USING BEAVER DAM ANALOGS TO REDUCE DOWNSTREAM SEDIMENT LOADS

A Pilot Project in California Creek, Spokane, Washington, USA

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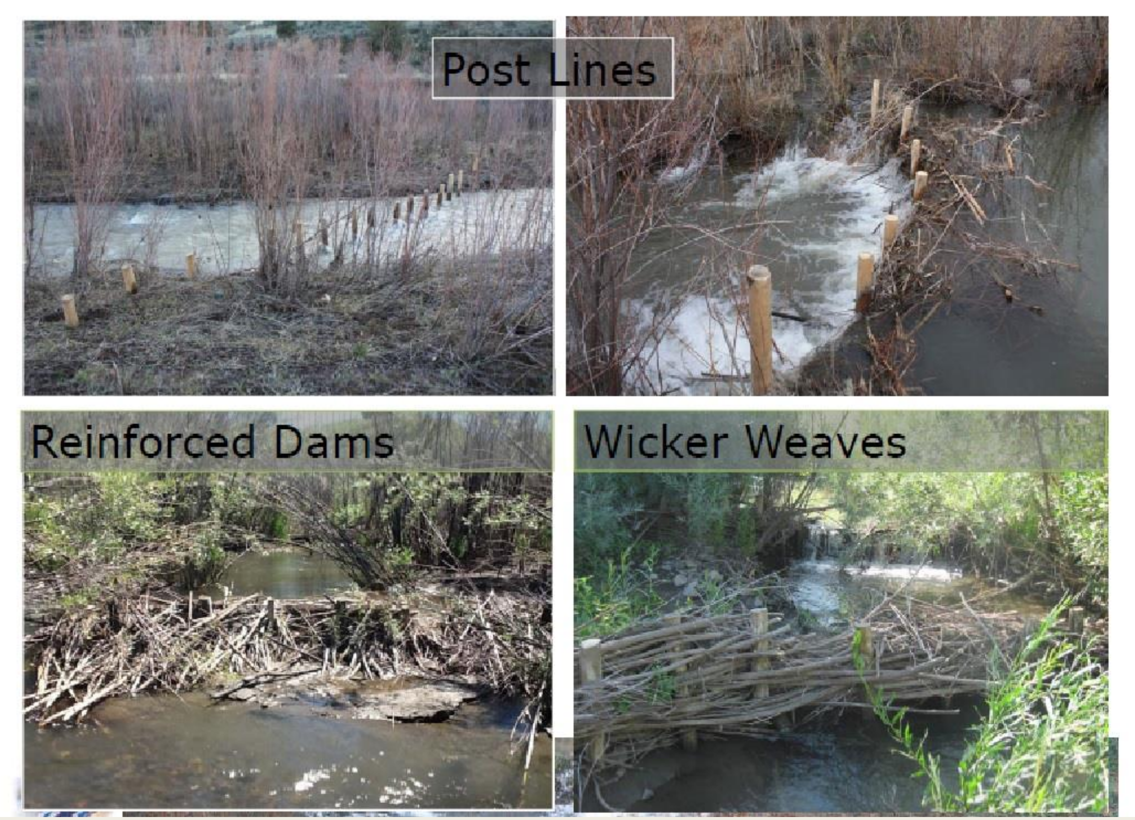
What are Beaver Dam Analogs?

- "Structures completely or partially built by humans that mimic many of the functions of natural beaver dams"
  - *Characteristics reduce velocities*
  - *Reduce bedload and washload tran*
  - *Disperse flow*
  - *Create ponds, pools and wetlands*
  - *Create riparian habitat*
  - *Passable to fish*
  - *100% Organic*
  - *Ephemeral, Dynamic, and Porous*
  - *Often used by beaver*



BDA Materials and Equipment

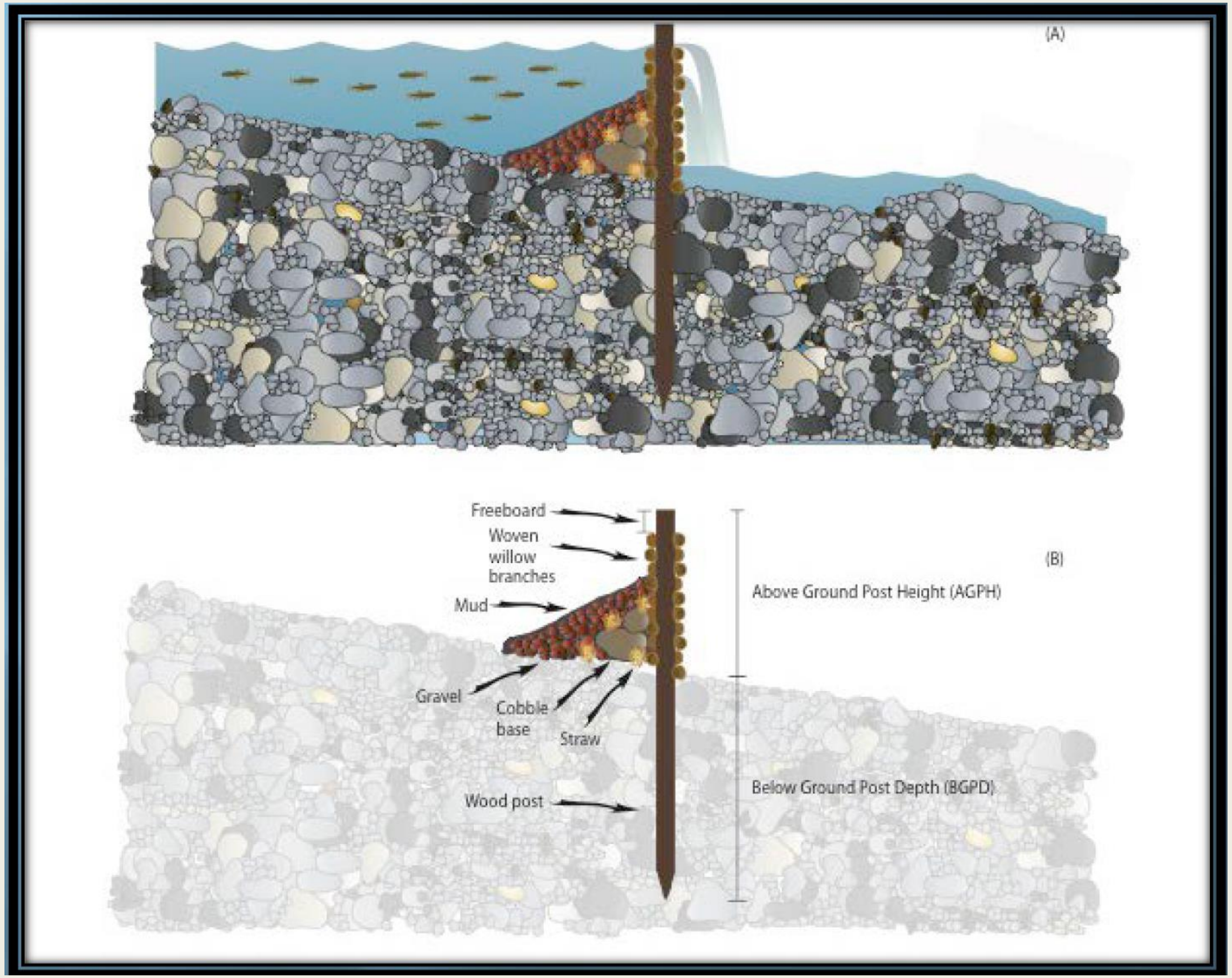
- Materials-similar to beaver dams
  - *Willow branches*
  - *Herbaceous vegetation*
  - *Rocks, mud*
  - *Wood posts (typically non-treated)*
- Equipment needed
  - *Chainsaw-to cut and sharpen posts*
  - *Hand saws to cut willow*
  - *Post pounder/power source (hydraulic or pneumatic)*
- Material cost and labor = $500-$5000/structure
  - *Size of structure (length)*
  - *Size of stream (depth of posts)*
  - *Source distance of building materials*
  - *Labor costs*
    - Students – FREE LABOR! ☺

Beaver Dam Analog Placement

- Where are BDAs placed? In reaches that can or could support beaver
  - *Site-specific considerations include:*
    - Habitat unit (e.g. glide, pool, riffle) - Riffle crests preferred
    - Degree of incision
    - Floodplain width
    - Stream planform
    - Stream slope
    - Bed material
    - Beaver presence/absence
    - Proximity to infrastructure
    - Vegetation
    - Landowner buy in!! - Most technically challenging aspect of BDAs

