# Yakama Nation

## Upper Columbia Habitat Restoration Project

# Quantifying Geomorphic Response to Helicopter Restoration in the Twisp River

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inter·fluve
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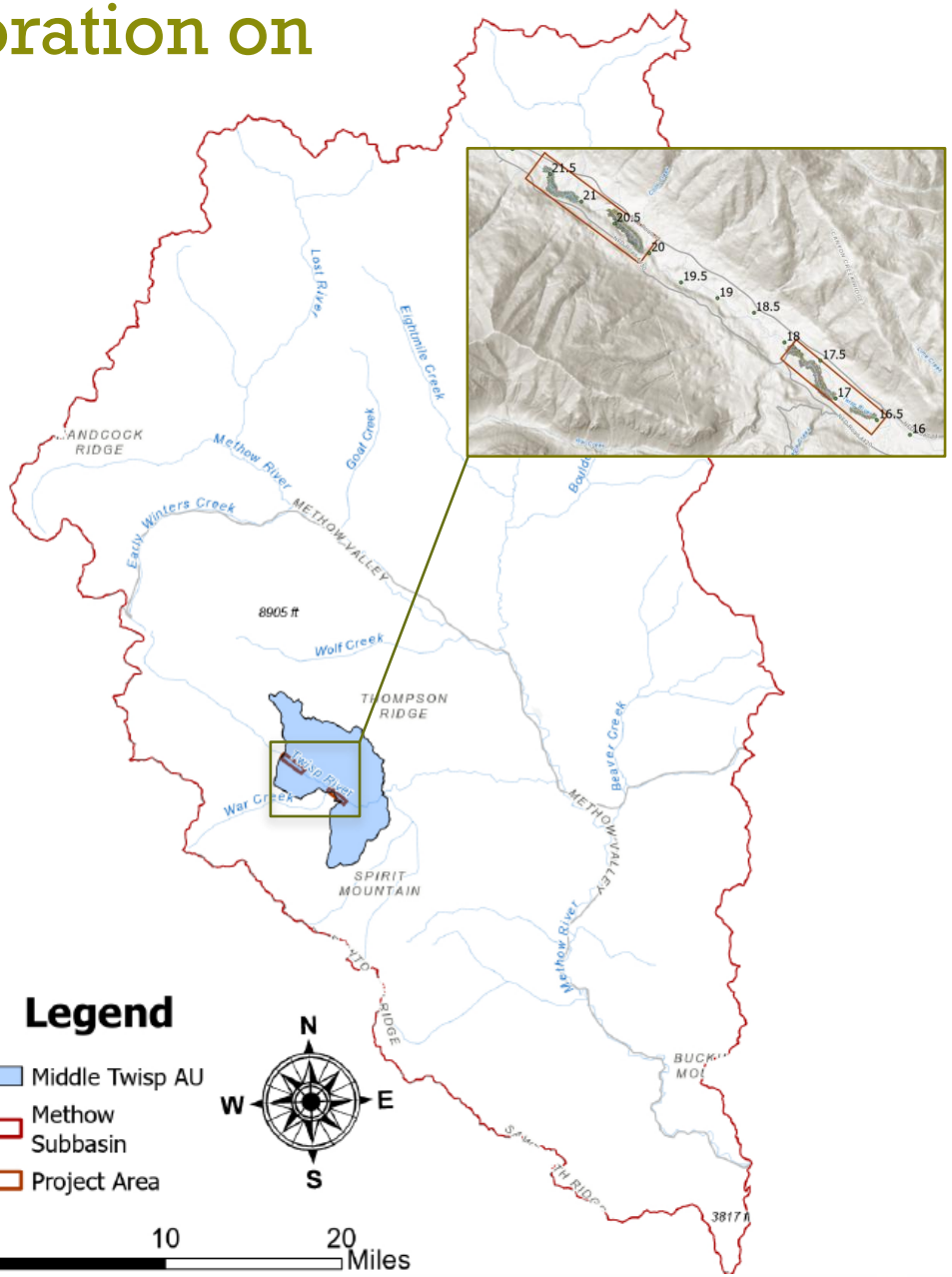
# Large Scale Wood Restoration on the Twisp River

**2022 - Tribal Sponsored Projects**

- Mystery Reach Project – 2.0 mi.
- War Creek Reach Project – 1.0 mi.
- Horseshoe Large Wood – 0.7 mi.
- Lower Little Bridge Creek – 1.5 mi.
- Upper Twisp Project – 3.9 mi.
- Upper Little Bridge Creek – 1.9 mi.

Total 11.0 miles

*Approximately 3,000 pieces of LW*



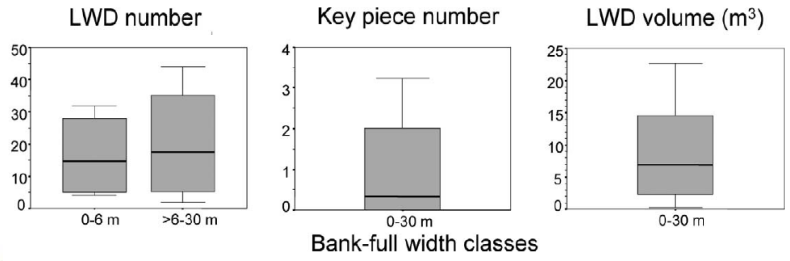
# Restoration Project Background

- GOAL
  - Increase LW loading to restore natural riverine processes that create and maintain complex fish habitat.
- OBJECTIVES
  - Use the best available data to develop wood loading and structure targets
  - Construct LW structures to create geomorphic change and habitat diversity.

