Restoration Approaches to Large Wood Augmentation Workshop

A workshop at the 39th Annual Salmonid Restoration Conference held in Santa Cruz, California from April 19 – 22, 2022.

- **Session Coordinator:**
  - Anna Halligan, *Trout Unlimited*
  - Daisy Schadlich, *Trout Unlimited*

Due to the important role of large wood in restoring and maintaining instream salmonid habitats, wood augmentation has become a common element in stream restoration. Given the frequency and intensity of instream large wood restoration eff orts in California over the last several decades, restoration practitioners and agencies alike have learned a great deal about the success and applicability (or lack thereof) of a wide variety of large wood implementation methods. In order to help improve the efficacy of these types of projects, and to help identify when and where specific application of these methods may be the most appropriate, it is important for restoration practitioners to communicate their lessons learned and experiences with one another. This workshop will focus on presenting several instream large wood implementation methods and techniques, followed by a discussion of where and when it is best to apply specific methods.

Presentations

Slide 4 – **Wood is Only Part of the Solution- Wood's Role in Restoring fluvial Geomorphic Processes in disturbed Timberland Watersheds**, Thomas H. Leroy, *Pacific Watershed Associates*

Slide 39 – **Go Big or Go Home-The Use of Large Wood in Stream Habitat Restoration**, Kristine Pepper, PE, *California Department of Fish and Wildlife*

Slide 63 – **One Approach to Assessing Risk for Large Wood Structures-A Case Study from the Albion River,** Rachel Shea, P.E., *Michael Love & Associates*

Slide 125 – **How Big Can You Go with Your LWD Structures Before You Start Breaking Things,** Rachel Shea, P.E., *Michael Love & Associates*

Slide 147 - **Designing & Implementing Non-Engineered Large Wood Projects with the CCC,** Marisa McGrew, *Eel River Watershed Improvement Group*

Slide 165- **The Scott River Mine Tailings Restoration Underground- Is There a Role for Large Wood?** Michael Pollock, *NOAA Fisheries-Northwest Fisheries Science Center*

Slide 185- **Accelerated Recruitment: Cost- Efficient Restoration Techniques for Enhancing Instream Habitat,** Prepared By Christopher Blencowe, *Blencowe Watershed Managment*

WOOD IS ONLY PART OF THE SOLUTION

WOODS ROLE IN RESTORING FLUVIAL GEOMORPHIC PROCESSES IN DISTURBED TIMBERLAND WATERSHEDS

2022 Salmonid Restoration Federation Conference

Santa Cruz, CA

4-18-2022

Thomas H. Leroy
Pacific Watershed Associates
toml@pacificwatershed.com

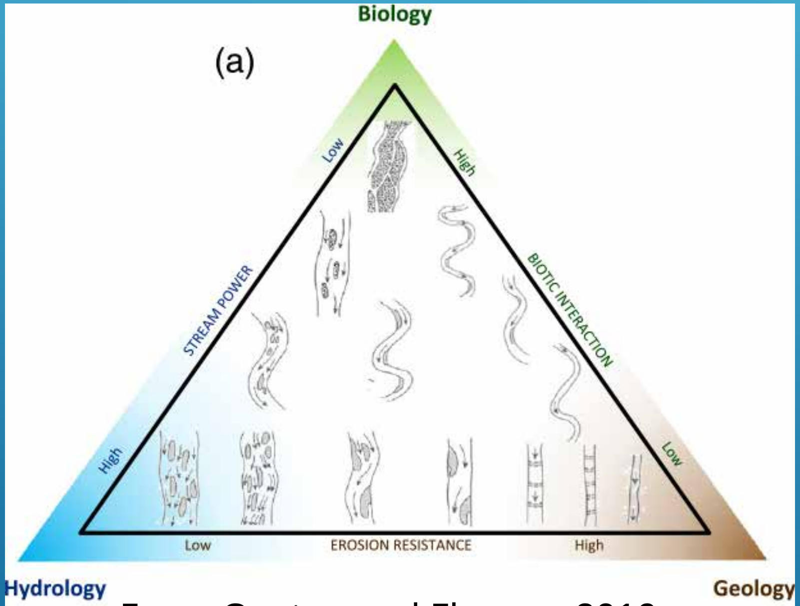
GOALS OF THIS TALK

- 1) Provoke thoughts that encourage restorationists to closely examine dysfunctional PROCESSES that lead to less than desirable fish habitat in their watersheds
- 2) Provide some fundamental observations of existing dysfunctional fluvial geomorphic processes, in heavily disturbed watersheds, so restorationists can consider the role large wood will play in restoring their watershed to fully functioning conditions.
- 3) Provide a scientific basis for a general understanding that simply adding wood for habitat may not be the best approach to recovering anadromous fish populations…it can't hurt, but it may only provide short term benefits if the fundamental watershed processes are not functioning.
- 4) Provide a few ideas on how to use wood to facilitate process recovery

WHAT GOVERNS STREAM MORPHOLOGY?

AND IN TURN AVAILABLE HABITAT

Water, Wood and Sediment



From Castro and Thorne, 2019

DYNAMIC EQUILIBRIUM

A STATE OF BALANCE BETWEEN CONTINUING PROCESSES

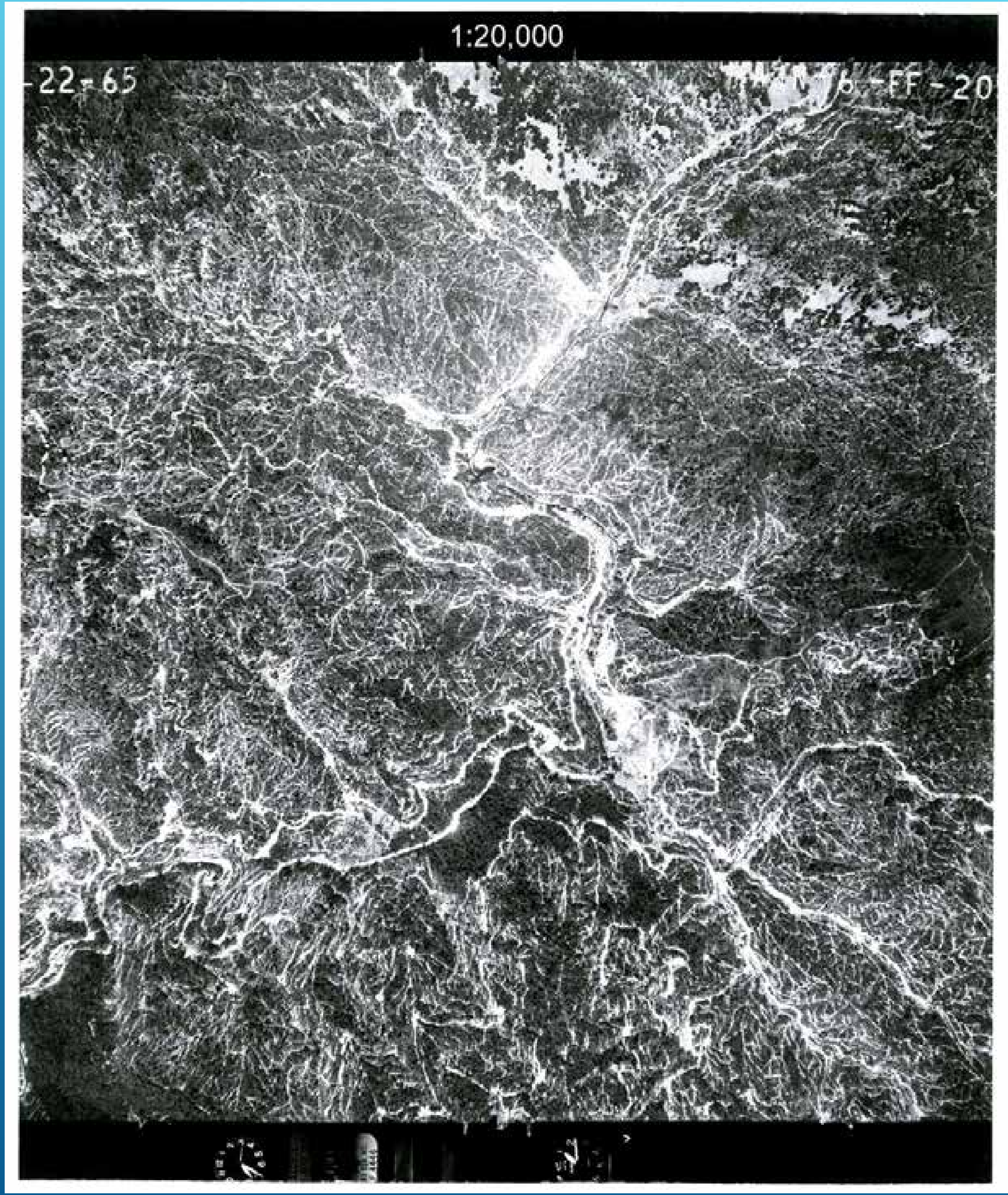
- Water, vegetation (including large wood) and sediment all constantly interact with each other in a river channel.
- As the characteristics of one element change, the other elements change to form new fluvial geomorphic conditions consistent with the characteristics of the fundamental processes
- Fluvial geomorphic conditions are not static in a river, they vary around a quasi-stable state depending on stochastic inputs from the fundamental driving processes such as variability in runoff or large sediment inputs from landslides. This is dynamic equilibrium.

LET'S LOOK AT SOME OF THESE DISTURBANCES IN HEAVILY LOGGED WATERSHEDS, AND HOW THEY'RE MANIFEST IN OUR STREAM CHANNELS

HYDROLOGY

- Road and skid trail construction
  - Rapidly routes water off the landscape into the stream system
  - Intercepts and drains shallow ground water into the stream system
  - Creates hillside gullies which drain shallow groundwater resources

In other non-forested watersheds hydrology may be impacted by impermeable surfaces, land conversion, ect.



ROAD AND SKID TRAIL CONSTRUCTION

Garcia River Watershed…1965

A QUICK CALCULATION

”

RIPARIAN DISTURBANCES

RIPARIAN DISTURBANCES

- Changes the species composition and size classes of the riparian trees
- Eliminates or significantly suppresses naturally recruitable trees that exhibit the size and durability required to provide fluvial geomorphic services for the stream system
- Resets the process of succession to its beginning stages
- If left to regrow without proper management, can result in a decent looking riparian corridor that meets almost none of the criteria that can be used to define a fully functioning riparian zone.


2014/11/06

SOME ATTRIBUTES OF A FULLY FUNCTIONING RIPARIAN ZONE

Developed in coastal Washington for coniferous forests

- Basal area-
- Quadratic mean diameter-
- Snags-
- Large downed wood- 2400 cu. Ft. /acre
- Vertical stand structure- maintain at least 2 canopy layers
- Species diversity- Maintain at least 2 main canopy tree species suited to the site

From Bigley and Deisenhofer, 2006

WATERSHED SCALE SEDIMENT BUDGETS

- Where does the substrate in a creek come from in a heavily forested environment?....Where does it go?....How is it regulated?
- Input-Storage-Output

uplands (landslides, debris torrents)

gullies

Streambanks

Channels

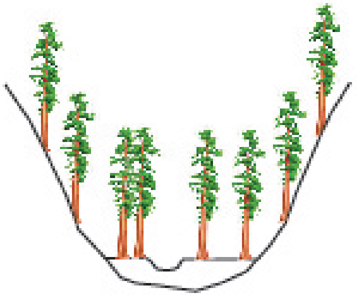
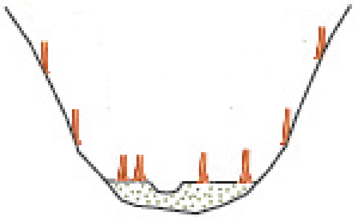
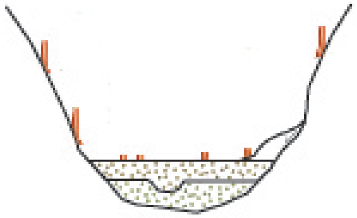
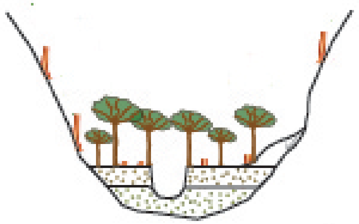
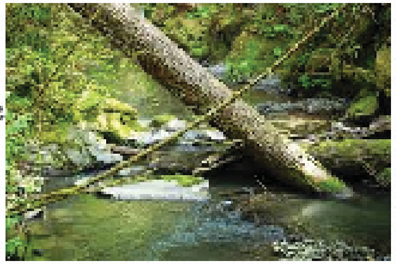
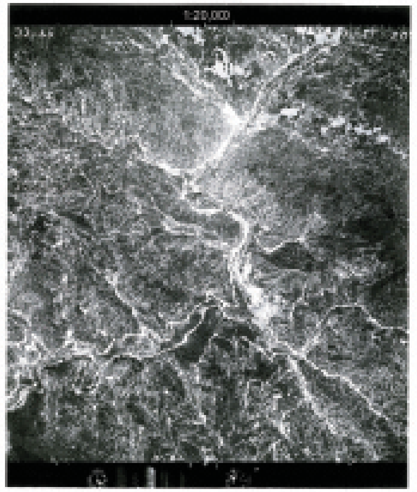
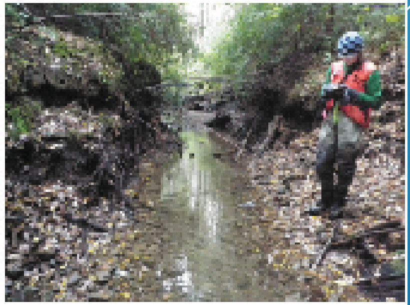
Upstream of poorly designed stream crossings

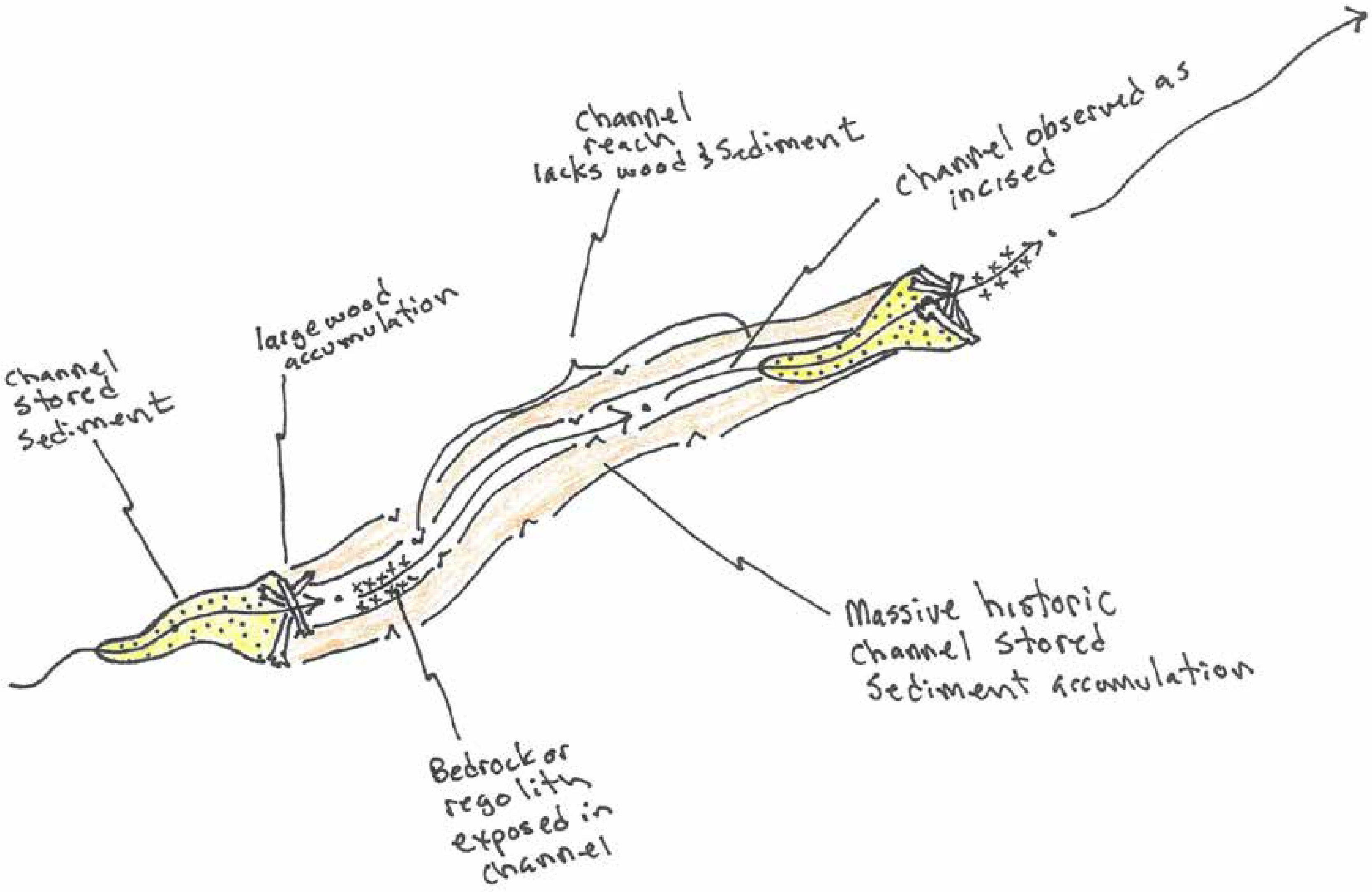
ANTHROPOGENIC INFLUENCED SEDIMENT DELIVERY

SO HOW DO THESE DISTURBANCE EVENTS CONSPIRE TO DEGRADE FISH HABITAT?

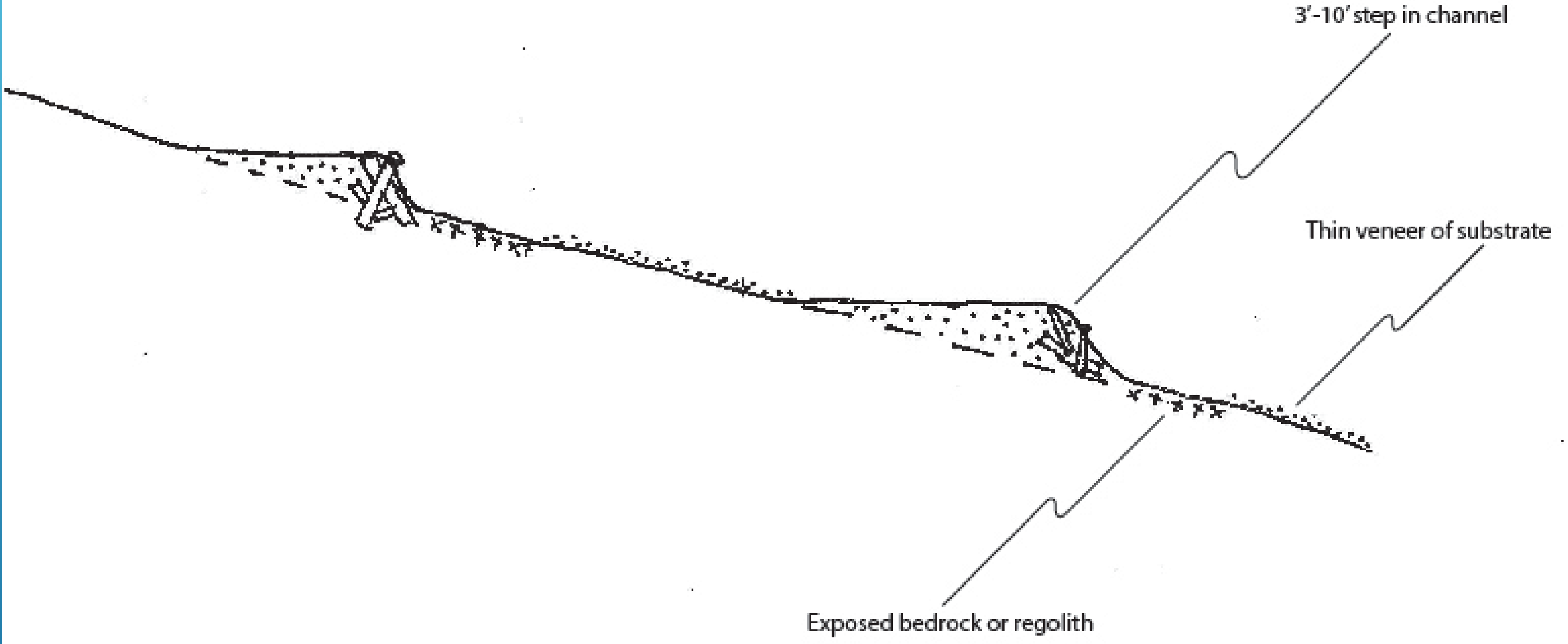
- Hydrology
  - Increased runoff from roads and impermeable surfaces allows for unnatural peaks in storm hydrographs
- Riparian Disturbances
  - Destruction of riparian zones significantly degrades the existing large wood features, breaks the natural process of wood recruitment and retention to streams and significantly reduces other riparian services (food production, nutrient delivery, ect.)
- Sediment budget alterations
  - Road construction and extensive clearcutting caused most of the streamside landslides to fail over a short period of time, where under undisturbed conditions, they would have individually delivered into the stream over thousands of years.

Channel Evolution Model for Heavily Managed Landscapes in Some Northern California Streams

Status	Original Conditions	Immediate Post Disturbance Conditions	Post Disturbance Geomorphic adjustment (after storm events)	Current Conditions
Typical Cross section				
Defining Characteristics	- Riparian dominated by old growth conifer - Floodplain fully connected to channel - Sediment input and output in balance -Bank heights low and relatively stable - Biogeomorphic system resilient to natural disturbance events - Habitat diverse and resilient	- Riparian and hillside mostly devoid of trees - Floodplain unprotected - Sediment input higher than sediment output - Bank heights low and unstable - Biogeomorphic system highly vulnerable to natural disturbance events - Habitat vulnerable	- Riparian and hillside mostly devoid of trees - Floodplain buried by heavy sedimentation - Sediment being stored in channel reaches - minimal channel banks evident - Biogeomorphic system succumbs to anthropogenic disturbance - Habitat severely impacted	- Riparian dominated by hardwoods - Floodplain disconnected from channel due to incision through recent sediment deposits - Sediment locked in storage by hardwood forest, no basal flare observed on old growth stumps - Channel banks relatively stable and supported by tree roots - Biogeomorphic system dysfunctional and out of balance with watershed characteristics. - Habitat simplified
Representative photo				



Typical map view along a stream channel subjected to alterations to its hydrologic, biologic, and geologic processes



Typical profile along a stream channel subjected to alterations to its hydrologic, biologic, and geologic processes

Large wood accumulation on Chimney Rock Creek.

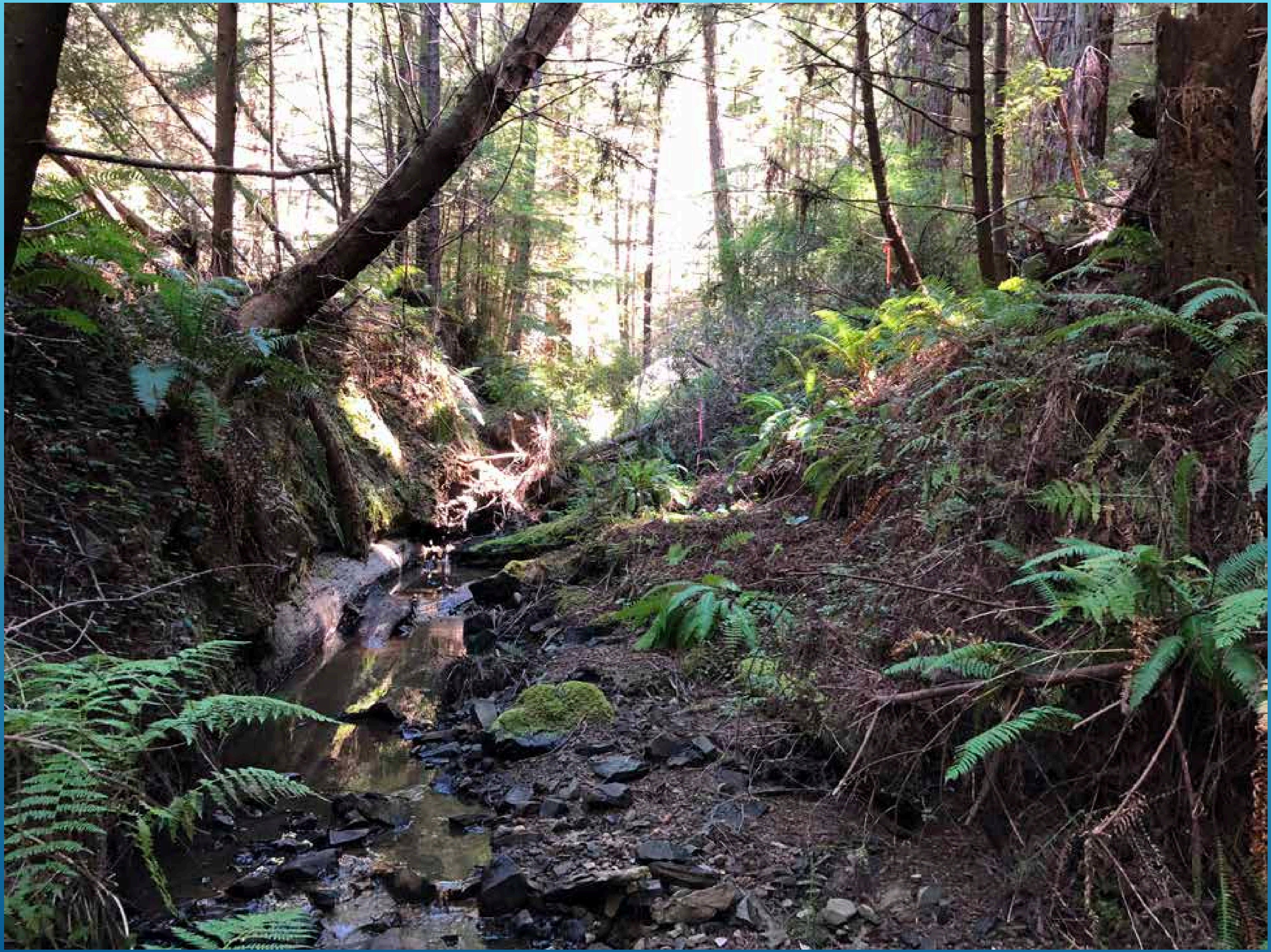
Note:
(1) Large step in channel
(2) Sediment accumulated upstream of jam
(3) Lack of jump pool

Remnants of blown out jam

Note:

(1) Incision into sediment accumulation
(2) Buried alders
(3) Suspended substrate

What's missing here?

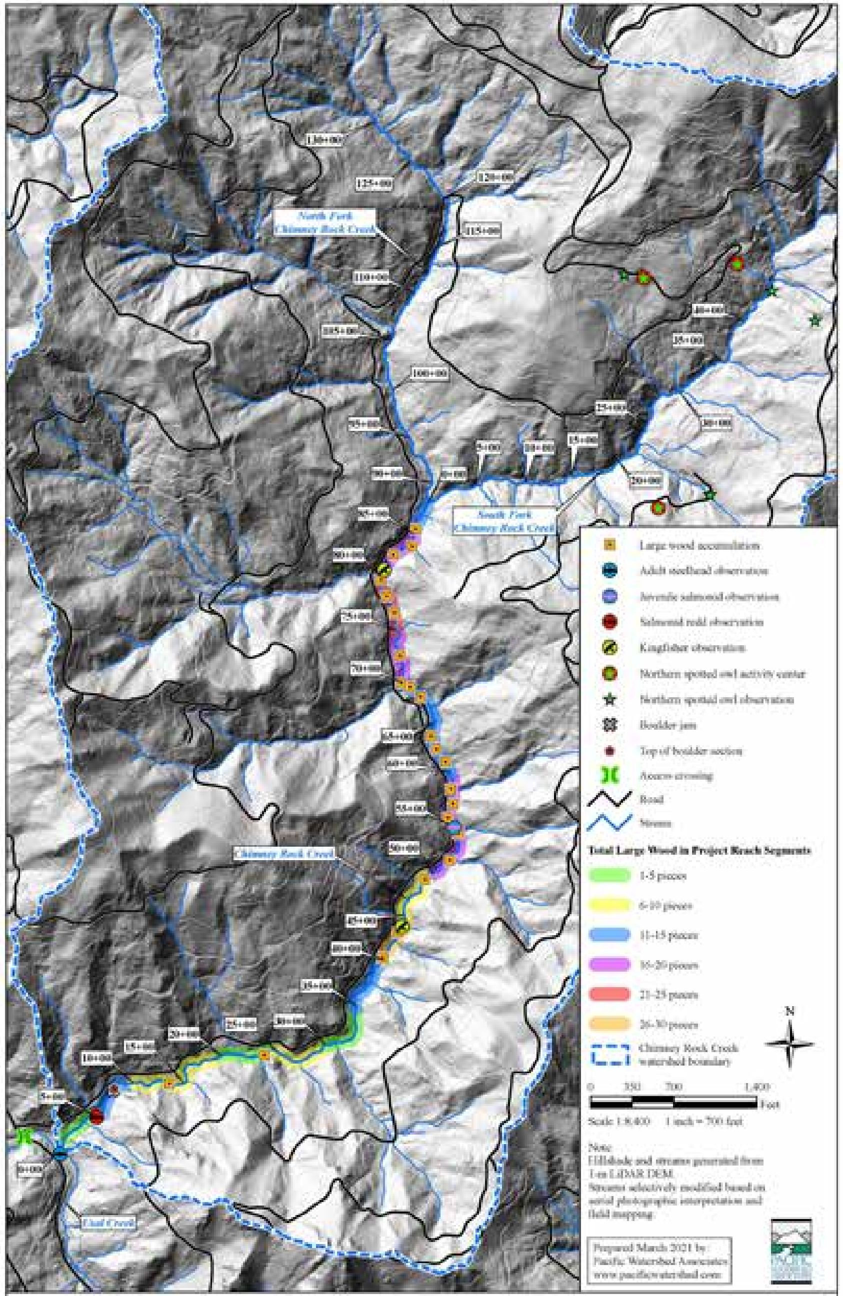


Incision into anthropogenic deposit, down to regolith

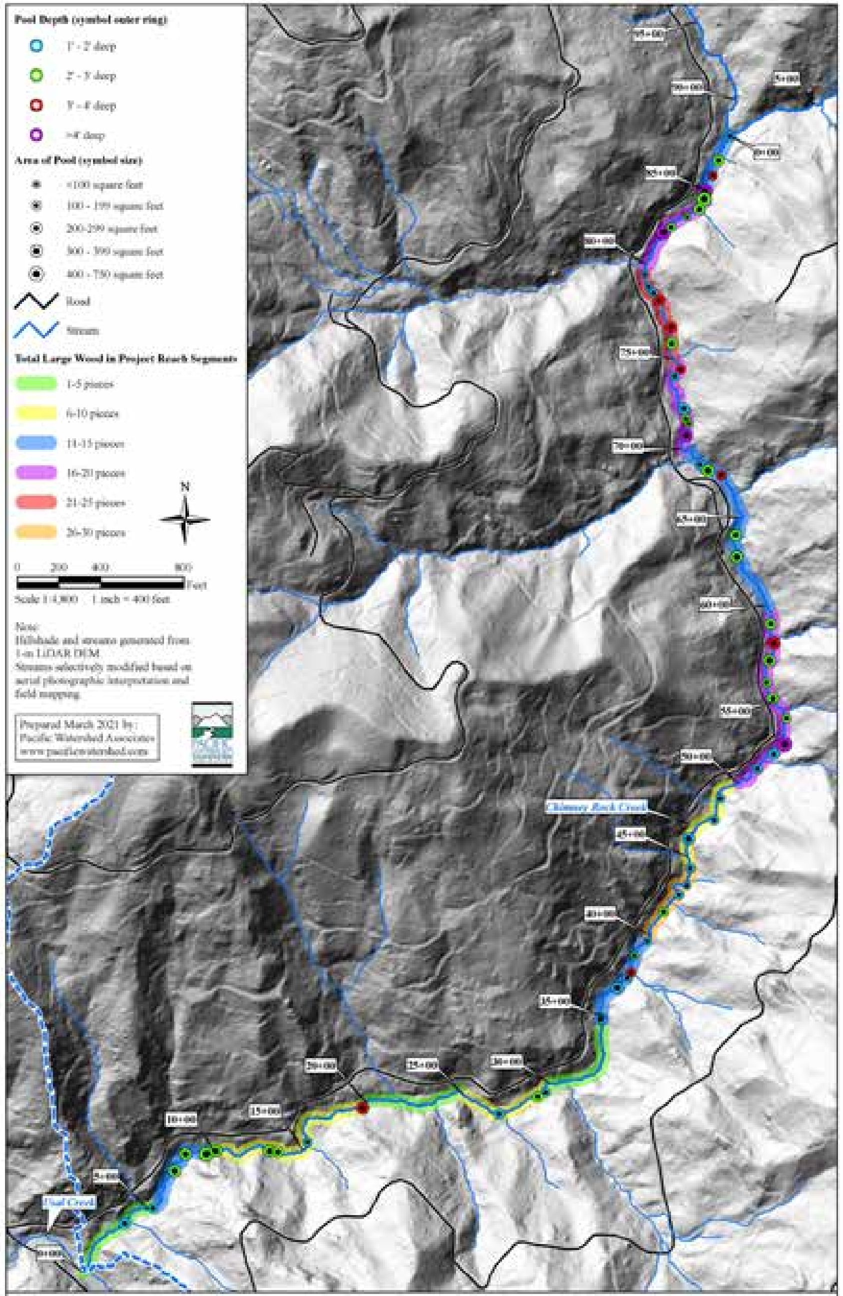
Beginning of incision into large anthropogenic deposit

OK....WHAT'S THIS WORKSHOP ABOUT AGAIN? OH YEAH.....WOOD......

Planning maps from Chimney Rock Creek

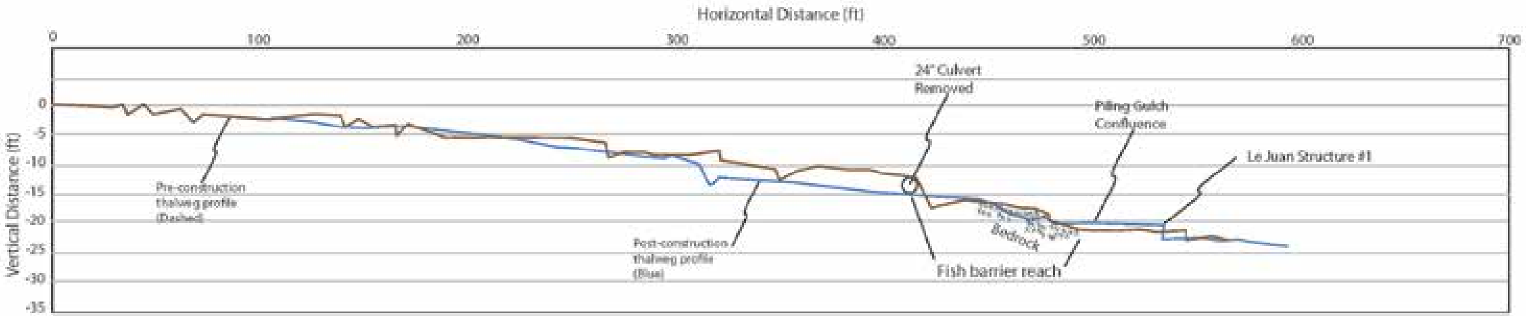


Map 3. Large woody debris location and biological occurrence map for the Chimney Rock Creek Instream Habitat Enhancement Project, Mendocino County, California. Grantee/Applicant: Trout Unlimited



Map 4. Pool size and large woody debris location map for the Chimney Rock Creek Instream Habitat Enhancement Project, Mendocino County, California. Grantee/Applicant: Trout Unlimited

PRE AND POST CONSTRUCTION LONG PROFILES, LNF NOYO RIVER, MENDOCINO CA



Before (Black) and after (Blue) stream thalweg profiles on the upper Little North Noyo River. The pre-implementation channel conditions contributed to a fish barrier, that persisted for decades, where a combination of a bedrock cascade and an arrested head-cut resulted in non-passable conditions for anadromous fish. The thalweg profile was modified through a combination of: (1) adding several channel spanning wood structures downstream of the bedrock to raise the channel bed, (2) chiseling the edge of the bedrock exposed in the channel bottom with a hydraulic excavator, and (3) removing a 24" culvert that was maintaining a large step in the channel.

LITTLE NORTH FORK NOYO PRE-IMPLEMENTATION CONDITIONS

Upper reach

Lower reach

LITTLE NORTH FORK NOYO POST-IMPLEMENTATION CONDITIONS

2 Examples of “LeJuan” structures

Little North Fork Noyo
downstream of the headcut

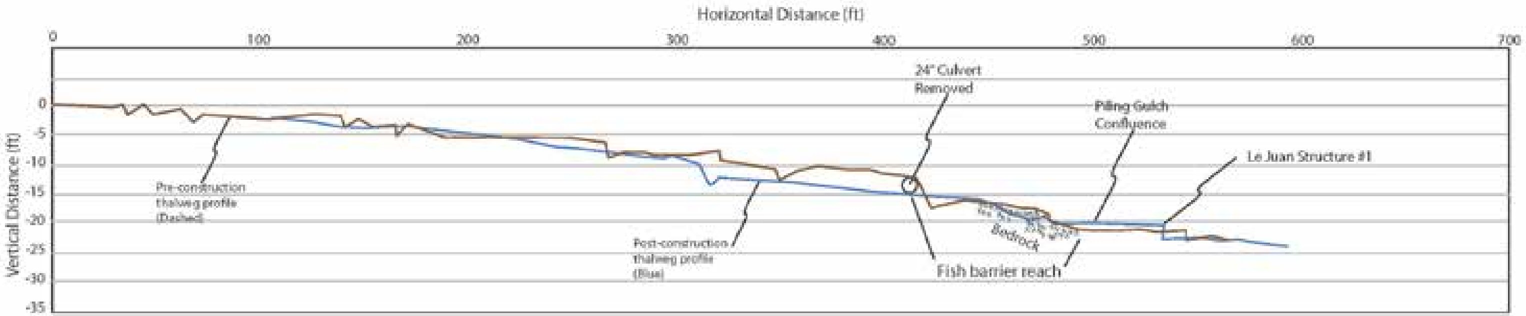
The “LeJuan” wood structures

Pistol butt Le Juan wood structure

Little North Fork Noyo
Upstream of headcut

Wood designed to deflect stream into massive sediment accumulation

PRE AND POST CONSTRUCTION LONG PROFILES, LNF NOYO RIVER, MENDOCINO CA



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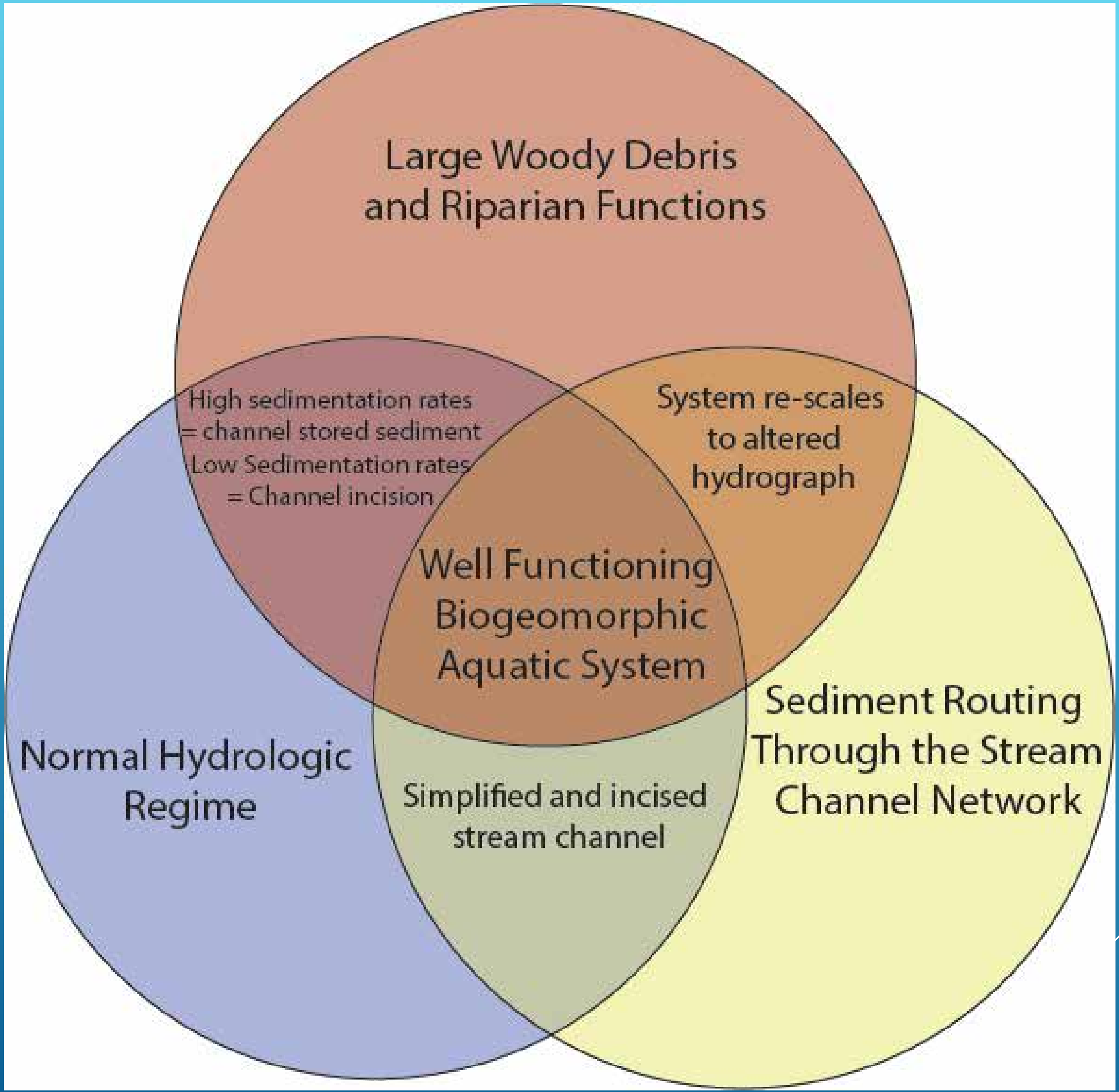
CONCLUSIONS/RECOMMENDATIONS

- Fully characterize your target streams past and ongoing disturbances and existing conditions to inform your designs
- Identify dysfunctional processes in your watershed and try to address them with a comprehensive project ….What role can large wood play in addressing the dysfunctionalities?
  - Hydrology- upgrade/decom roads
  - Riparian- characterize and plan riparian improvements
  - Sediment budgets- identify areas lacking or unnaturally storing channel stored sediment and design around redistribution
- Design at the reach scale, think past simply building habitat
- Implement your wood loading project concurrently with other projects that reduce increased runoff in the watershed, restore the riparian zones to fully functioning conditions
- Wood is not a panacea
- Go big or go home!