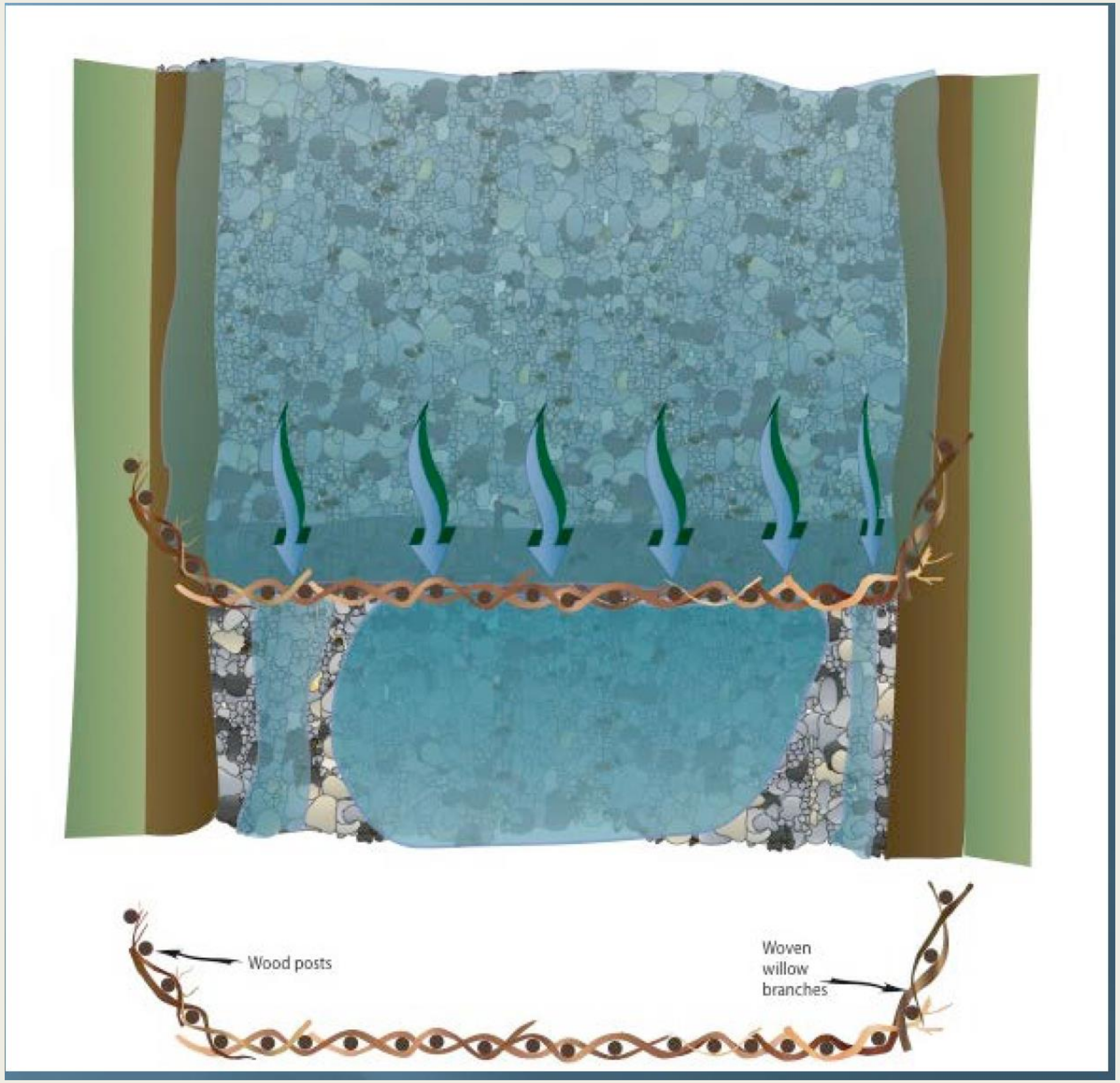
Beaver Dam Analog Design

Side/Profile View



Beaver Dam Analog Design

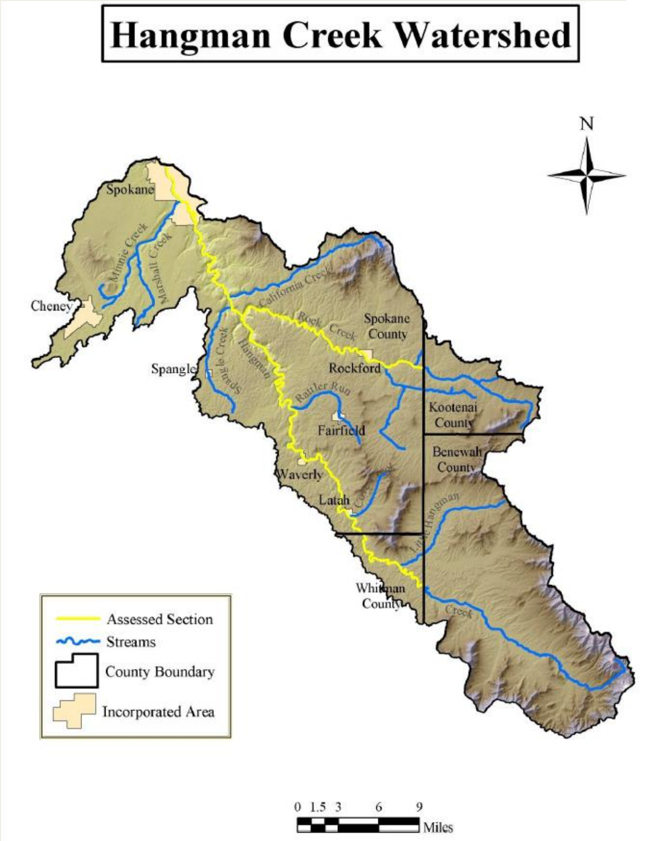
Plan View

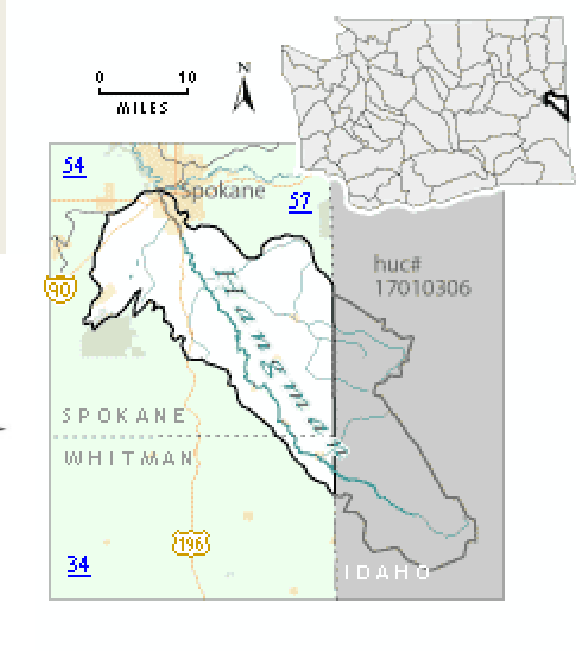


Sediment Trapping in Hangman Creek Watershed

- Facts
  - *441,000 acres*
  - *275,000 acres of dryland agriculture*
  - *222 miles of perennial streams*

- Issues
  - *Major changes in vegetation*
  - *Altered hydrology*
  - *Easily erodible soils*
  - *Human impacts*