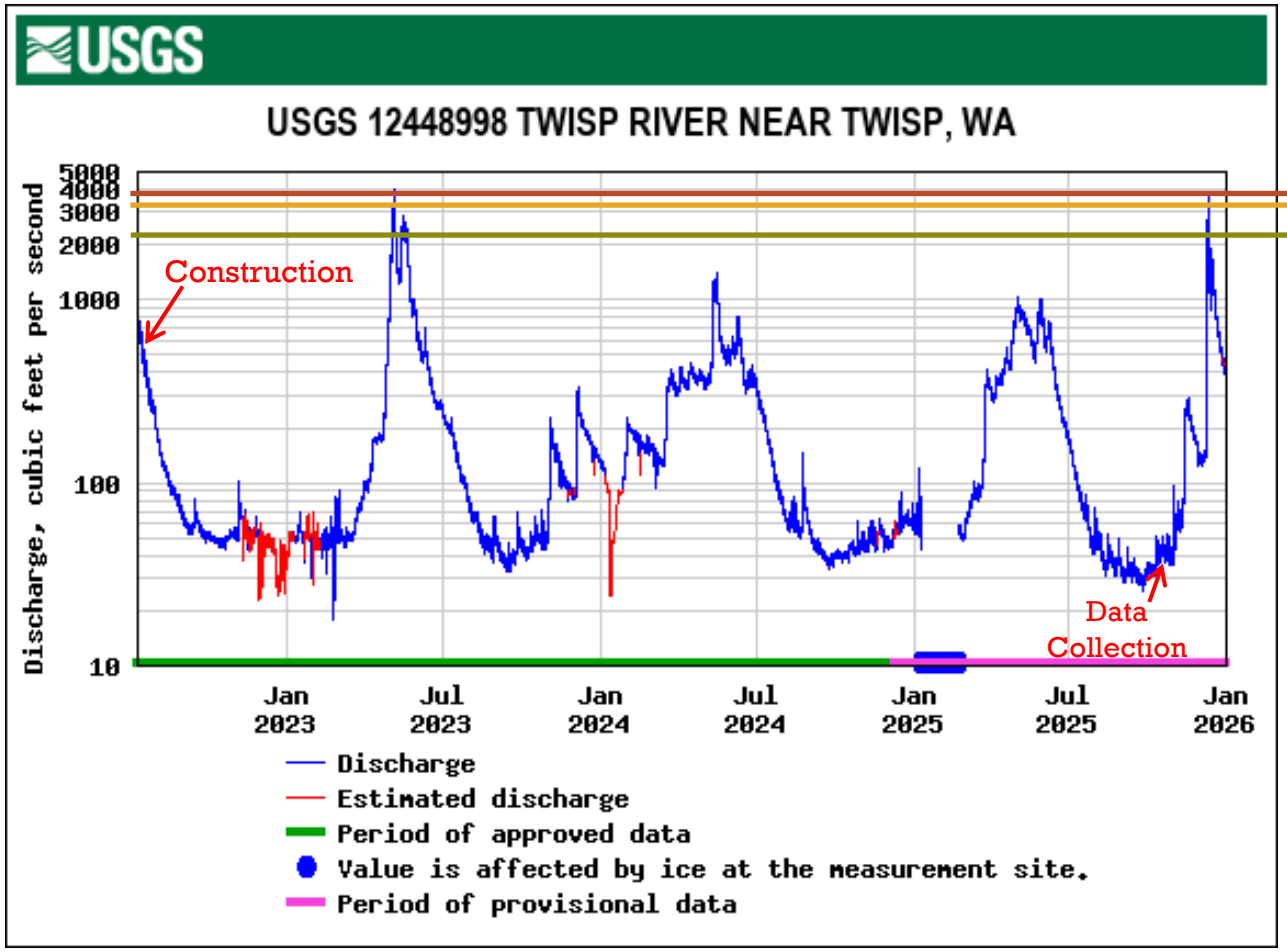
**A Regional and Geomorphic Reference for Quantities and Volumes of Instream Wood in Unmanaged Forested Basins of Washington State**

MARTIN FOX*
*Post Office Box 569, Roslyn, Washington 98941, USA*

SUSAN BOLTON



# Site History / Evolution




Q10 (3,890 CFS)
Q5 (3,160 CFS)
Q2 (2,120 CFS)

# Monitoring History

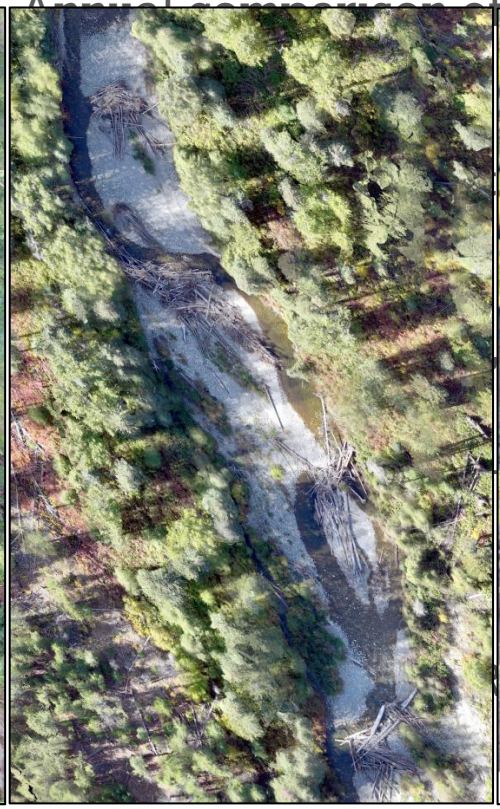
- Repeat drone imagery
- Desire to quantify the observed change for adaptive management planning
- Annual review of hydrologic conditions

Mystery Reach and War Creek Reach
Habitat Restoration Project

November 2020

August 2022

October 2023



November 2025

# Why SfM?

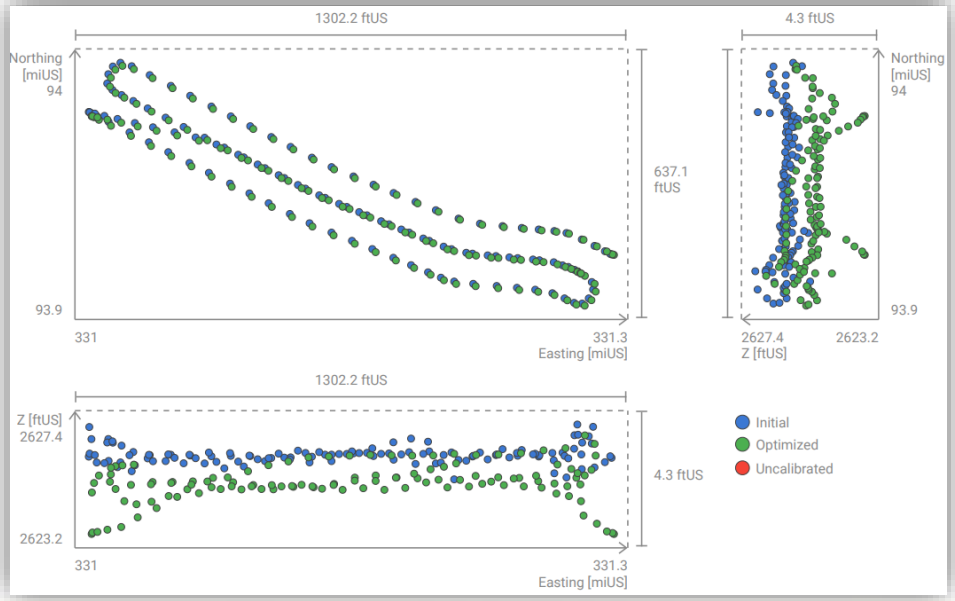
- Goal of SfM Project
  - Quantify geomorphic changes
    - Evaluate project effectiveness
    - Inform adaptive management strategy