Large Woody Debris
and Riparian Functions
High sedimentation rates
= channel stored sediment
Low Sedimentation rates
= Channel incision
System re-scales
to altered
hydrograph
Well Functioning
Biogeomorphic
Aquatic System
Normal Hydrologic
Regime
Simplified and incised
stream channel
Sediment Routing
Through the Stream
Channel Network

The Use of Large Wood in Stream Habitat Restoration

go BIG or go home

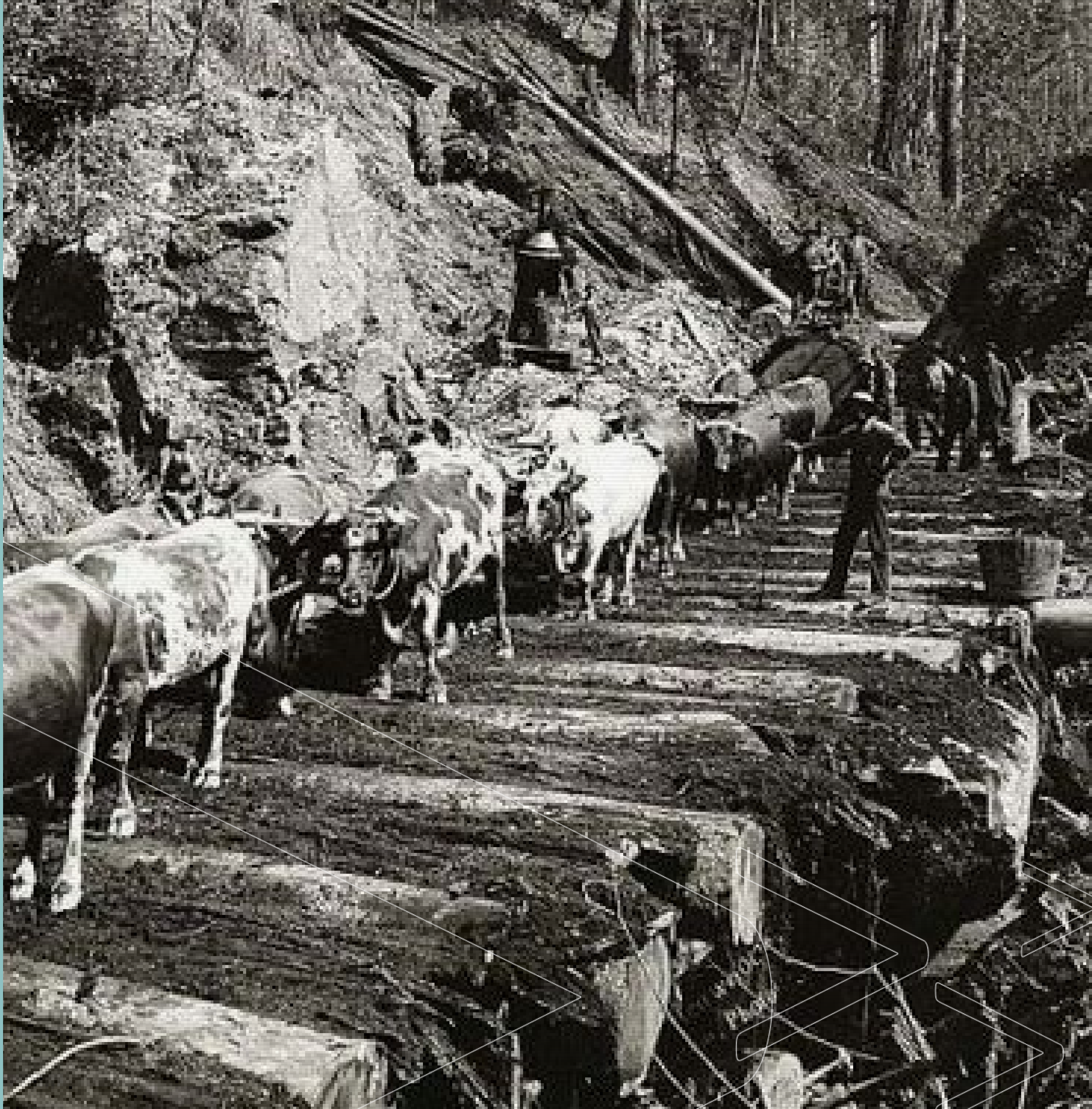
Kristine Pepper, P.E.
Senior Hydraulic Engineer
California Department of Fish and Wildlife

Overview

- Historic and Ecological Context of systems today
- Goal of Large Wood projects
- Site selection/characterization is an important for all projects to clearly define goals
- Risk must be assessed
- Go Big – Be aggressive
  - Don’t avoid complex structures or high-risk settings
  - Craft significant geomorphic change

Historical Context of Large Wood in Streams

- Role of instream wood – geomorphic → biologic
- Log transport: splash dams, skid roads
- Timber harvesting of riparian
- Channel clearing for navigation, anadromous fish passage, or flood control



Ecological Context of Large Wood in Streams

- Large wood improves channel and floodplain function
- Provide habitat to salmonids
- Add nutrients to the system
- Accelerate natural recovery

Go Big?
Goal of Large Wood Projects

Improved geomorphic function - Reverse impacts of channel incision - where unnatural state

- Stream, floodplain, side channels and riparian zone
- Functioning stream is good Salmonid habitat

Restore Physical Processes
Functioning stream is good Salmonid habitat

Raising the bed to reconnect to floodplains and side channels will

- Reduce stream power
- Deposit finer sediment such as gravel
- Allow pools to form at lower flows and scour deeper
- Retain spawning gravels
- Channels and floodplains become habitat again
- Food sources - invertebrate production
- Recover groundwater levels and increase summer base flows

Project Planning

FRGP Guidelines 2022

- Data Requirements
  - Purpose and Site Selection – Clearly define project goals
  - Risk and Uncertainty Analysis
  - As-builts map and details –inspection monitoring
  - Inspection monitoring program

Site Characterization for ***All*** Projects

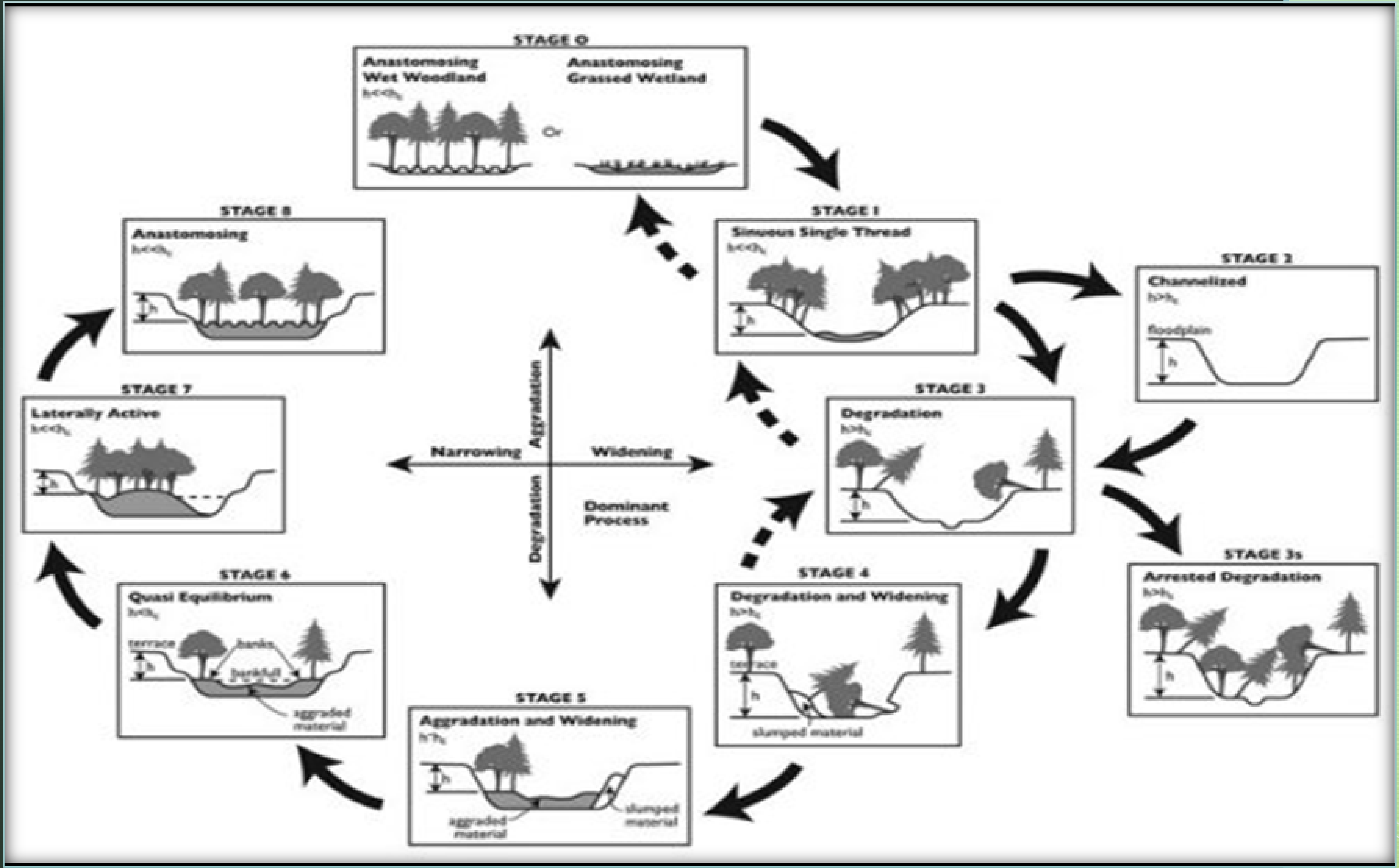
- Identify specific stream reaches
- Geomorphic description of the stream reach
  - Planform, confinement, bed forms, floodplain, slope
  - Stable - aggrading or degrading – cause?
  - Substrate composition – scour potential, bedrock, subsurface
  - Streambank composition
  - Riparian vegetation / sources of wood
  - Construction access

Site Characterization for *High-risk* Projects

- Additional studies required
  - Geomorphic study
  - Topographic survey
  - Hydrologic and hydraulic analysis
    - Scour and stability calculations
    - Re-connecting floodplain or side channel

What Stage?

- LW projects to restore stream channel to Stage 0 or Stage 1
  - If you don't address the drivers of incision, it won't last
- Beware of stabilizing banks in Stage 4
  - Material for aggradation
- Stage 3 may result from lack of sediment
  - No supply = no aggradation



The Stream Evolution Model (Cluer and Thorne 2013)

Key Piece Logs

Key Piece Logs – independently stable

- Length
  - With root wads 1.5x bankfull
  - No root wad 2x bankfull
- Diameter
  - ½ depth at bankfull or 12 inches, whichever is greater
- Preferred species (In coastal N. CA)
  - Second growth redwood (durability 10yrs +)
  - Douglas fir (durability 25yrs +)

Table 2. Minimum log diameter for key log piece (Adapted from ODFW 2010).

Bankfull Width in Feet	Minimum **Diameter in** Inches
<10	12
10 to <20	16
20 to <32	18
>32	22

Risk and Uncertainty Analysis

- Professional liability for damages
  - Minimize by rigorous and defensible analyses of risk
- Risk assessment
  - RiverRAT (Skidmore, et al, 2011)
  - Washington Manual (Cramer, 2012)
  - Large Woody Material-Risk Based Design Guidelines (USBR, 2014)

RiverRAT (Skidmore, et al, 2011)

Low-risk Projects vs. High-risk

- Low-risk
  - Little or no consequence of failure
  - Low-risk to public safety, infrastructure, or private property
  - Structures with key piece sized logs with no added stability
- High-risk
  - Where there is risk to public safety, infrastructure, or private property
  - Complex structures – added stability (even in "low-risk" setting)
    - Require stability calculations-Licensed engineer

When Risk is Low “Go BIG”

- Key piece logs or anchored to existing trees or bedrock
- Best location/ orientation to achieve goal
- Accelerated recruitment
- Mix in more tools such as BDAs
- Control the water surface – make sure you meet your goal

When Low-risk Requires Complex Structure

- Ideal geomorphic location for a structure may lack anchor points
  - No trees on the bank at a bend
  - Need a structure mid channel
- Stream is too wide to have opposing structures meet
- Entrenchment Ratio is less than 1.4 and stream power can rotate or break logs
- Control the water surface – make sure you meet your goal

Structure Locations and Configurations

With the clearly defined goal of the project

- Avoid unstable streambanks – unless part of larger effort
- Geomorphic complexity – typically obstruct streamflow
- Floodplain re-connectivity
- Re-engaging side channels
- Promote scour and collect additional wood-upstream angle
- Equipment access

Structure Locations and Configurations

Low-risk - Upper Noyo River

Wood placed at an upstream angle

- promote scour
- collects additional large and small wood.

Same feature after the first winter.

Photos courtesy of Alan Ader, (CCC).

Structure Locations and Configurations

Low-risk location

Hardened banks, entrenched, disconnected from floodplain

- Channel spanning features
- Simple structures placed closely
- Restricting flow
- Collects additional debris

Albion
Photos courtesy of Scott Monday (CDFW)

Low-risk

Redwood Creek, Upper Noyo River

Photos courtesy of Brett Leonard (CCC)

Structure Locations and Configurations

Large wood cut may be a result of stream clearing efforts in 80s. Small logs installed by Chris Blencowe and anchored by CCC.

Multiple pieces need to make up difference

Upper Noyo River above Burbeck Creek (Oct 2016)

Structure Locations and Configurations

Low-risk required complex structure

Cottaneva Creek 2018
Photos courtesy of Margie Caisley (CDFW)

Vertical post used in a bend

- Captured large and small wood
- Gravel deposition and sorting both upstream and downstream
- Increasing sinuosity

Structure Locations and Configurations

Low-risk

The “Wing” Redwood Creek Noyo River
Photos courtesy of Brett Leonard (CCC)

- Smaller BFW stream with properly sized, good placement and anchoring
- Height help captured large and small wood
- Gravel deposition and sorting both upstream and downstream

The same location on Redwood Creek in summer

Conclusions

- Streams are deficient in large wood necessary to maintain salmonid habitat
- Go Big – Be aggressive
  - Don’t avoid complex structures or high-risk settings
  - Craft significant change
  - Stream reach approach
- Site selection/characterization is an important for all projects to clearly define goals
- Risk must be assessed
  - High-risk must be designed before implementation
  - 65% design can be developed within a year - for late summer early fall funding programs

Salmonid Restoration Federation 2021
Large Wood Field School

One Approach to Assessing Risk for Large Wood Structures

A Case Study from the Albion River

Albion River, Comptche California

Rachel Shea P.E.

Engineering Geomorphologist

Michael Love & Associates
Hydrologic Solutions

Elias J. Steinbuck, CEG

TROUT UNLIMITED

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

MENDOCINO

Risk Assessment

The *process of identifying __Hazards__ and assessing associated __Risks__*

<u>Hazard</u> – A condition or process with the potential to threaten public safety, property, or operations

<u>Risk</u> –Combination (product) of the hazard’s <u>severity</u> and <u>probability</u>

<u>Severity</u> – Consequences from the identified hazard when it occurs

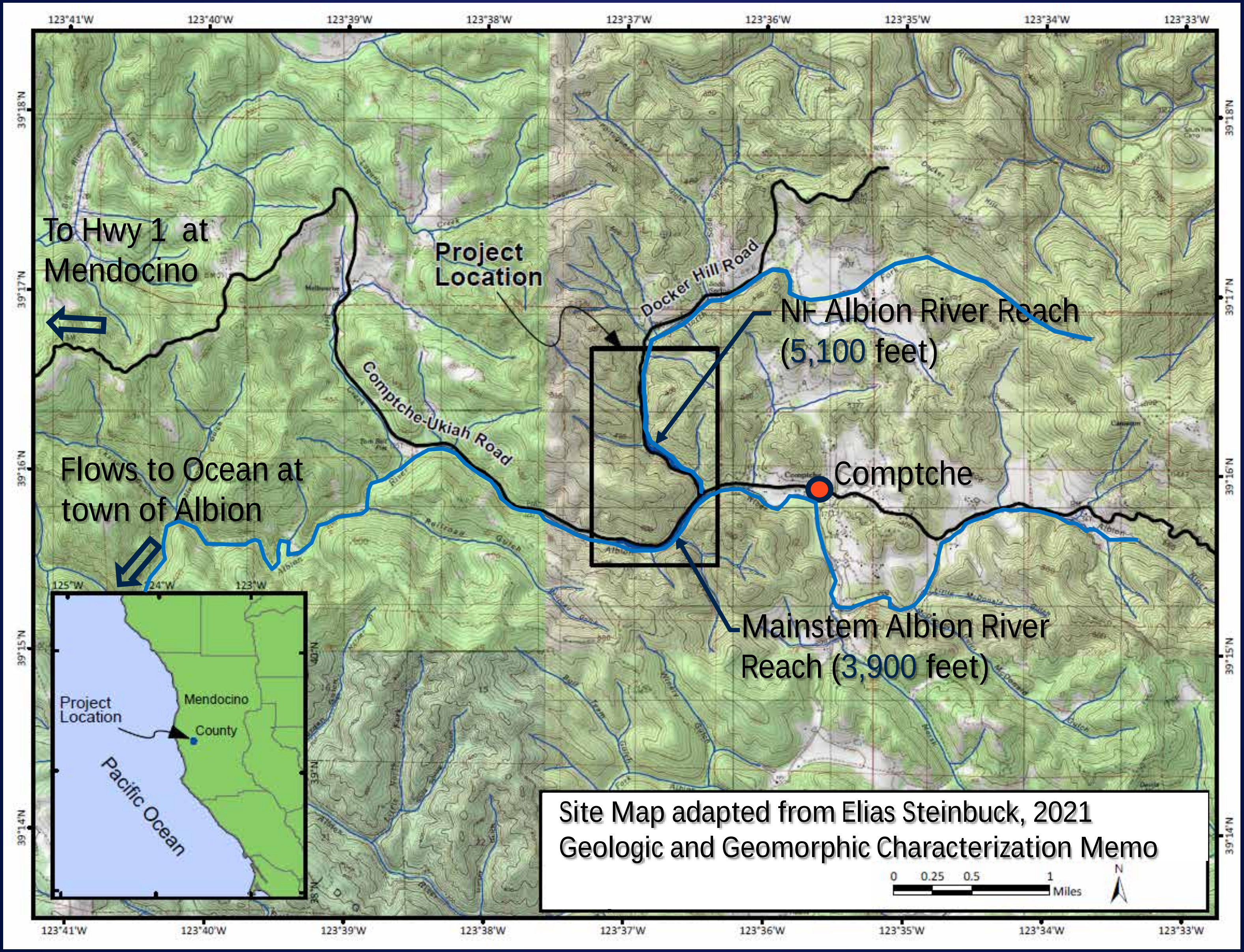
<u>Probability</u> – Likelihood of occurrence

<u>Risk Management</u>

Identify Hazard → **Assess Hazard** → **Determine Risk Level** → **Mitigate Risk to Acceptable Level**

Albion River Wood Loading Project

Project Location



Albion River Wood Loading Project

Project Reaches Incised to Bedrock and Lacks Large Wood Controls

The Dream Project

Replicate Massive Log Jam downstream of Project

Bedrock Bank Saves Adjacent County Road from Lateral Scour

Alluvial Bed Extends Far Upstream of Log Jam

Albion River Project

Project Goal

- Restore bedrock reaches to an alluvial-bed throughout project length as feasible to improve salmonid habitat

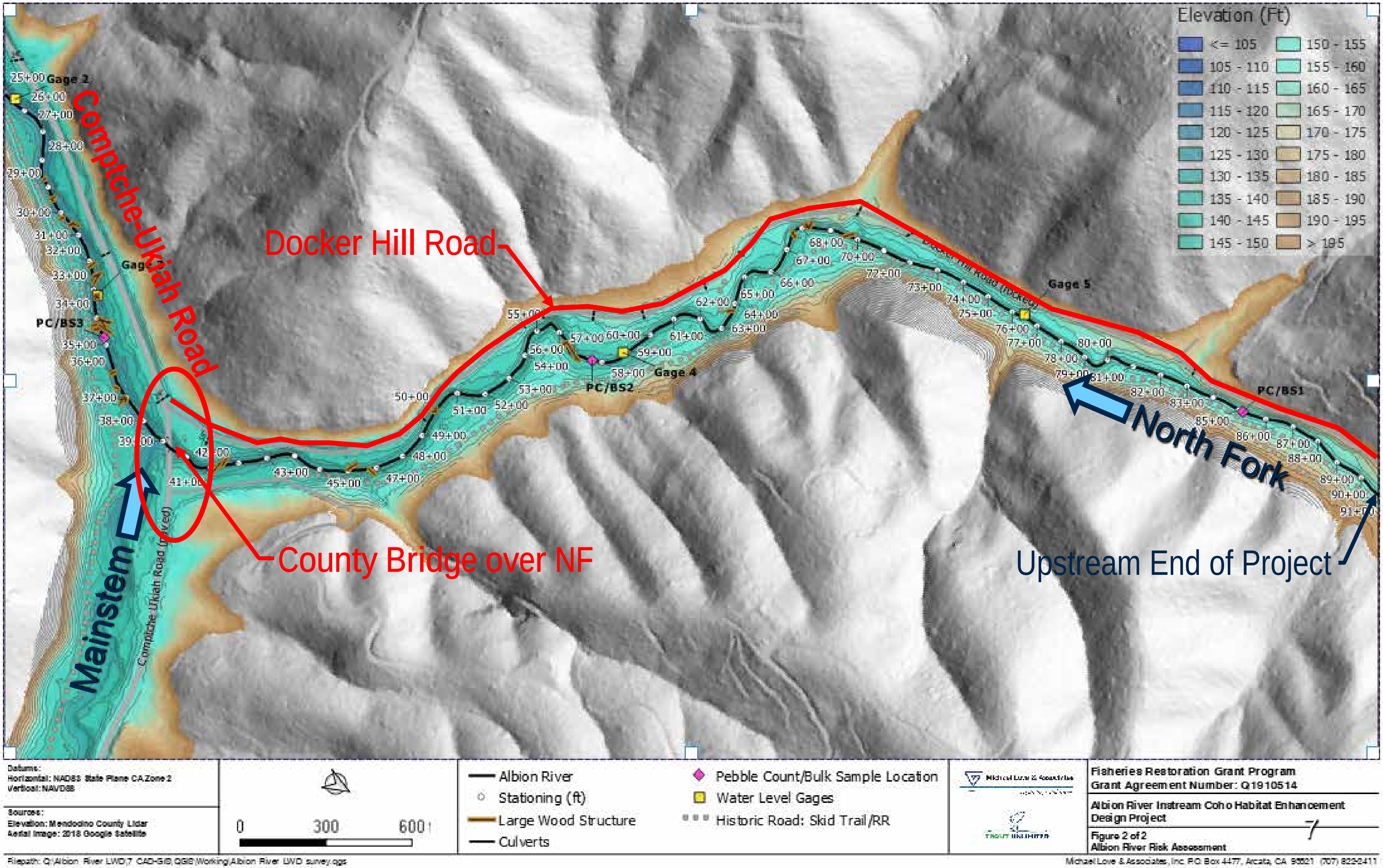
Project Objectives

- Install large wood structures to initiate process of in-channel alluvium accumulation and storage
- Meet NMFS CCC recovery plan wood loading densities for “very good” (11 pieces/330 feet)

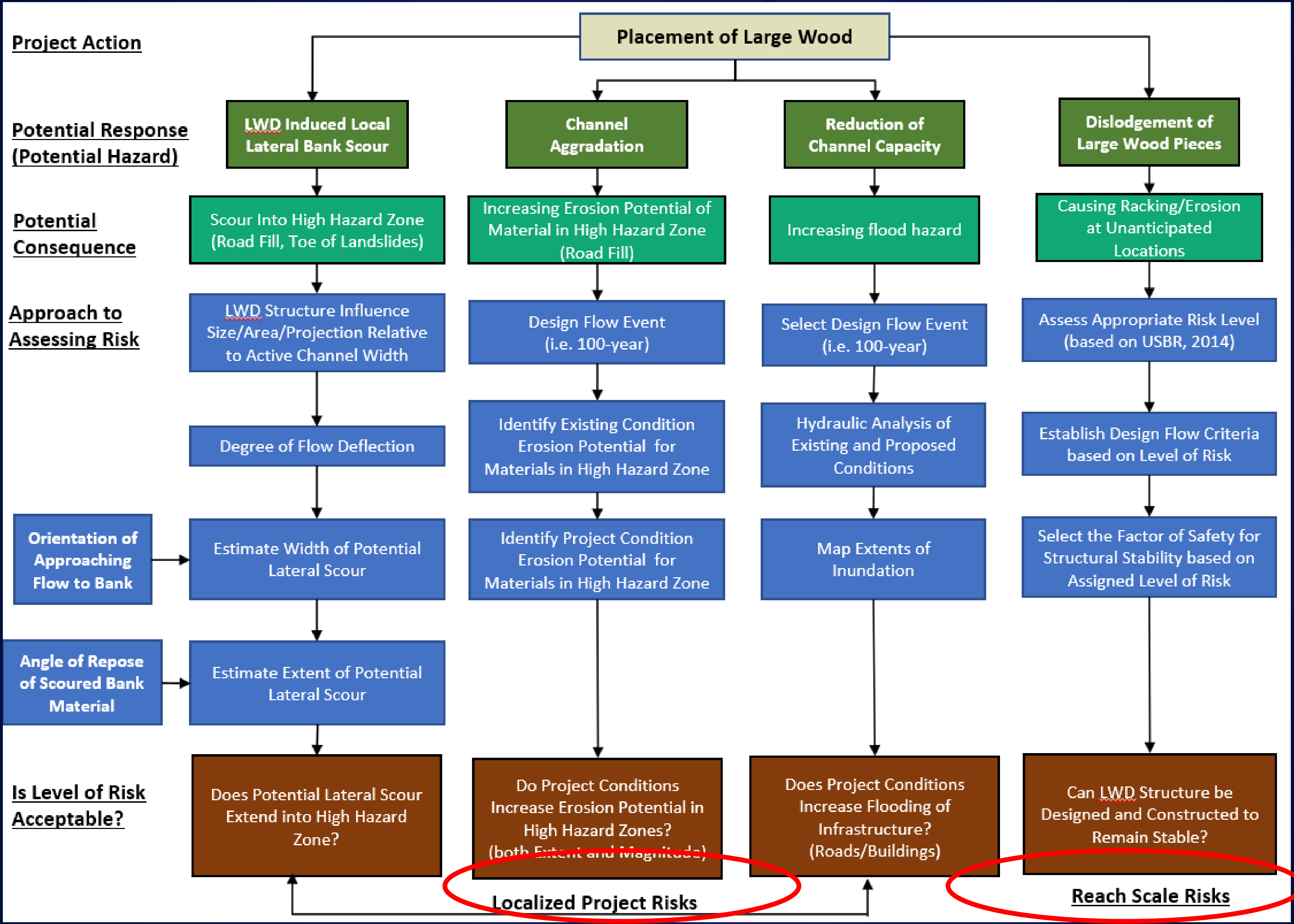
Causes for Elevated Risk Identified During Scoping

- River reaches in close proximity to County and private roads, bridge, and utilities
- County bridge causes upstream flooding (100-year)
- Bridge pier in middle of channel
- Erodible Channel banks and localized roadway failures

Typical Project Reach



Assessment of Risk from Large Wood Structures



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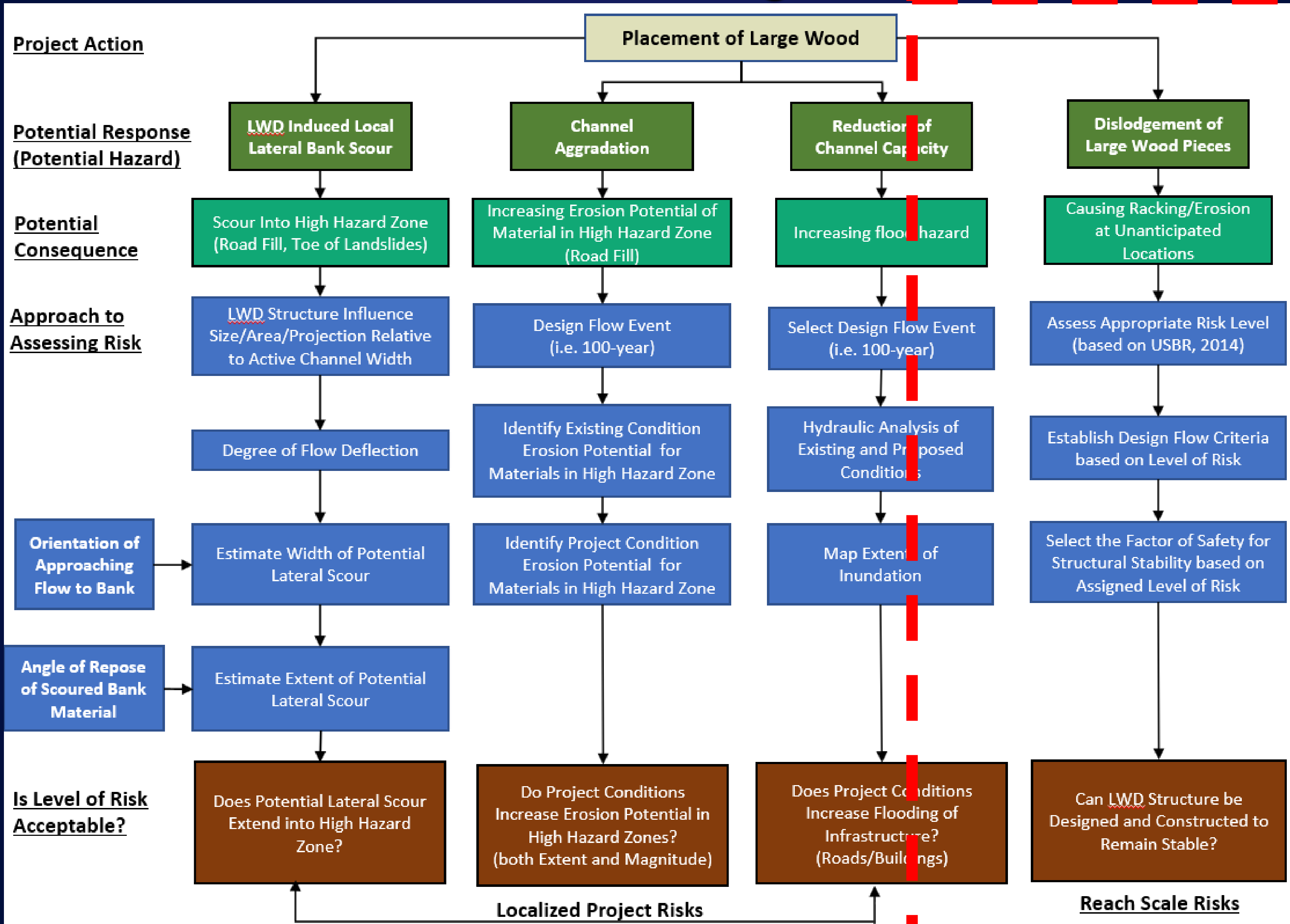
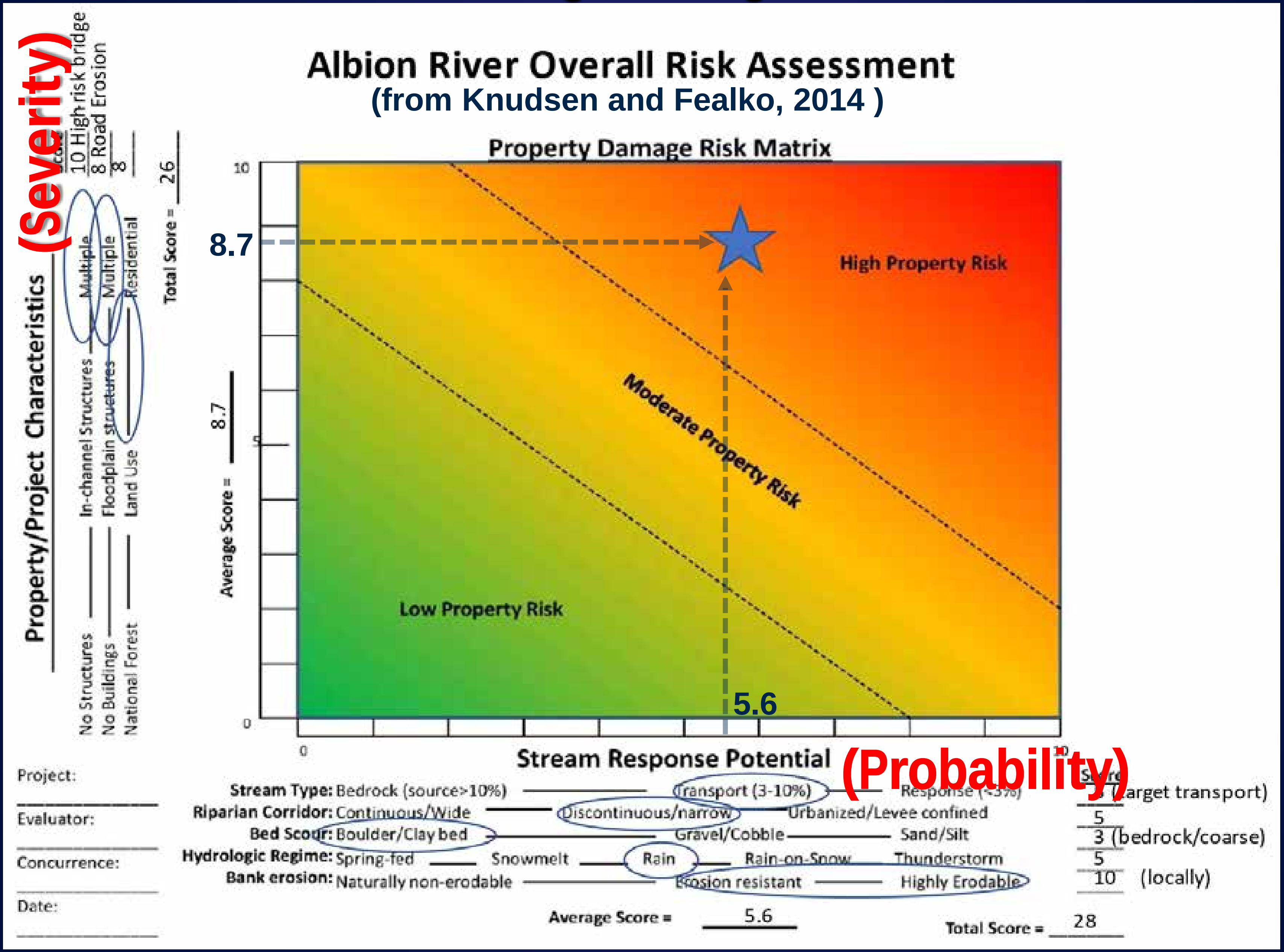


Albion River Reach-Scale Risk Assessment for Log Dislodgement



Reach-Scale Risk Mitigation

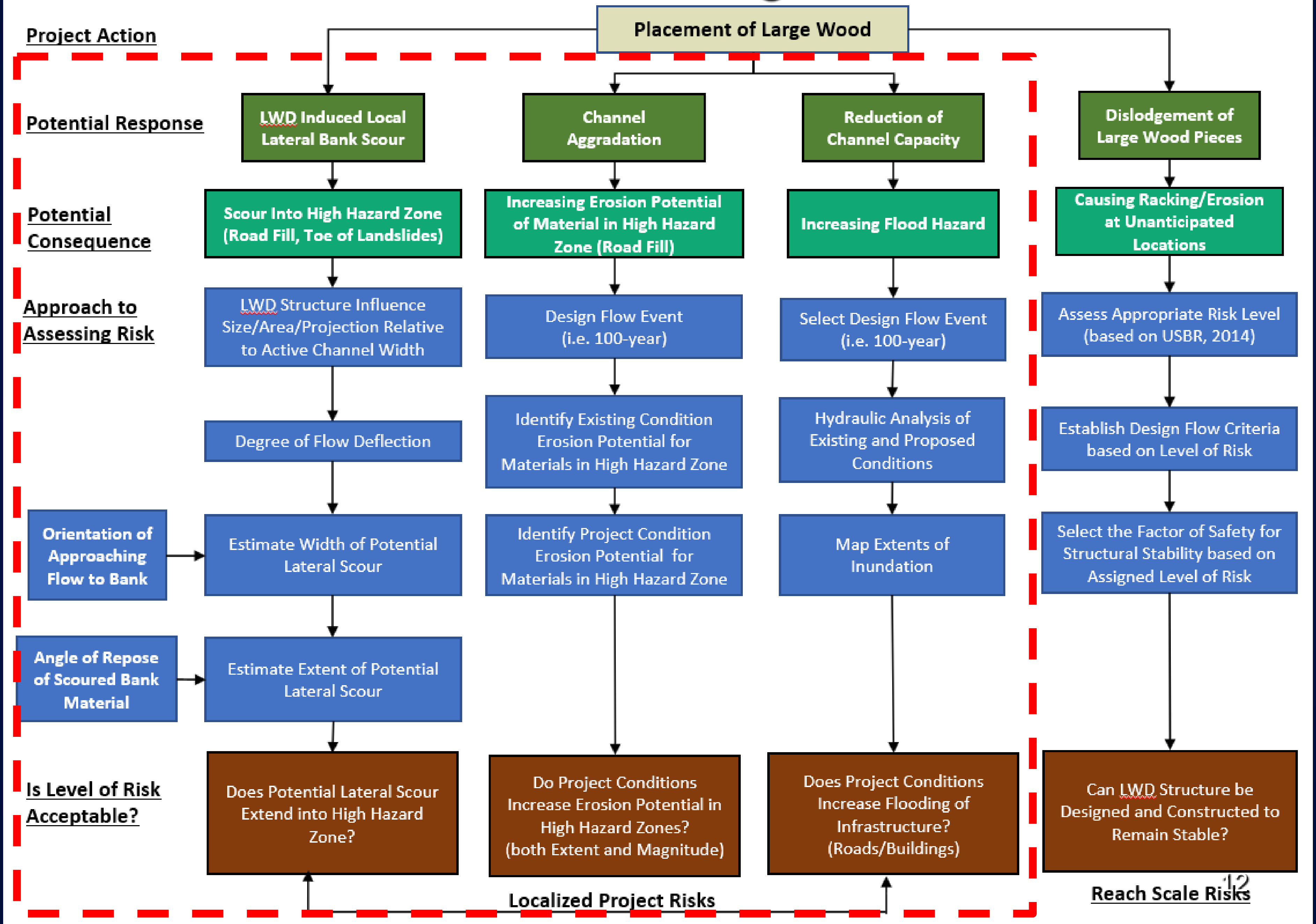
<u>Due to High Risk</u> All large wood structures need to be engineered to remain stable

Table 4. Minimum recommended factors of safety.

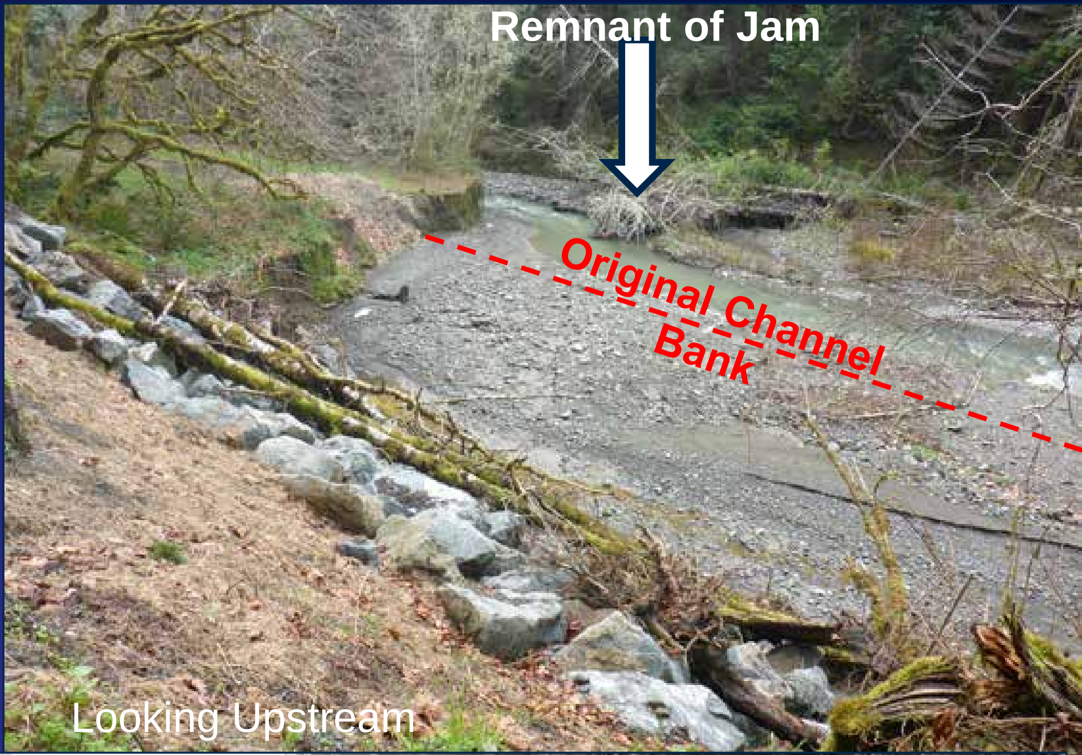
Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

(from Knudsen and Fealko, 2014)

Assessment of Risk from Large Wood Structures



Lateral Scour Example

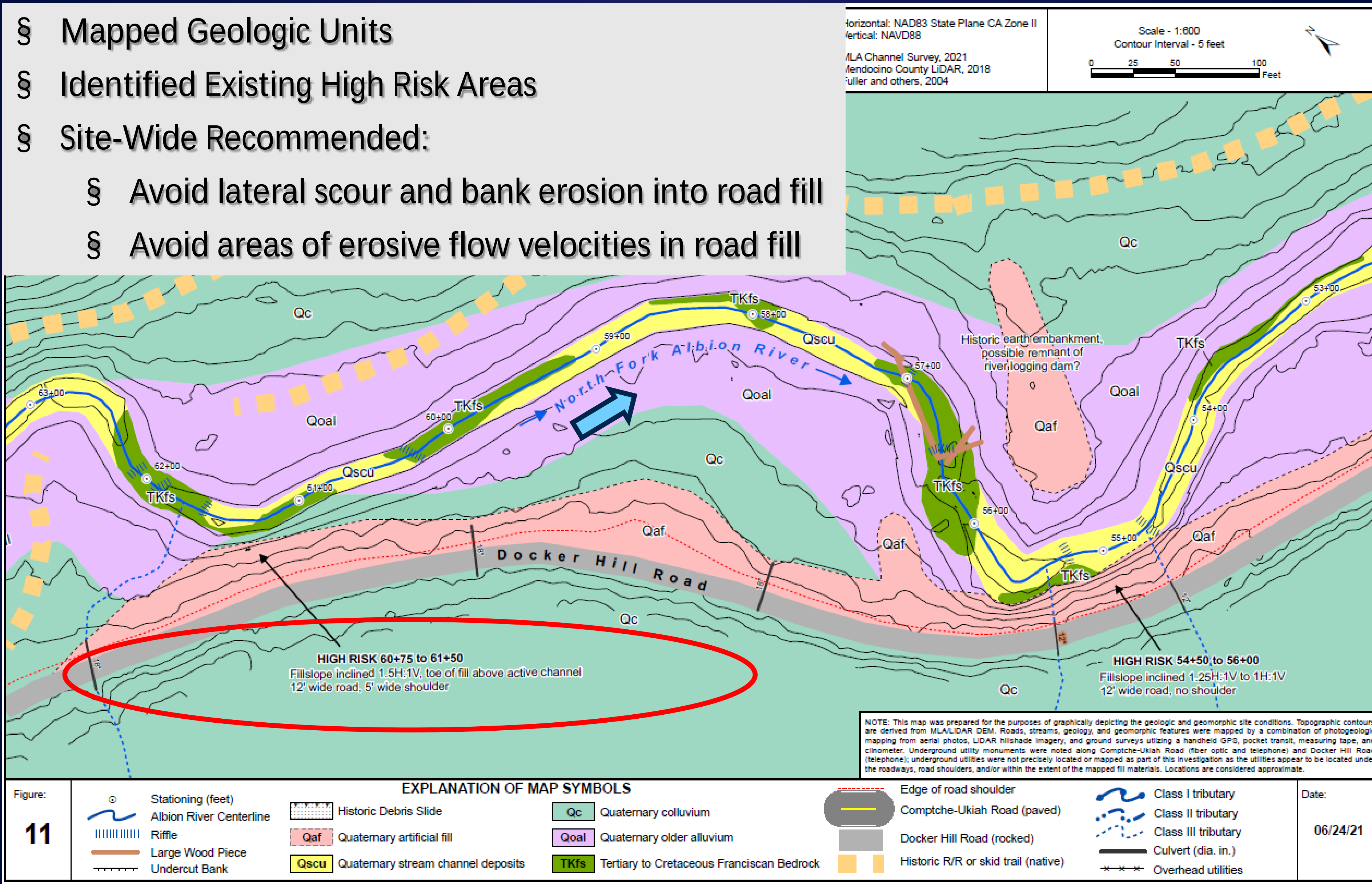


Price Creek
Tributary To Eel River

Racking on LWD Structure Causes Lateral Scour into County Road Embankment Leading to Emergency Repair

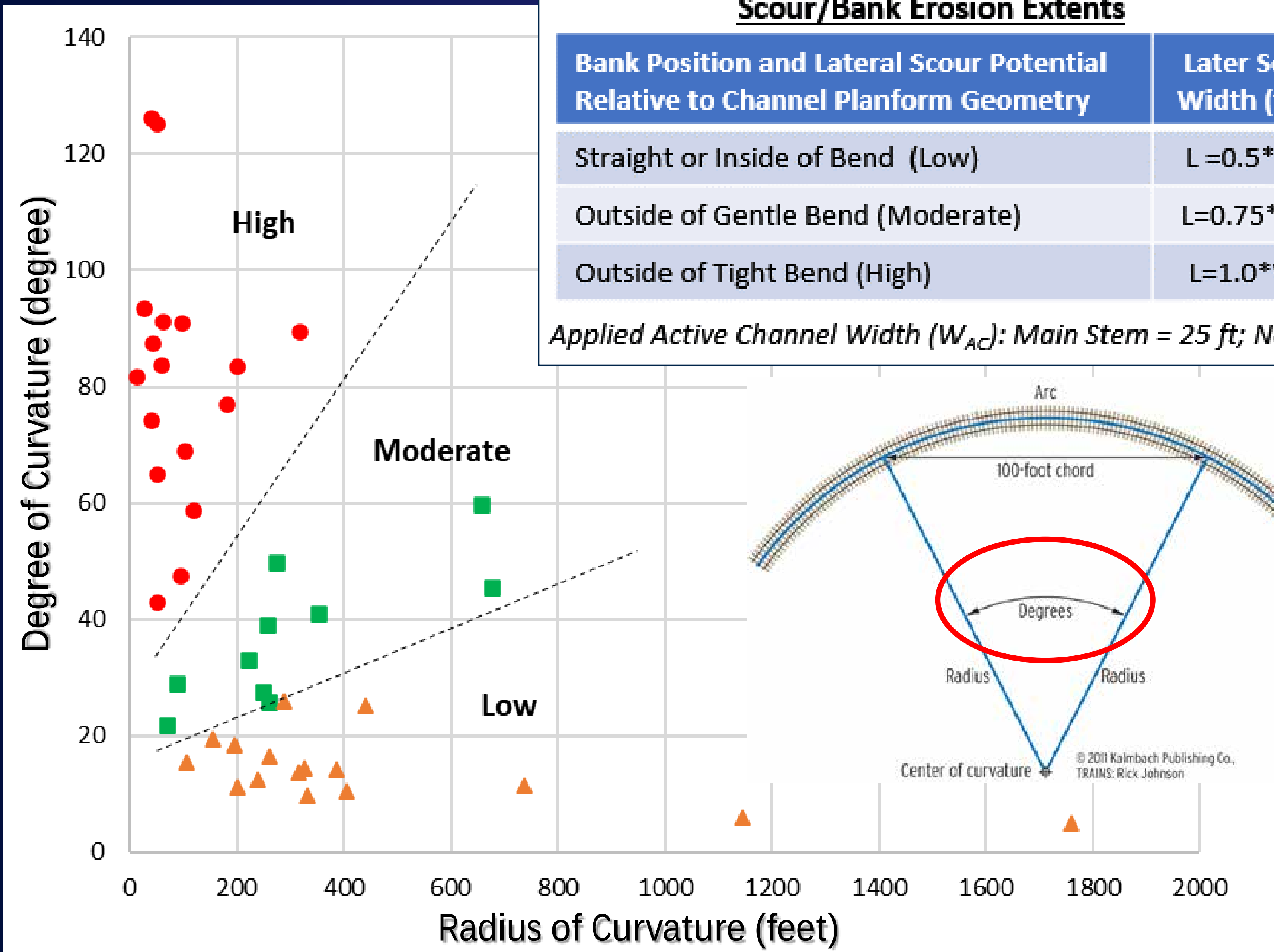
Geologic and Geomorphic Mapping

- Mapped Geologic Units
- Identified Existing High Risk Areas
- Site-Wide Recommended:
  - Avoid lateral scour and bank erosion into road fill
  - Avoid areas of erosive flow velocities in road fill



From Elias Steinbuck, 2021. Geologic and Geomorphic Characterization Memo

Predicting Lateral Scour Extents

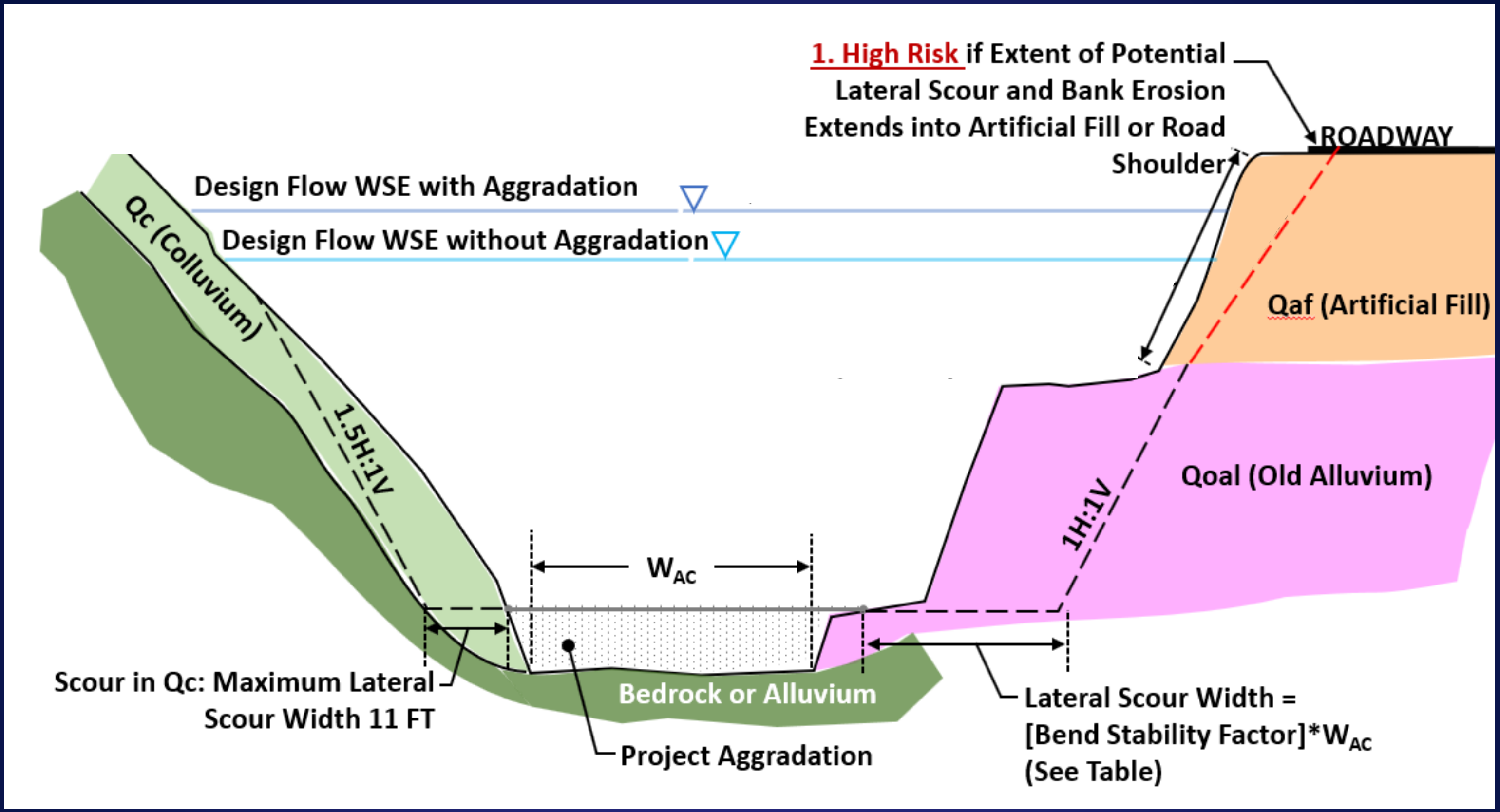


Values Applied to Assessment of Potential Lateral Scour/Bank Erosion Extents

Bank Position and Lateral Scour Potential Relative to Channel Planform Geometry	Later Scour Width (feet)
Straight or Inside of Bend (Low)	$L = 0.5 * W_{AC}$
Outside of Gentle Bend (Moderate)	$L = 0.75 * W_{AC}$
Outside of Tight Bend (High)	$L = 1.0 * W_{AC}$