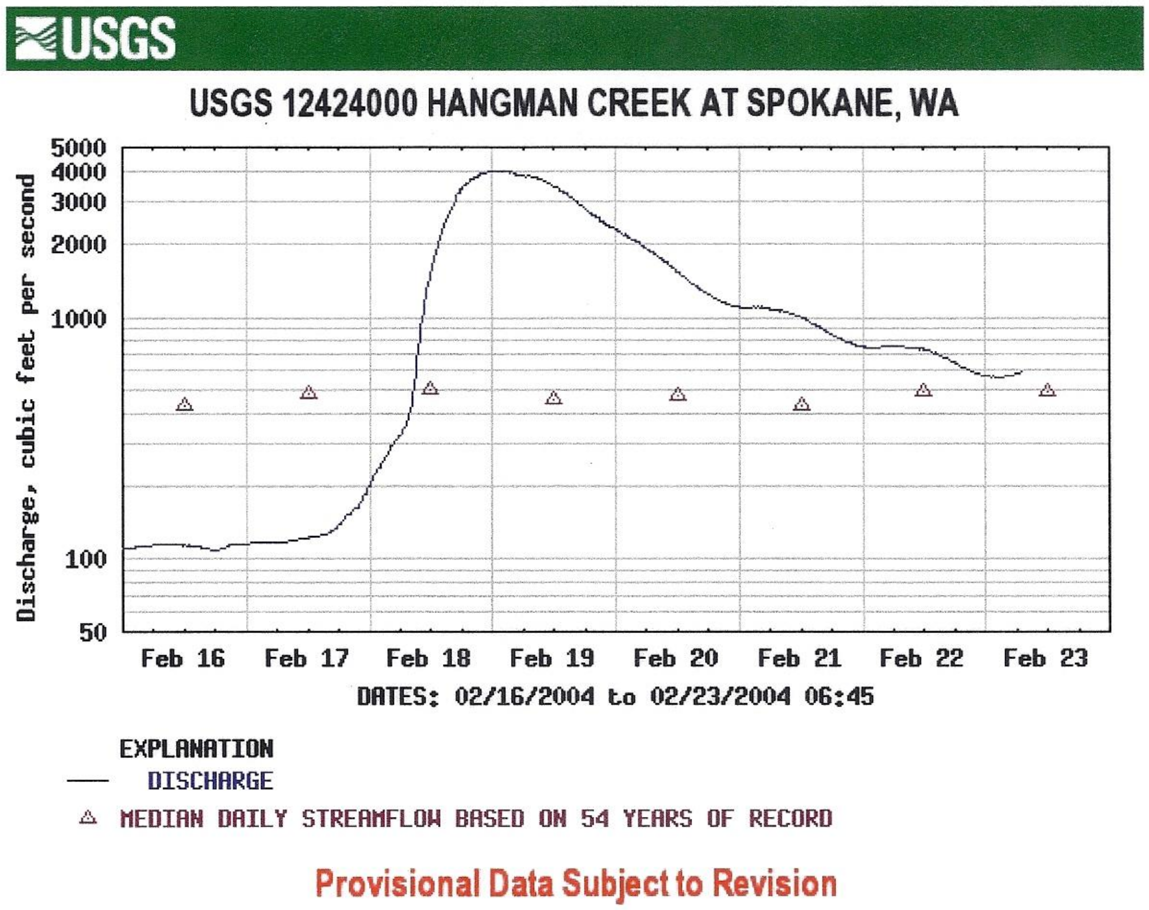




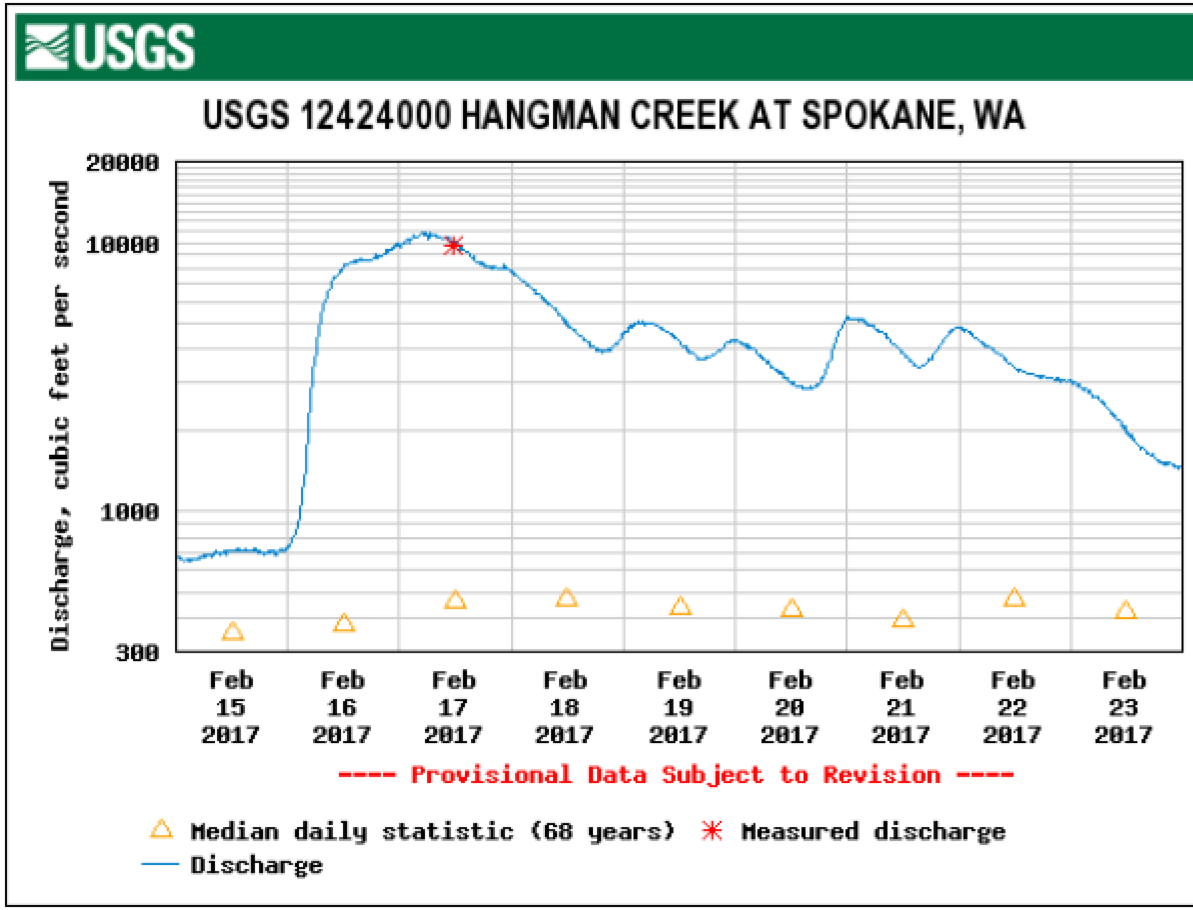
Hangman Creek Hydrology

Q_2 = 6,480 cfs
Q_{10} = 13,100 cfs
Q_{100} = 21,000 cfs

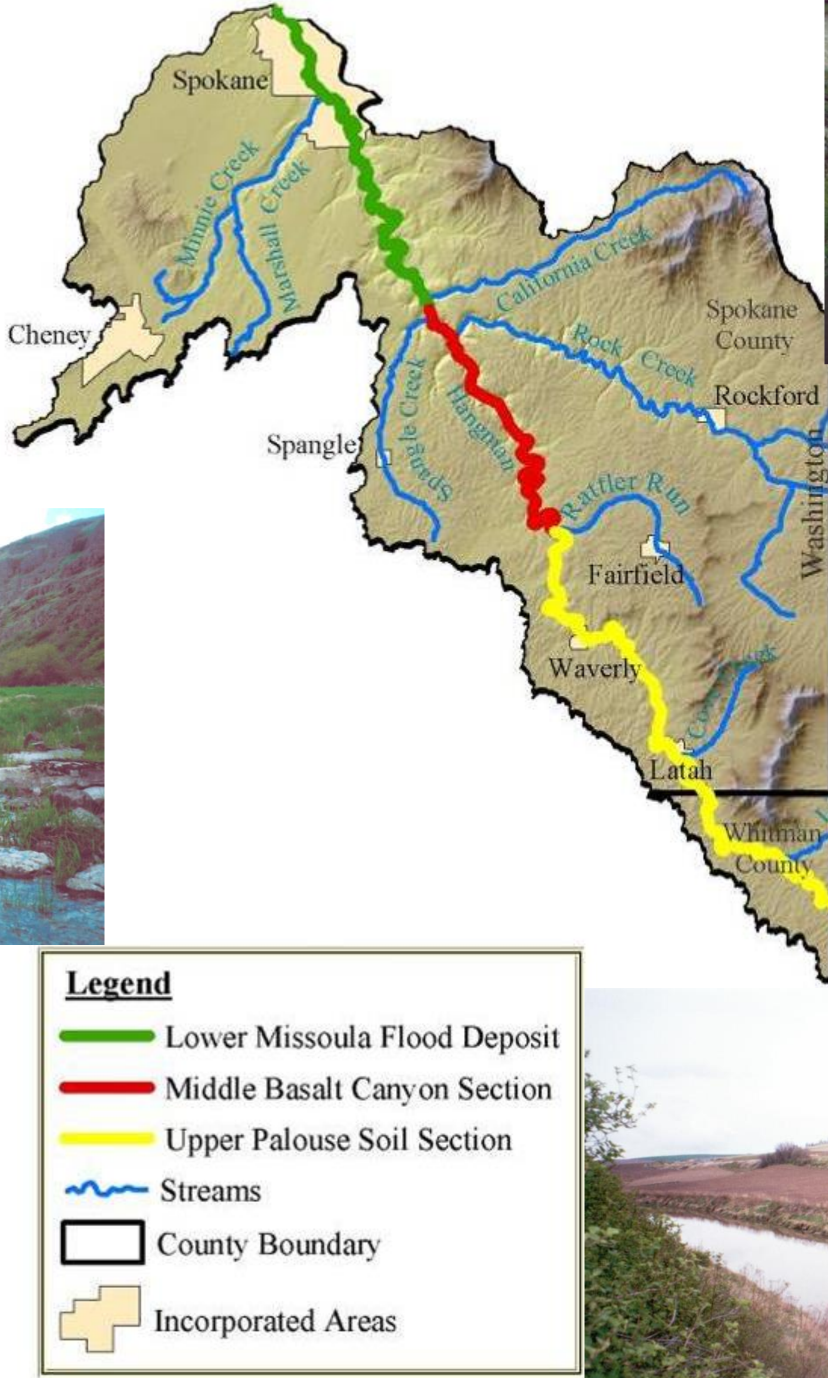
2004



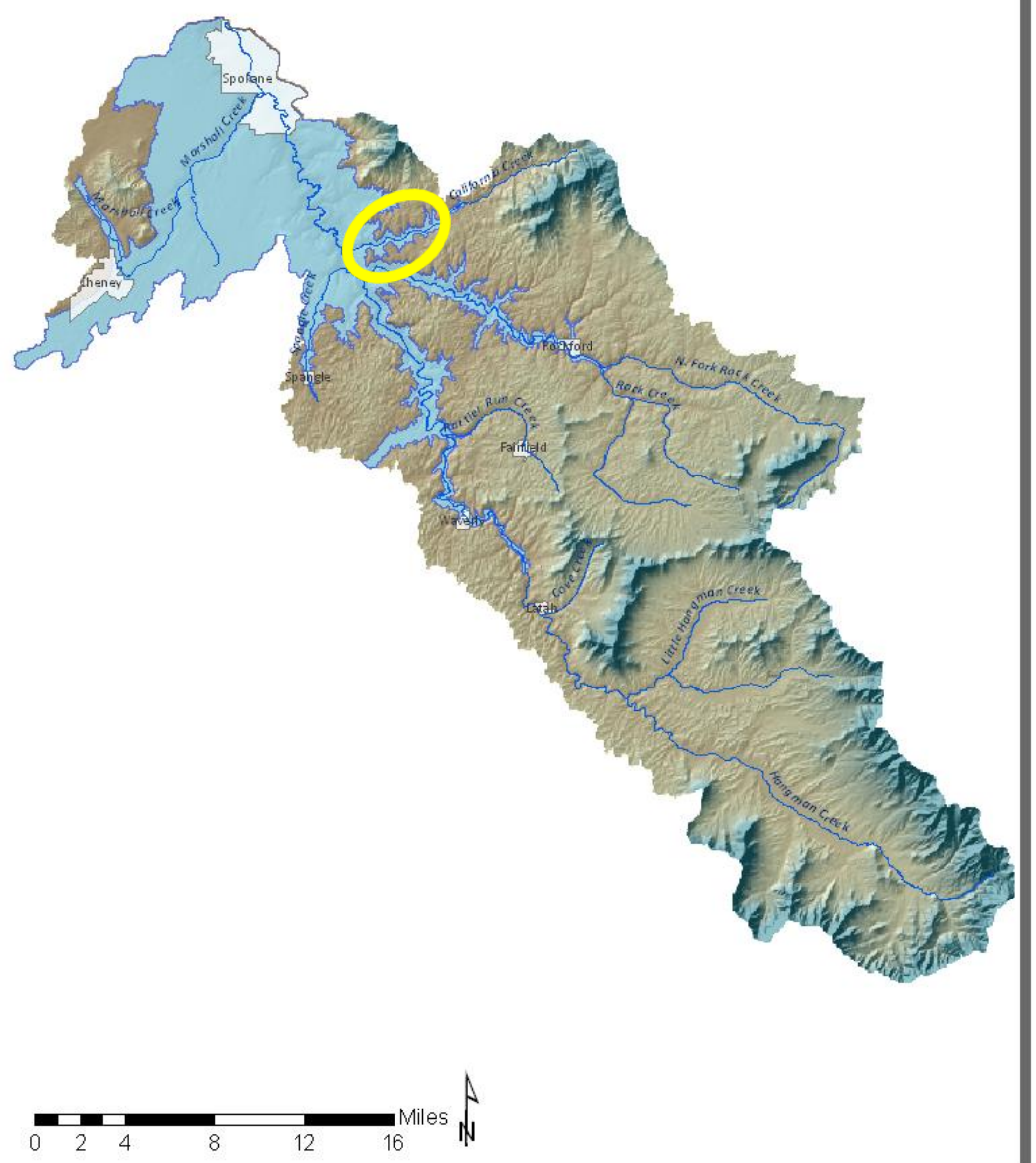
2017

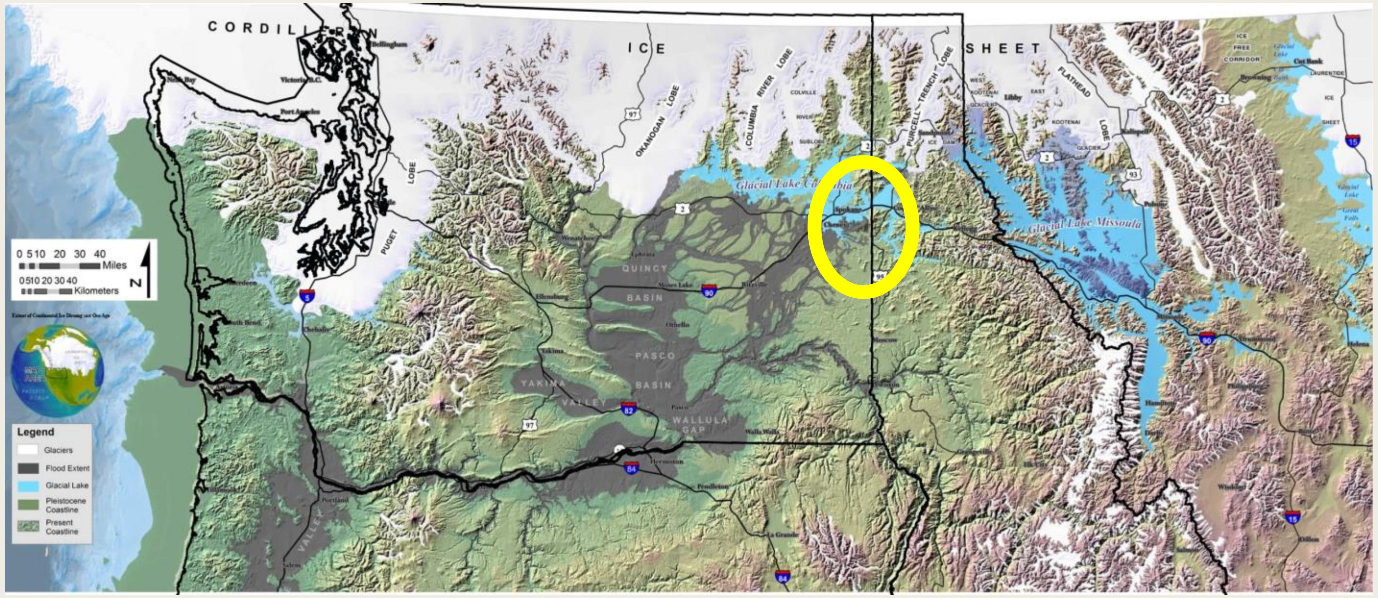


Hangman Creek Sediment



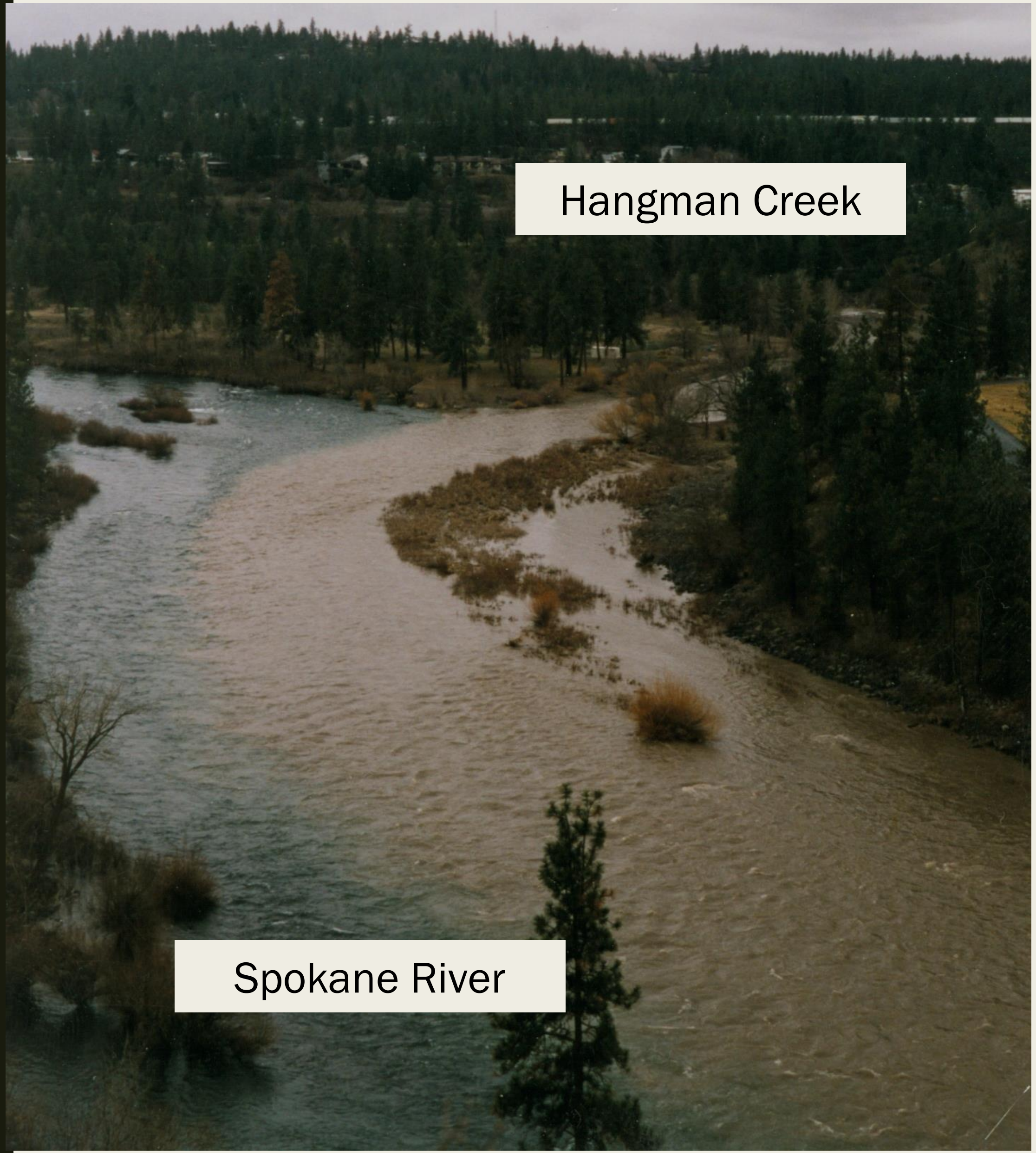
Glacial Lake Columbia Extent in Hangman Watershed