- Objectives
  - Identify locations of streambank erosion and quantify recruitment volumes
  - Identify depositional areas and stored volumes
  - Quantify changes to habitat metrics

# Methodology

## Data Collection

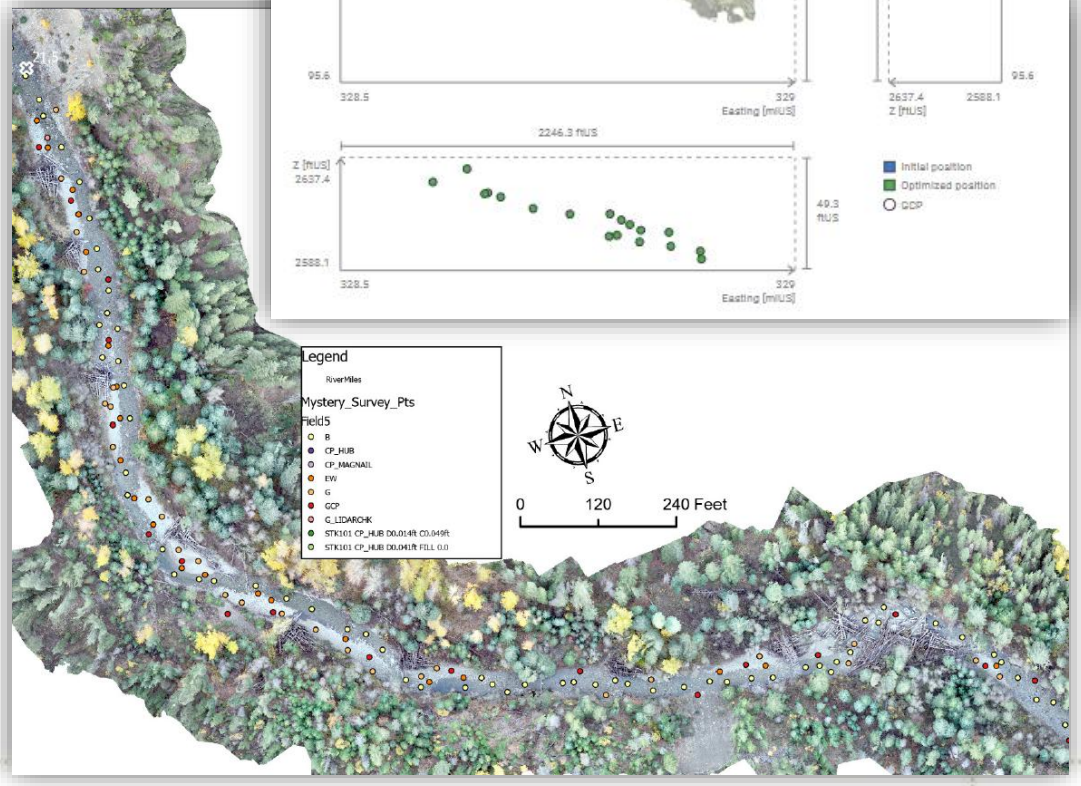
- Equipment
  - RTK GPS
  - UAS: DJI Mavic 3 Enterprise
  - Flight settings: 300 feet AGL; 80% overlap front & side
- Topographic survey
  - Survey control network
  - Set temporary ground control points (GCP)
  - Opportunistically survey the channel – evaluate accuracy
- Collect aerial imagery of each site to develop orthomosaic imagery, DSMs

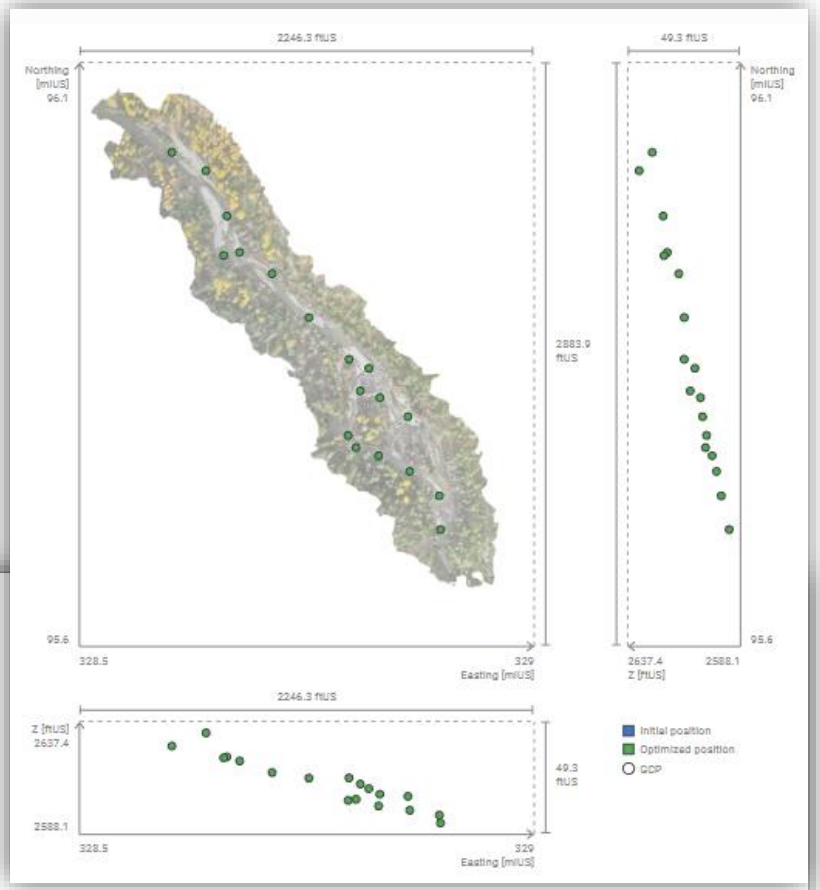


# Methodology

## Data Processing

- Process aerial imagery to generate orthomosaic imagery, DSMs
  - Software: Pix4D Matic
  - Key processing details:
    - GCP picked in 15 images
    - Minimum 4 images per point cloud point
    - Spatial resolution of data products: ~0.07–0.09 ft/pix