Applied Active Channel Width (W_{AC}): Main Stem = 25 ft; North Fork = 16 ft

Predicting Lateral Scour and Bank Erosion Extents



Values Applied to Assessment of Potential Lateral Scour/Bank Erosion Extents

Bank Position and Lateral Scour Potential Relative to Bend Stability	Later Scour Width (feet)
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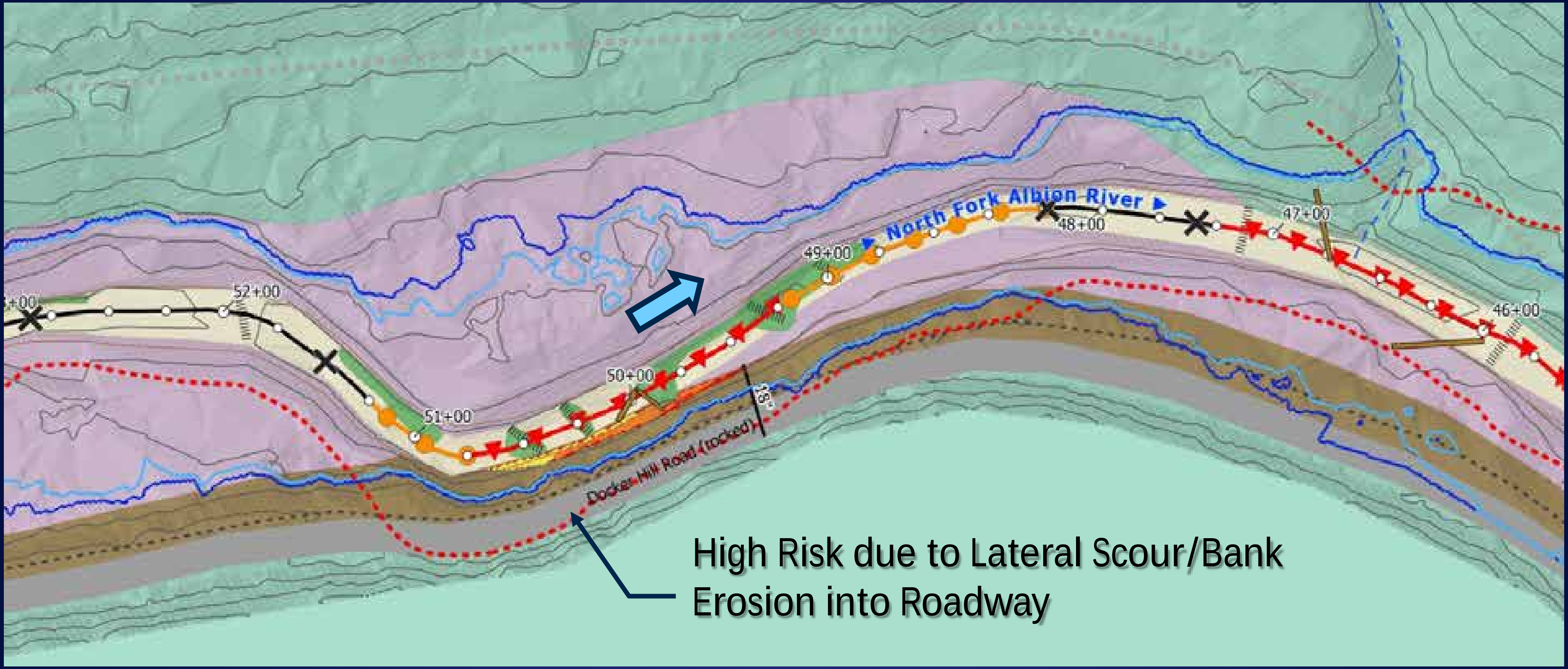
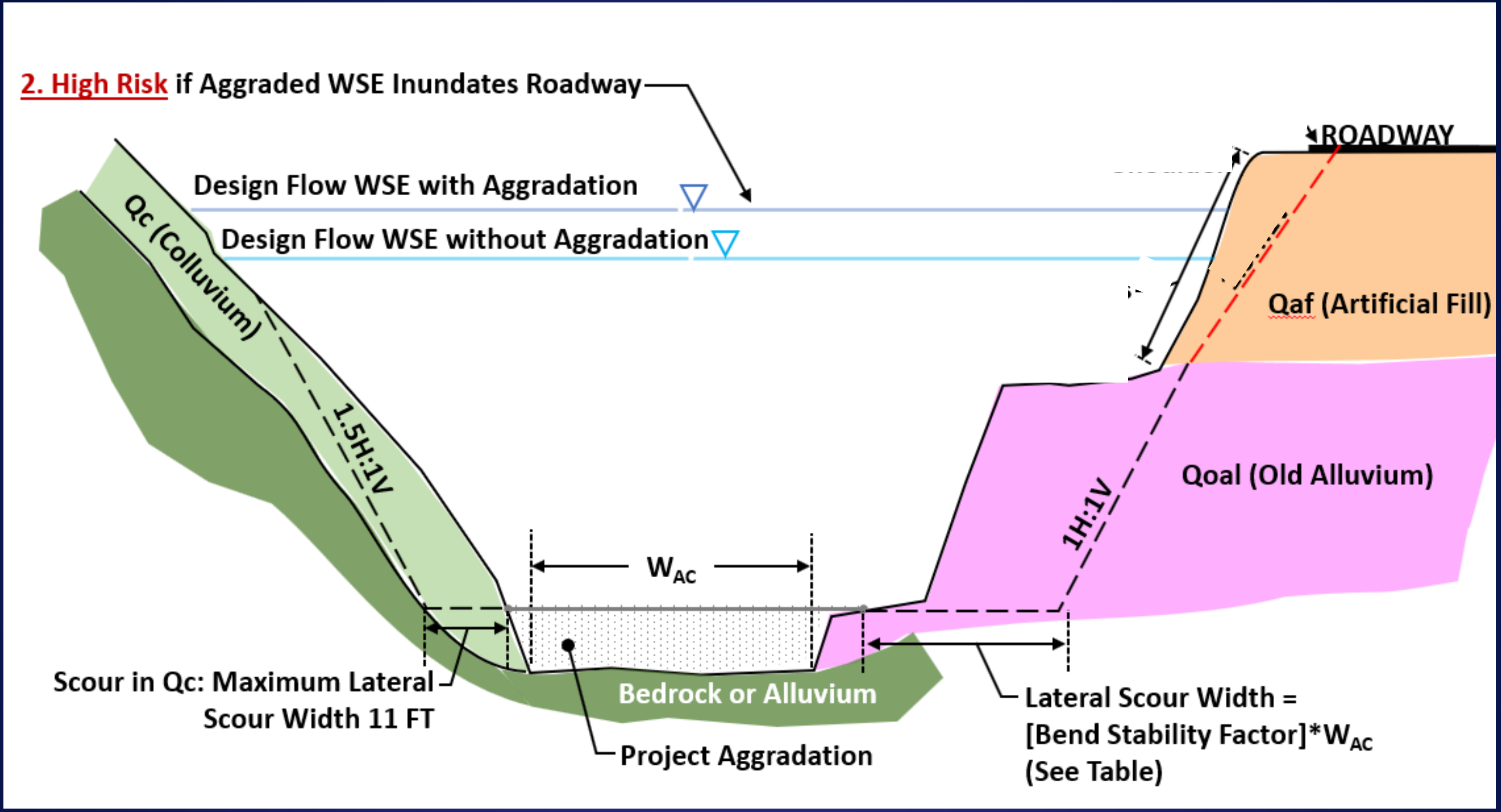
Predicting Lateral Scour and Bank Erosion Extents



Predicting Increased Roadway Flooding



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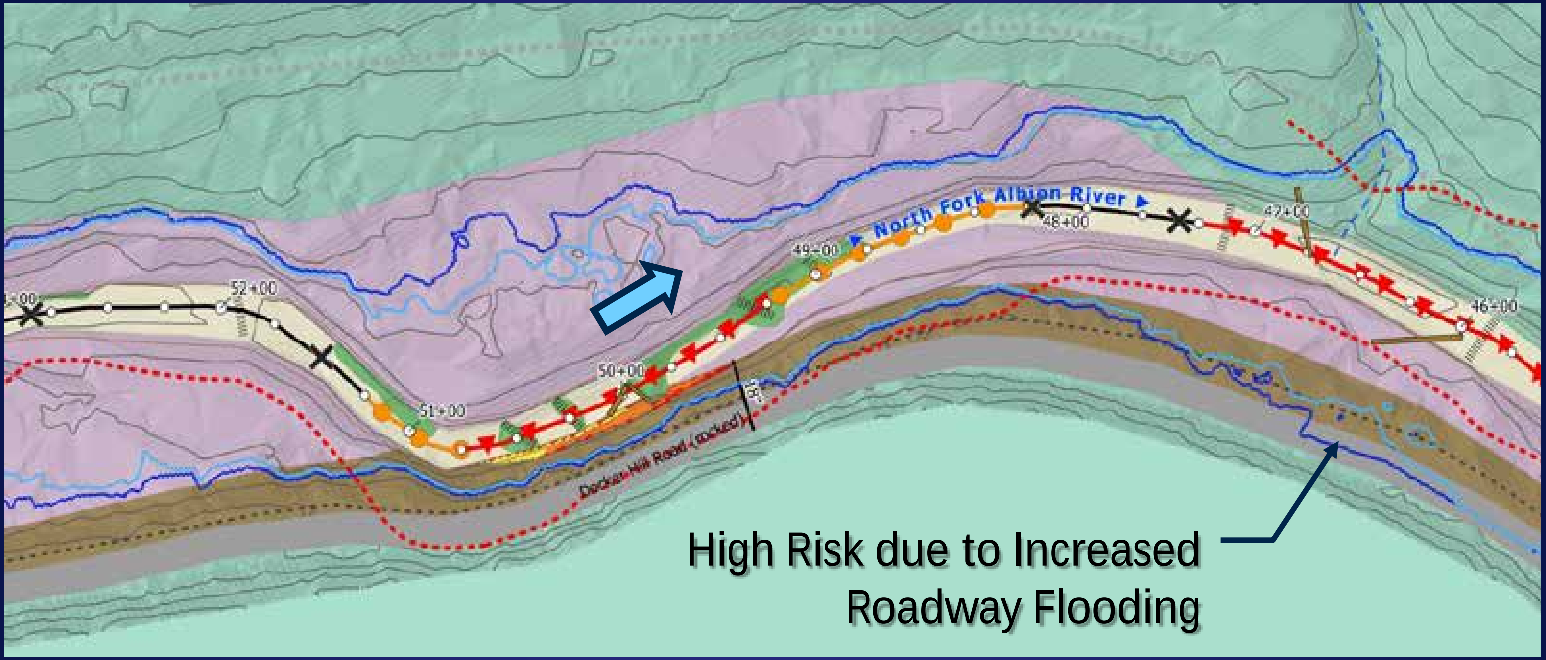
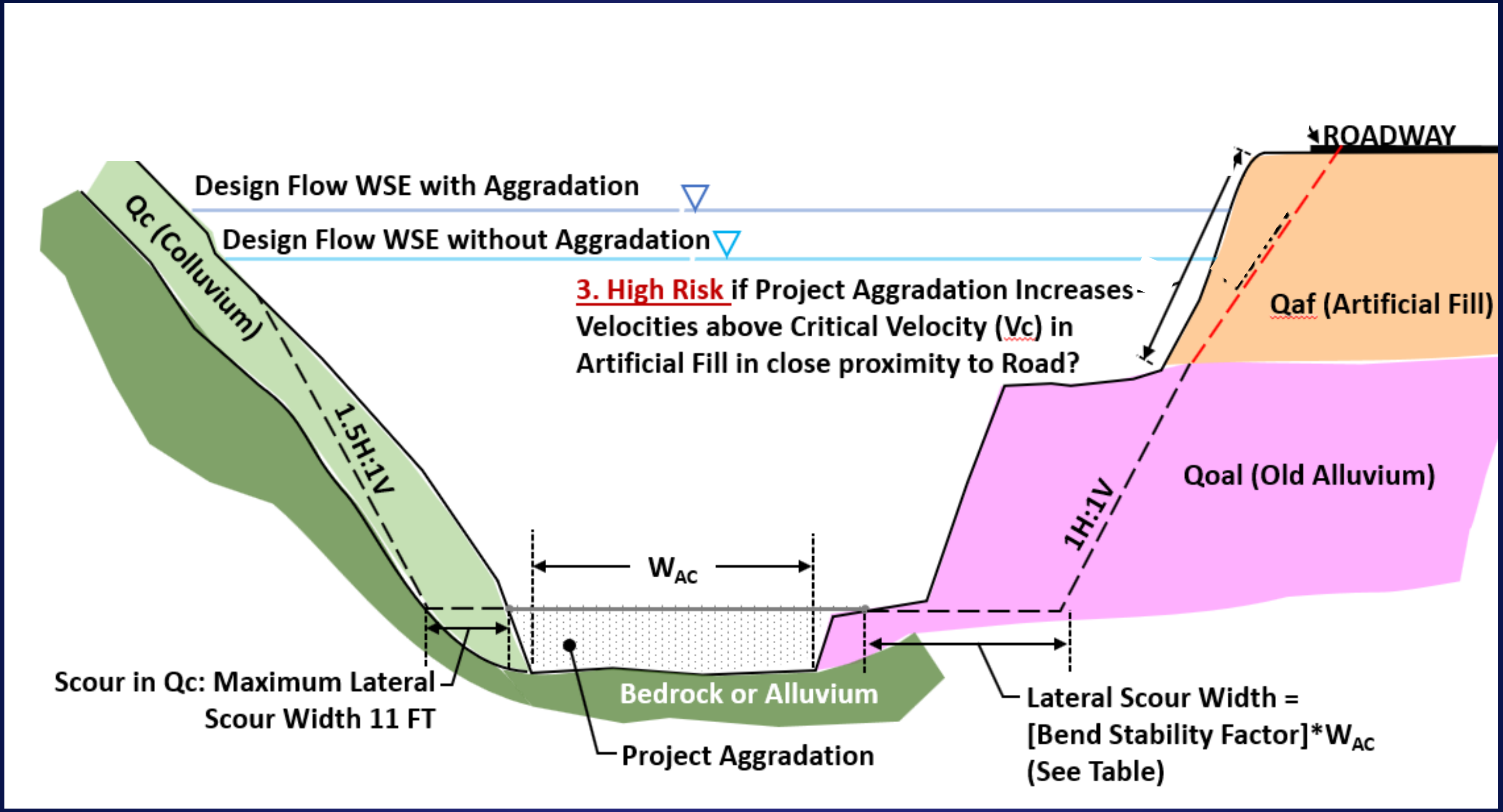


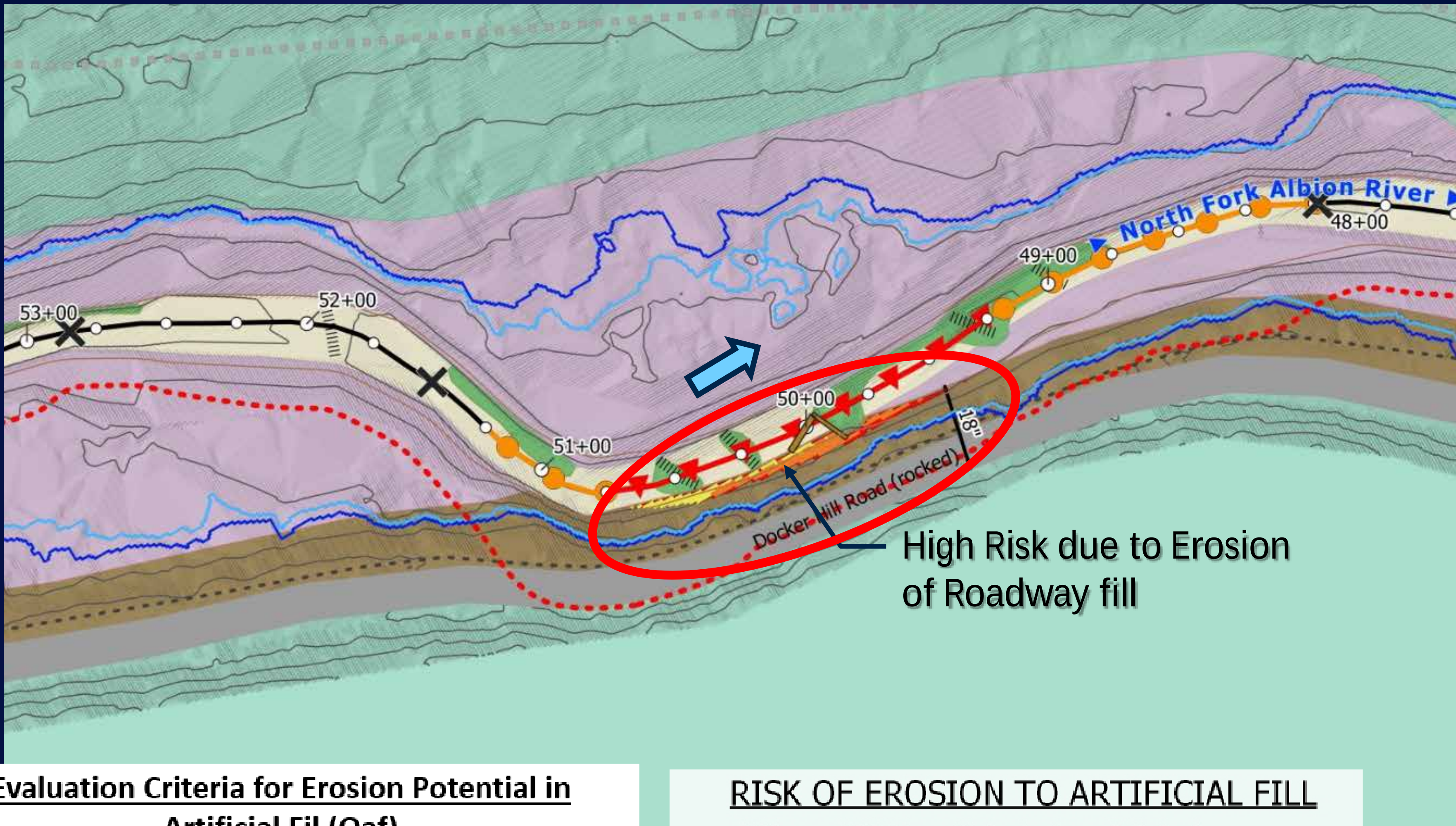
Predicting Increased Erosion Potential in Artificial Fill



Evaluation Criteria for Erosion Potential in Artificial Fil (Qaf)

- 100-year return period flow velocities
- Applied Critical Velocity for Artificial Fill = 3.5 ft/s based on NRCS Threshold Channel Design (NRCS, 2007)

Predicting Increased Erosion Potential



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- 100-year return period flow velocities
- Applied Critical Velocity for Artificial Fill = 3.5 ft/s based on NRCS Threshold Channel Design (NRCS, 2007)

RISK OF EROSION TO ARTIFICIAL FILL

(Where 100-Year Velociteis > 3.5 fps)

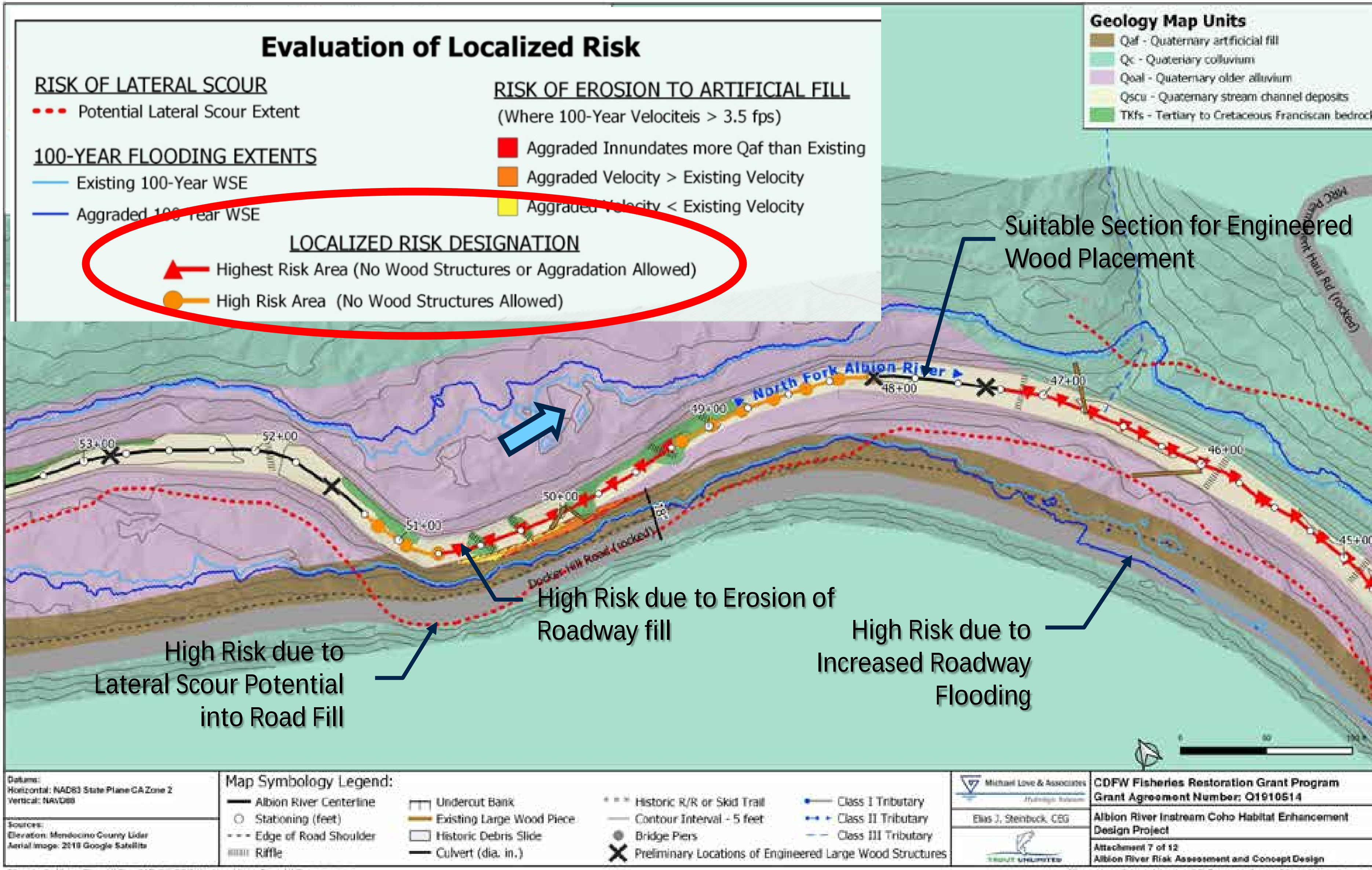
- Aggraded Innundates more Qaf than Existing
- Aggraded Velocity > Existing Velocity
- Aggraded Velocity < Existing Velocity

Putting it all Together…

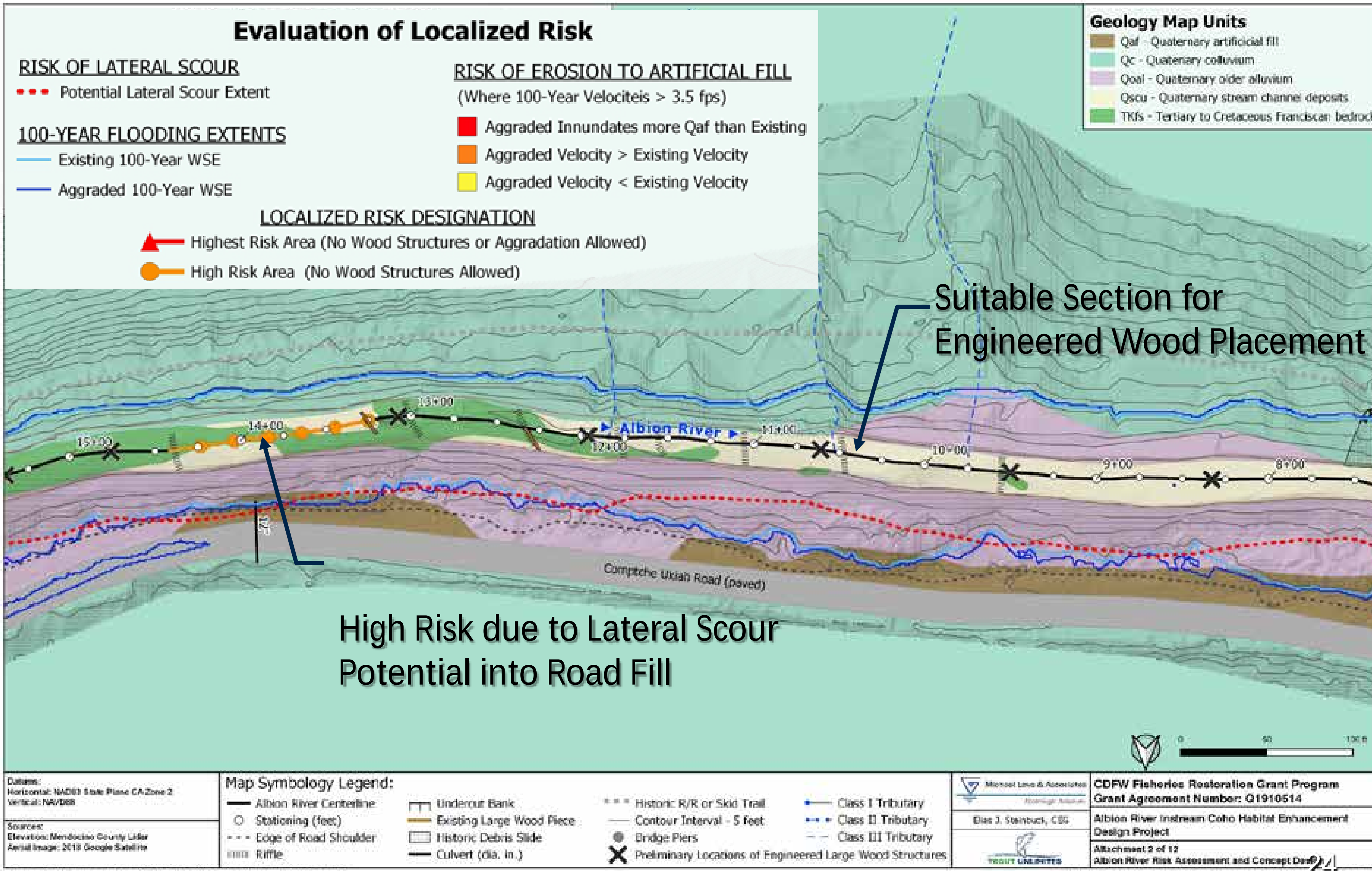
Mitigation Actions for Identified Hazards based on Risk Level

Identified Hazards	Mitigation for High Risk Locations
Reach Scale Hazard: Potential Log Dislodgement and downstream impacts	Engineer Structures for Stability based on High Risk Criteria
Local Hazards: 1. Potential Lateral Scour into Roadway	• No Structures In these Locations BUT • Aggradation is Allowed
2. Potential Increase of Erosion along Road Fill	• No Structures AND • No Aggradation above Overall Existing Channel Profile
3. Roadway Inundation and Loss of Bridge Capacity	

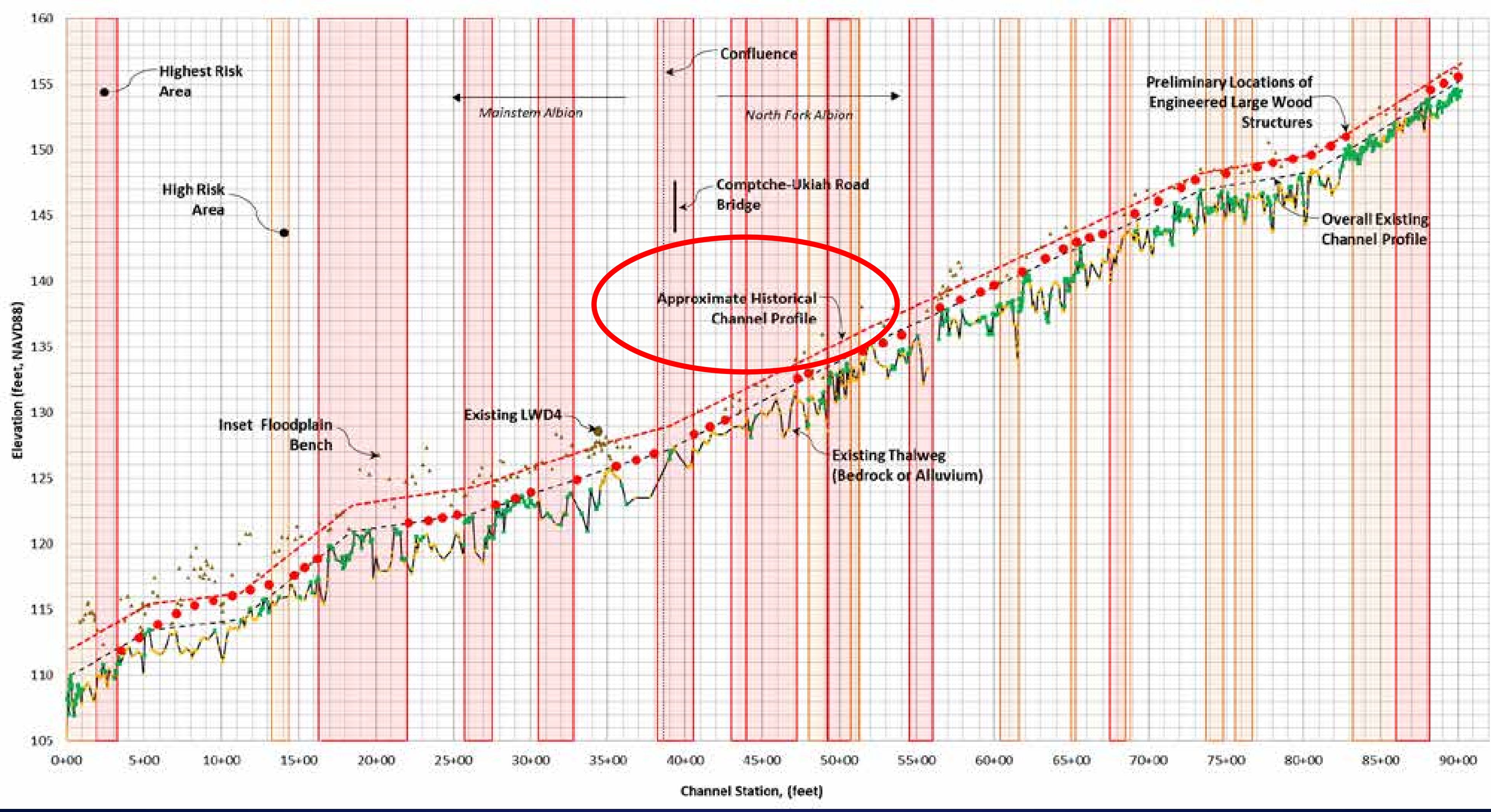
Putting it all Together-Plan View



Putting it all Together-Plan View



Putting it all Together-Profile View



Summary

- This is one approach to assessing risk in a "risky reach"
  - Pilot study for large wood risk assessment
  - Tried a wide breath of analysis
  - Likely can be simplified
- Need to Identify Reach-Based and Localized Risks and mitigate according
- If structure dislodgement poses downstream risk to property/safety due to unanticipated scour/racking

<u>All structures must be engineered for stability</u>

Questions?

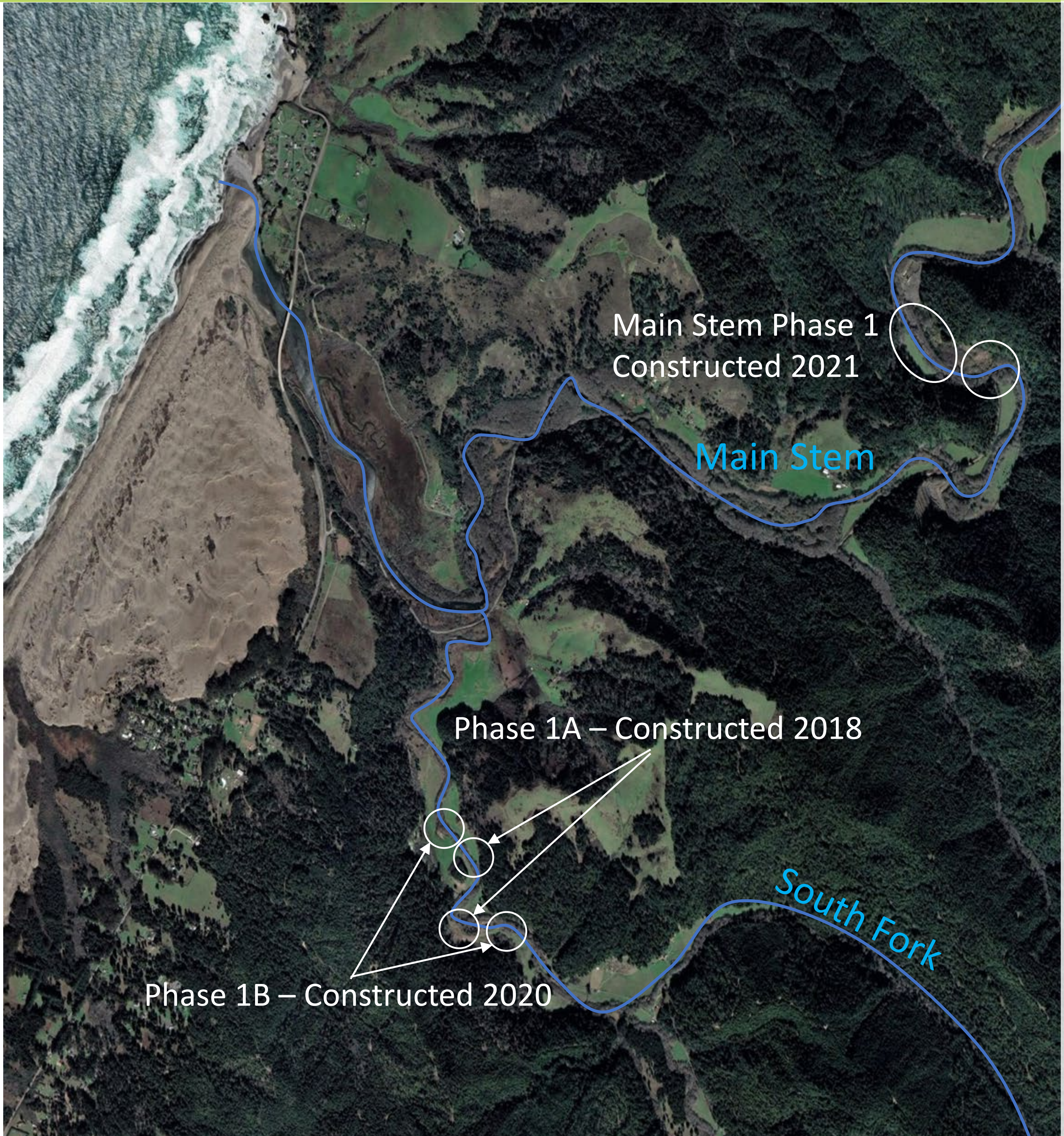
Design Approaches and Lessons Learned from the Ten Mile River Projects

Luke Walton (Prunuske Chatham, Inc.)

SRF Conference – Santa Cruz

4/19/22

Ten Mile River



<u>Historical land use - Ranching & Logging:</u>

- Legacy sediment
- Veg clearing
- Large Wood Removal
- Wetland draining

Led to simplified, moderately incised/entrenched channels

<u>Biological Imperative:</u>

- Coho, Chinook, Steelhead, with up to 25% of the entire coastal coho population

<u>Restoration Project</u>

In 2015, PCI began working with TNC to rebuild historic habitat throughout lower Ten Mile River using LWD and off-channel features

Goals and Design Objectives – Reach Based

Goals

- Significantly increase winter/spring high flow refugia and rearing habitat for juvenile salmonids (with focus on coho).
- Improve in-channel complexity and cover for summer juvenile salmonid rearing.

Design Objectives

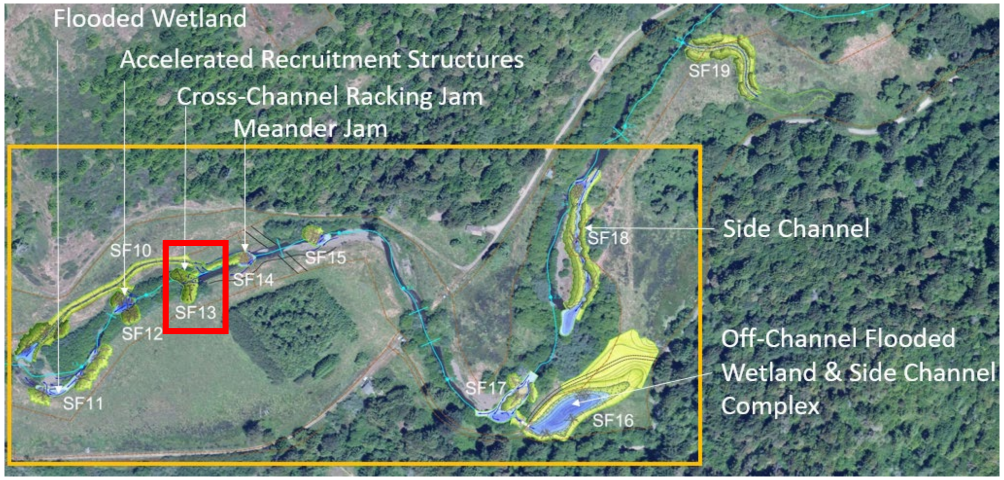
- Increase prevalence of low velocity environments at range of winter flows.
- Increase number of deep pools with complex wood cover.
- Engage existing floodplain benches at lower winter flows.
- Drive channel widening and stable vegetated gravel bar formation.
- Accelerate natural recruitment of riparian trees.
- Trap and accumulate woody debris.
- Link accessibility to range of habitats
- Use a range of large wood designs and techniques
- Relatively unconstrained, low risk environment

The problem - Entrenchment and Lack of Complexity

- Sediment deposition in floodplains have led to 5 to 15 feet of homogenous, silty sand - no buried soil layers
- Alluvial gravels, buried logs, intact tree roots below floodplain fine sediments. At existing channel elev.
- Flood and alluvial fan deposits from intense logging periods, cleared and smoothed for agriculture.
- Historic large wood removal
- Minimal wood recruitment and delivery to reaches

South Fork Ten Mile – Constructed 2018 & 2020

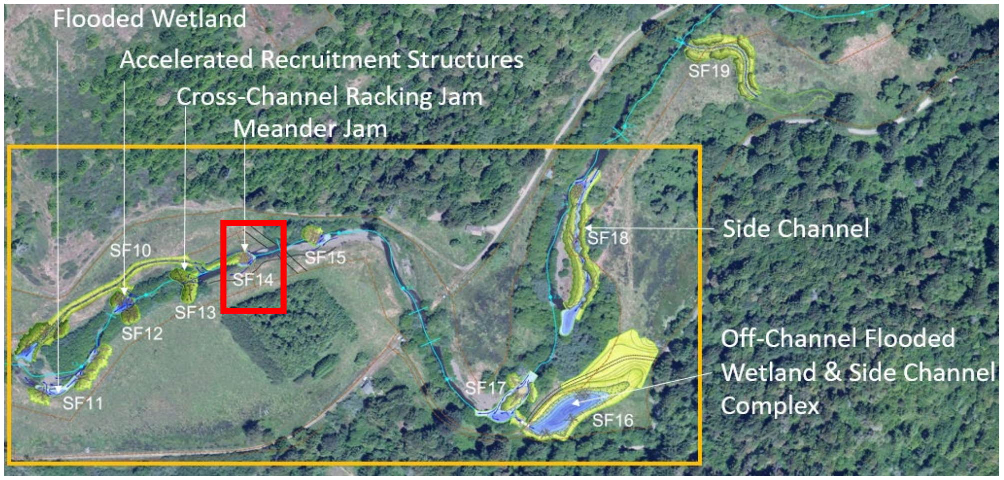
Cross-Channel Racking Jam



Lessons Learned:

- Install backing behind vanes.
- Compact temporary trenches used to place logs.
- Angled logs may need to go deeper

Meander Jam



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- Consider flanking of structure.
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Off-channel flooded wetland and side channel complex

Lessons Learned:
- Burying 8’ diameter redwood may have been wasteful.
- Using only 1 nut on allthread connections is adequate.
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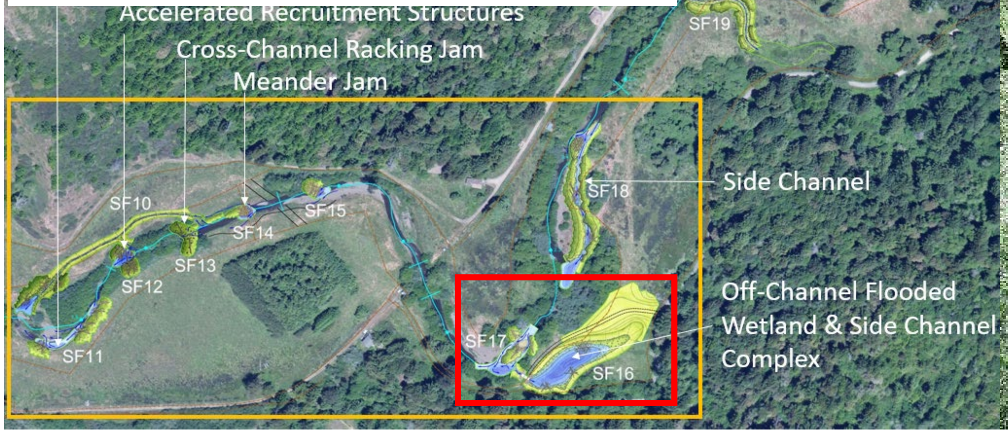
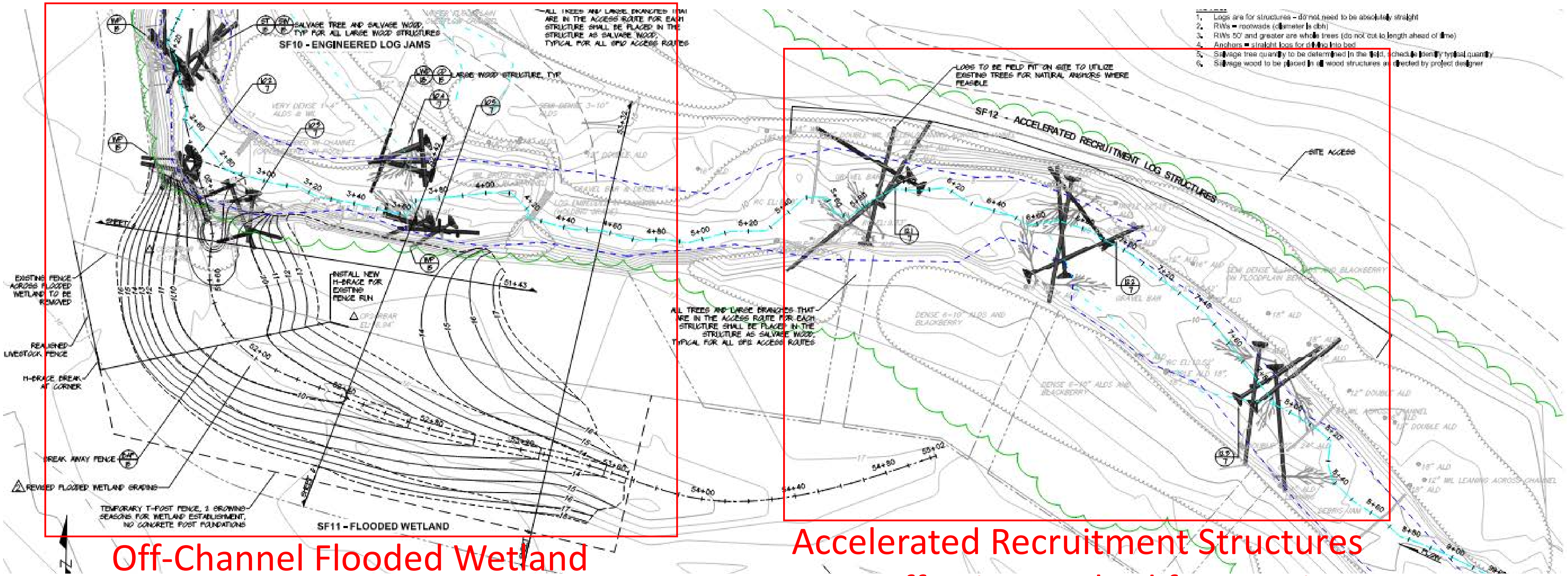


Off-Channel Flooded Wetland, Accelerated Recruitment



Off-Channel Flooded Wetland
-Log structures to create backwater

Accelerated Recruitment Structures
-Cost effective method for creating complex habitat