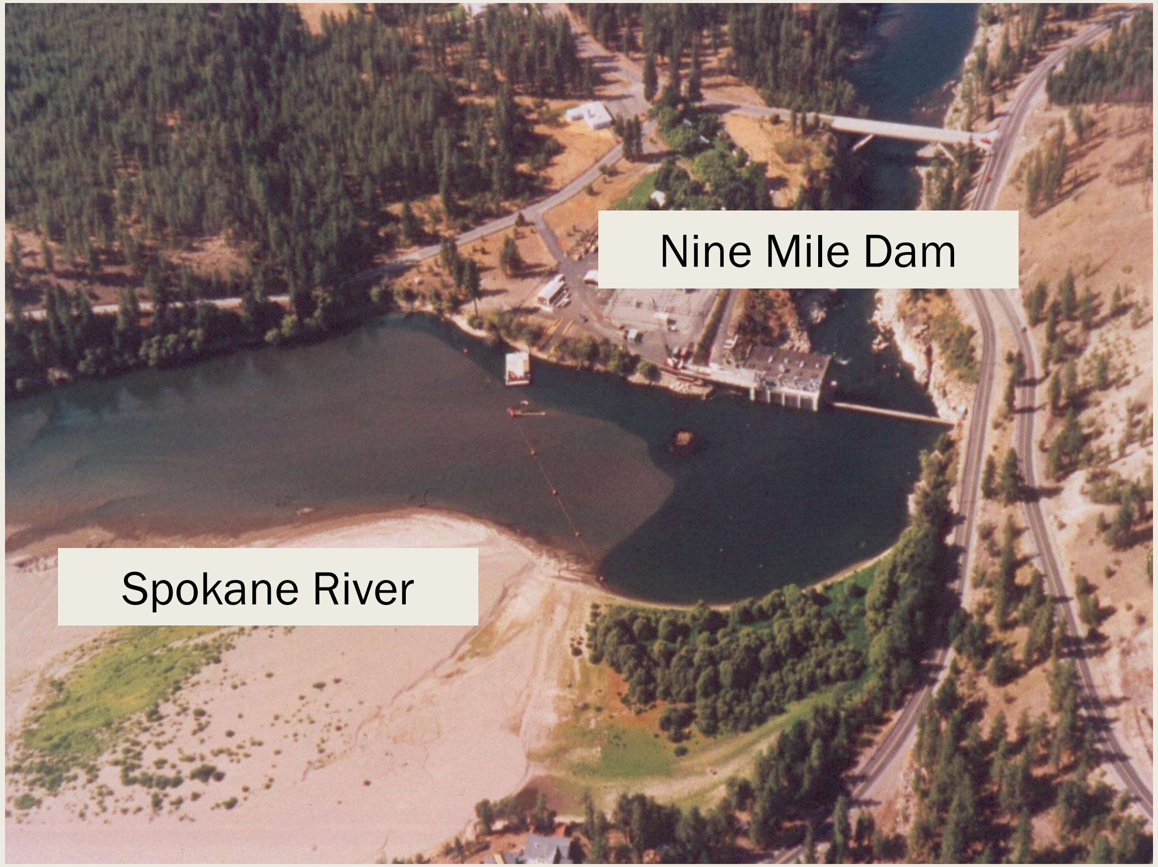


Modified from : ***ICE AGE FLOODS IN THE PACIFIC NORTHWEST – MAP,*** *Ice Age Flood Institute and Eastern Washington University*

Sediment sources from the Hangman Watershed



Flashy Hydrology
Large Sediment Supply



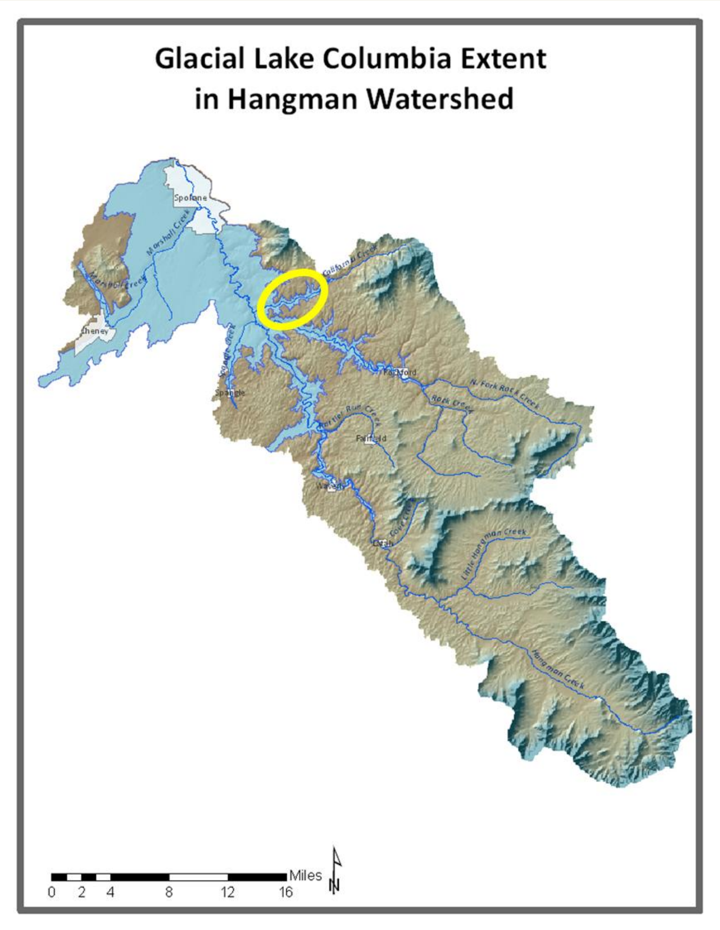
Hangman Creek - California Creek BDA Pilot Study

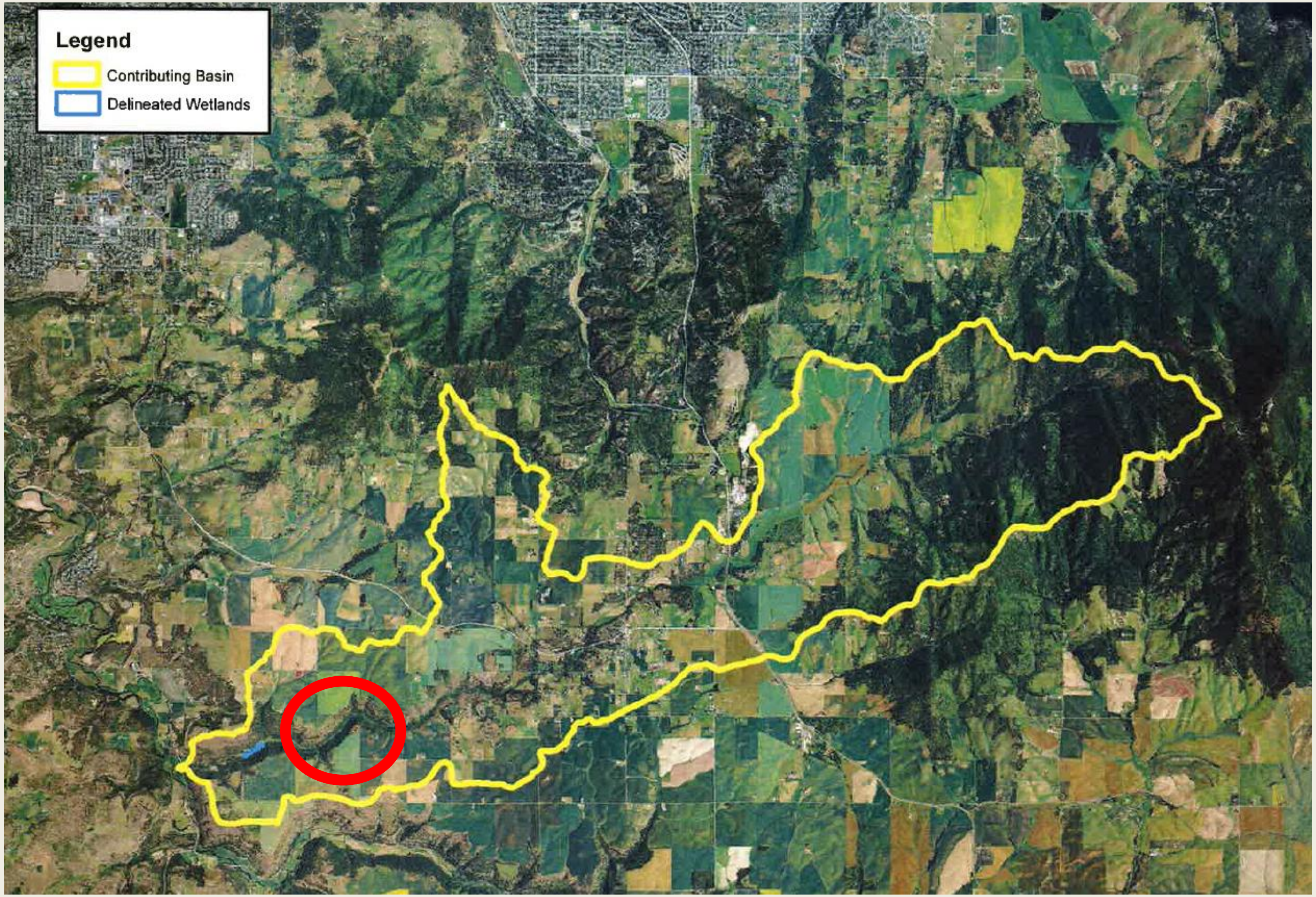
- The Lands Council – Beaver Solution Project
  - *"Beavers are progressively acknowledged and utilized as a silver-bullet solution to our natural resource and environmental health concerns."*
- US Fish and Wildlife Service (Turnbull Wildlife Refuge)
  - *The Partners for Fish & Wildlife program works with private landowners to improve fish and wildlife habitat on their lands. We are leaders in voluntary, community-based stewardship for fish and wildlife conservation.*

California Creek BDA Pilot Study

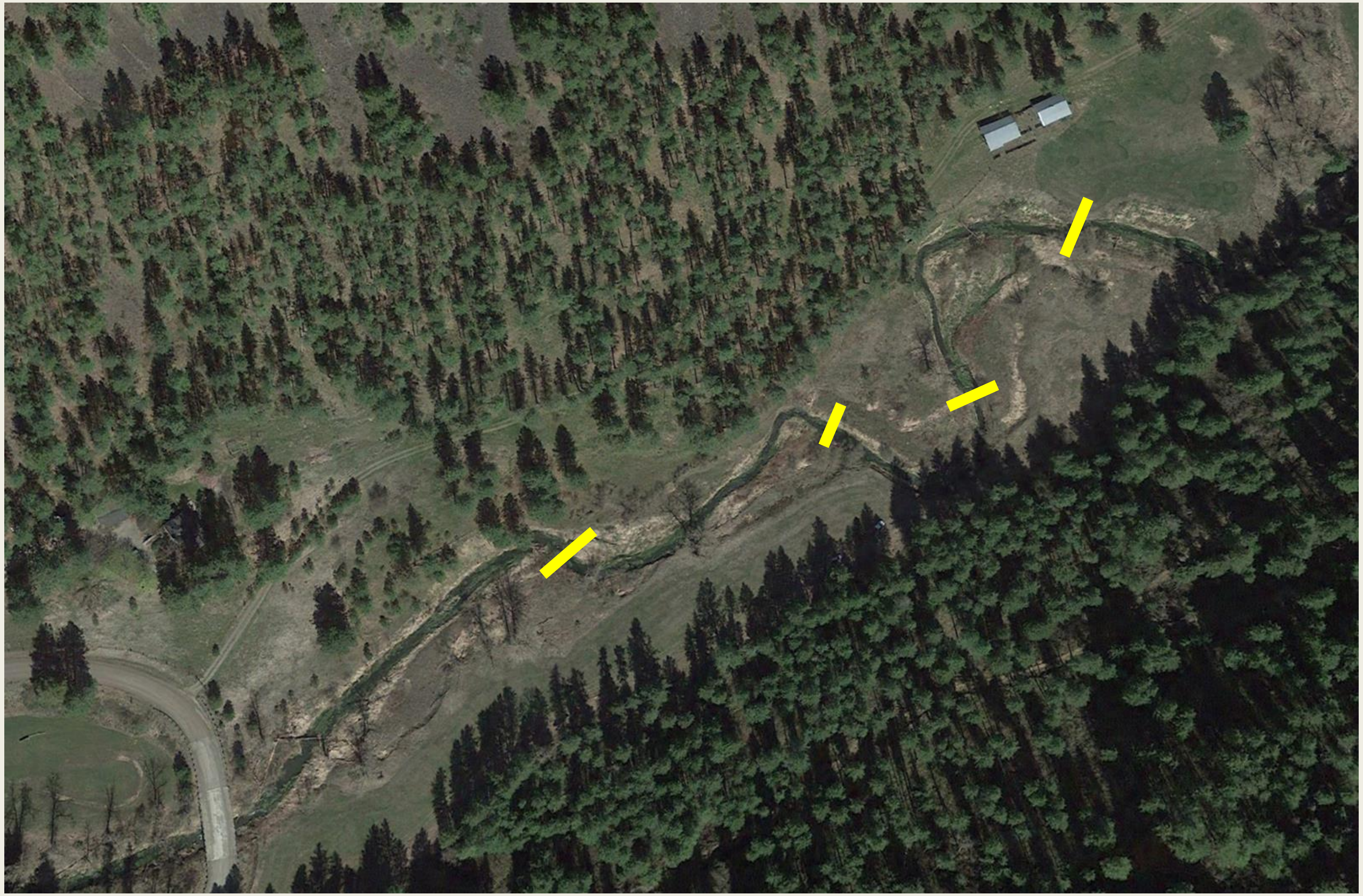
- Research Goal
  - *Strategically examine effectiveness and sustainability of BDAs to enhance ecosystem benefits and reduce sediment loads and erosion in California Creek and the Hangman Creek Watershed.*
- Research Objectives
  - *Collect preliminary monitoring data in California Creek to help establish a long-term intensely monitored watershed (BACI) study to test sediment trapping hypotheses in the larger Hangman Creek Watershed*
    - Examine use of drone aerial footage to document channel change and design location and orientation of BDAs
    - Examine the feasibility of implementing BDAs throughout Hangman Creek watershed and estimate the potential sediment load reduction
    - Examine influence of BDAs on hydraulics, sediment transport, and channel erosion
  - *Develop structural design guidelines for BDAs in a variety of stream reaches with varying stream power*