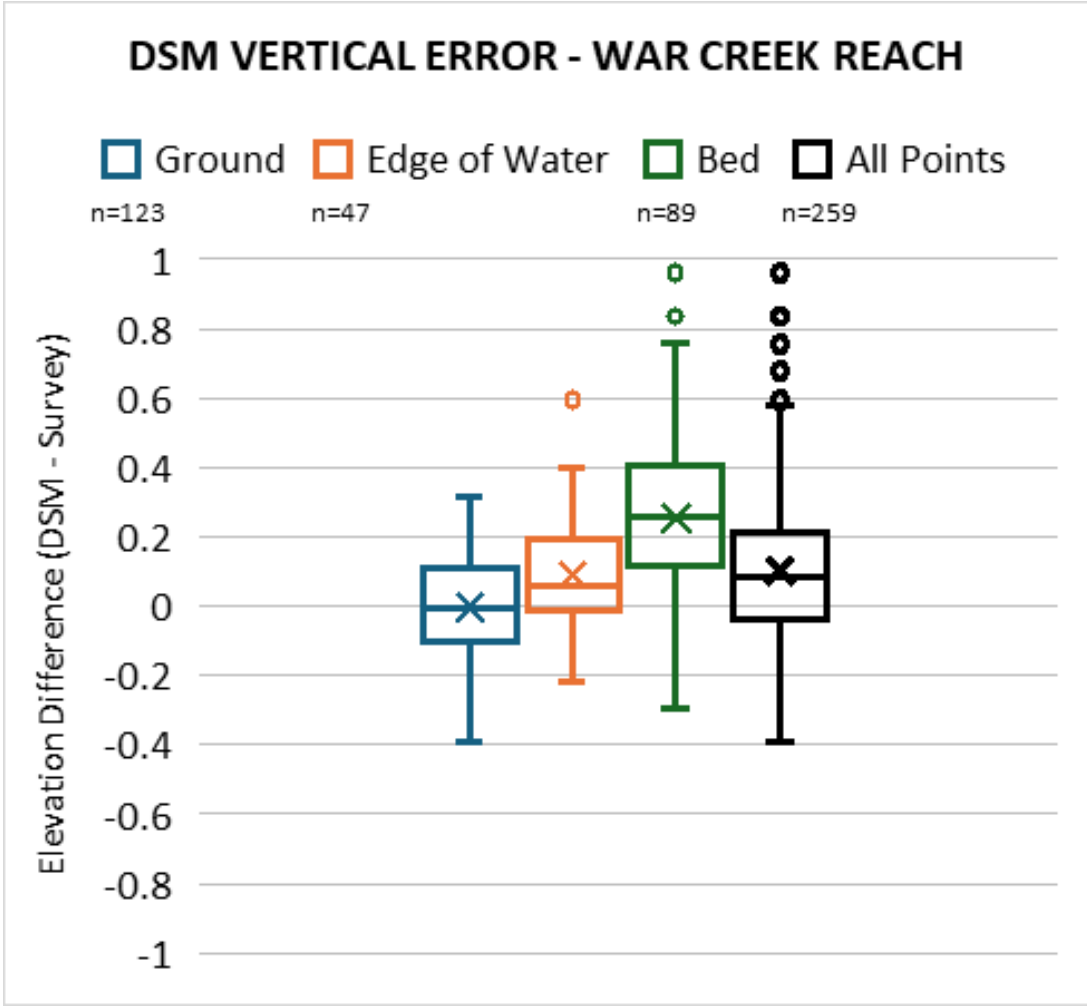



# Methodology
## Data Analysis

- Evaluate performance of DSMs
  - Compare DSM and survey elevations; calculate vertical errors
- Clip DSMs to areas of bare ground or streambed
  - Delineate ROI based on imagery and elevation data; clip to ROI
- Create elevation & volume differencing data products
  - Difference DSM and LiDAR DEM (2025 DSM minus 2022 LiDAR)
- Utilize dZ & dV data products to evaluate geomorphic change and habitat formation at the project sites

# DSM Accuracy and Performance

| Parameter / Dataset | DEM/DSM Vertical Error Evaluation | | |
|---|---|---|---|
| | Check Points | Avg. Error (ft) | RMSE (ft) |
| War Creek Reach DSMs | 259 | 0.1 | 0.24 |
| Mystery Reach DSMs | 400 | 0.17 | 0.32 |
| *2022 LiDAR Bare Ground* | *54* | *-0.02* | *0.09* |
| 2022 LiDAR Bathymetry | 350 | 0.13 | 0.23 |
| **War/LiDAR Combined Error** | - | **0.23** | **0.47** |
| **Mystery/LiDAR Combined Error** | - | **0.3** | **0.55** |



# Results

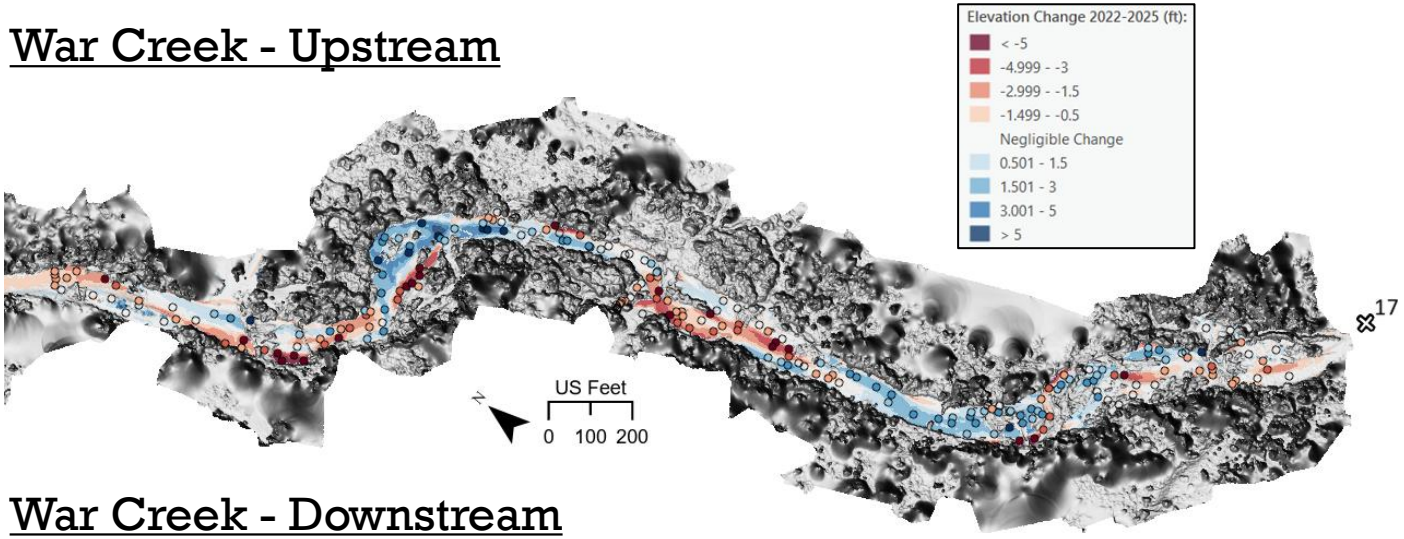
## Geomorphic Response

- Geomorphic Processes
  - Bed response
    - Erosion
    - Deposition
  - Channel-Floodplain exchange
    - Bank erosion, channel avulsion, floodplain formation
  - Sediment transport
    - sorting and storage