Side Channel w/ Deflection Jam & Bank Jams

- Side channel left narrow to allow stream to do the work.
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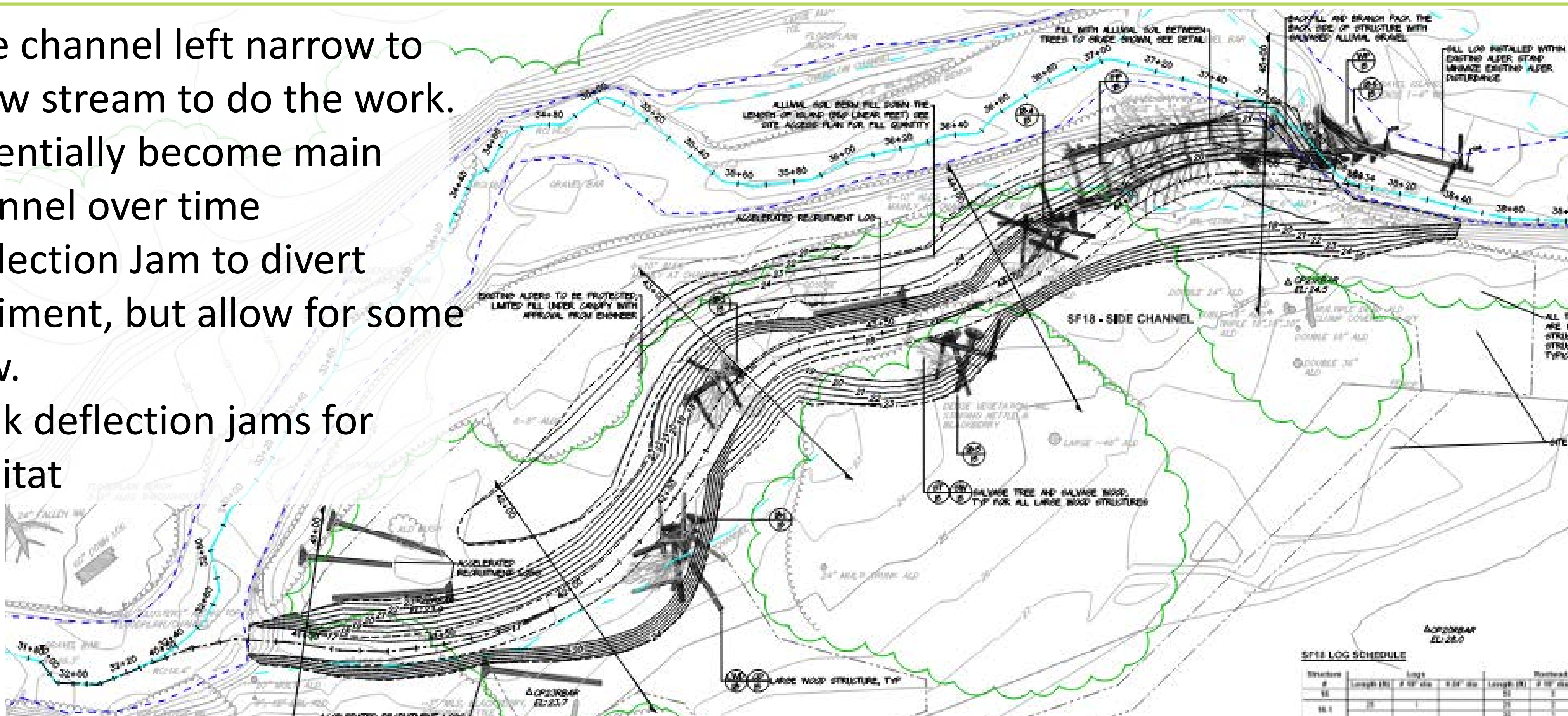
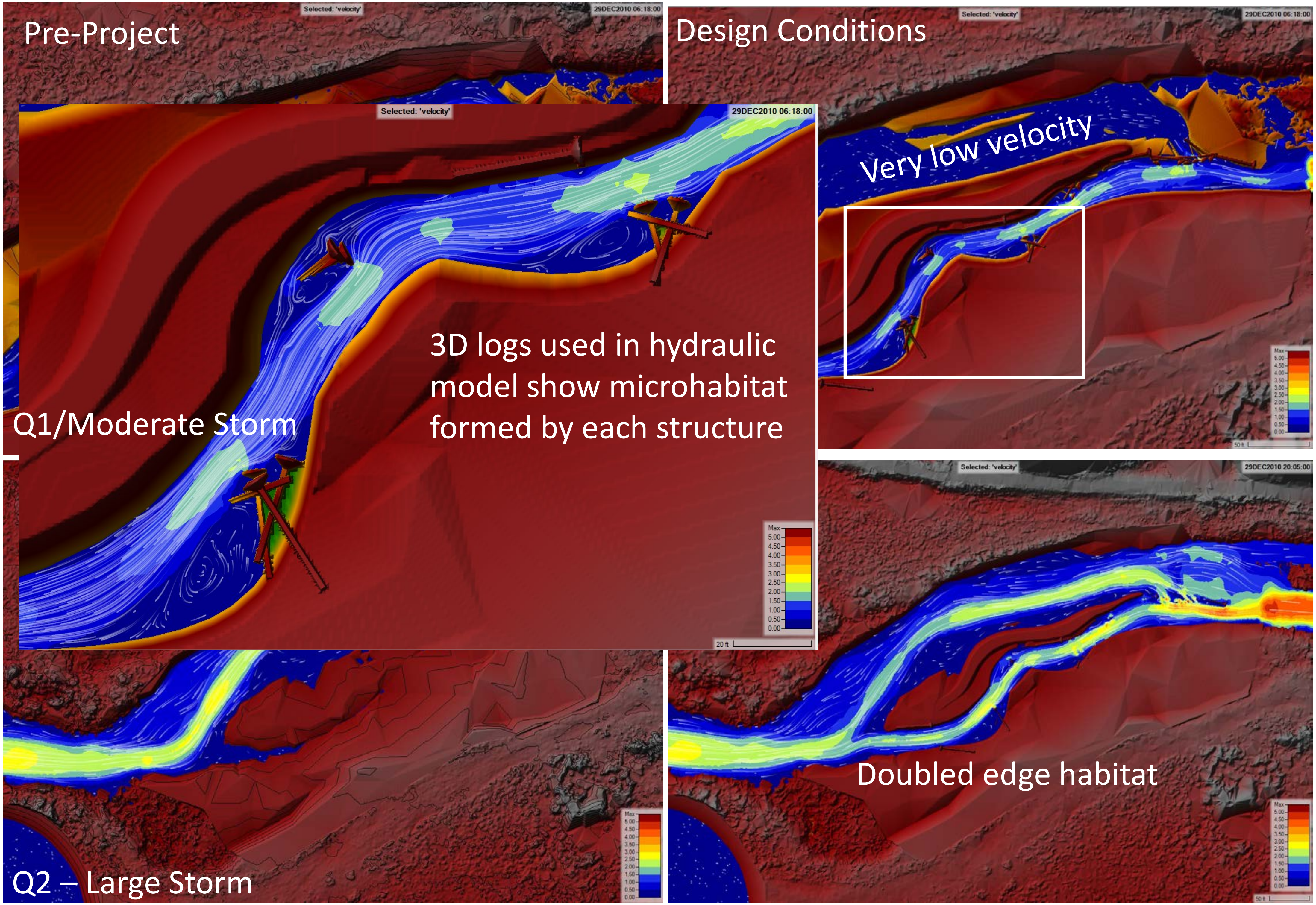
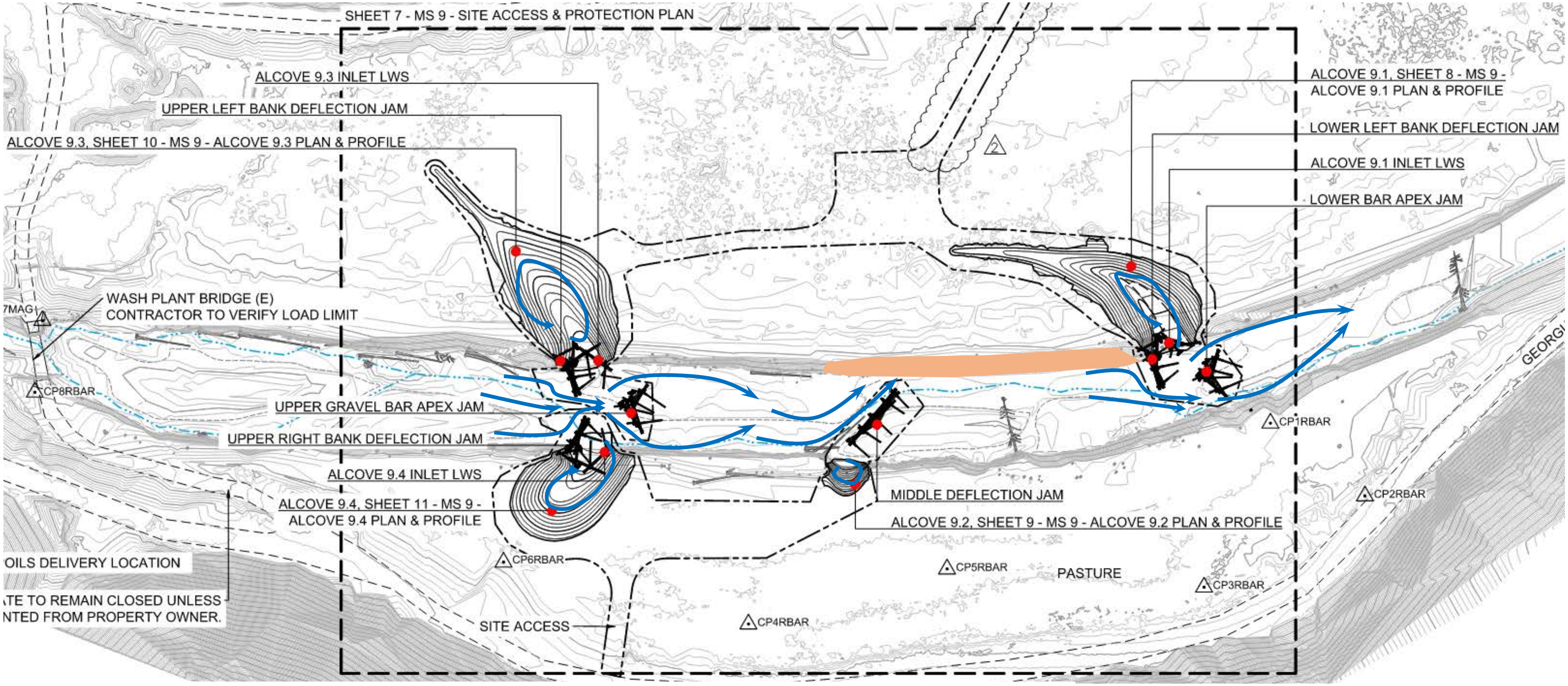


Side Channel Hydraulic Results



Mainstem Ten Mile – Constructed 2021



- Existing reach straight, uniform, with banks armored by mature alders
- Design:
- Large Alcoves (high flow refuge, summer rearing)
- Deflection Jams (divert coarse sediment, force constriction pools, bank erosion and channel widening)
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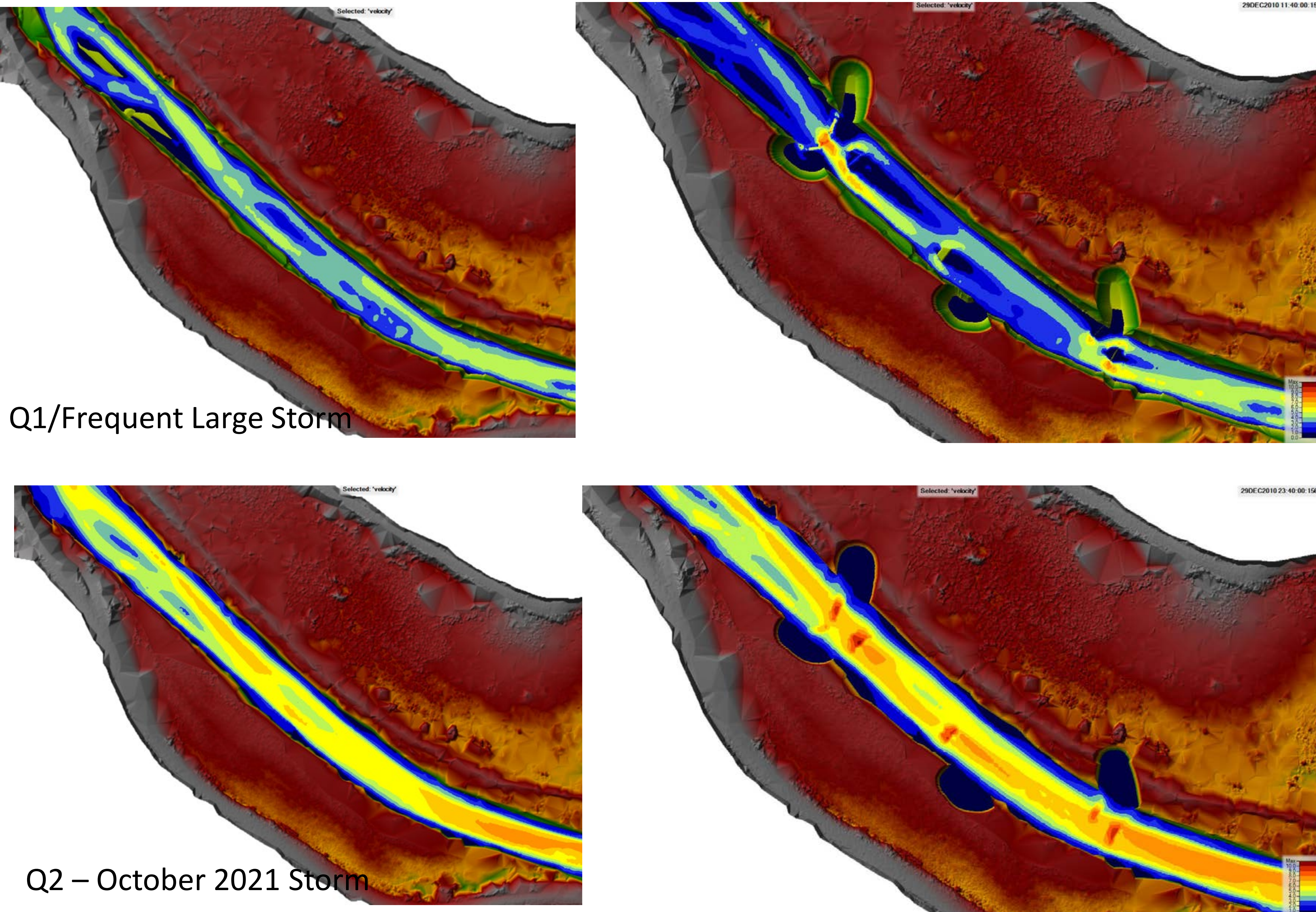
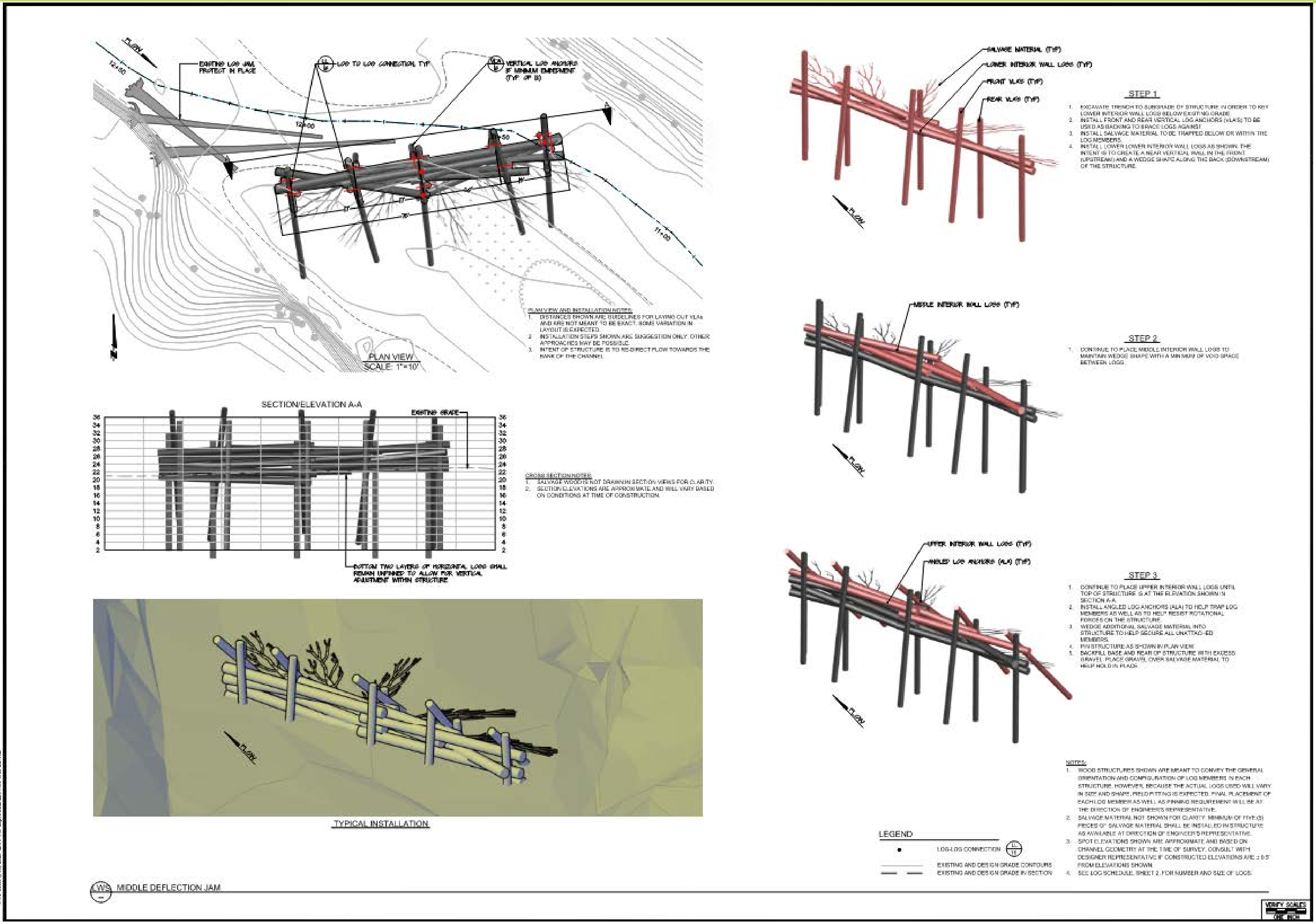
- Use of explosives to soften bank and facilitate recruitment of existing mature alders

June 2022!

Pre-Project Preliminary Design



Engineered Log Jam Designs



- 3D design allows for designers to collaborate on complex structures before construction.
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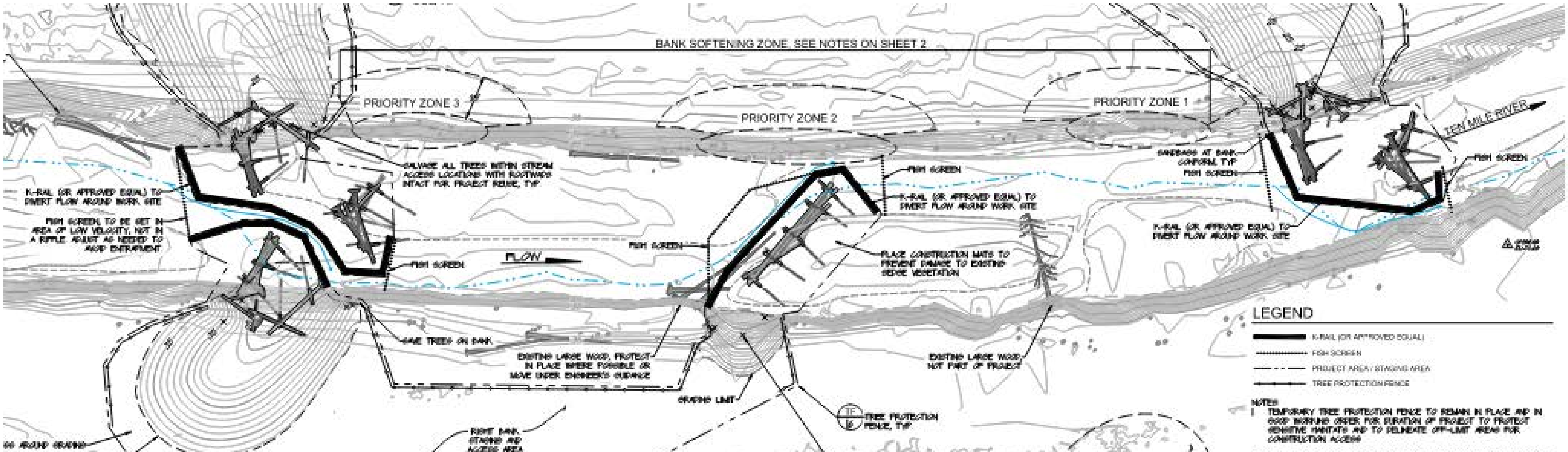
Construction - Deflection Jam

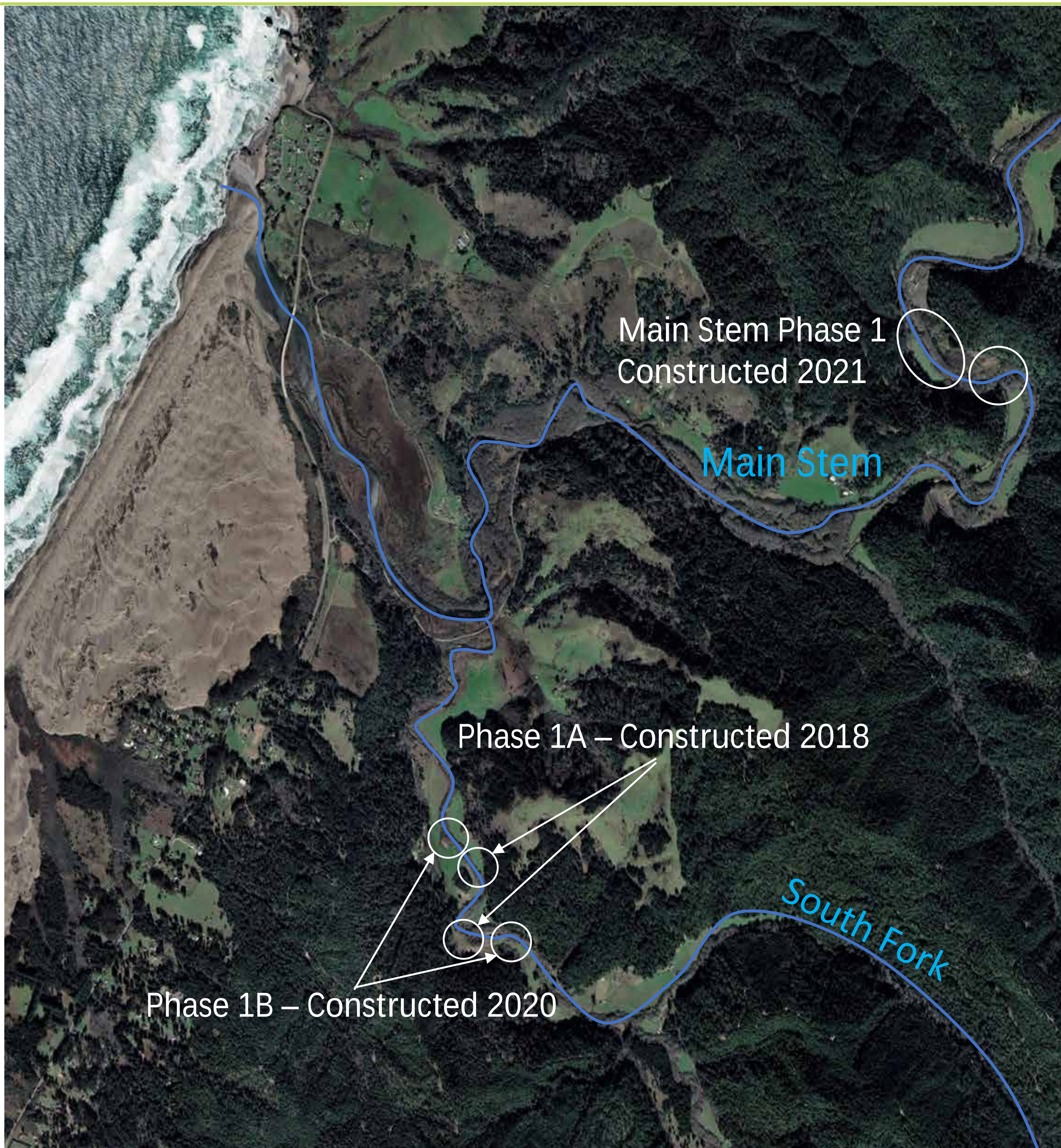


Upstream Deflection and Bar Apex Jams

Deflection jam

Downstream Deflection and Bar Apex Jams

Ten Mile River



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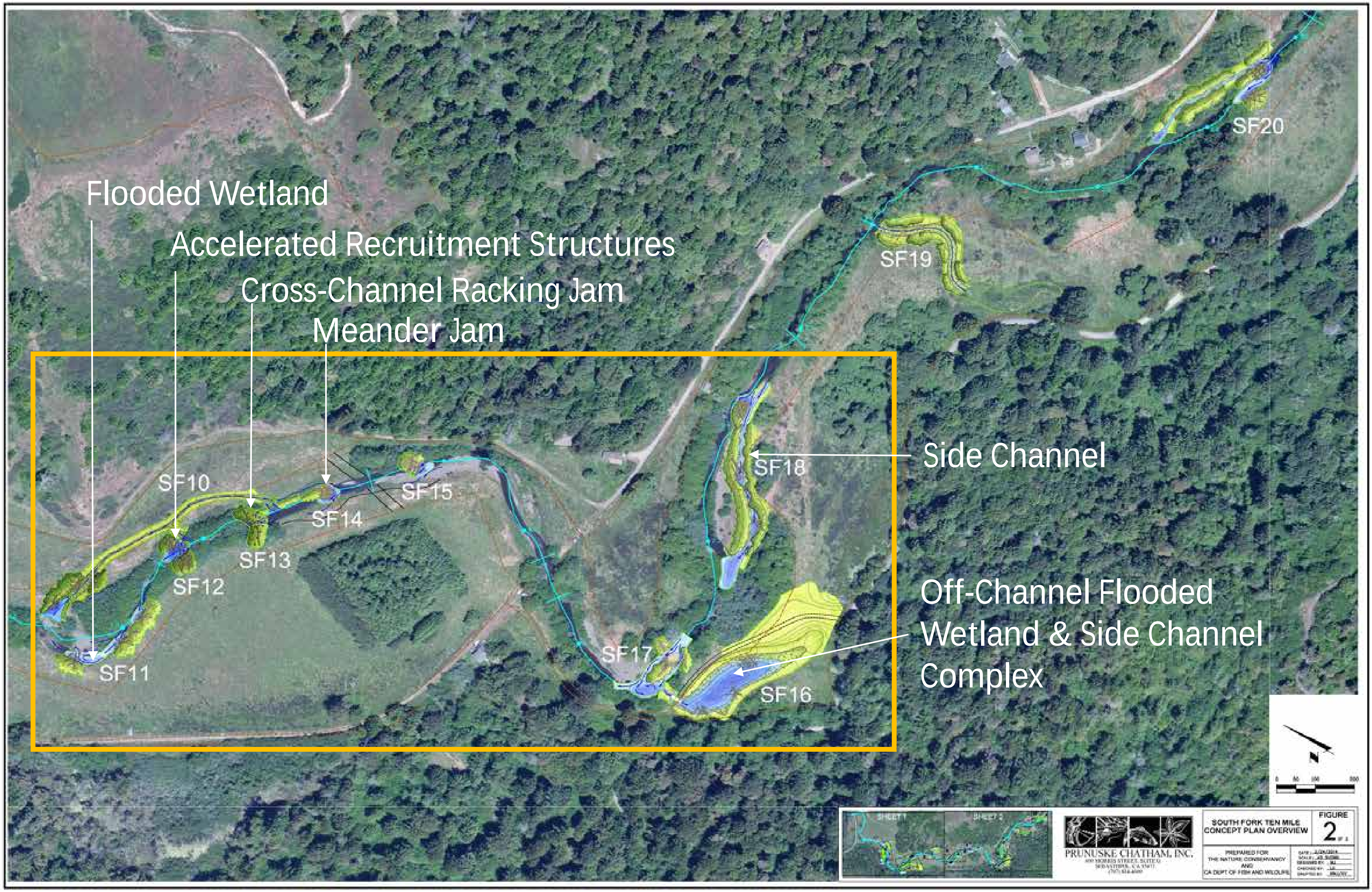

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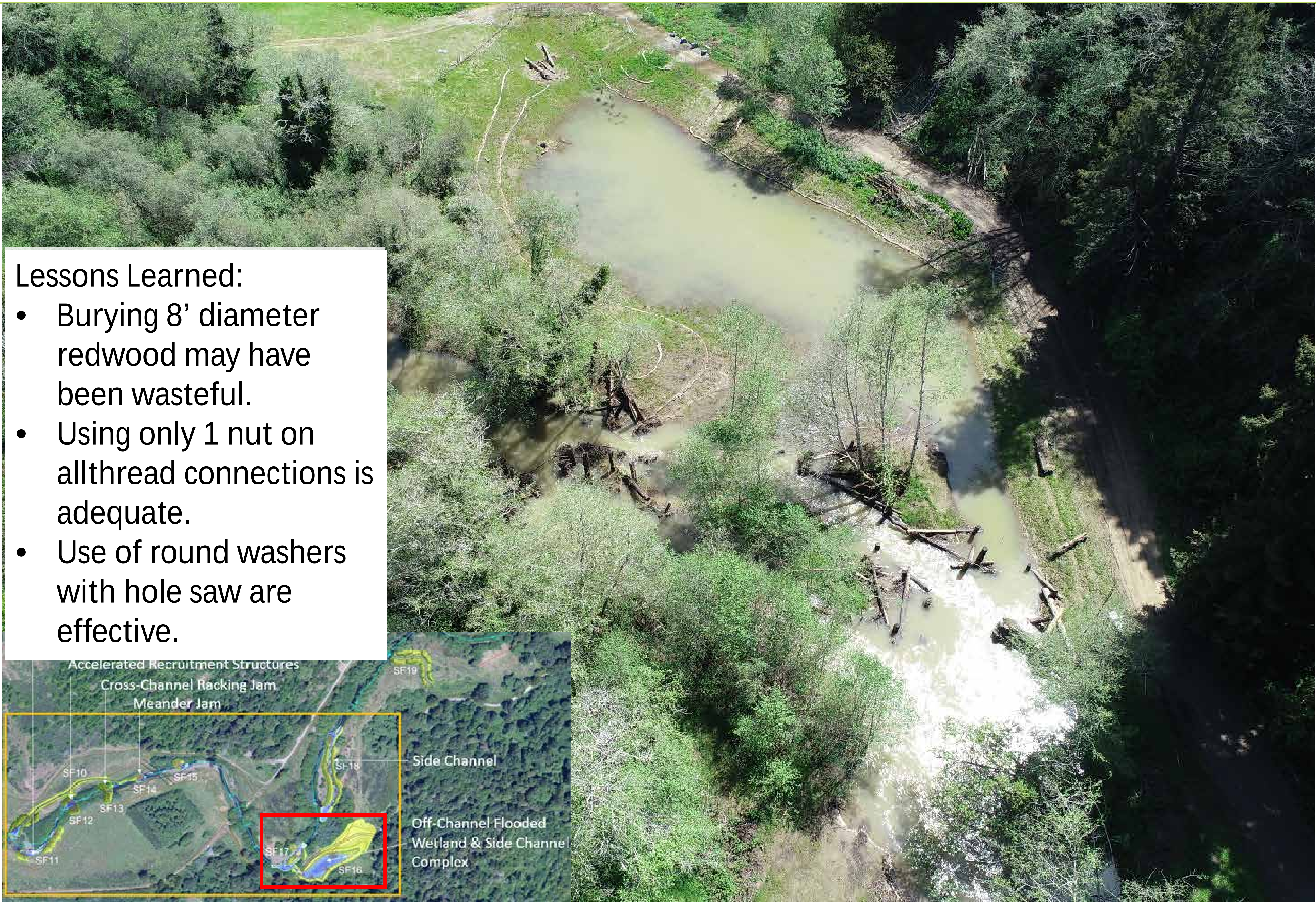

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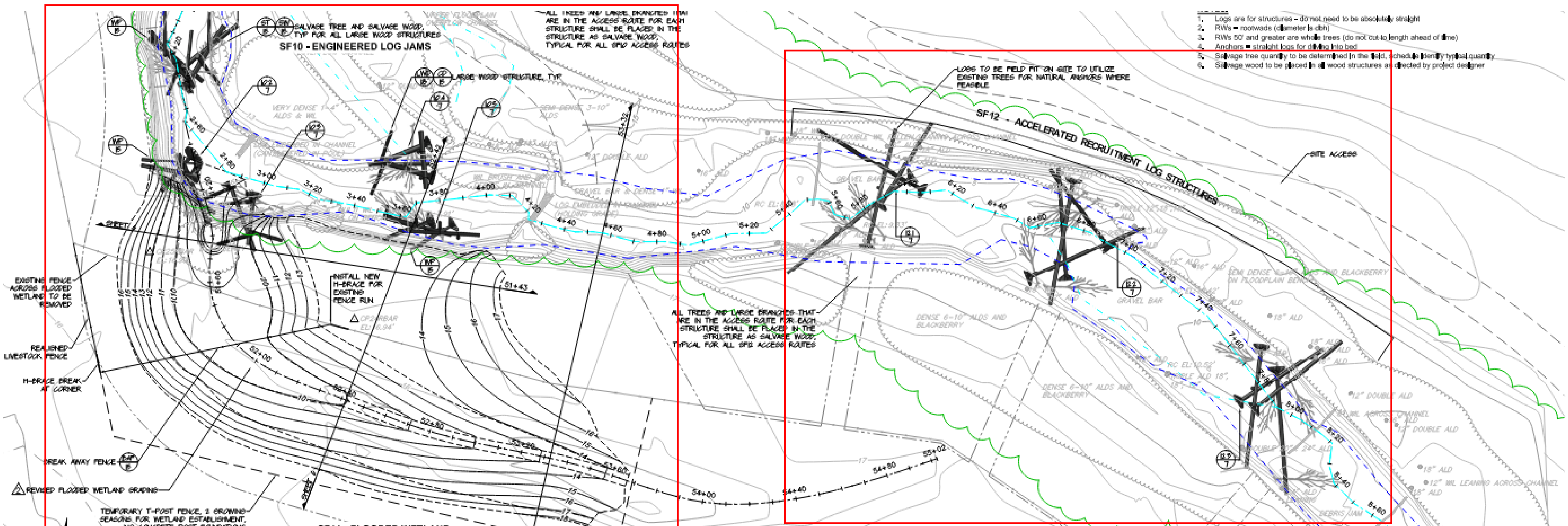

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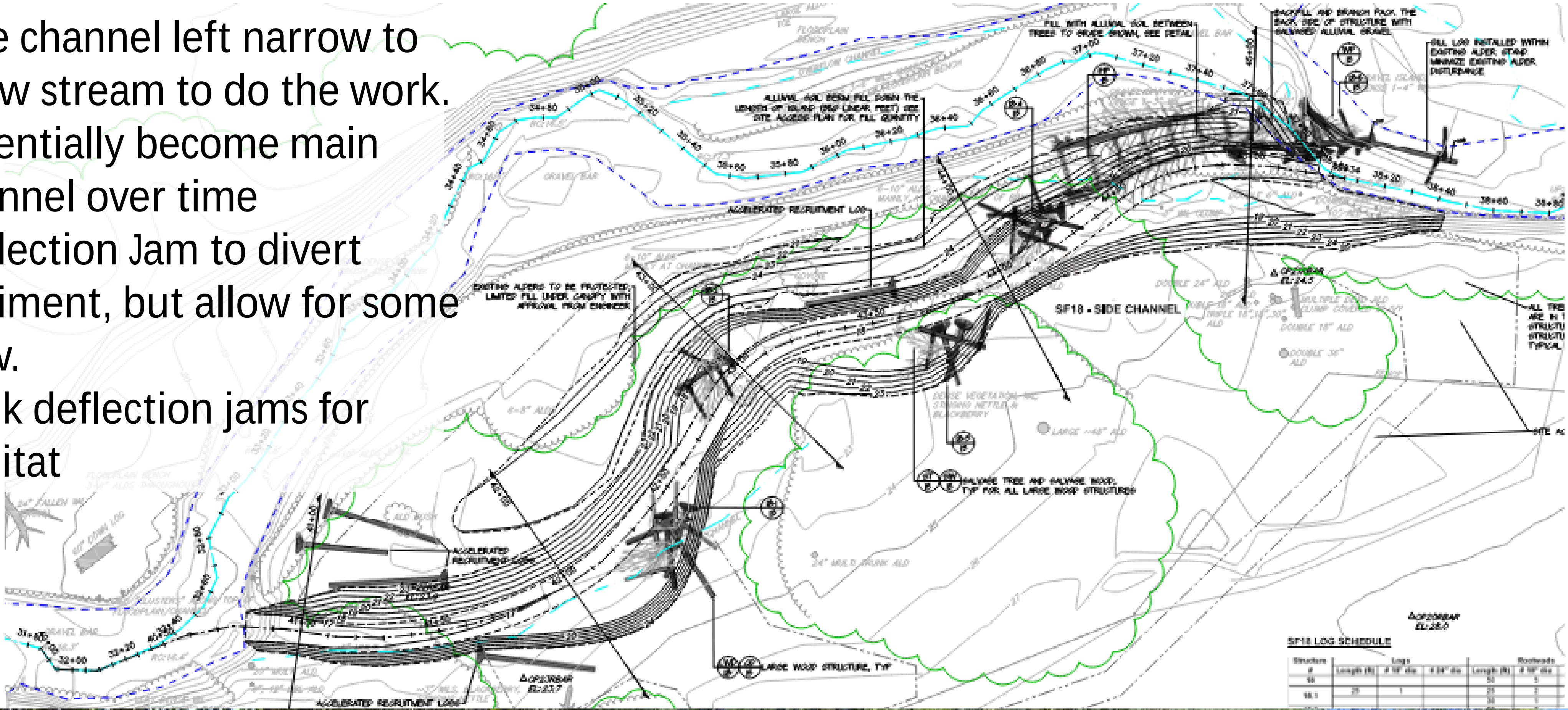

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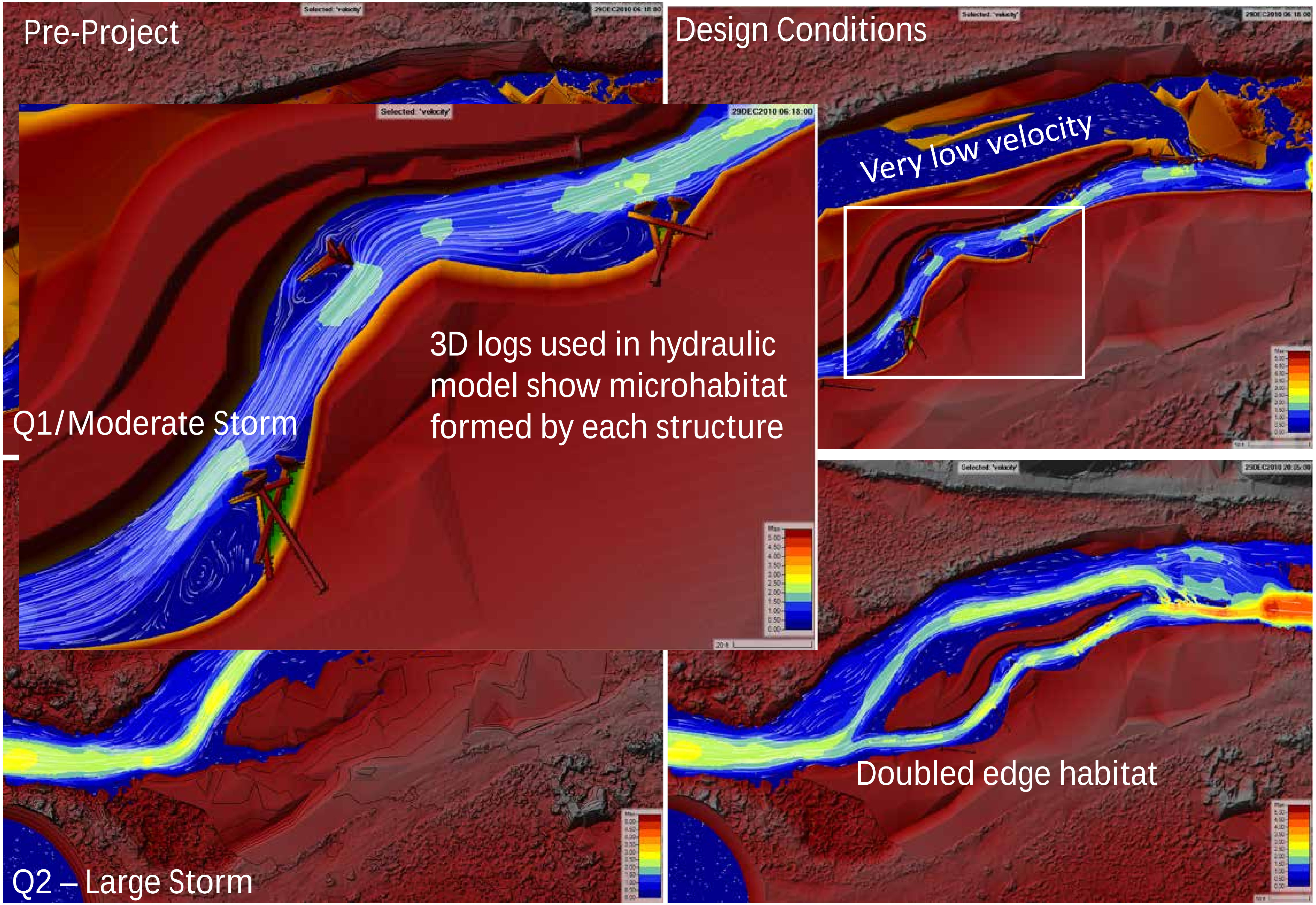

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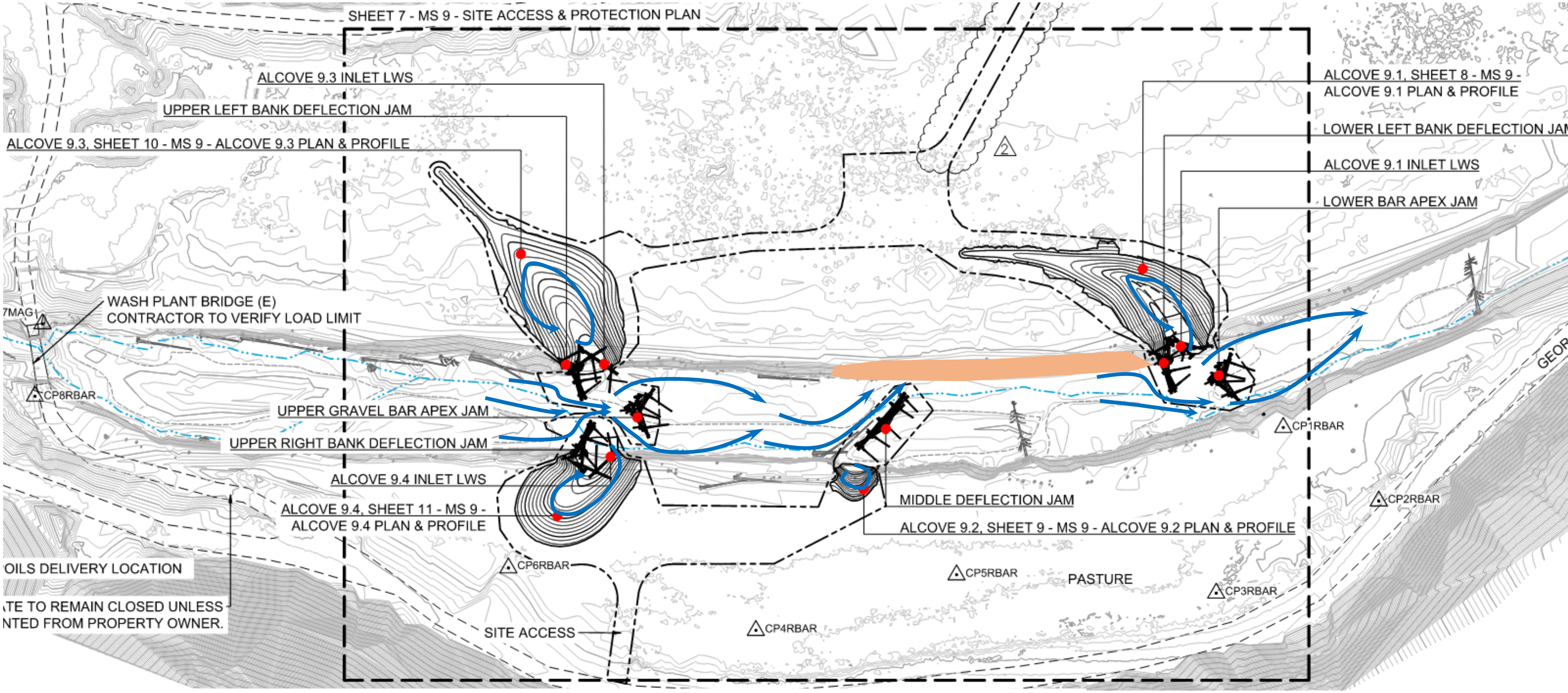

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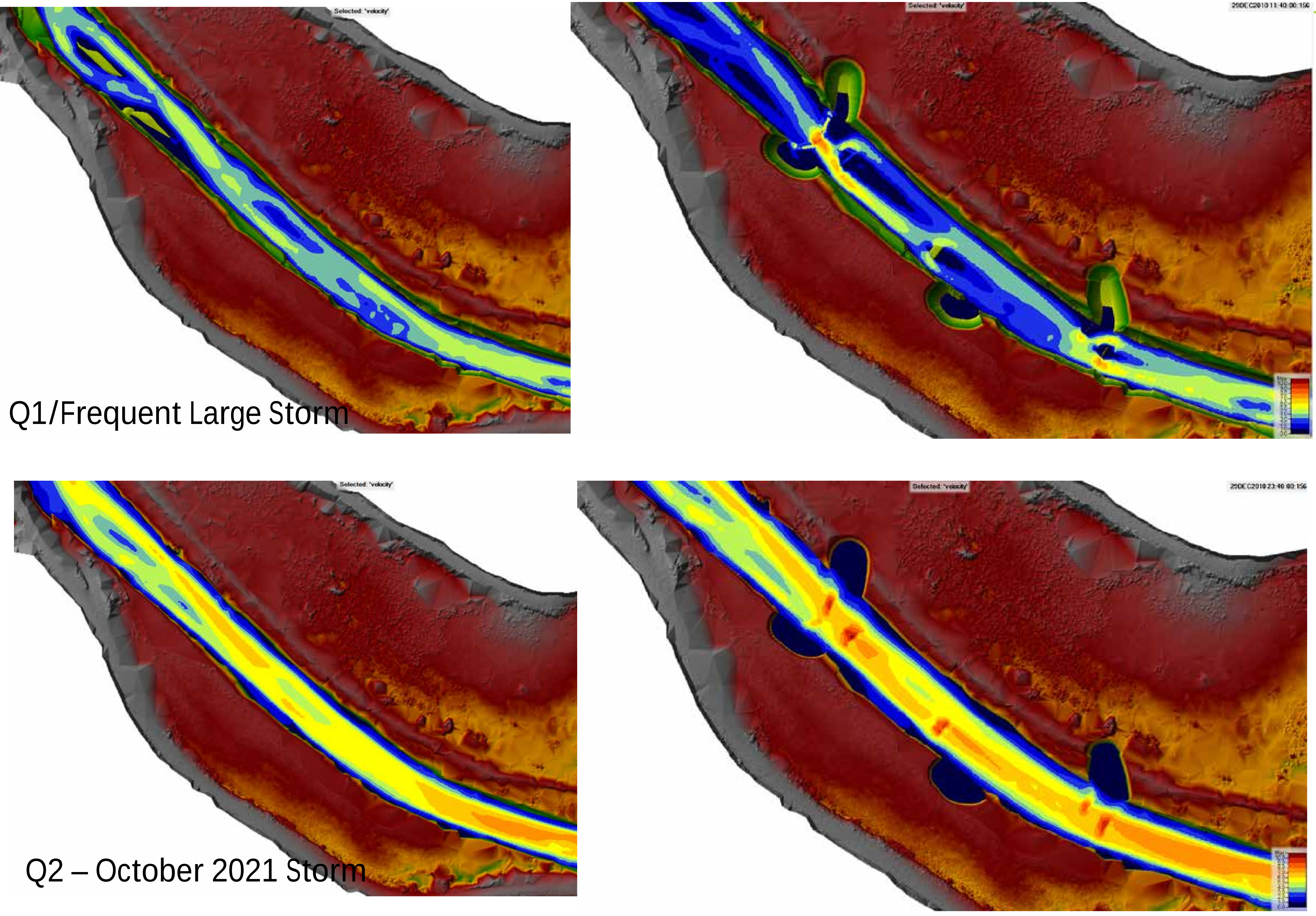
June 2022!

