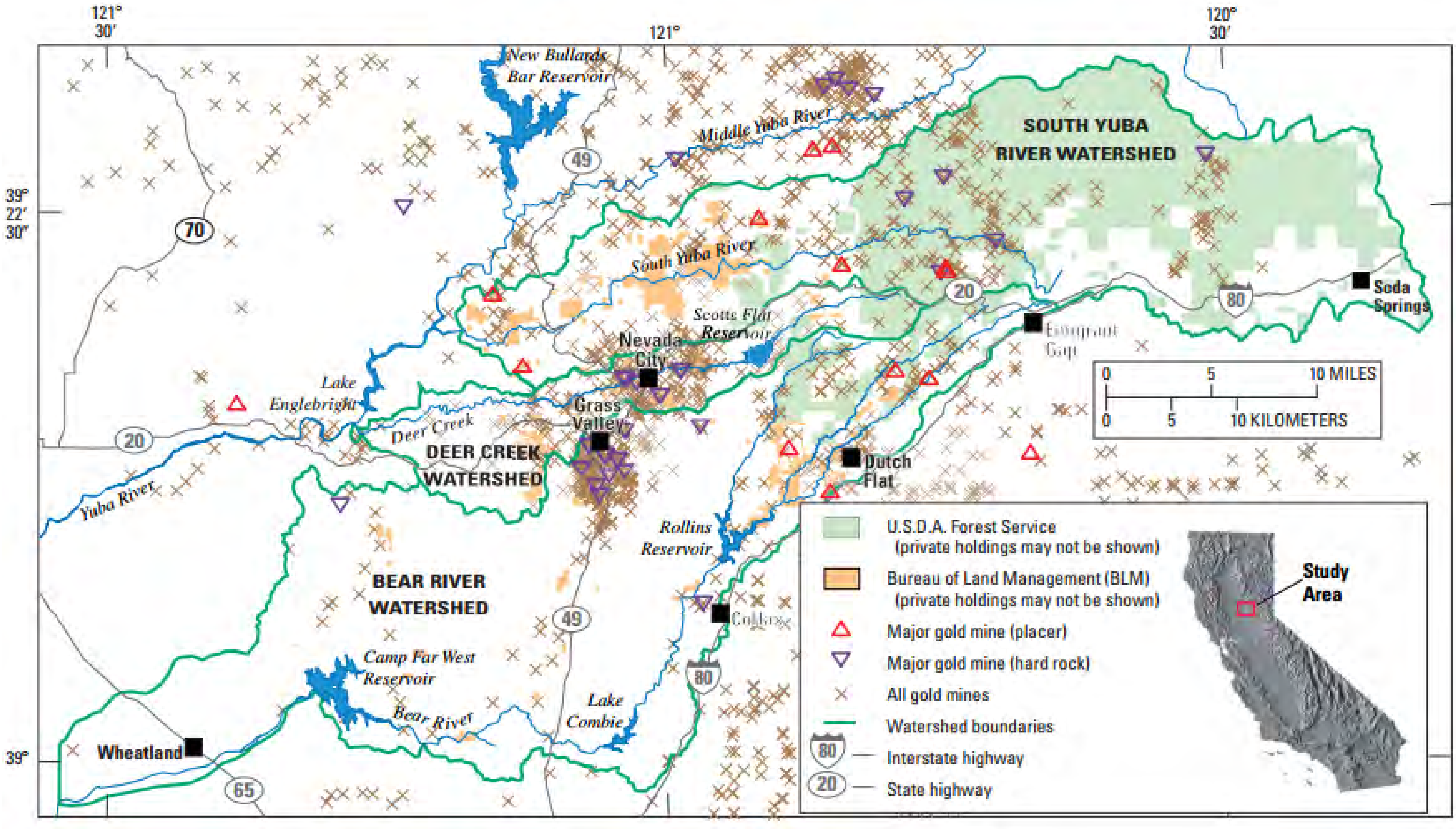
HYDRAULIC-MINING DÉBRIS IN THE SIERRA NEVADA

BY

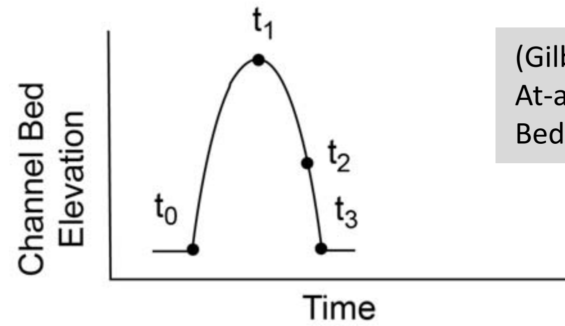
GROVE KARL GILBERT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

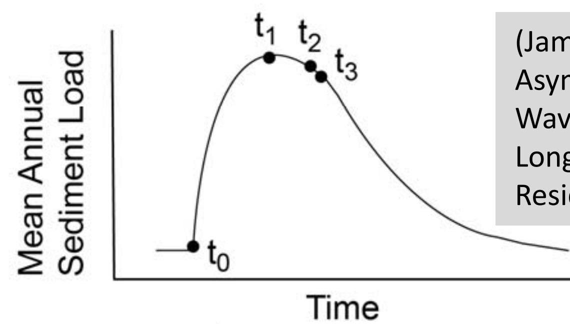
Fate and transport of mine-related sediment and Hg in Bear-Yuba system



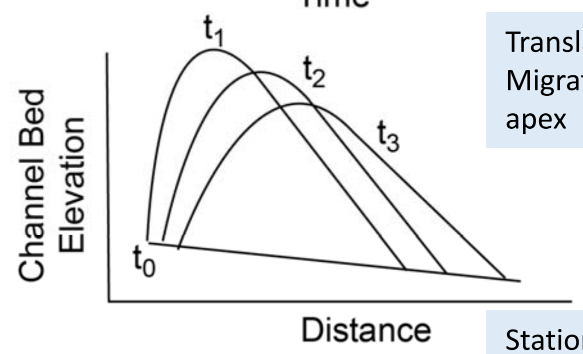
#1 Fluvial response to valley aggradation - Steephollow Creek …



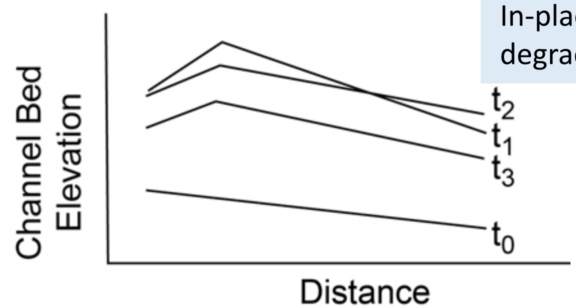
(Gilbert, 1917)
At-a-station
Bed Elevation



(James, 1989)
Asymmetrical
Wave
Longer
Residence Time



Translation – Migration of apex

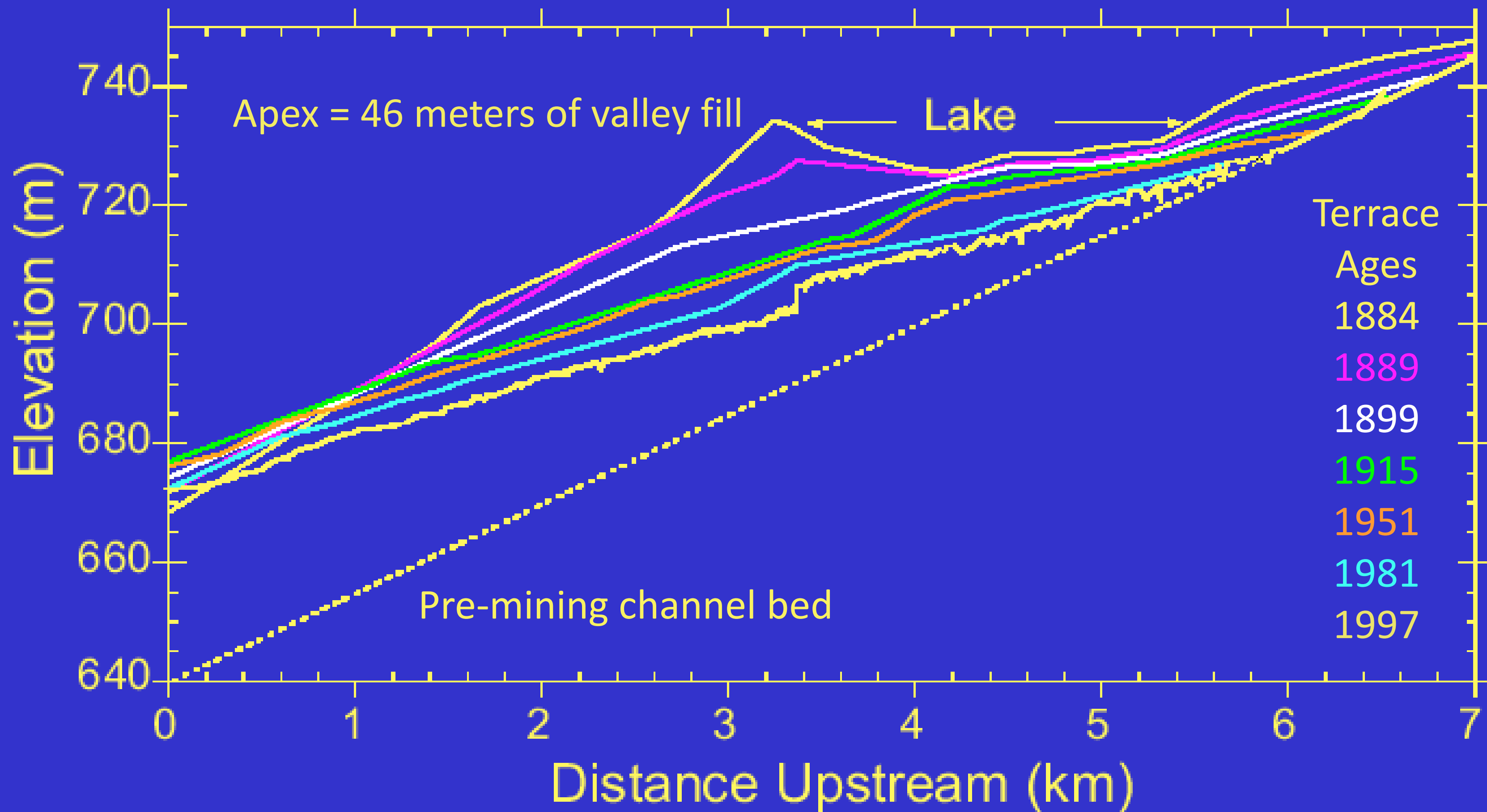


Stationary – In-place degradation

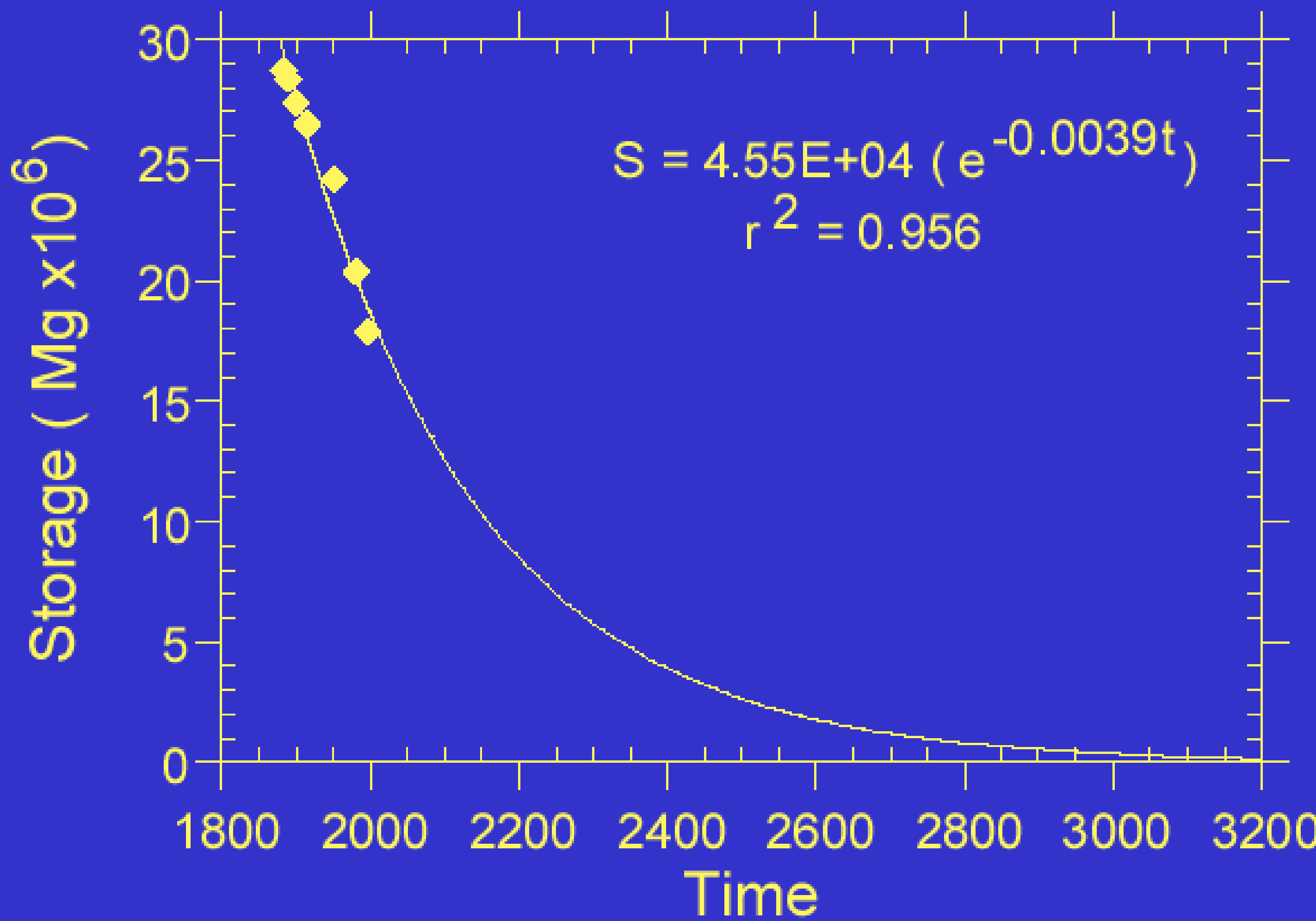
Steephollow Creek Sediment Budget …

- $I = O + \Delta S$
- Mine Production
  - Pre-1884 = 26 x 10^6 m^3
  - Post-1893 = 1.4 x 10^6 m^3
- Partitioning of a Sediment Slug
  - 35% Delivered as Qss
    - 7% insitu
    - 28% hydraulically converted
  - 65% Stored Valley Fill as Qb
- Series of budgets
  - Defined by terrace formation
  - Age-dated using dendrochronology

Sediment Slug



Millennial Scale Impact

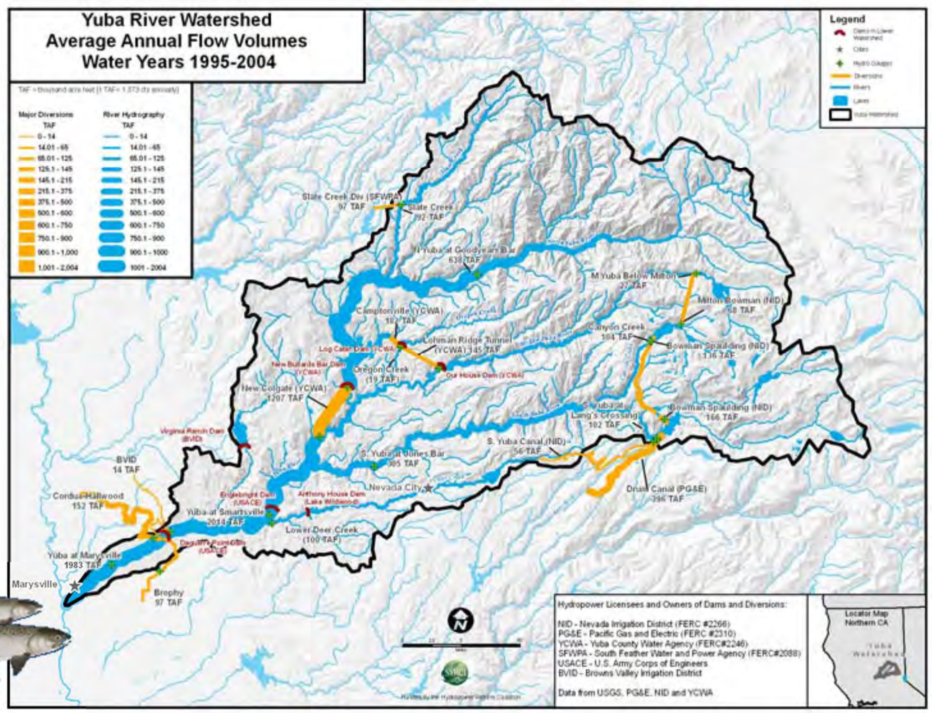


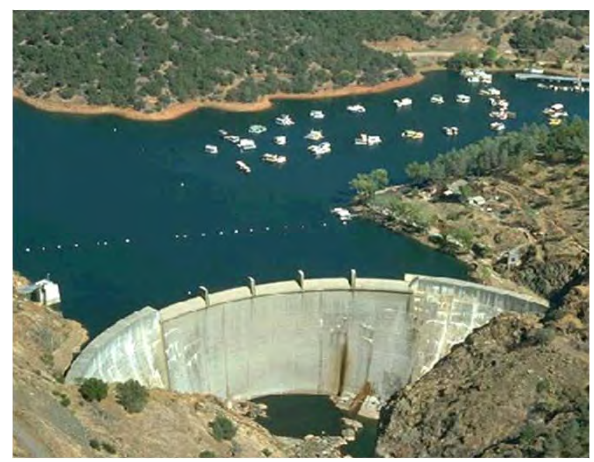
Graf, W.L., 1977, The rate law in fluvial geomorphology, American Journal of Science, v.277, p.178-191.

#2 Reintroduction of salmonids above Englebright Dam (SYRCL 1998)

- UYRSP Sediment Studies - Existing reservoir and upper watershed conditions
- Collaborators : Charlie Alpers, Jon Childs,

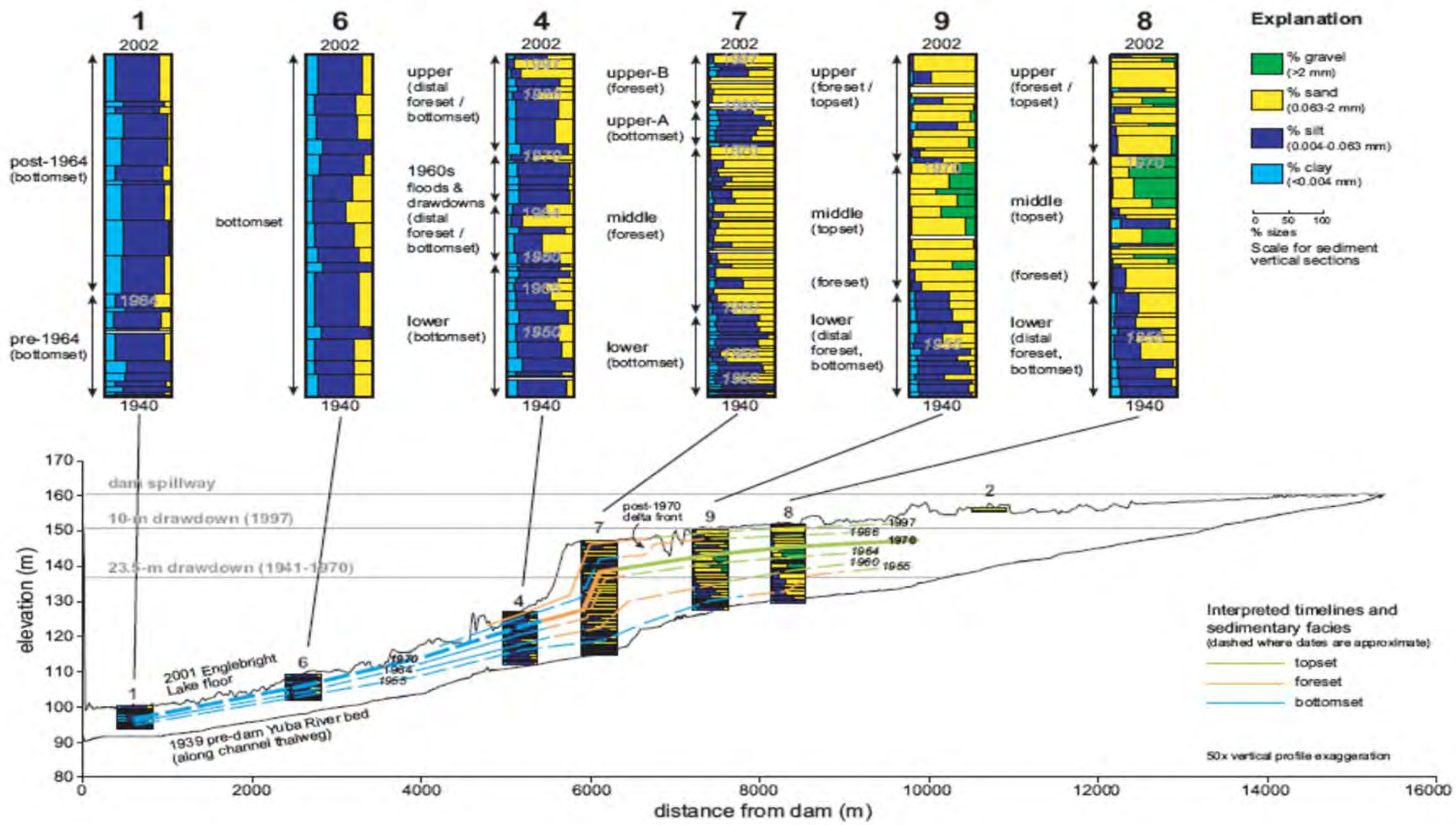
Dave Rubin (USGS); Noah Snyder (BC)





Existing reservoir conditions…

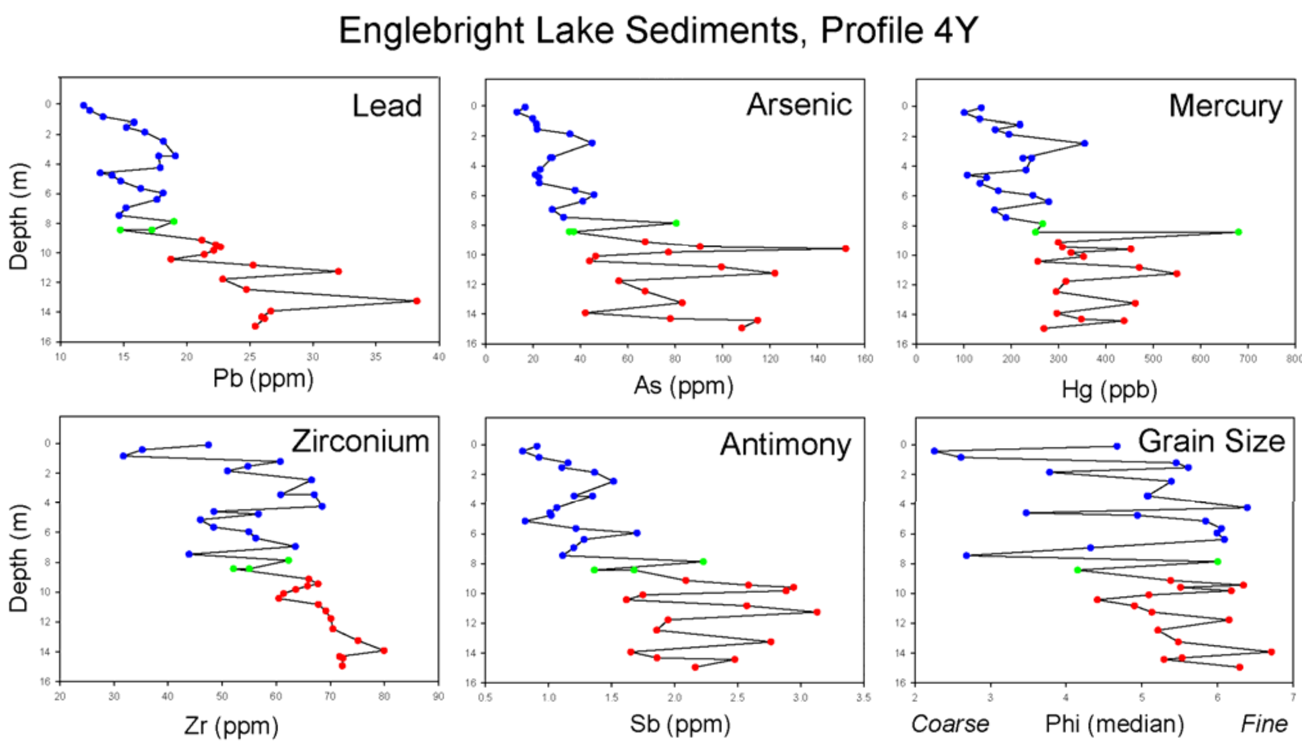
- Volume of material = 21.9×10^6 m^3 of material, 26% full
- Grain size = 69% gravel + sand, 31% silt + clay
- Curtis (1999) = 65% Qb and 35% Qss



Snyder et al. 2006, Reconstructing depositional processes and history from reservoir stratigraphy: Englebright Lake, Yuba River, northern California, Journal of Geophysical Research, v. 111, F04003, doi:10.1029/2005JF000451.

Reservoir geochemical data ….

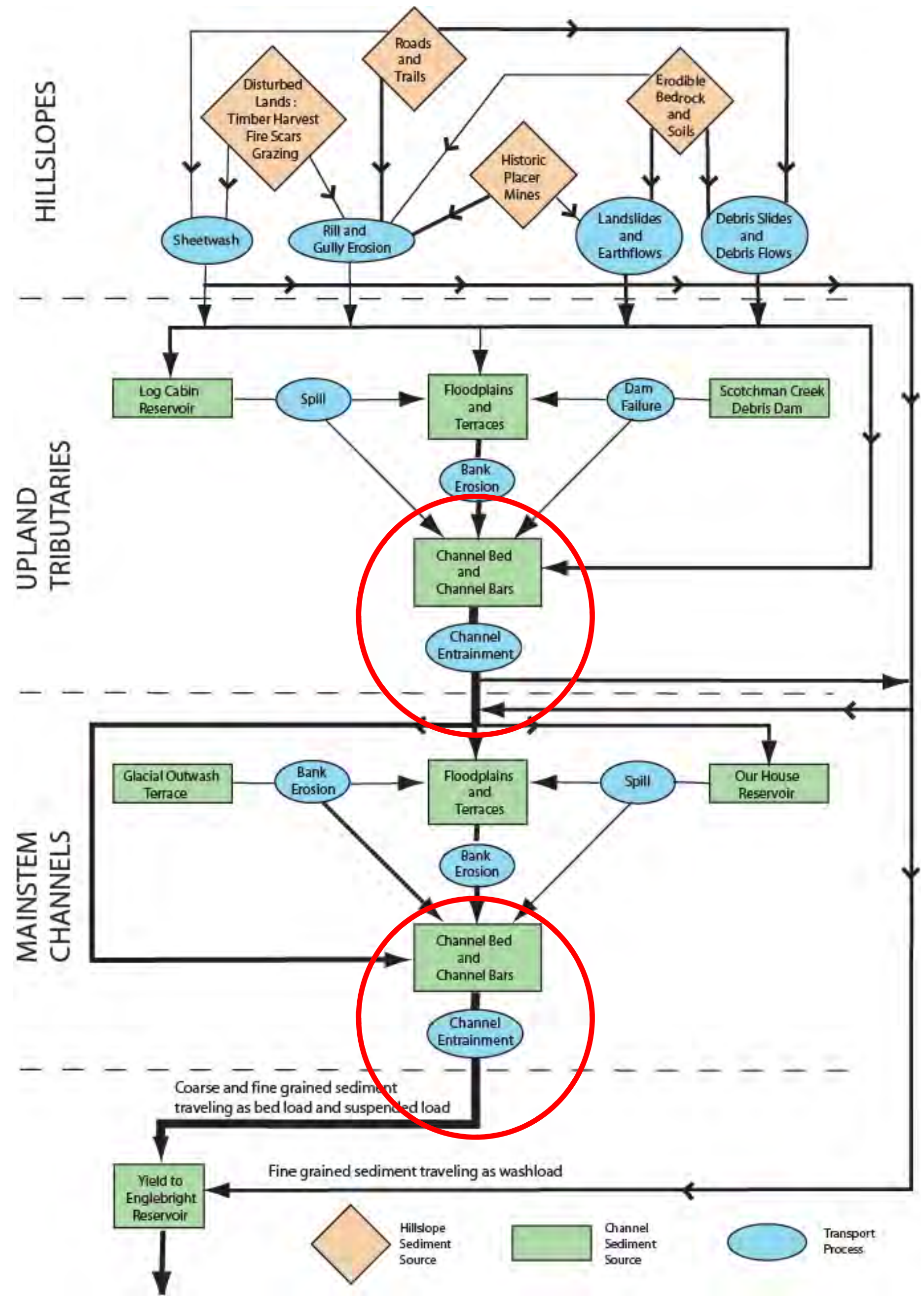
- Correlation with grain size
  - Hg in fines (silt + clay) ~ 280 ng/g
  - Hg in coarse (sand + gravel) ~12 ng/g
- Pre-1970 > Post-1970
- Total mass of mercury ~ 2,500 kg = 0.1% total lost to rivers



Alpers et al. 2006, Geochemical data for mercury, methylmercury, and other constituents in sediments from Englebright Lake, California, 2002: U.S. Geological Survey Data Series 151, 95p.

Upper Watershed Sediment Processes…

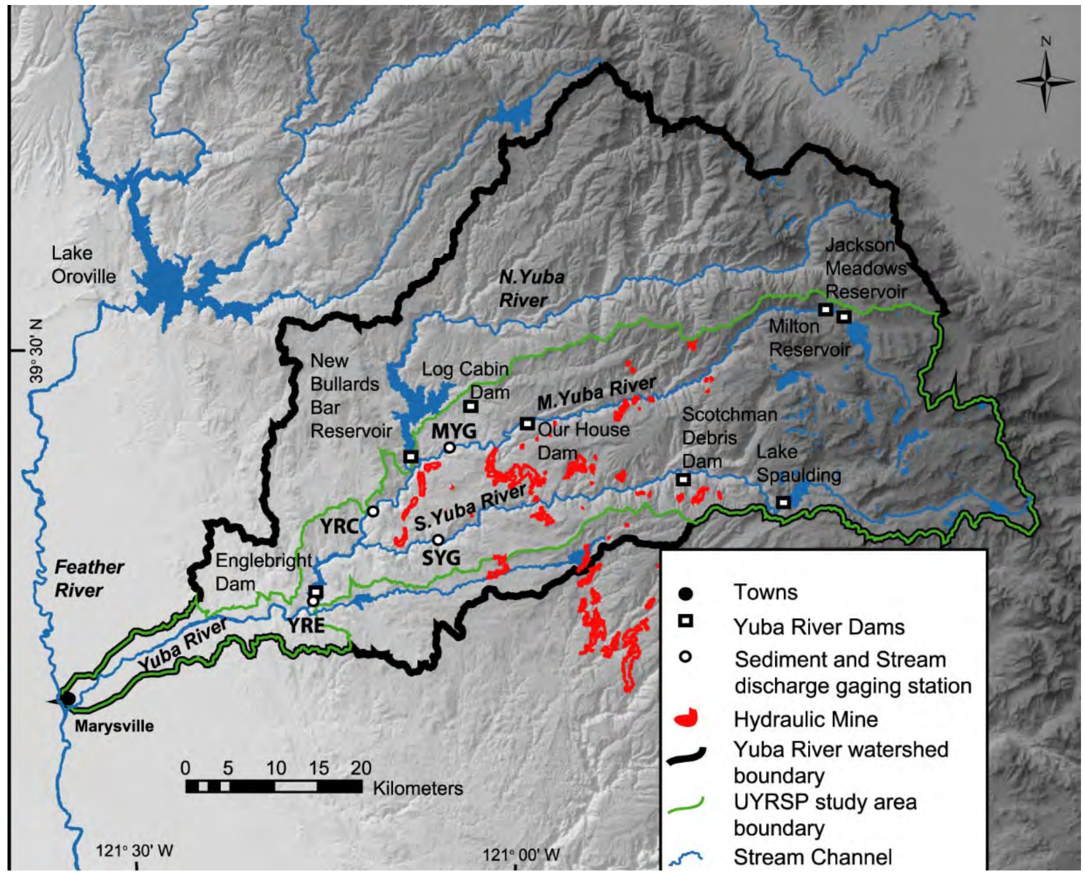
- Roadmap to understand linkage between sediment sources and transport processes
- Remobilization of stored sediment is dominate sediment source



Curtis et al, 2005, Conceptual model of sediment processes in the upper Yuba River watershed, Sierra Nevada, CA: Geomorphology, v. 68, p. 149-166.

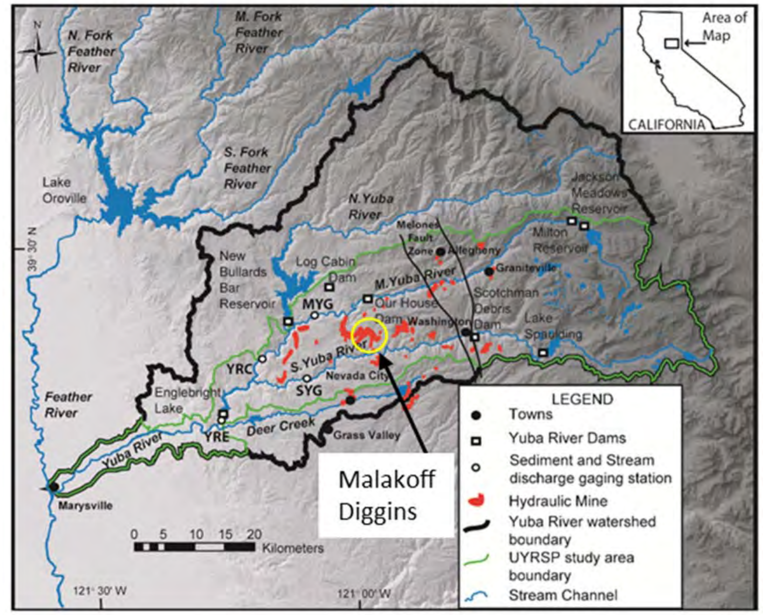
Sediment Transport WY 2001 -2003

- 4 gaging stations
- Low SSC relative to Coast Range
  - Average Daily SSC < 10 mg/L
  - SSC > 100 mg/L < 2% of the project period
- SYR - larger and coarser annual sediment load
  - Higher capacity and competence
  - Higher sediment production from mines
- Bed load < 1 % of annual load during WY2001-03
  - Below average water years during project period



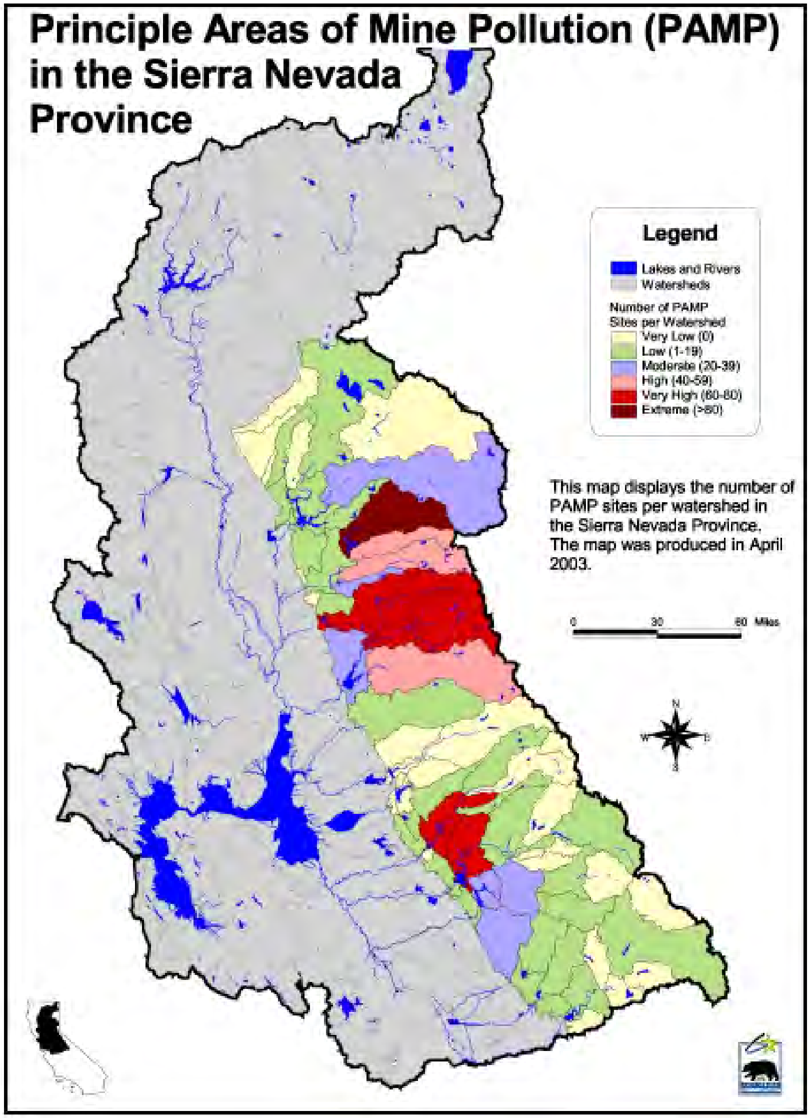
Curtis et al, 2006, Sediment transport in the Upper Yuba River Watershed, California, 2001-03, U.S. Geological Survey Scientific Investigations Report 2005-5246, 74 p.