California Creek





California Creek Original BDA Locations

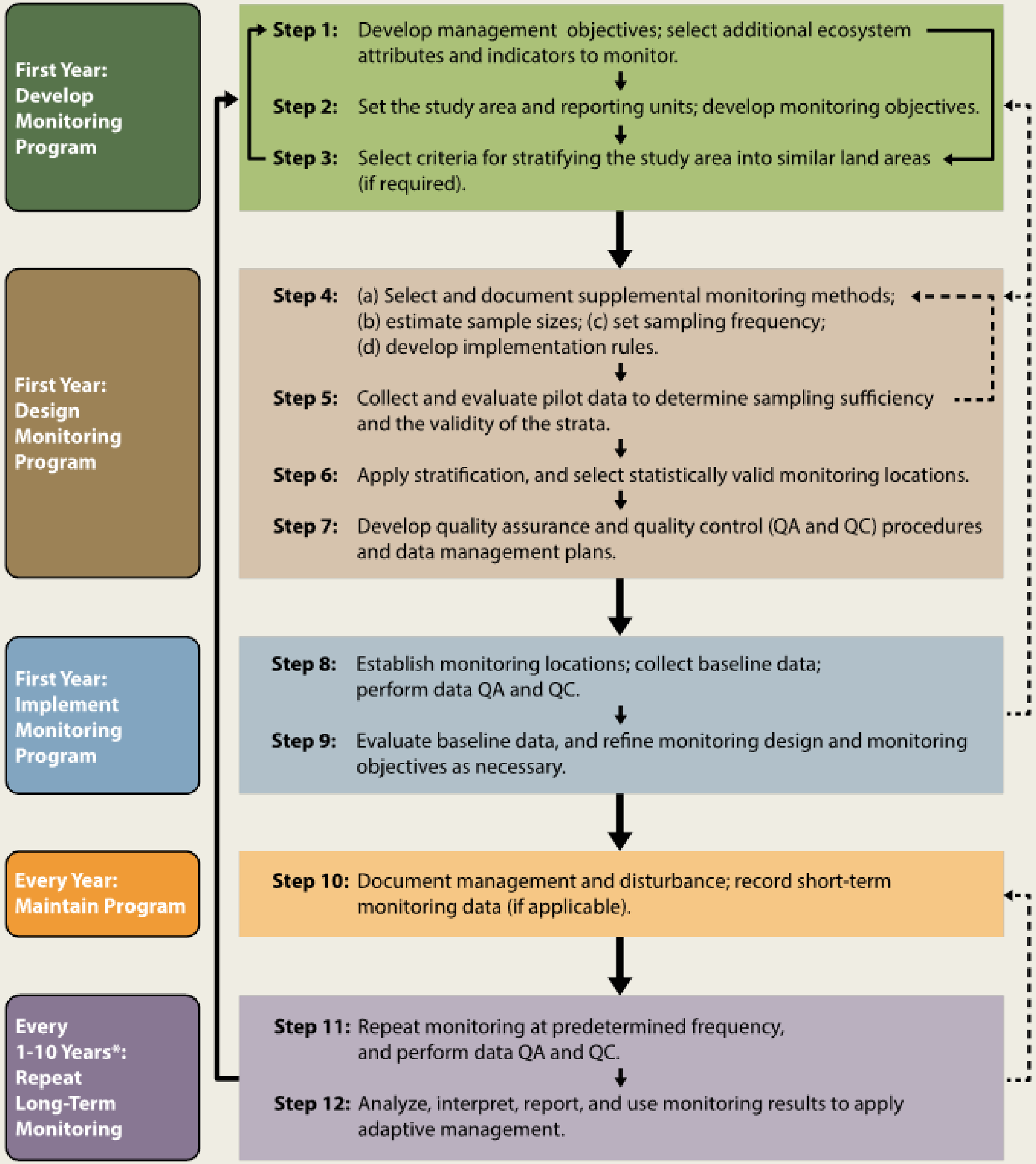


California Creek BDAs

Installed Sept 28 2016

California Creek Monitoring Plan

- Set Hypotheses
  - *Sediment Trapping*
  - *Water Storage*
  - *Reduced Erosion*
- Develop Monitoring Plan
  - *Methods, Equipment, Personnel*
  - *QA/QC*
- Implement Monitoring Plan
  - *Analyze and Synthesize Results*
  - *Adaptively Manage Monitoring Plan*
  - *Feedback into Adaptively Managing BDAs*



Monitoring Hypotheses

- BDAs are effective at trapping and aggrading sediment and reducing sediment loads downstream (as compared to natural beaver dams and/or no beaver dams).
- BDAs will create surface and groundwater storage that will attenuate the frequent peak flows that contribute to erosion during wet times of year, and increase base flows for fish habitat during dry times of year.
- BDAs are effective at reducing local streambank erosion in meander bends located downstream of the BDA structures by increasing roughness, reducing stream power and shear stress, and promoting flow deflection.

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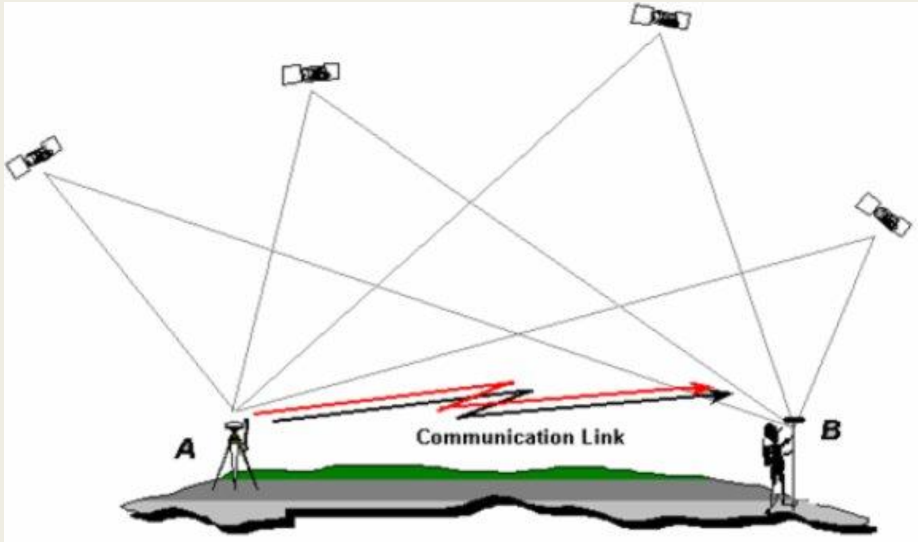
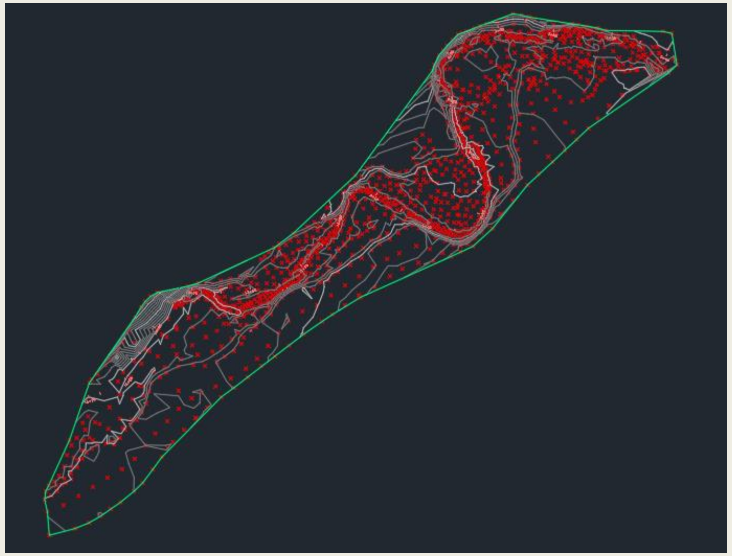
Monitoring Parameters



- Aggradation and Sediment Trapping
  - *Repeat Surveys, Sediment Probing, Sediment Size Analysis*
- Streamflow
  - *Staff Gage and Rating Curve*
- Groundwater Levels
  - *PVC wells*
- Streambank Erosion
  - *Repeat Surveys*

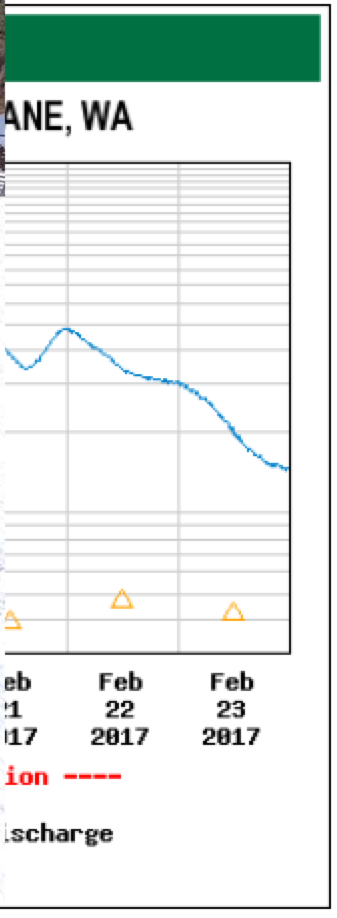
Monitoring Data - Fall 2016, Spring and Fall 2017

- Permanent Cross Section Surveys
- RTK Topographic Survey
- Flow and Groundwater Levels
- Longitudinal Profile Survey
- Soil Probing
- Pebble Counts
- Volumetric Sieve Analysis