# Geomorphic Response Overview

## War Creek

### War Creek - Upstream



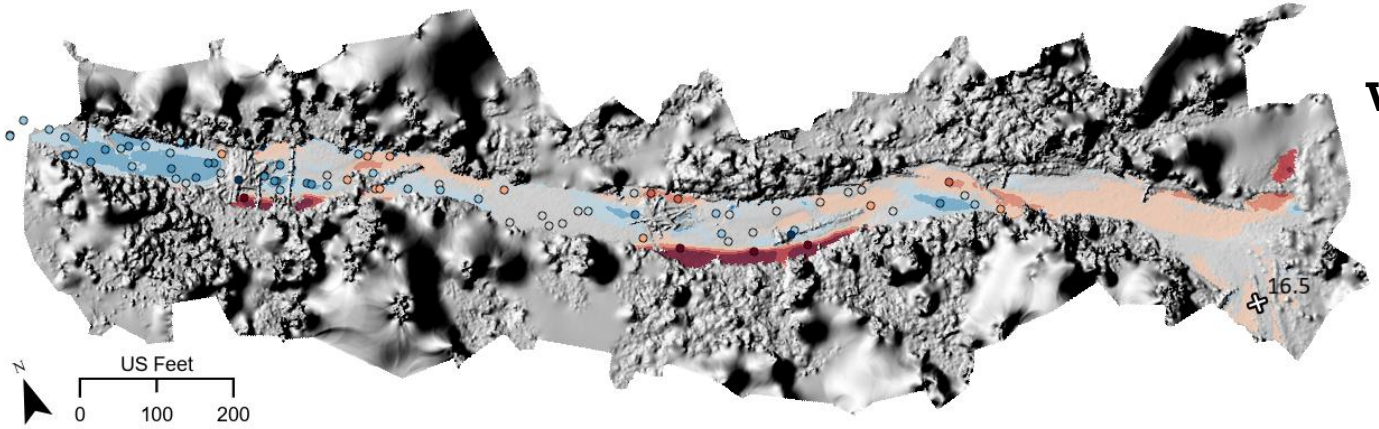

**War Creek Upstream Summary of Change**

Deposition: 6,000 $yd^3$

Erosion: 6,000 $yd^3$

Net Change: 0 $yd^3$

### War Creek - Downstream




**War Creek Downstream Summary of Change**

Deposition: 1450 $yd^3$

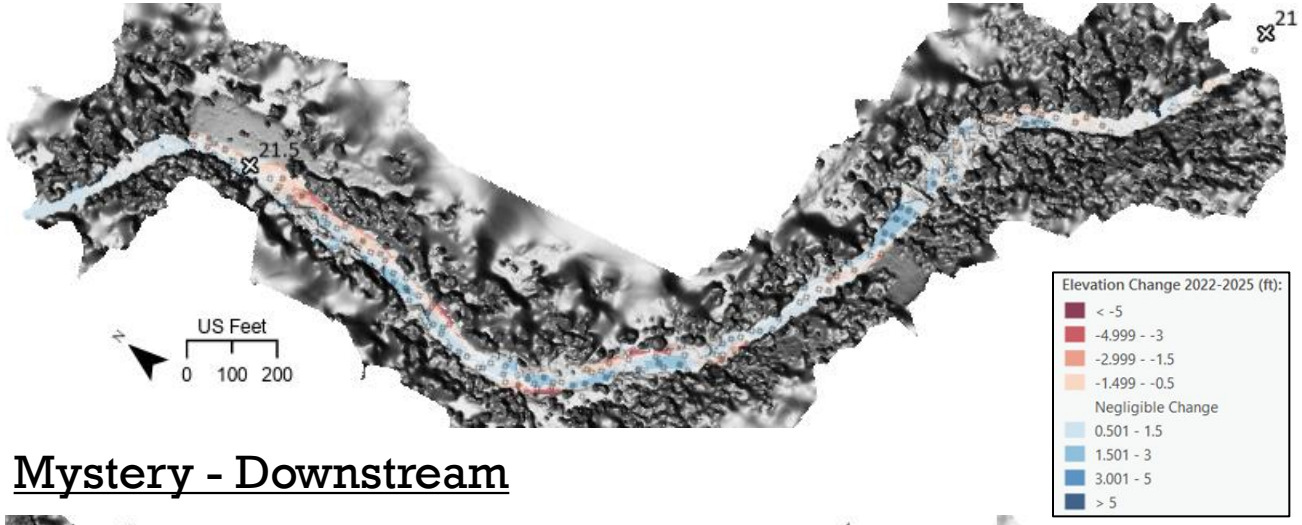
Erosion: 2,500 $yd^3$

Net Change: -1,050 $yd^3$

# Geomorphic Response Overview

## Mystery Reach

### Mystery - Upstream



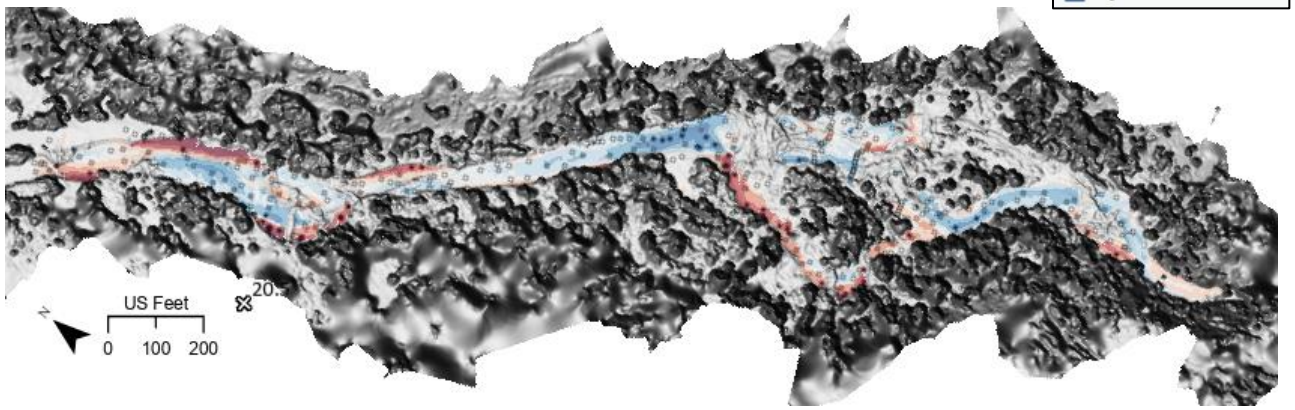

**Mystery Upstream Summary of Change**

Deposition: 3,360 $yd^3$

Erosion: 1,410 $yd^3$

Net Change: 1,950 $yd^3$

### Mystery - Downstream



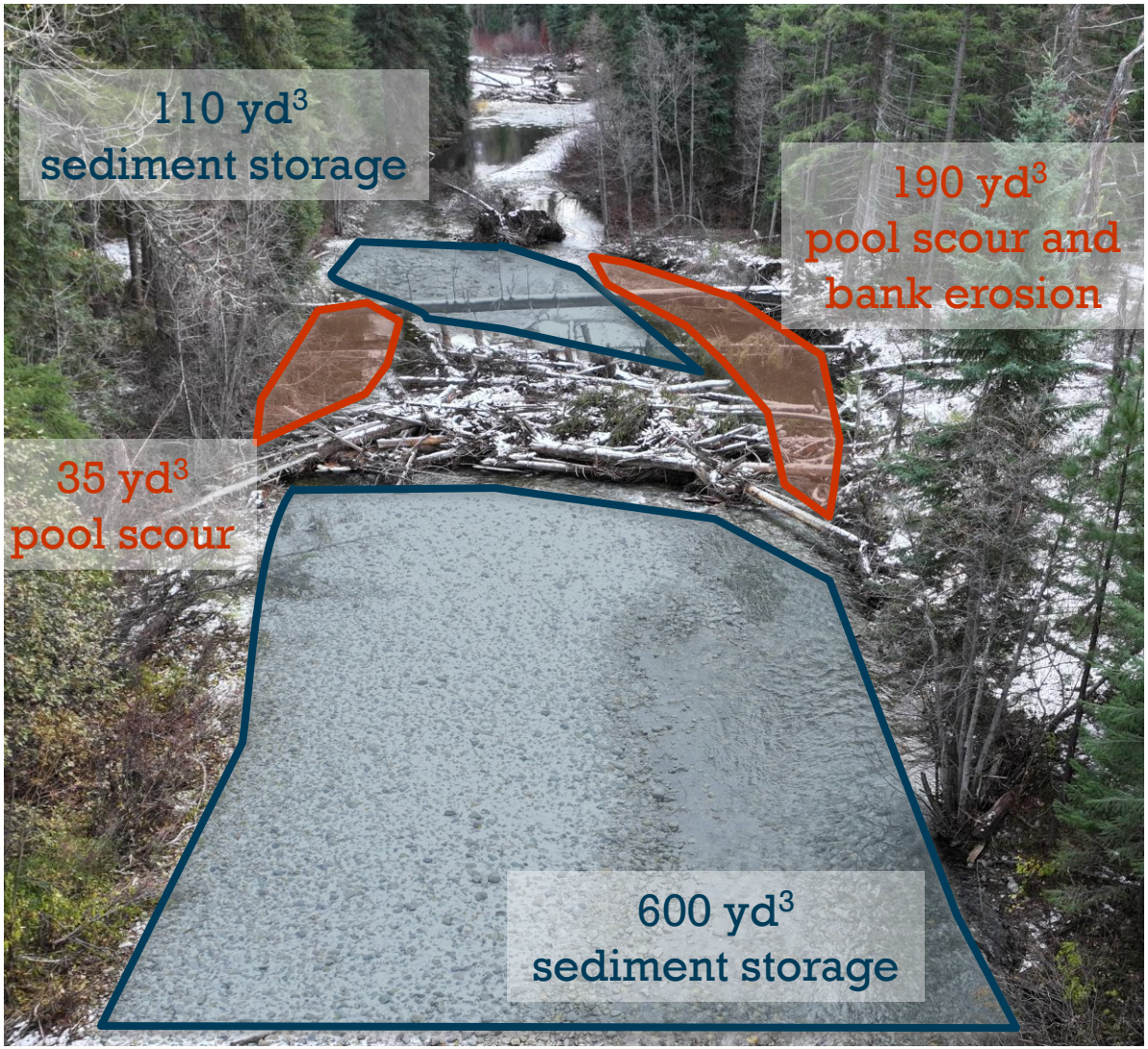

**Mystery Downstream Summary of Change**

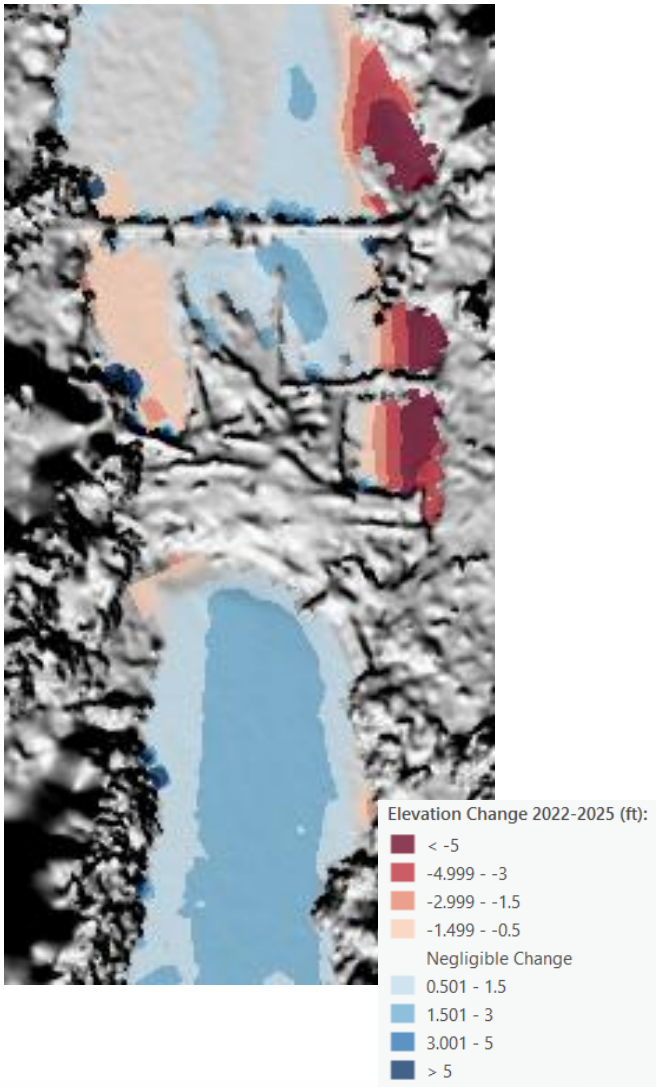