#3 CABY - Hg and Sediment Abatement Initiative



- Collaborators = Charlie Alpers and Jim Howle (USGS); Carrie Monahan (Sierra Fund) and John Ward (CSU)
- Malakoff Diggins State Park
  - North Bloomfield Gravel Mining Co.
    - Defendant in 1884 Sawyer Decision
  - 303(d) list for sediment, mercury, copper and zinc
  - State Parks pays an annual waste discharge fee
  - National Registry of Historic Places
    - Gold mining history and for the precedent setting environmental decision
    - Typicak large scale terracing and re-vegetation are not feasible
  - investigating primary sources of fine-sediment and mercury
    - Targeted remediation

Mercury hotspots …



California Department of Conservation. 2003

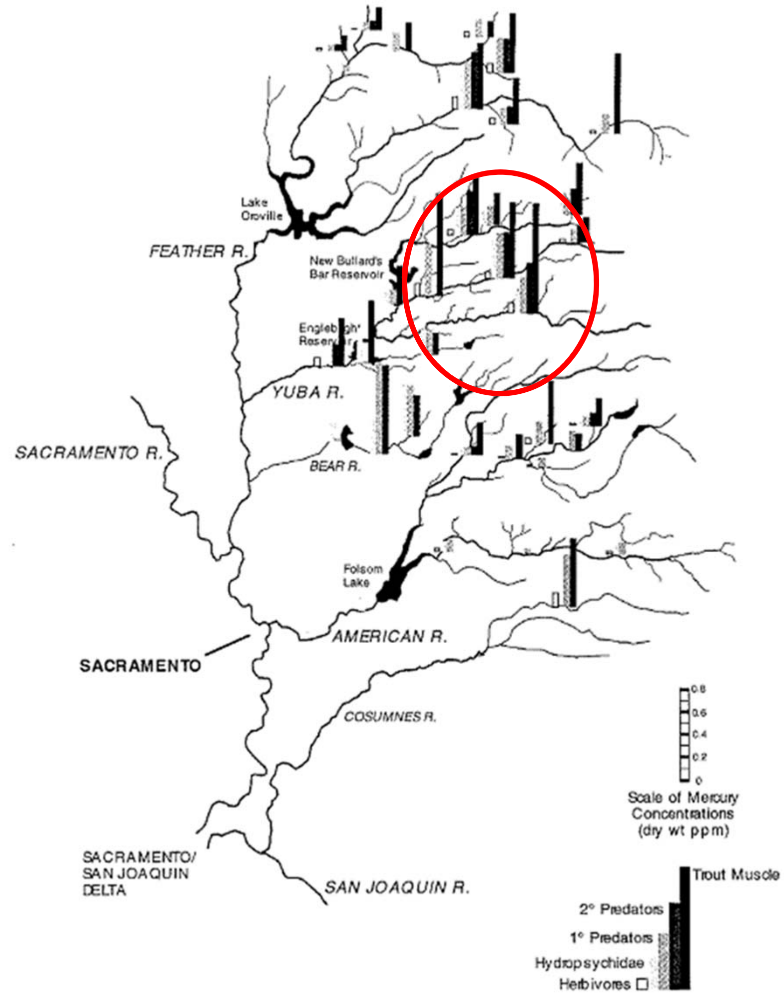
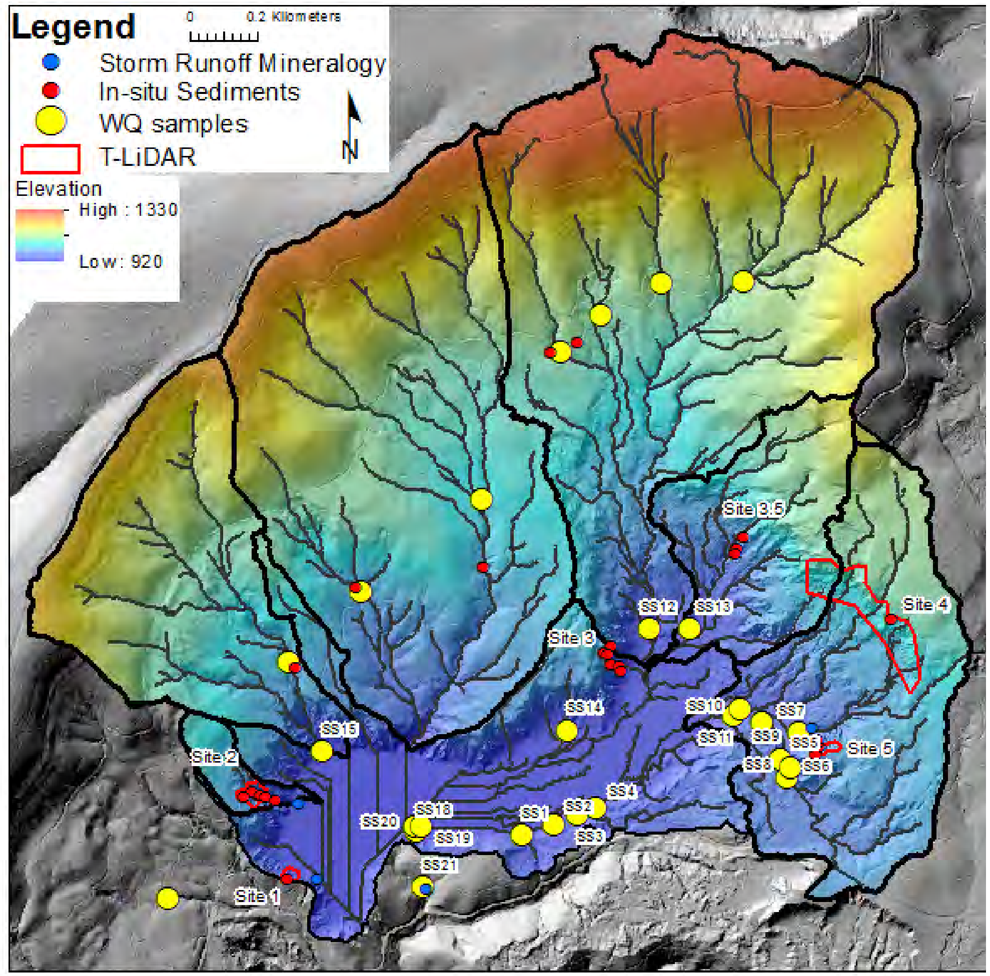


Fig. 2. Superimposed Regional Mercury Data for All Main Trophic Levels
(all as dry weight parts per million mercury)

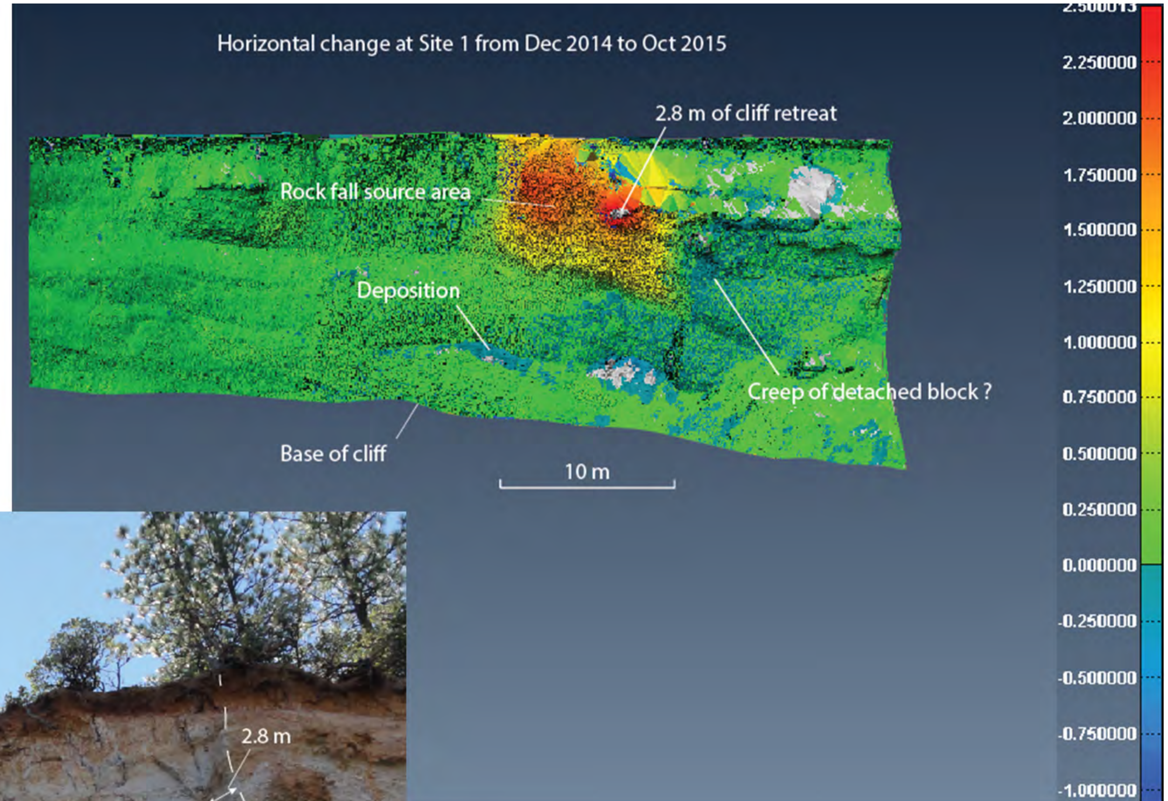
Slotton et al., 1997

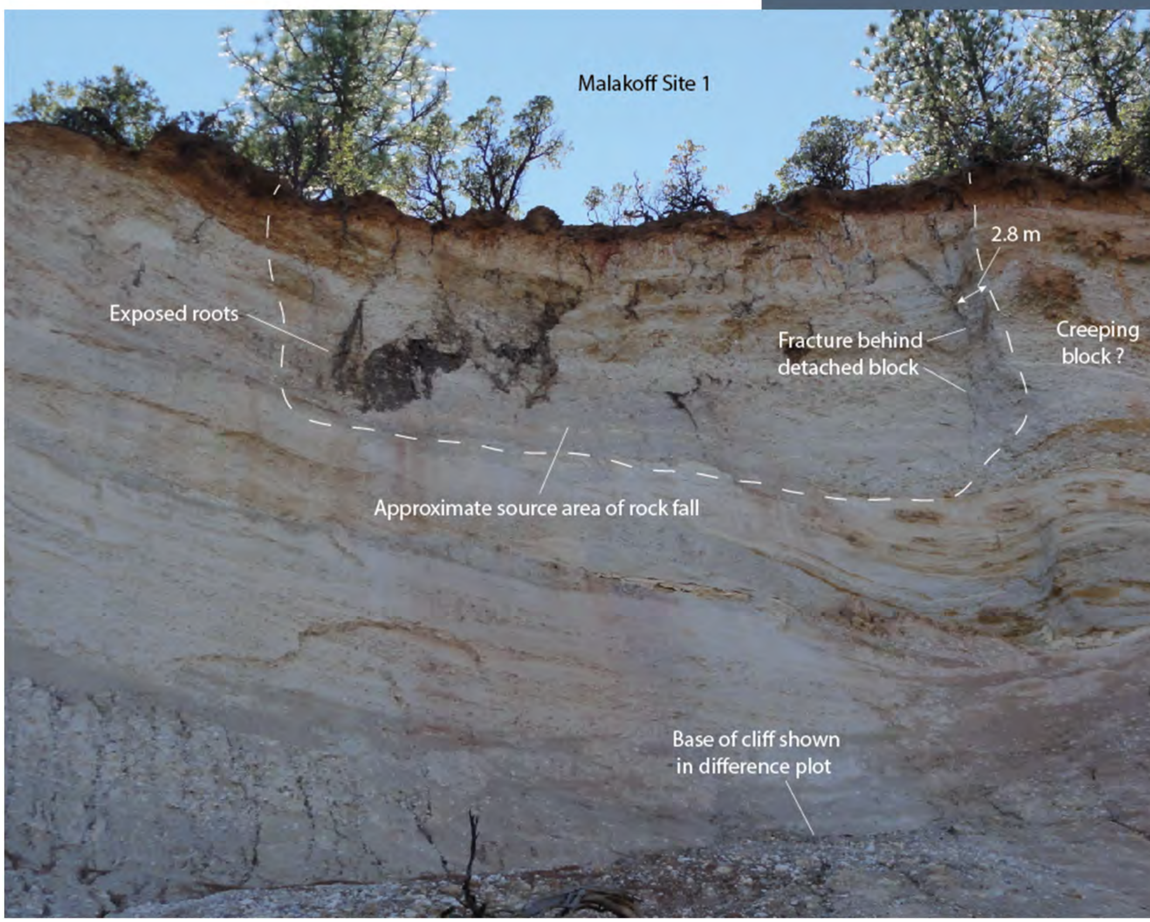
Malakoff Diggins Study

- Hillslope erosion
  - Short-term annual rates
    - Annual T-LiDAR scans
    - 4 locations
    - 2014, 2015, and 2016
  - Long-term decadal rates
    - 1992 DTM using stereo-photogrammetry
    - 2014 DEM aerial LiDAR
    - DEM differencing
- Fine-sediment sources
  - Mineralogy, geochemistry, and particle size



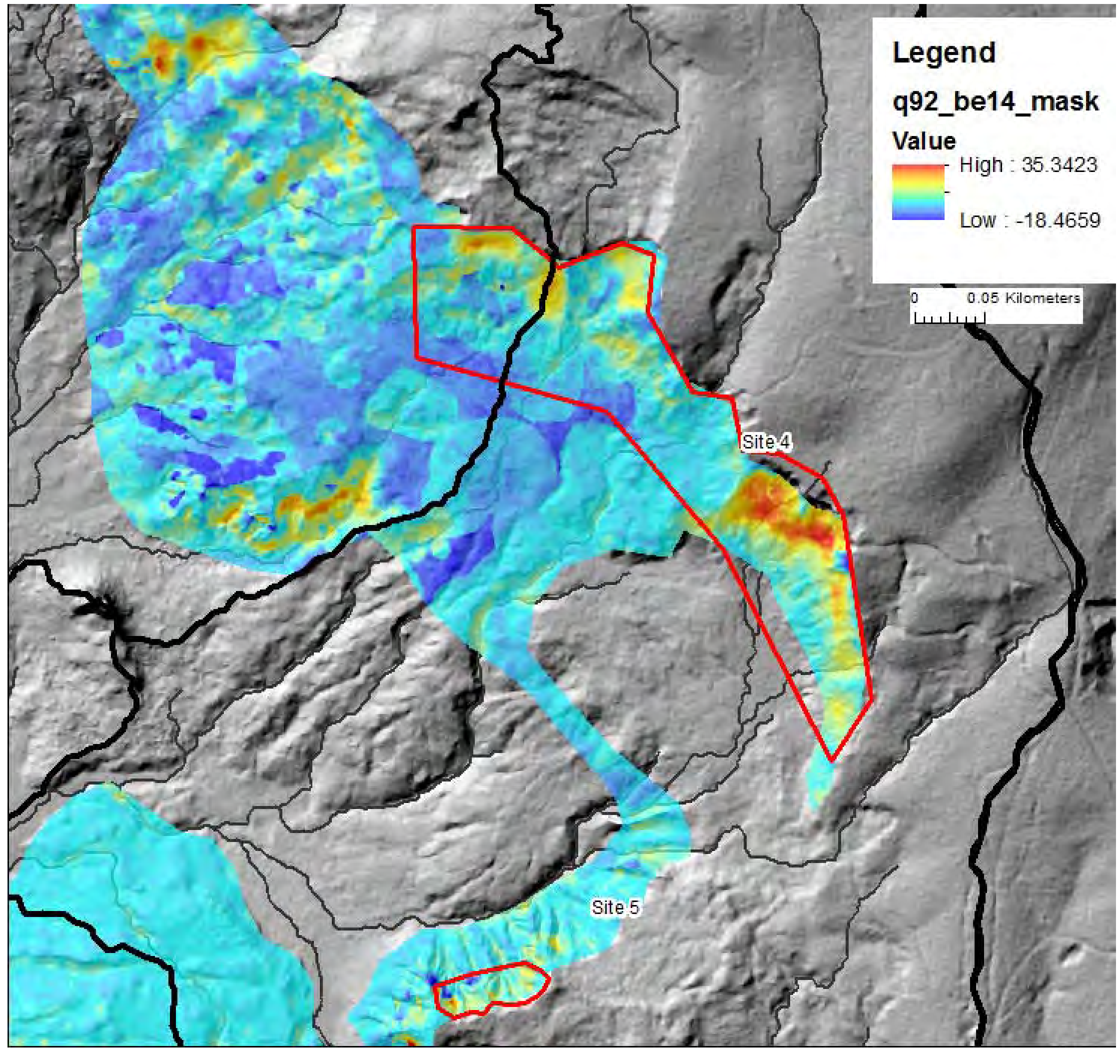
T-LiDAR scans



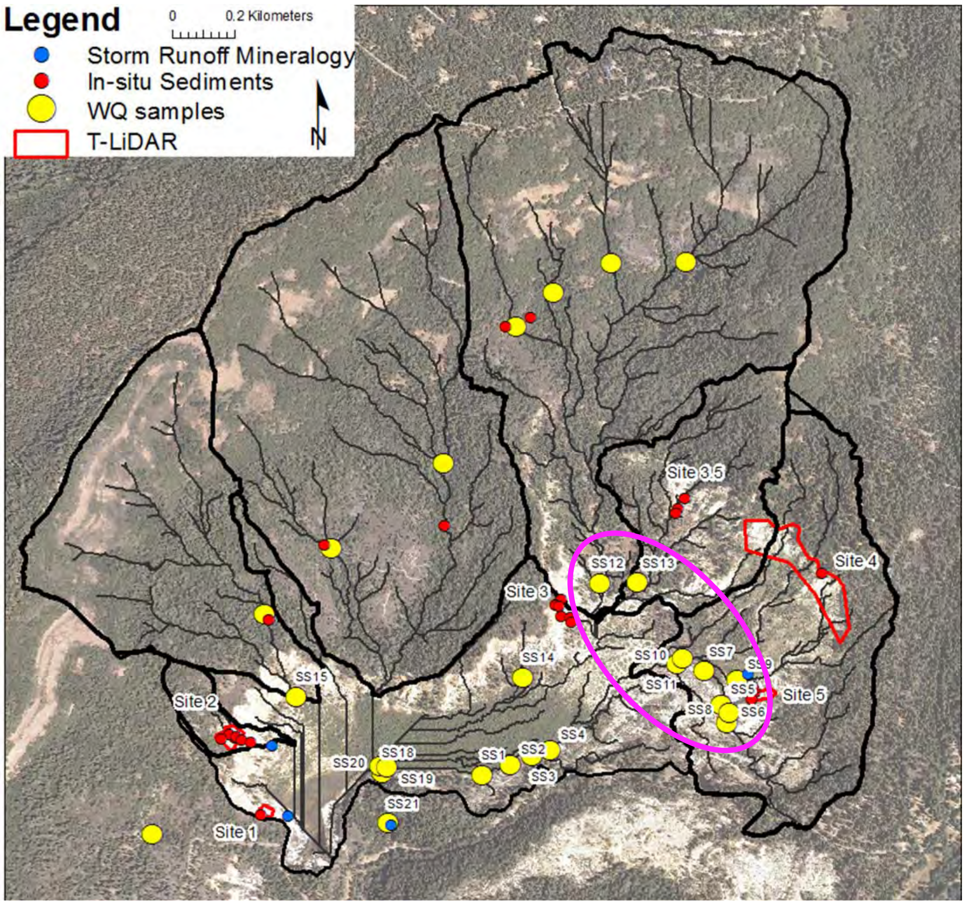


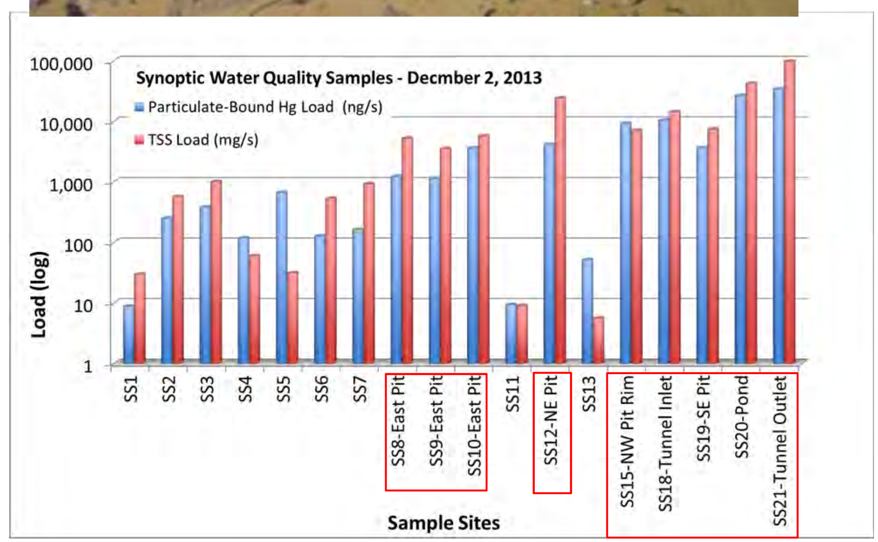
Long term erosion – 1992 to 2014

- Bailey and Curtis (2016)
  - Preliminary estimates of ~100,000 m^3/yr
- Yuan (1979) and Peterson (1980)
  - ~35,000 m^3/yr
- Arcata Square = 4000 m^2
  - Bury 8 to 25 m



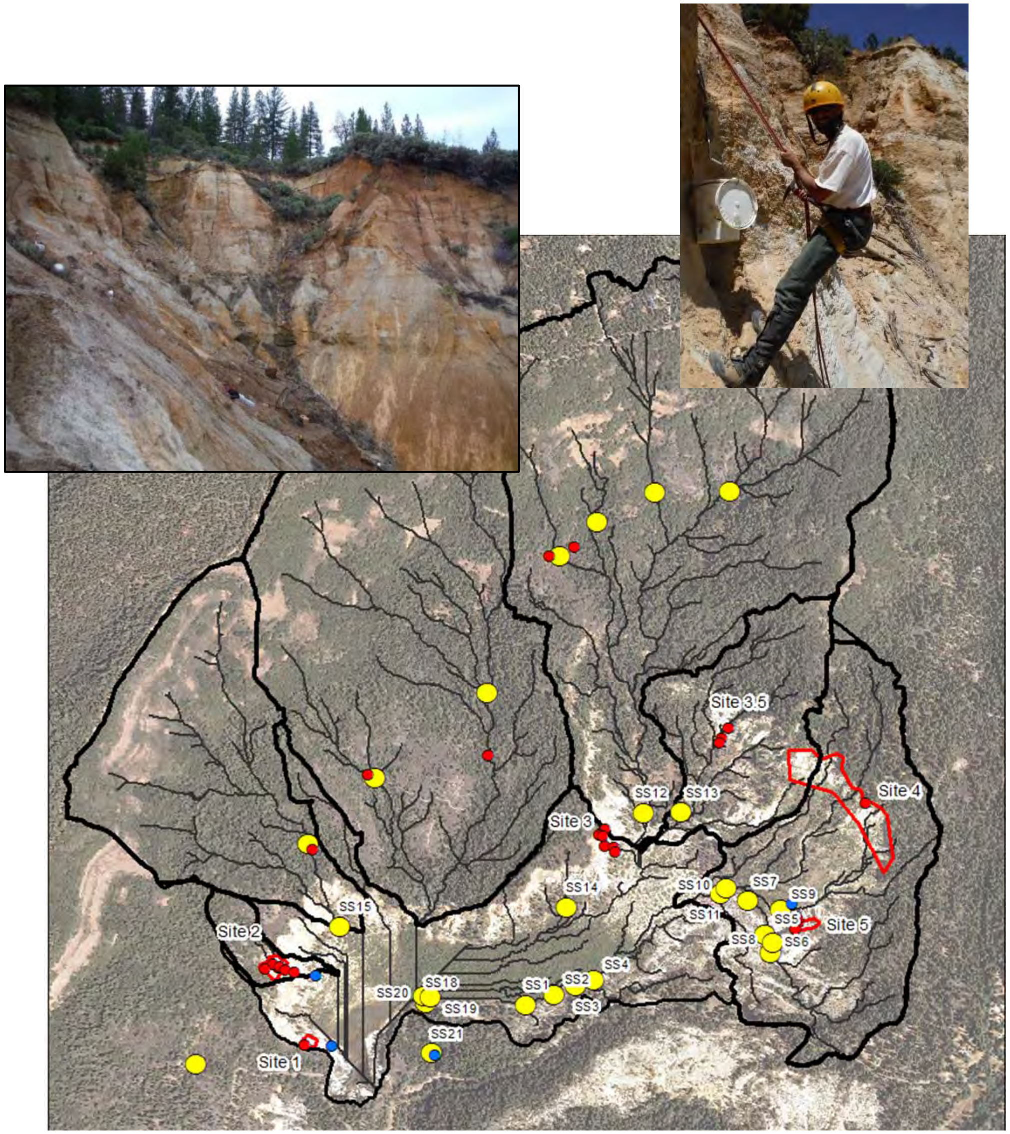
Mercury and Sediment Loads

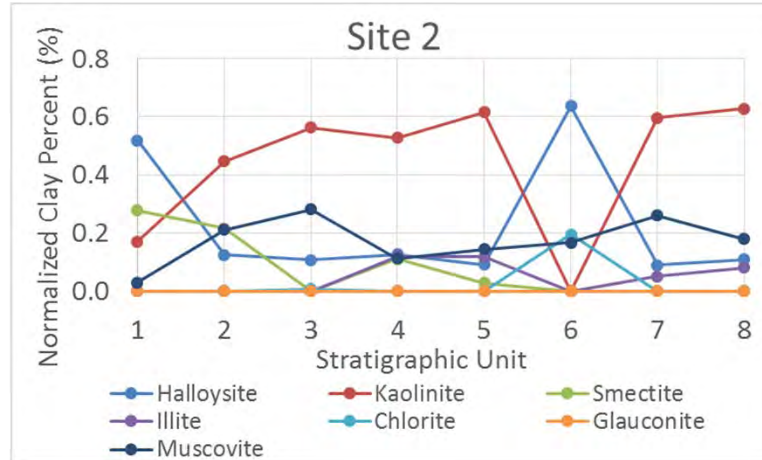


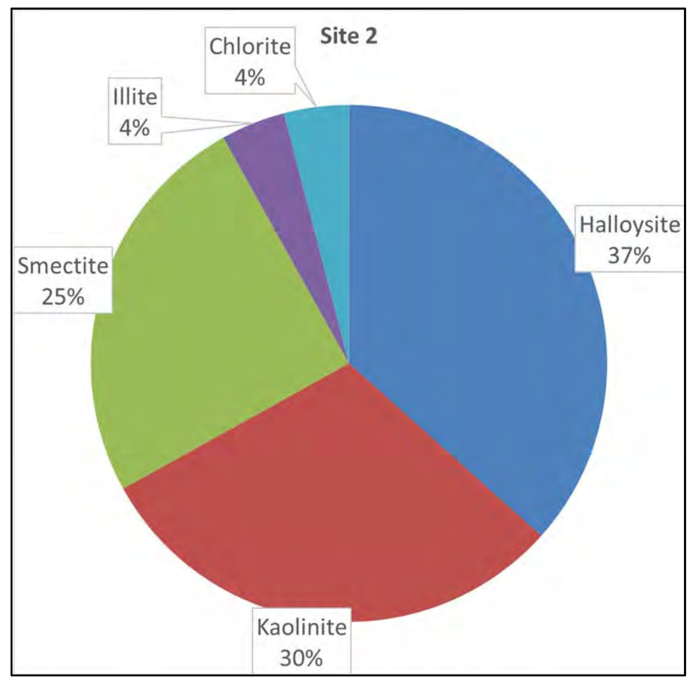


Sierra Fund, 2015, Humbug Creek Watershed Assessment and Management Recommendations, p.216

"Fingerprint" of source sediments







What have we learned…

- Source to sink spatial footprint and millennial scale impact
- Trajectory of recovery hampered by dams
  - Longer residence times in severely aggraded headwater tributaries with lower capacity and competence
  - Declining sediment loads due to retention by dams
- Hg concentrations are well-correlated with fines (silt + clay)
  - Hg is not a “showstopper” for dam removal

Restoration of Central Valley mined landscapes…

- Ho: Fines reduction could equate to reduction in Hg transport
  - Hg powerful neurotoxin that produces behavior changes and decreased reproductive success
- Limited funds should target hotspot remediation
  - Bear-Yuba , Clear Creek
- Channel and floodplain designs should consider potential of remobilization and transport of fines and Hg and methylation potential
- Sediment fingerprinting as a TMDL tool
  - Fine sediment and Hg abatement


Anthropogenic-Badlands

Reclaiming California's Gold Fields

Rocko Brown, PhD

In collaboration with Joe Merz, PhD, Jason White, MS,
Jesse Anderson and many others

34th Annual Salmonid Restoration Conference

April 8th, 2016

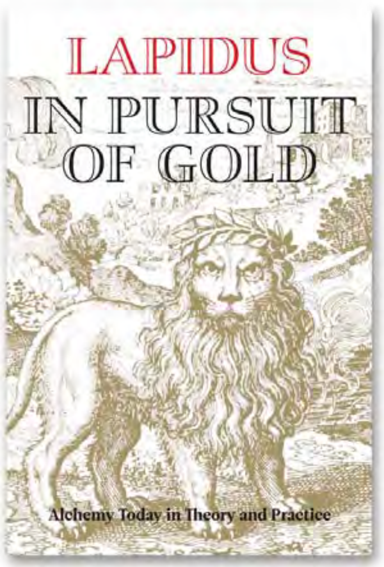
Fortuna, California

ESA

Our first love?

First mineral used by early hominids

Gold was called “tears of the Sun” by Incas

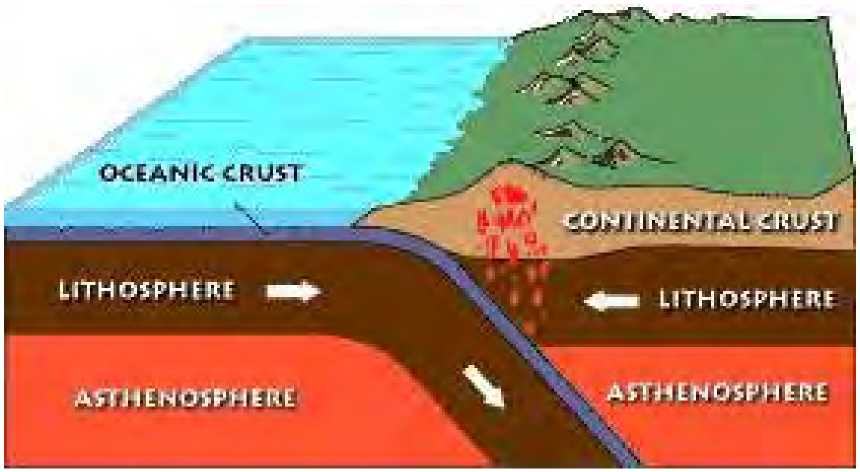


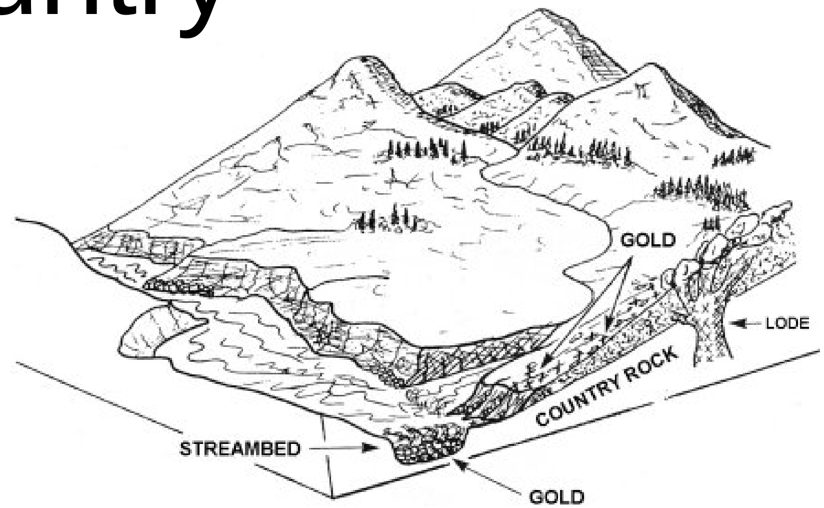
Alchemy and chemistry

The 7 golden cities

Opportunity

Gold country





- Tectonic activity in the Sierra Nevada and other mountains in California raised solidified minerals and rocks subjected them to erosion.
- Weathering exposed gold and other materials were carried downstream by water. Because gold is denser than almost all other minerals it sinks and collects
- The California mountains rose and shifted several times within the last fifty million years…
- Newer rivers and streams then developed, and some of these cut through the old channels, carrying the gold into still larger concentrations

Gold dredgers ("doodle bugs")

Photo 53. Cherokee Mining Company Dredge, Oroville District. This 1904 photo shows one of the earliest bucket-line dredges in California, operating here in Butte County.

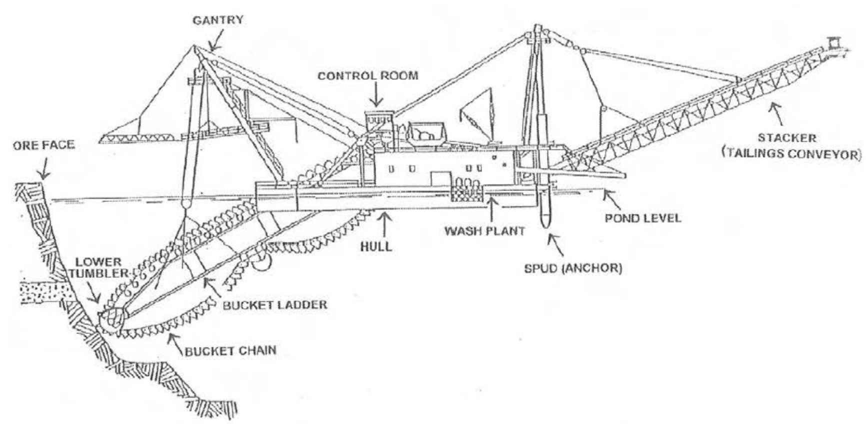
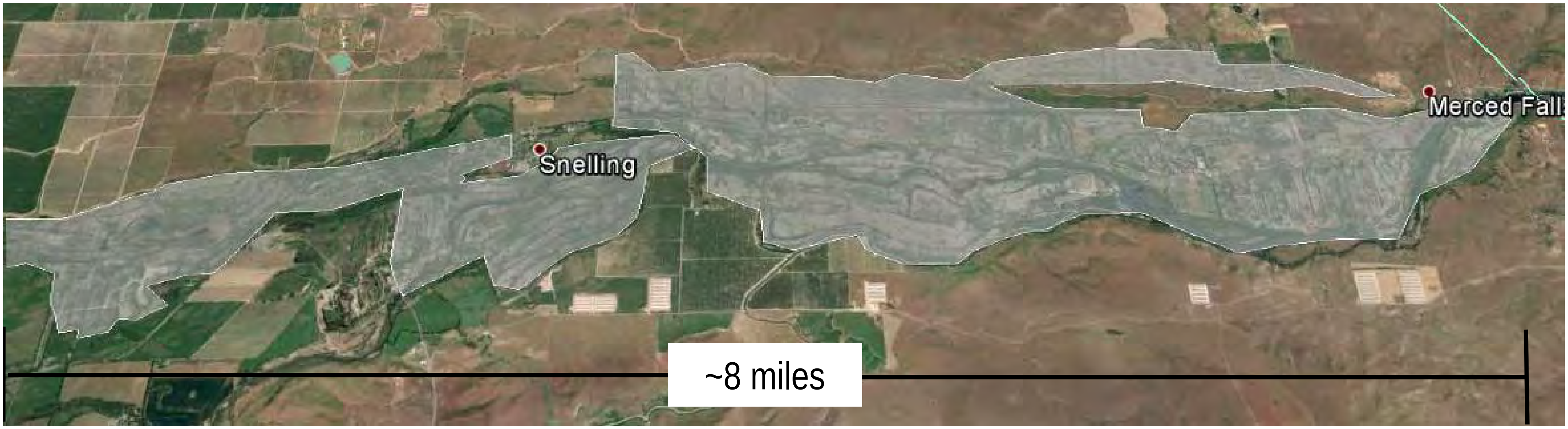


Figure 1 Schematic diagram of floating bucket-line dredge. From files of N. W. Kirshenbaum.

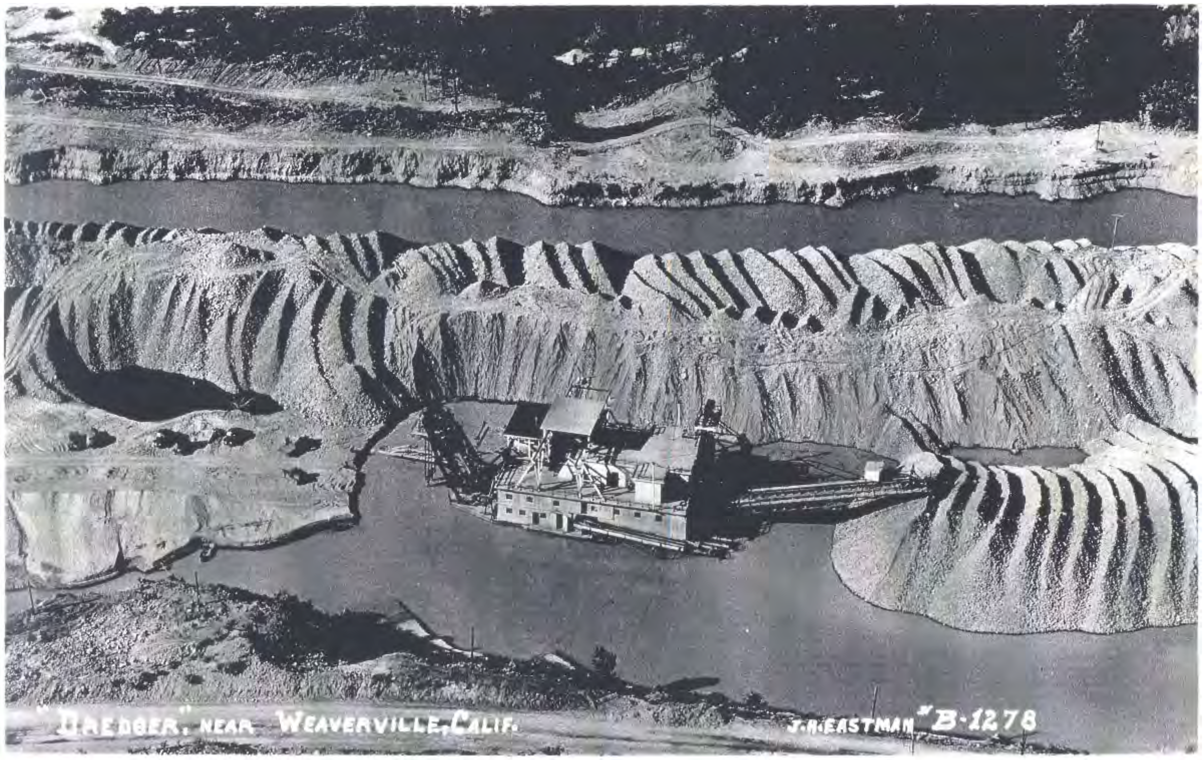
Goldfields - Merced River, Ca



Gold(fields) everywhere!