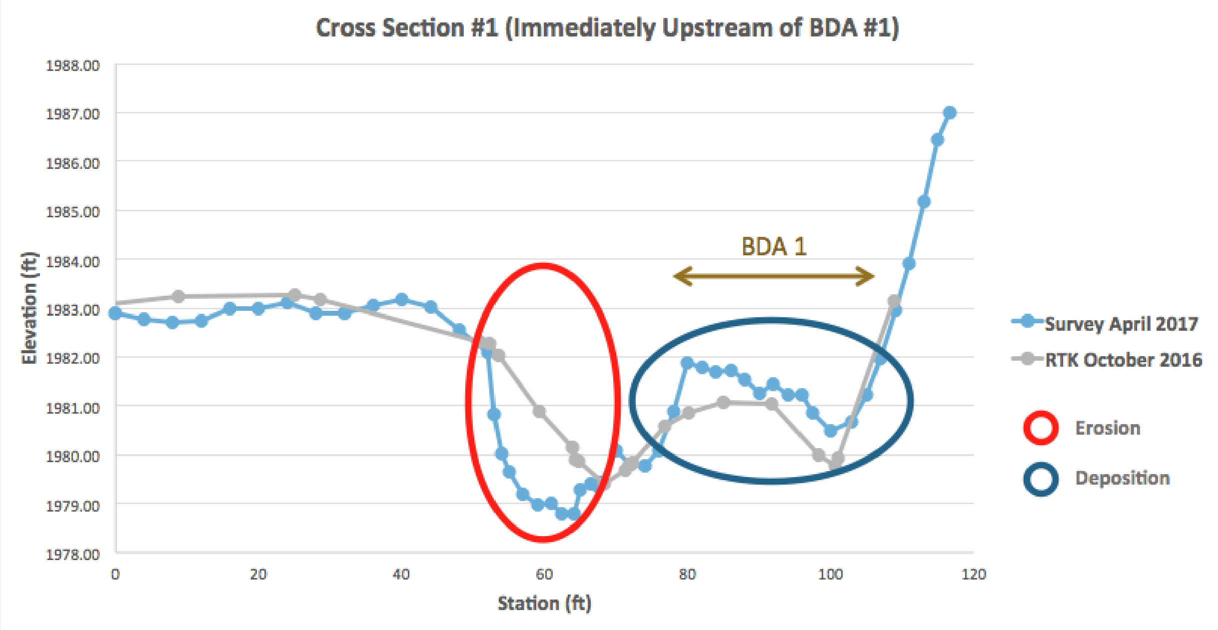


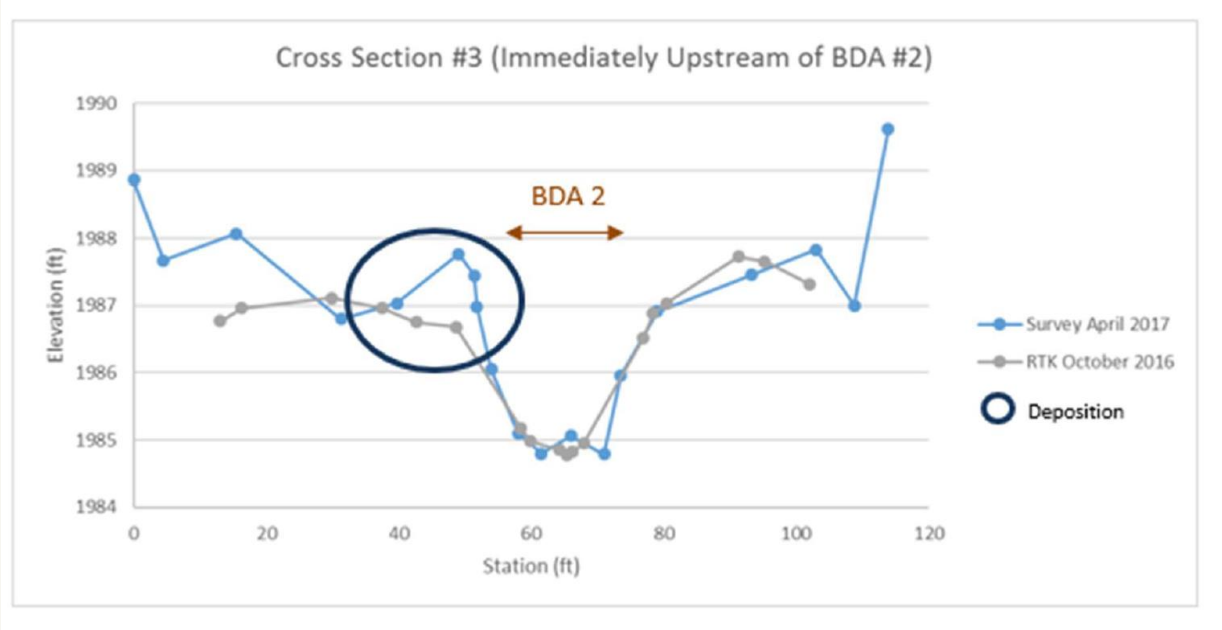
Spring Flood – Feb 16-17, 2017

- R
- H
- C

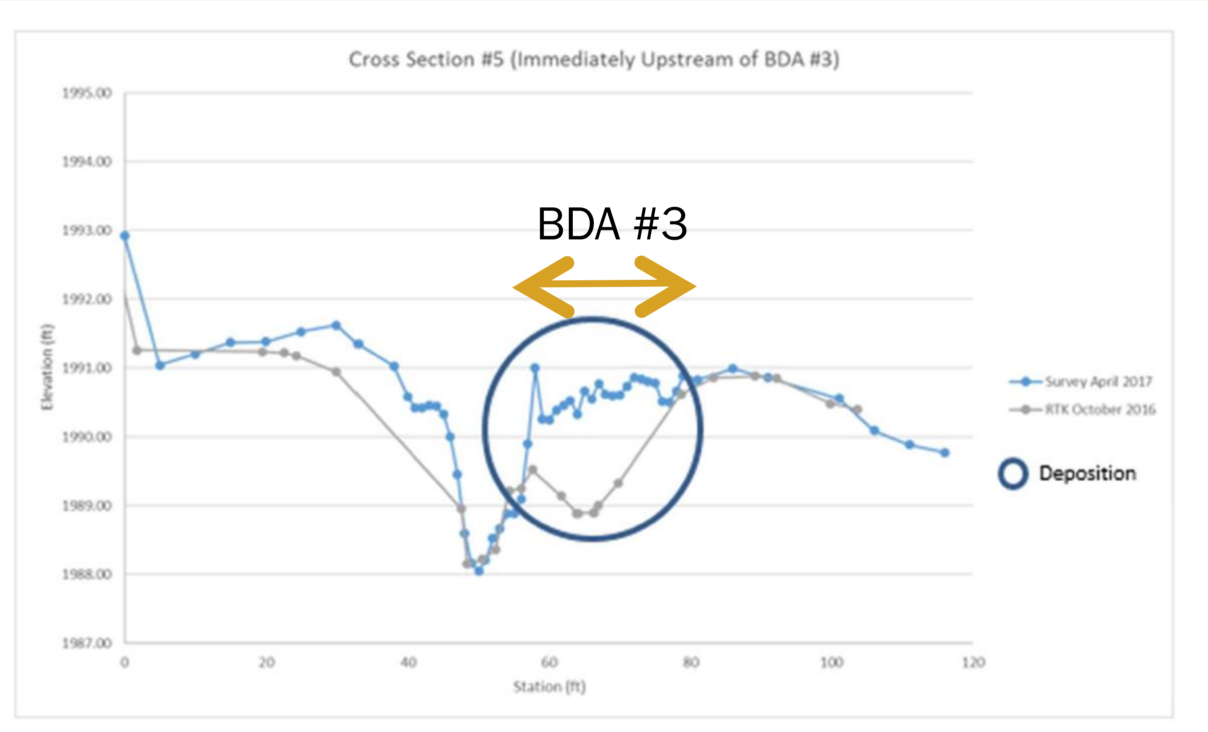


Monitoring Results - Cross Section Surveys

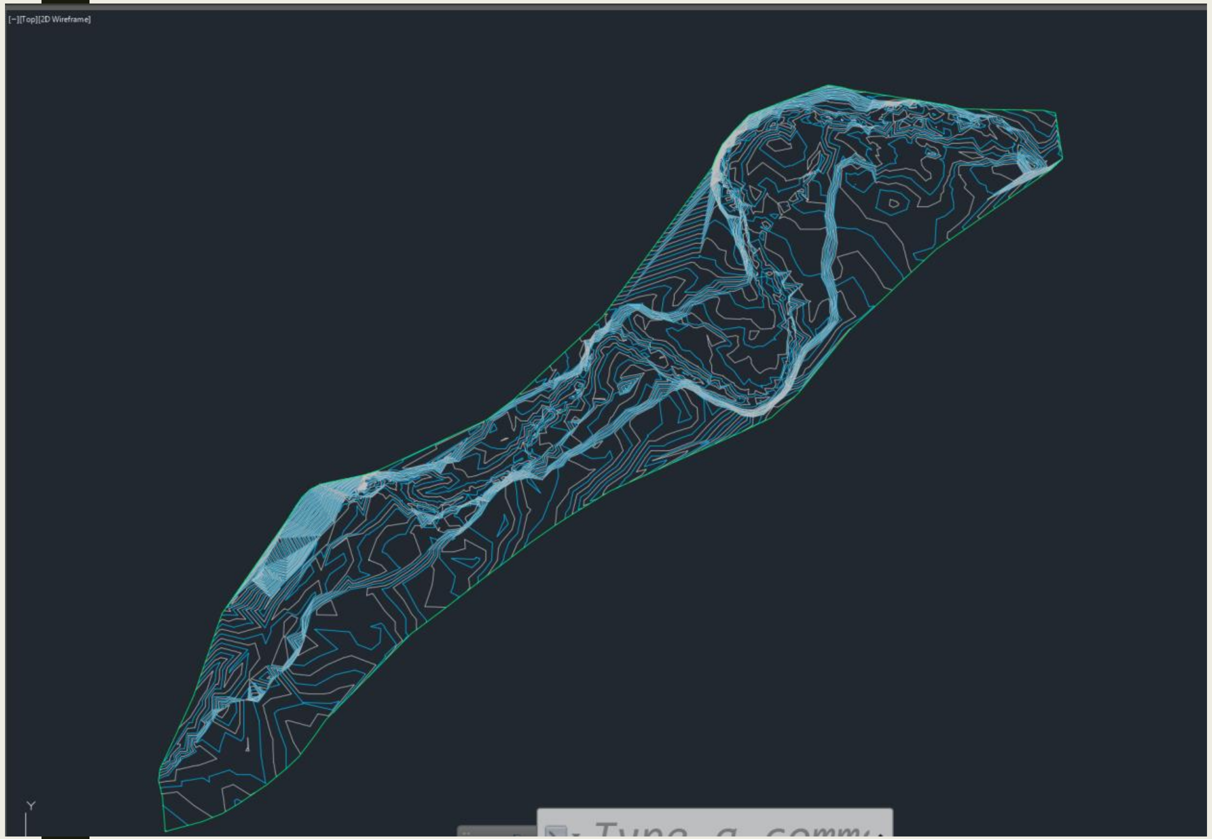




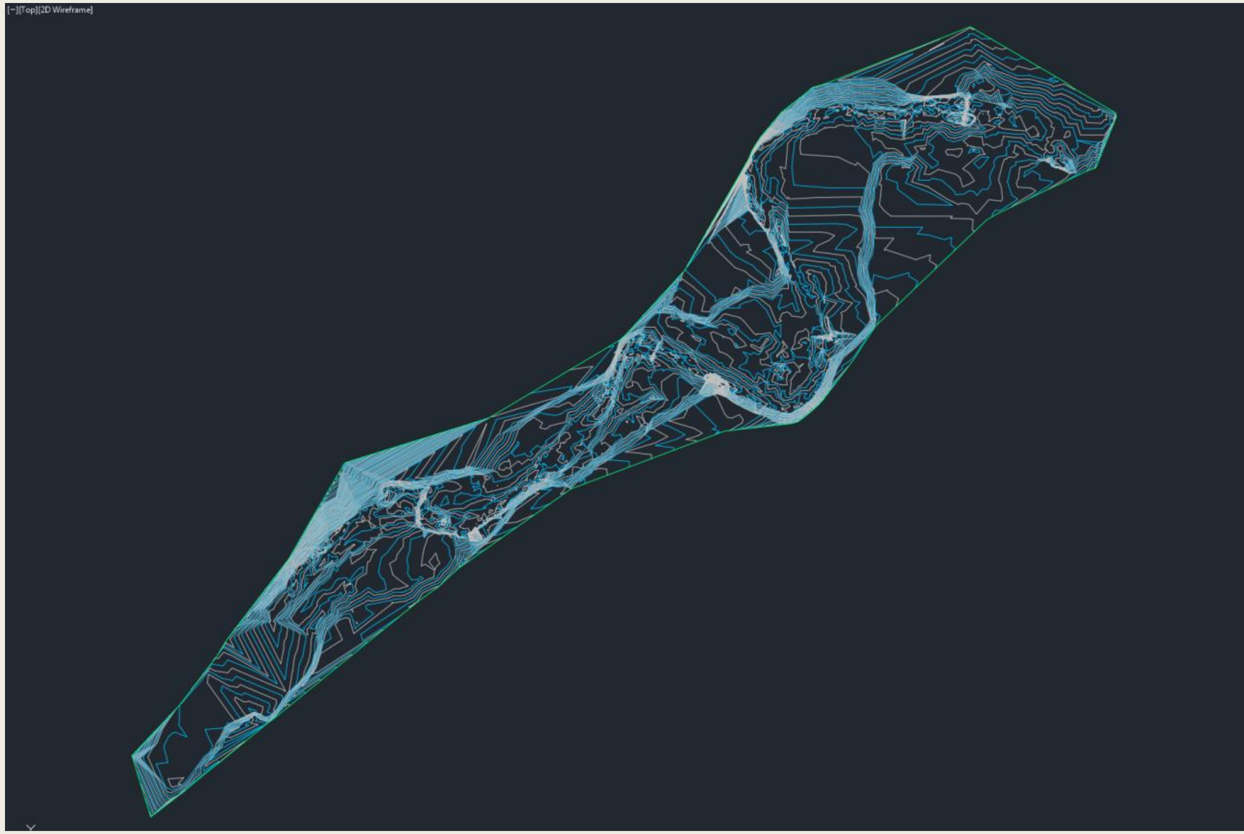
Monitoring Results - Cross Section Surveys