Pre-Project

Preliminary Design



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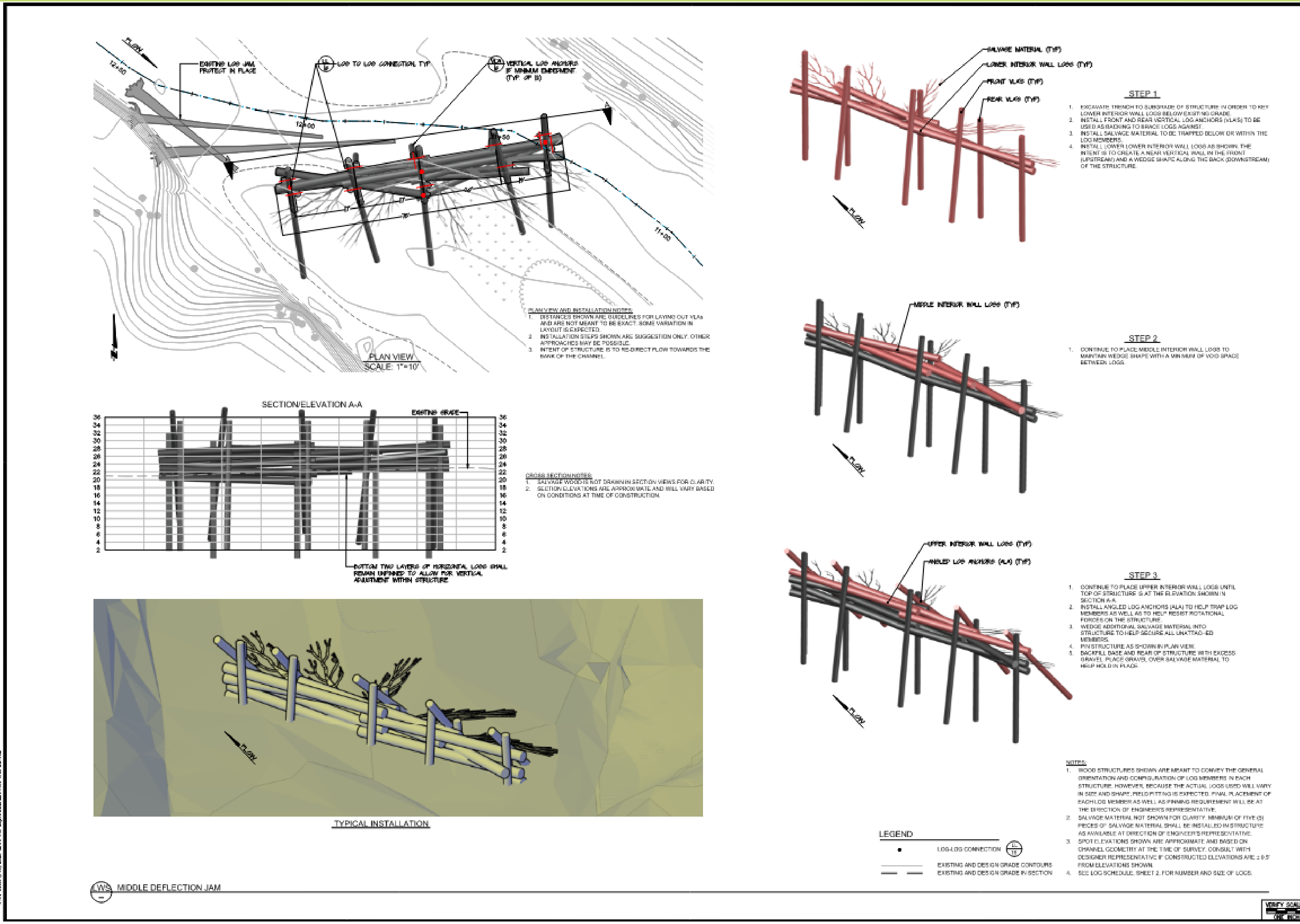

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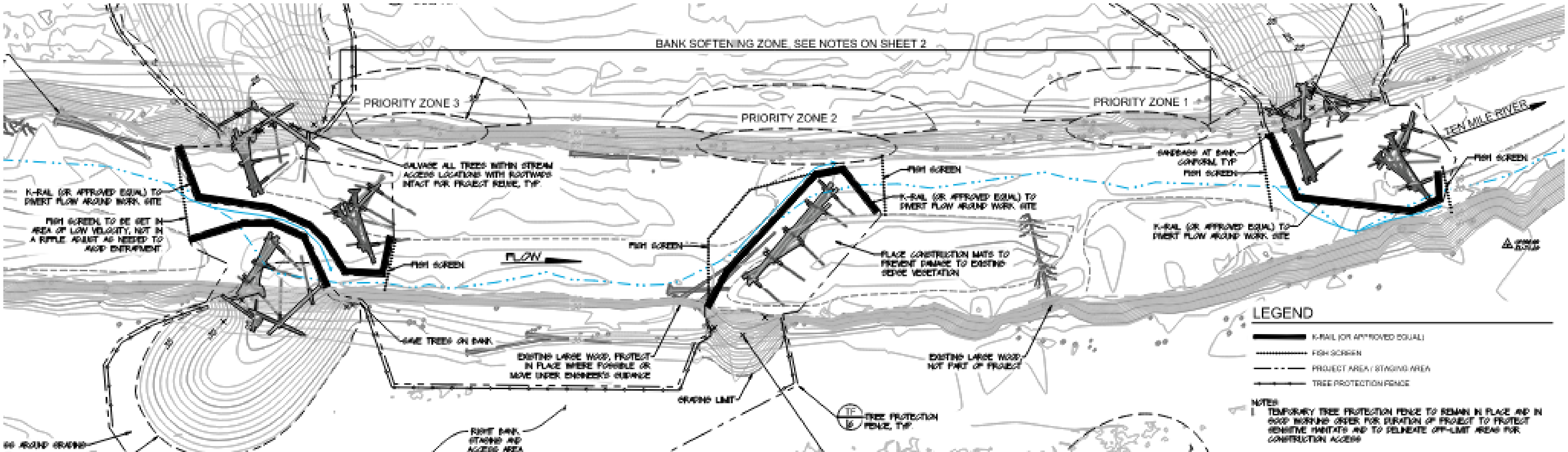


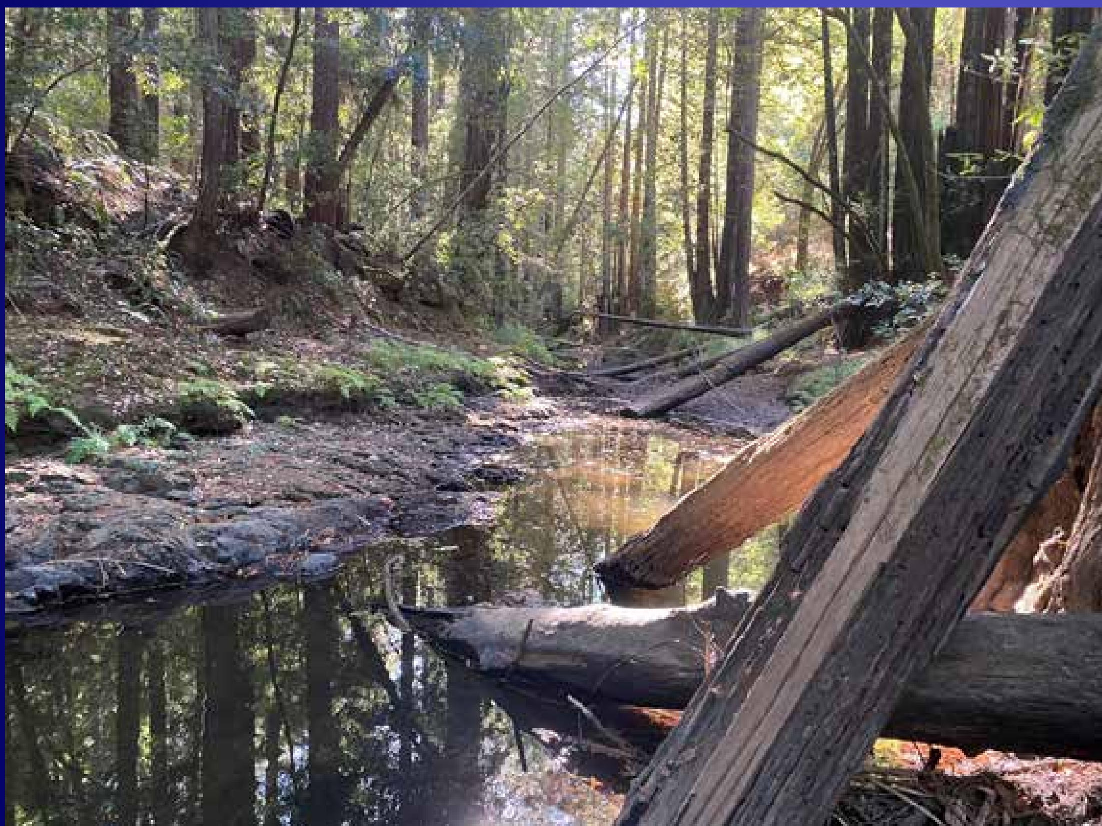
Upstream Deflection and Bar Apex Jams

Deflection jam

Downstream Deflection and Bar Apex Jams

Salmonid Restoration Federation Large Wood Field School

HOW BIG CAN YOU GO WITH YOUR LWD STRUCTURES BEFORE YOU START BREAKING THINGS?



Rachel Shea P.E.

Engineering Geomorphologist

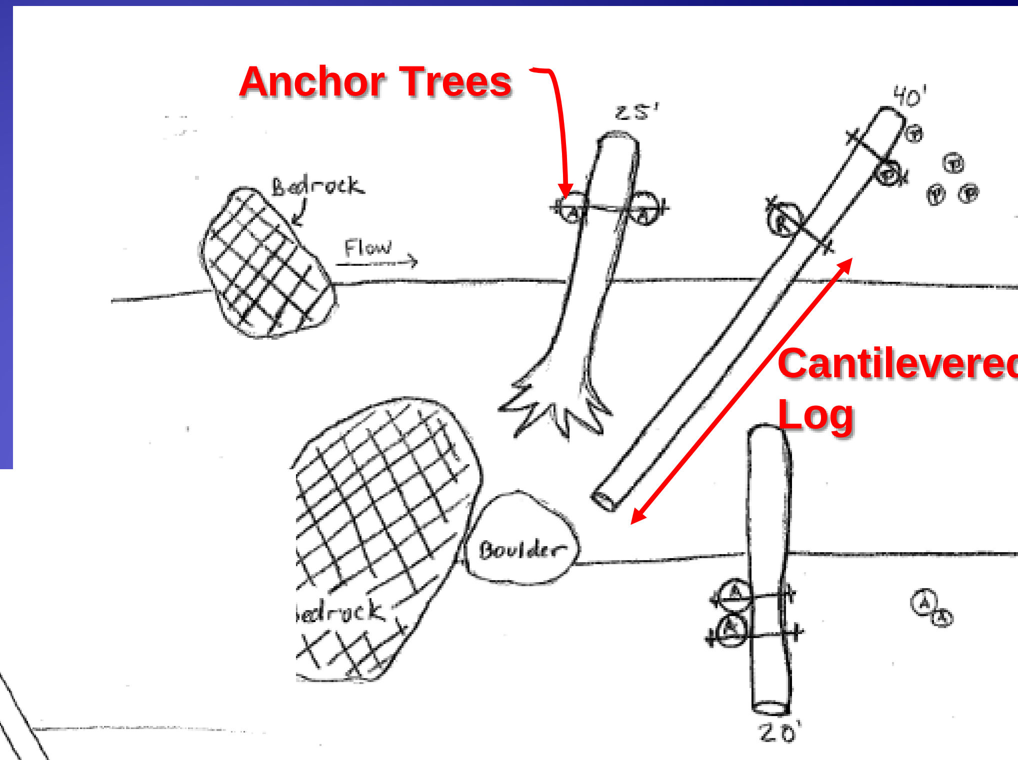
Michael Love & Associates
Hydrologic Solutions
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

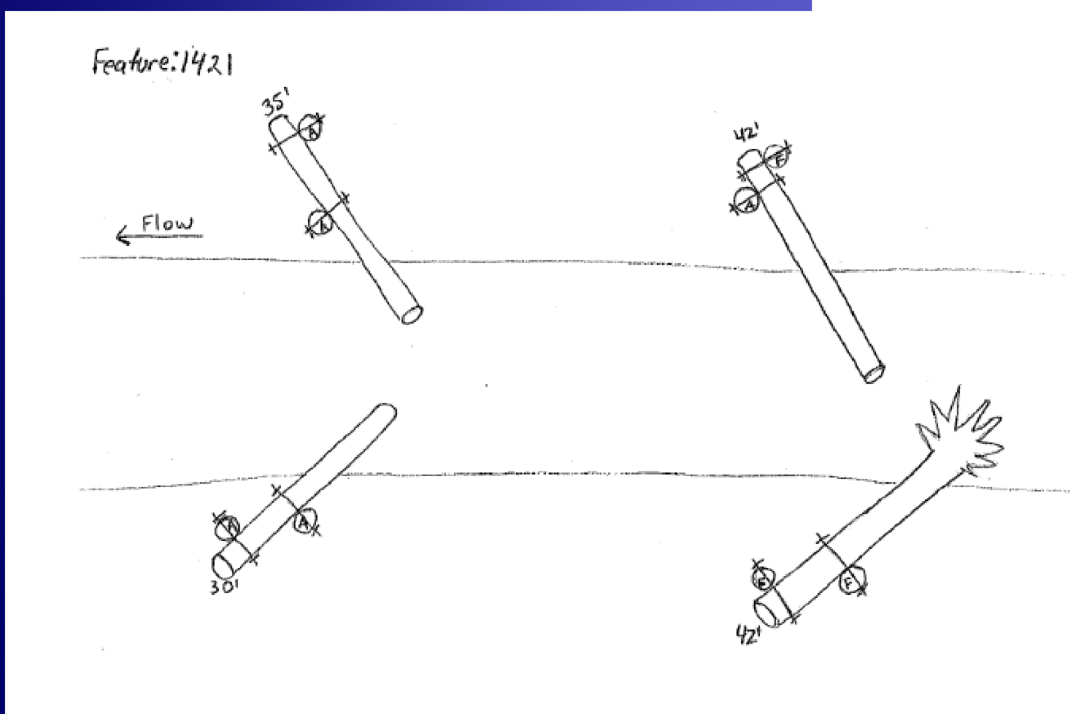
CALIFORNIA DEPARTMENT OF FISH&GAME

CDFW
FRGP
Q1910522

SRF April 2022

Kenny Creek Case Study: Cantilever Log Structure Stability Assessment

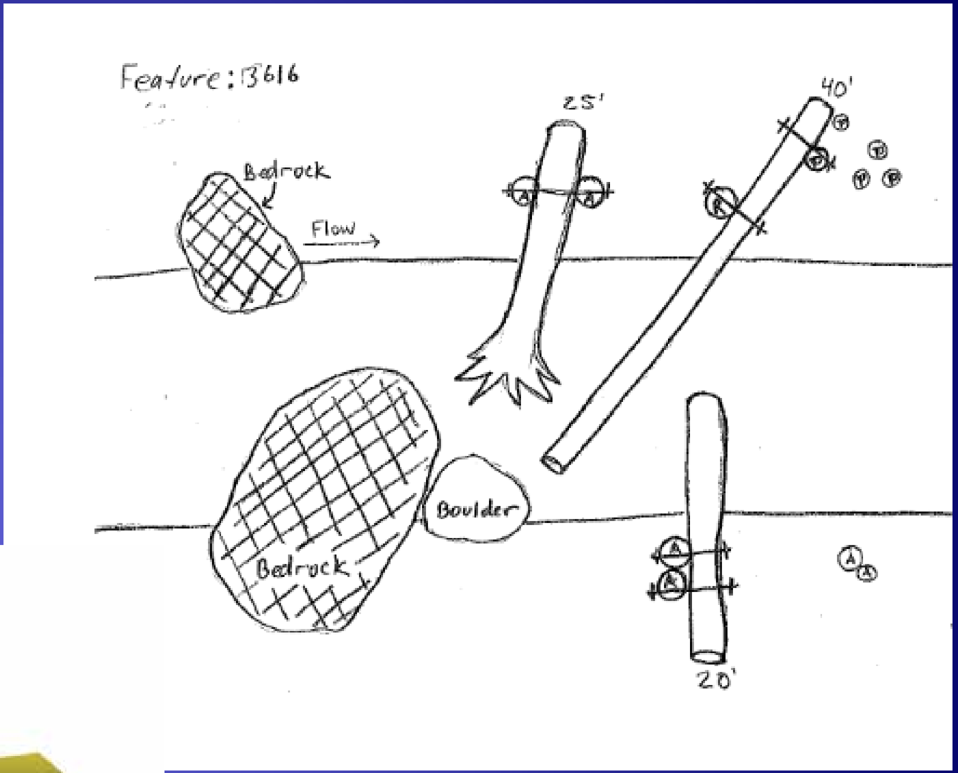


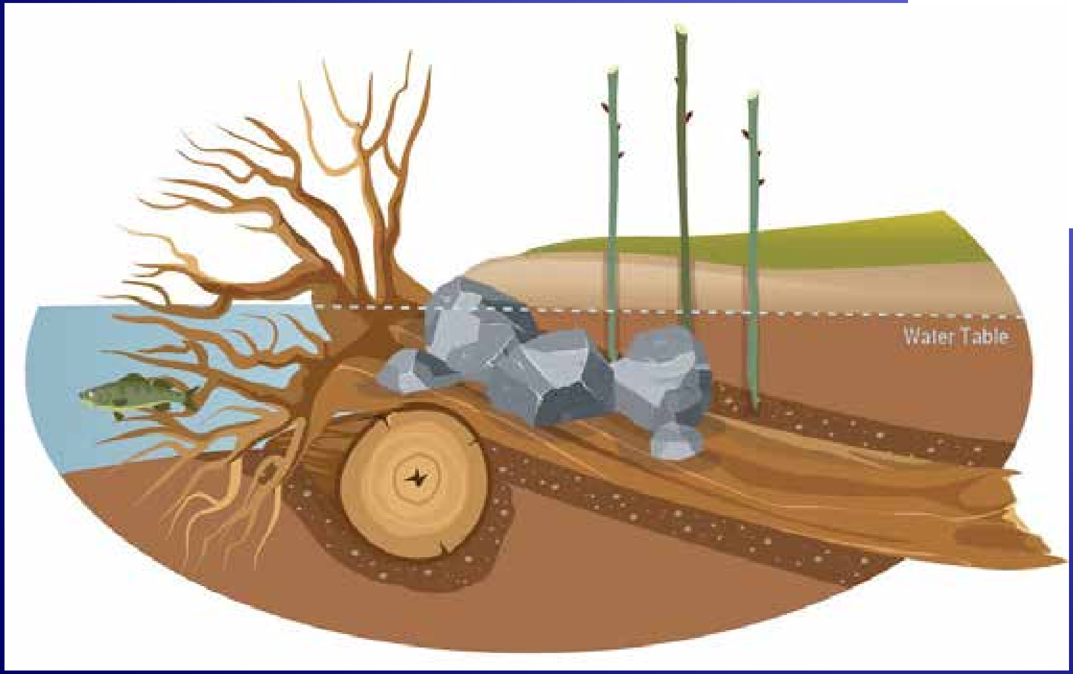


Kenny Creek Case Study

Given the hydraulic properties of a channel

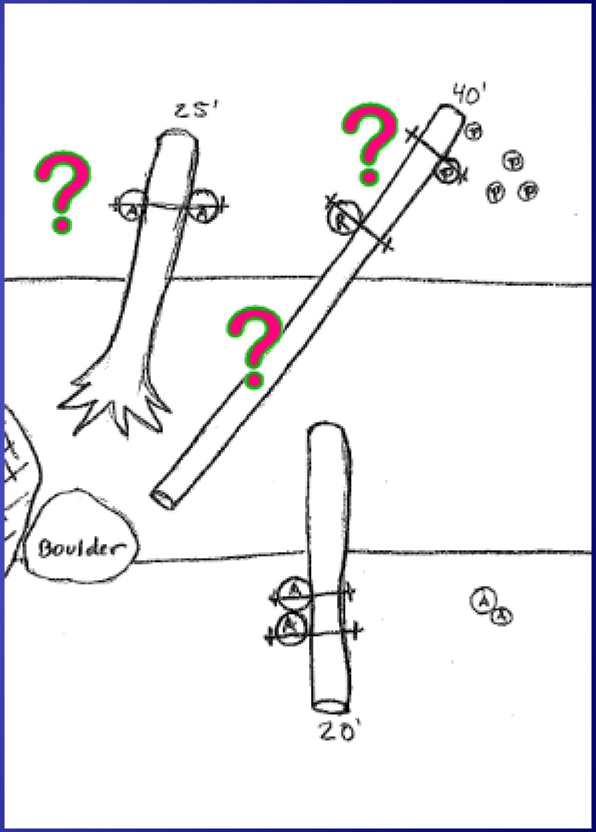
Cantilever Log Structure Stability is Dependent on the Strength of Materials Comprising the Structure



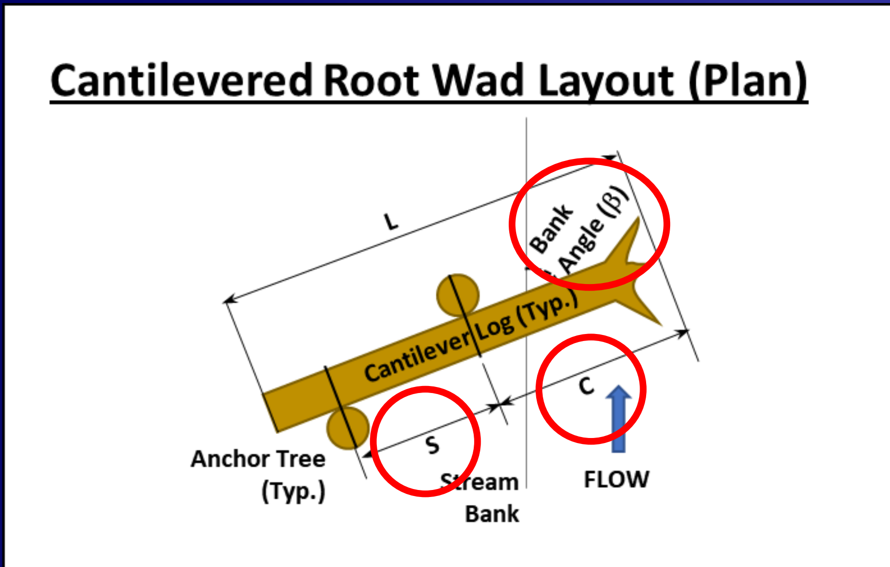


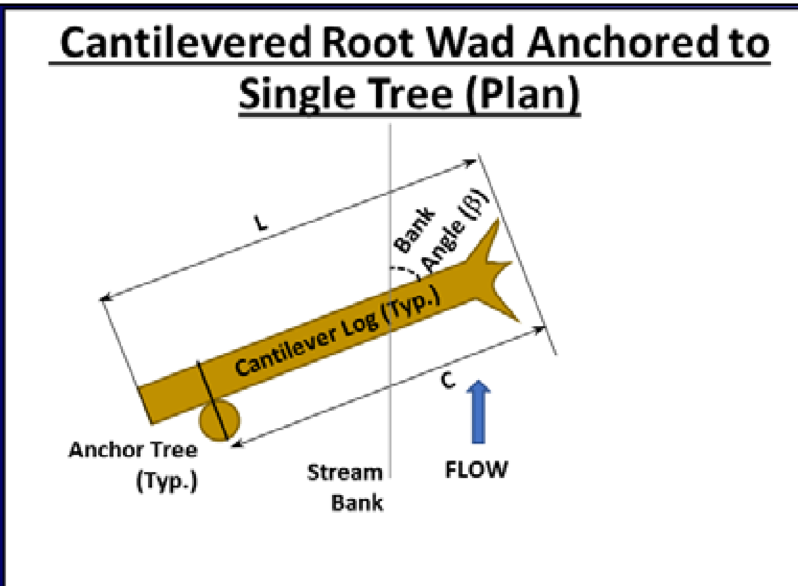
So how BIG can I make it?

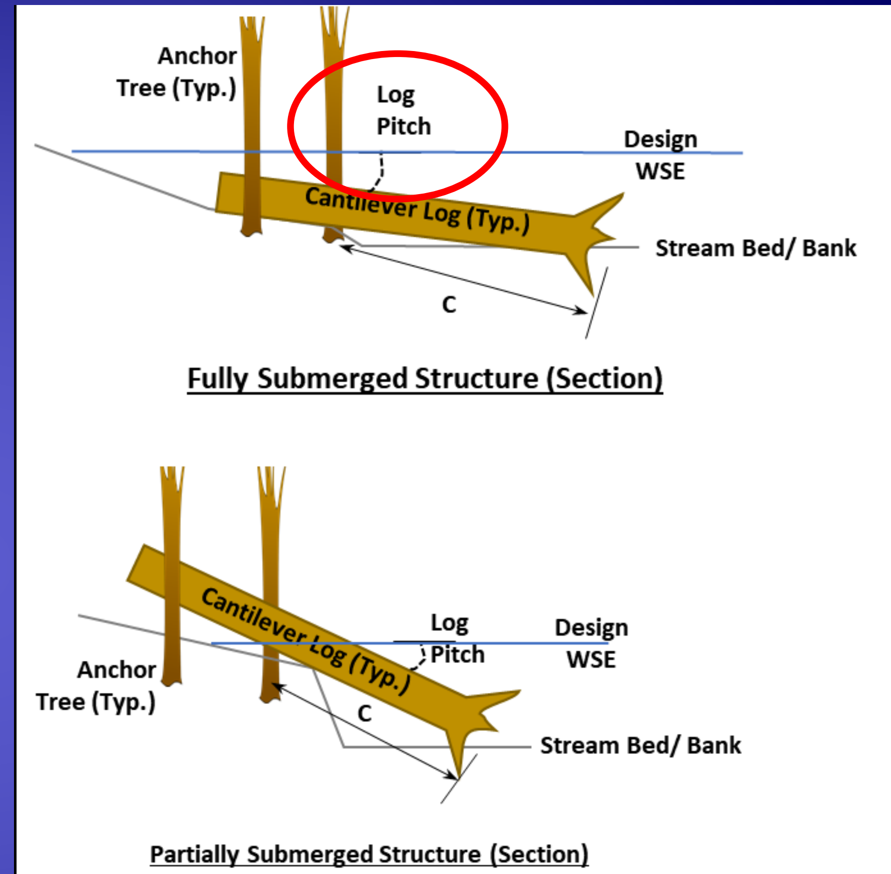
1. How far can I stick my cantilever log into the channel before it breaks?
2. Does it matter what kind of wood I use?
3. How big do my anchor trees need to be to not break?
4. Can I get away with one anchor tree?
5. Will my rebar bend?
6. Do log pitch and bank angle matter?



Kenny Creek Typical Structure Layouts





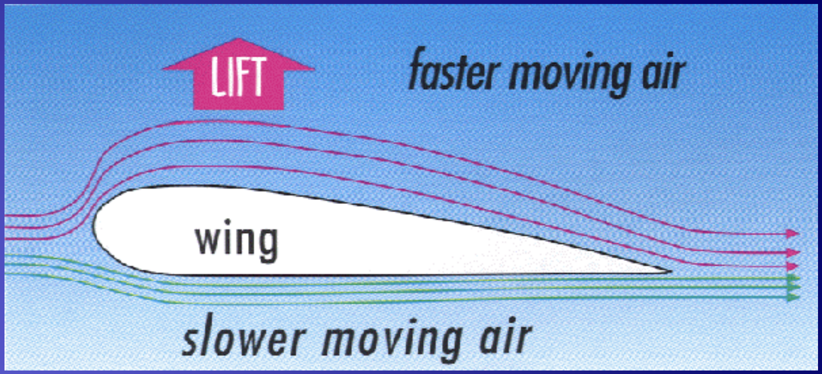


Driving Forces Acting on Logs to Destabilize

Vertical Forces

1. **Buoyancy**
2. Lift

Buoyancy



Horizontal Forces

1. **Drag**

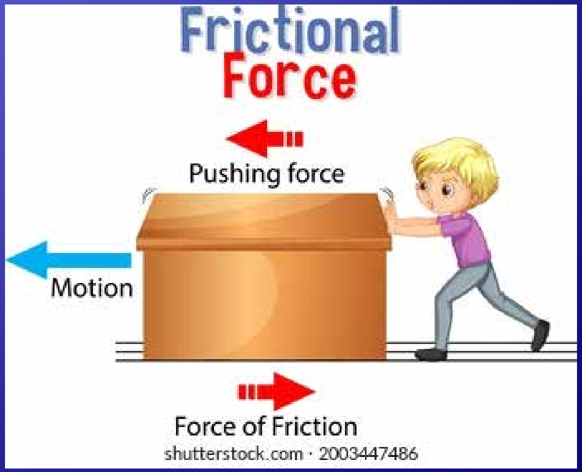
Stabilizing Forces Acting on Logs

Vertical

1. Weight of logs
2. Ballast (Soil/Rocks)
3. **Wood Strength**
4. **Rebar Strength**

Horizontal

1. Ground Friction
2. **Wood Strength**
3. **Rebar Strength**



Kenny Creek Hydraulic Geometry

Bankfull Width: 25 feet

Channel Slope: 1.3 to 3.1%

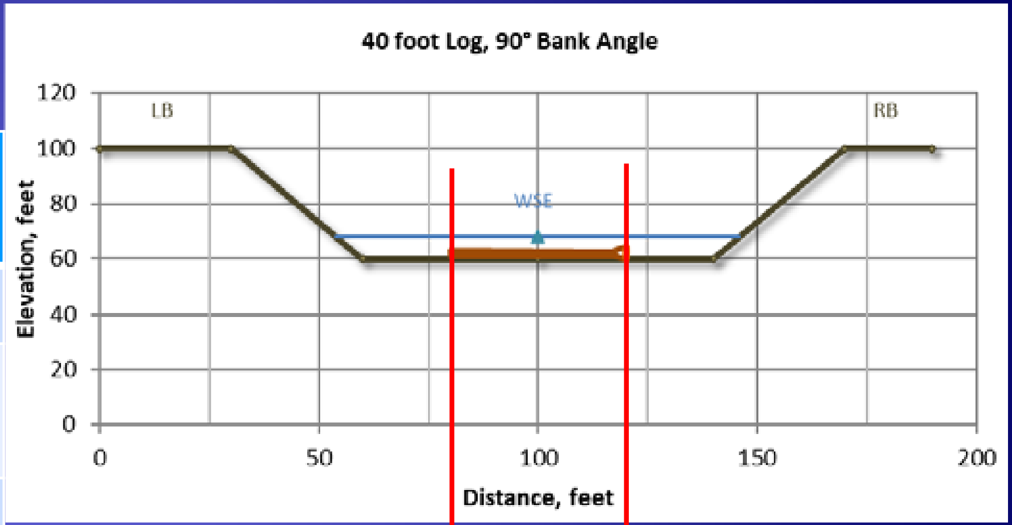
Design Flow Event: 25 Year RP

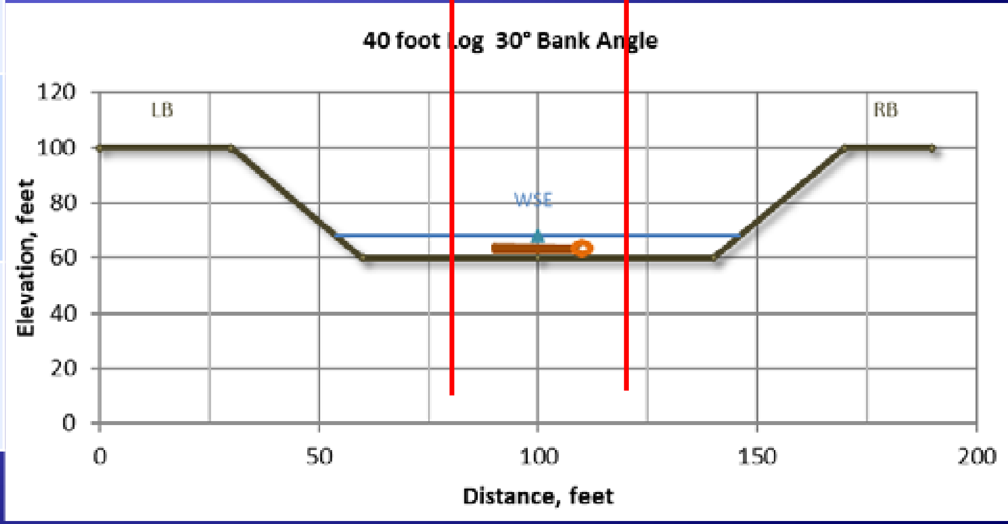
- **Design Flow Depth: 8 feet**
- **Design Flow Velocity: 8.2 fps**
- **Flow Area: 180 square feet**

All Results presented here are site specific to Kenny Creek!

Summary of Forces On a Submerged 40 Foot Long, 1.5 foot Diameter Doug Fir Rootwad

Force on Log	90° Bank Angle	30° Bank Angle
Buoyancy (lbs)	7,038	7,038
Weight of Log (lbs)	3,783	3,783
Drag (lbs)	**13,673**	**8,005**
Lift	63	0
Ground Friction (lbs)	0 (assumed)	0 (assumed)
Area Obstructed	40%	28%



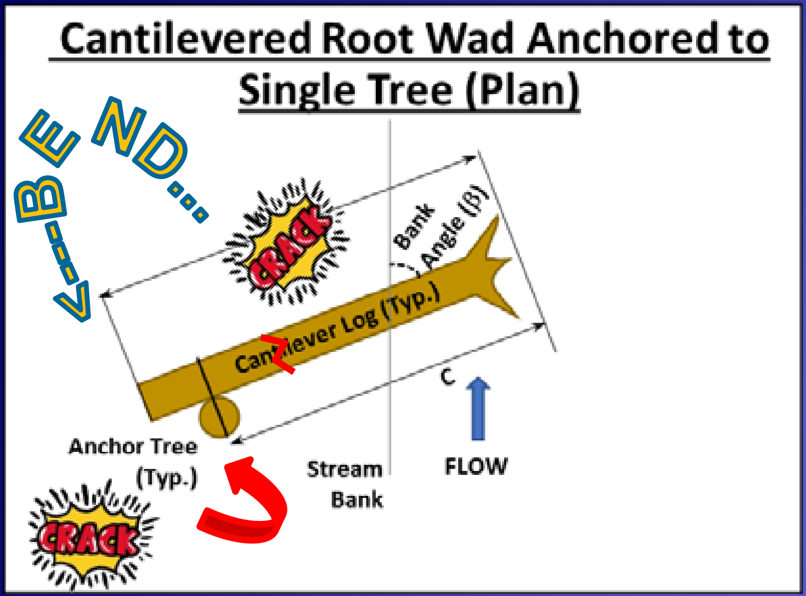


Excluding Moments!

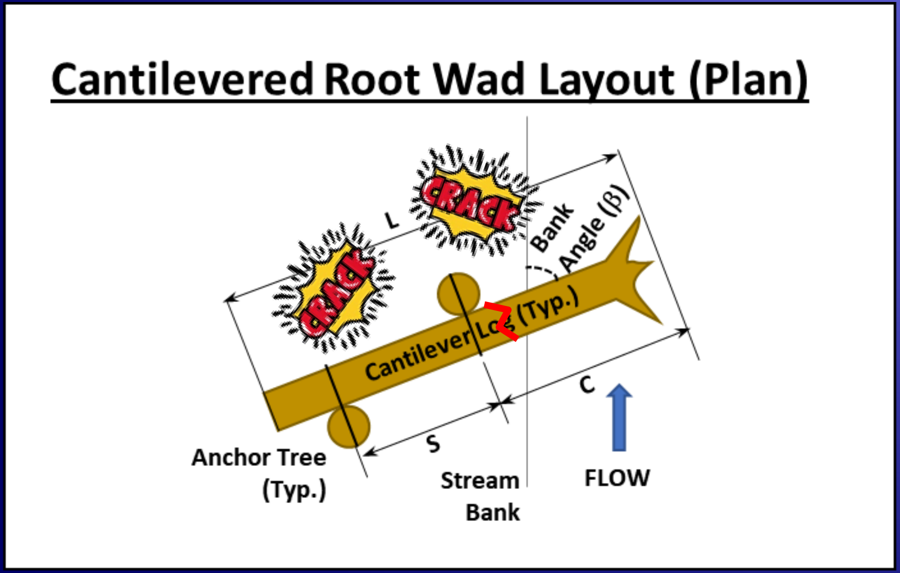
How Things Break under Applied Force/Stress

1. Bending Failures
   1. Deformable (rebar)
   2. Non-deformable (trees)
2. Tension Failures
3. Torsion Failures
4. Shear Failures

Material Strength/Failure Mechanism Varies with Direction of Stress



Bending, Torsion and/or Rebar Stresses/Failures



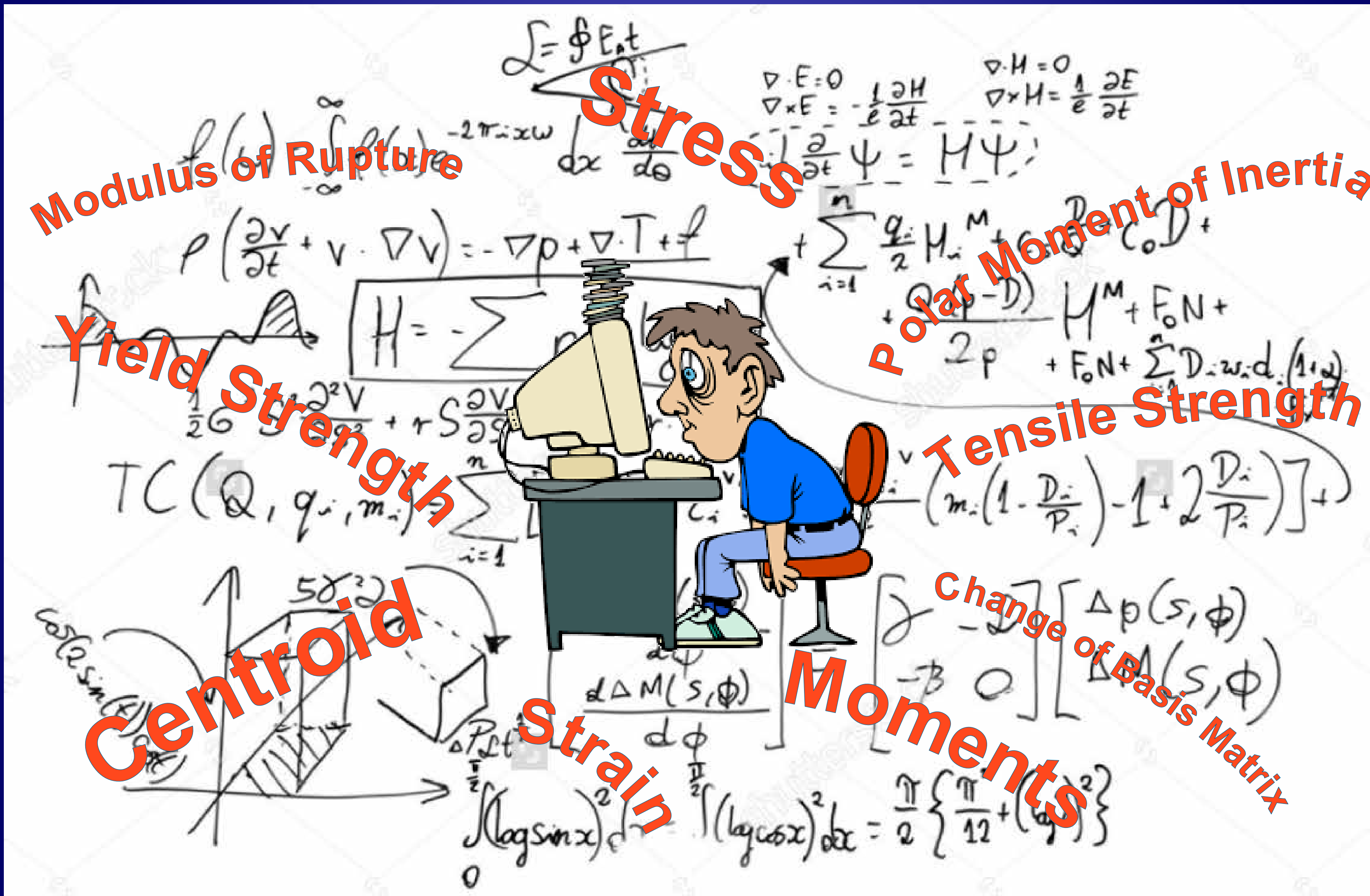
Bending Stress/Failure

Typical Material Properties

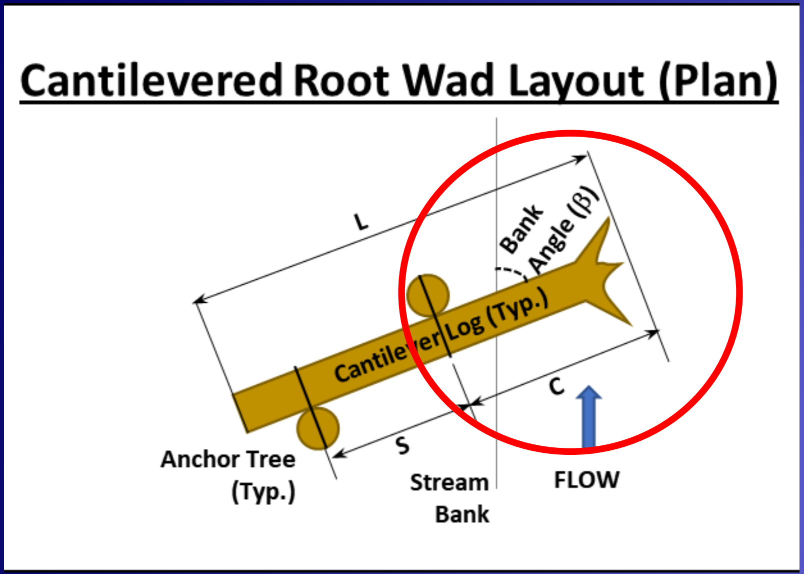
Material Strengths of Wood and Rebar		
Material	Bending Strength (lbs/in^2)	Twisting Strength (lbs/in^2)
Douglas Fir (Dry)	12,400	1,130
Douglas Fir (Green, Live)	7,700	900
Redwood (Dry)	7,900	1,100
Redwood (Green, Live)	5,900	890
Red Alder (Green, Live)	6,500	770
1” Rebar (Grade 75/80)	75,000	-

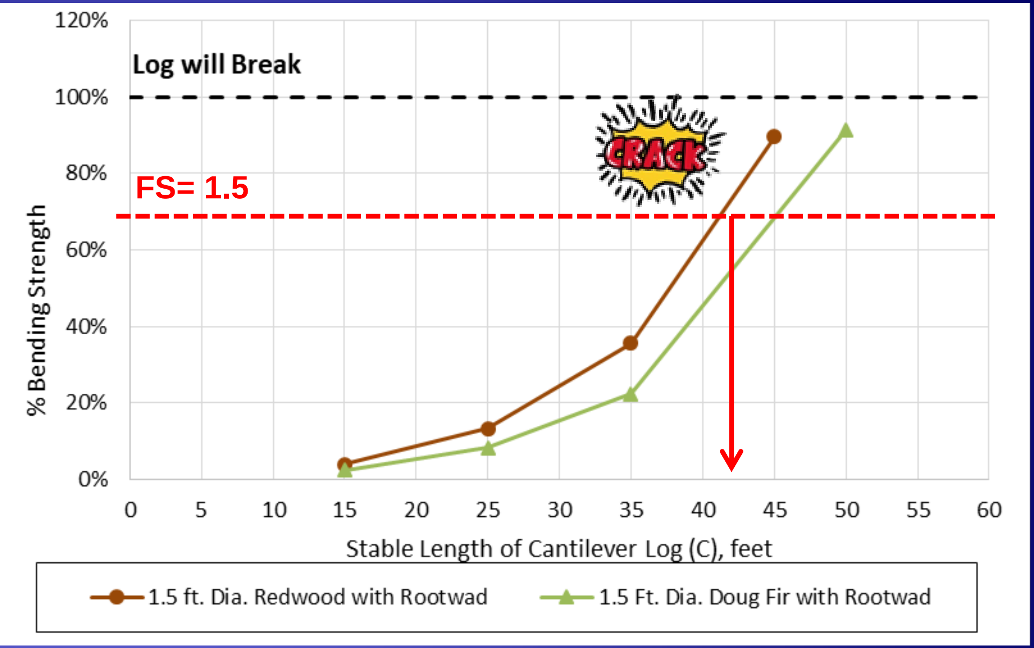
Wood Type	Dry Density (lbs/ft3)
Douglas Fir (Coast)	33.5
Redwood (young)	24.5

Interlude for Mind Numbing Math



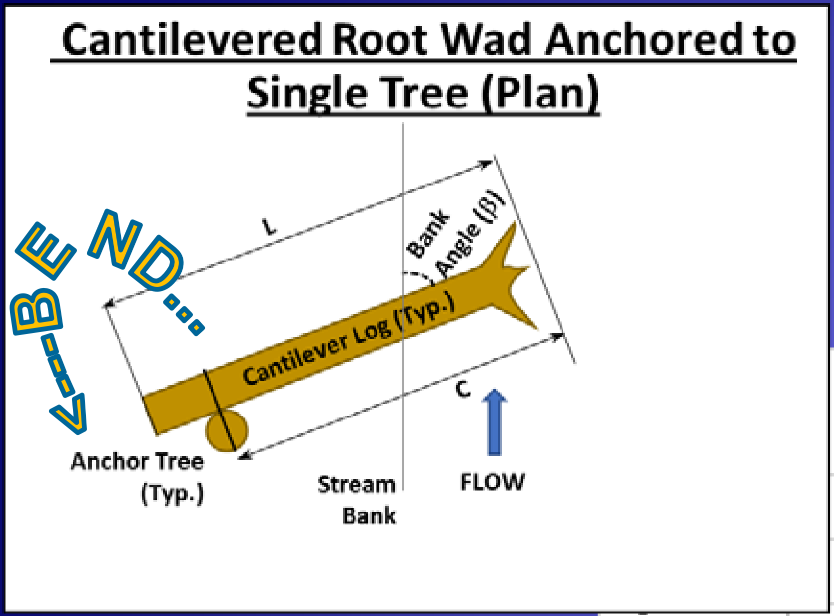
How Far Can I Stick my Cantilever Log into the Channel without it Breaking?