- Major California rivers such as the Stanislaus, Tuolumne, Merced, American, Yuba, Feather, Trinity, Scott all had or still have gold fields
  - Numerous tribs also have smaller tailing piles

Trinity River, Ca (see Andreas's talk)



- 1898-1958 Gold dredges extensively work many reaches of the Trinity River
- *Subsequent dredger mining overturned more than 70 percent of the floodplains.*

Krause et al., 2010. ONE HUNDRED AND FIFTY YEARS OF SEDIMENT MANIPULATION ON THE TRINITY RIVER, CA

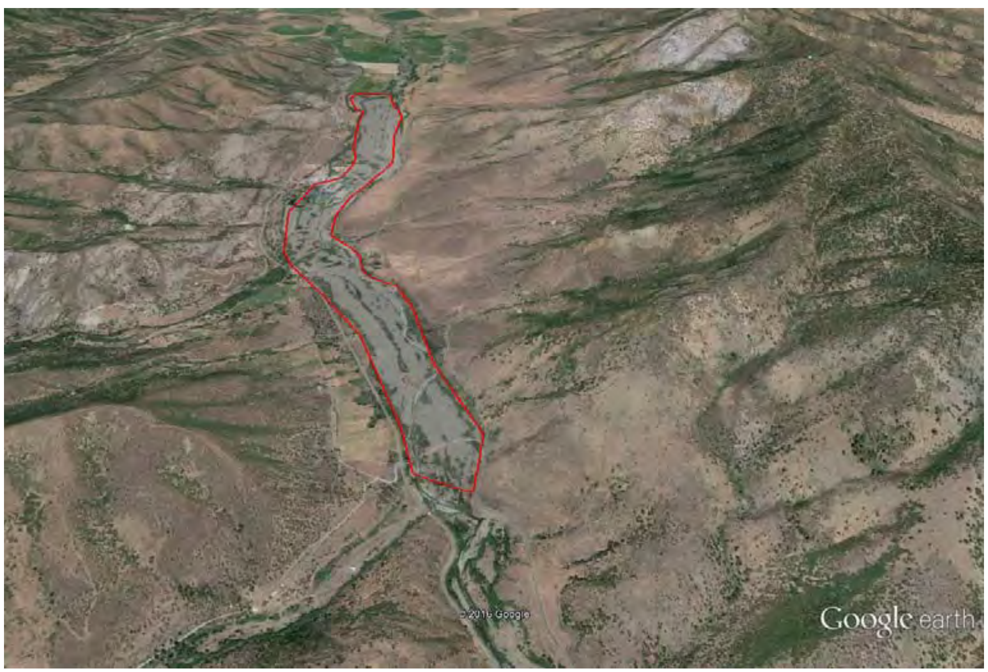
Yuba River

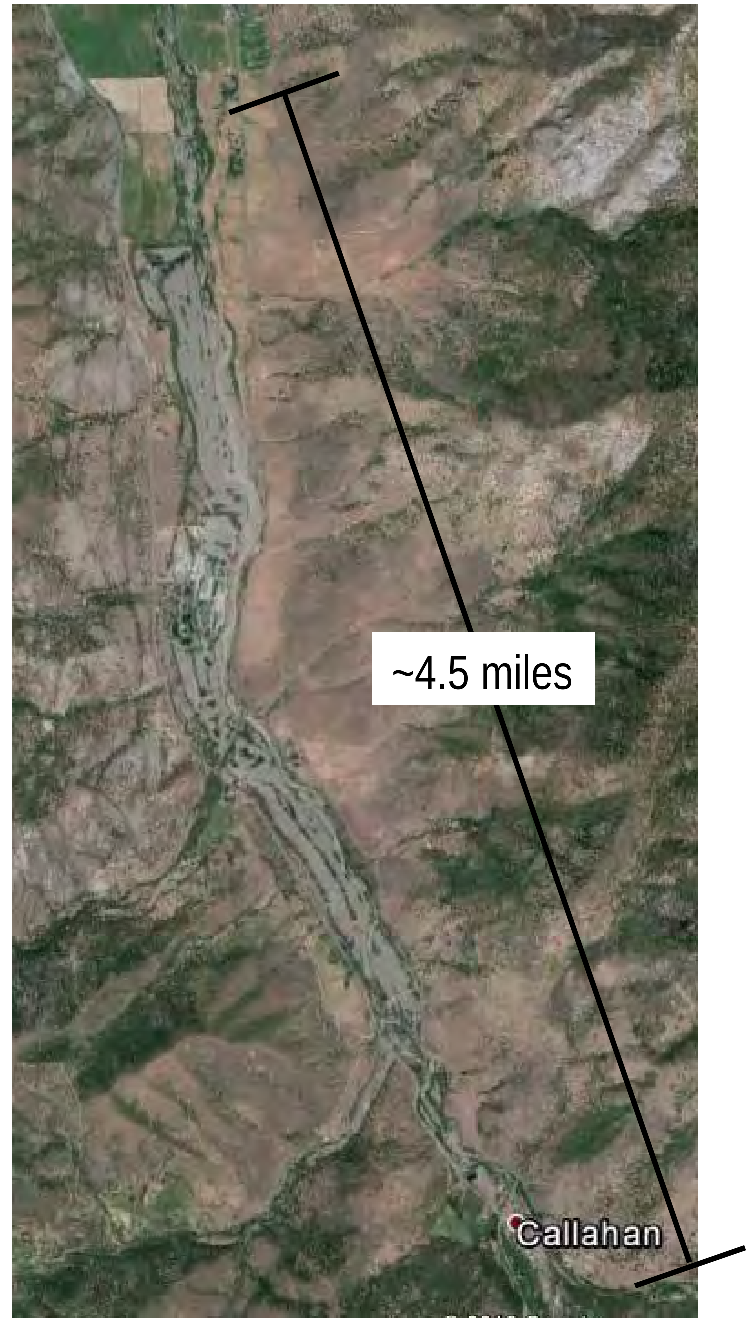
(see Gary's talk)

- >4,000 acres

Scott River Valley

- ~500 acres
- Complete upper river corridor is fossilized





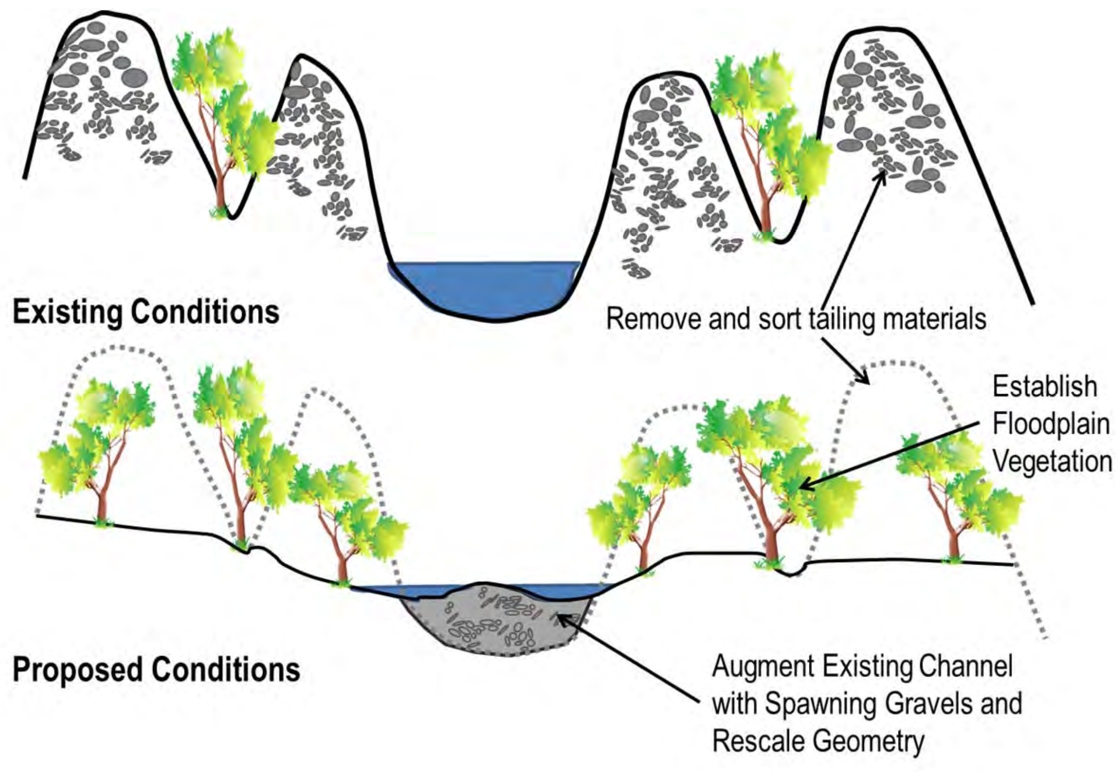
Stanislaus River

- Some gold fields have been transformed over time
- Some areas are being restored

AFRP
Anadromous Fish Restoration Program

Golden opportunities

- Large scale transformations of gold fields to other land uses could significantly increase riparian, flood and agricultural corridors



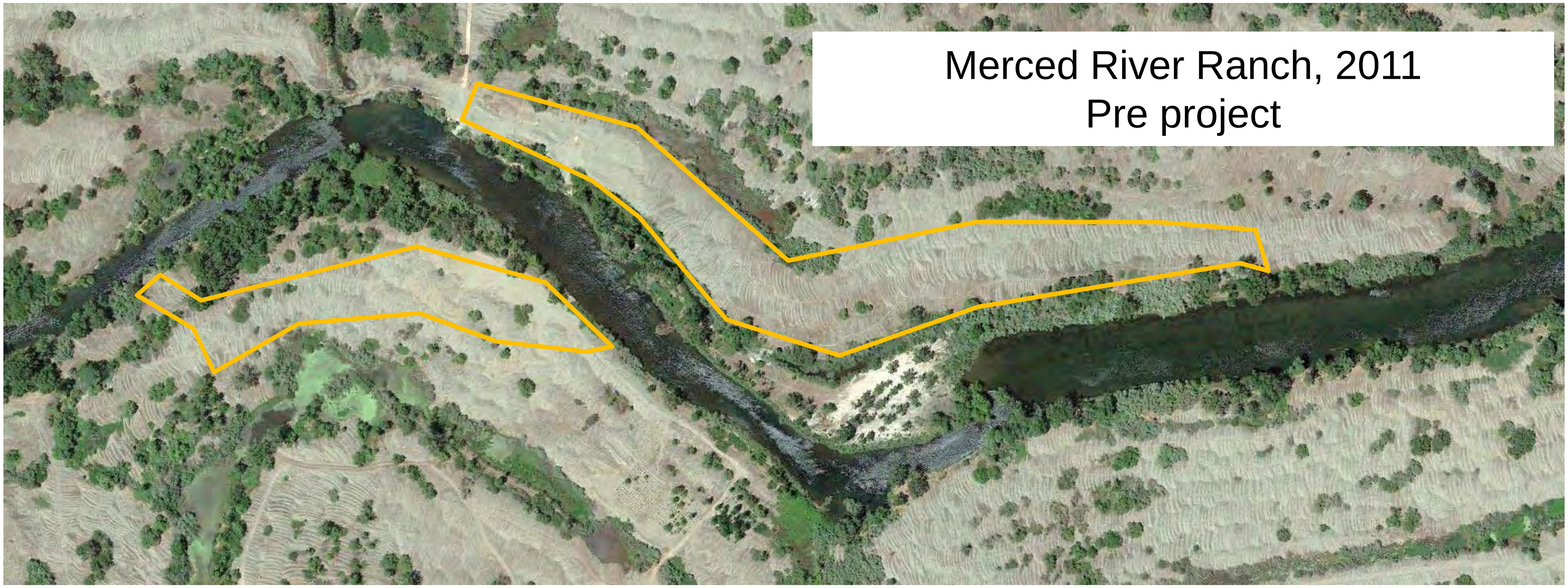
Golden opportunities

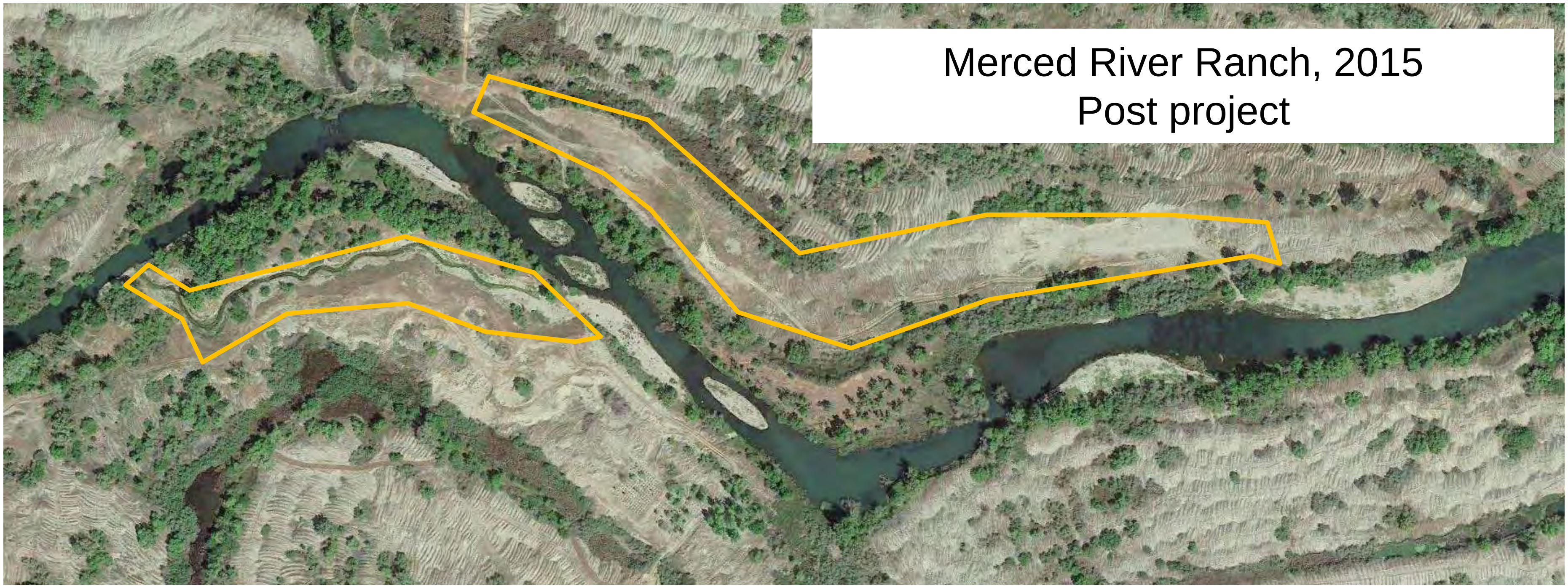
Surfers Point Managed Retreat
Venturariver.org

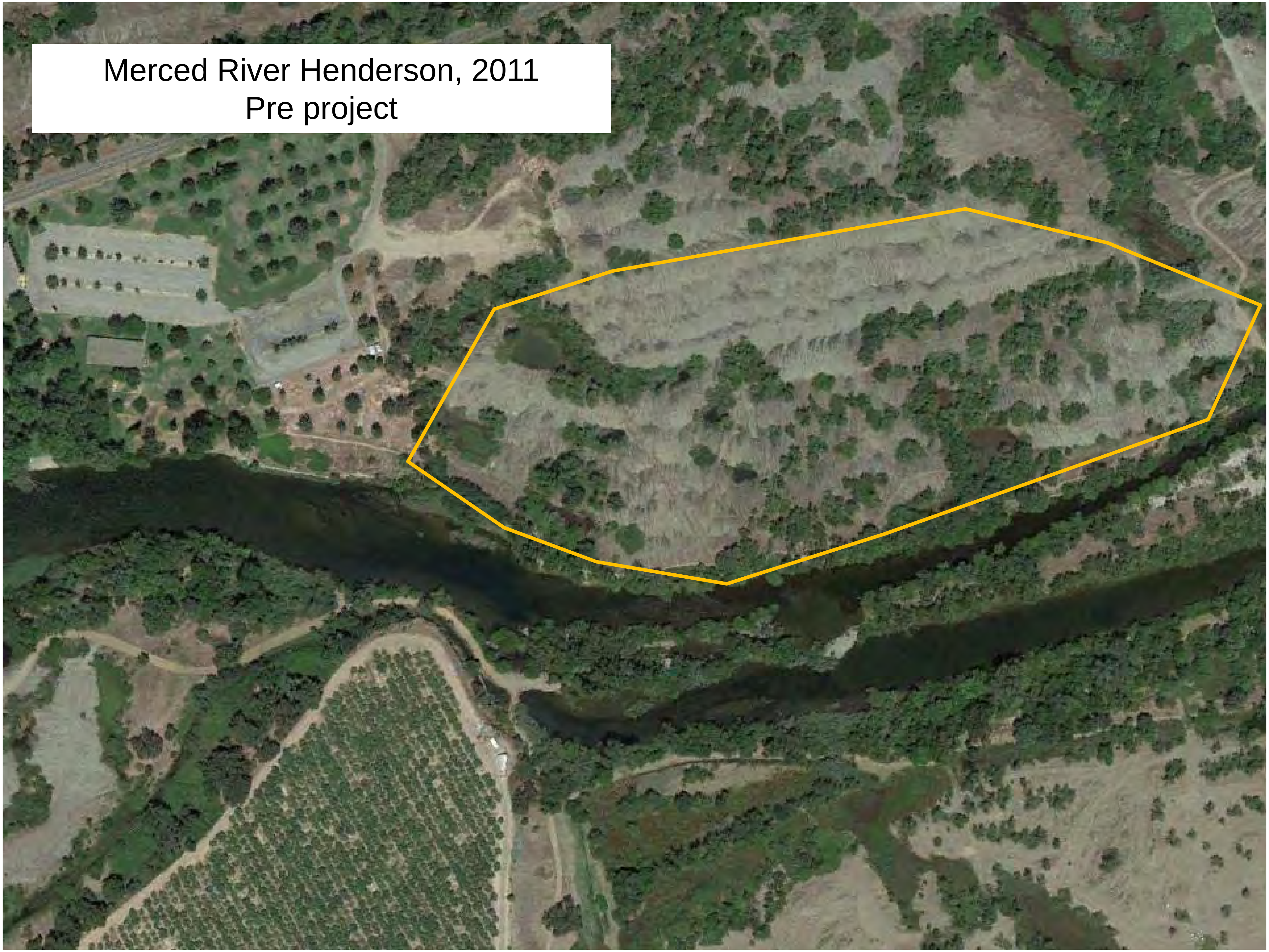
Gravel augmentation

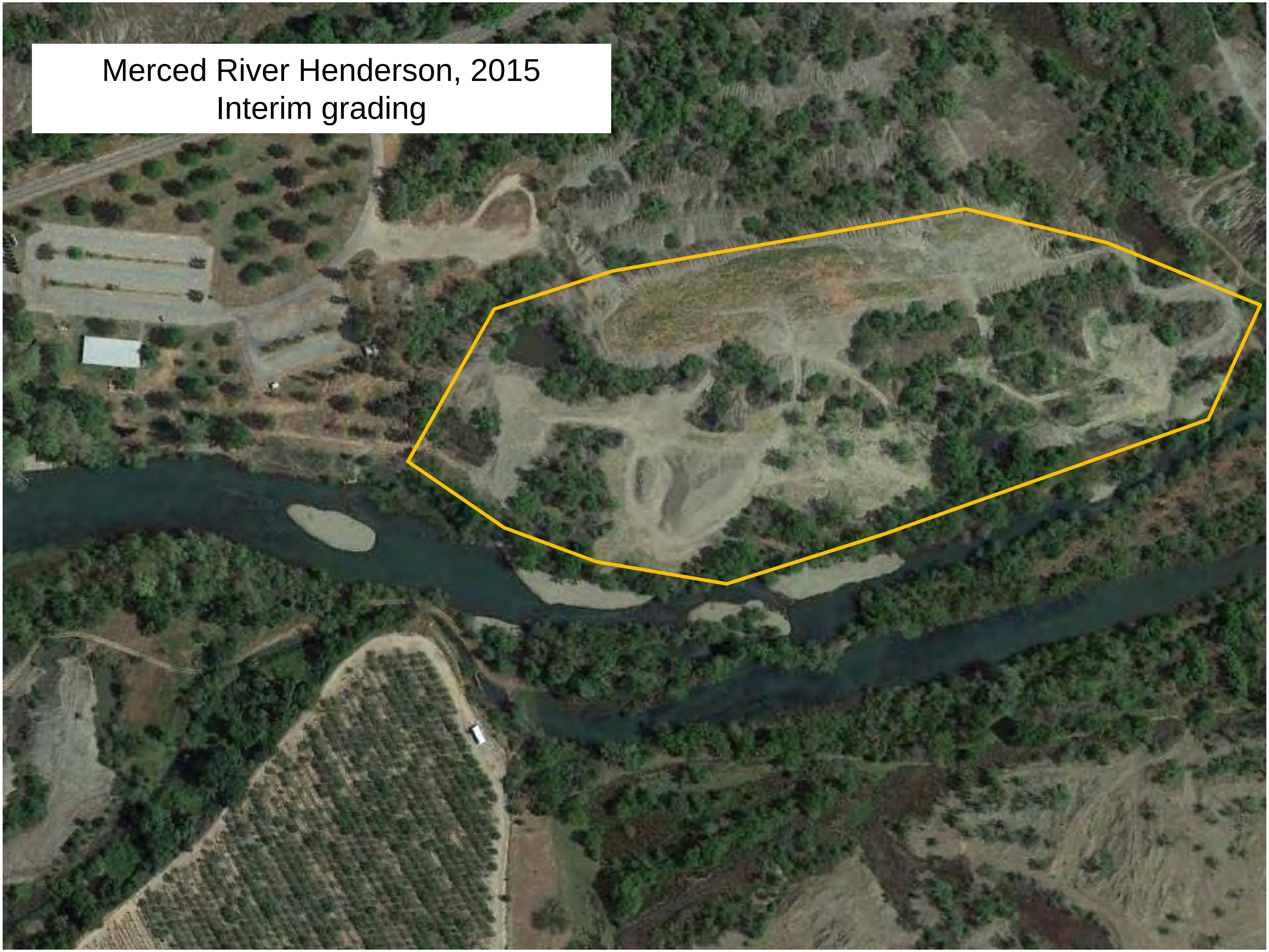
Merced River Restoration

- Baseline planning by Stillwater Sciences
- Funding implementation by NOAA, CDFW and AFRP
- 2 completed projects


Merced River Ranch, 2011
Pre project


Merced River Ranch, 2015
Post project


Merced River Henderson, 2011
Pre project


Merced River Henderson, 2015
Interim grading

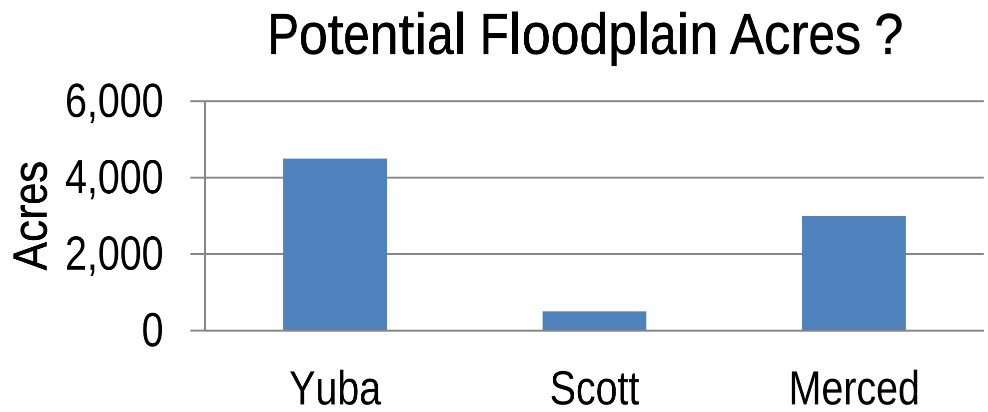
Merced River Henderson, 2015
Complete

CRAMER FISH SCIENCES

Merced River Henderson, 2015
Complete

State wide potential

- Opportunity for large scale transformations of gold fields for
  - – Fish habitat
  - – Flood control
  - – Wildlife corridors
  - – Groundwater banking
  - – Recreation



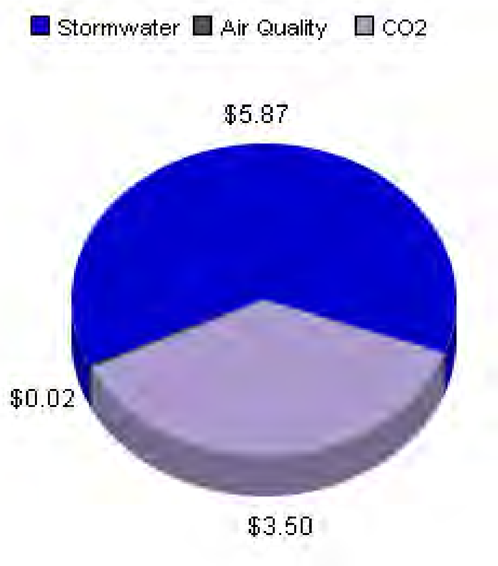
- Several goldfields restoration projects completed or in progress

What if we reclaimed the Merced River Corridor?

- Up to 3,000 acres of rearing and spawning habitat

•$120,000,000 in value over 50 year period by trees alone

http://www.itreetools.org/design.php



A 12” oak will provide a total of $1,062 worth of overall benefits over next 50 years.

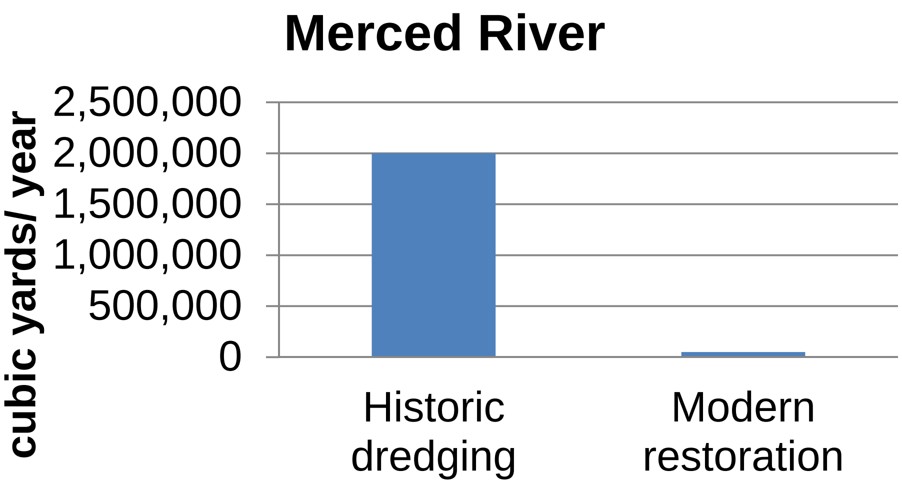
<u>Assumptions</u>
2,000 acres (cut in half)
60 trees per acre
120,000 trees

Constraints

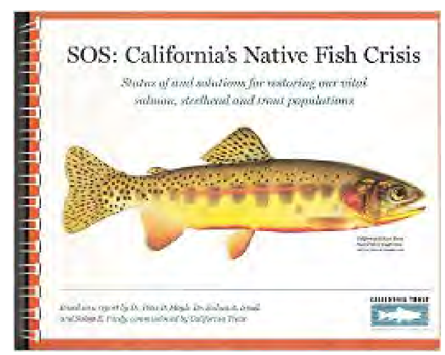
- If it was easy it would already be done
  - – Disjointed ownership
  - – Trucking and processing
  - – Mercury
  - – Existing wetlands and trees
  - – Base flood elevations
  - – Consistent funding
  - – Permitting

Time

- We need more efficient mechanisms to facilitate more rapid land conversion



- Essentially we can do restoration at a rate of ~10 acres/year
  - Including planning, permitting, design and implementation
- <u>At this rate we could restore the Merced River corridor by 2416!*</u>



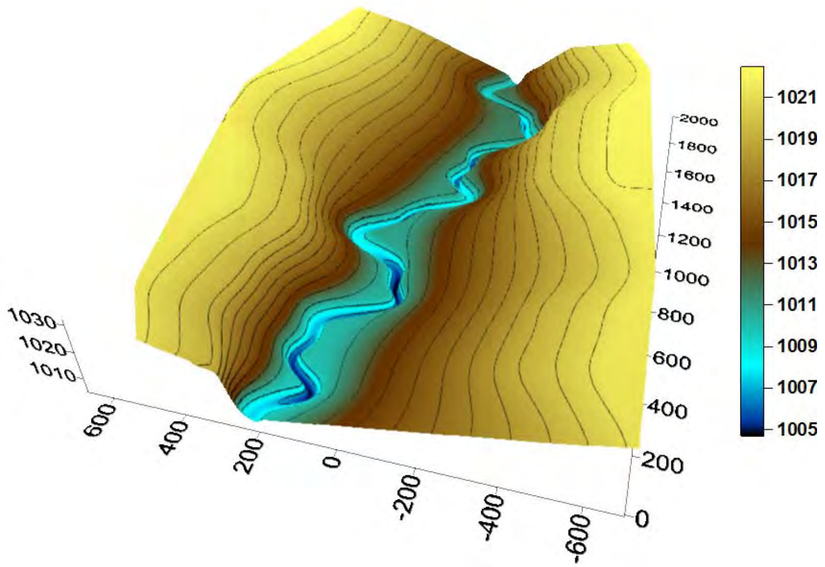
*We probably won't have salmon, or maybe even a habitable planet, but hey, don't kill the messenger

Where do we go?

- Develop integrated statewide and regional reclamation plans that integrate multiple uses
  - Fish habitat
  - Flood control
  - Living river corridor
  - Wildlife corridors
  - Groundwater banking
  - Recreation

- Programmatic permitting
- Develop and strengthen relationships between habitat managers, private industry and mineral resource managers

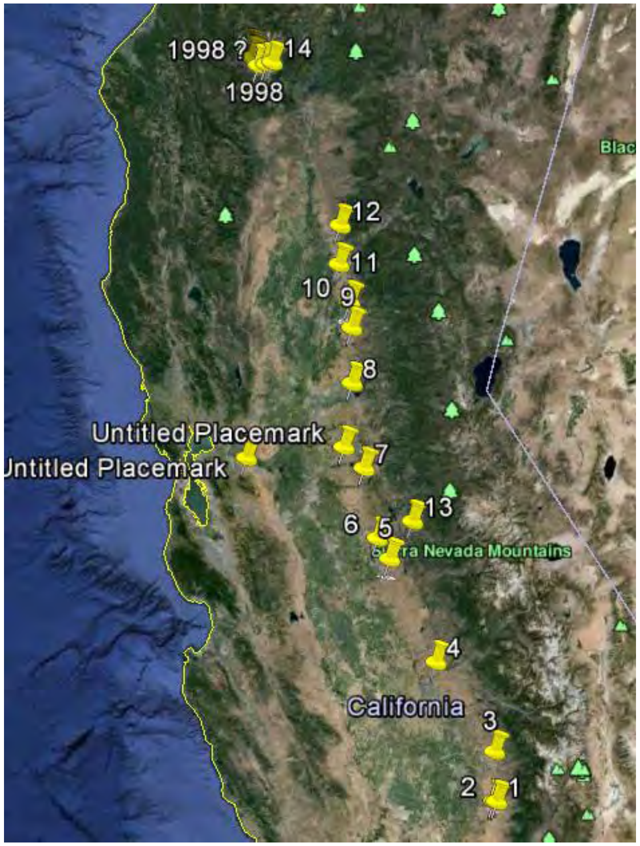
Digital rivers and visioning



An important step is developing a vision for what could be…..

Brown, R.A., Pasternack, G.B., Wallander, W.W., Synthetic river valleys: creating prescribed topography for form-process inquiry and river rehabilitation design, Geomorphology (2014), doi: 10.1016/j.geomorph.2014.02.025

What could be?



Thank you!

Please send me locations, extents, studies, photos, etc… of your goldfields
rbrown@esassoc.com

Thank you!

Please send me locations, extents, studies, photos, etc… of your goldfields

rbrown@esassoc.com

Lower Yuba River Restoration and the Yuba Goldfields

Presentation Outline:

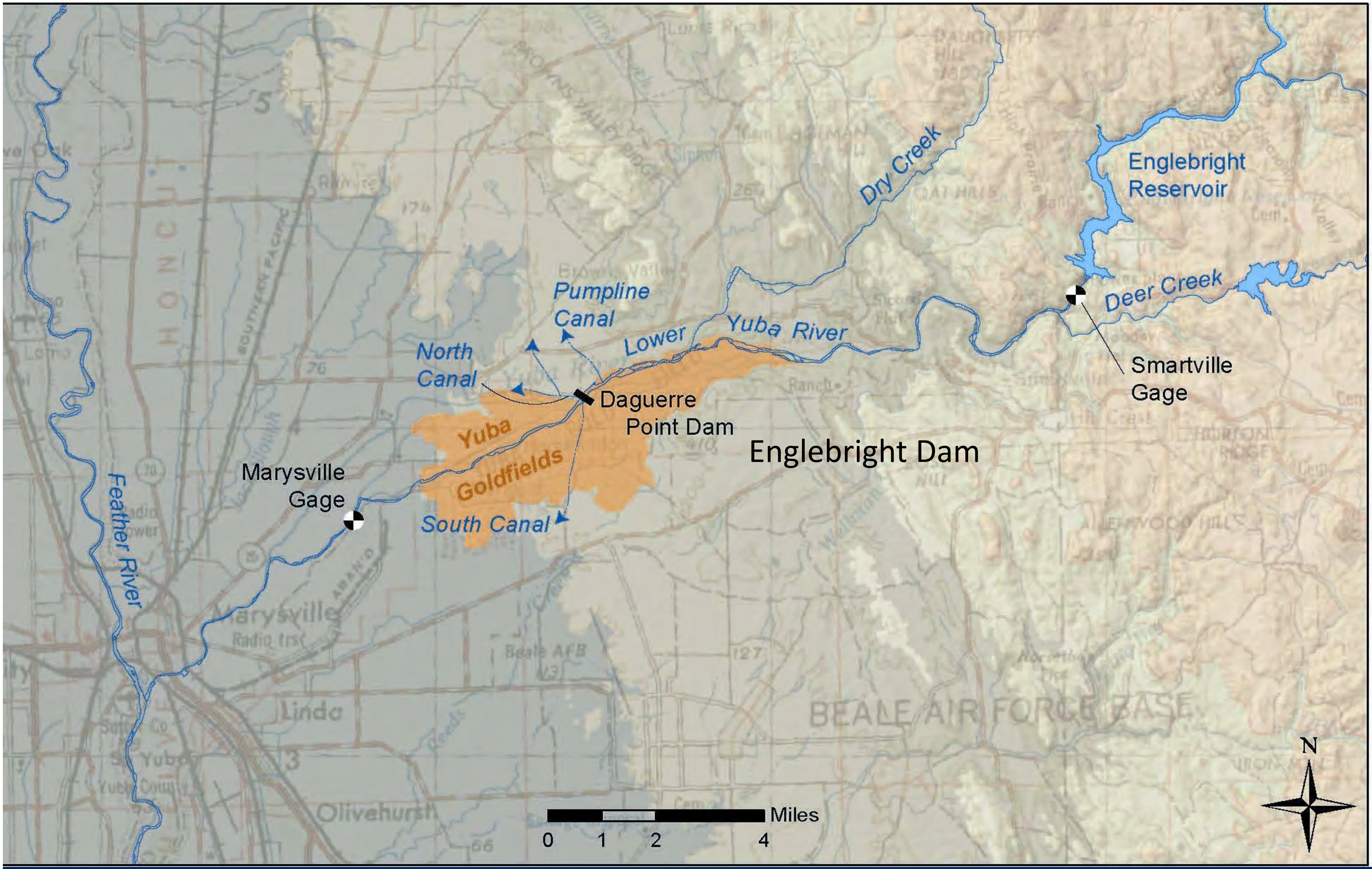
- **Background on Yuba River Goldfields**
- **The Hammon Bar Pilot Project**
- **The Hallwood Side Channel Project**
- **The Upper Rose Bar and Blue Point Mine Project**
- **Challenges and Opportunities for Restoration**

Salmonid Restoration Federation, April 2016

Gary Reedy, South Yuba River Citizens League

SYRCL

The Lower Yuba River



Map from Yuba County Water Agency

Hydraulic mining (beg. 1852) in the Yuba Watershed produced 685 million yd^3 of sediment.

In the lower Yuba River this sediment completely smothered the river channel and floodplain.

Average depth of deposits ranged from 20-45 ft across floodplain and channel.

Giant dredges then worked the Yuba River and floodplain from 1906 up into the 1980s.

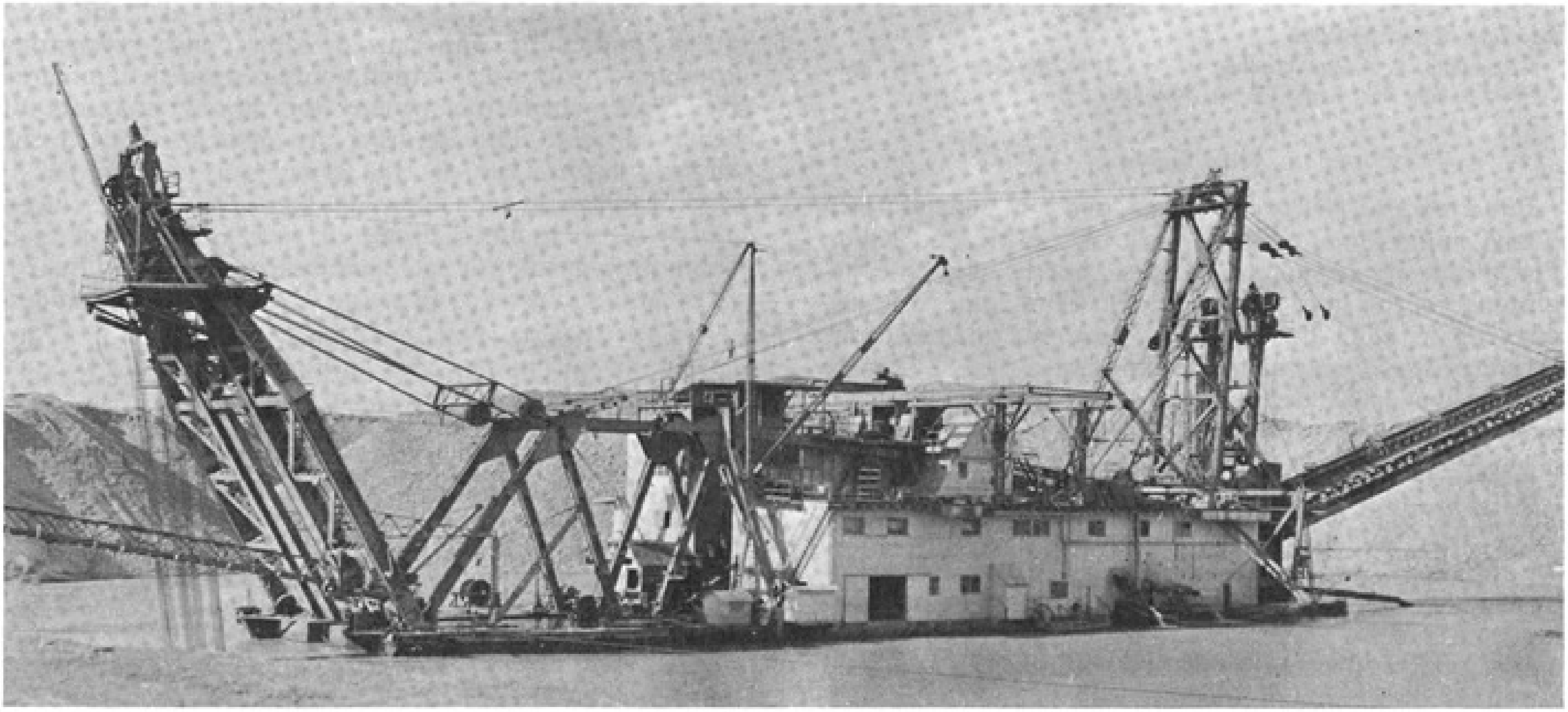


Photo 28. Yuba Consolidated Dredge, Hammonton District. Dredge No. 17 operated in the district in Yuba County until 1966. This photo was taken a decade earlier.