Monitoring Results – Repeat RTK Survey

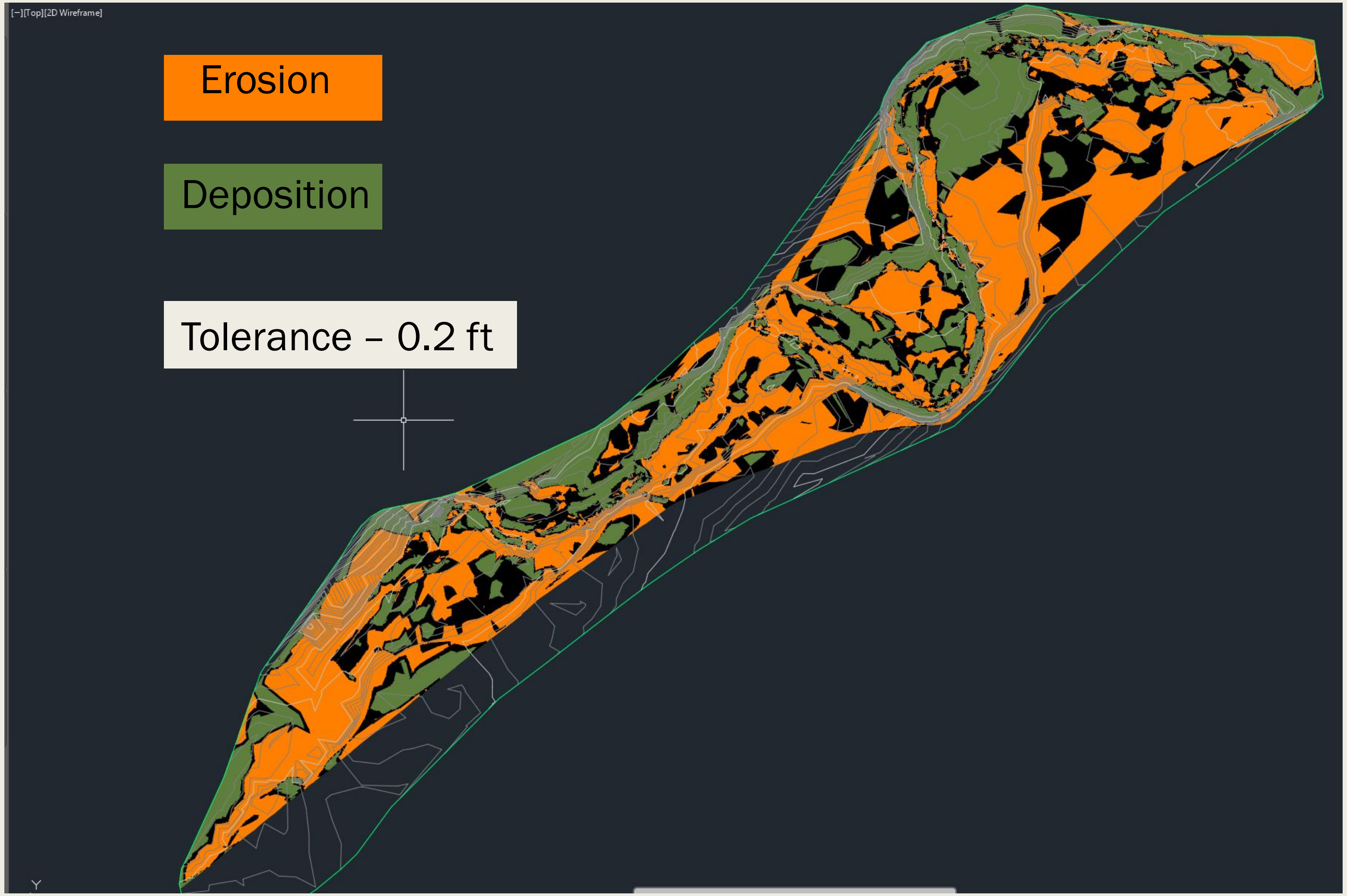


2016

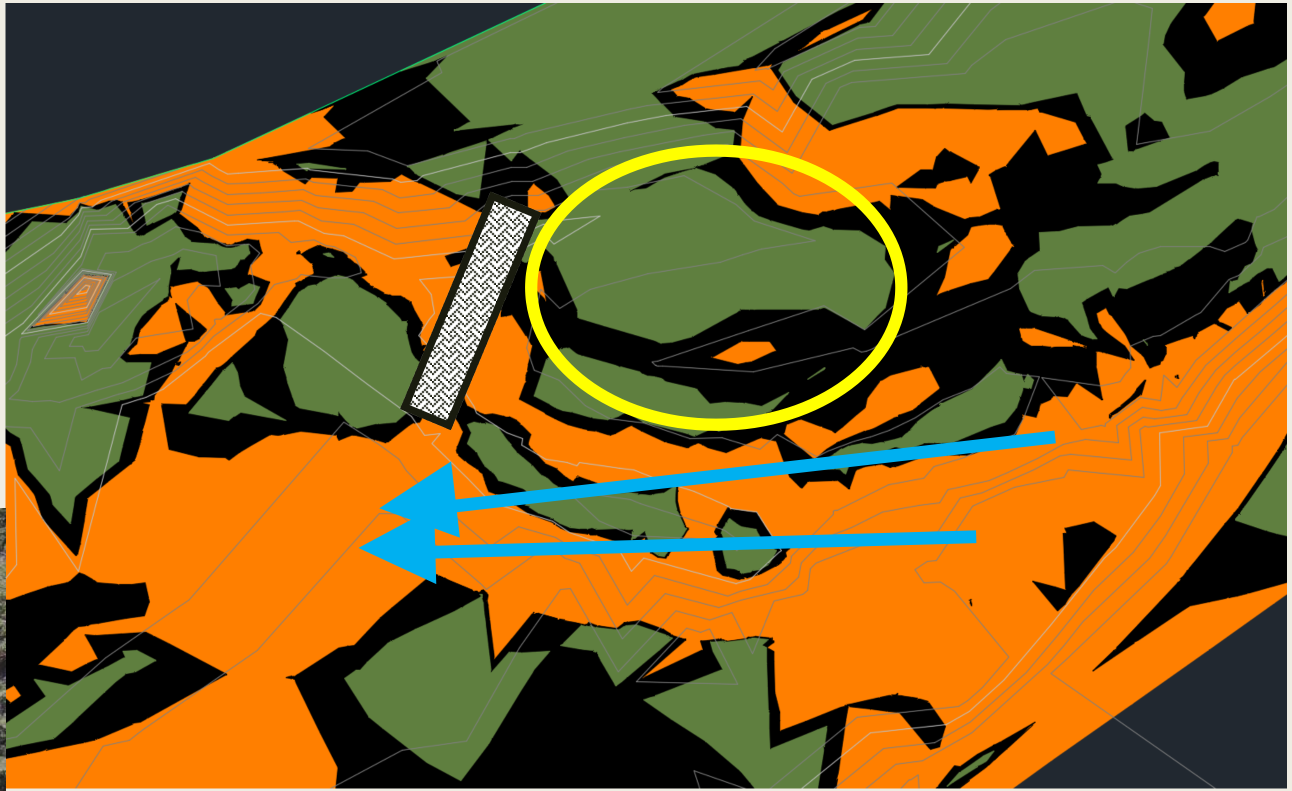


2017

Monitoring Results – Repeat RTK Surveys Comparison of 2016 and 2017

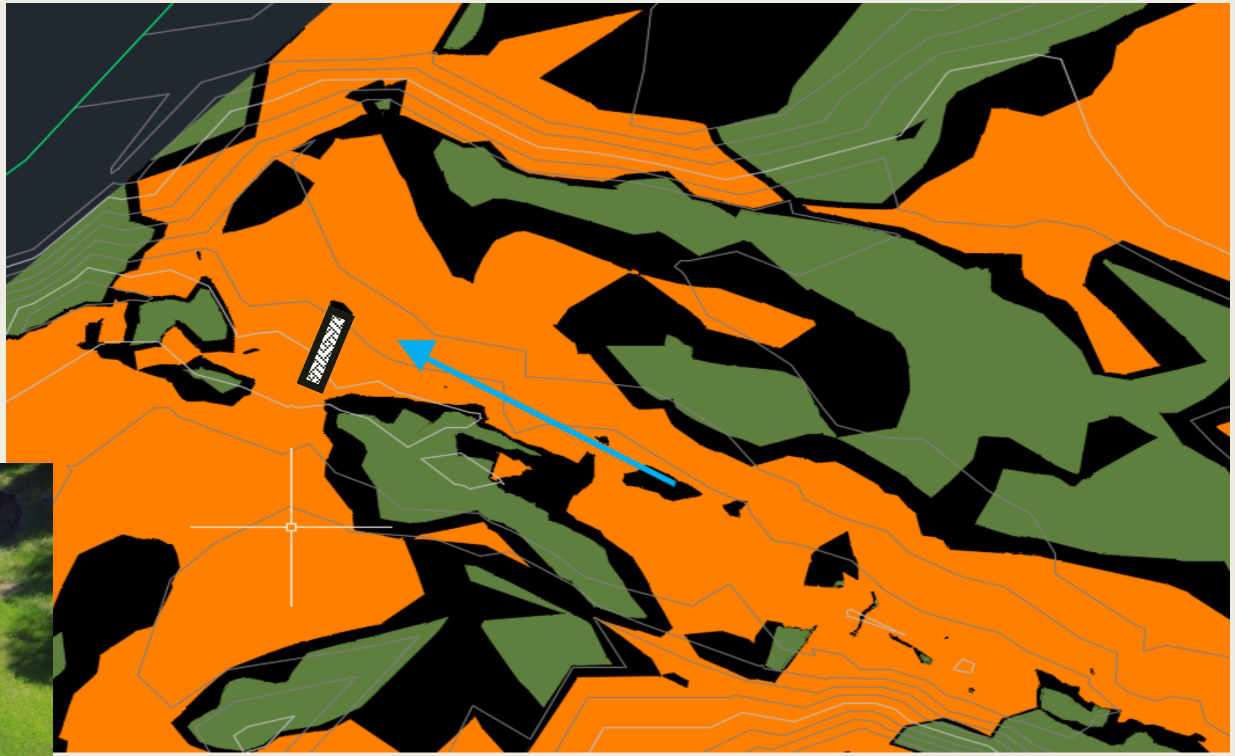


Monitoring Results – RTK Comparison



Avg, Deposition Upstream of BDA (ft)	Volume of Deposition Upstream of BDA (cu. ft.)
0.5	350

Monitoring Results – RTK Comparison

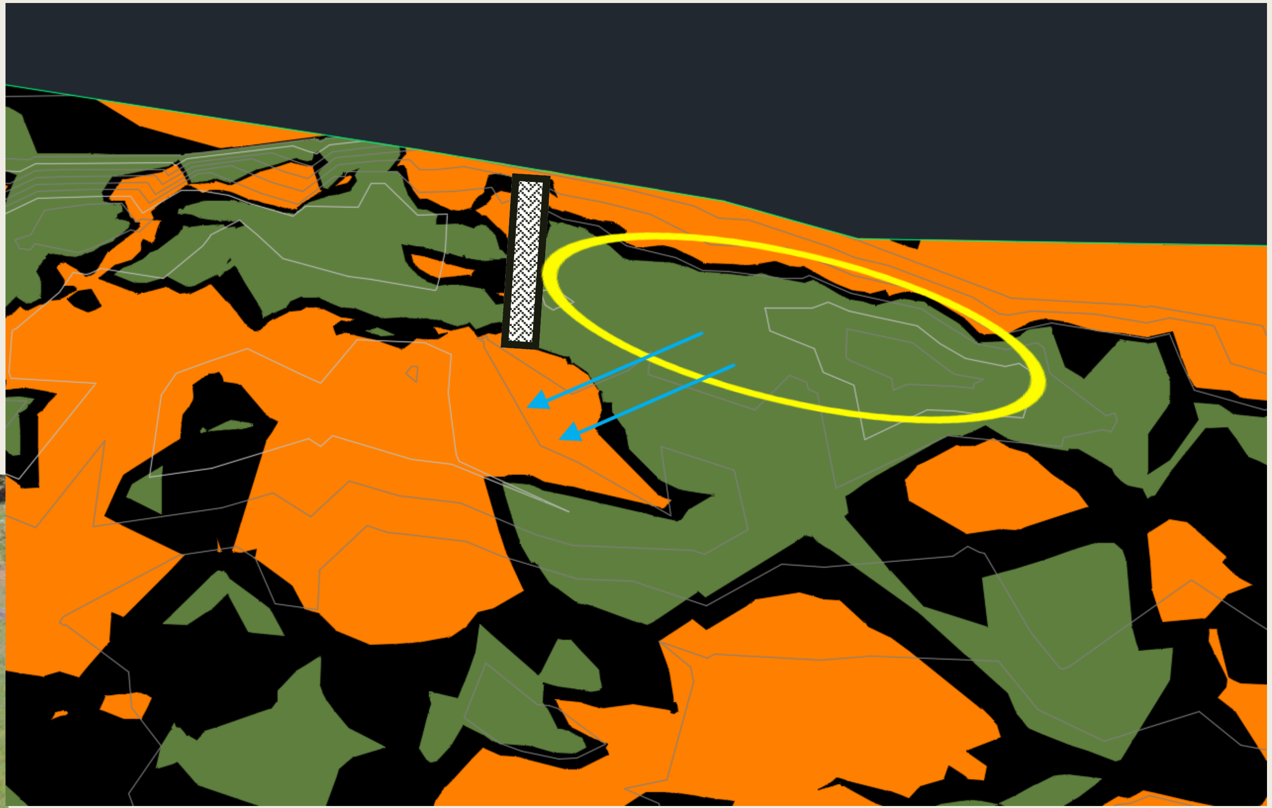


Avg, Deposition Upstream of BDA (ft)	Volume of Deposition Upstream of BDA (cu. ft.)
0	0