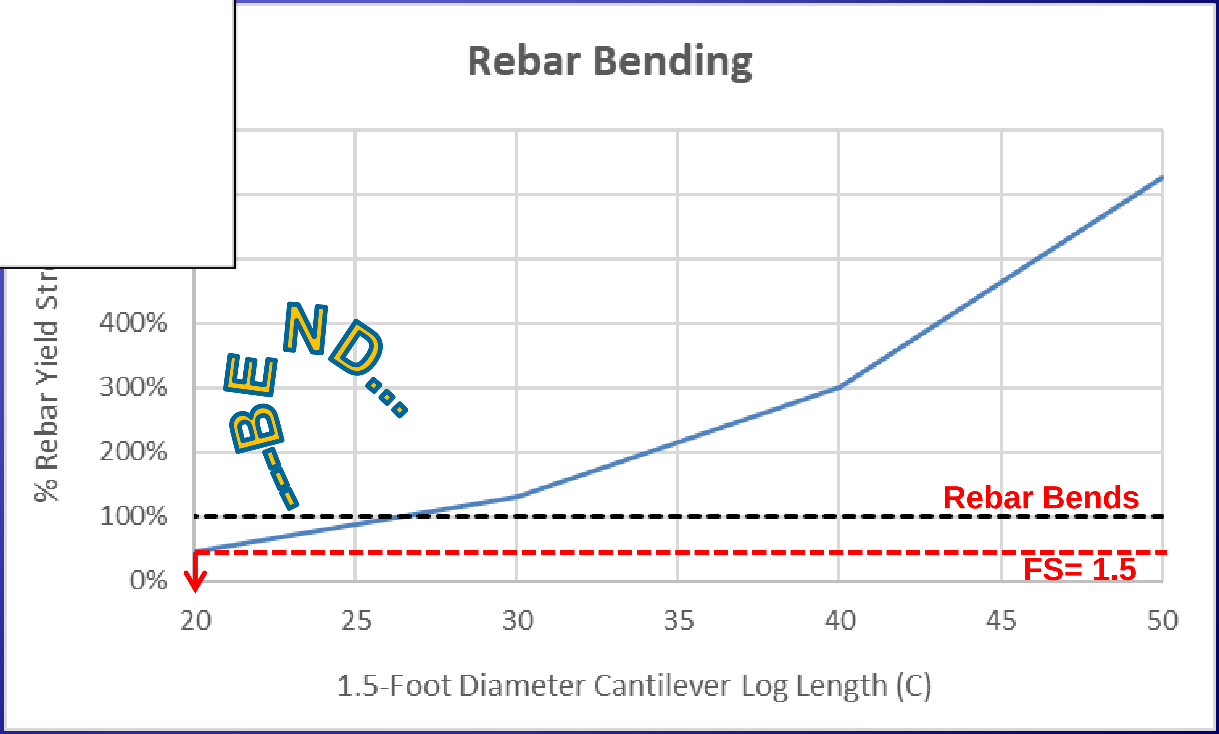




Assumptions: Worst Case- Fully submerged, perpendicular to flow, dry wood, <u>Stable Anchor Point</u>

Can I get away with One Anchor Tree? Will my Rebar Bend?

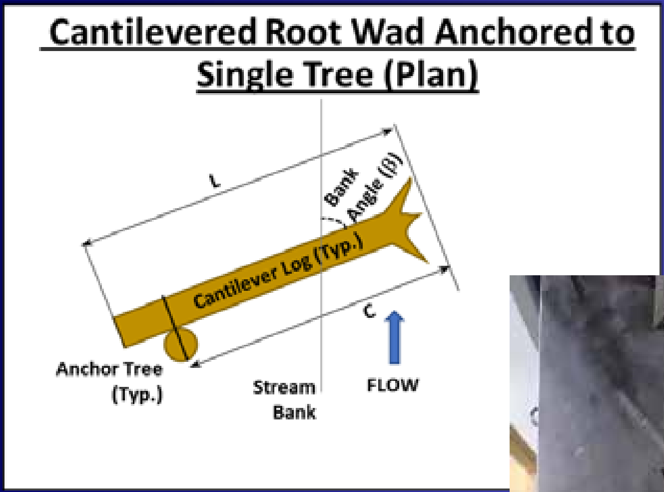


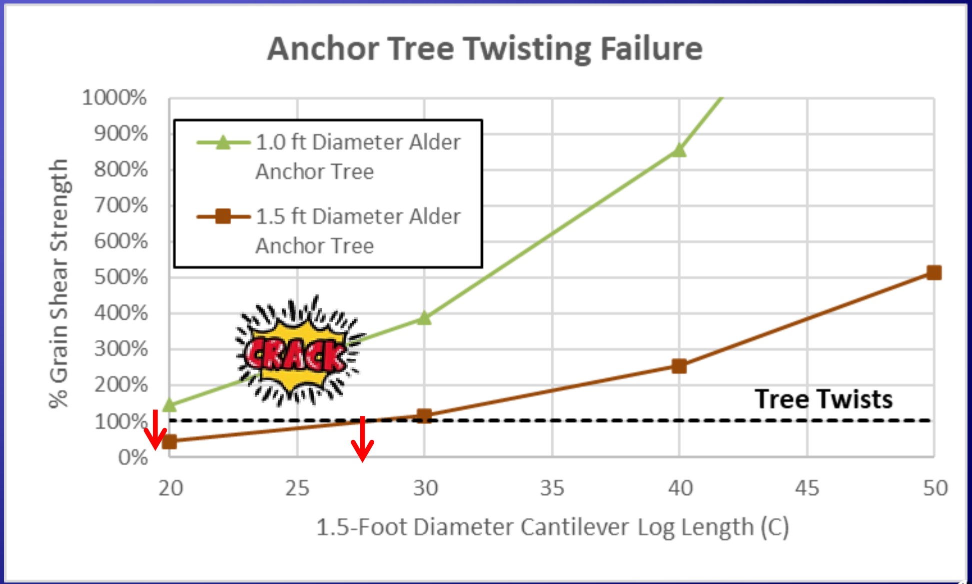


Assumptions: Worst Case- Fully submerged, perpendicular to flow, dry wood

Can I get away with One Anchor Tree?
Can I break my Anchor Tree by Twisting?

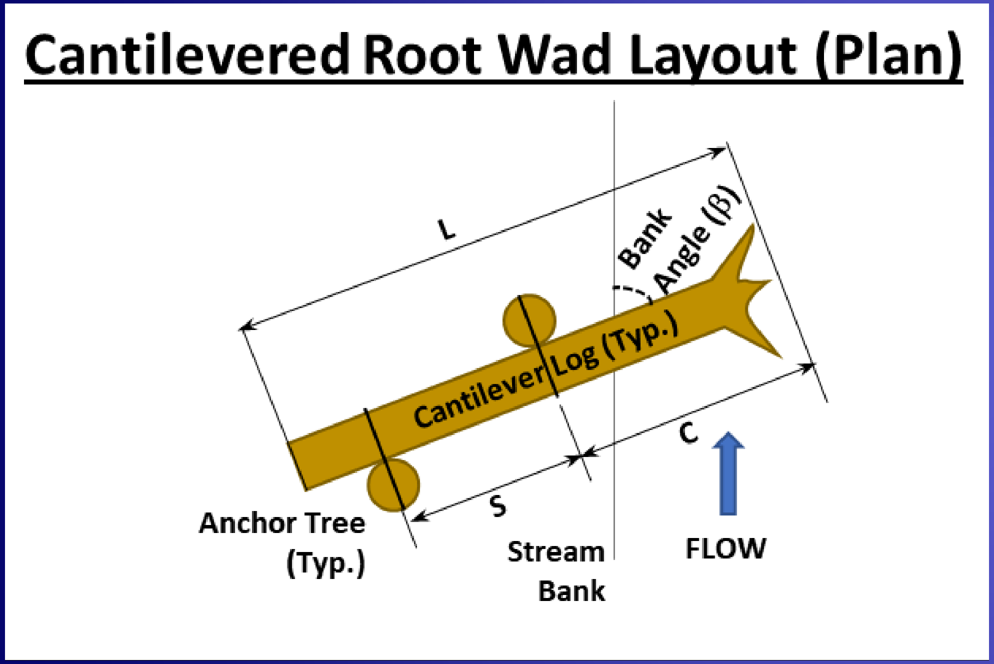
Grain Shear Strength (Twisting) of Live Trees	
Material	Twisting Strength (lbs/in^2)
Douglas Fir (Green, Live)	900
Redwood (Green, Live)	890
Red Alder (Green, Live)	770

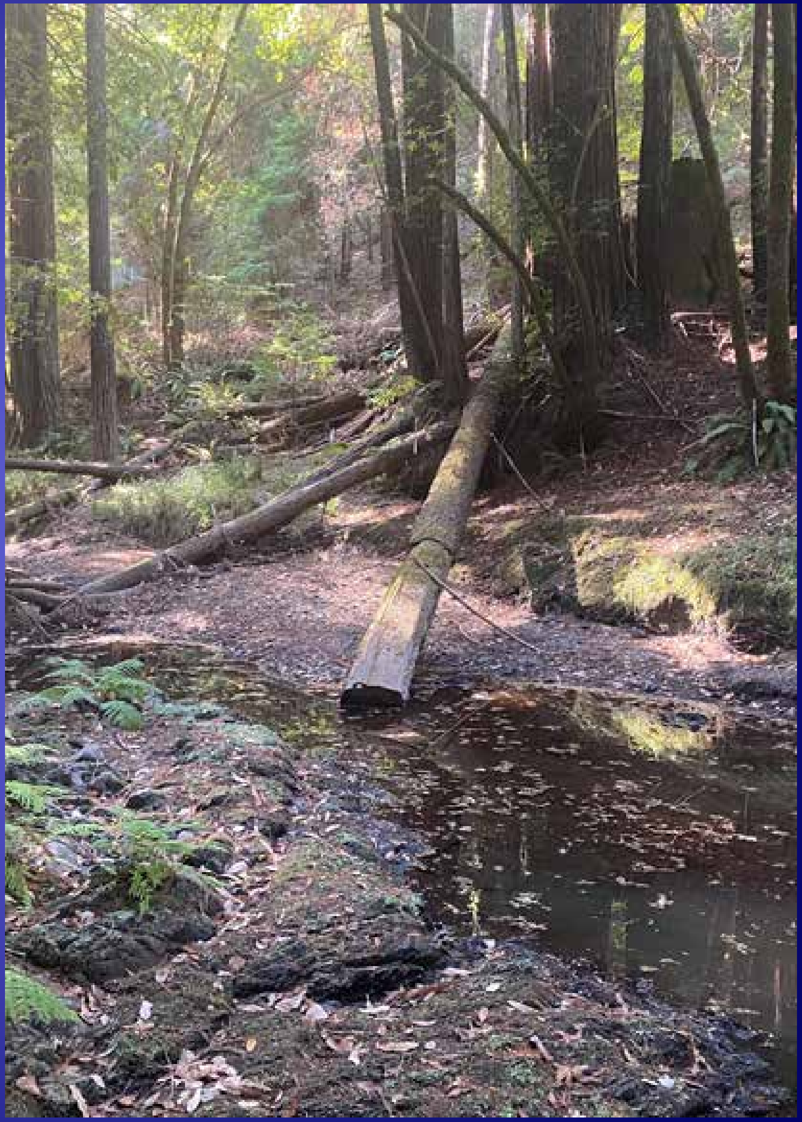




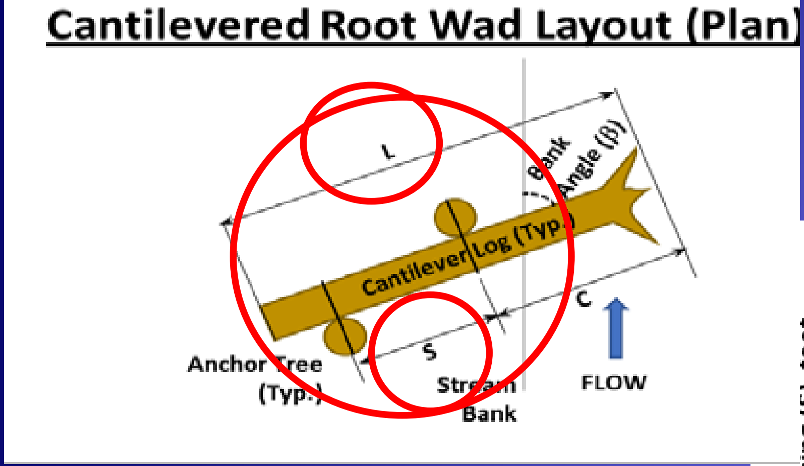
Assumptions: Worst Case- Fully submerged, perpendicular to flow, dry wood

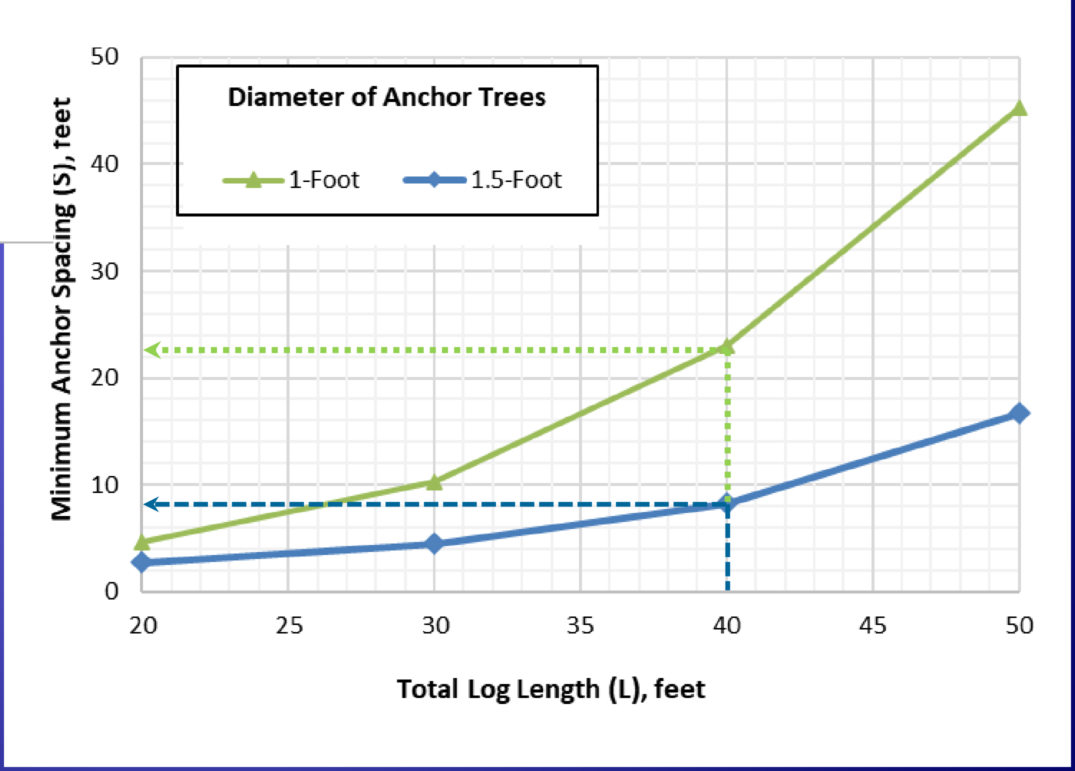
Are 2 anchor trees Better? How Big? How far Apart?



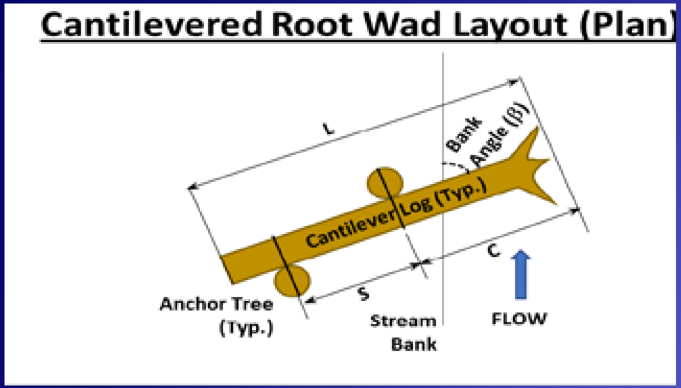


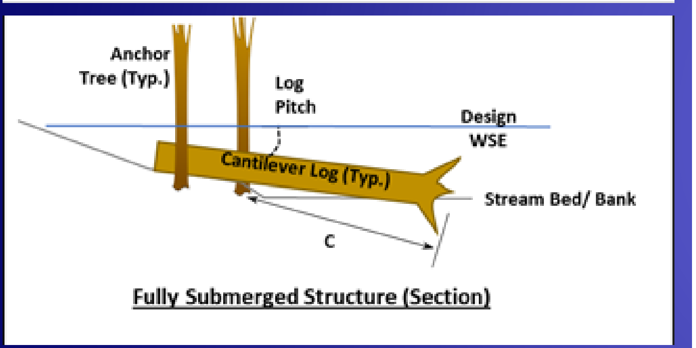
Are 2 anchor trees Better? How Big? How far Apart?

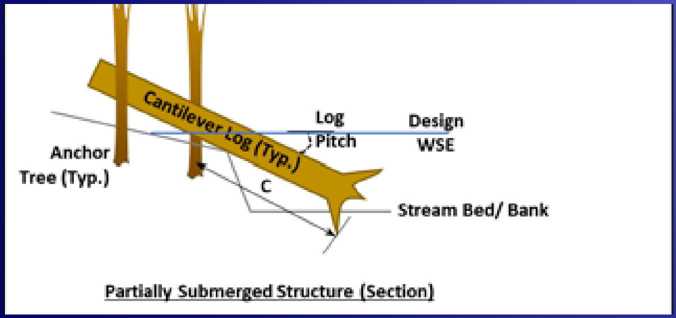


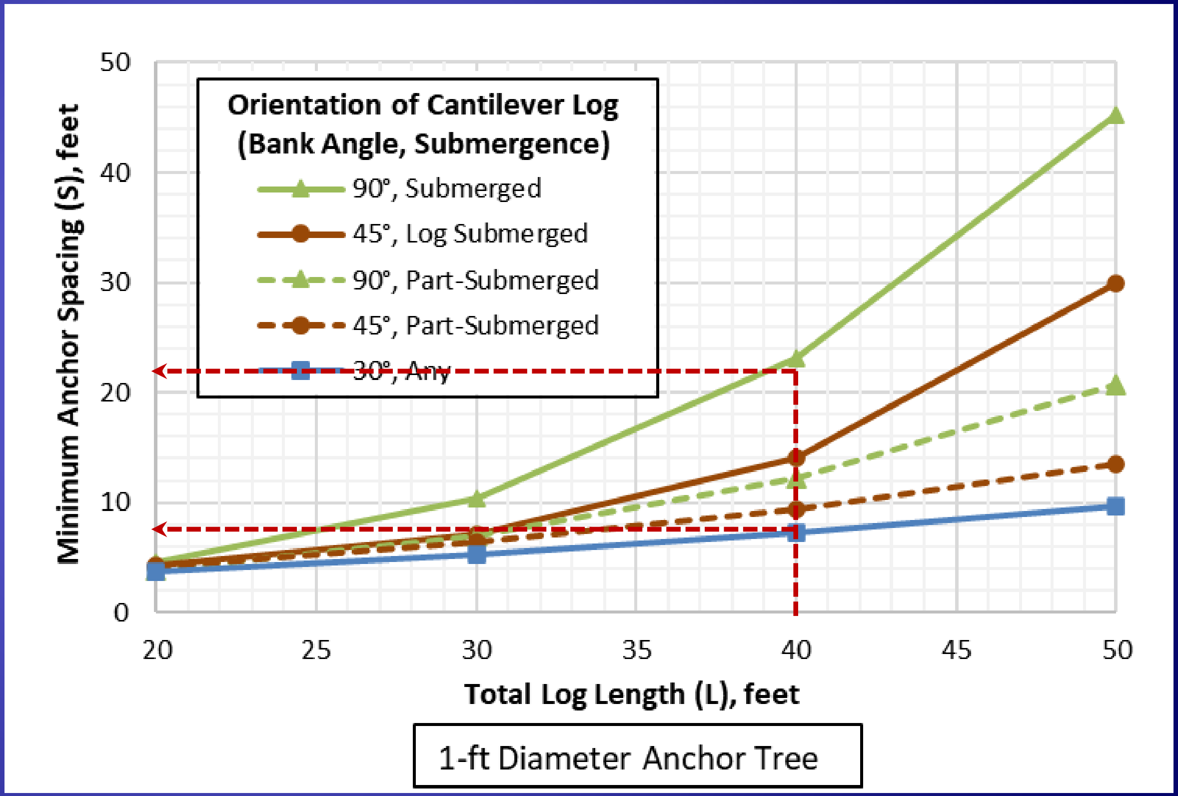


Do Log Pitch and Bank Angle Matter?







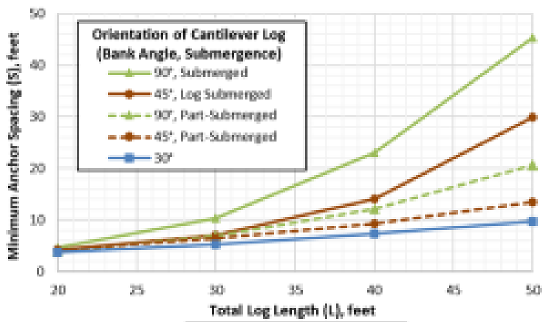


Michael Love & Associates
Hydrologic Solutions
PO Box 4477 • Arcata, CA 95518 • (707) 822-2411

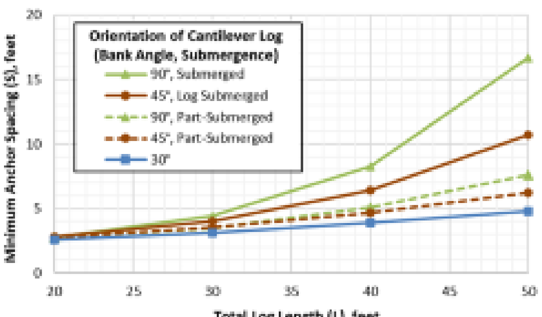
Kenny Creek Cantilevered Log Layout Sheet

Eel River Watershed Improvement Group

ANCHOR TREE SPACING AND TOTAL CANTILEVER LOG LENGTH



1-ft Diameter Anchor Tree



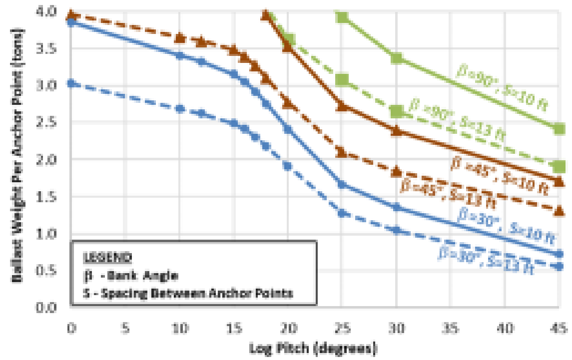
1.5-ft Diameter Anchor Tree

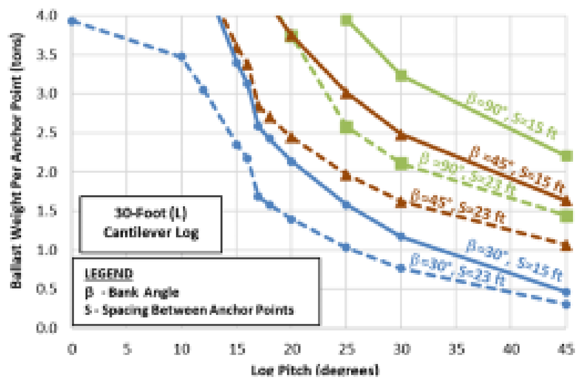
NOTES:

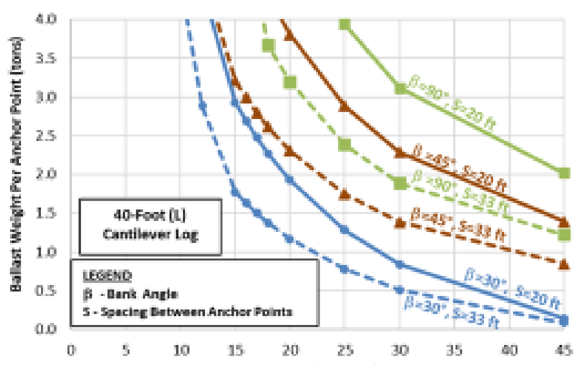
1. Verify all dimensions, bank angles, and log pitches before construction.
2. Rebar connections shall be 1-inch grade 70/80 bar (Williamsform.com or equivalent), with a minimum 3.5" diameter washer.
3. Stability for a 25-year flow event, using a velocity of 8.2 fps, channel area of 180 square feet, flow depth of 8 feet, and dry wood.
4. Minimum design Factors of Safety 1.5 (horizontal forces), 1.75 (vertical Forces), 1.75 (moments).
5. All calculations assume cantilever log is a 1.8-foot diameter log with rootwad with the specified bank angle and pitch (submergence). Anchor trees were assumed to be redwood.

FOR USE WITH THE KENNY CREEK LWD PROJECT ONLY (June 2021)

MINIMUM BALLAST WEIGHTS FOR EACH ANCHOR POINT



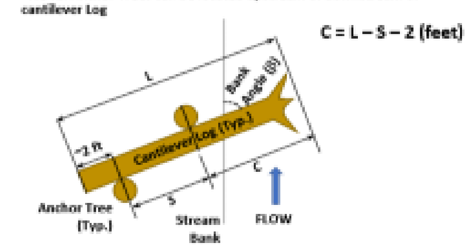




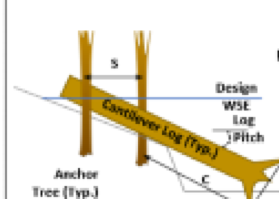
Cantilevered Root Wad Layout (Plan)

*NOTE: Anchor Trees can be located upstream of downstream of cantilever Log

C = L – S – 2 (feet)



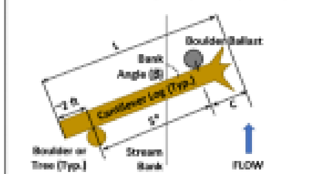
Cantilevered Root Wad Layout (Section)



Log Pitch when a Cantilever Log Becomes Partially Submerged

Log Length (feet)	Log Pitch
20 feet	≥30°
30 feet	≥20°
40 feet	≥15°

Combination Anchor Tree/Ballast Anchoring Layout (Plan)



* Anchor spacing shall be greater than ½ the log length (0.5L)

MAXIMUM CANTILEVER LOG LENGTH (C)

Bank Angle/Submergence	Maximum Stable Cantilever Log Length (C), feet*
90°, Submerged	44 feet
45°, Submerged	50 feet
30°, Submerged	72 feet

**Assuming the anchoring system is stable*

Conclusions

1. Buoyancy and drag cause the most stresses on a LWD structure
2. More drag causes more geomorphic change
3. Material strength is direction dependent
   - Rebar bends easily
   - Trees twist easily
4. Larger anchor trees are stronger and more stable
5. The further apart the anchor trees are the more stable
6. Bank angle and submergence have big impact on structure stability

Resources

- Knutson & Fealko. 2014. Large Woody Material-Risk Based Design Guidelines. Bureau of Reclamation, Pacific Northwest Region Resource & Technical Services.
- Rafferty, M. 2016. Computational Design Tool for Evaluating the Stability of Large Wood Structures. Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p. http://www.fs.fed.us/biology/nsaec/products-tools.html
- U.S. Department of Agriculture, U.S. Forest Service. 2009. Specific Gravity and Other Properties of Wood and Bark for 156 Tree Species Found in North America. Research Note NRS-38. Table 8.

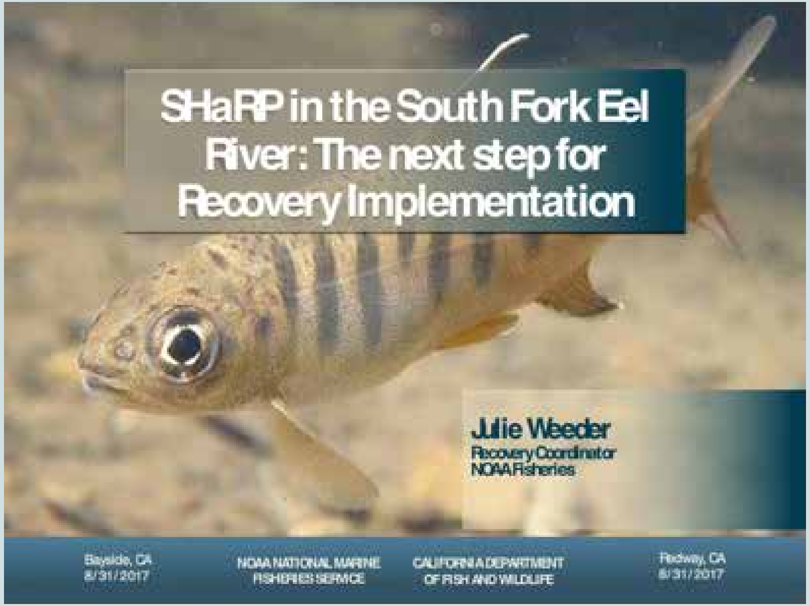
Designing & Implementing Non-Engineered Large Wood Projects with the CCC

ERWIG

Eel River Watershed Improvement Group
Marisa McGrew, Project Manager
Presentation created by Isaac Mikus, Executive Director

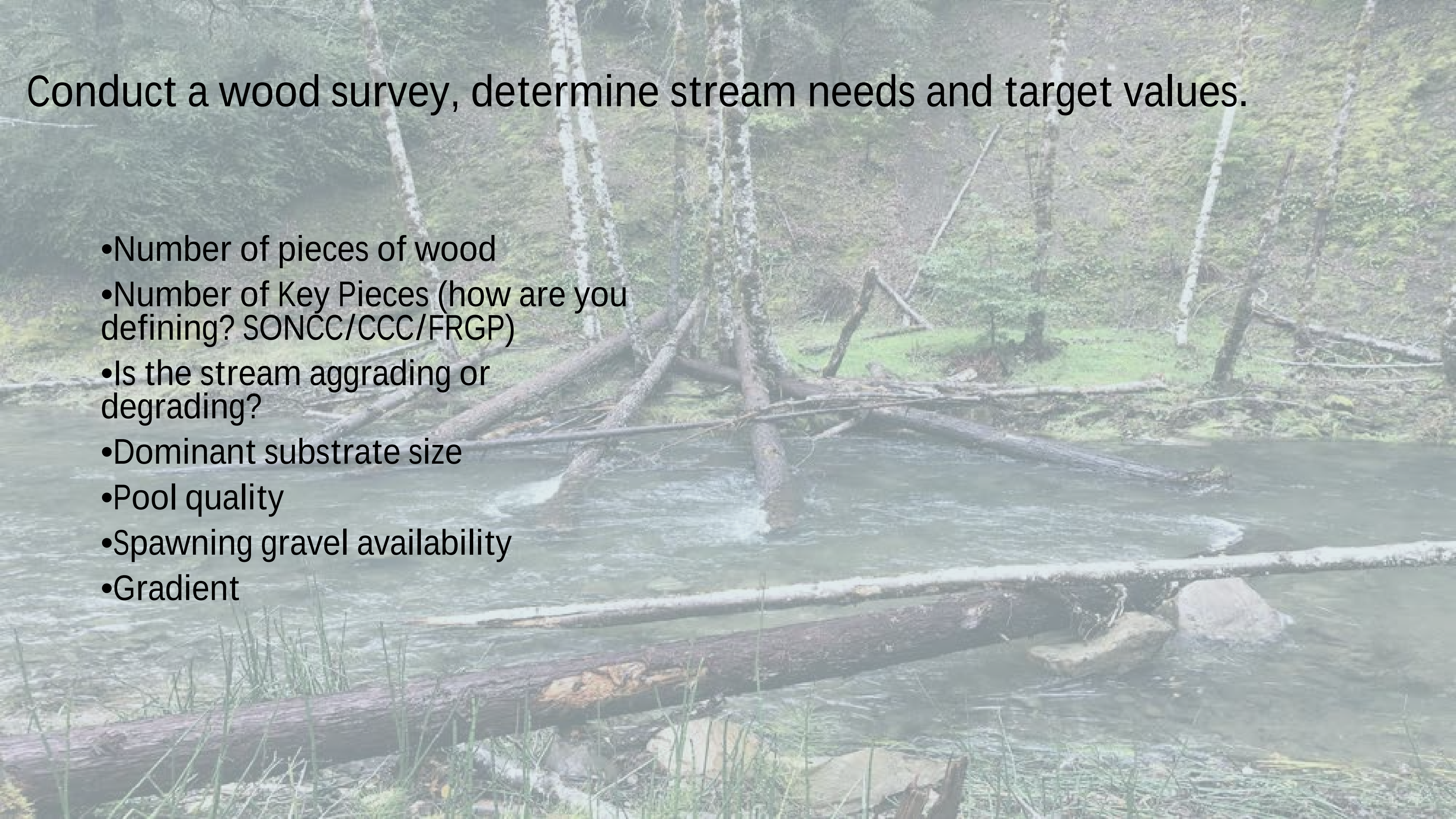
The Design Process

Determine streams to target for restoration using local knowledge, recovery plans, assessments, and/or landowner requests.

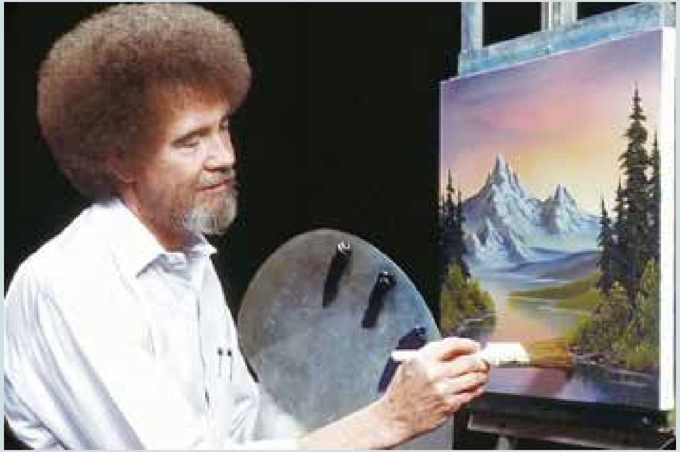


Conduct a wood survey, determine stream needs and target values.

- Number of pieces of wood
- Number of Key Pieces (how are you defining? SONCC/CCC/FRGP)
- Is the stream aggrading or degrading?
- Dominant substrate size
- Pool quality
- Spawning gravel availability
- Gradient



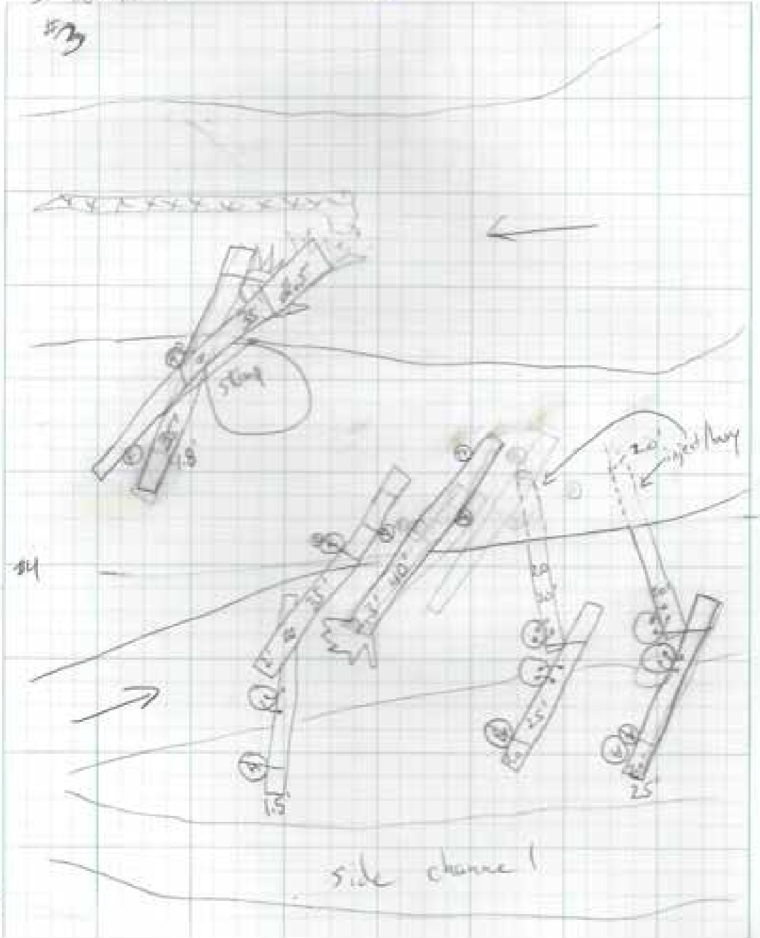
Gather crew, tools, artist materials



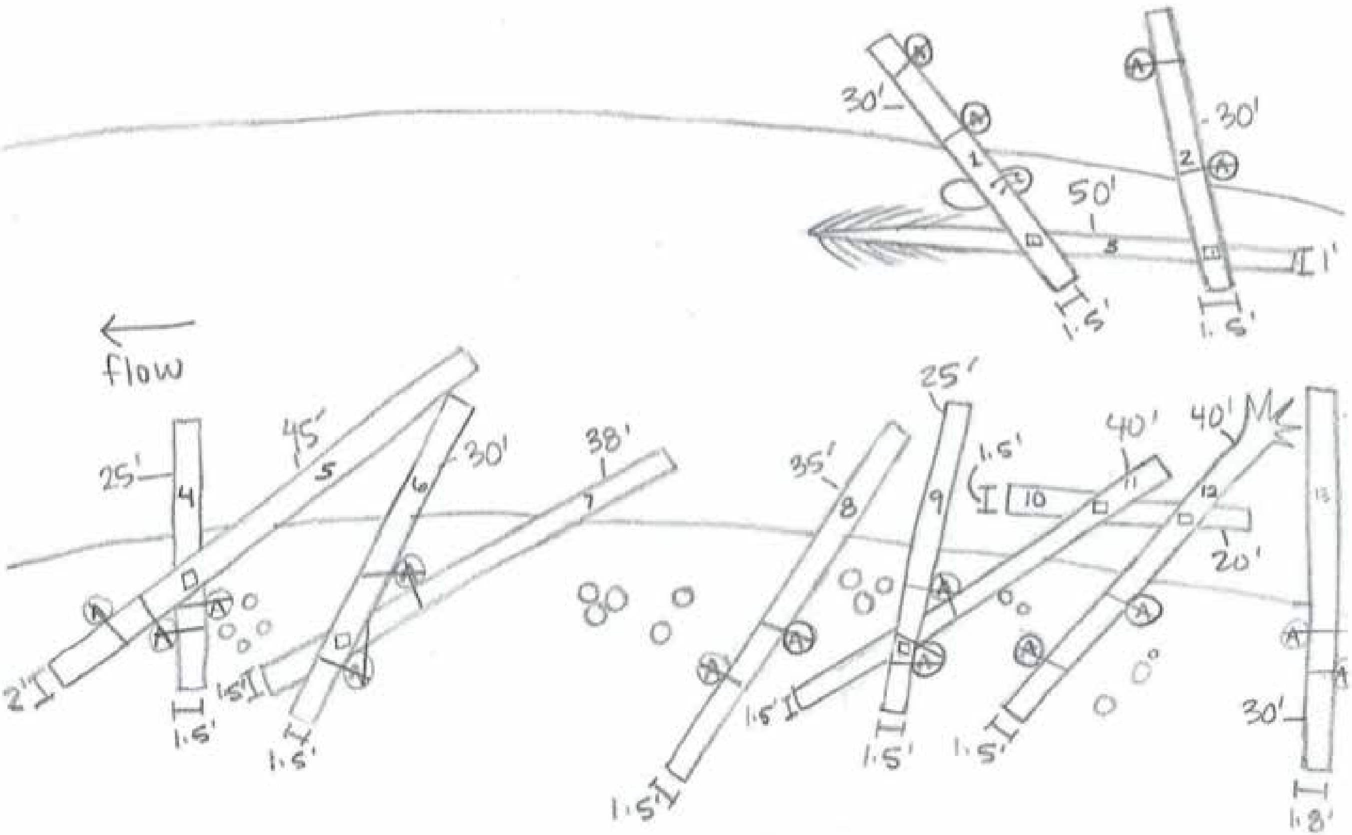
Sketch designs and collect measurements

- Feature Number (footage)
- Coordinates
- Existing Habitat Classification
- Dominant substrate
- Dominant cover type and %
- Max residual pool depth
- Bankfull width
- Brief feature description
- Estimated length to be treated
- Estimated length to be disturbed
- Estimated feature square footage
- Objective
- Log lengths
- Photos

SF Eel River



Feature # 13143



Feature: 6876 **Coordinates:** 40.05918, -123.83939

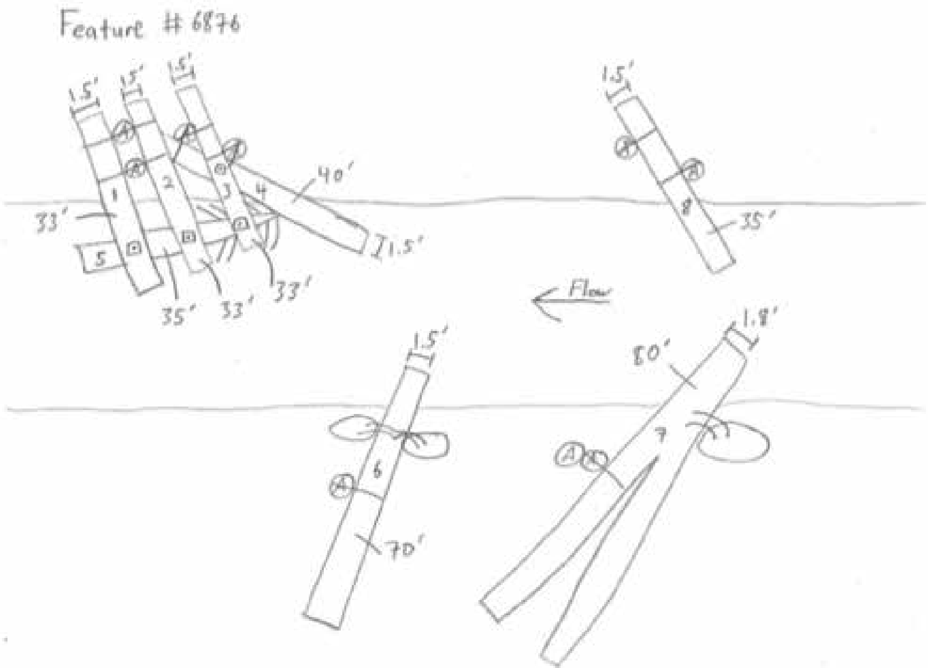
Existing Conditions: Run **Bankfull Width:** 38 feet **Max residual depth:** 1 foot

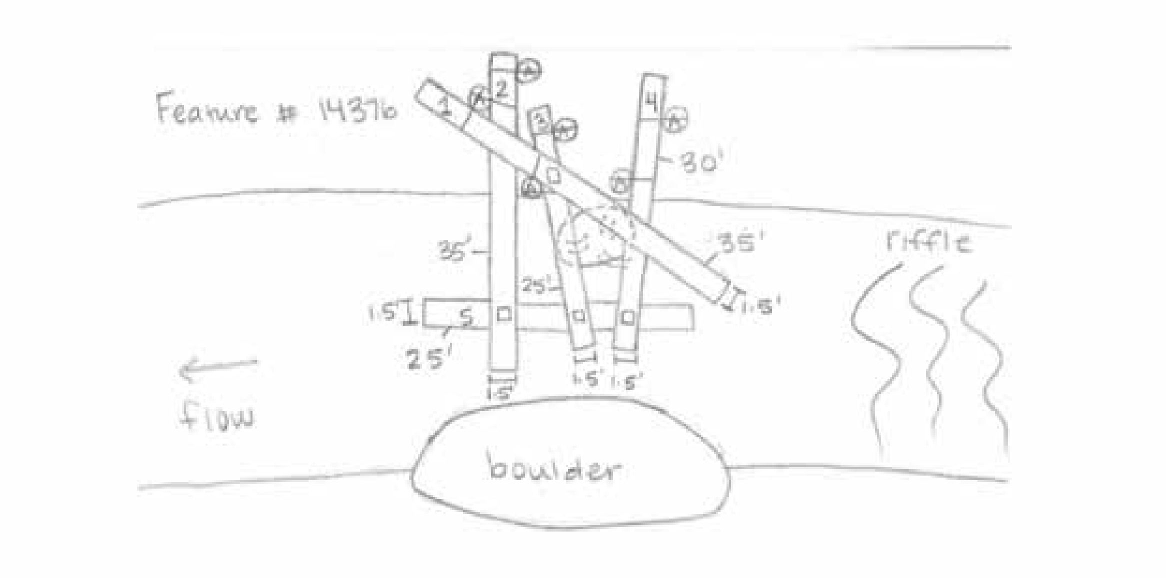
Dominant substrate: Cobble/boulder **Dominant cover type:** Small wood, <5%

Project: Log 5 is a cover log and is underneath and anchored to logs 1, 2, and 3. Log 4 is also underneath and anchored to log 3. Three logs will be sourced from riparian and upslope redwoods and Douglas firs and the rest will be purchased.

Length Treated: 50 feet **Length Disturbed:** 20 feet **Square Footage:** 220 ft^2

Objective: Increase cover, scour, and velocity refugia.