Mining Legacy: Narrowed Floodplain and Coarse Substrate

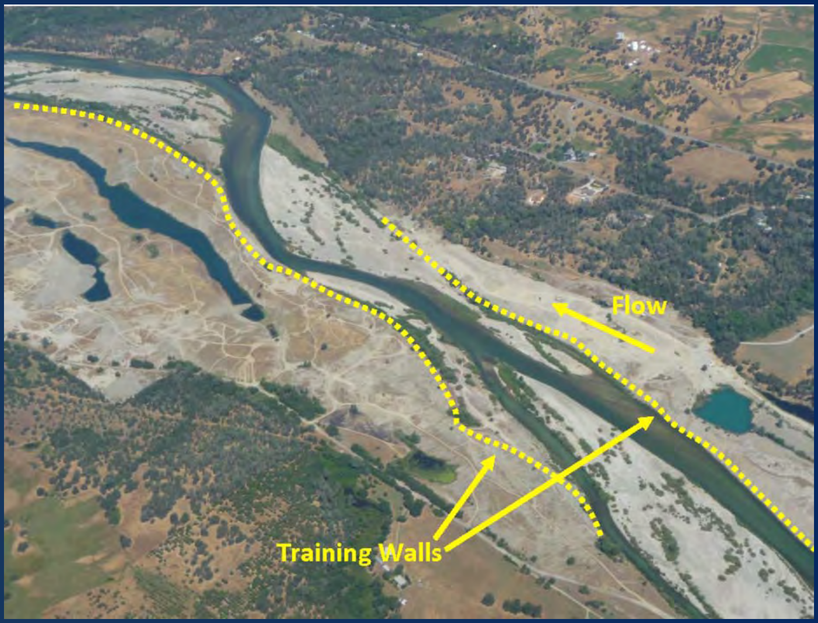
Goldfields Reach Conditions in the Lower Yuba River

- Dynamic, wandering, high energy, w/ gravel/cobble bed
- Laterally constrained by the training walls (300-1600 ft)
- Alternating bars, high flow secondary channels and high floodplains are common
- Off channel areas that are frequently inundated for extended periods (juv. rearing habitat) are not common
- Lacks well developed fine textured soils
- Supports ESA-listed Spring-run Chinook and steelhead, as well as one of Central Valley's most abundant fall-run Chinook populations.

Training Walls

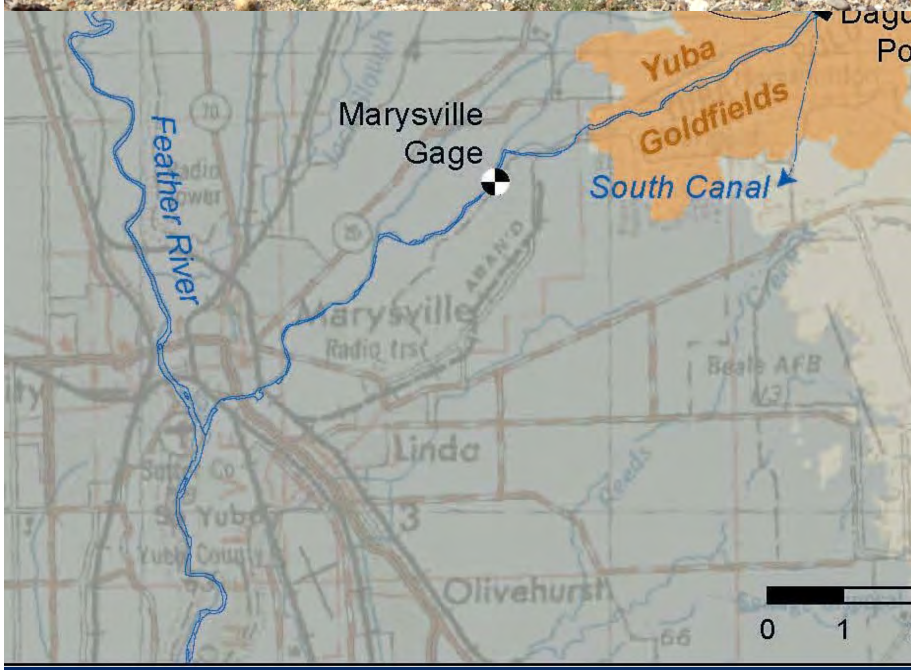
- Constructed by dredges to control the alignment of the river to the north of the previous alignment

- Although not engineered levees, the linear tailings mounds in the Goldfields provide limited flood protection

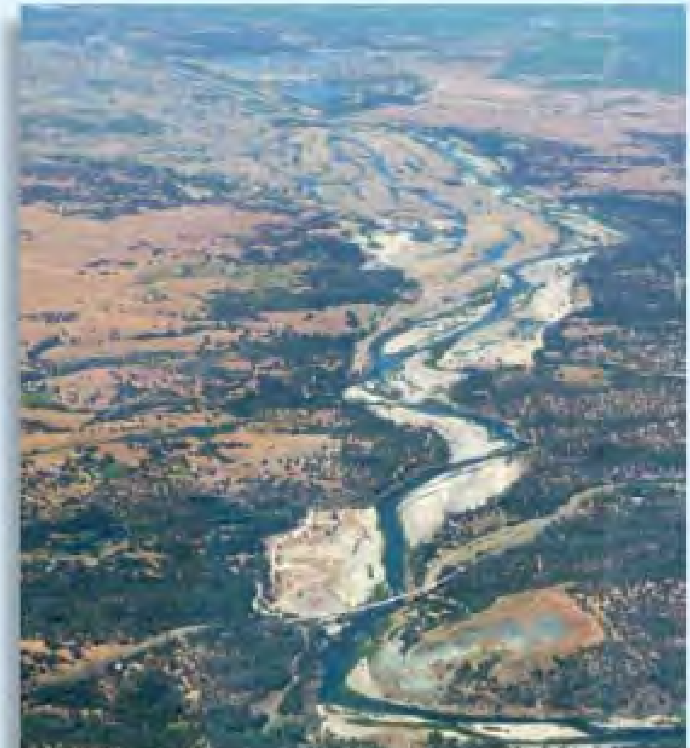


Photos courtesy of cbec


Englebright
Reservoir
Deer Creek
Spawning Habitat Limited


Marysville
Gage
Yuba
Goldfields
South Canal
Feather River
Marysville
Linda
Olivehurst
Beale AFB
0
1


Englebright Dam



Rehabilitation Concepts for the Parks Bar to Hammon Bar Reach of the Lower Yuba River

Prepared by:
cbec, inc. eco engineering
South Yuba River Citizens League
McBain & Trush, Inc.

November 2010

Funding provided by: U.S. Fish and Wildlife Service - Anadromous Fish Restoration Program

The Hammon Bar Riparian Enhancement Project

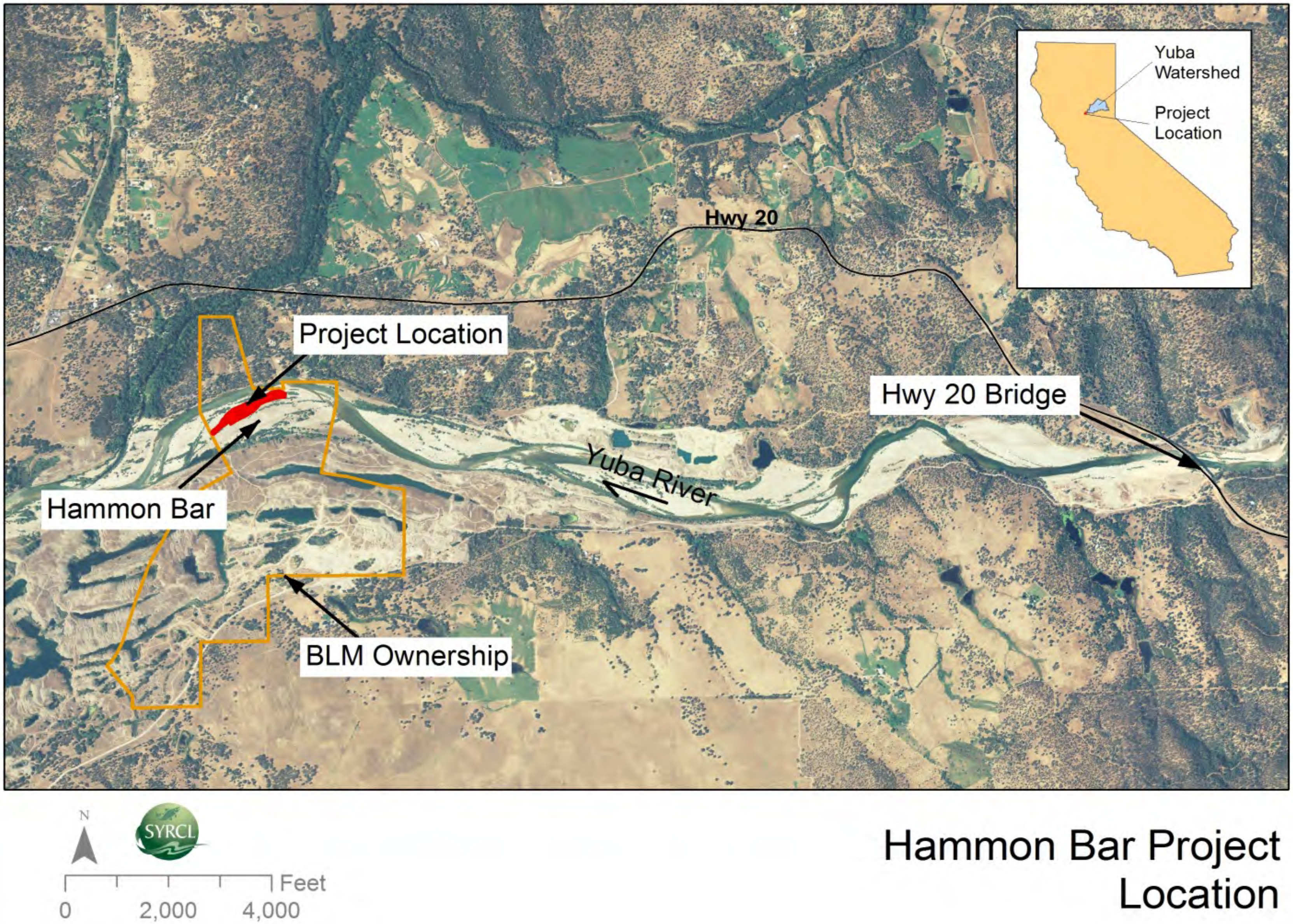
Riparian Vegetation – Current Conditions and Trends

Hammon Bar Riparian Enhancement Project

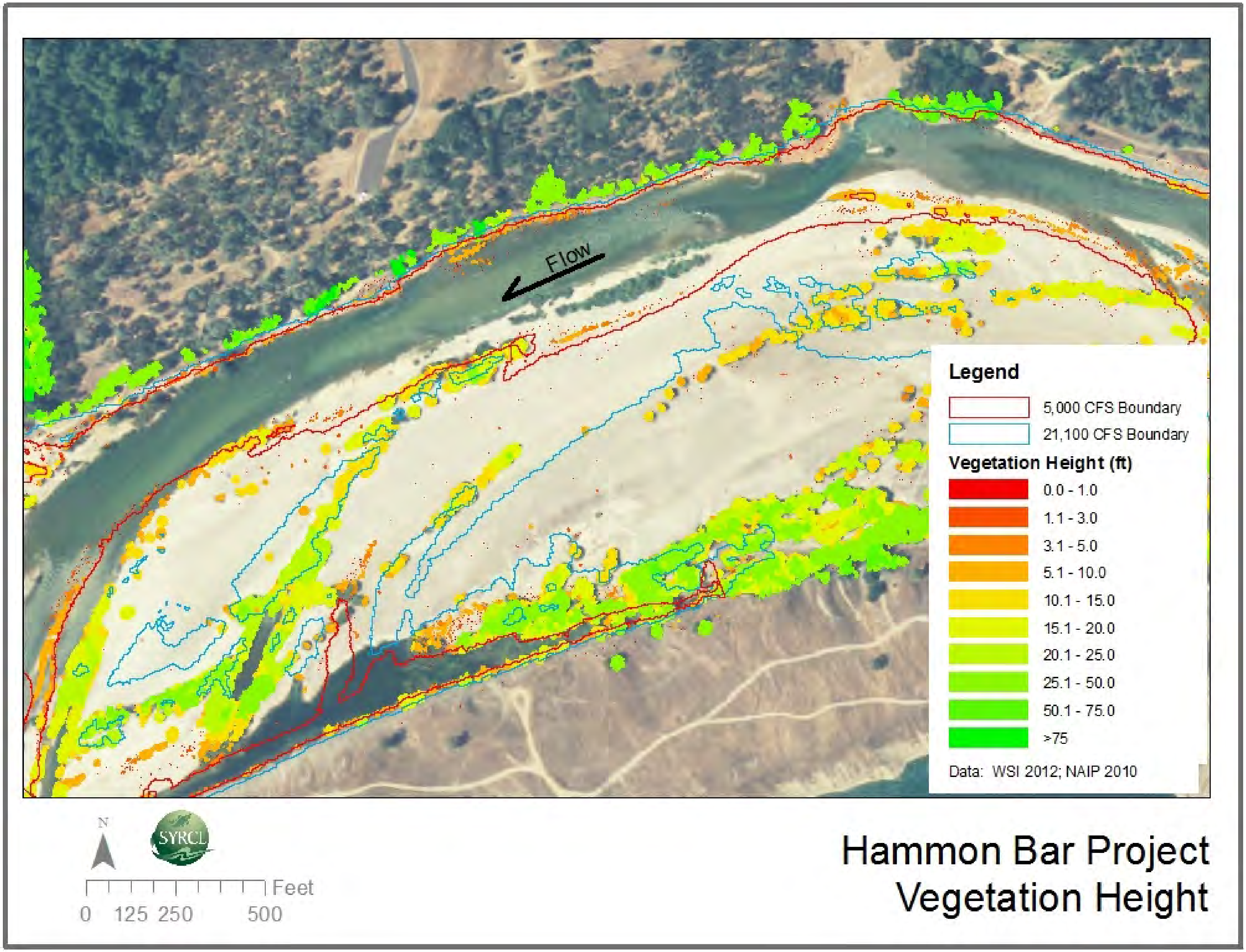
Goal:

New stands of structurally and biologically diverse riparian vegetation, and resulting enhancement of fish habitat through …

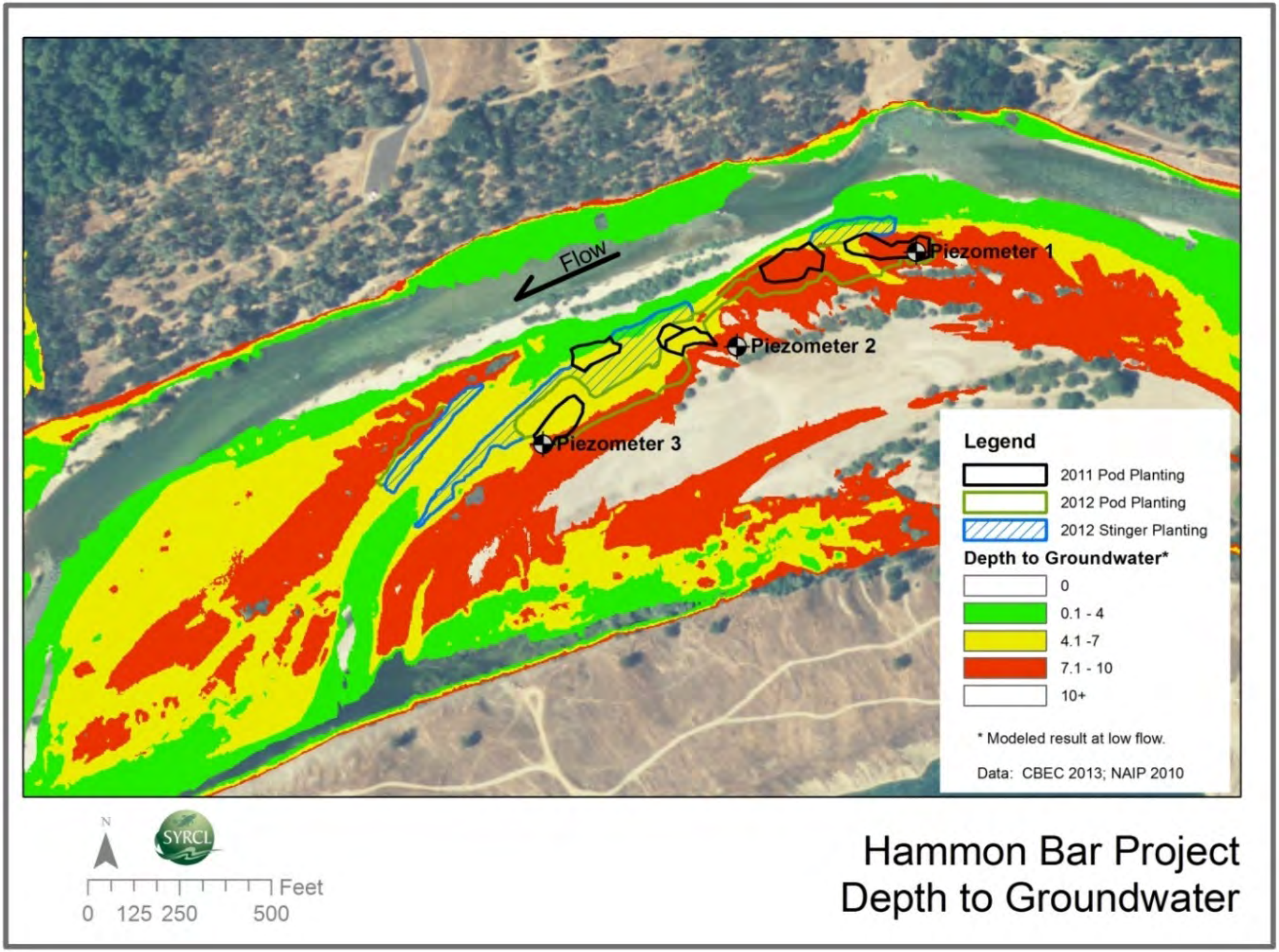
- additional shading, cover, and food supply
- additional hydraulic and geomorphic complexity including streamwood

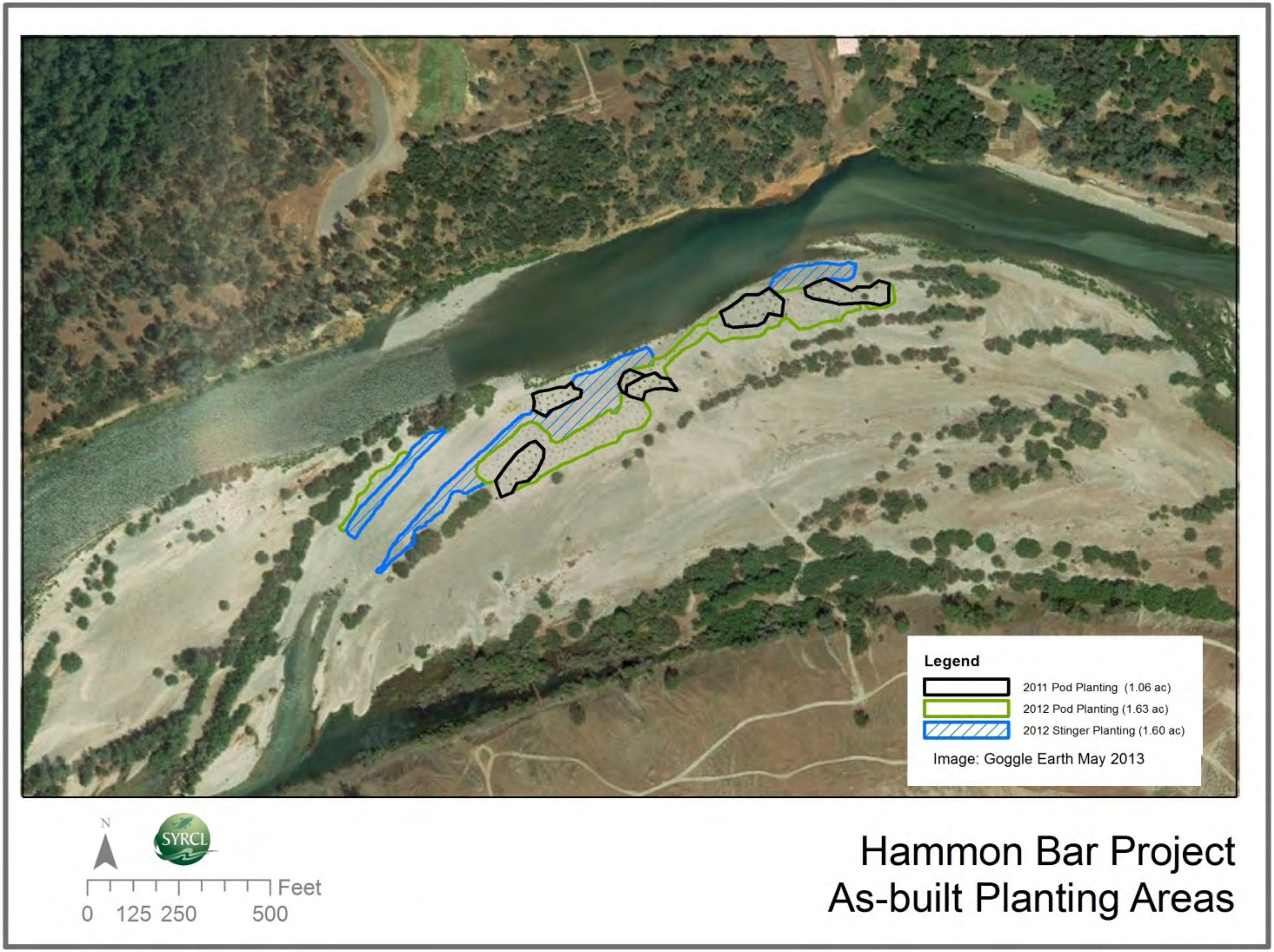


Hammon Bar Project Location



Hammon Bar Project
Vegetation Height


Flow
Piezometer 1
Piezometer 2
Piezometer 3
Legend
2011 Pod Planting
2012 Pod Planting
2012 Stinger Planting
Depth to Groundwater*
0
0.1 - 4
4.1 -7
7.1 - 10
10+
* Modeled result at low flow.
Data: CBEC 2013; NAIP 2010
N
SYRCL
0 125 250 500 Feet
Hammon Bar Project
Depth to Groundwater


Legend
2011 Pod Planting (1.06 ac)
2012 Pod Planting (1.63 ac)
2012 Stinger Planting (1.60 ac)
Image: Goggle Earth May 2013
N
SYRCL
0 125 250 500
Feet
Hammon Bar Project
As-built Planting Areas

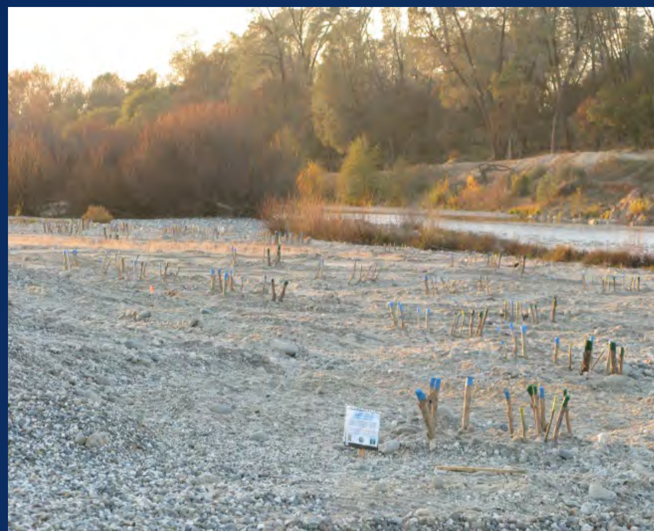
Marking, harvesting and soaking cuttings, 2011.

Two planting methods: pods by excavator, and 1-2 cuttings by stinger

April 27, 2012
Planting Area A at 10,000 cfs

Captured woody material and deposited sand following inundation, Spring 2012

First-year, before and after





Planting survivorship by year and technique

Species	Total Planted (2011/12)	2014	2015
Cottonwood	3073	47%	39%
Red Willow	705	51%	34%
Arroyo Willow	1110	79%	71%
Gooddings Willow	1411	73%	62%

Hammon Bar Riparian Enhancement Project

SYRCL

yubariver.org/restoration

Funded by the Bella Vista Foundation, the Anadromous Fish Restoration Program, and PG&E

U.S. FISH & WILDLIFE SERVICE

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT

cbec eco engineering

PG&E

WESTERN AGGREGATES

TEICHERT AGGREGATES

From Pilot Project toward Restoration Program:

- Stakeholder input and coordination
- Depth to Water Mapping
- Geomorphic and Ecological Flows Analysis
- Grading and Large Wood Placement Alternatives

cbec
eco engineering

Hydrology | Hydraulics | Geomorphology | Design | Field Services

Photo courtesy: Tom Johnson

Hydrologic and Geomorphic Analysis to Support Rehabilitation Planning for the Lower Yuba River from Parks Bar to Marysville

SYRCL

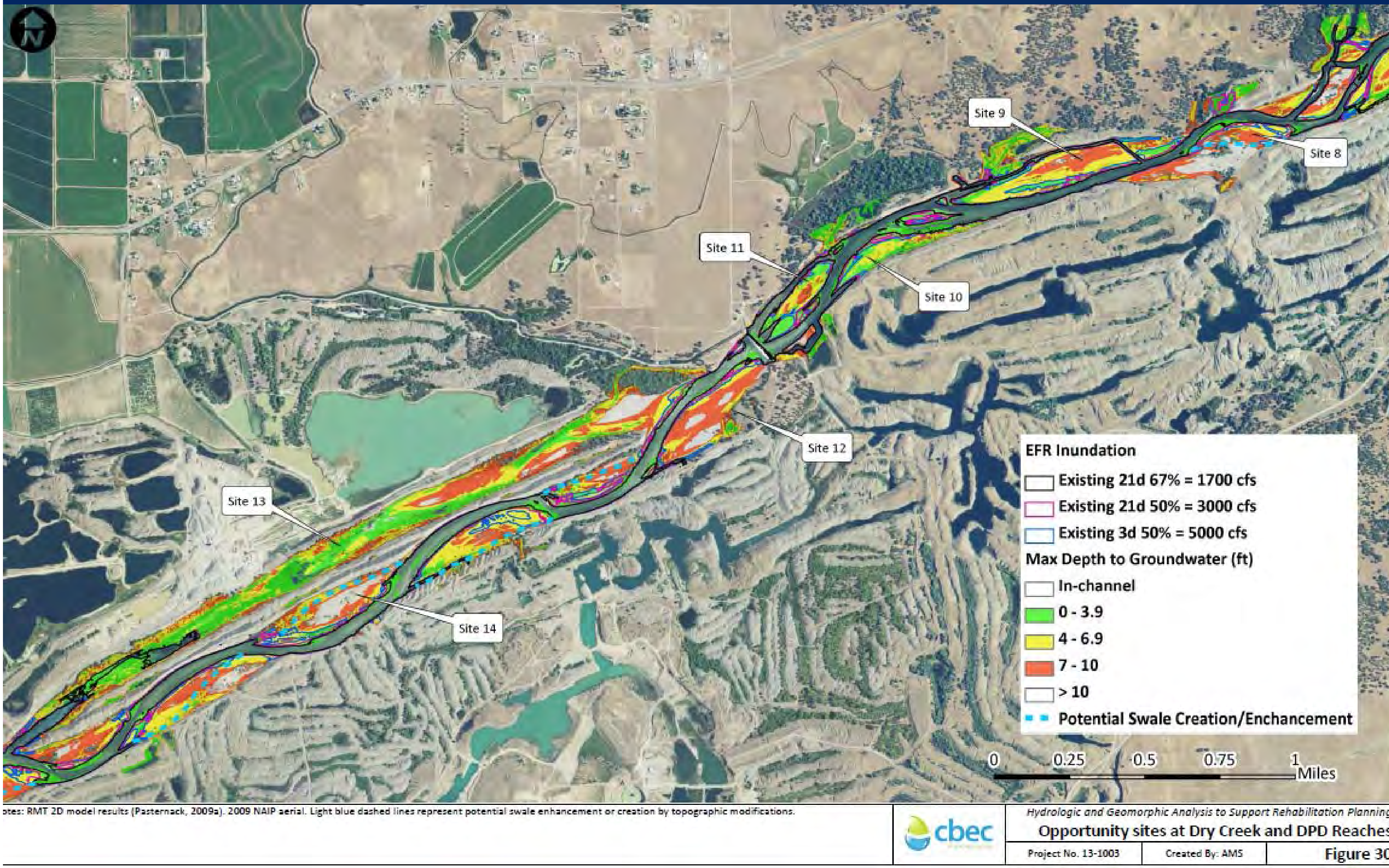
Prepared for:
South Yuba River Citizens League

November 2013

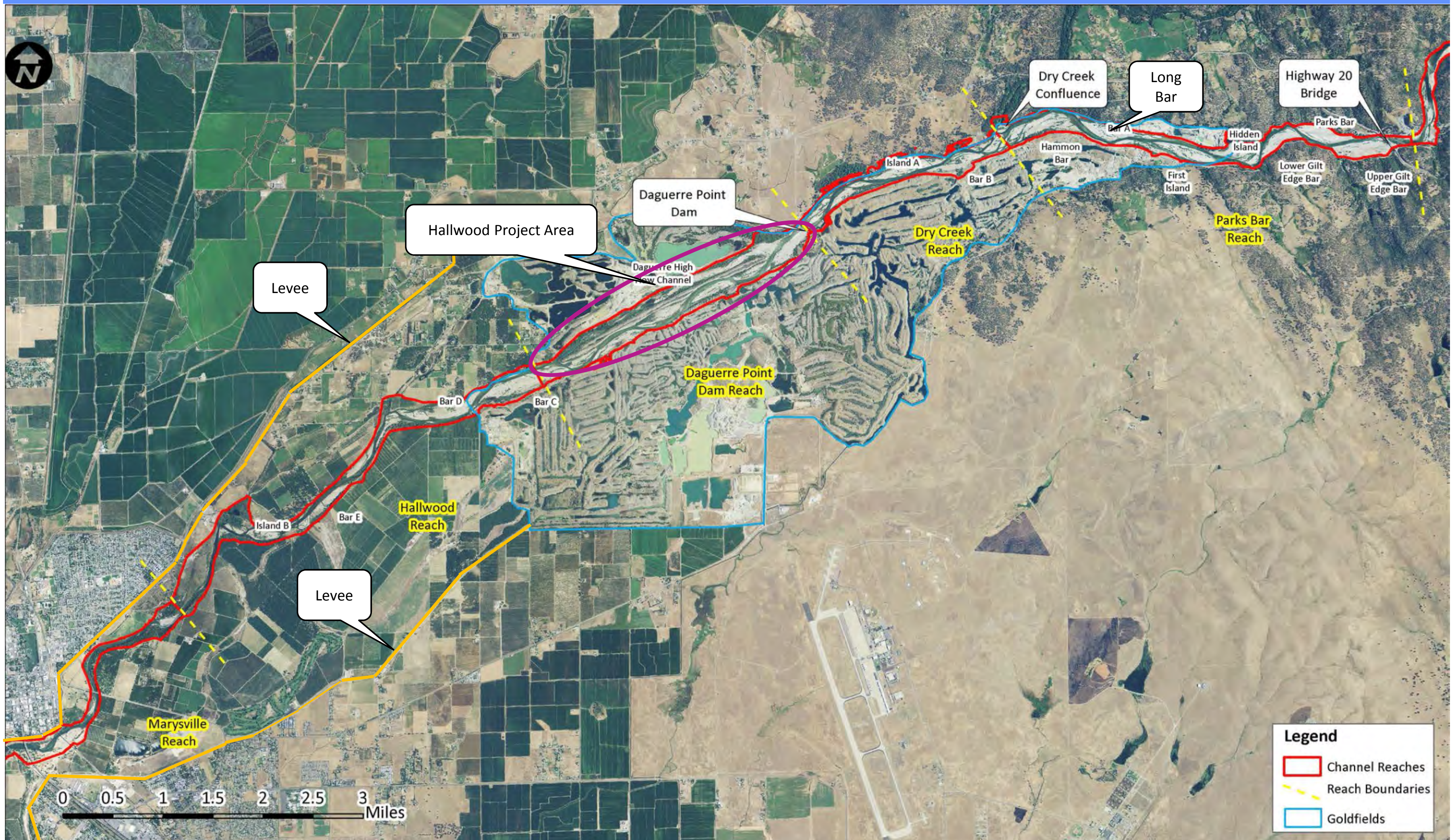
Funding provided by: U.S. Fish and Wildlife Service - Anadromous Fish Restoration Program

cbec Project # 13-1003

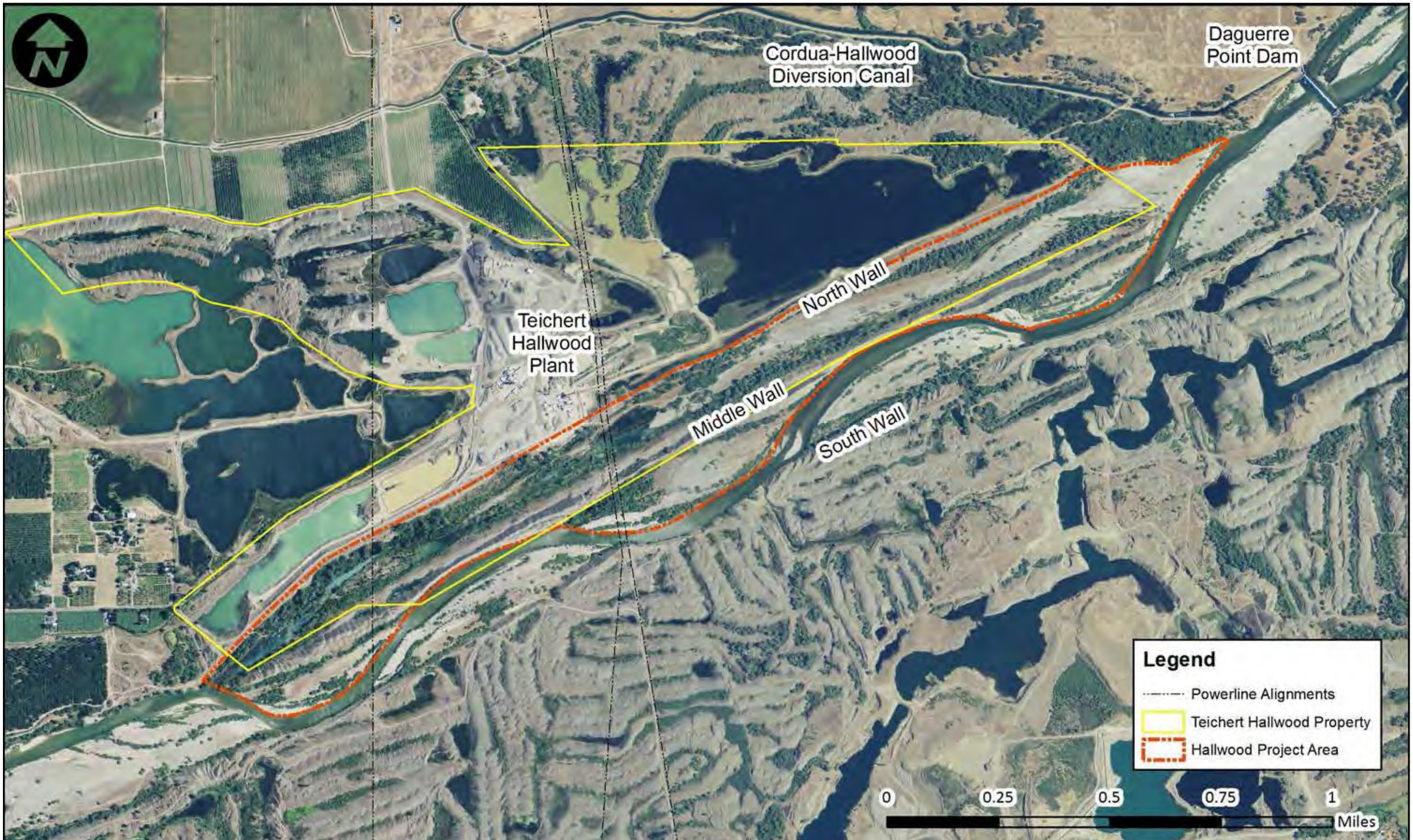
Mapping Habitat Enhancement Opportunities