Monitoring Results – RTK Comparison

Avg, Deposition Upstream of BDA (ft)	Volume of Deposition Upstream of BDA (cu. ft.)
0.8	440

Monitoring Results – RTK Comparison

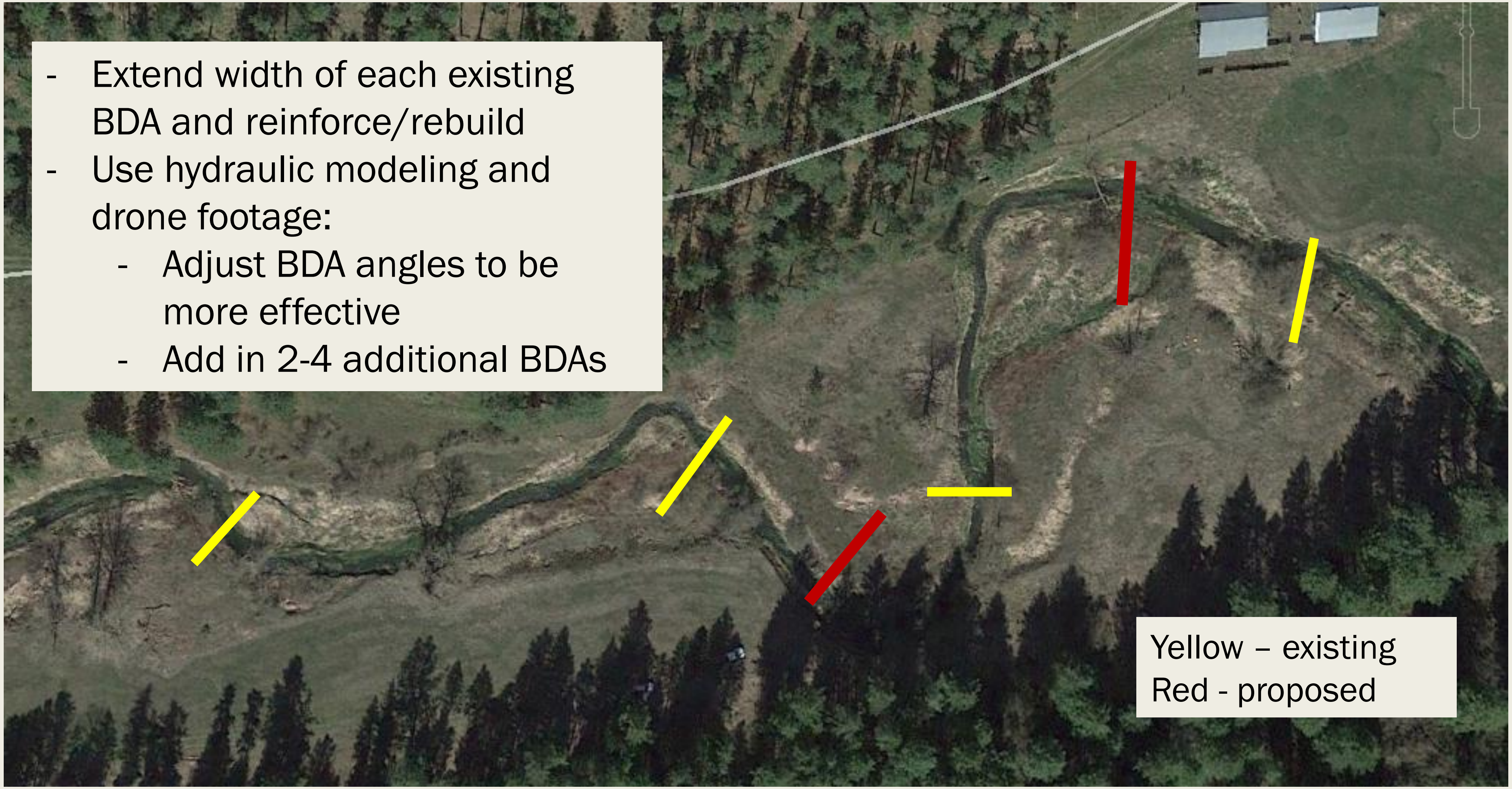


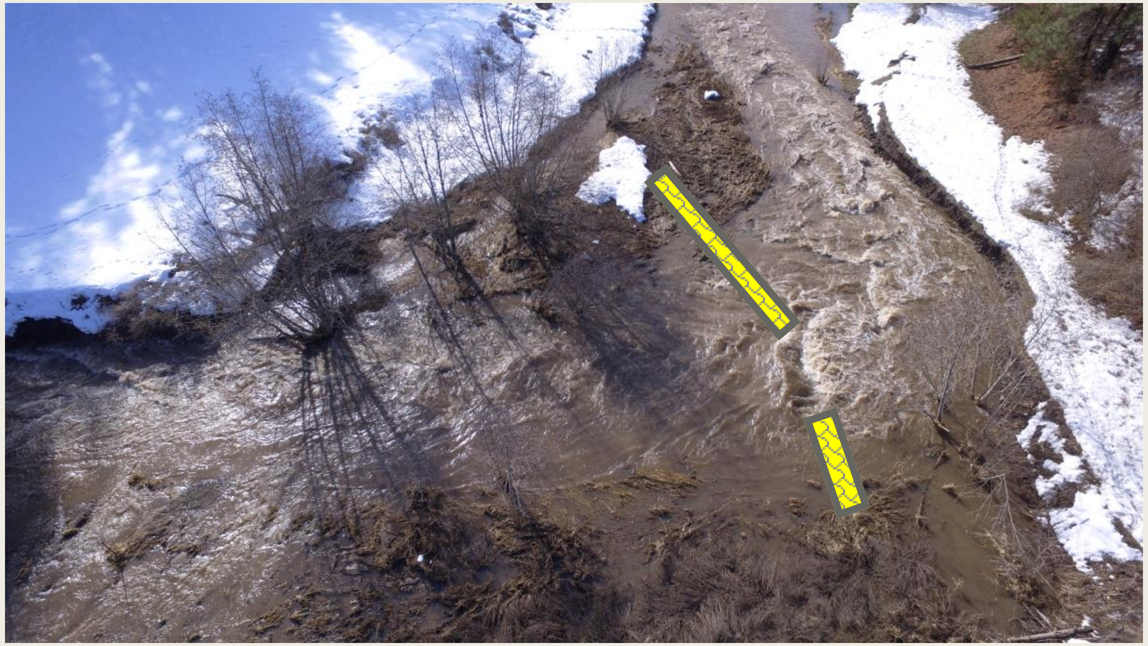
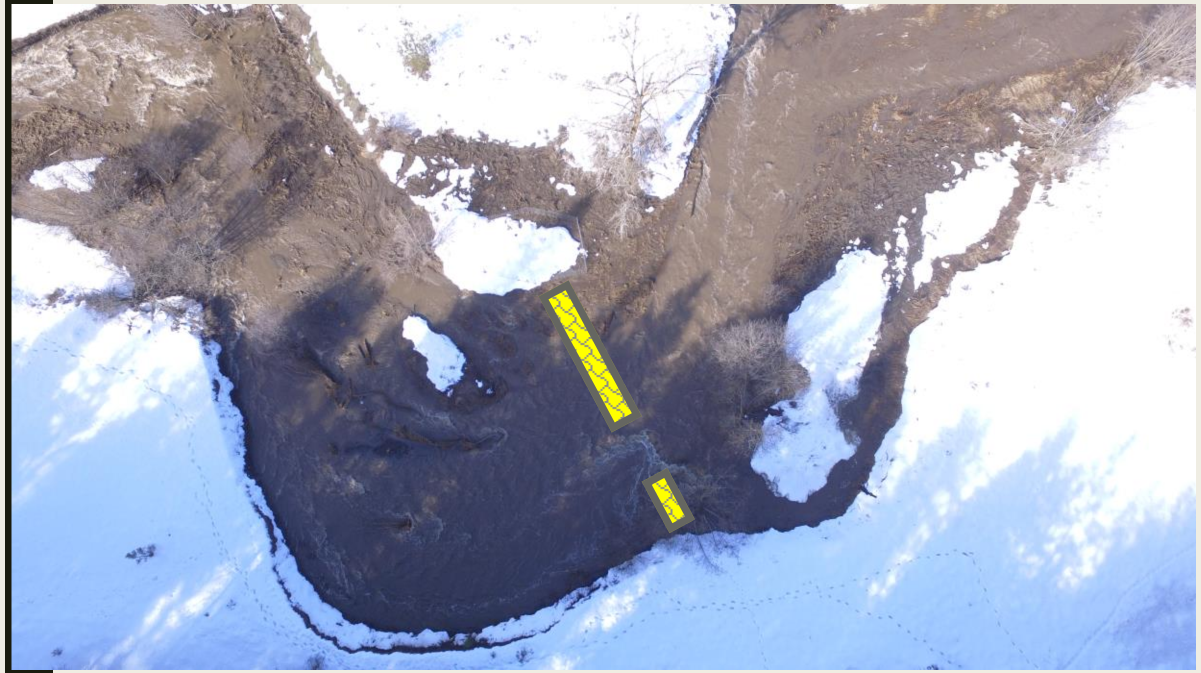
Avg, Deposition Upstream of BDA (ft)	Volume of Deposition Upstream of BDA (cu. ft.)
1.0	600

Flow and Groundwater

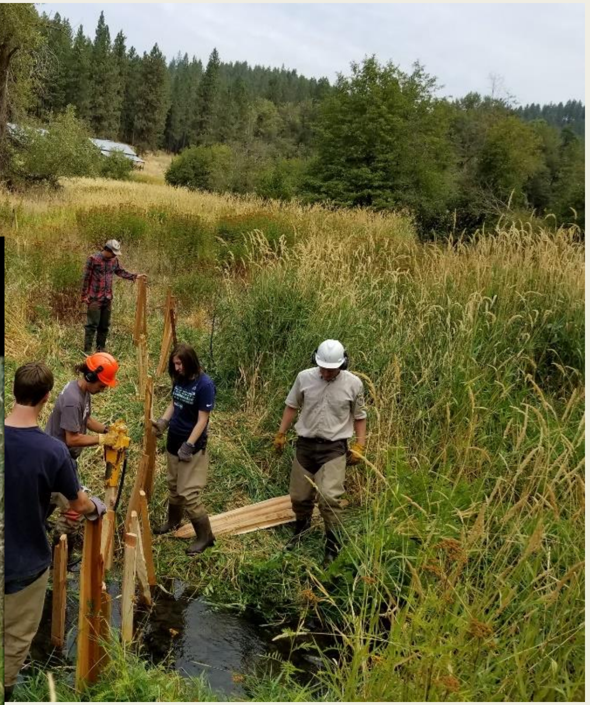
BDA Adaptive Management

- Extend width of each existing BDA and reinforce/rebuild
- Use hydraulic modeling and drone footage:
  - Adjust BDA angles to be more effective
  - Add in 2-4 additional BDAs




New BDA Installation



Conclusions and Lessons Learned

- Hypothesis Testing:
  - *BDAs trapped sediment behind their structure*
    - Preliminary estimates 300-600 cu.ft./year (rough estimate, more data needed)
  - *BDAs raise ground water levels and store water longer*
    - Observational evidence only of this over first year (more data needed)
  - *BDAs are slowing down and deflecting flow away from high banks and reducing bank erosion*
    - Observational evidence only over first year (more data needed)
- Lessons Learned
  - *Not built wide enough into floodplain and several were flanked*
    - Drone footage during floods can help with redesign (location and orientation) – should spread out over at least 100 year floodplain width
  - *Structure is quite stable even under high flows*
  - *Channel substrate material is important to BDA stability*
    - If very fine, easy to install posts, but more likely to scour under
    - If course, hard to install posts, and more likely to scour around
  - *Inexpensive to build and modify, low risk*

Some Considerations of BDA Risk

- BDAs are inexpensive!
  - *Less chance of wasting money on ineffectual restoration efforts than with more standard—and more expensive—restoration approaches.*
- BDAs are small and use natural materials
  - *Less risk to downstream habitat or infrastructure than with other treatments*
- BDAs are meant to be temporary features on the landscape and may breach or fail completely during high-flow events and contribute to flood peaks.
  - *Can design posts to reinforce and reduce the potential for failure, where failure could have severe consequences to downstream infrastructure.*
  - *Bring in an engineer or consider not using BDAs in high consequence areas!*