Feature # 14376
1
2
3
4
5
30'
35'
35'
25'
25'
1.5'
1.5'
1.5'
1.5'
1.5'
1.5'
riffle
flow
boulder

Feature: 11245 **Coordinates:** 40.05378, -123.84845

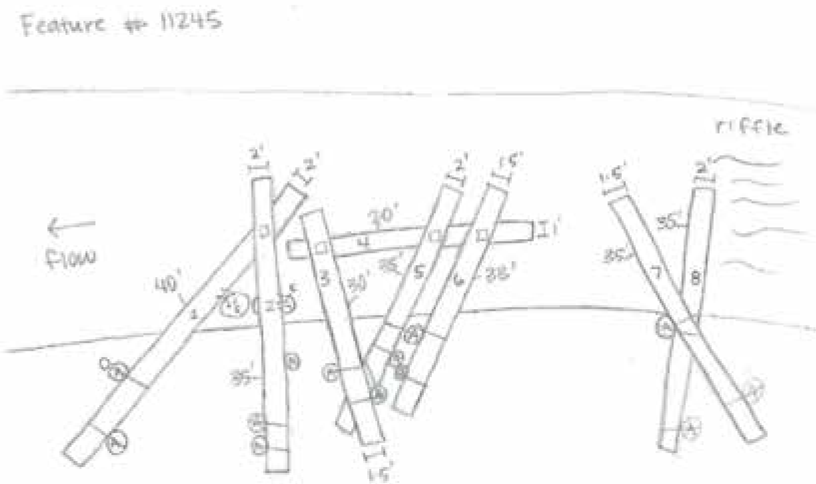
Existing Conditions: Pool/run-riffle **Bankfull Width:** 40 feet **Max residual depth**: 3.1 feet

Dominant substrate: Gravel, small cobble **Dominant cover type:** Undercut banks, 5%

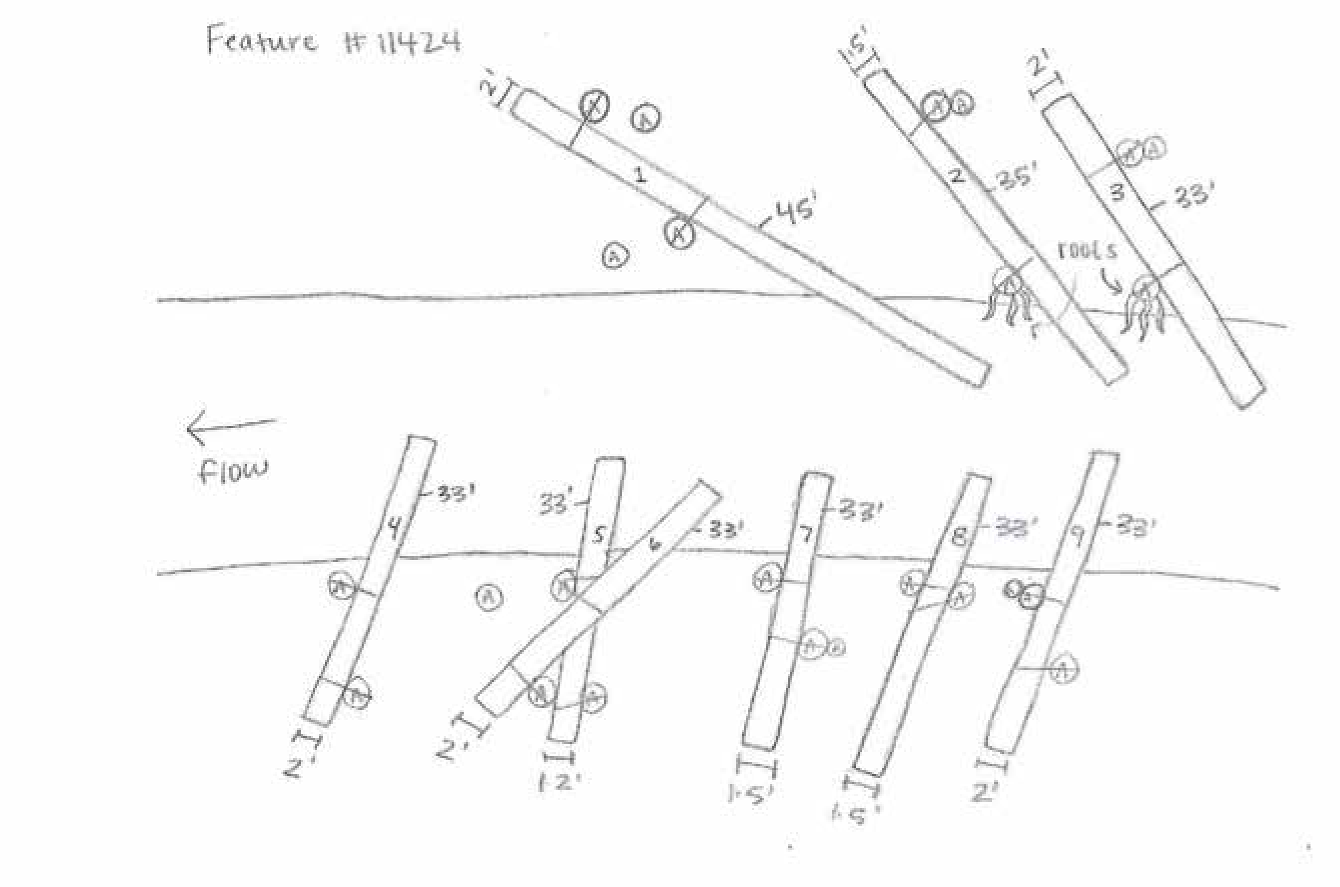
Project: Log 2 is on top of and anchored to log 1. Log 4 is a cover log and is underneath and anchored to logs 3, 5, and 6. Log 3 is on top of log 5. Log 7 is on top of log 8. Logs for this feature will be purchased.

Length Treated: 50 feet **Length Disturbed:** 20 feet **Square Footage:** 265 ft^2

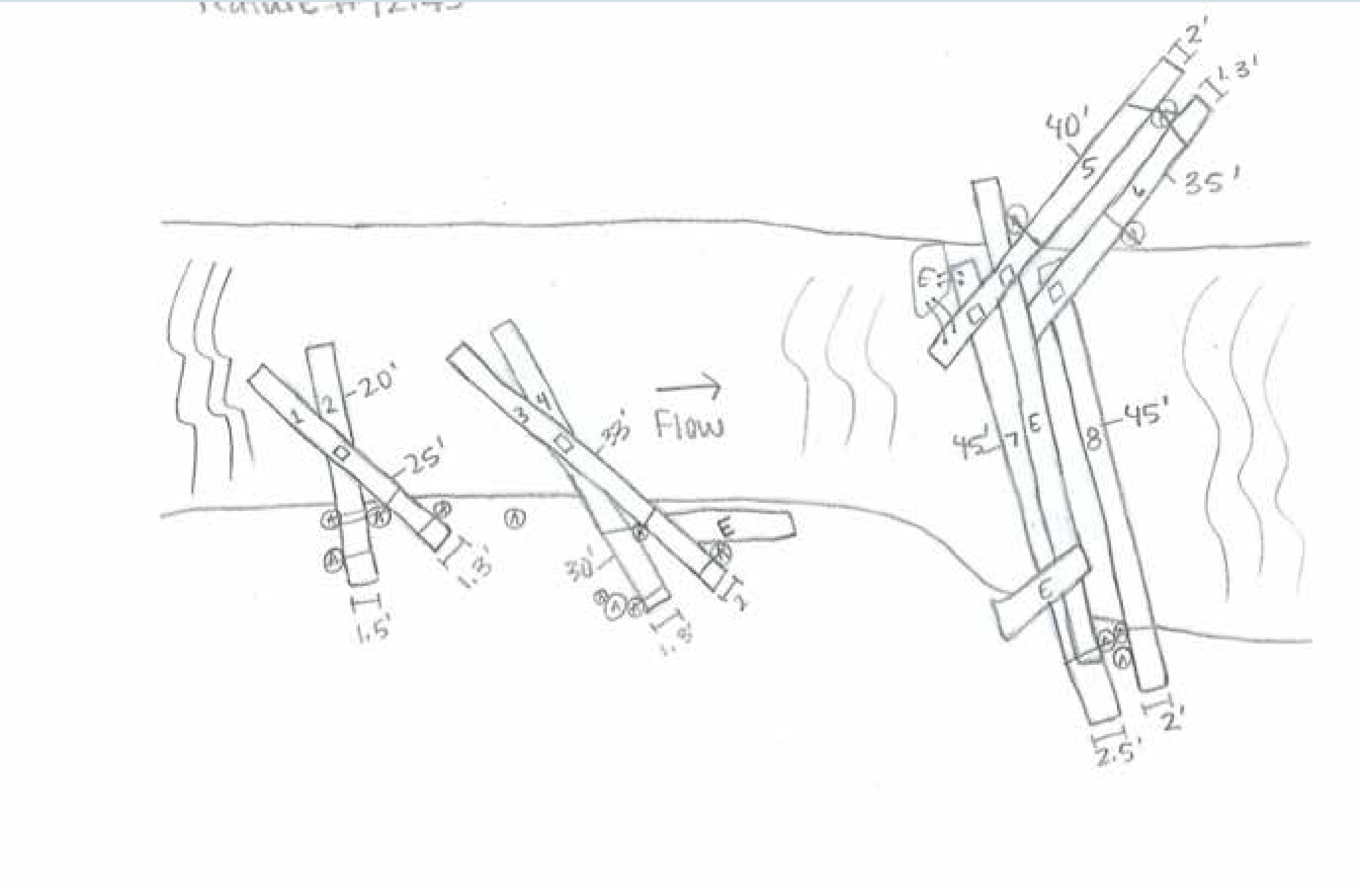
Objective: Increase cover, scour, and velocity refugia.



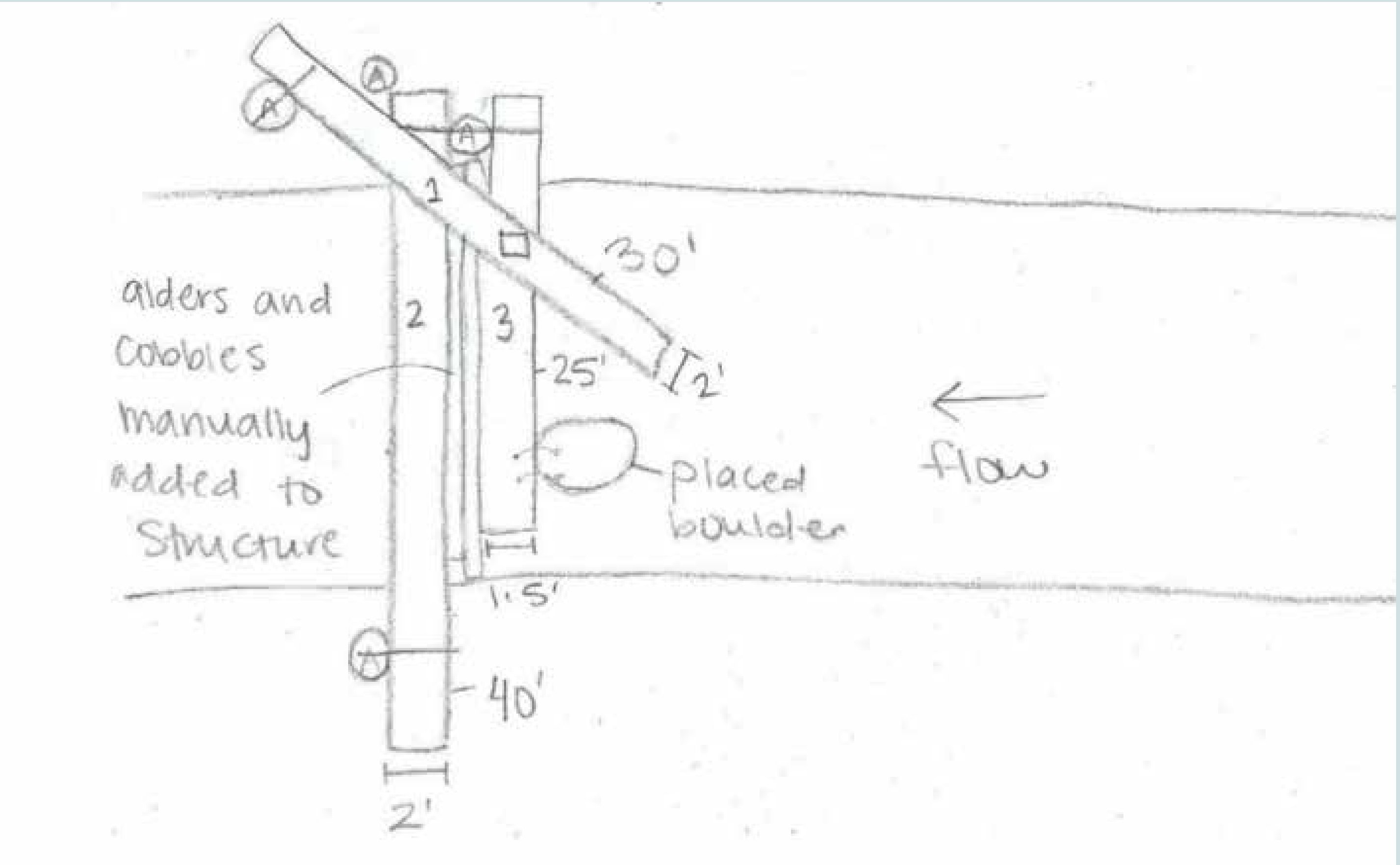
Scour/Cover/Velocity Refugia



Woody Debris Capture



Geomorphic Change & Aggradation

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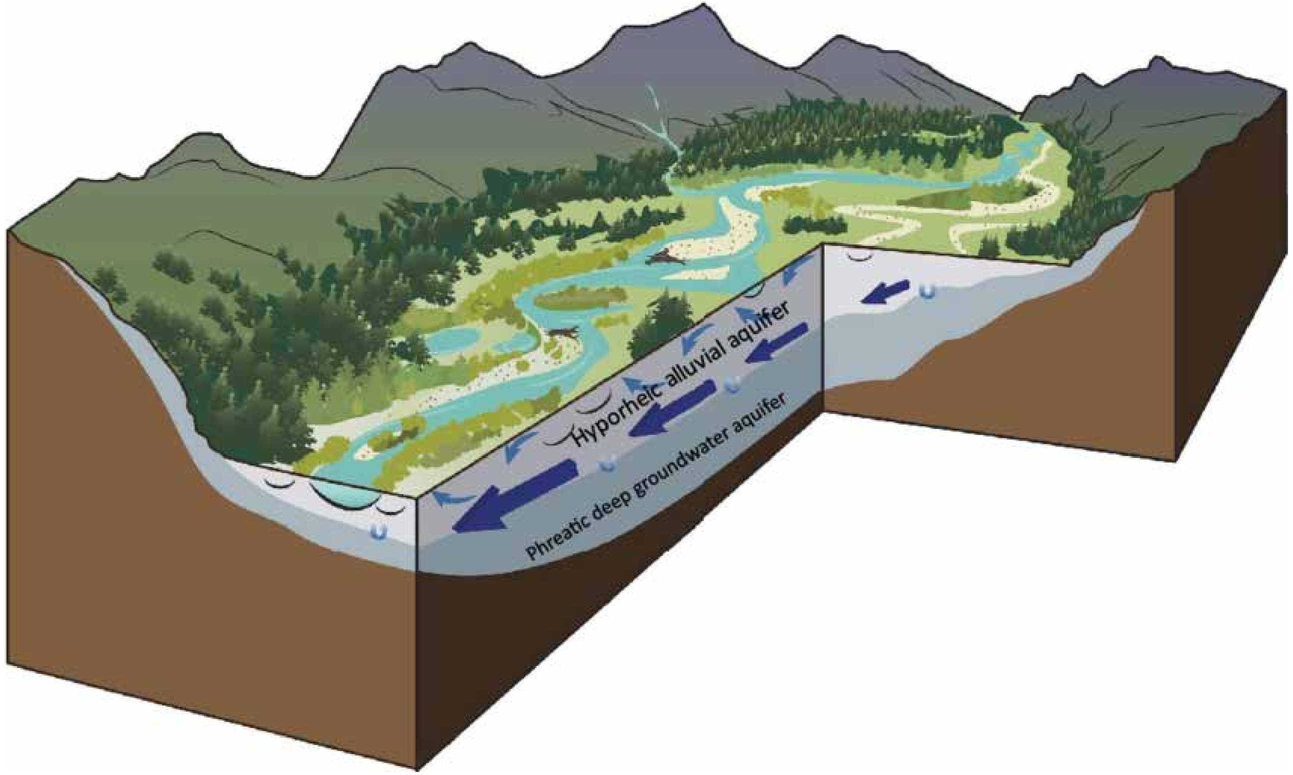
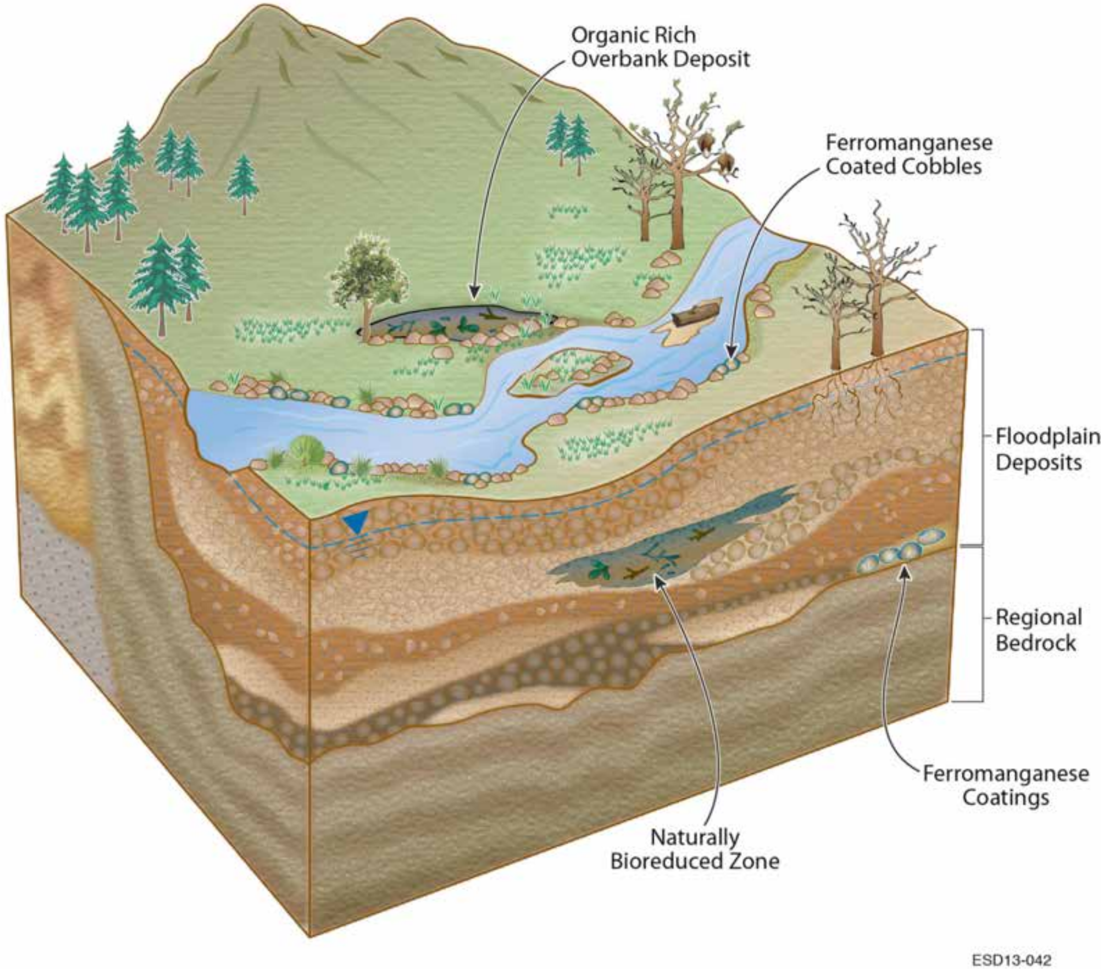
Designing & Implementing Non-Engineered Large Wood Projects with the CCC

Eel River Watershed Improvement Group
Marisa McGrew, Project Manager
Presentation created by Isaac Mikus, Executive Director

The Scott River Mine Tailings Restoration Underground- Is There a Role for Large Wood?



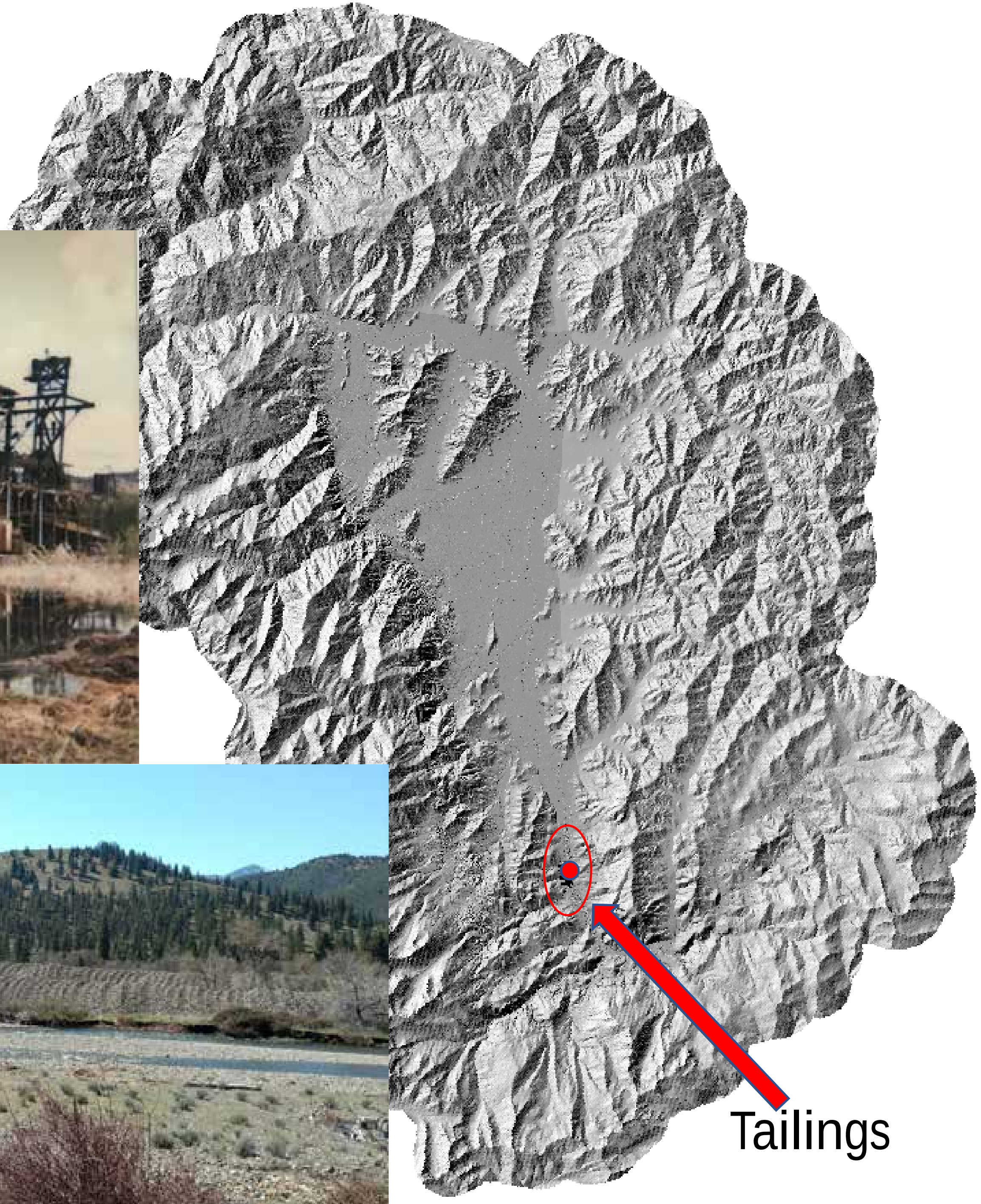


Scott River Dredge Tailings Reach

- 4 miles of bucket dredging across entire valley
- Stream Slope = 0.78% for entire reach
  - 0.93% above Sugar Ck confl.
  - 0.64% below Sugar Ck confl.
- Valley Width 300-500 m
- Depth to Bedrock max 30-40 ft?
- Depth to Bedrock nr Sugar = 12-15 ft
- Meander Ratio <1.1

Problems

- Altered Subsurface Structure
- Increased Hydraulic Conductivity of Alluvium, Loss of Calcareous or Fe-S (cementation) Layer
- Floodplain Disconnection
- Altered Floodplain Morphology
- Removal of Alluvium
- Incision
- Loss of Surface Flow



Scott River Dredge Tailings Reach

1944-Aug

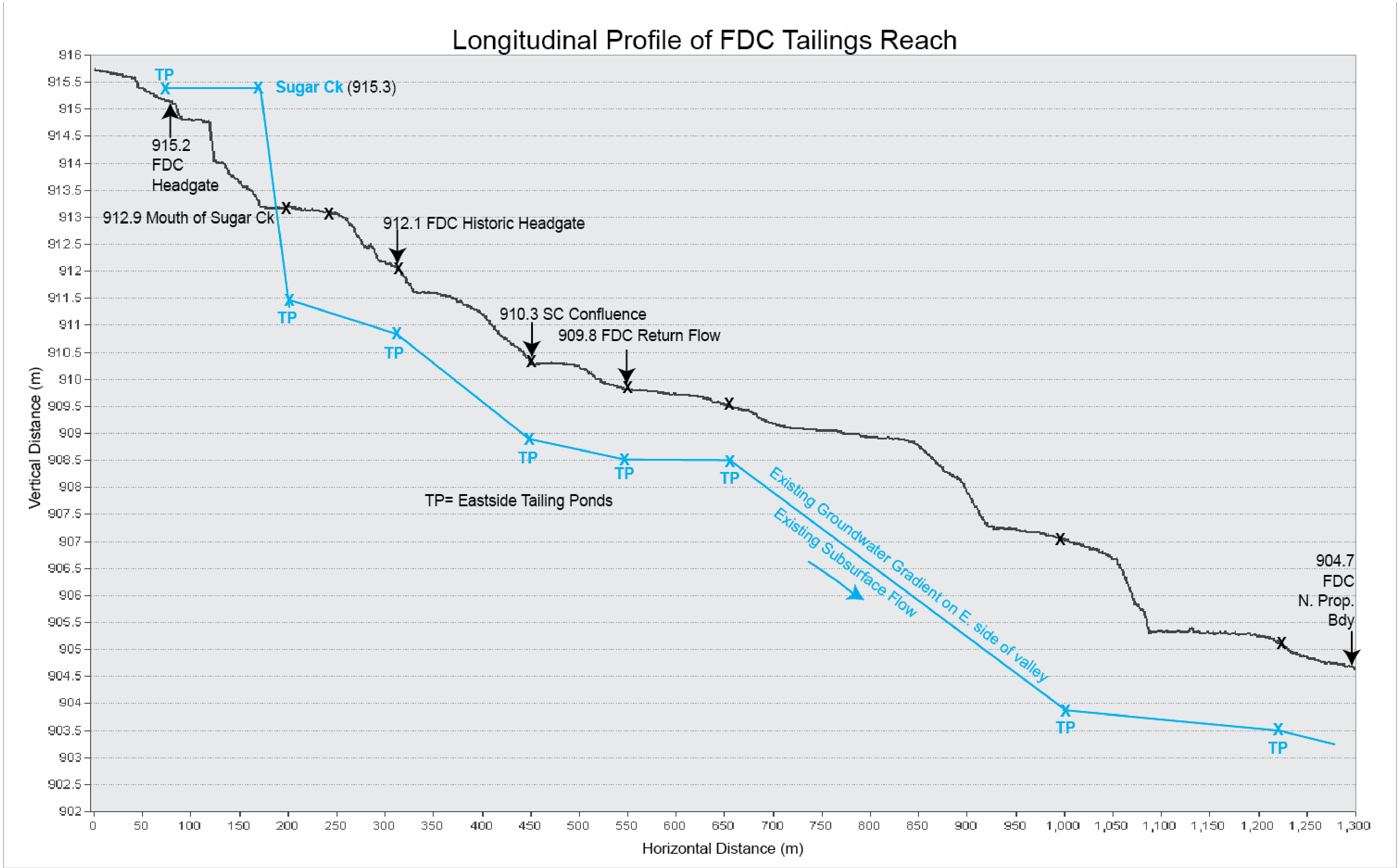

Flowing Water
Standing
Water
FDC Diversion
Sugar Ck, Backwatered from Scott R.
Standing Water

1955-Aug


No Flowing Water
Standing Water
FDC Diversion
Sugar Ck, Backwatered from Scott R.
Standing Water

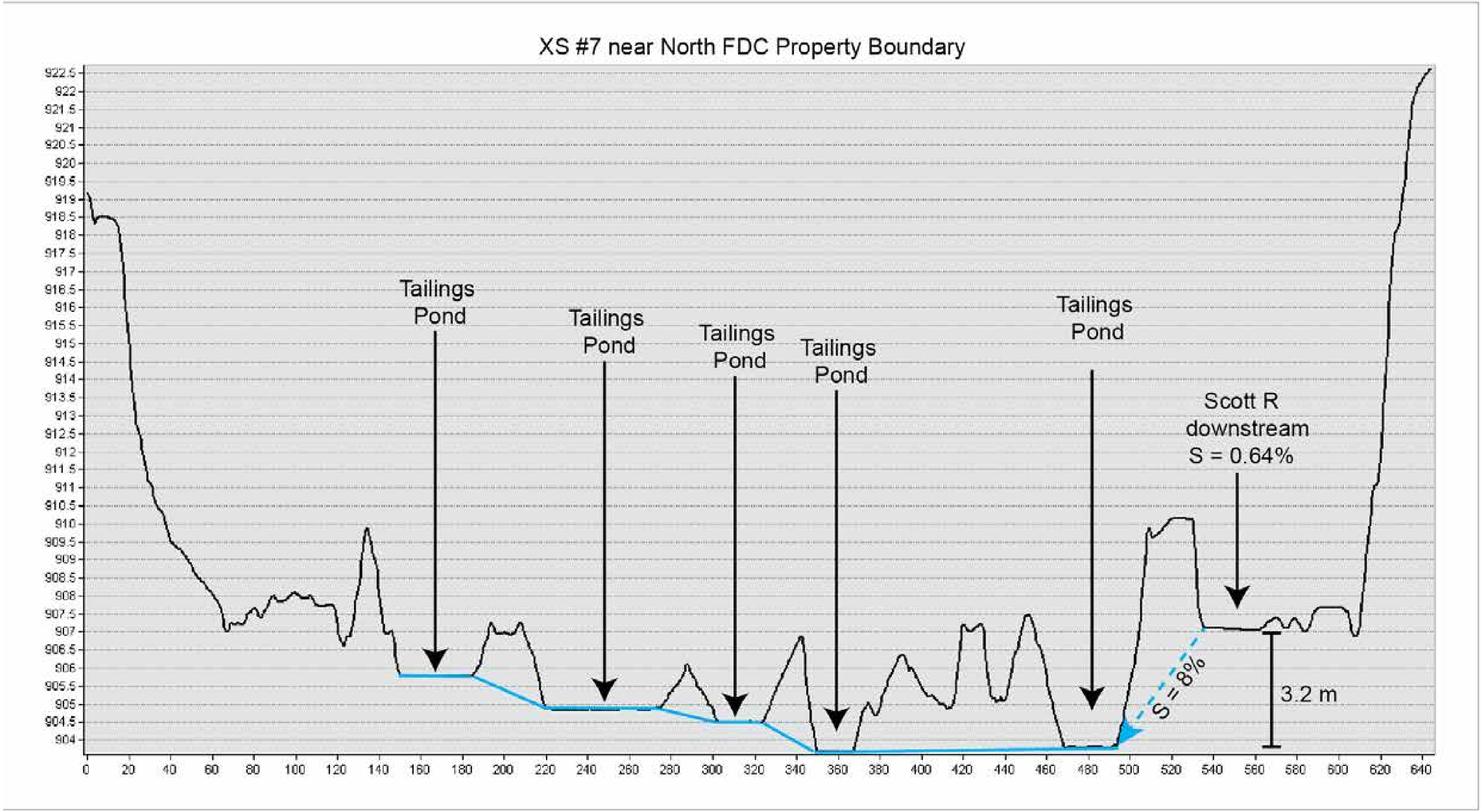

1965-Aug
Flowing Water
FDC Diversion
1964
Flood
Deposits.
Sugar Ck, Backwatered from Scott R.
Standing Water


2018-Aug
Gravel Mining Ponds
No Flowing Water (for > 2 mi. downstream)
Diversion Return Flow
Critical Rifle
Sugar Ck Water
Boulder Weirs
FDC Diversion
No Standing Water

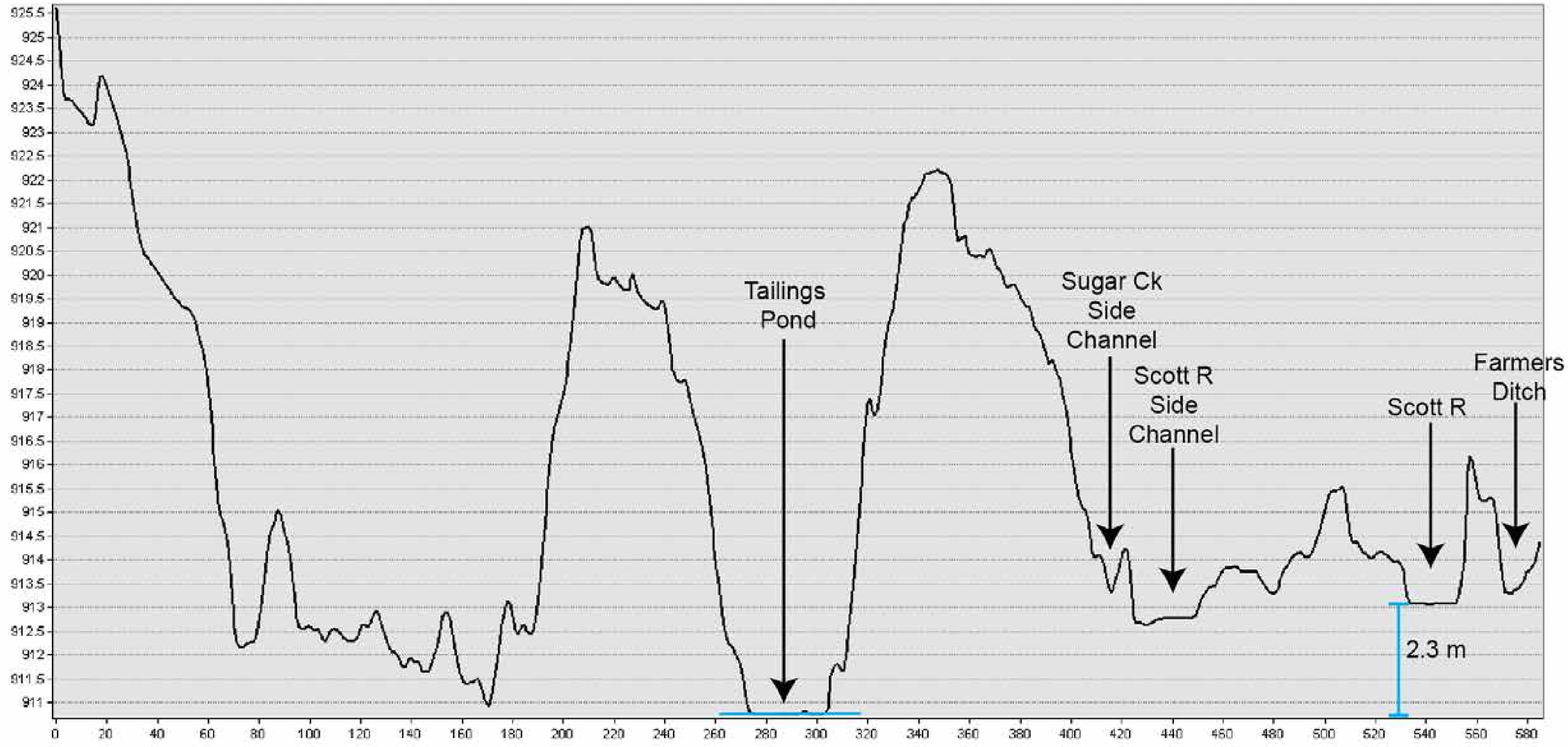


Longitudinal Profile of FDC Tailings Reach
Vertical Distance (m)
Horizontal Distance (m)
TP
Sugar Ck (915.3)
915.2
FDC
Headgate
912.9 Mouth of Sugar Ck
912.1 FDC Historic Headgate
910.3 SC Confluence
909.8 FDC Return Flow
TP= Eastside Tailing Ponds
Existing Groundwater Gradient on E. side of valley
Existing Subsurface Flow
904.7
FDC
N. Prop.
Bdy

Why Does the Tailings Reach Lose Water?



Cross Section at Scott River-Sugar Creek Confluence



Around the world, groundwater dams are being used to address
The interrelated problems of incision and alluvial groundwater lowering, particularly in arid regions

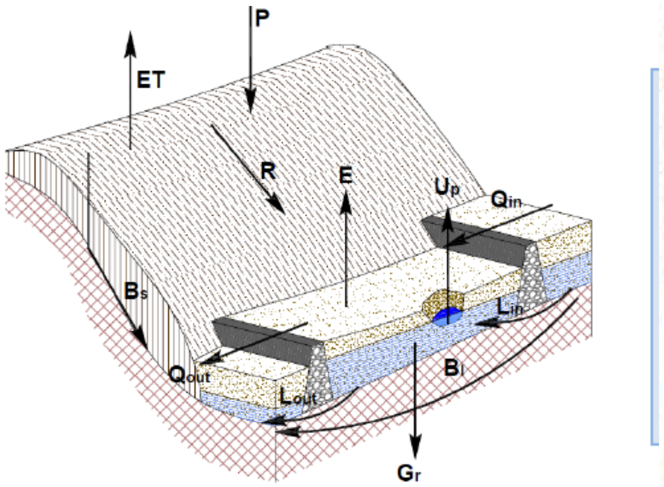


Figure 4: Water balance components (Borst & de Haas, 2006)

JARQ 45 (1), 51 - 61 (2011) http://www.jircas.affrc.go.jp

REVIEW

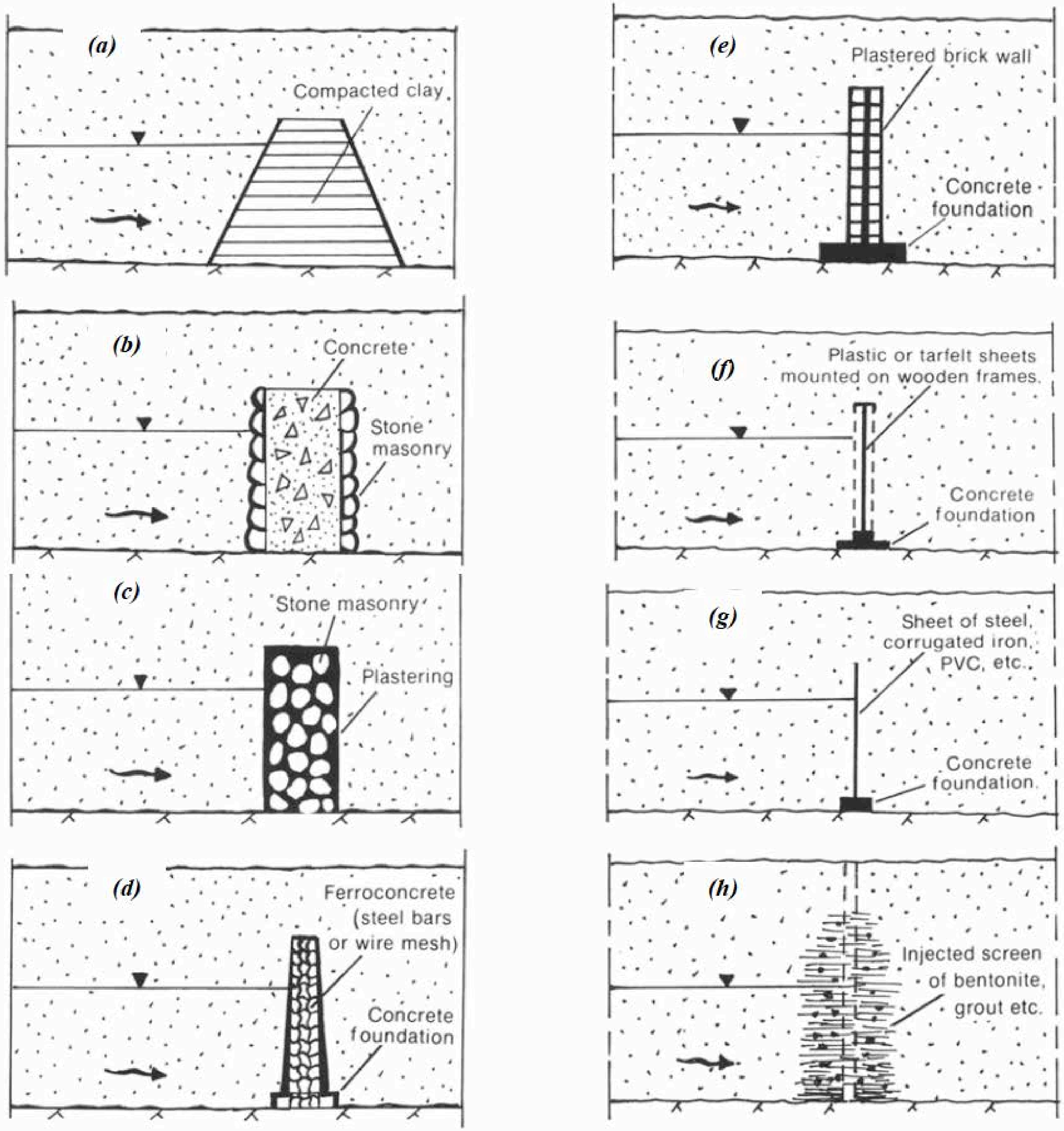
Sustainable Use of Groundwater with Underground Dams

Satoshi ISHIDA[1*], Takeo TSUCHIHARA[1], Shuhei YOSHIMOTO[1] and Masayuki IMAIZUMI[2]

[1] Department of Rural Technologies, National Institute for Rural Engineering, National Agriculture and Food Research Organization (NARO) (Tsukuba, Ibaraki 305-8609, Japan)

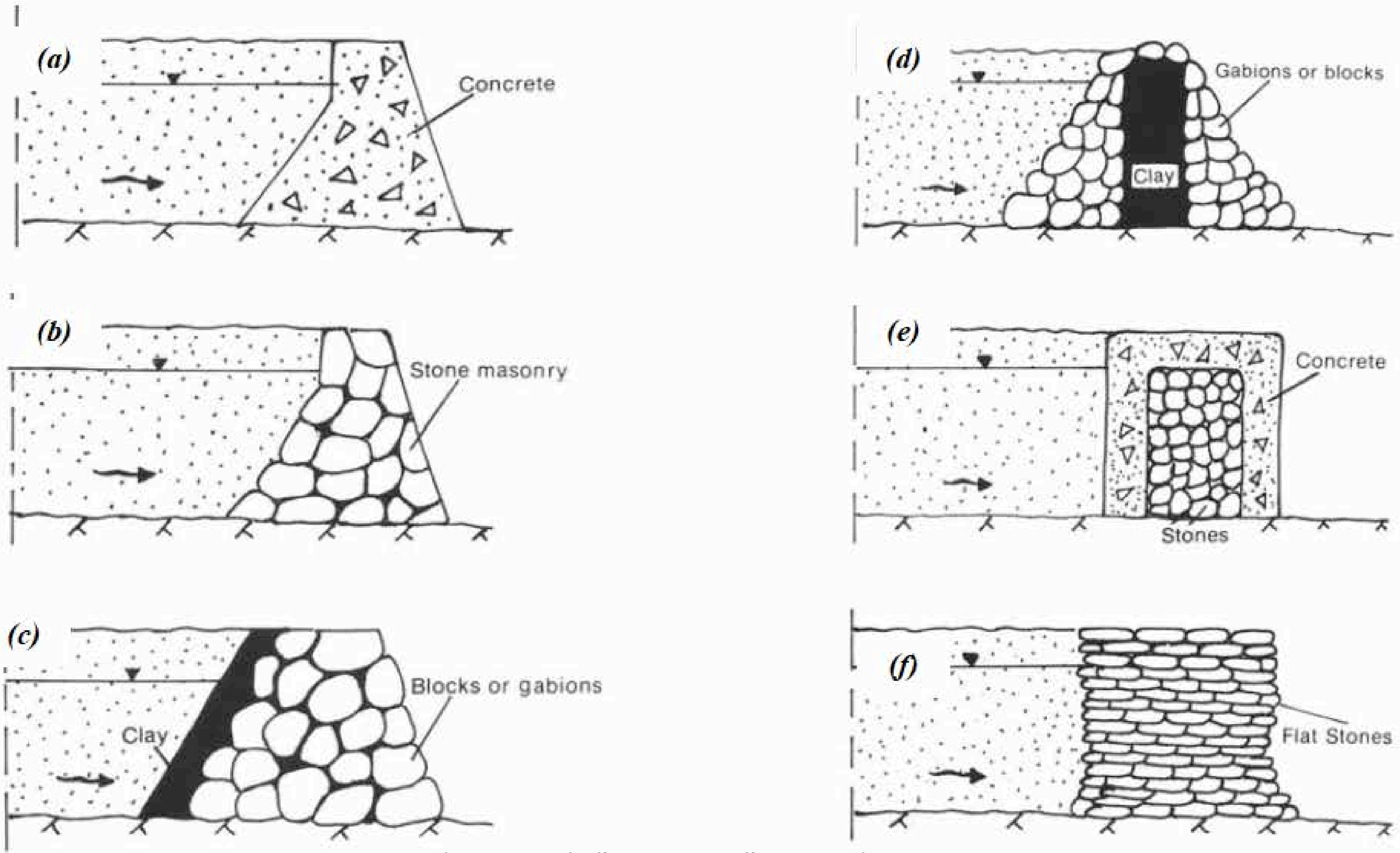
[2] Department of Rural Environment, National Institute for Rural Engineering, NARO (Tsukuba, Ibaraki 305-8609, Japan)

Types of Groundwater Dams-Subsurface



(Hanson and Nilsson 1986, Nilsson 1988)

Types of Groundwater Dams-Surface



(Hanson and Nilsson 1986, Nilsson 1988)