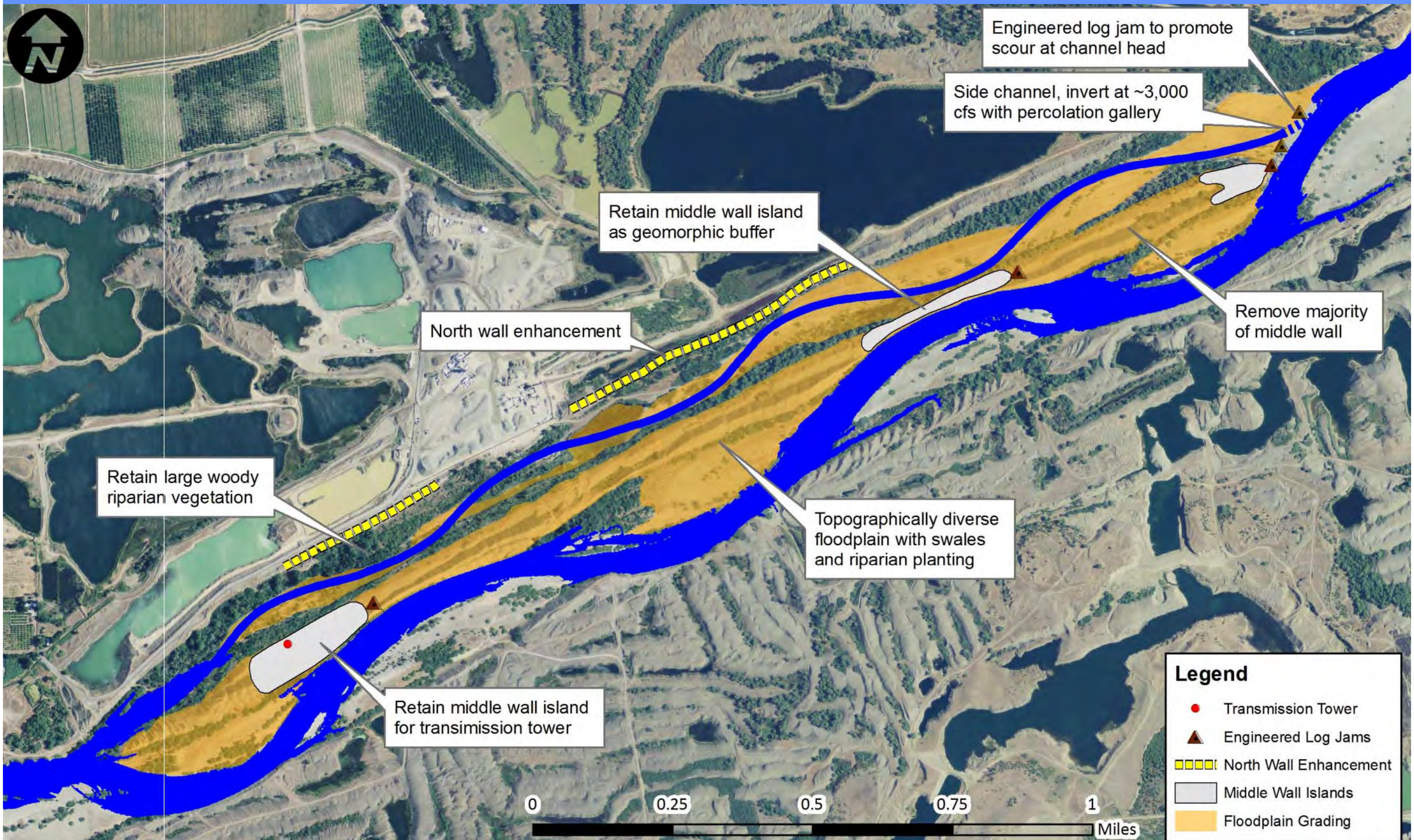
Hallwood Project Area



Hallwood Project Area

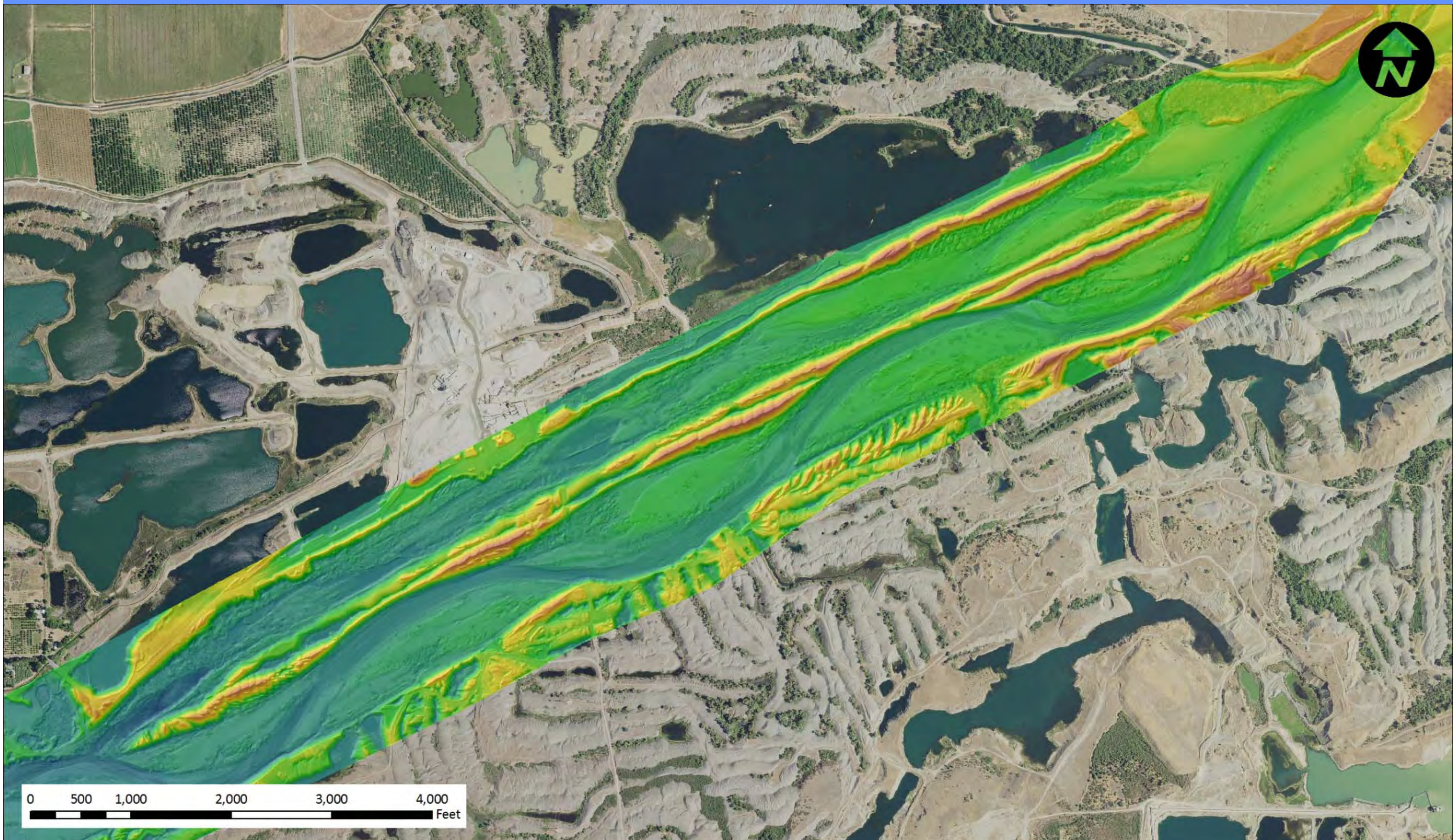


Project Concept



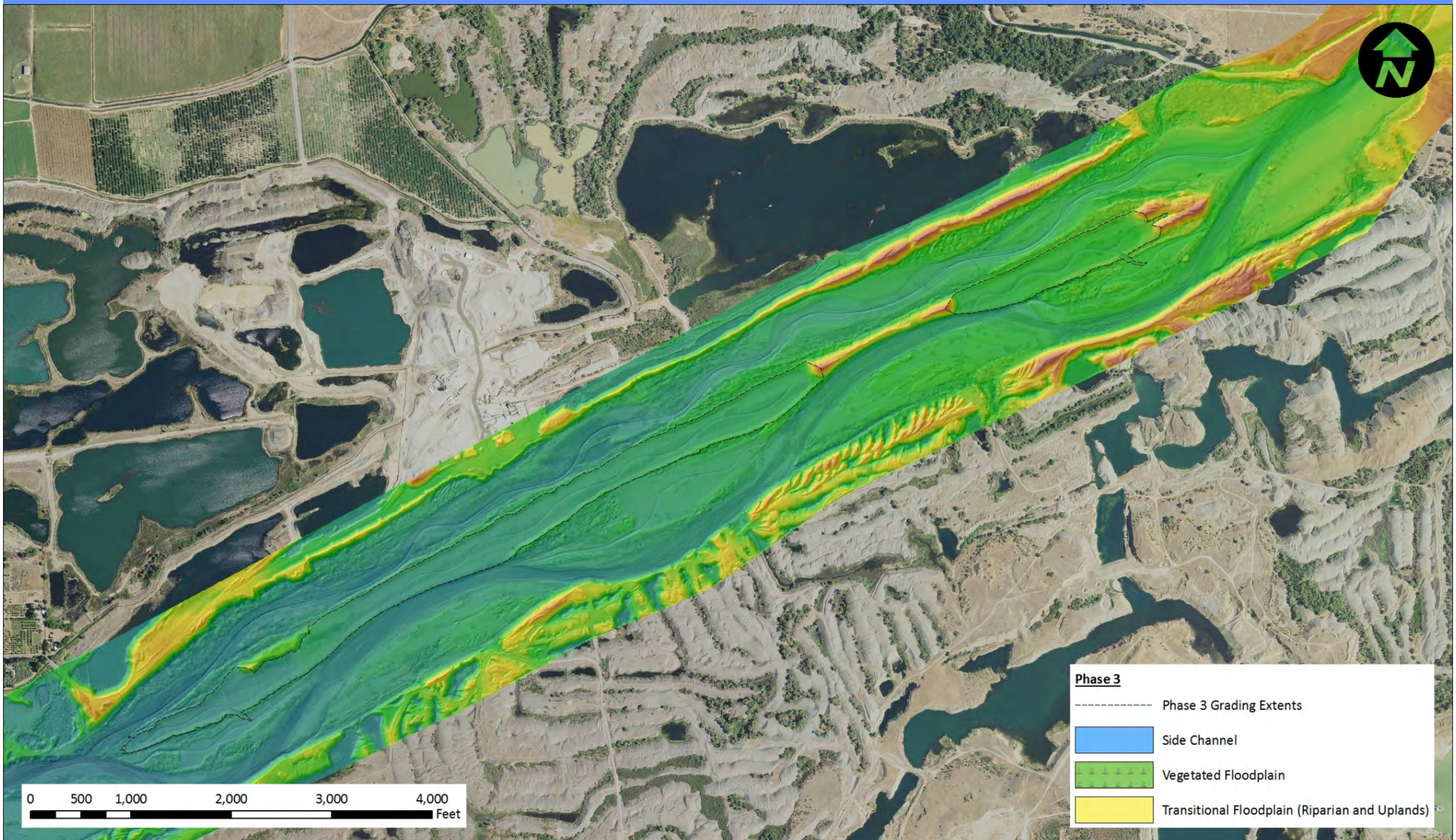
Hallwood Side Channel and Floodplain Restoration Project

Existing Condition Topography

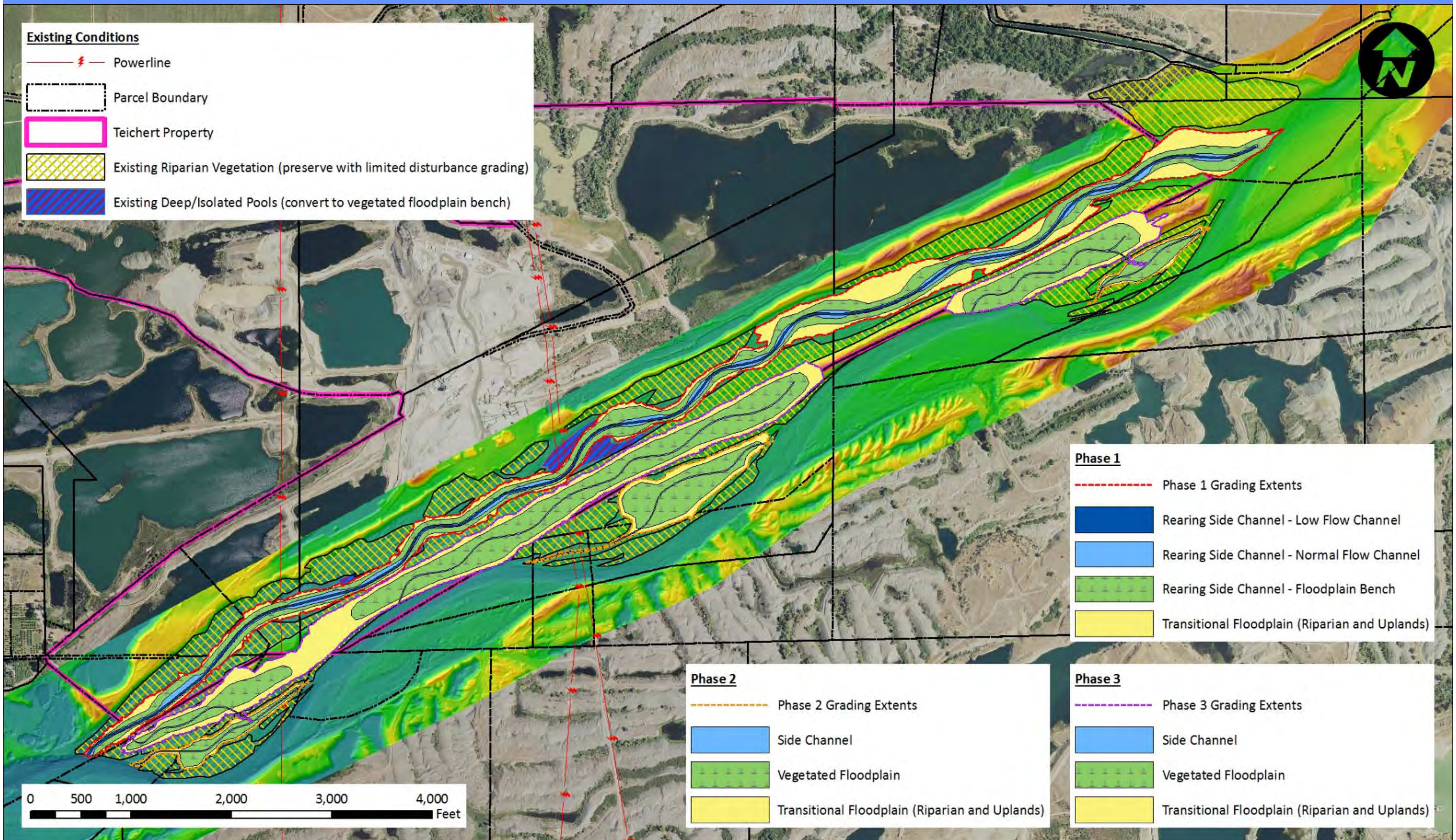


Hallwood Side Channel and Floodplain Restoration Project

Preliminary Design



Preliminary Design



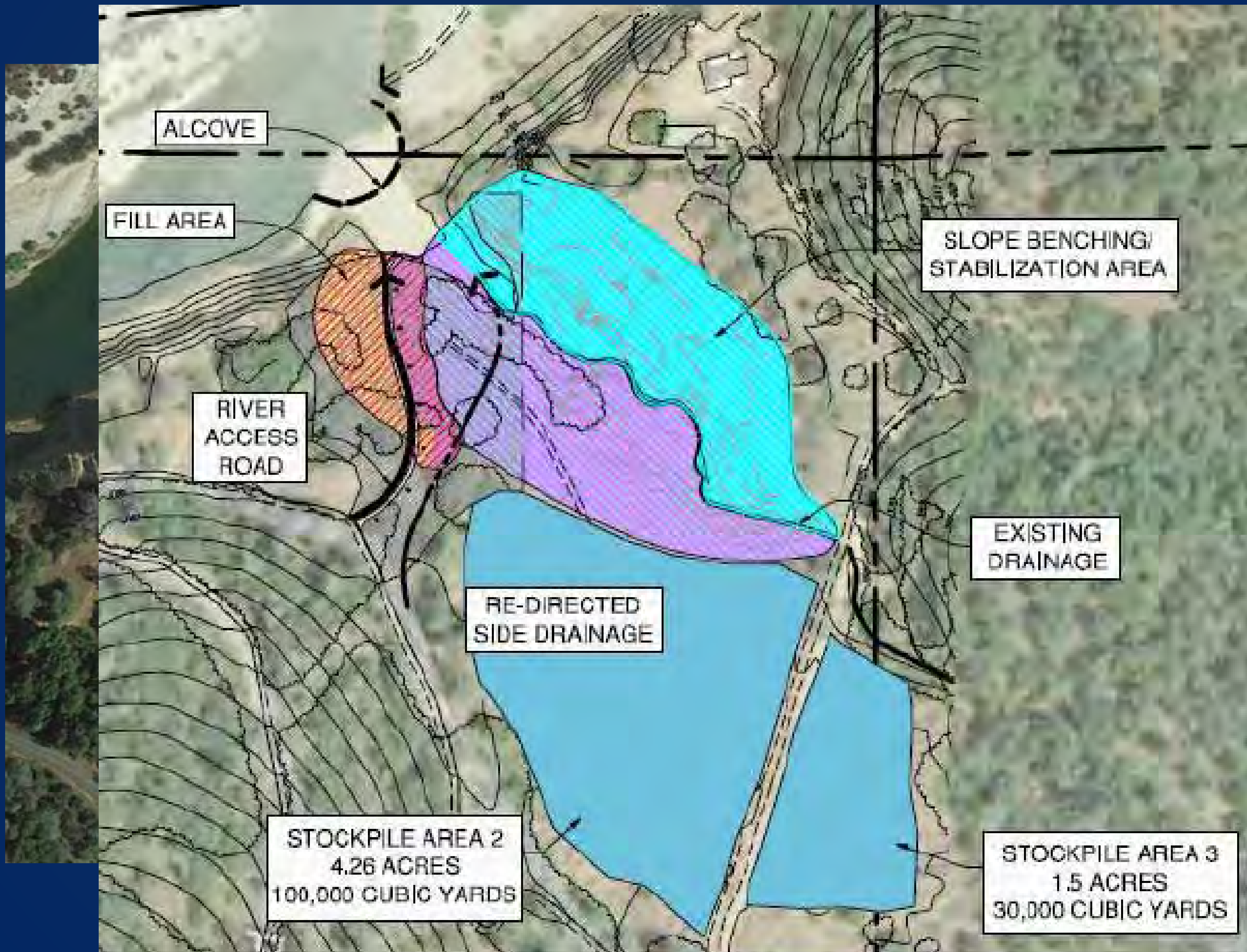
Hallwood Side Channel and Floodplain Restoration Project

UPPER ROSE BAR

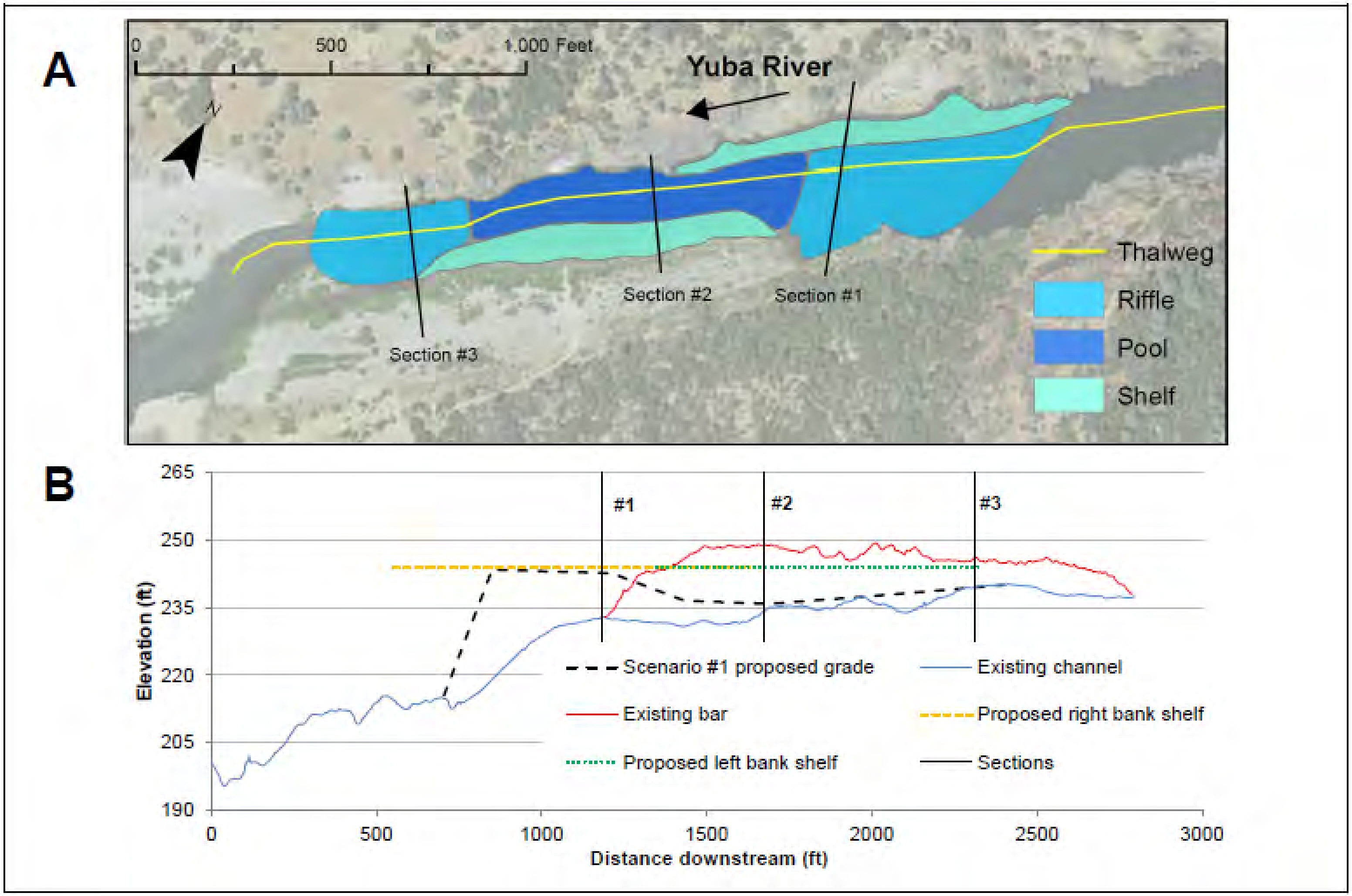
ESA




Gravel source and mine waste remediation



Concept Design for Gravel Placement at Upper Rose Bar



Challenges and Opportunities for Lower Yuba River Restoration

- Floodplain constraint from Training Walls
- Land ownership interests complicated by overlapping claims
- Lack of fine sediment due to dredger activity and Englebright Dam
- FERC relicensing
- The Army Corps of Engineers

Hammon Bar Project Site during planting, 2012

Acknowledgements: U.S. Fish and Wildlife Service's AFRP, PG&E. Bella Vista Foundation, cbec, ESA-PWA and the Yuba Accord River Management Team.

Thank you, SRF and restoration professionals!

Hammon Bar Riparian Enhancement Project Site, 4/3/2016

gary@syrcl.org

SYRCL

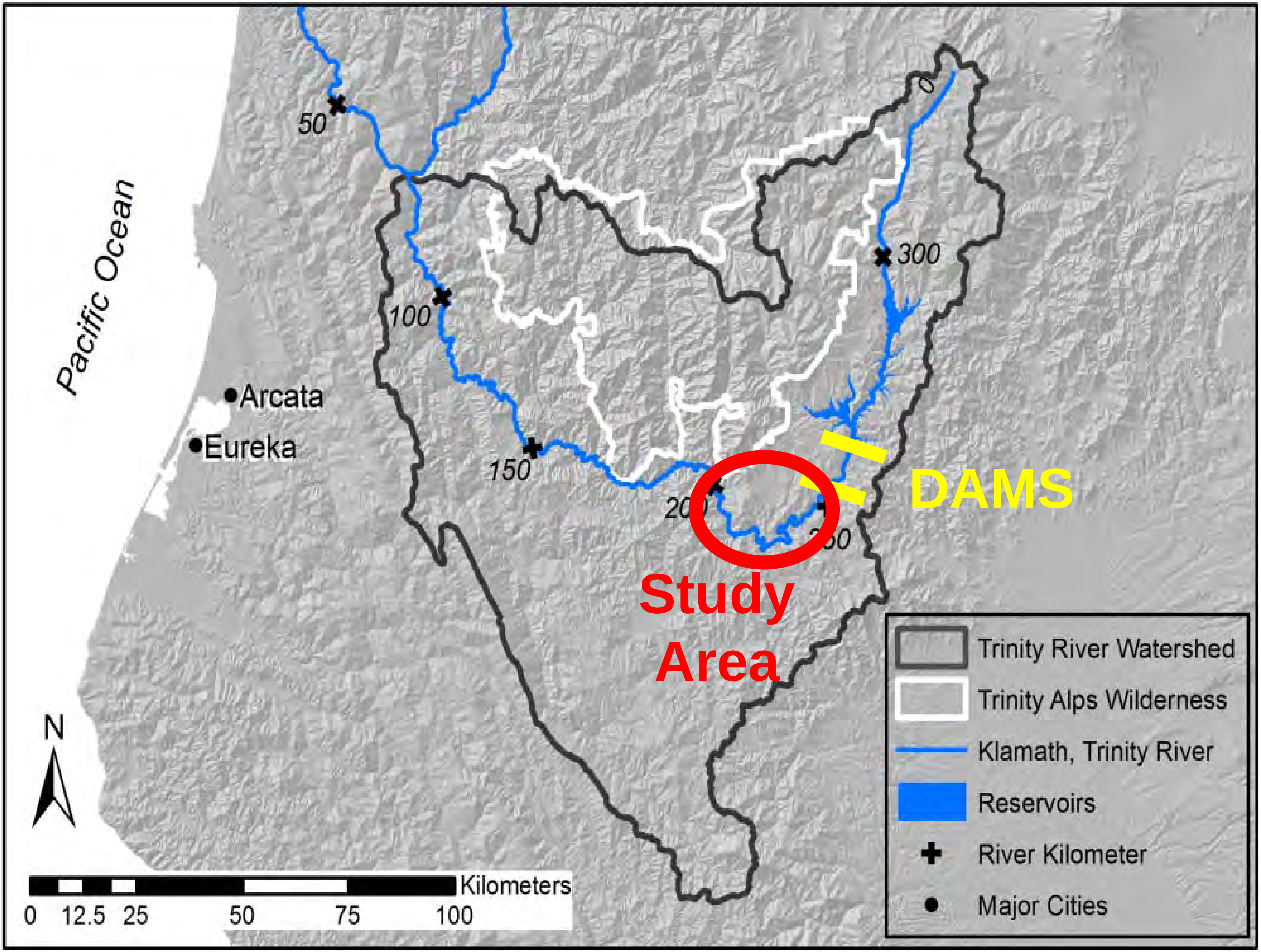
Gold Mining, Extreme Floods, and Geomorphic Context of the Trinity River, CA

Trinity River Restoration Program

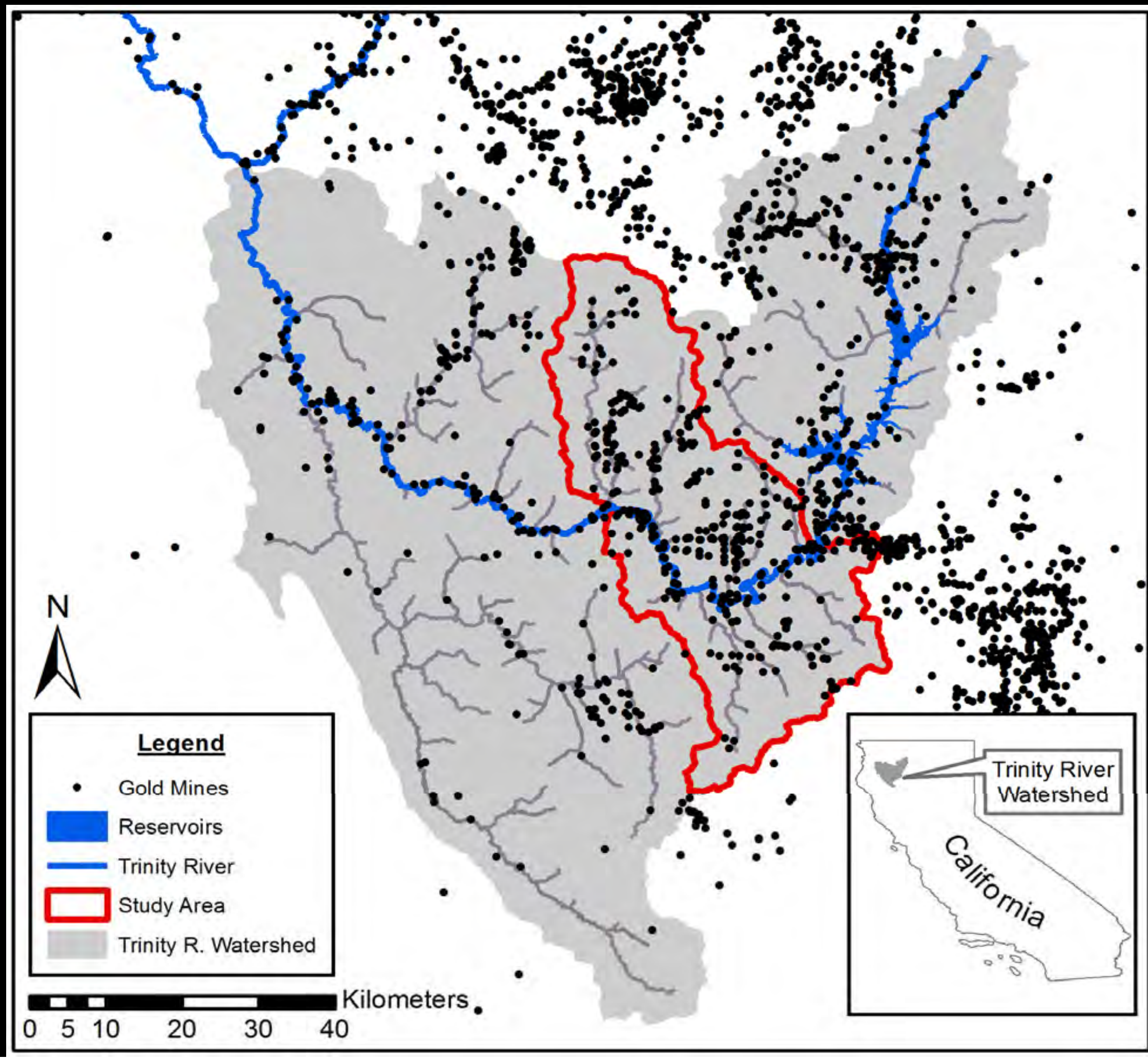
Restore • Adapt • Improve

Salmon Restoration Federation 2016

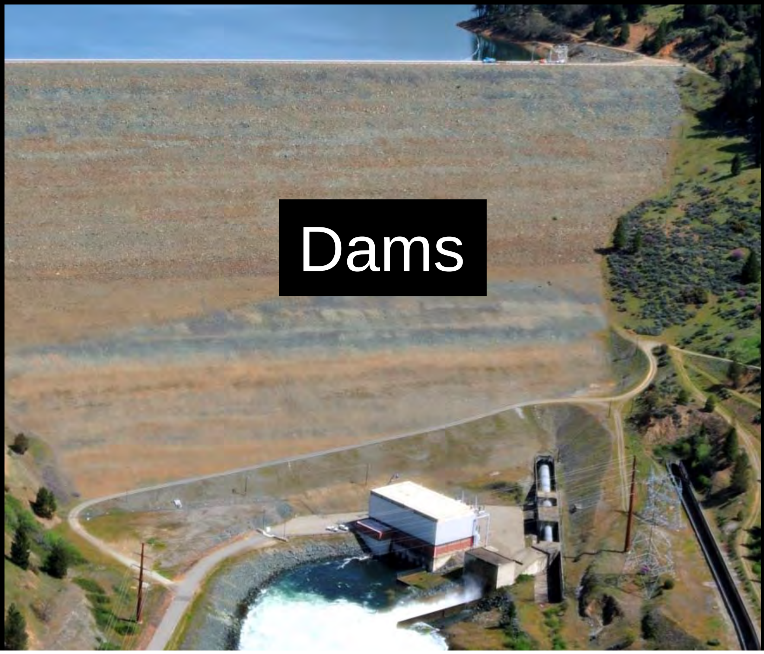
Andreas Krause, P.E.


Pacific Ocean
Arcata
Eureka
50
100
150
200
250
300
0
DAMS
Study
Area
Trinity River Watershed
Trinity Alps Wilderness
Klamath, Trinity River
Reservoirs
River Kilometer
Major Cities
N
Kilometers
0
12.5
25
50
75
100

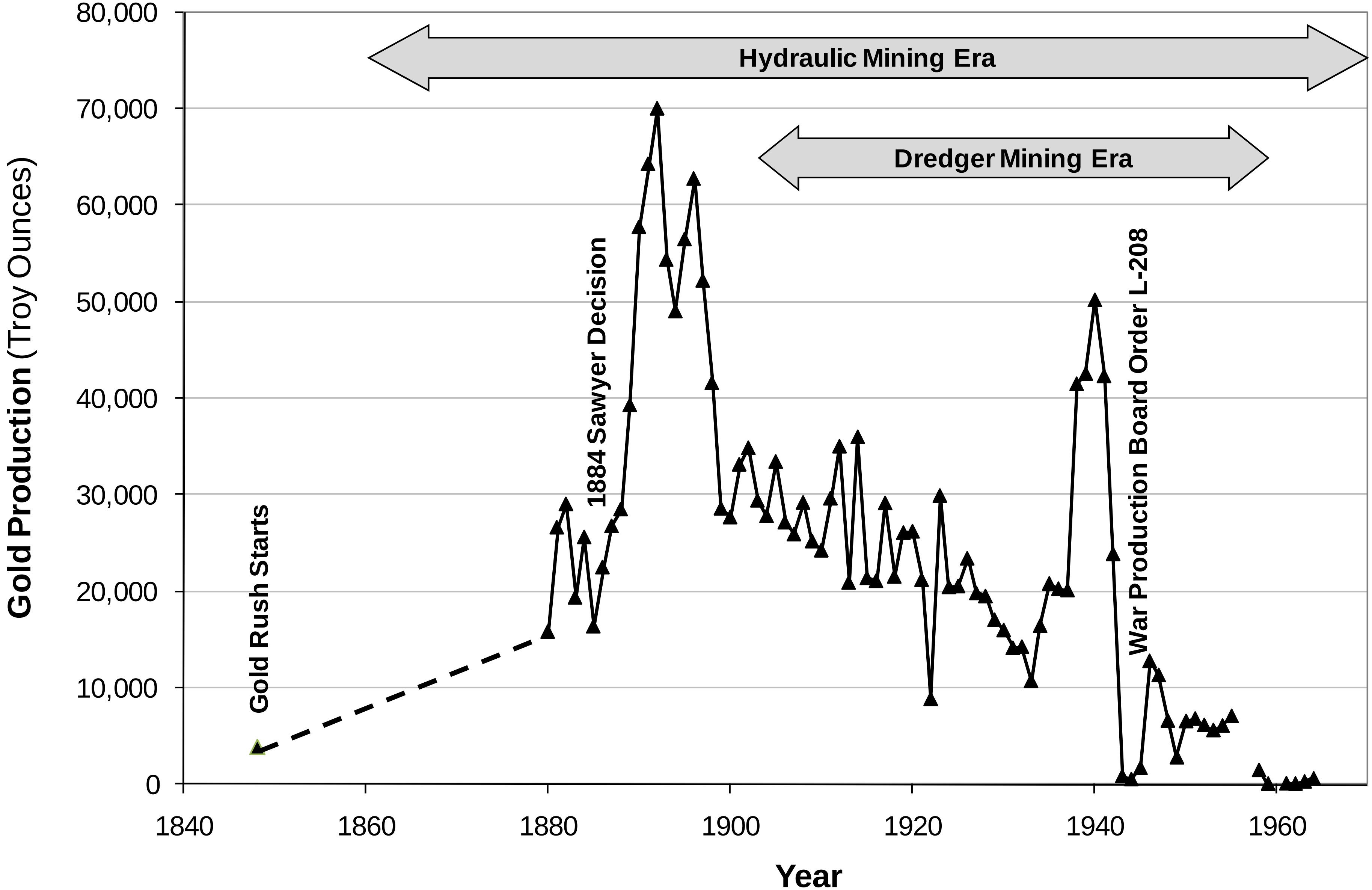
Gold Mines in Trinity County



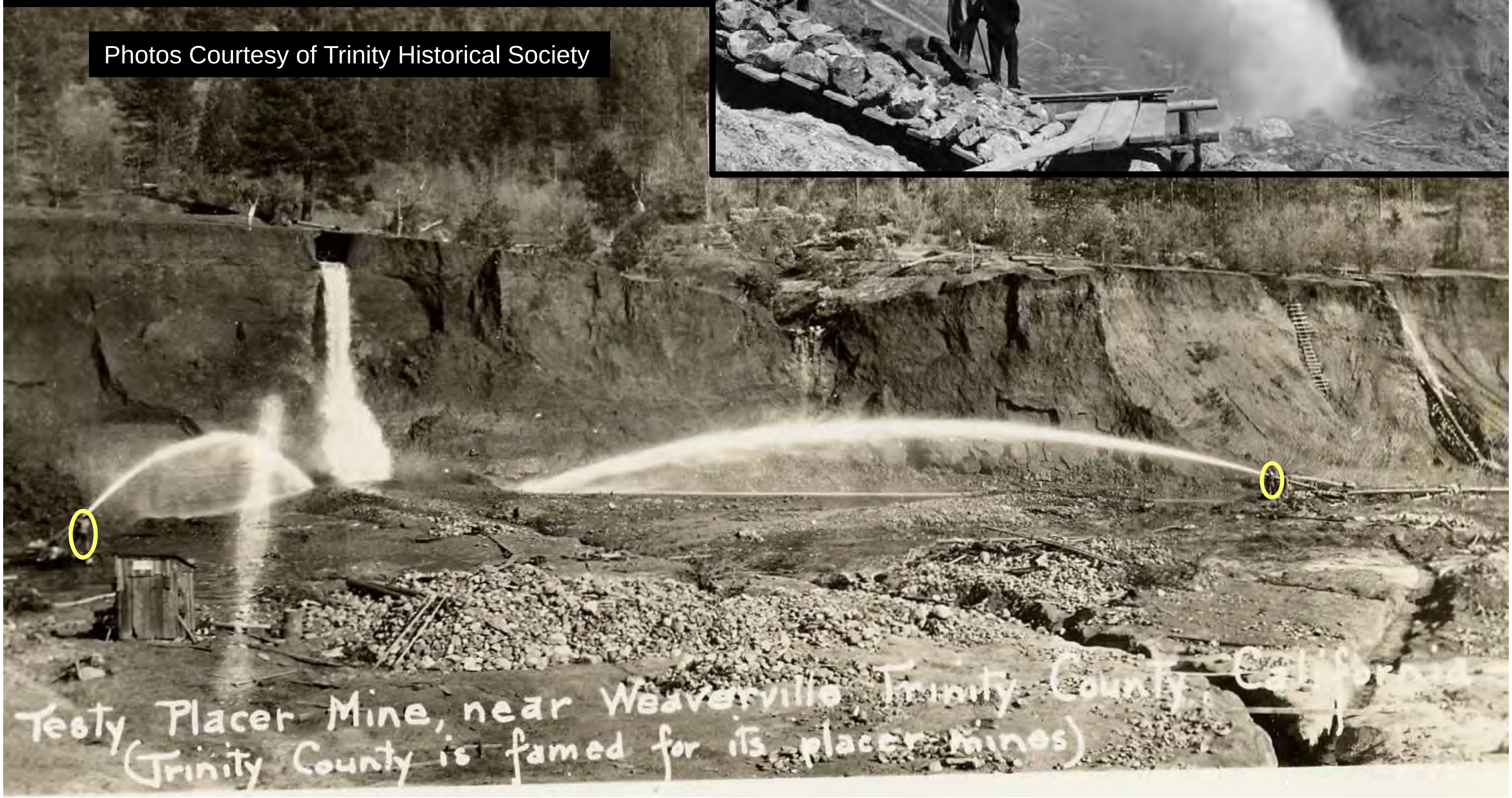
Human Impacts



Gold Production in Trinity County



Hydraulic Mining



Photos Courtesy of Trinity Historical Society

Cie Fse Mine, 1898

Photo Courtesy of Trinity Historical Society

Hydraulic Mining

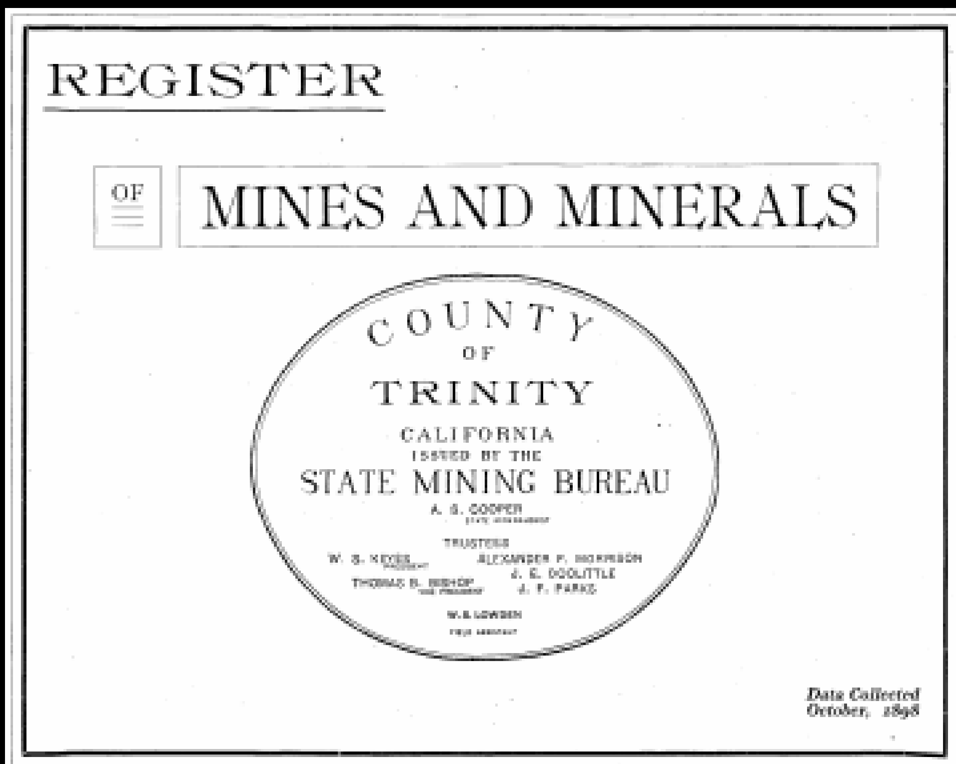
Photo Courtesy of Trinity Historical Society