Deposition: 5,420 $yd^3$

Erosion: 5,030 $yd^3$

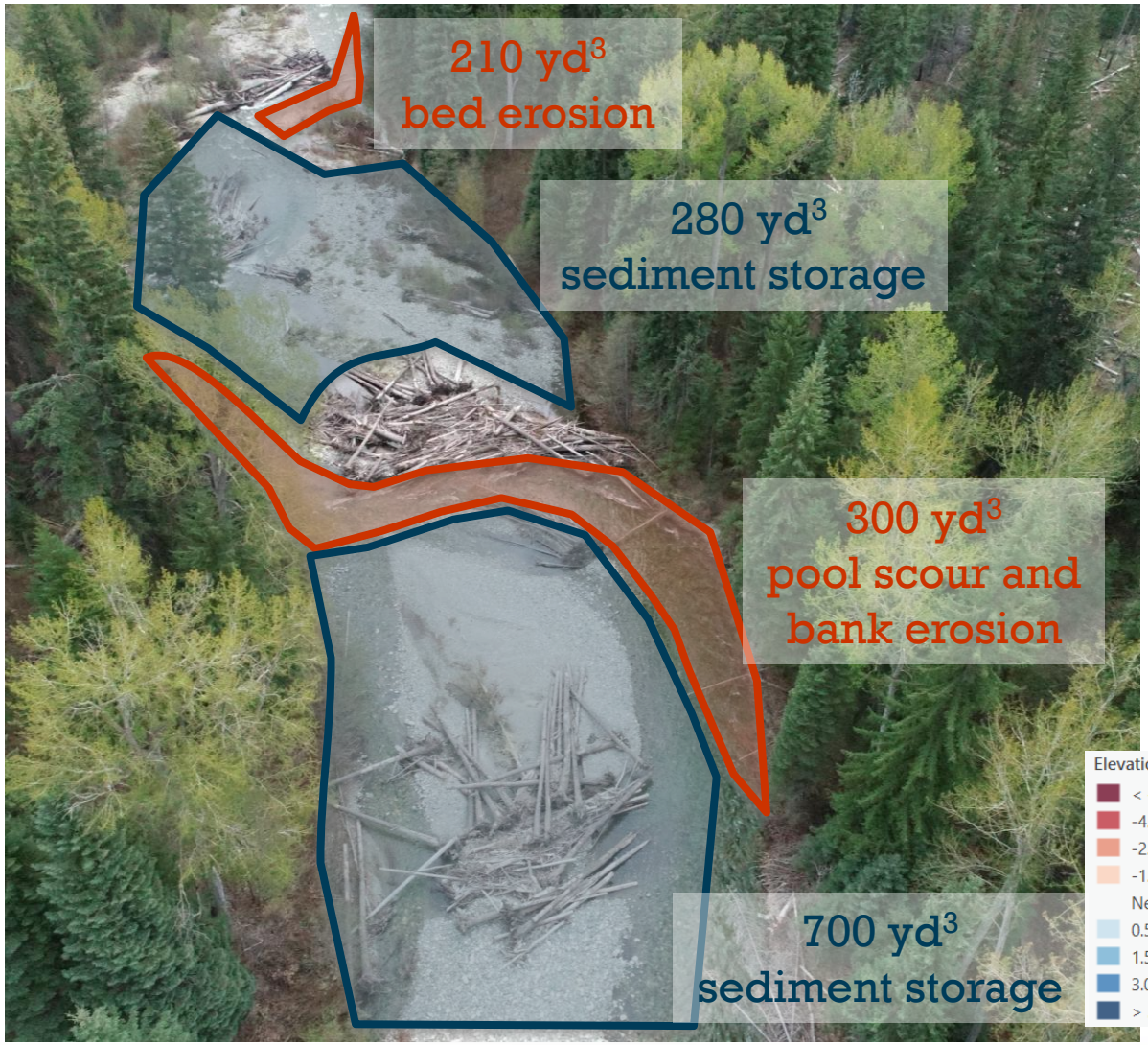
Net Change: 390 $yd^3$

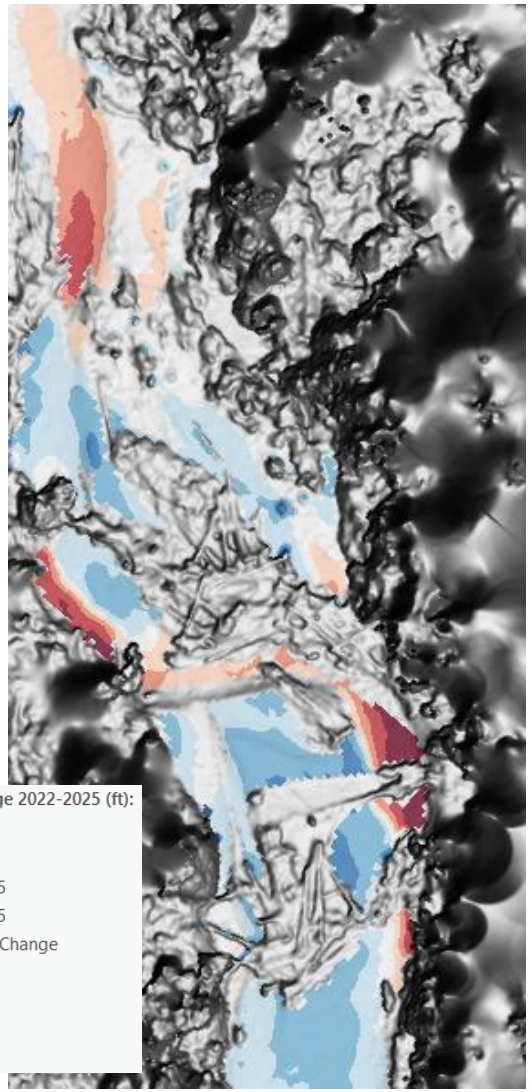
# Local Channel Response – Ex. 1



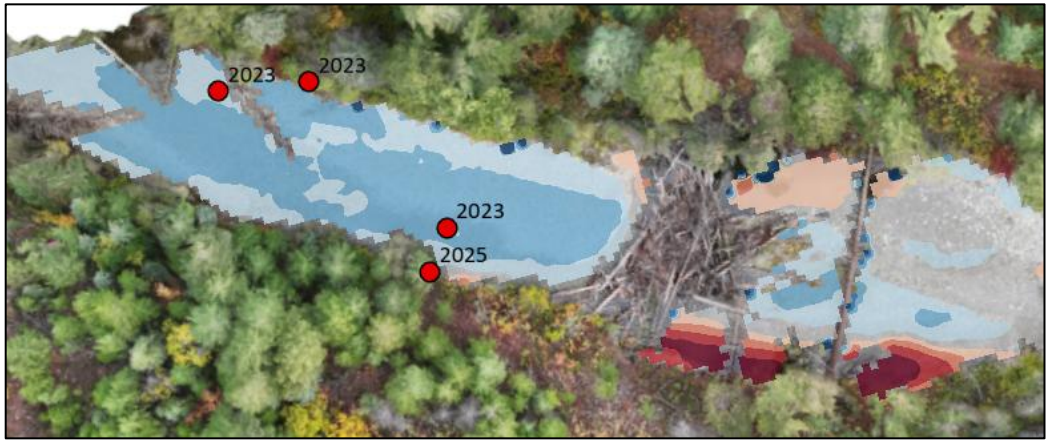
# Local Channel Response – Ex. 2



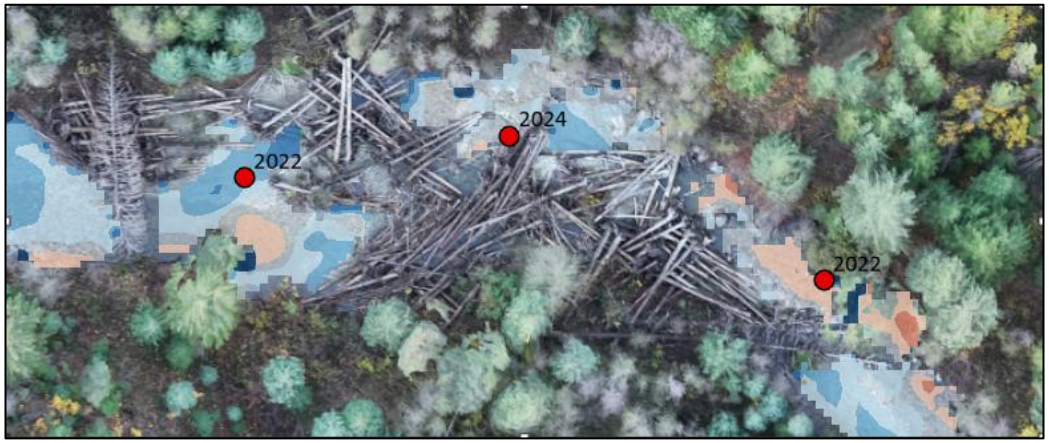



# SpCh Redd Distribution

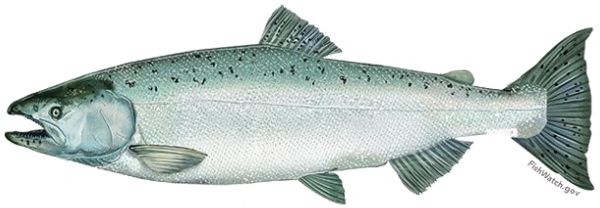
## War Creek - Downstream




## Mystery Reach - Upstream




- Redd locations 2022-2025 (4 yrs)
  - War Creek Reach (14 redds)
    - 10 in depositional areas
    - 7 proximal to LW
  - Mystery Reach (12 redds)
    - 11 in depositional areas
    - 7 proximal to LW



# Pool Data

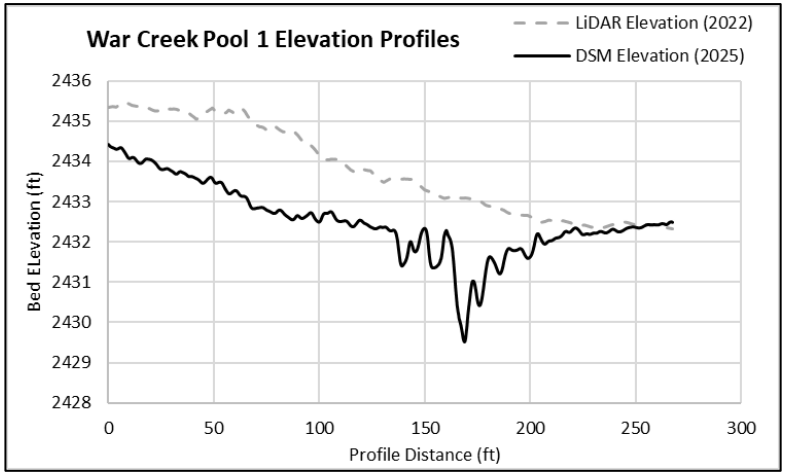
- Pool Metrics
  - Pool quantity (count) and change (from habitat survey)
  - Pool quality
    - Presence of wood (percent of pools associated with wood)
    - Pool depth and change (from habitat survey)
- Middle Twisp RA Pool Description (Reach 6)
  - Pools either have inadequate cover or there are few large pools (>3ft deep) in the reach

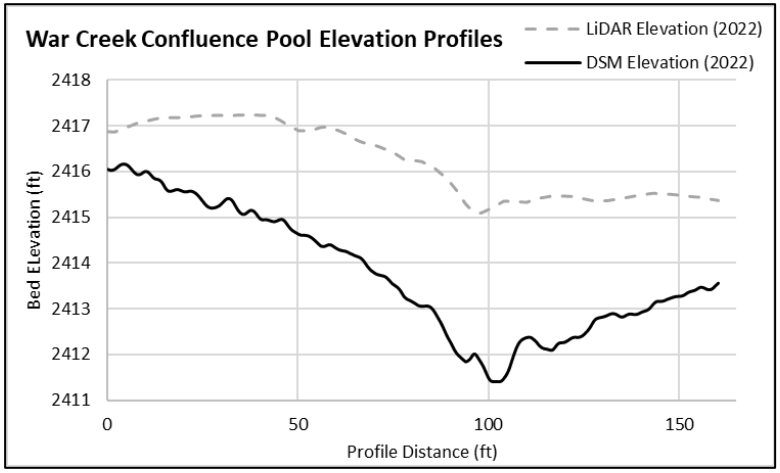
| 2025 DSM – War Creek Project Reach | | |
|---|---|---|
| | Middle Twisp Reach Assessment | 2025 - War Creek DSM |
| Pool Count | | 16 |
| Pools/Mile | 7.7 | 22.9 |
| Quality Pools (>3 ft deep) | 2 | 4 |
| % Pool Habitat | 15% | |
| | | |
| Pool Maximum Depth | | |
| Average | 3.3 | 2.2 |
| StDev | 1 | 1.3 |
| | | |
| Pool Residual Depth | | |
| Average | 2.1 | 1.6 |
| StDev | 0.9 | 1.3 |

- **Assessing pool metrics from DSM**
  - Quantity
  - Pool Depth (with caveats)
    - Error increases with depth
    - Surface projection moves up, decreasing pool depth measurement
- **DSM/LiDAR Analysis**
  - 13 of 16 (82%) of pools have large wood cover associated with them now.
  - Pools where we completed DSM-LiDAR differencing show significant scour.

# Pool Habitat Scour Analysis





# Takeaways

- Translatability to other monitoring projects

- Adaptive management strategy
- Potential Future Analysis:
  - Utility in hydraulic modeling?
  - Width:Depth Ratio
  - Channel Sinuosity
  - Floodplain interaction
  - Relate channel width: valley width: structure performance
  - LW Structure size, structure persistence, relative geomorphic response
  - Quantify and classify tree recruitment

# Contacts

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