La Grange Mine
Photo Courtesy of Trinity Historical Society
~ 250 foot cut
299

La Grange Mine / Oregon Gulch

Photos Courtesy of Trinity Historical Society

Hydraulic Mining
Volume Estimate



REGISTER

OF MINES AND MINERALS

COUNTY OF TRINITY

CALIFORNIA

ISSUED BY THE

STATE MINING BUREAU

A. S. COOPER

TRUSTEES

W. S. KEYES

ALEXANDER P. MORRISON

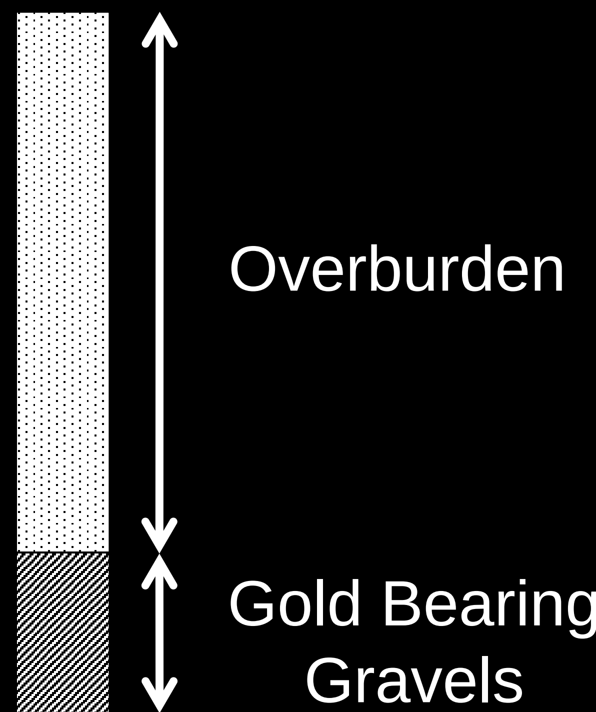
J. E. DOOLITTLE

THOMAS R. BISHOP

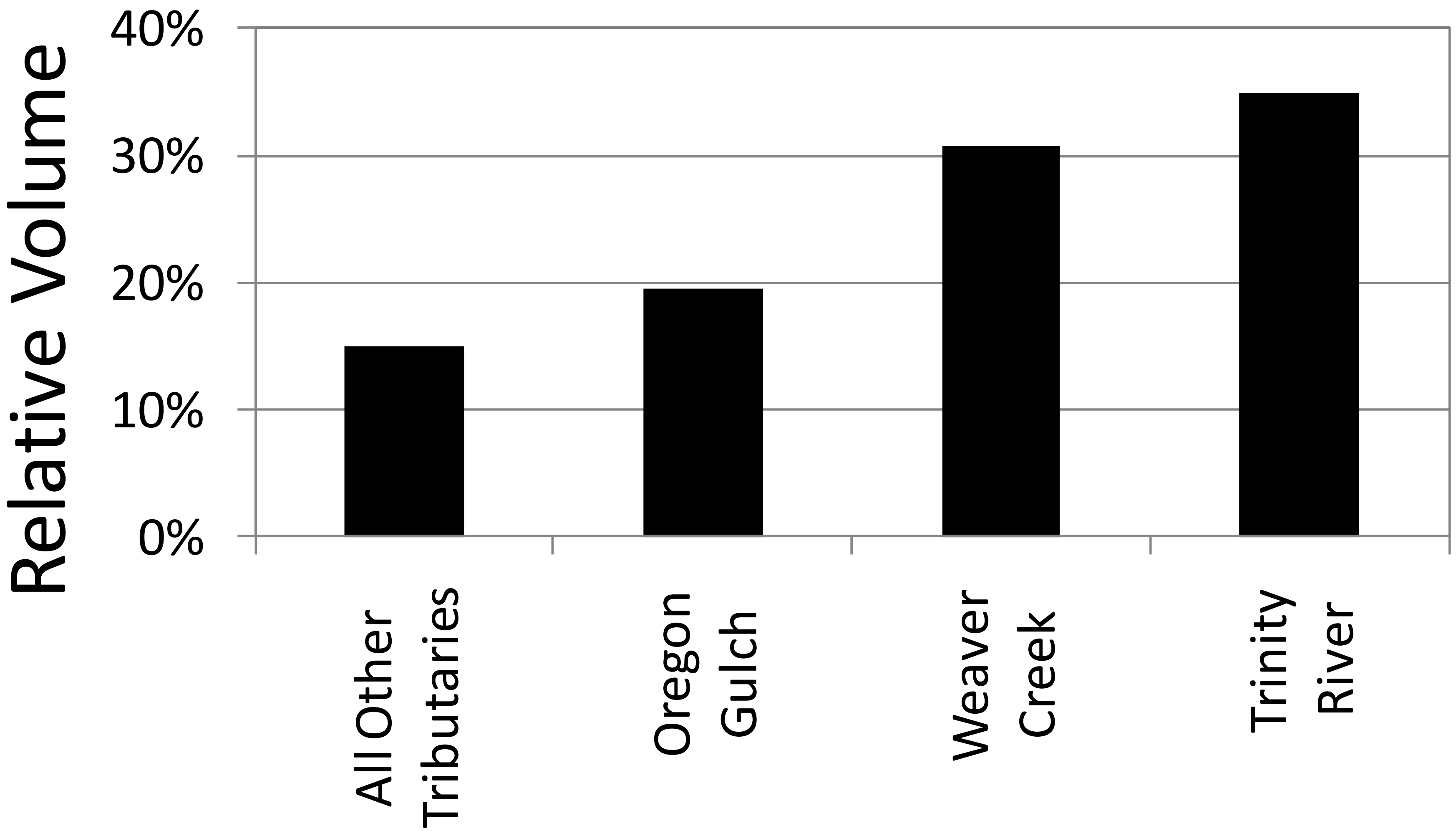
J. F. PARKS

W. S. LOWDEN

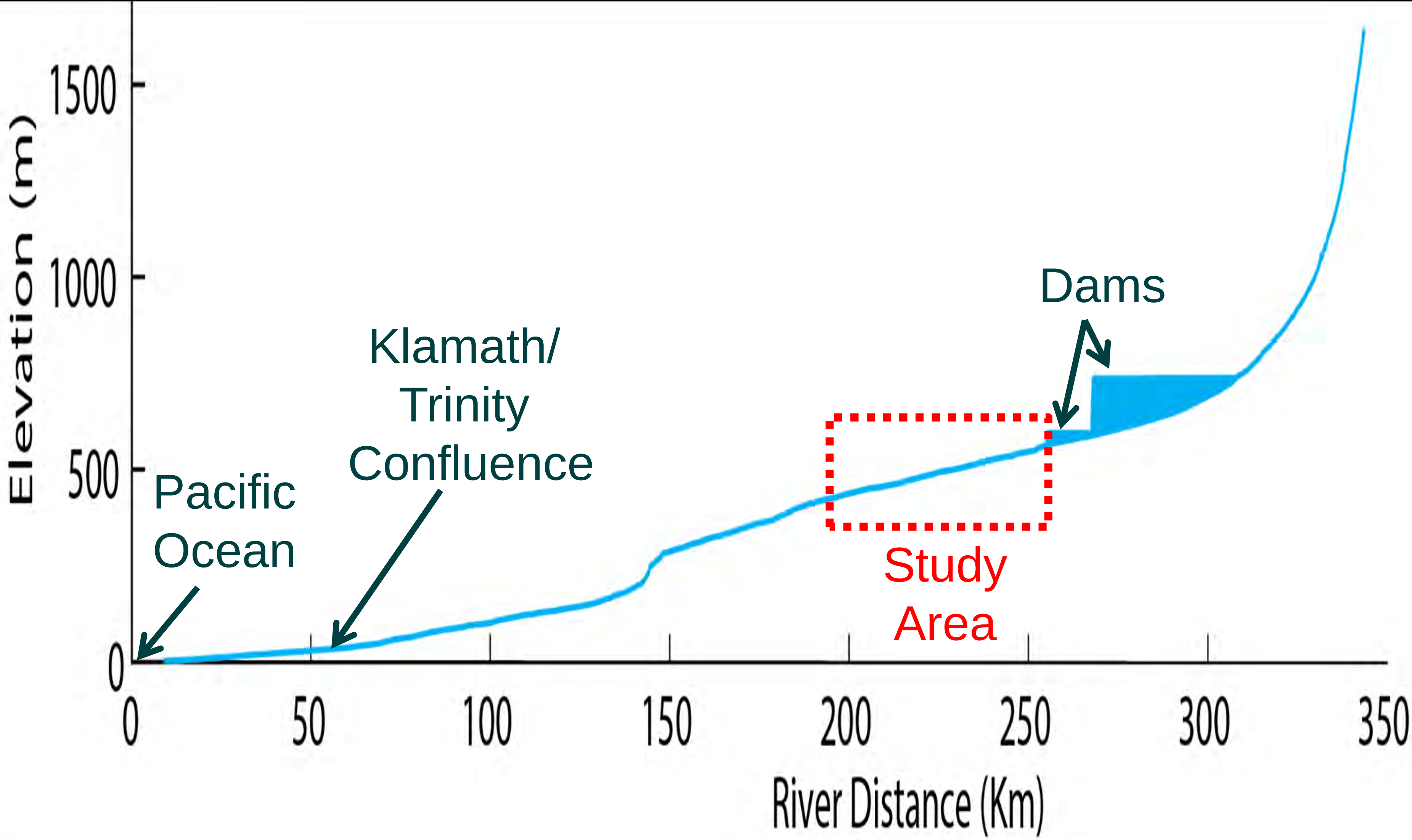
Data Collected October, 1898



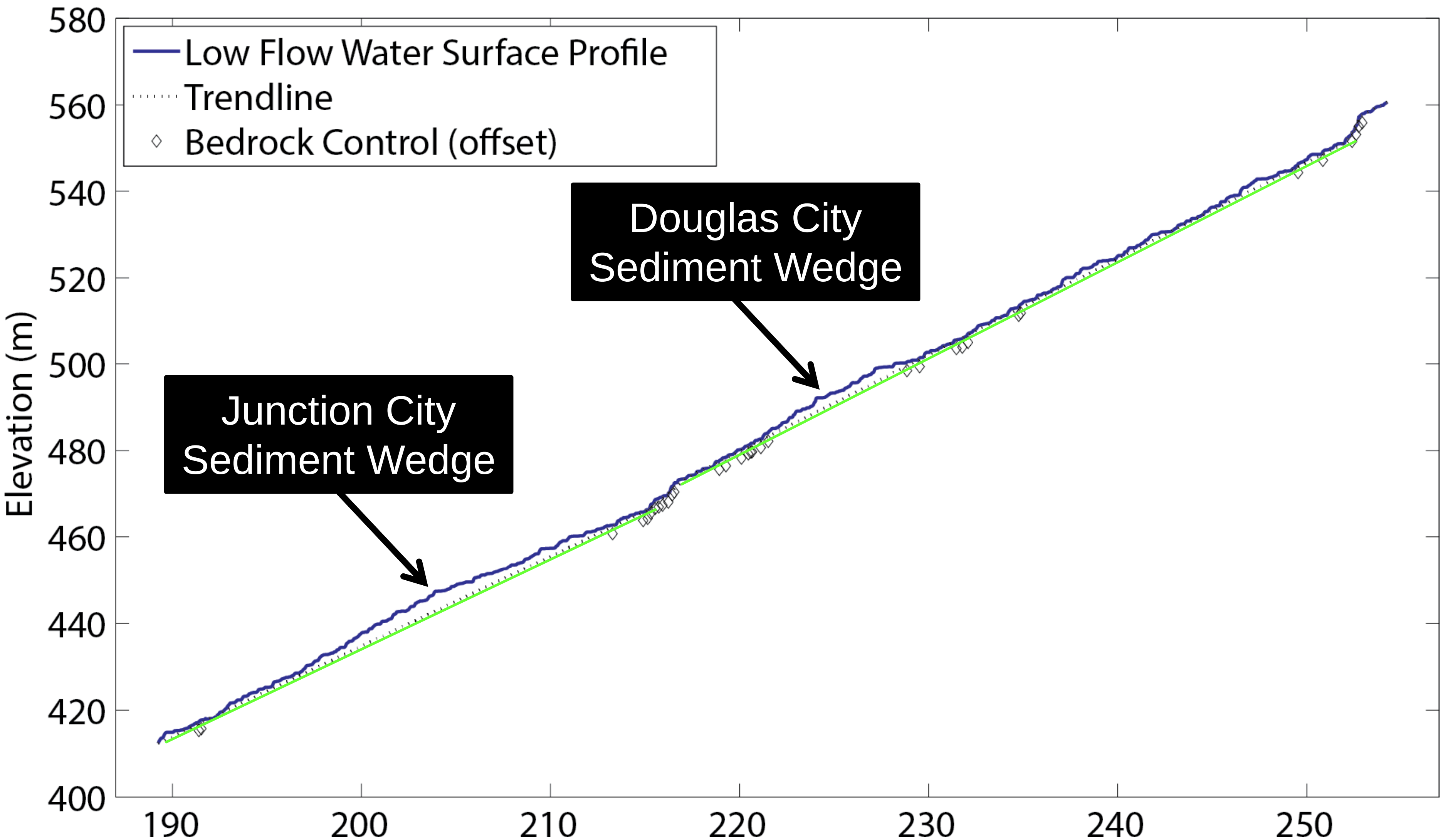
Hydraulic Mining
Tributary vs. Mainstem



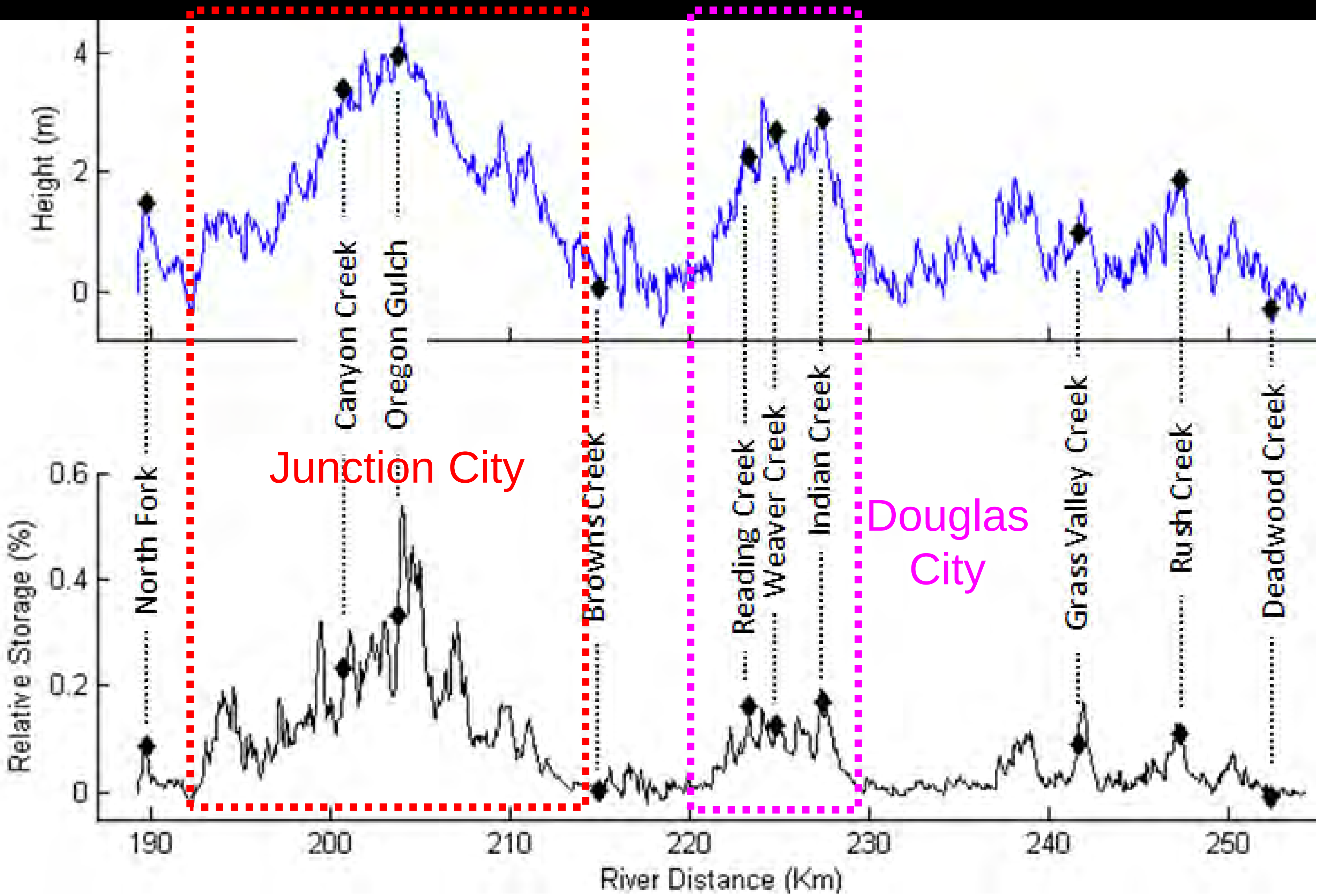
Trinity River Profile



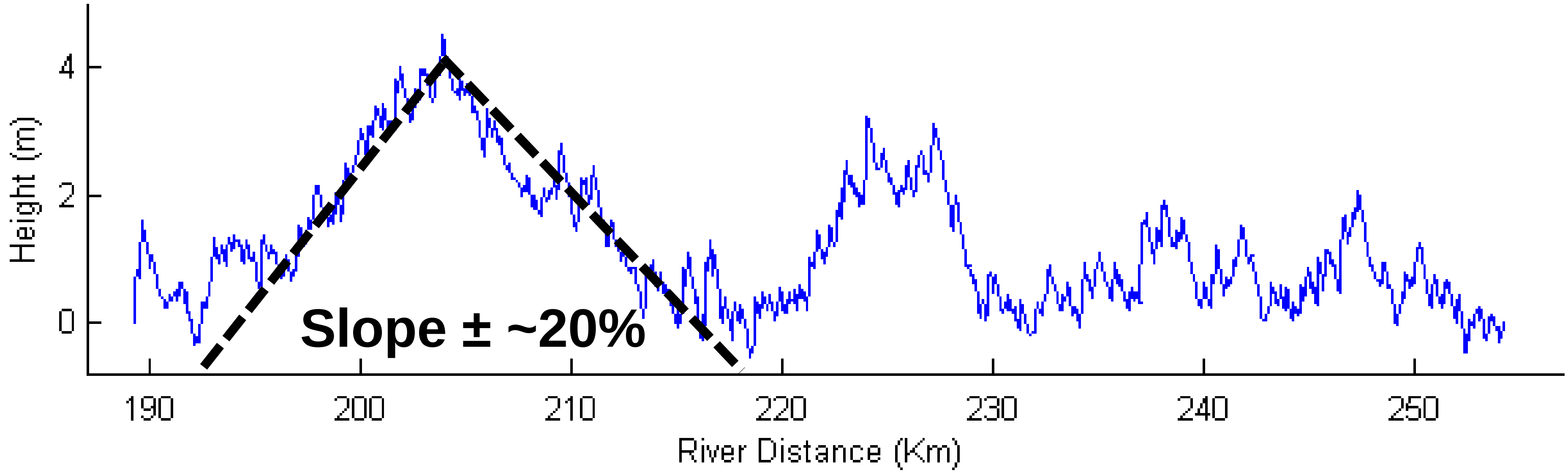
Longitudinal Profile

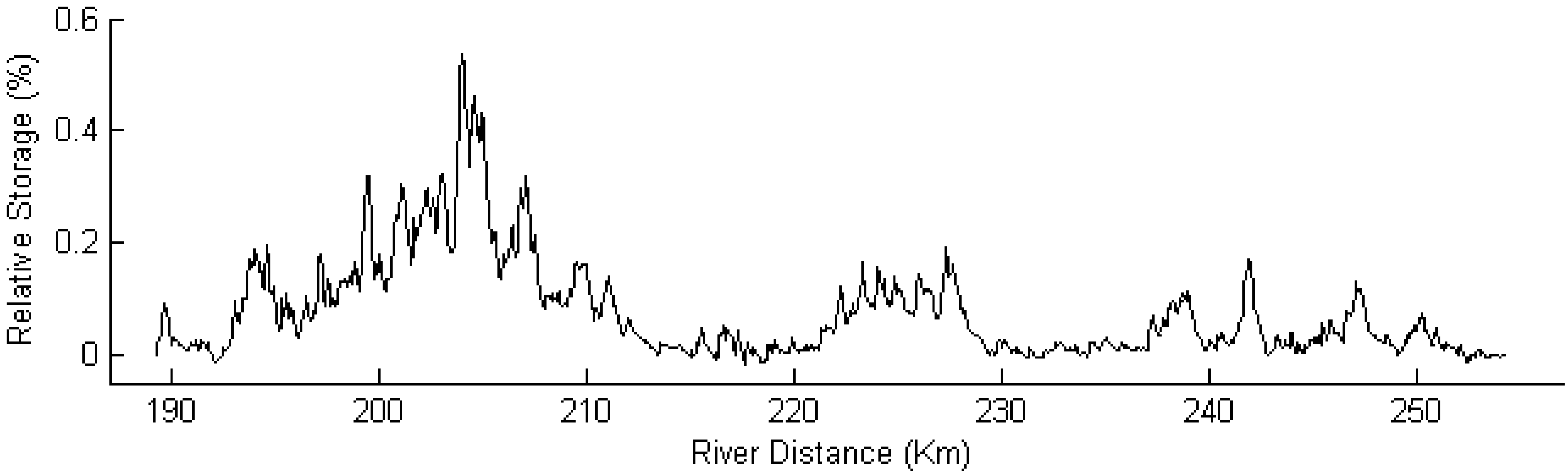


Detrended Profile



Persistent Sediment Waves

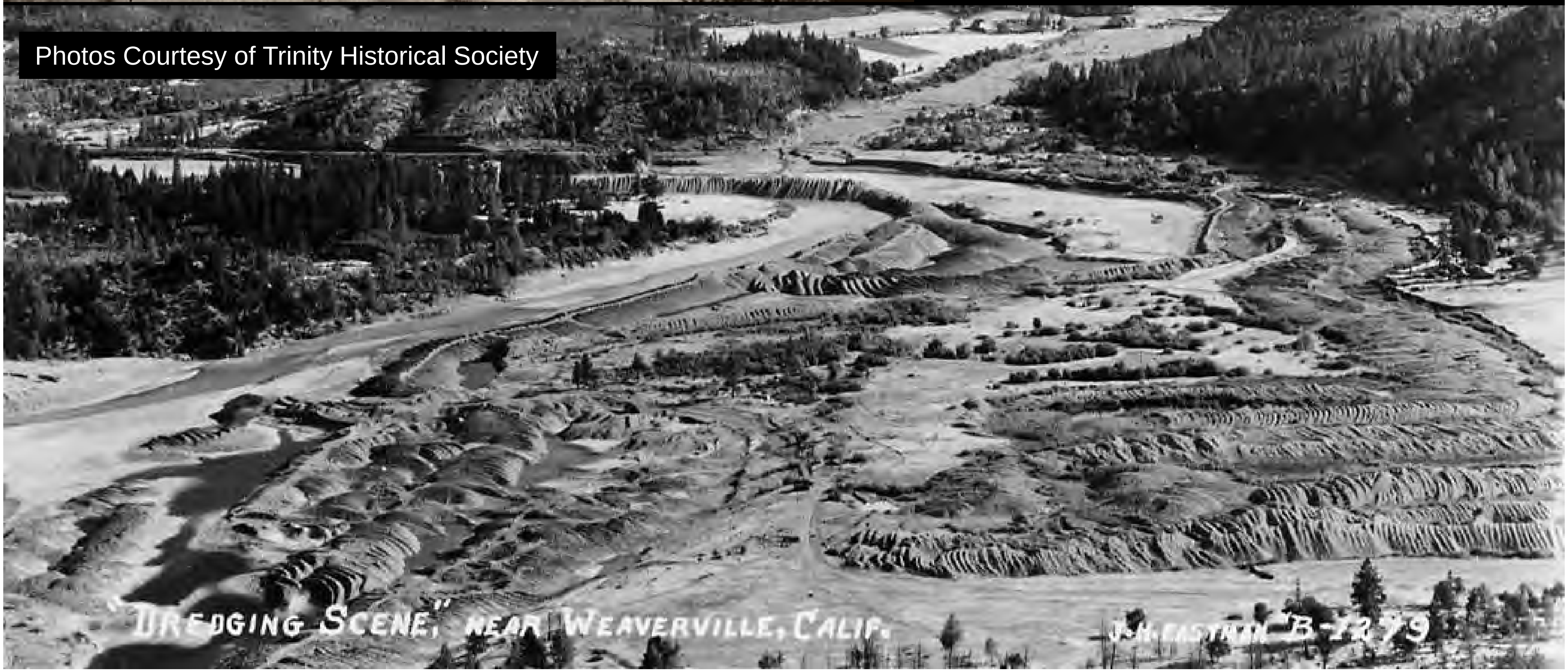




Dredger Mining

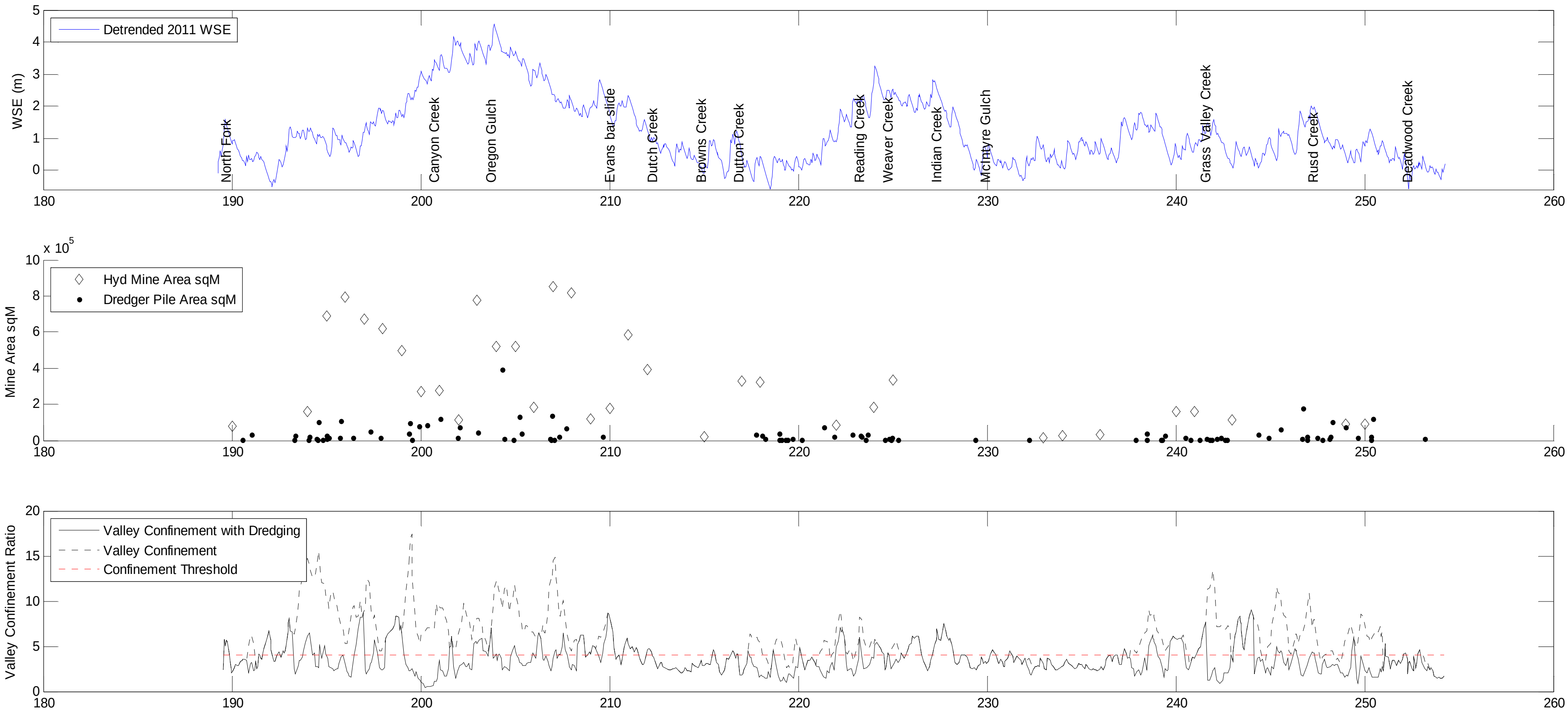
Photo Courtesy of Trinity Historical Society

Floodplain Impacts of Dredgers



Photos Courtesy of Trinity Historical Society

Valley Confinement

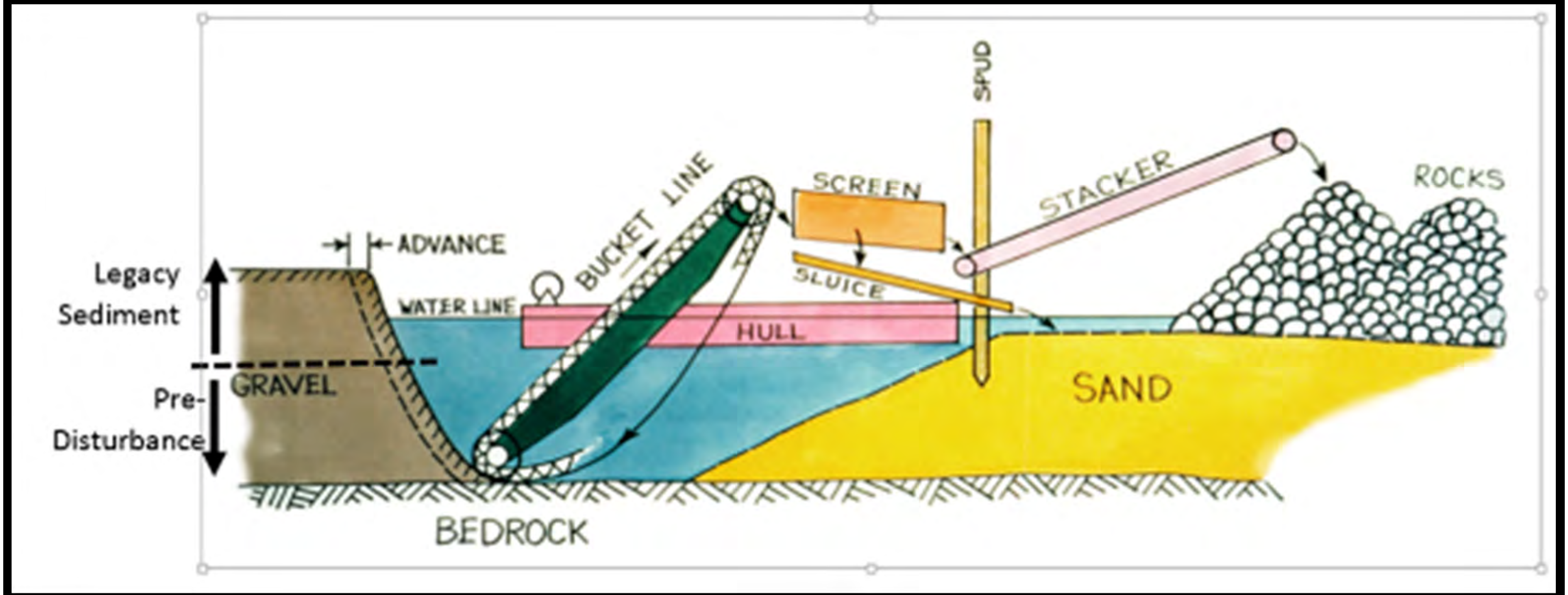


Unconfined Valleys:

Pre Dredge = 65% Post Dredge = 30%

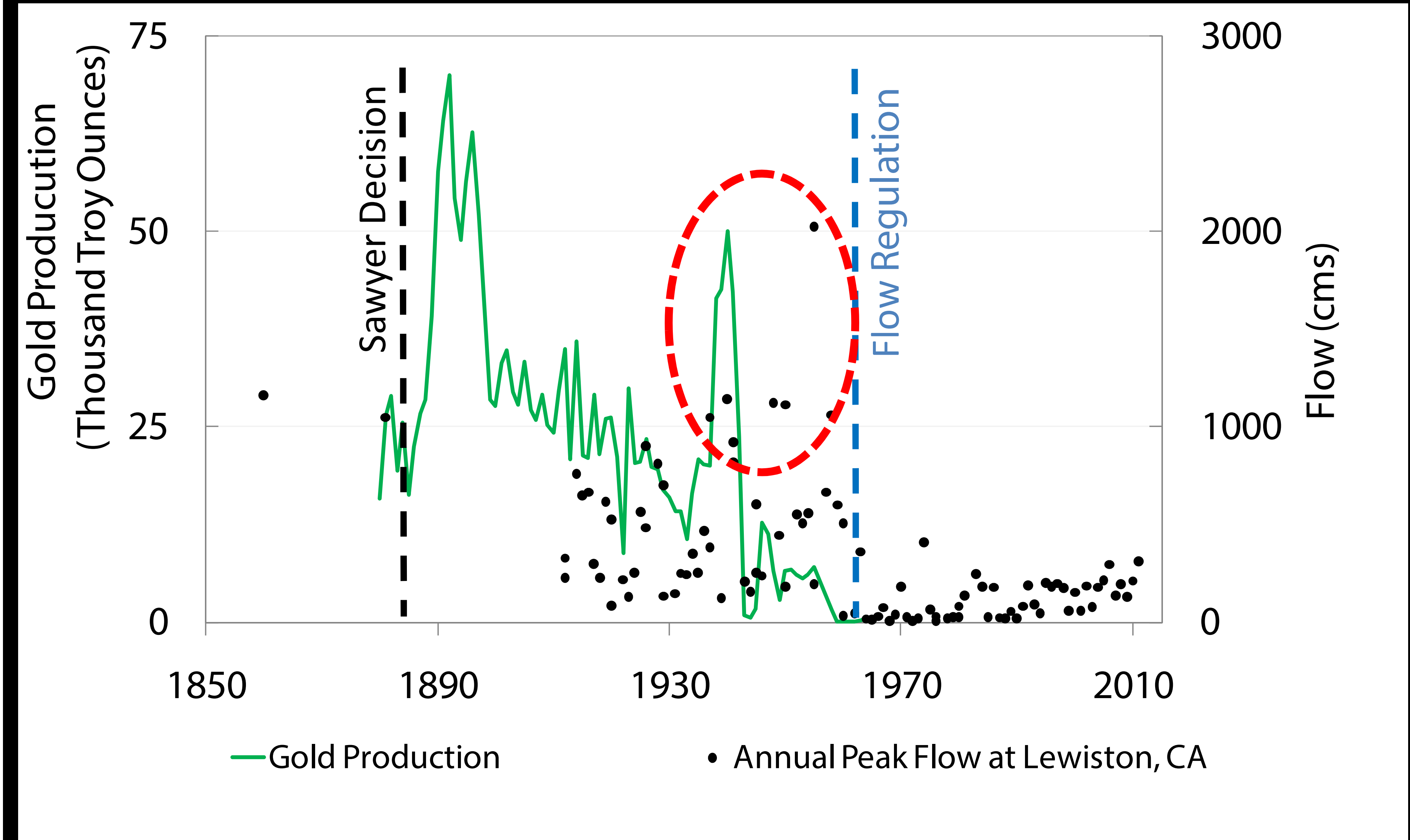
Channel Realignment

Mixed and Inverted Sediment

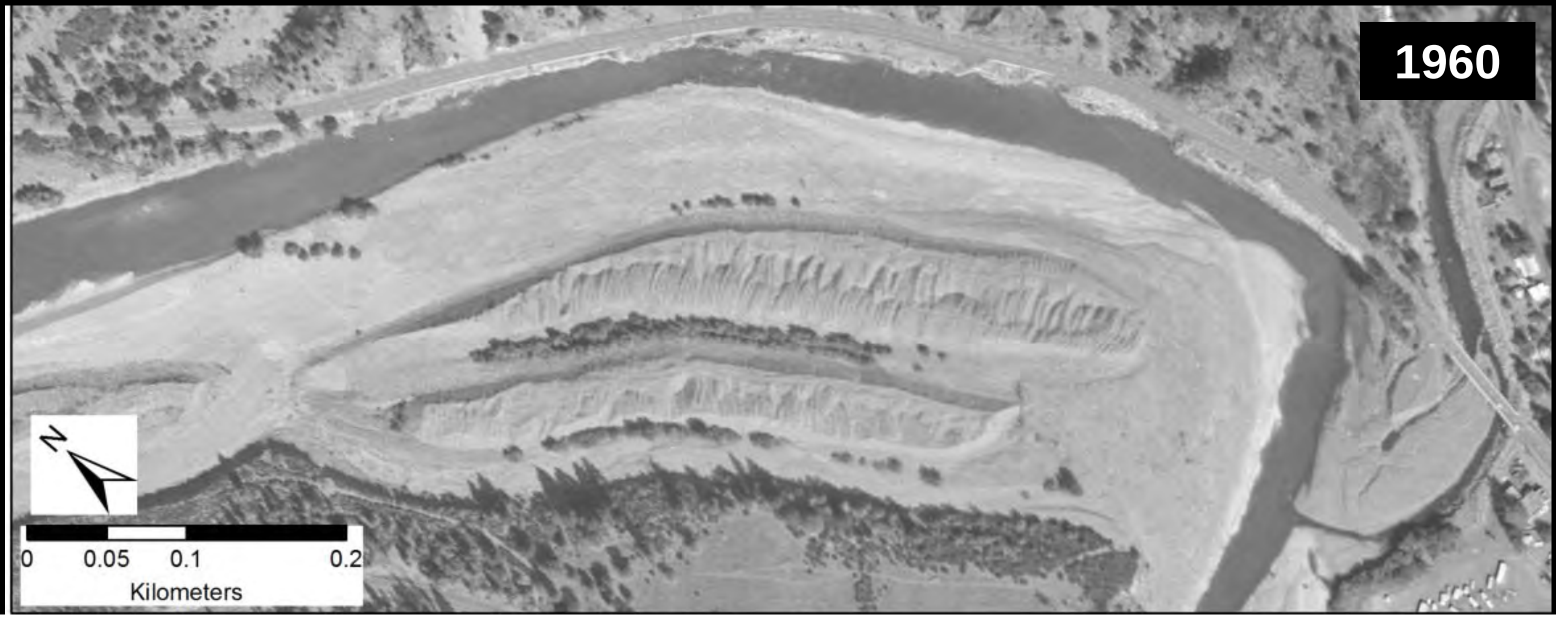


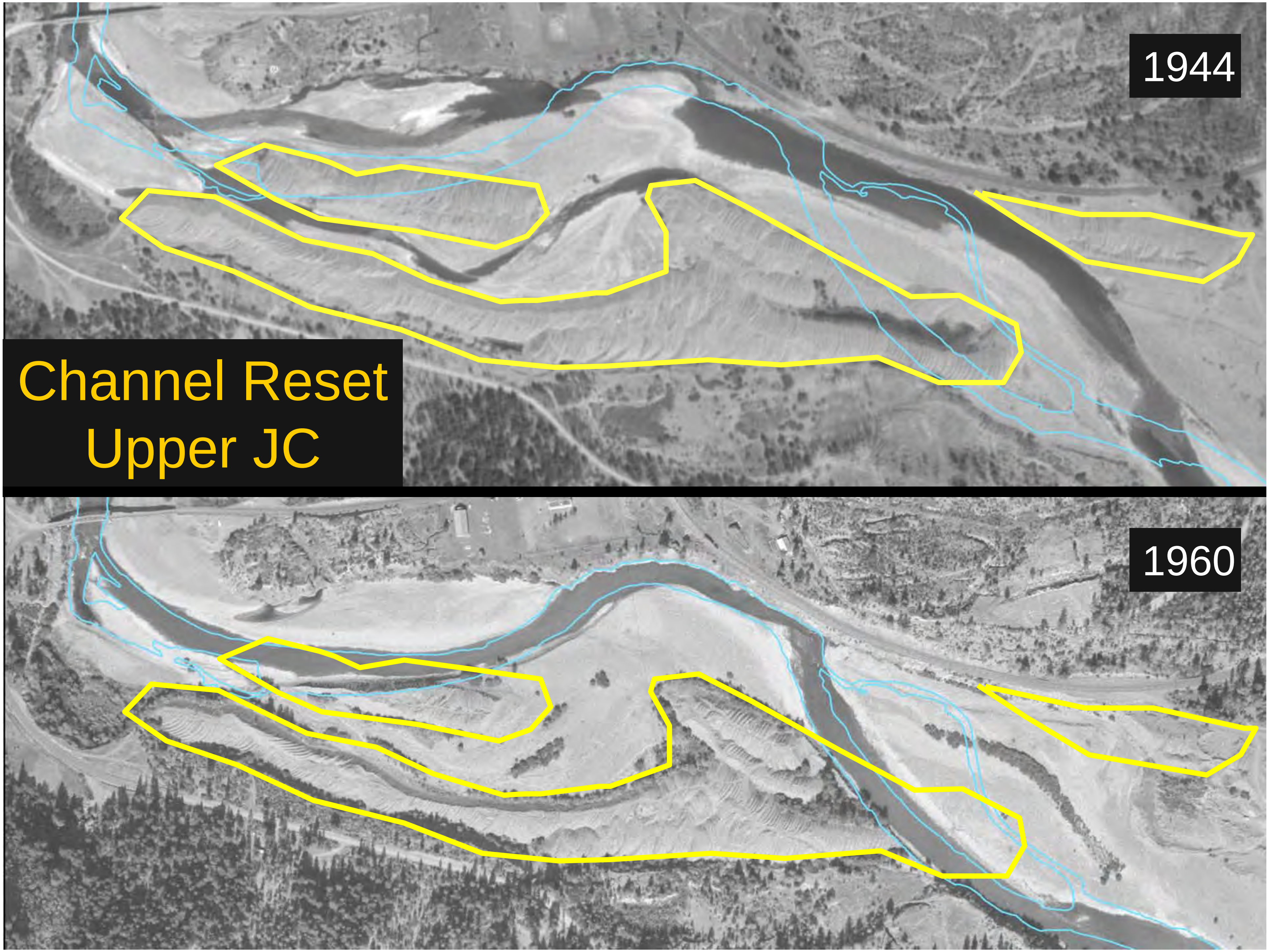
Dredger Tailings

Impact Timeline

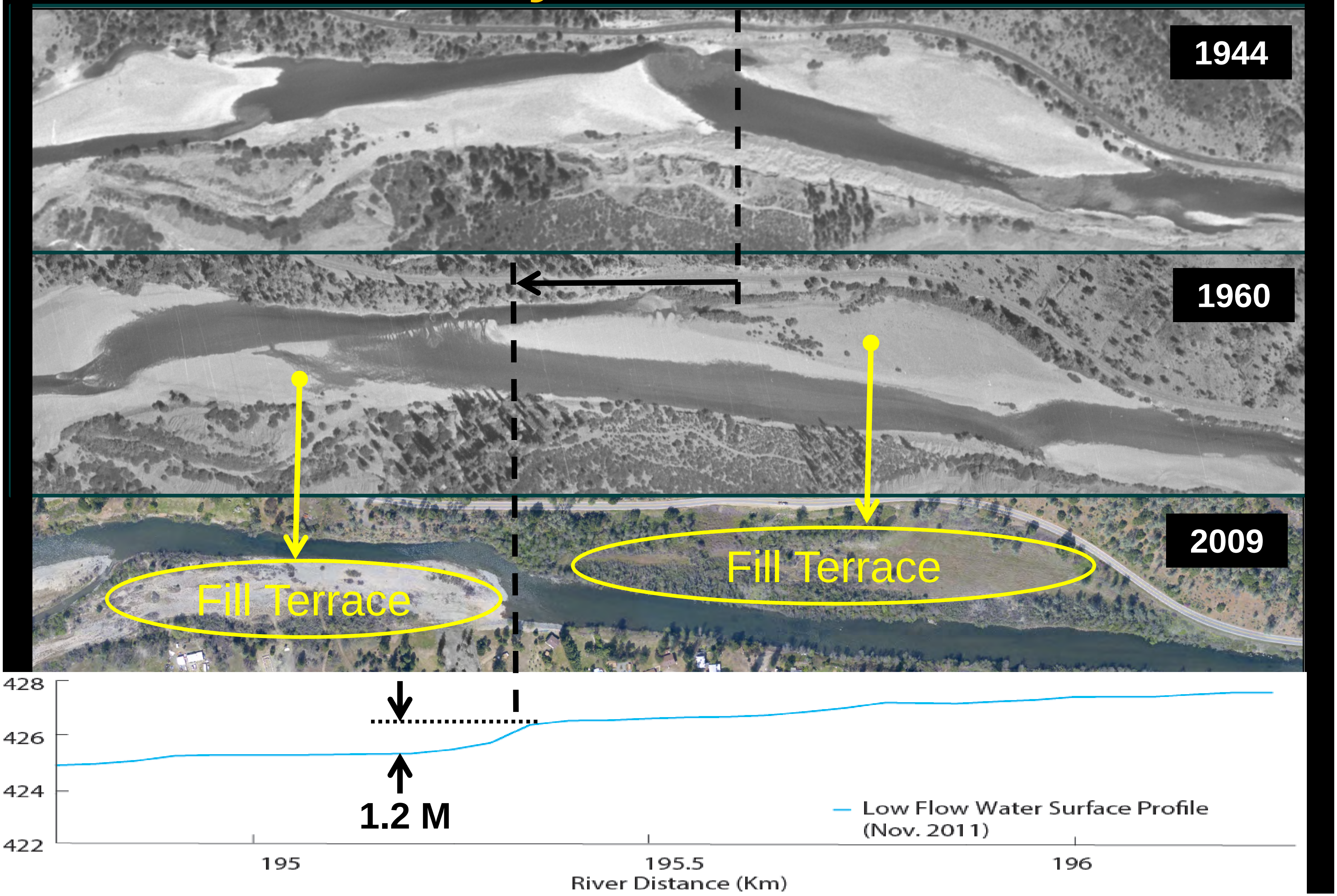


Dredger Tailings → Fill Terrace

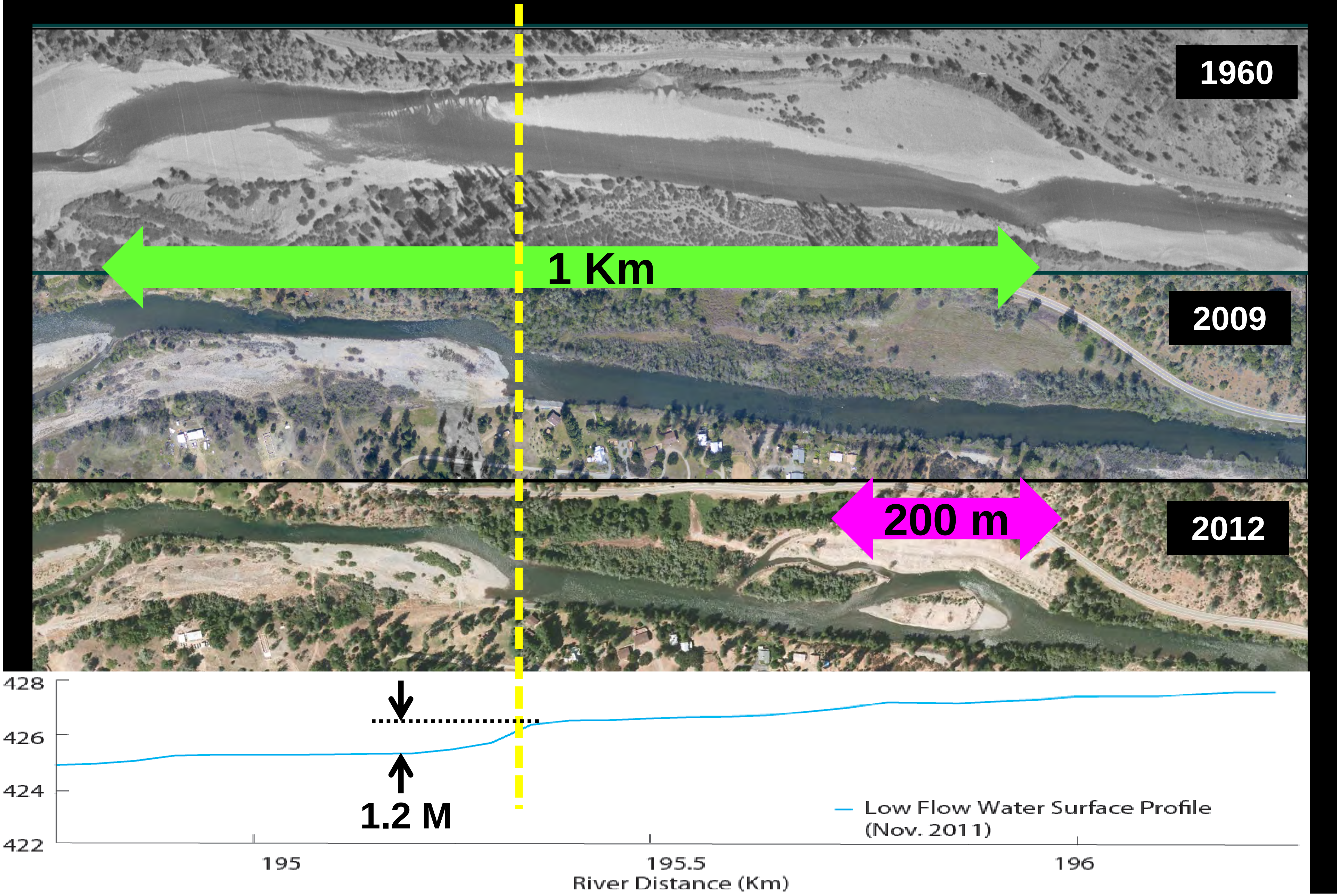



1944
Channel Reset
Upper JC
1960

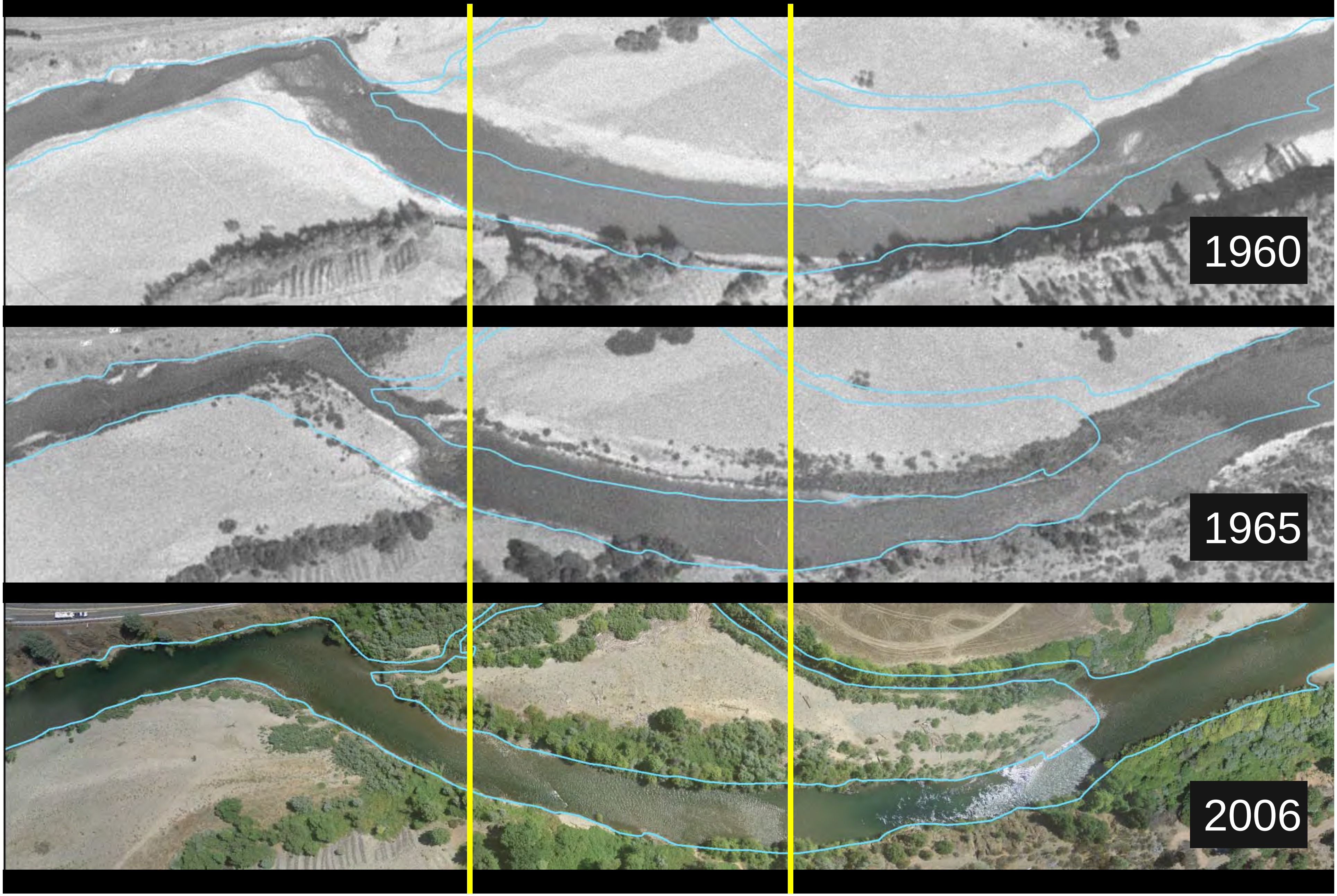
Valley Scale Bars



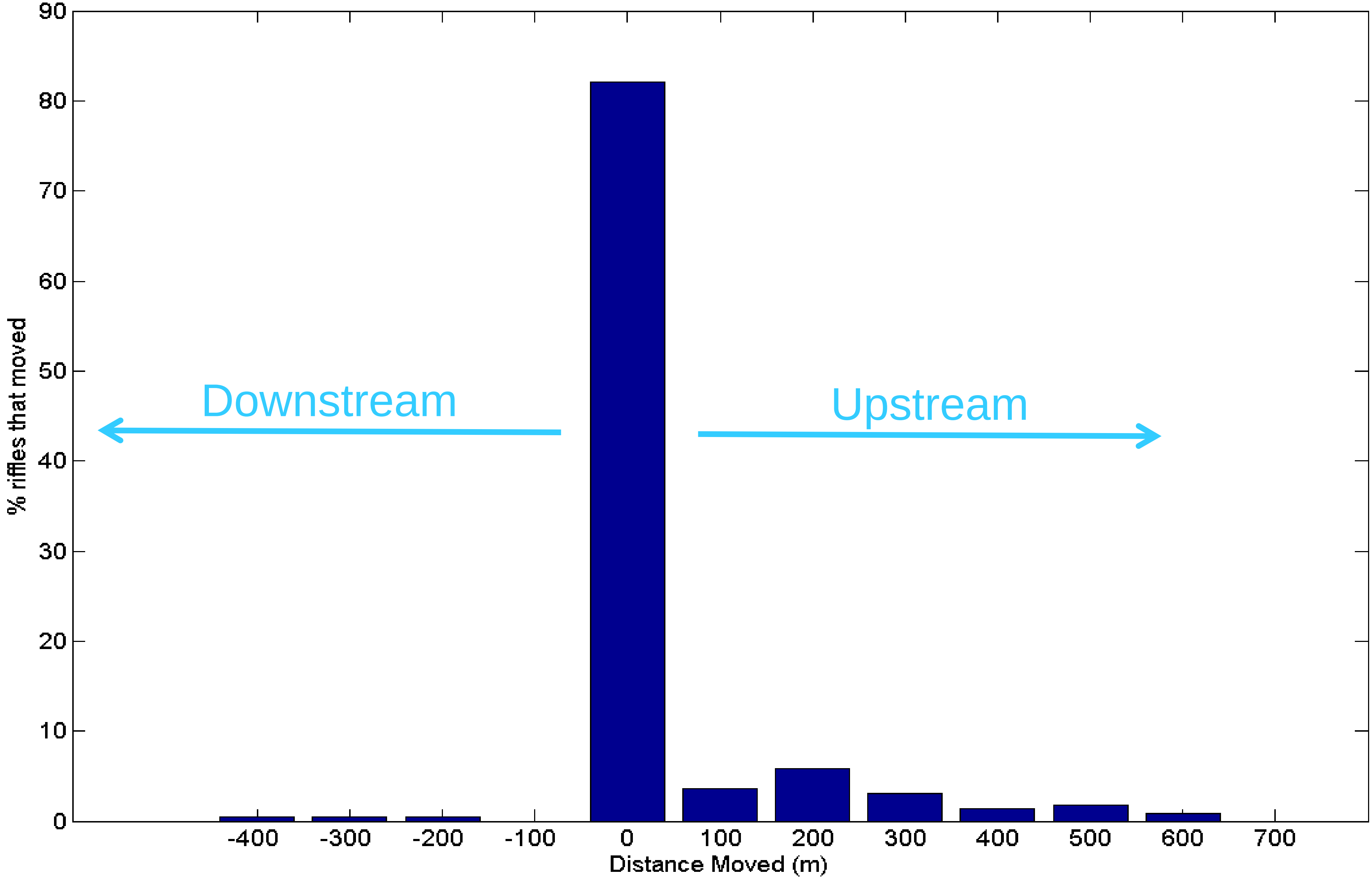
Rescales Bar Size



Riffle Headcut



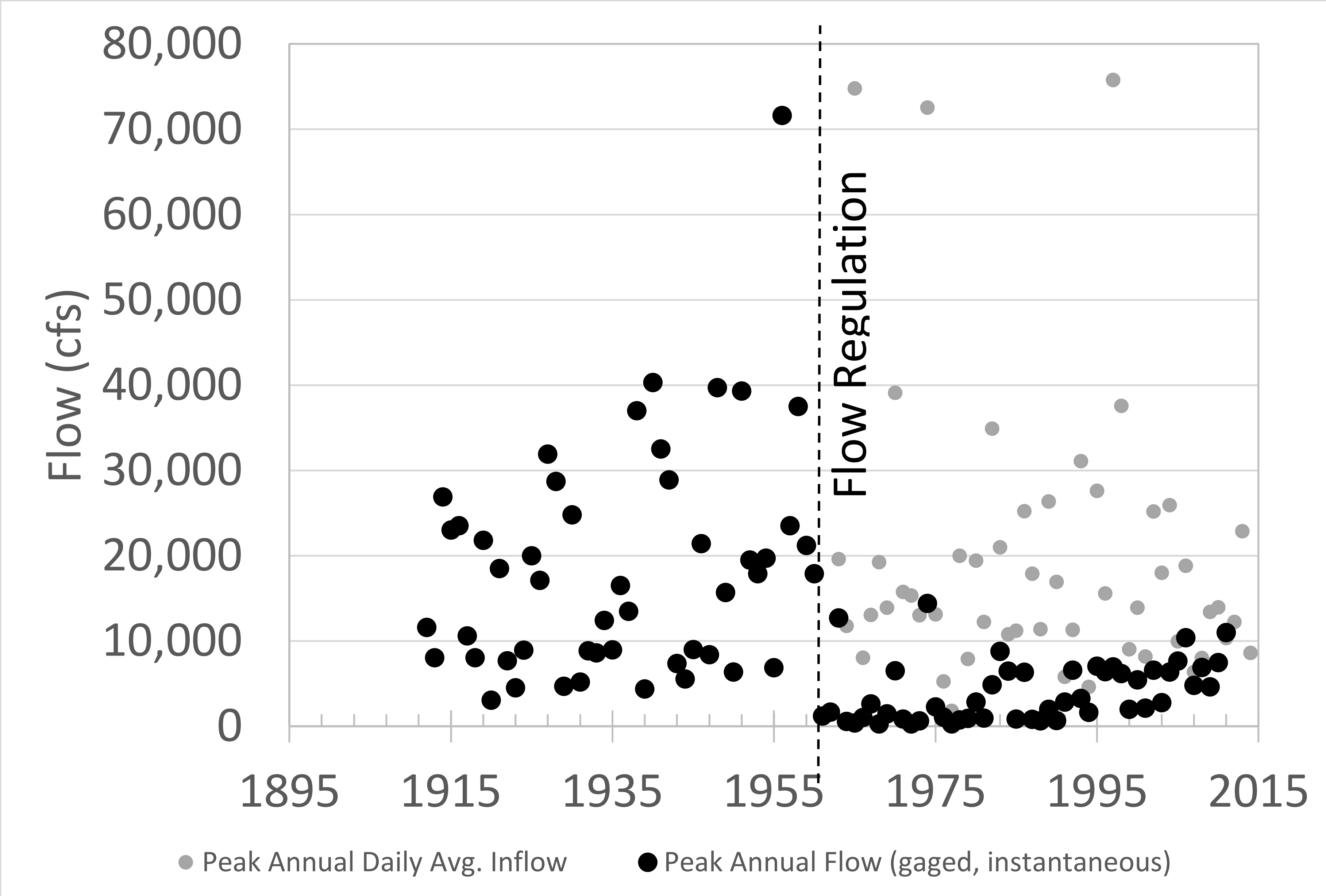
Riffle Crest Movement 1965-2011



Geomorphic Context

- Remarkable human impacts
  - Hydraulic mining → valley aggradation
  - Dredger mining → constrained valley width
    mixed sediment profile
  - Extreme floods → valley scale bars / terraces
    single thread river
  - Flow regulation → scaled down river
- Pre-dam features are persistent, control river slope, and affect modern geomorphology

Flow Regulation



Questions

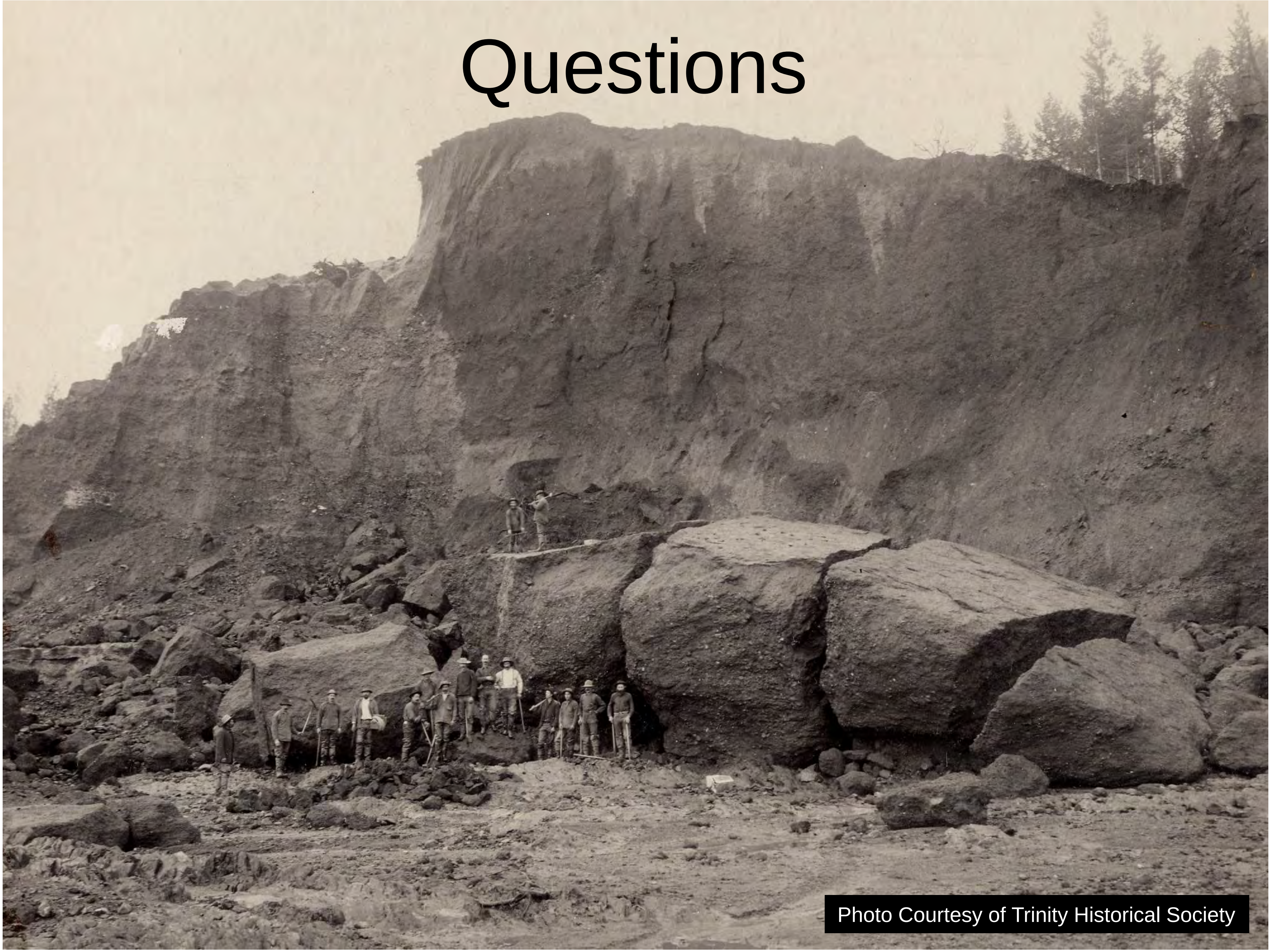


Photo Courtesy of Trinity Historical Society



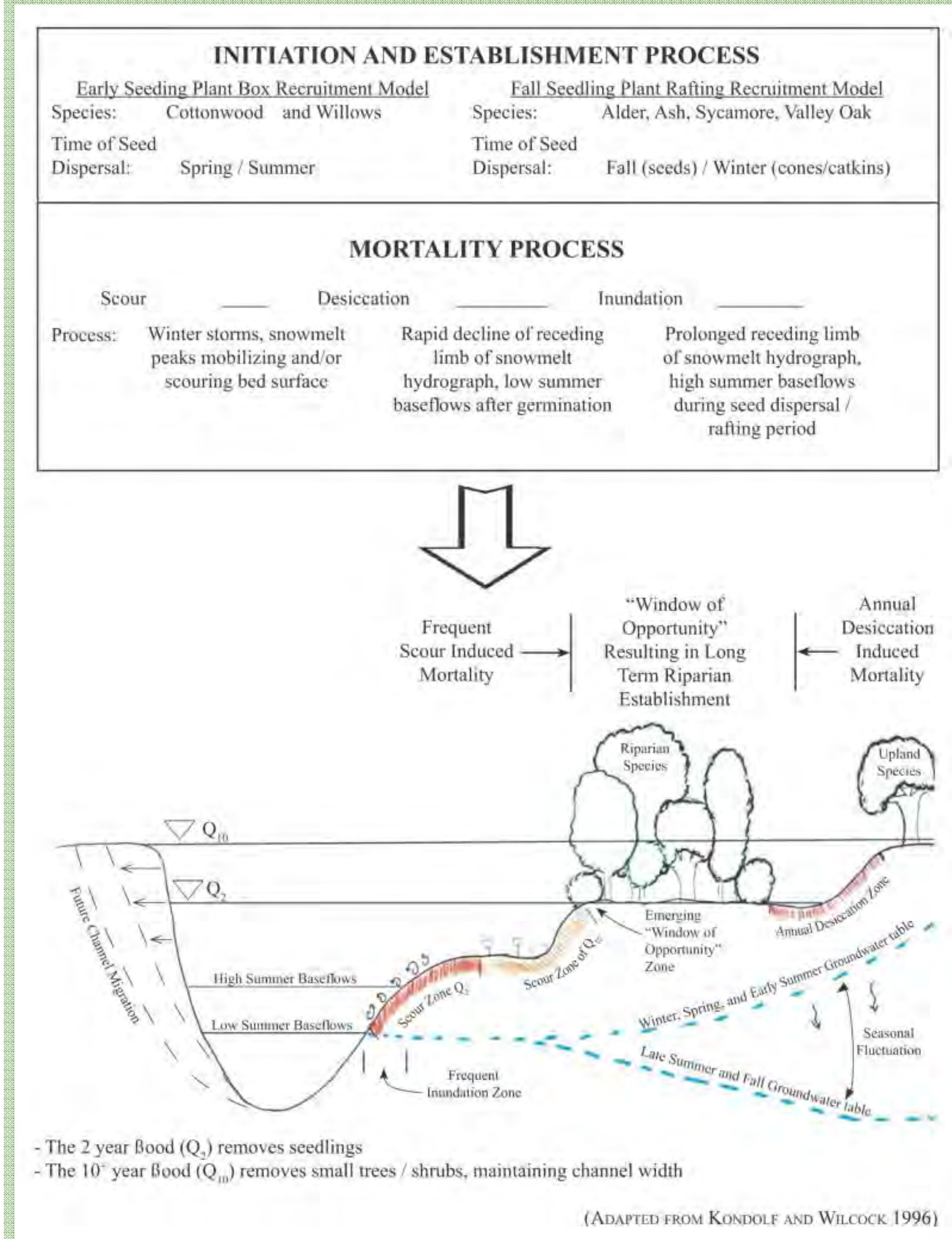
Riparian Area Rehabilitation After Gold Mining

John H. Bair MA

April 8, 2016

McBain Associates
APPLIED RIVER SCIENCES

Riparian (adj): Pertains to those terrestrial areas adjacent to freshwater (lakes, rivers, estuaries, springs, seeps, etc.) that are provided soil moisture sufficiently in excess of that otherwise available from precipitation alone (adapted from Warner and Hendrix 1984)



Riparian Zone Characteristics

- Transitional Areas

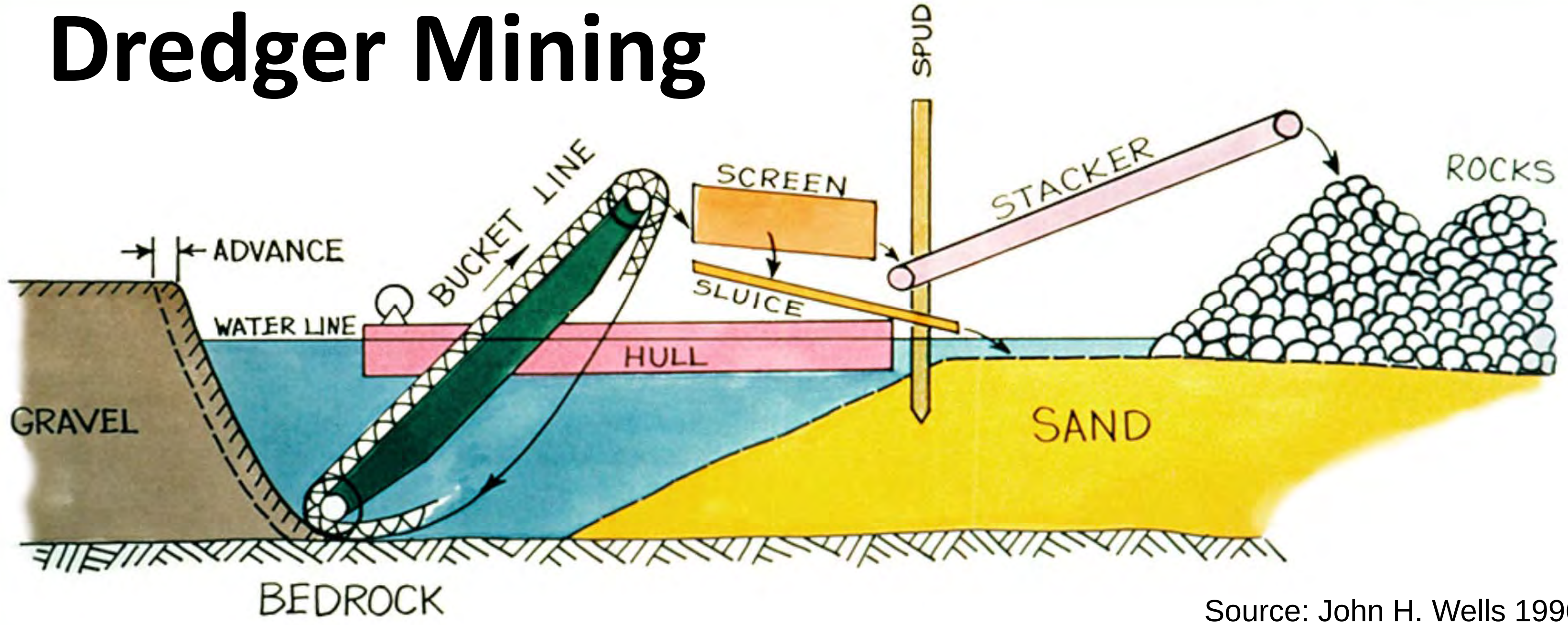
- <u>Gradients of nutrient and water</u> availability that vary with distance and elevation from water

- Surface and subsurface hydrology <u>connect aquatic to upland</u> (NRC 2002)

Portions of terrestrial ecosystems that <u>significantly influence exchanges of energy and matter</u> with aquatic ecosystems (i.e., a zone of influence; NRC 2002).

- Includes the area between aquatic body and uplands, <u>wetlands and portions of uplands that influence the aquatic biome</u> (SWRCB 2012)

Dredger Mining



Source: John H. Wells 1996

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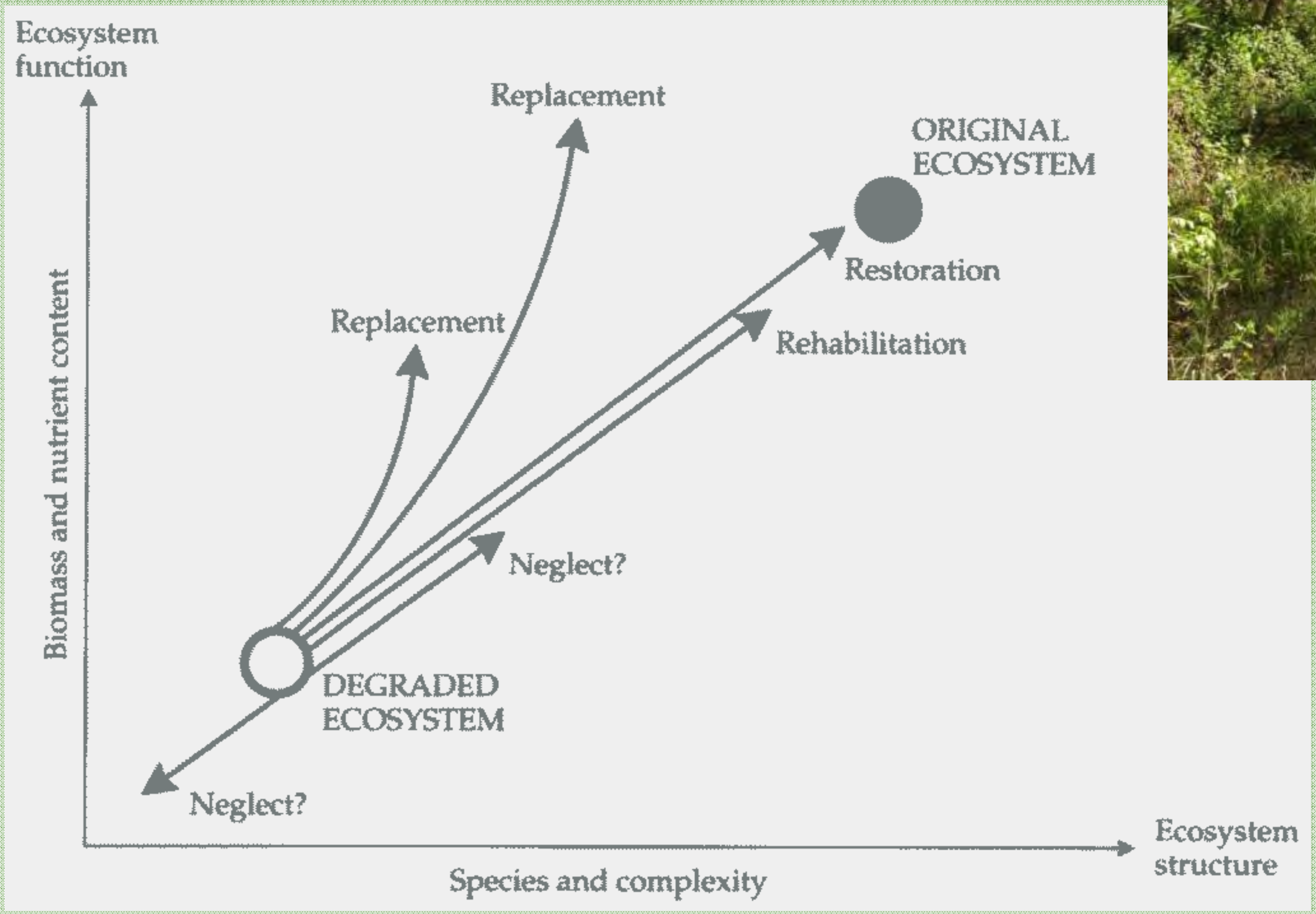
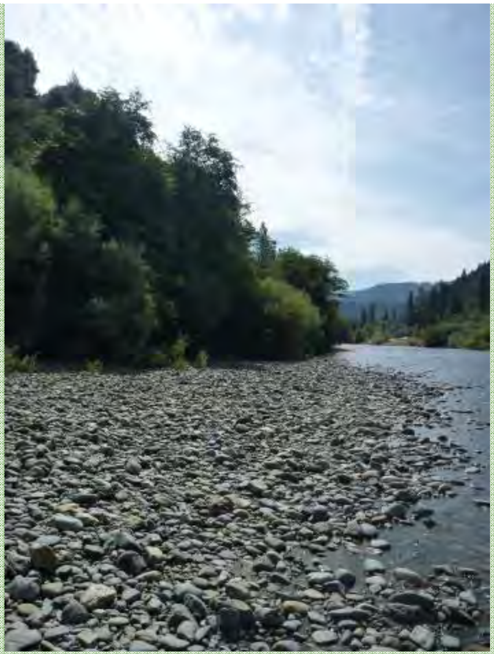
Rehabilitation vs. Restoration



Modified from Bradshaw 1984

Challenge



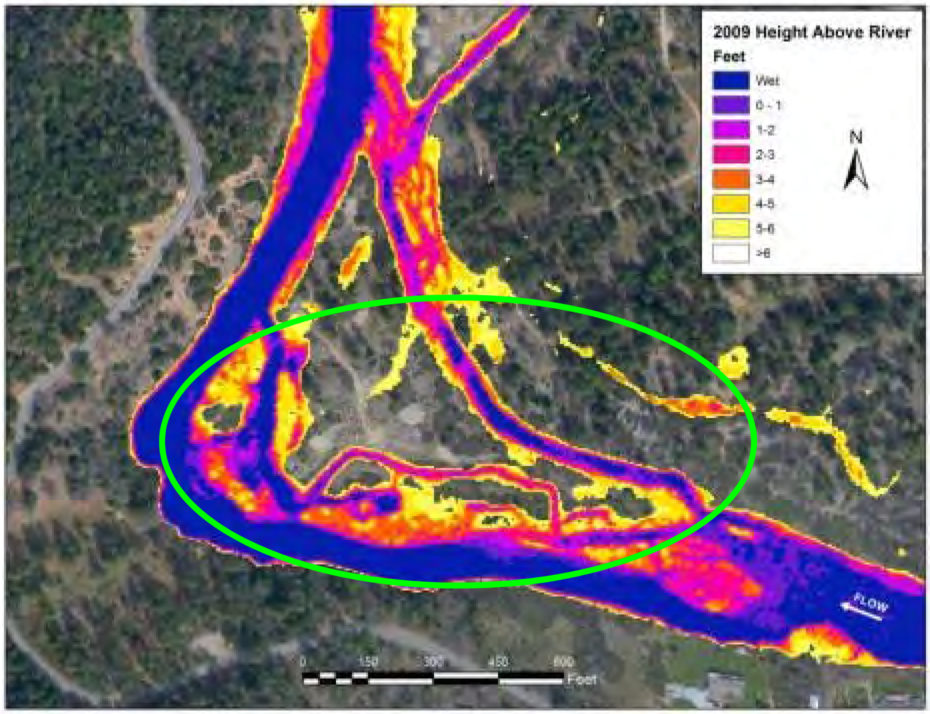
To physically rehabilitate the form and function of a natural river

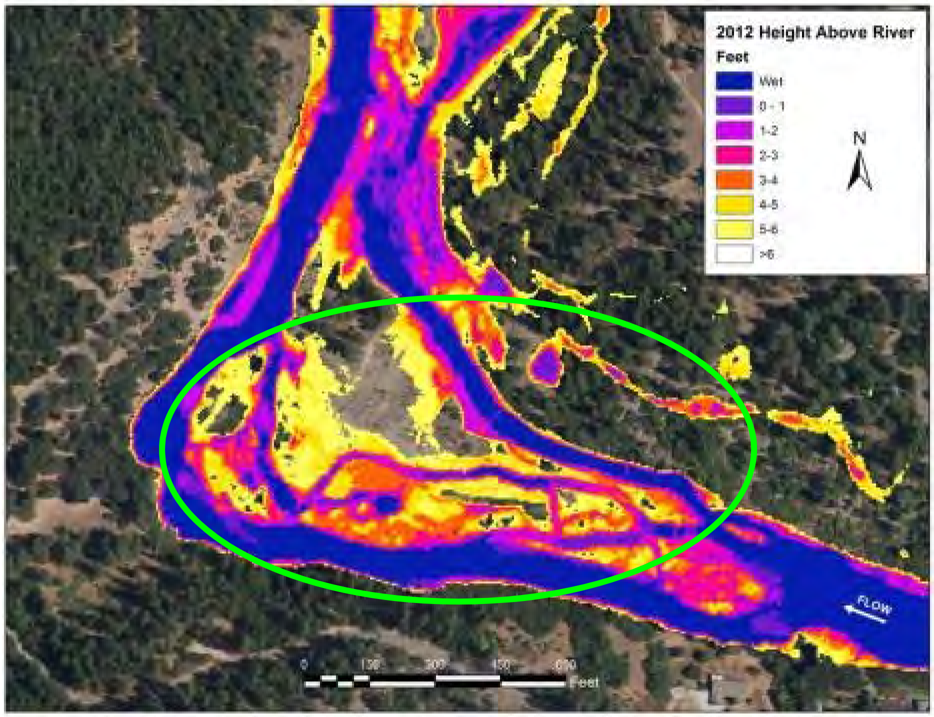
Our Goal is to Rehabilitate Surfaces That Do Not Currently Support Riparian Vegetation

Constructed Floodplains

Side Channels

Ground Height Above River





- Pre-construction
- Post -construction

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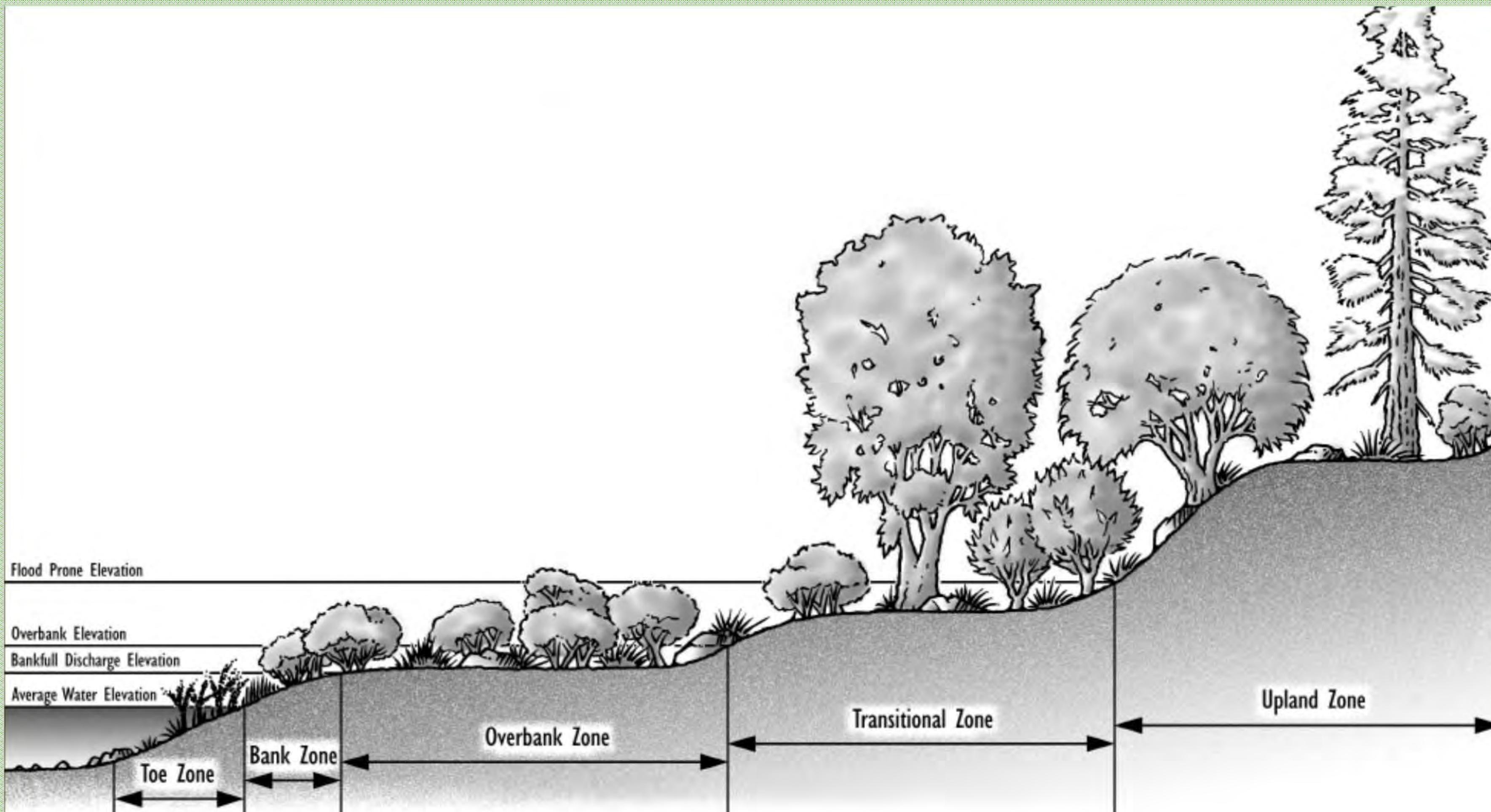
Changes in Ground Elevation = Riparian Zonation



Revegetation + Woody Plant Recruitment

= Self Sustaining

Short Term Habitat Recovery + Long Term Sustainability

= Compensation

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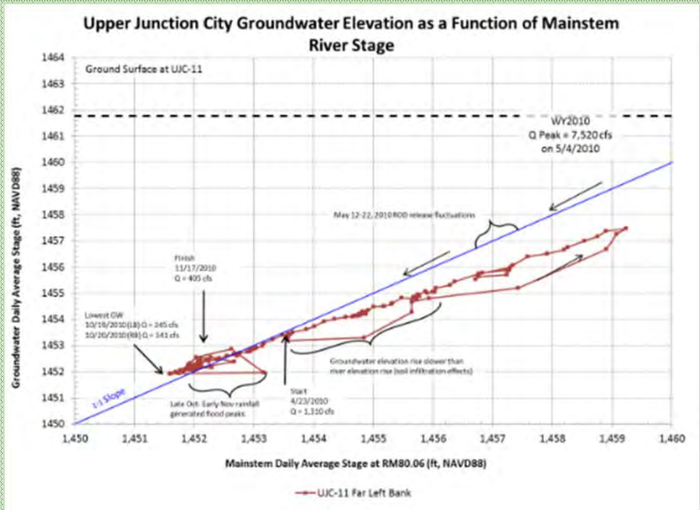
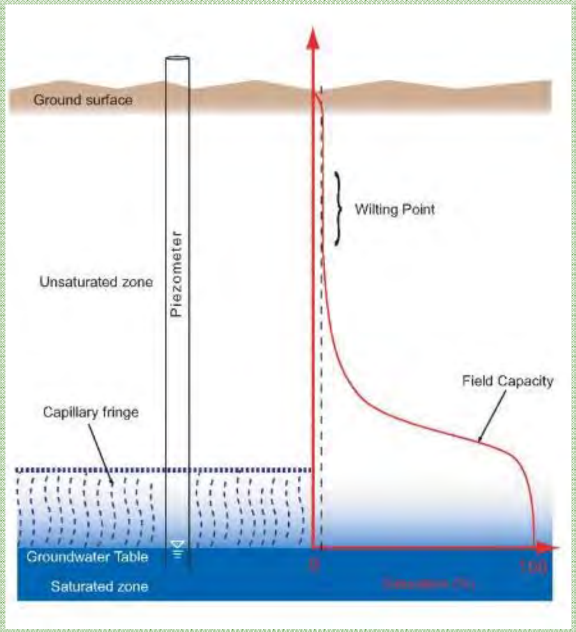
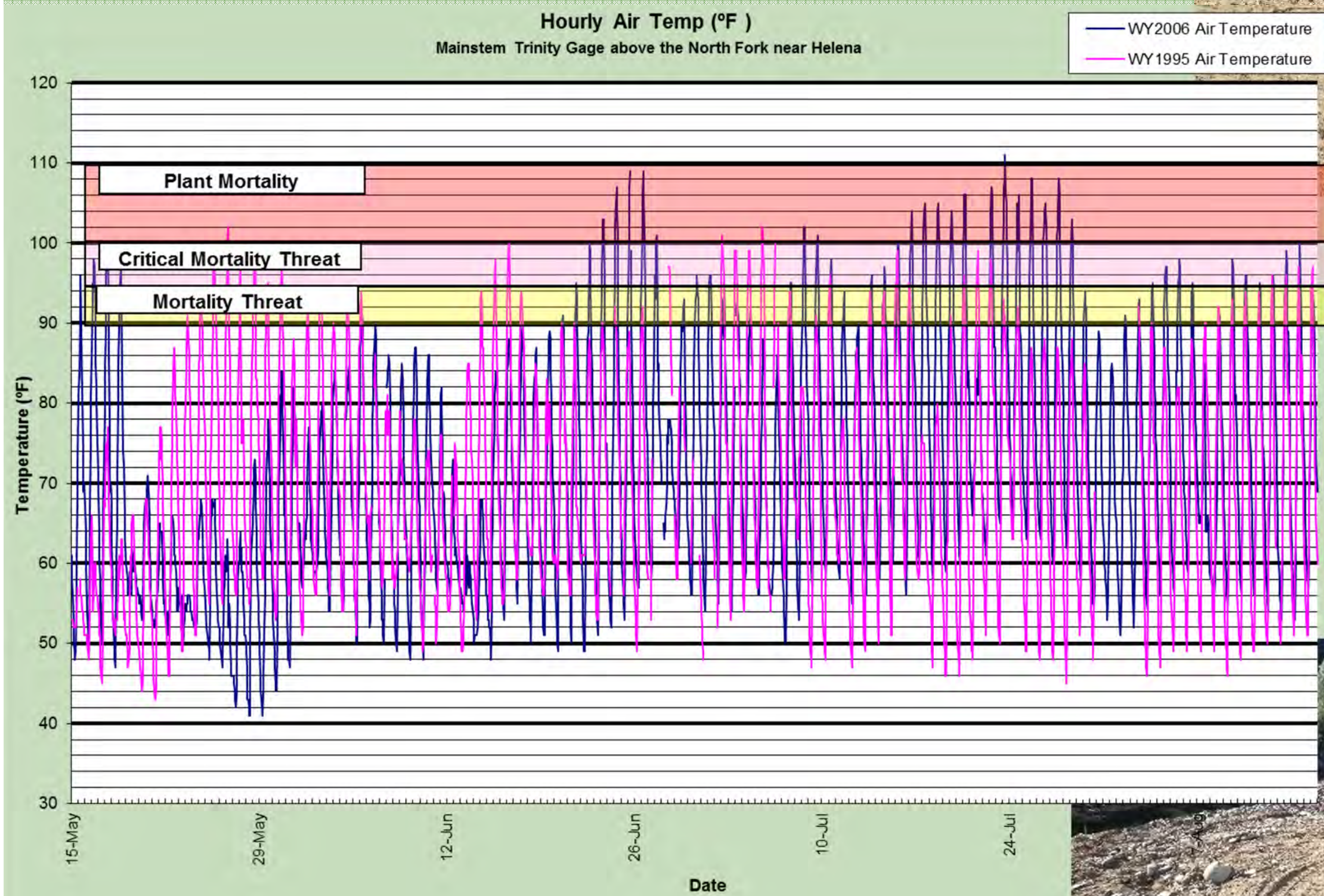
What are environmental conditions are needed?

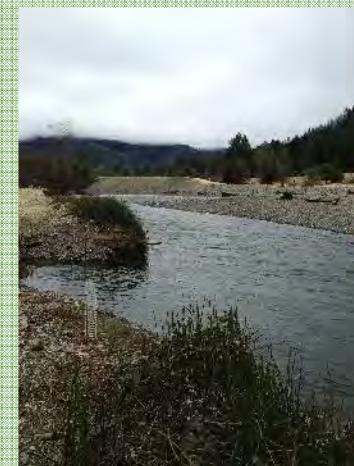




- Streamflow connection to groundwater
- Fine sediment
- Shallow groundwater to promote moist soils

Climate makes a big difference





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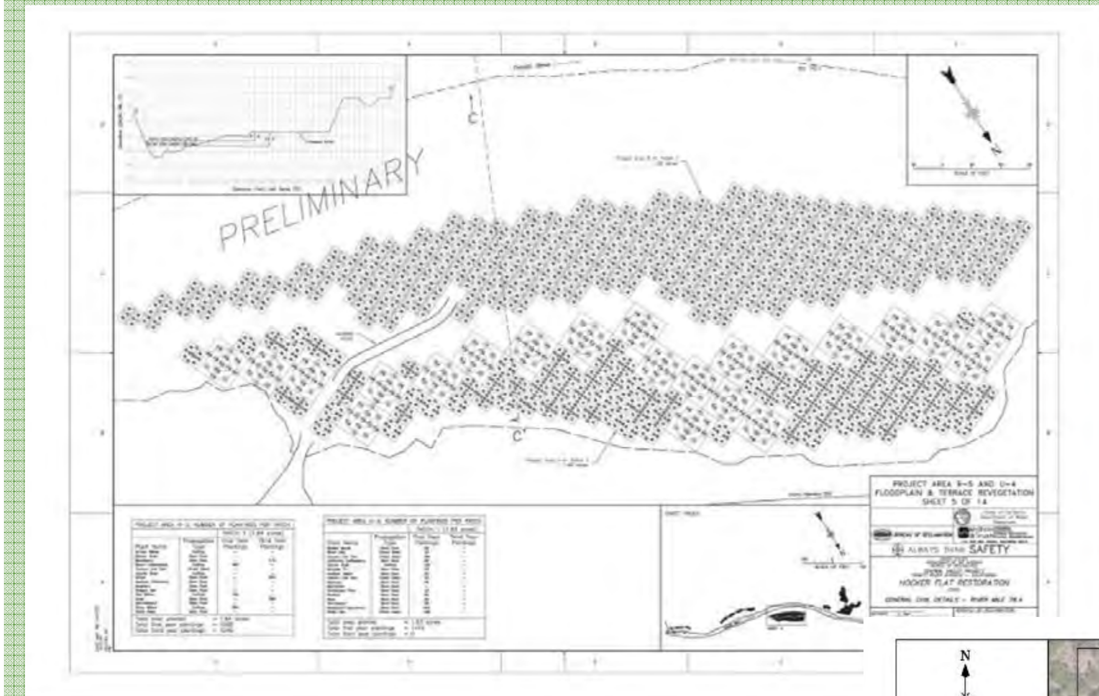
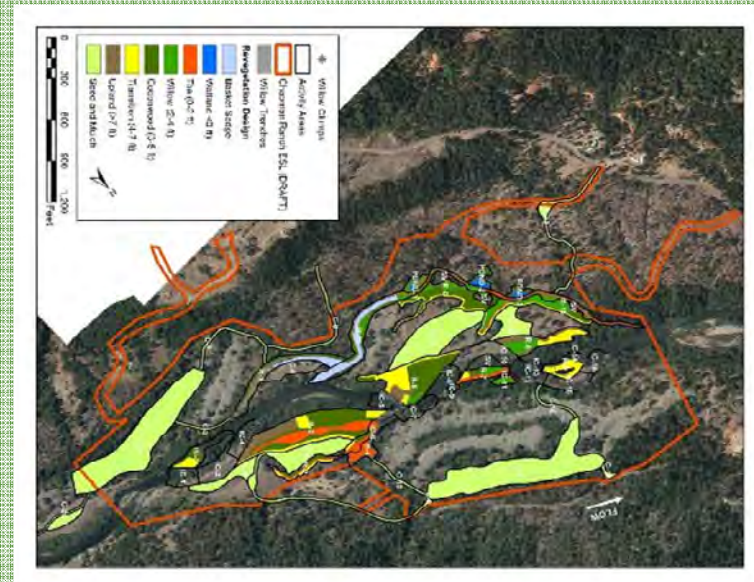
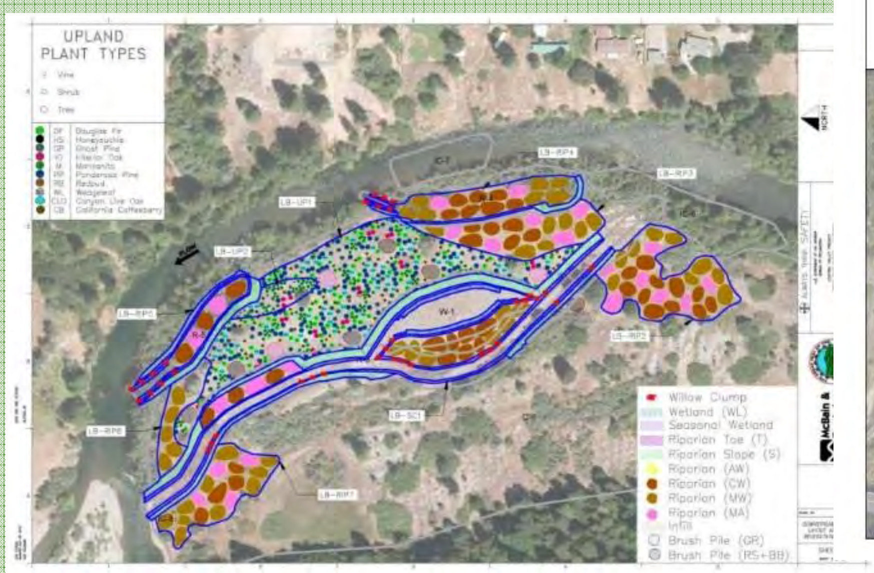
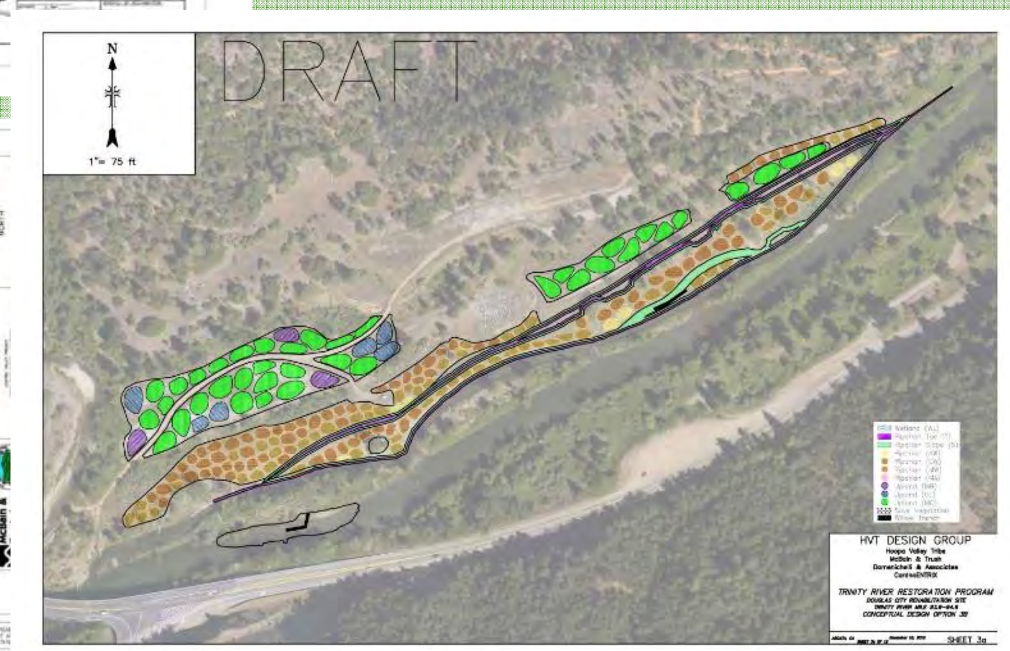
Riparian Woody Plant Floodplain Colonization

Revegetation









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Plant Material Collection and Handling

Photos Courtesy of the Trinity County Resource Conservation District

Nursery Material Collection and Handling

ociates

Planting with Mini-excavator

Photos Courtesy of the Trinity County Resource Conservation District

Willow Clump Salvage and Installation

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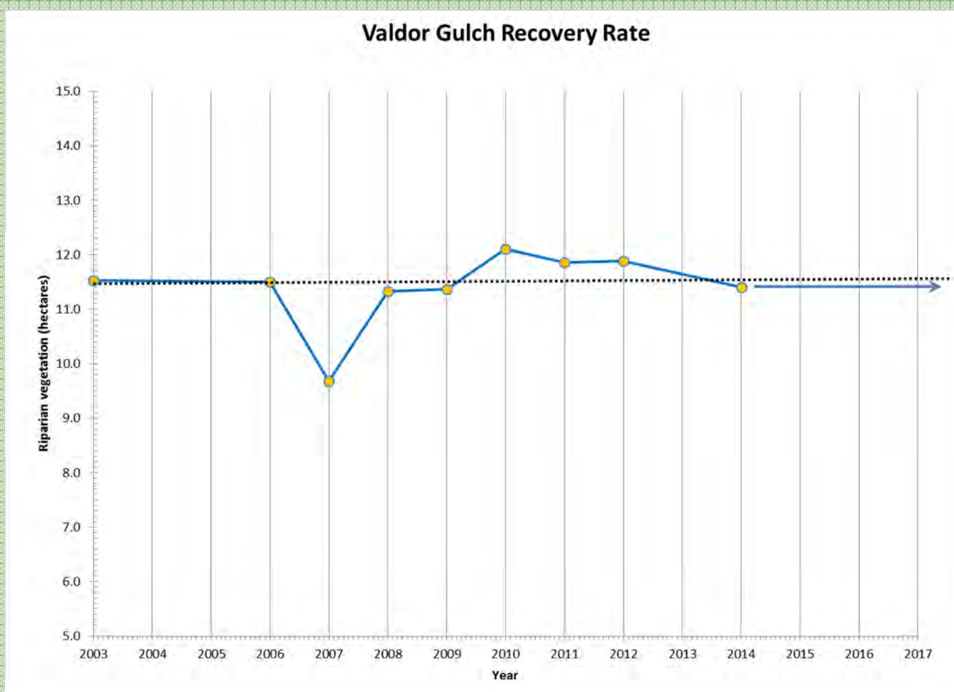
Willow Trenches

Mapping is used to quantify changes in riparian vegetation over time (TRRP 2008)

Discrete patches must be visible on air photos to be mapped

Mapping is conducted within fixed boundaries



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Revegetation Survival After 2 Growing Seasons

Arroyo Willow (cutting)	61%
Cottonwood (cutting)	38%
Shining Willow (cutting)	24%
Red Willow (cutting)	42%
Overall Planting Survival	41%

Revegetation Survival After 5 Growing Seasons (v1)

Arroyo Willow (cutting)	6-100%
Cottonwood (cutting)	7-60%
Shining Willow (cutting)	0-50%
Red Willow (cutting)	14-61%
Overall Planting Survival	26-51%

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Revegetation Survival After 5 Growing Seasons (v2)

Arroyo Willow (cutting)	26%
Cottonwood (cutting)	79%
Shining Willow (cutting)	44%
Red Willow (cutting)	28%
Overall Planting Survival	44%

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- Rooted Plant Material
- Fine sediment
- Organic material
- Mulch
- Browse Protectors
- Irrigation

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Revegetation Survival After 1 Growing Season

Arroyo Willow (nursery stock)	29-100%
Cottonwood (nursery stock)	32-57%
Shining Willow (nursery stock)	12-59%
Red Willow (nursery stock)	30-53%
Overall Planting Survival	26-67%

Revegetation Survival After 2 Growing Seasons

Arroyo Willow (nursery stock)	23%
Cottonwood (nursery stock)	77%
Shining Willow (nursery stock)	31%
Red Willow (nursery stock)	55%
Overall Planting Survival	47%

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What have we learned ?

- Substrate must be more than 20% fine sand and silt to support seed germination
- Constructed ground surfaces within 4 vertical feet of the of the summer water surface support cottonwood seedling germination and growth through the first year
- Pole cuttings and Nursery Container Stock can both be used effectively to recover short term habitat losses
- Plant protection is necessary to get plants above the browse level
- Mulch reduces weed competition and reduces local soil moisture loss
- Irrigation promotes rapid growth and may help increase plant species richness

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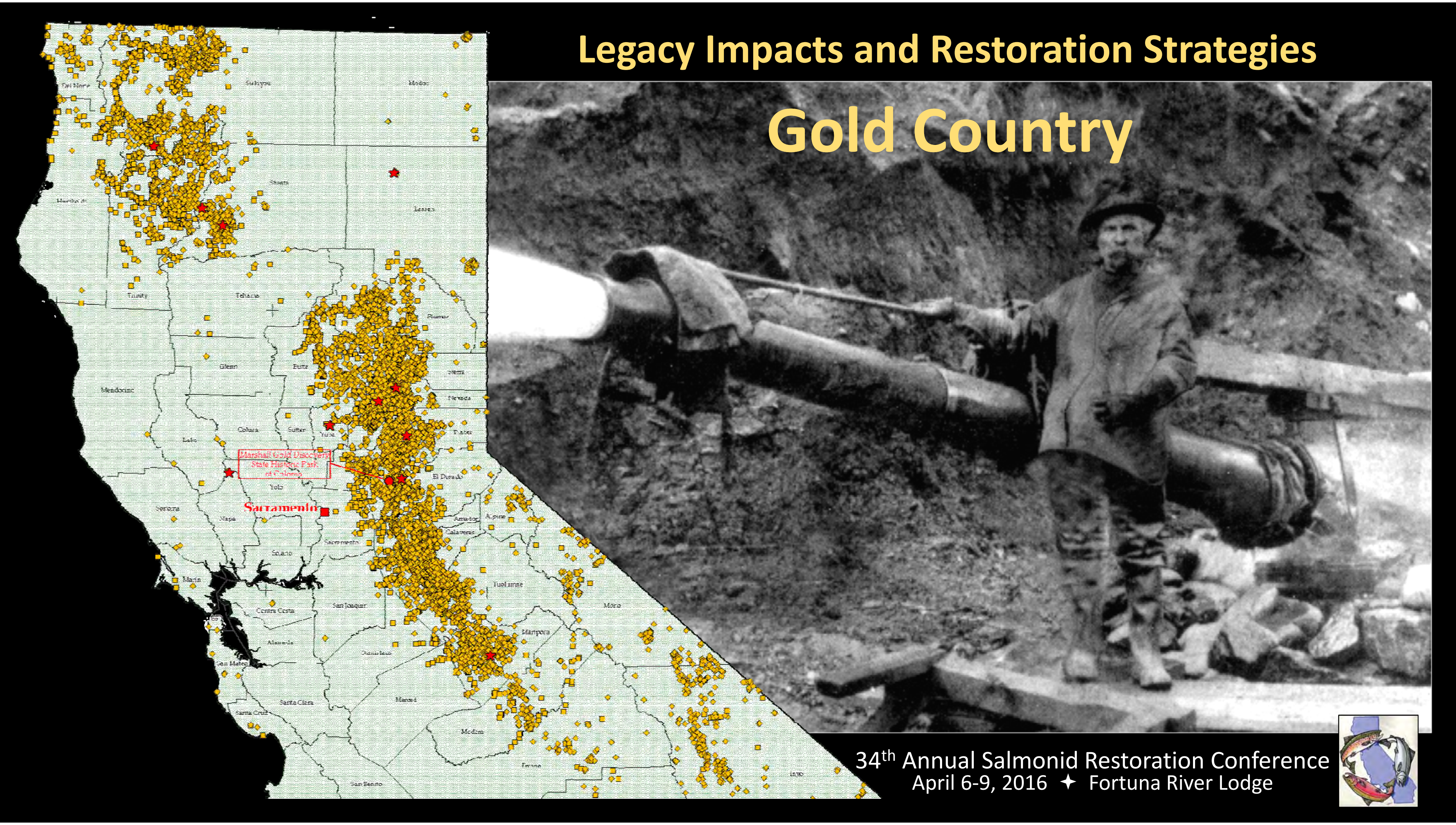
Thanks To:

The Fishes
Hoopa Valley Tribal Fisheries
Trinity River Restoration Program
Yurok Tribal Fisheries
United States Fish and Wildlife
California Department of Fish and Wildlife
Trinity County Resource Conservation District
McBain Associates
Salmonid Restoration Federation


Legacy Impacts and Restoration Strategies
Gold Country
Sacramento
34th Annual Salmonid Restoration Conference
April 6-9, 2016 ✦ Fortuna River Lodge

Placer Mining History

Region	Basin	Sub-basin	Methods	
			Ground Sluicing & Hydraulicking	**Bucket-line & Drag-line Dredging**
Sierra Nevada	many	many	1853	1890s – 1950s
Klamath Siskiyou	Upper Sacramento	Clear	1860s	1905 – 1915
	Klamath	Scott	1856	1934 – 1950
		Trinity	1860s	1890s – 1959
		Salmon	1870	1900s – ?
	Rogue	Illinois	1870s	1904 – 1960
		Applegate		
		Rogue		

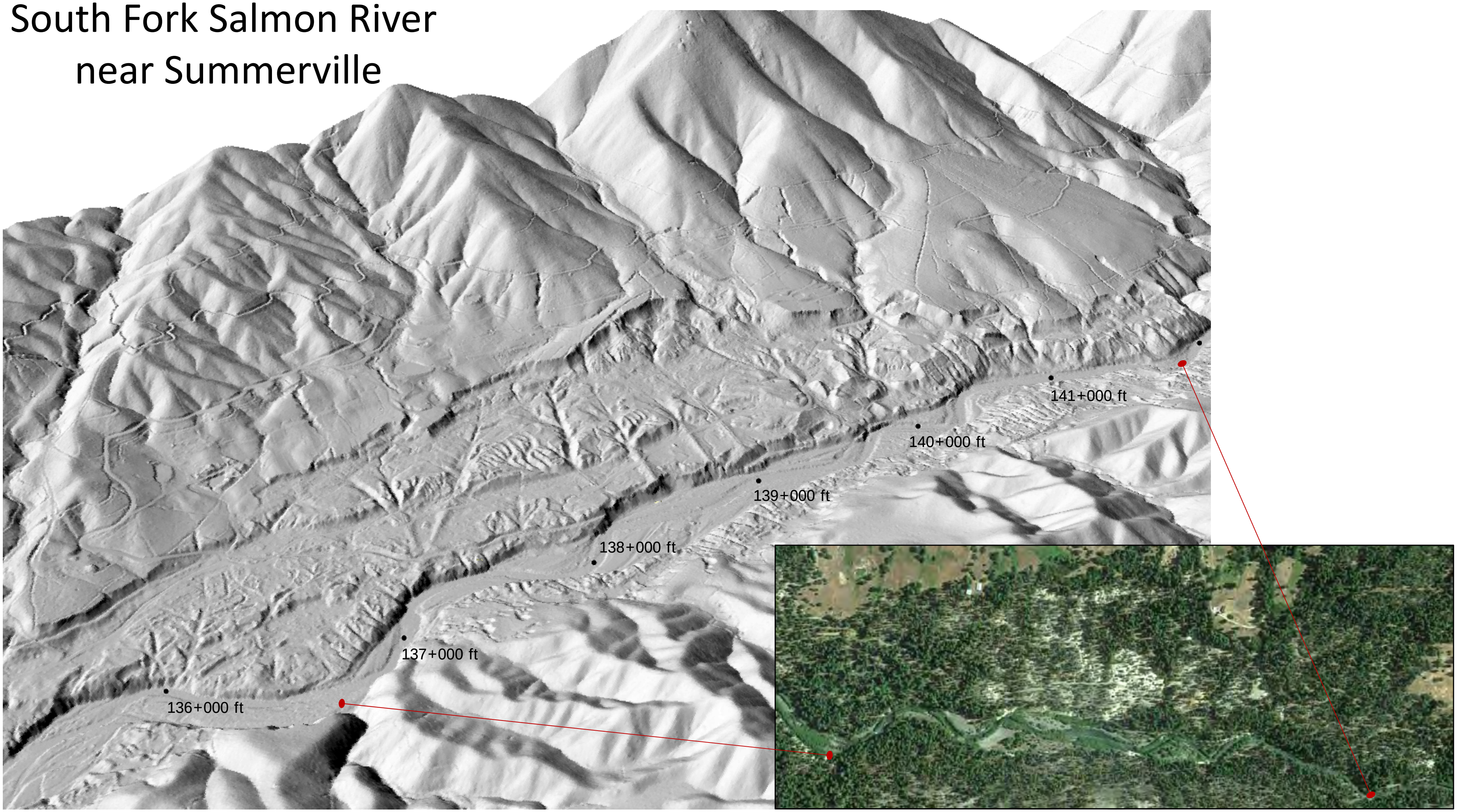
Regulatory History

- 1884 Sawyer Decision in Woodruff v. North Bloomfield Mining and Gravel
  Prohibited discharge of hydraulic mining debris to rivers in the Sierra Nevada
- 1893 Caminetti Act
  Prohibited hydraulic mining in the Sacramento River Basin
- 1936 Quin Bill
  Prohibited hydraulic mining in the Klamath Basin: July–November
- 1942 War Production Board Order L-208
  Halted gold mining, rescinded in 1945

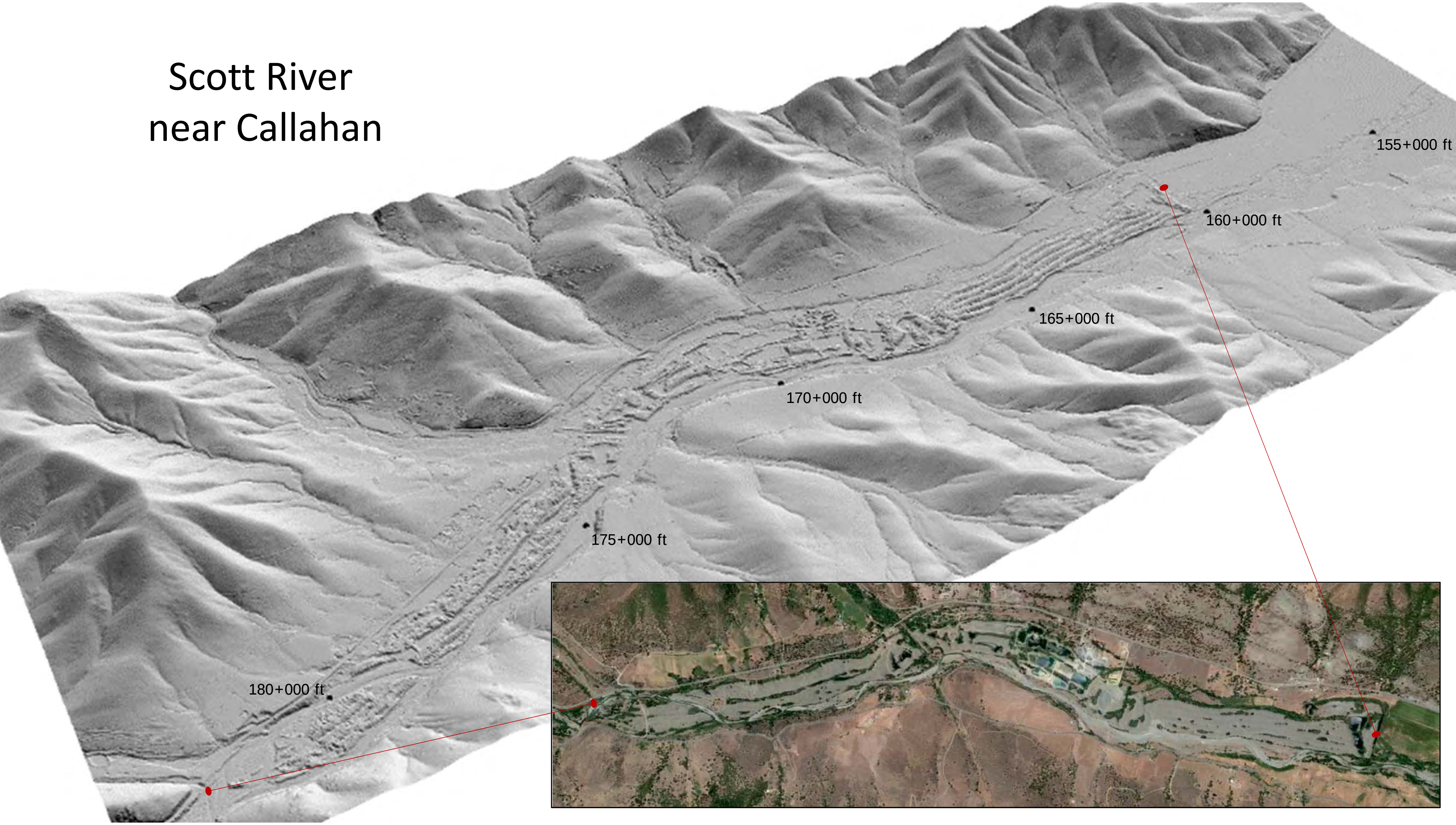
Effects

- Denudation
- Sediment delivery
- Channel and floodplain aggradation, estuary sedimentation
- Increased flooding, reduced floodplain inundation
- Reduced channel complexity
- Coarser bed particle size
- Increased water temperatures
- Mercury contamination

South Fork Salmon River near Summerville



Scott River near Callahan



Significance

- Hydraulic and dredger mining established present-day physical template
- Legacy in each river system based on:
  - Mining history
  - Valley and channel geometry
  - Sediment mass balance
  - Climate
- Dams constructed in 1940s–1960's altered flow and sediment dynamics