High-Tech Groundwater Dams

Sustainable Use of Groundwater with Underground Dams

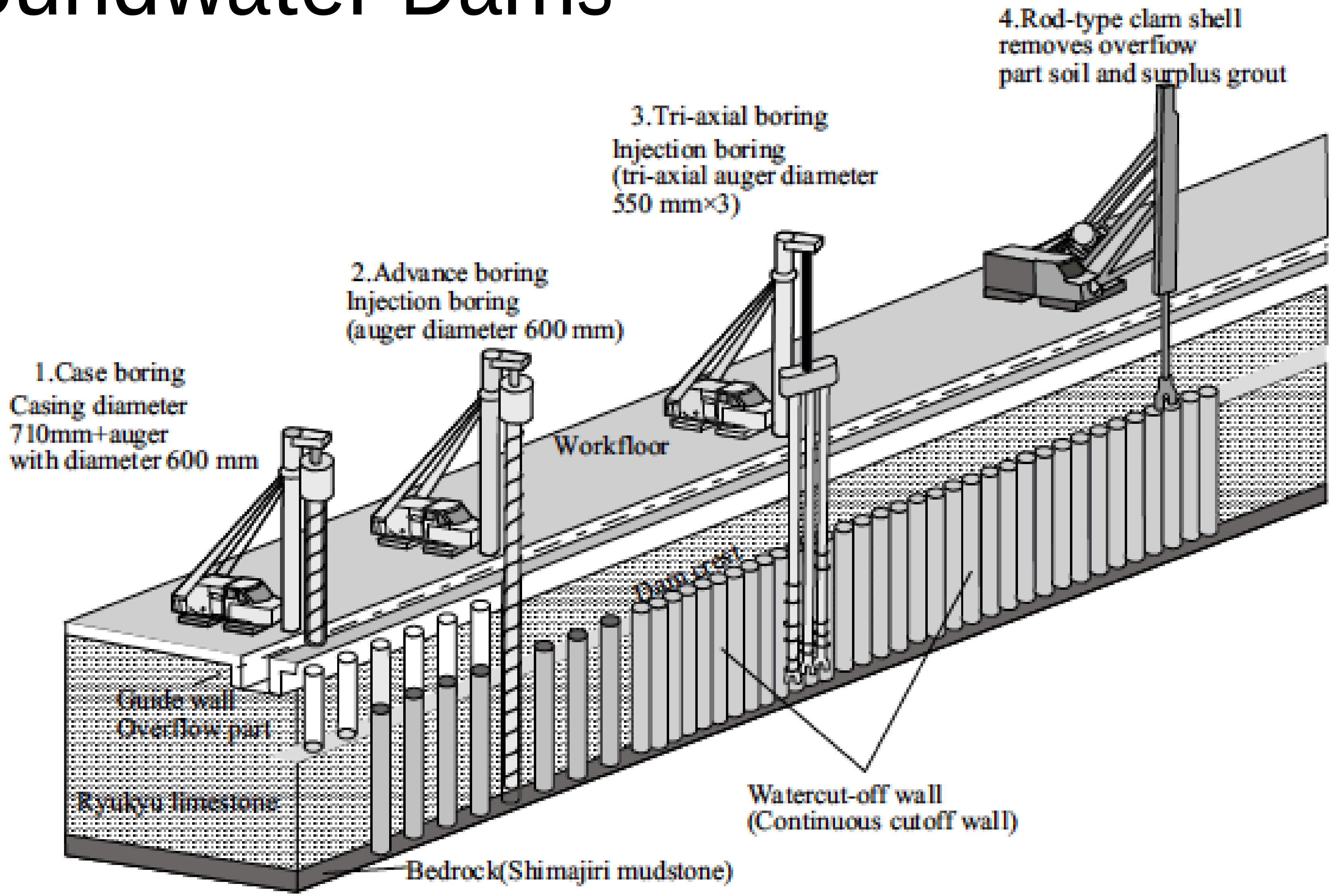
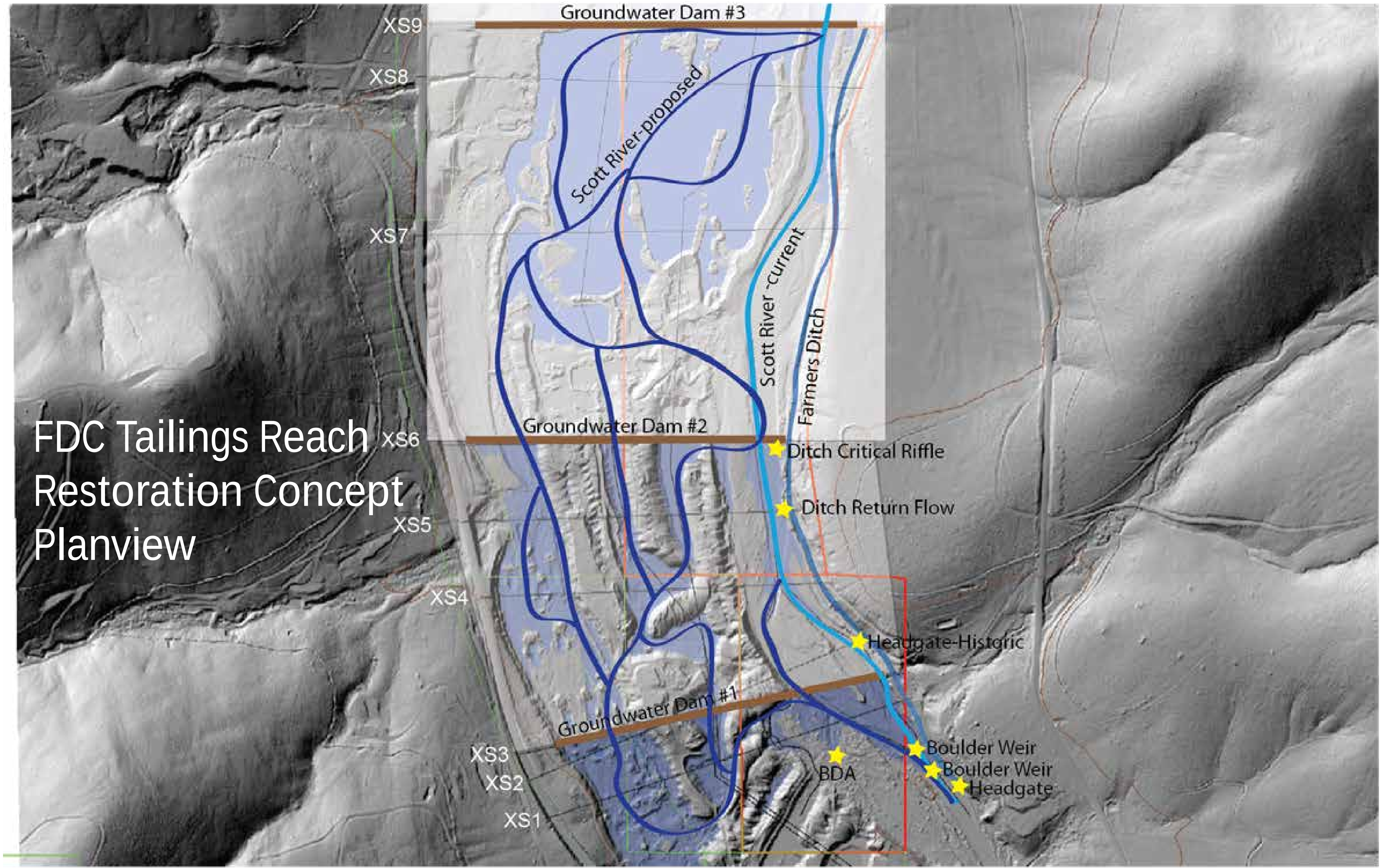
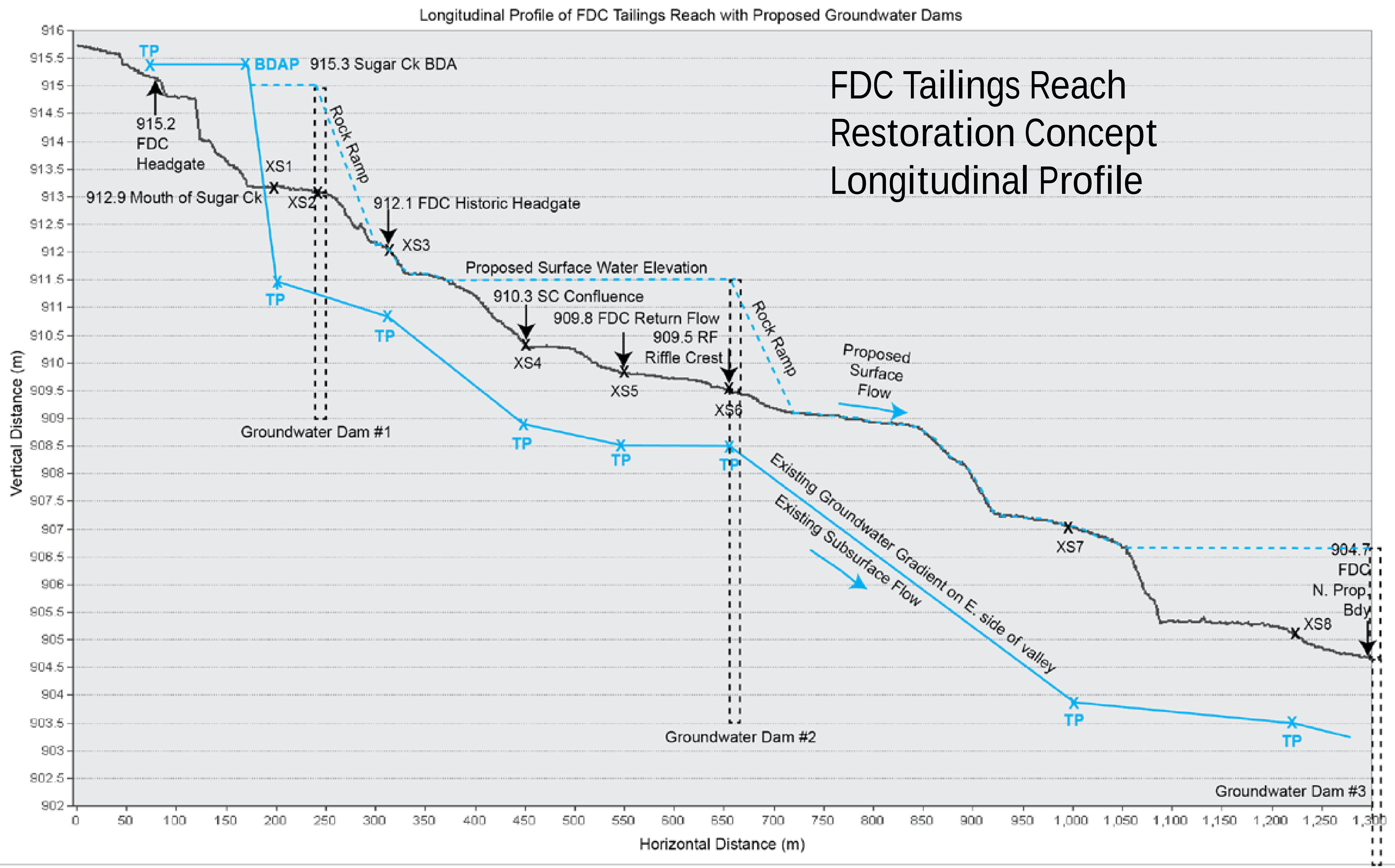


Fig. 3. Conceptual diagram of the mix-in-place construction method (Ishida et.al. 2003 retouched)

Rock Ramps for Fish Passage

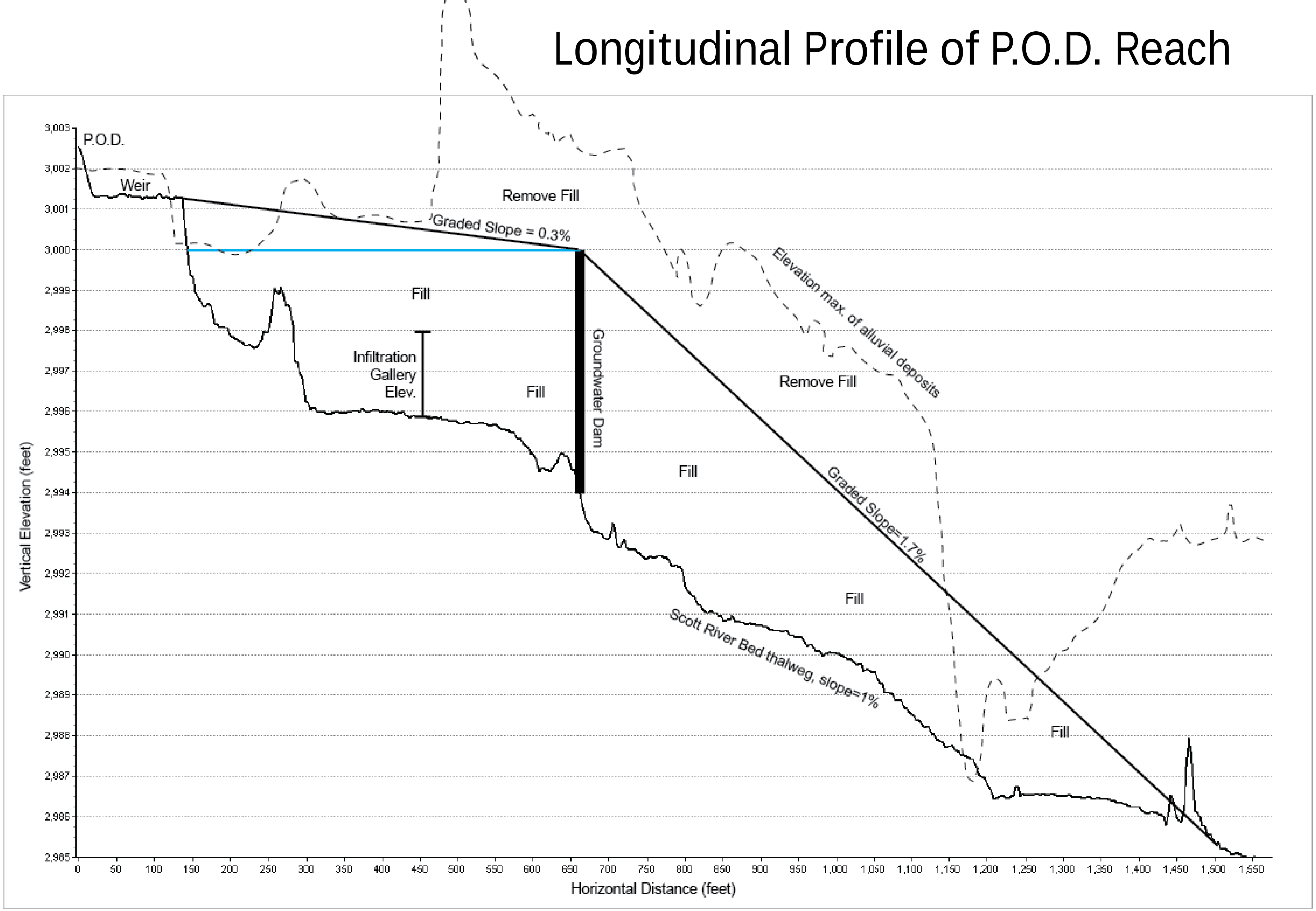


FDC Tailings Reach
Restoration Concept
Planview
Groundwater Dam #3
Groundwater Dam #2
Groundwater Dam #1
Scott River-proposed
Scott River -current
Farmers Ditch
Ditch Critical Riffle
Ditch Return Flow
Headgate-Historic
Boulder Weir
Boulder Weir
Headgate
BDA
XS9
XS8
XS7
XS6
XS5
XS4
XS3
XS2
XS1

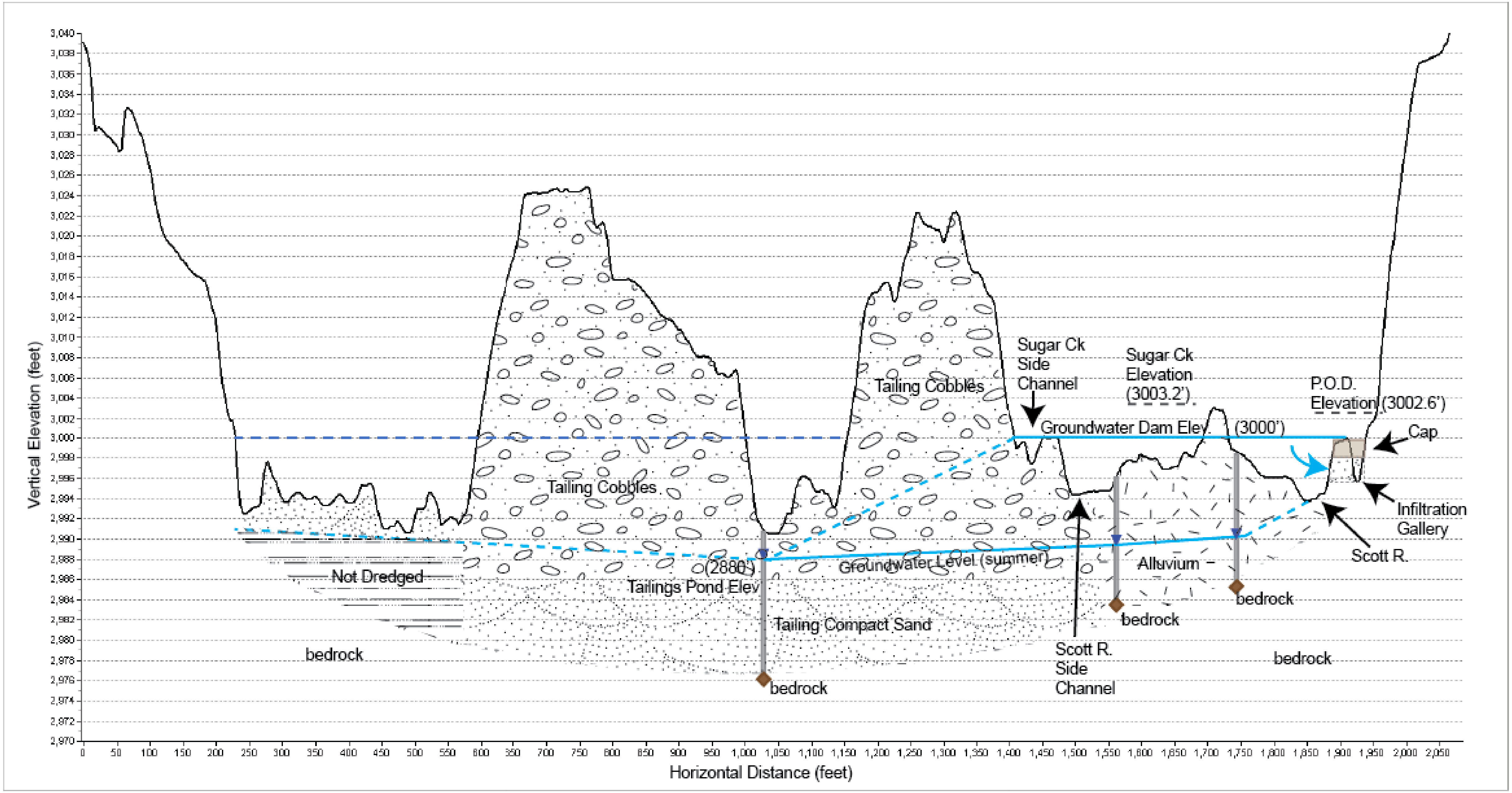


Longitudinal Profile of FDC Tailings Reach with Proposed Groundwater Dams
FDC Tailings Reach
Restoration Concept
Longitudinal Profile
TP
BDAP
915.3 Sugar Ck BDA
915.2
FDC
Headgate
Rock Ramp
XS1
912.9 Mouth of Sugar Ck
XS2
912.1 FDC Historic Headgate
XS3
Proposed Surface Water Elevation
910.3 SC Confluence
909.8 FDC Return Flow
909.5 RF
Riffle Crest
XS4
XS5
XS6
Proposed
Surface
Flow
Groundwater Dam #1
Existing Groundwater Gradient on E. side of valley
Existing Subsurface Flow
XS7
904.7
FDC
N. Prop.
Bdy
XS8
Groundwater Dam #2
Groundwater Dam #3
Vertical Distance (m)
Horizontal Distance (m)
916
915.5
915
914.5
914
913.5
913
912.5
912
911.5
911
910.5
910
909.5
909
908.5
908
907.5
907
906.5
906
905.5
905
904.5
904
903.5
903
902.5
902
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1,000
1,050
1,100
1,150
1,200
1,250
1,300

Longitudinal Profile of P.O.D. Reach



Cross Section of Scott River Valley Floor at Historic Point of Diversion (approx.)



Claimant	Current Owner	Proportion	CFS at POU (no ditch loss)	CFS right	Irrigated Acreage-Table	CFS/Acre	Acres/CFS	CFS %	Irrigated Acreage-Individual	CFS	Days of Use	Total Volume (CF)	Total Acre-Feet	Acre-Ft/Acre
Duffy	Alexander	0.01	30.0	0.4	15	0.029	34.7	1%	15	0.4	180	6,729,231	154	10.3
Brock	Merlo	0.02	29.6	0.6	175	0.003	307.8	2%	50	0.6	180	8,842,899	203	4.1
Merlo	Merlo	0.06	29.0	1.7	58	0.029	34.7	6%	58	1.7	180	26,018,531	597	10.3
Wolford	Hurlimann	0.10	27.3	2.7	57	0.048	20.9	9%	57	2.7	180	42,496,934	976	17.1
Barnes	Barnes	0.13	24.6	3.1	108	0.028	35.1	10%	246	3.1	180	47,809,051	1,098	4.5
Hammond	Hammond	0.13	21.5	2.7	134	0.020	49.8	9%	118	2.7	180	41,832,919	960	8.1
Denny	Denny	0.13	18.8	2.4	217	0.011	92.2	8%	8	2.4	180	36,603,804	840	105.0
Tobias	Tobias	0.50	16.5	8.2	241	0.034	29.3	27%	42	8.2	180	128,113,315	2,941	70.0
Spencer	Fowle	0.25	8.2	2.1	55	0.037	26.7	7%	5	2.1	180	32,028,329	735	147.1
Fowle	Fowle	0.25	6.2	1.5	40	0.039	25.9	5%	22	1.5	180	24,021,247	551	25.1
Friden	Plank	1.00	4.6	4.6	138	0.034	29.8	15%	7	4.6	180	72,063,740	1,654	236.3
Total				30	1238	0.312	41.3	1	628	30.0	180	466,560,000	10,711	17.1

Accelerated Recruitment: Cost-Efficient Restoration Techniques for Enhancing Instream Habitat

SRF Large Wood Technical Workshop

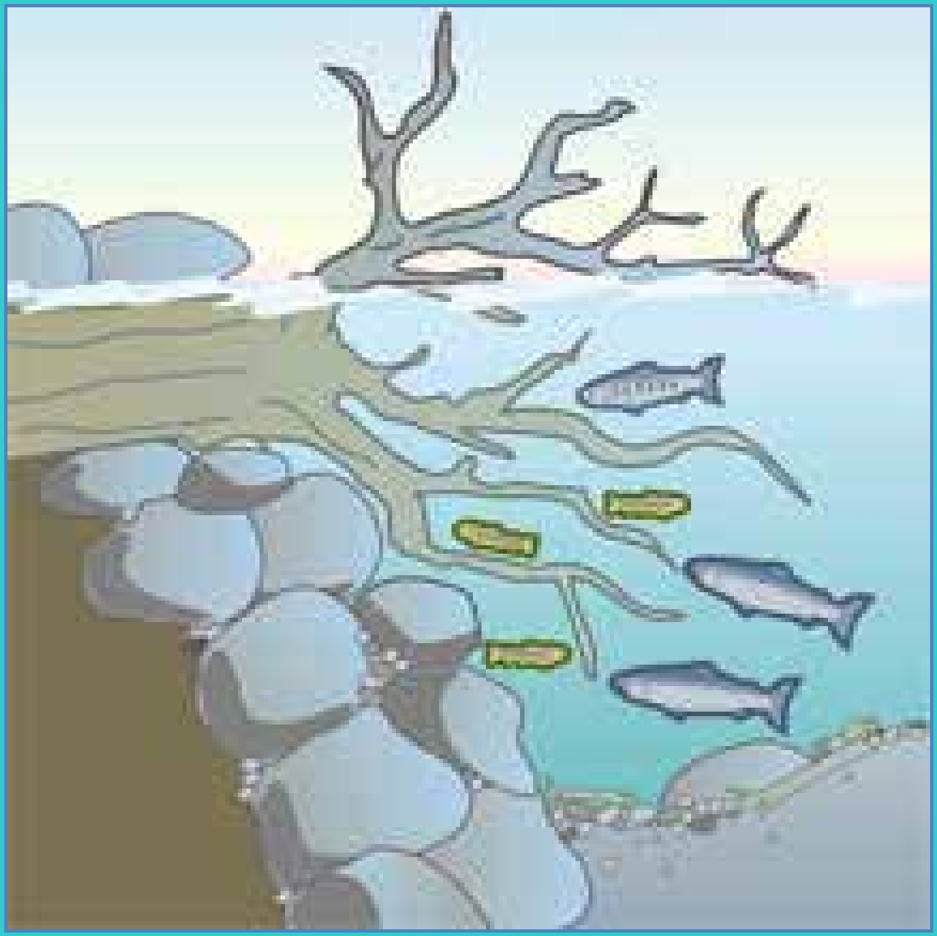
Prepared By Christopher Blencowe RPF
Blencowe Watershed Management

Design/Build Approach

- Structure designer is onsite for implementation everyday
- Oversee/modify designs in real time as necessary ‘field fitting’
- Refined/revised through real world, on the ground situations and processes
- Critical to success of any one piece of wood, structure, project, etc

Restoration Strategies

- **Accelerated Recruitment strategy:**
  - Increase pace and scale
  - Rapid, efficient accelerated recruitment of large wood as a stop-gap measure
  - ‘Nucleate’ the stream with functional key LWD pieces
  - Natural LWD recruitment is the goal



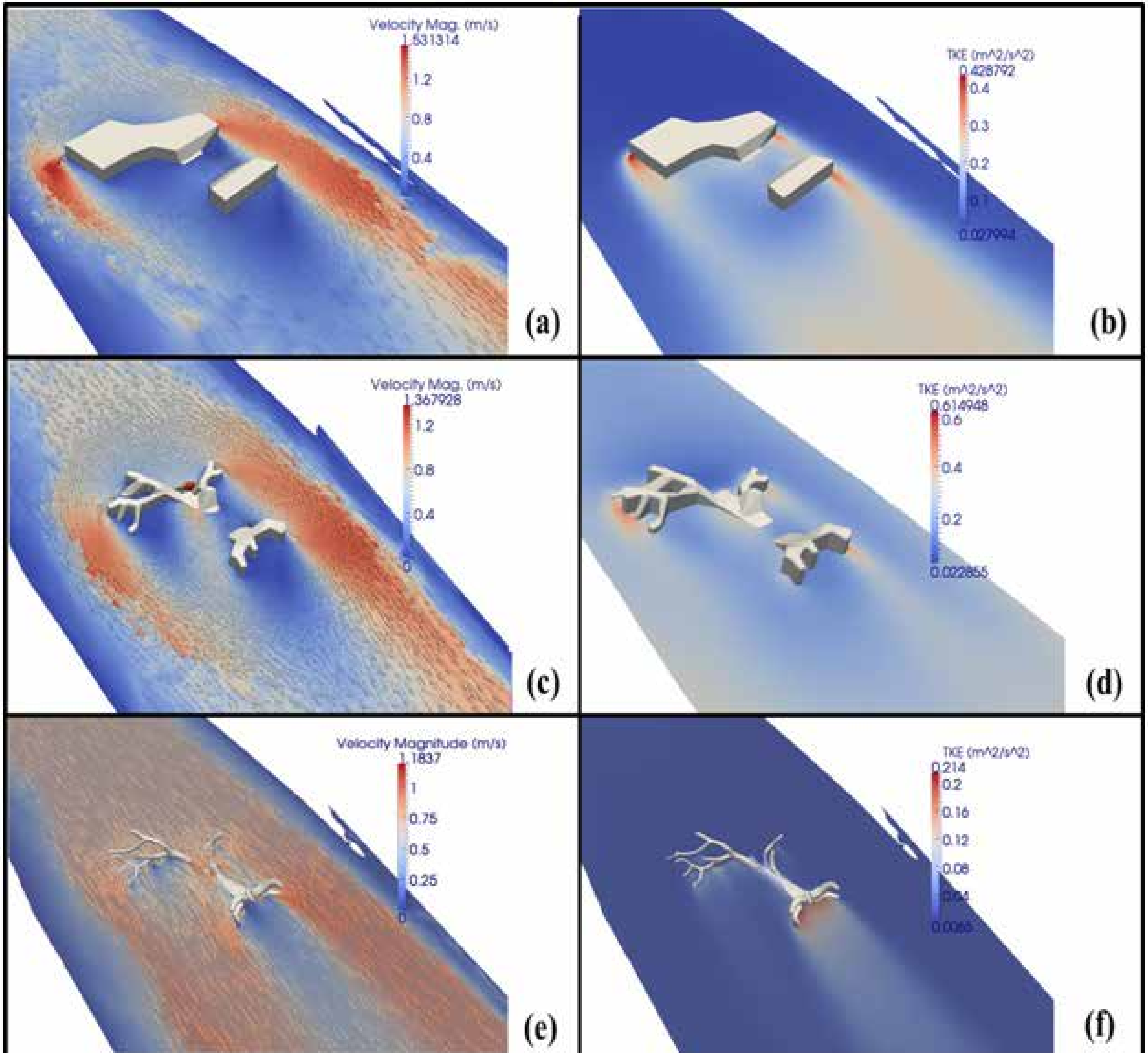
Implementation Methods

- Using rubber tired equipment to directly place logs through riparian roughness elements
- Use skidder to winch logs from onsite/upslope
- Direct falling near-stream conifers where appropriate
- Whole tree tipping/placing with excavator
- Sourcing logs onsite/near project area


CATERPILLAR

Structure Design Considerations

1. Evaluation of pre-existing in stream conditions including local channel morphology, thalweg location and quality of instream shelter. Prioritization of aggradated pools, flatwater, avoid tail outs/riffles
2. Orientation of riparian roughness elements for wedging/anchoring of LWD
3. Availability of equipment access
4. Log source ie. upslope trees, salvageable logs, direct falling, or offsite (delivered) logs
5. Potential disturbance to riparian resources
6. Infrastructure/aesthetic concerns



Characterizing the Impact of Geometric Simplification on Large Woody Debris Using CFD

Jeffrey B. Allen [1], **David L. Smith**

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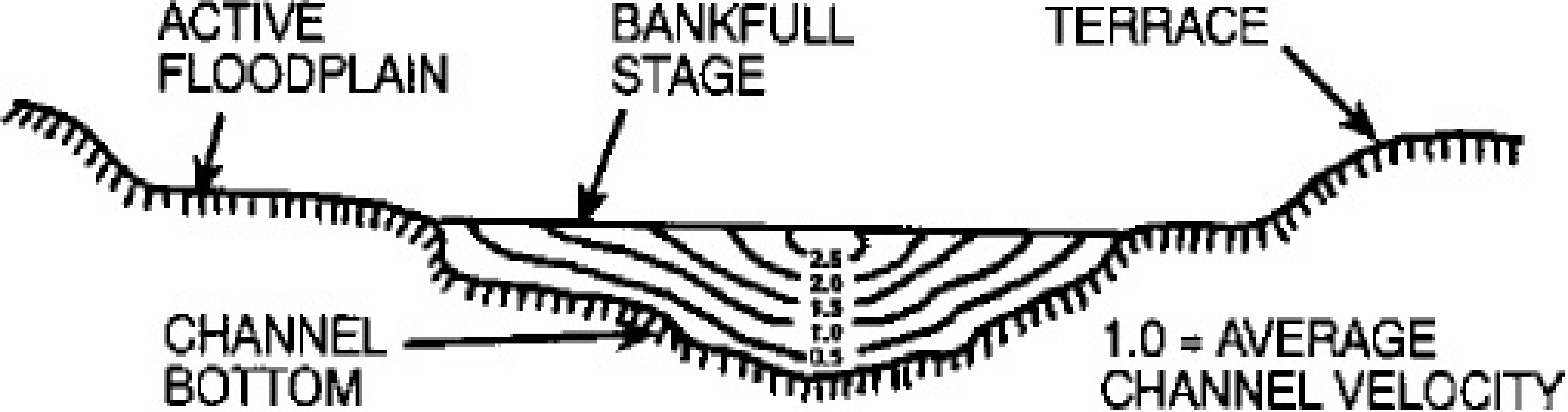
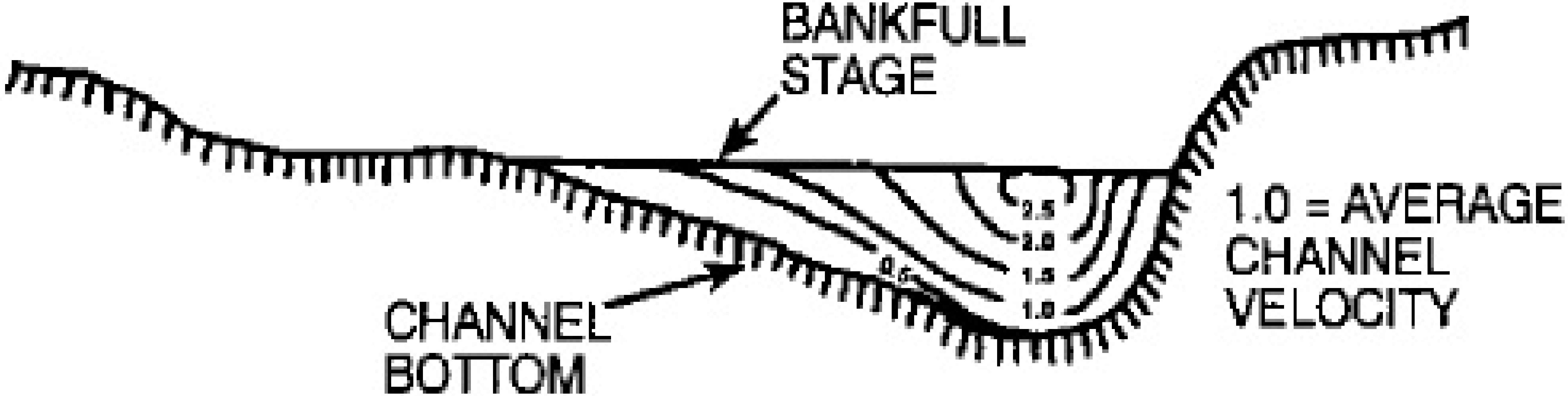
‘Throttle the Channel’

- Increase x-sectional surface area of project wood
- Increase velocity/TKE around obstruction
- Scour pool, create slow water refugia, sort store gravels
- Ability to rack and retain existing instream SWD/MWD/LWD
- Must design and size wood/anchoring appropriate for channel



(a) STRAIGHT CHANNEL



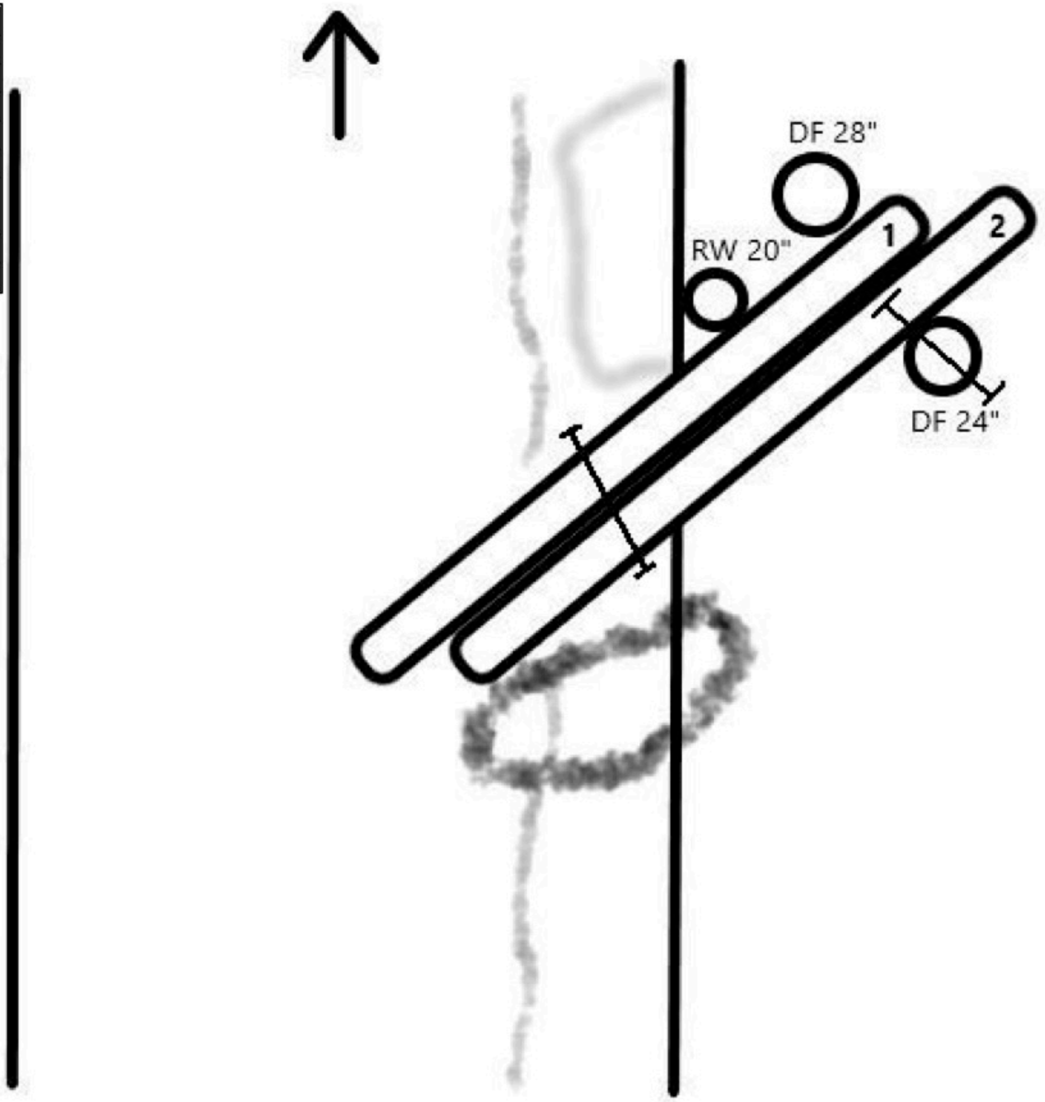
(b) CHANNEL BEND

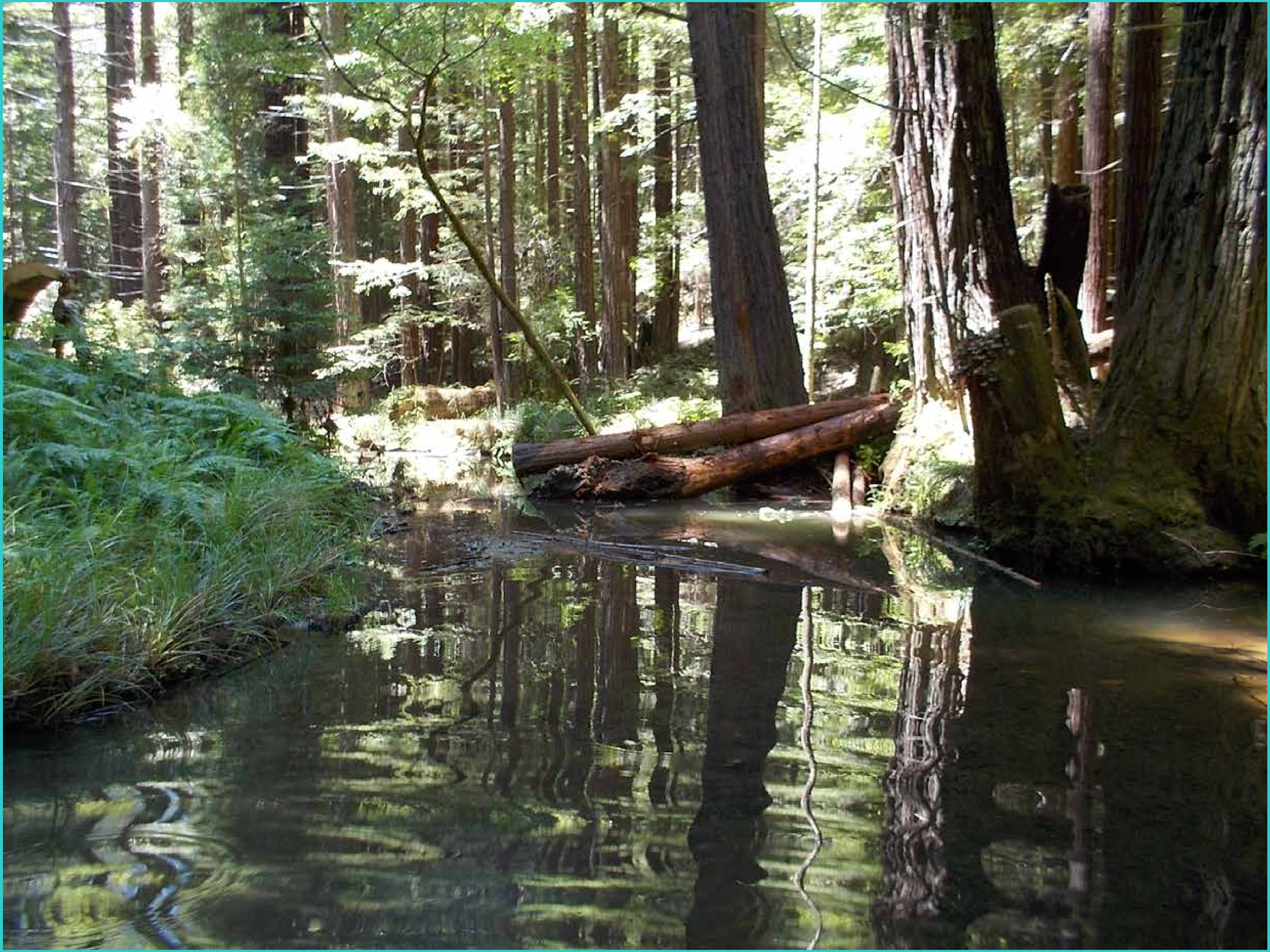
Dynamic Anchoring

- Generally all wood is designed to be retained at structure location
- Wood is ‘wedged’ amongst riparian roughness elements providing the structural anchoring mechanisms
- Dynamic Anchoring can be with or without hardware
- Onsite logistics dictate feasibility

Feature #	00+10
Bankfull (ft)	21
Bankfull height (ft)	2
Length treated (ft)	10
Aq. habitat disturbed (ft)	5
Area w/in bankfull (sq. ft)	50
Existing habitat (depth)	Pool (1') very low shelter
Existing substrate	Gravel, small cobble
Goal of feature	Scour, shelter

# of logs	2
Size of logs	1- 22"< x 33'
	2- 22"< x 33'
# of bolts	2
Wood source	Offsite
Notes	Add SWD





Small Woody Debris (SWD)

- SWD is may be manually added where appropriate
- Direct falling indirectly contributes SWD
- Stobbing of limbs
- High quality material that can be activated during winter flows. May be staggered up bank/channel
- Green SWD removed from wetted channel
- SWD not always desirable

Design appropriate to bankfull width

Some Design Concerns

- Locations without appropriate upslope anchors and lack of suitable onsite material
- Large deep pools with little cover

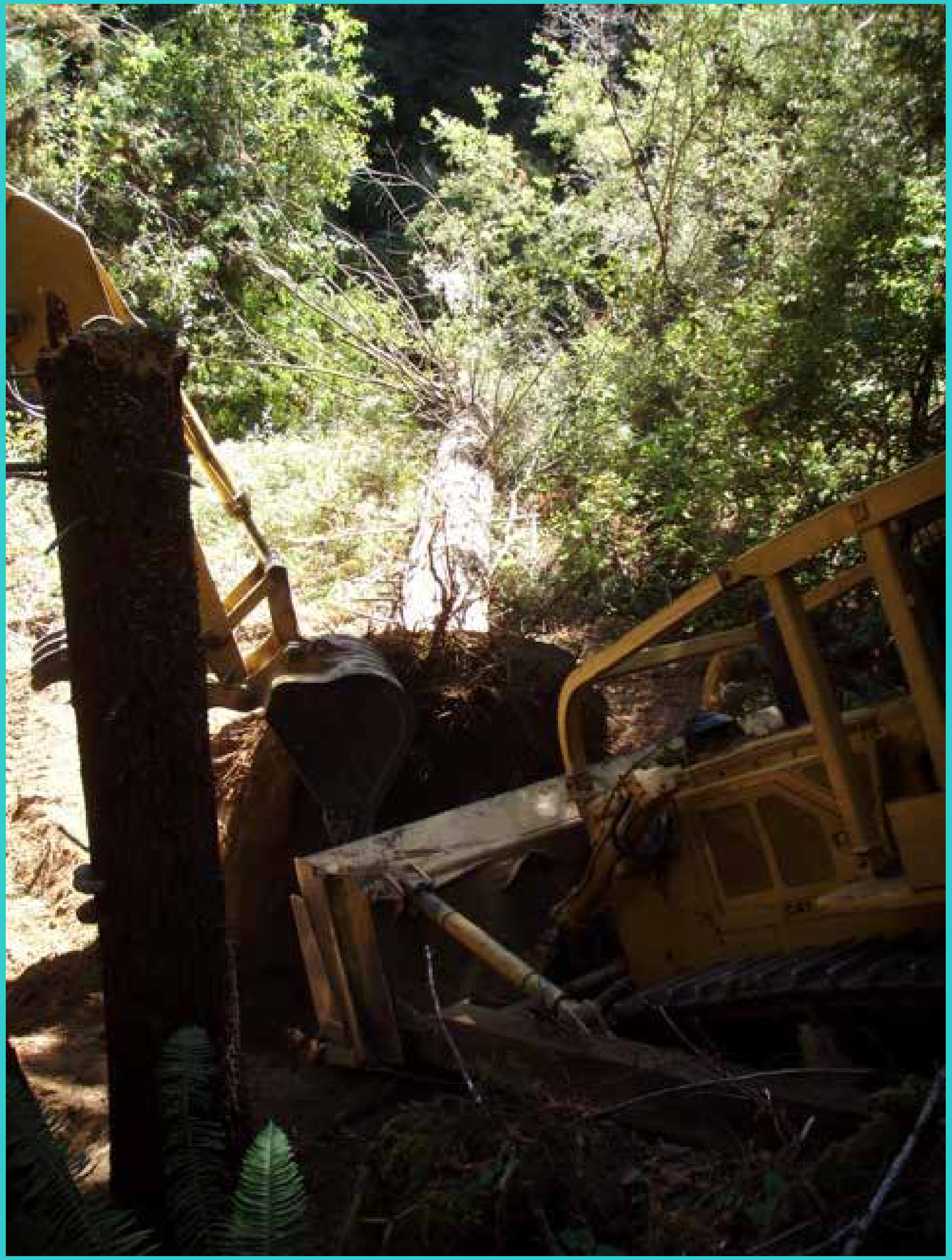
  -Real concern for slowing velocities and contributing to aggradation

  -Promote overhead cover and less LWD surface area into thalweg

  -Difficult to design for ie. less aggressive, passive/deflective structure

Whole Tree Tipping

- 2016 SF Ten Mile
- 7 structures
- 320 Excavator w/D-8
- RW trees need to be singles, not from clumps
- ‘Really Big Wood Project’



Costs of Anchored vs. Unanchored LWD

Cost Comparison of Engineered vs. Unanchored on SF Ten Mile River

Anchored Project on SF Ten Mile River (2005) (FRGP, CTM):

- 3-mile reach treated
- 40 logs
- 11 sites
- Total cost: $41,000
- $1000 per log
- 13 logs/mi

Accelerated Recruitment Project on SF Ten Mile River (2007-2008) (FRGP, CTM):

- 9.4-mile reach treated
- 309 logs
- 133 sites
- Total cost: $73,000
- $236 per log
- 32 logs/mi

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Low-Cost Restoration Techniques for Rapidly Increasing Wood Cover in Coastal Coho Salmon Streams

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ARTICLE

Low-Cost Restoration Techniques for Rapidly Increasing Wood Cover in Coastal Coho Salmon Streams

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Abstract

Like many rivers and streams in forests of the Pacific Northwest, California north coast rivers and streams have been depleted of downed wood through timber harvest and direct wood removal. Due to the important role of wood in creating and maintaining salmonid habitat, wood augmentation has become a common element of stream restoration. Restoration efforts in North America often focus on building anchored, engineered wood structures at the site scale; however, these projects can fail to meet restoration goals at the watershed scale, do not closely mimic natural wood loading processes or dynamics, and can be expensive to implement. For critically imperiled populations of Coho Salmon *Oncorhynchus kisutch* in California, there is a strong impetus to achieve as much habitat restoration as possible in priority watersheds in the shortest time and with limited resources, so cost-efficient techniques are necessary. In this multi-site project, we investigated unanchored techniques for wood loading to evaluate cost and contribution to salmonid habitat in Mendocino County, California. Over a period of 6 years, 72.4 km of stream were treated with 1,973 pieces of strategically placed wood. We found that unanchored wood loading techniques were much less costly than commonly used anchored techniques, reliably improved habitat, and retained wood at high rates (mean = 92%) in small- to moderate-sized streams, at least over the short term (<6 years). The average cost of design and construction for the unanchored projects was US$259 per log, equivalent to 22% of the cost associated with the anchored wood augmentation methods examined here. Our results suggest that this unanchored wood loading approach has the potential to increase the pace and scale at which wood augmentation projects are implemented in the Pacific Northwest and beyond.

Downed wood plays an essential role in stream morphology and productivity, particularly in salmon-bearing streams of the Pacific Northwest (House and Boehne 1986; Bisson et al. 1987; National Research Council 1996; Abbe et al. 2003a) and northern California (Keller et al. 1981; Lisle 1986; Lassettre and Harris 2001). Wood influences instream erosion and deposition processes by locally altering water velocities and shear stress (Lisle 1986; Abbe and Montgomery 1996). These processes trap sediments, increase bar and other depositional features, provide gravels necessary for salmon spawning, and increase floodplain development and connectivity (Lisle 1986; Bisson et al. 1987; Fetherston et al. 1995). Wood can increase scour in other areas, creating slow-water habitats like pools, backwaters, and side channels, thus providing both oversummer and overwinter

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Performance Metrics

- Pre- and post-treatment surveys

  -CDFW Stream Habitat Typing Level II w/LWD survey

  -Longitudinal profile
- Tagging/GPS project wood
- Photo points

Survey results by CDFW's Coastal Restoration Monitoring and Evaluation Program on SF Ten Mile, July 2012

- 82% of original pieces of tagged LWD pieces were located.
- 93% tagged LWD are currently considered to be positively functioning.
- 92% sites had minimal movement and/or maintained their original position.
- A significant increase (393%) in large (L>20ft) LWD.
- No significant percent change in maximum pool depth and residual pool depth was seen between 2007 and 2012.

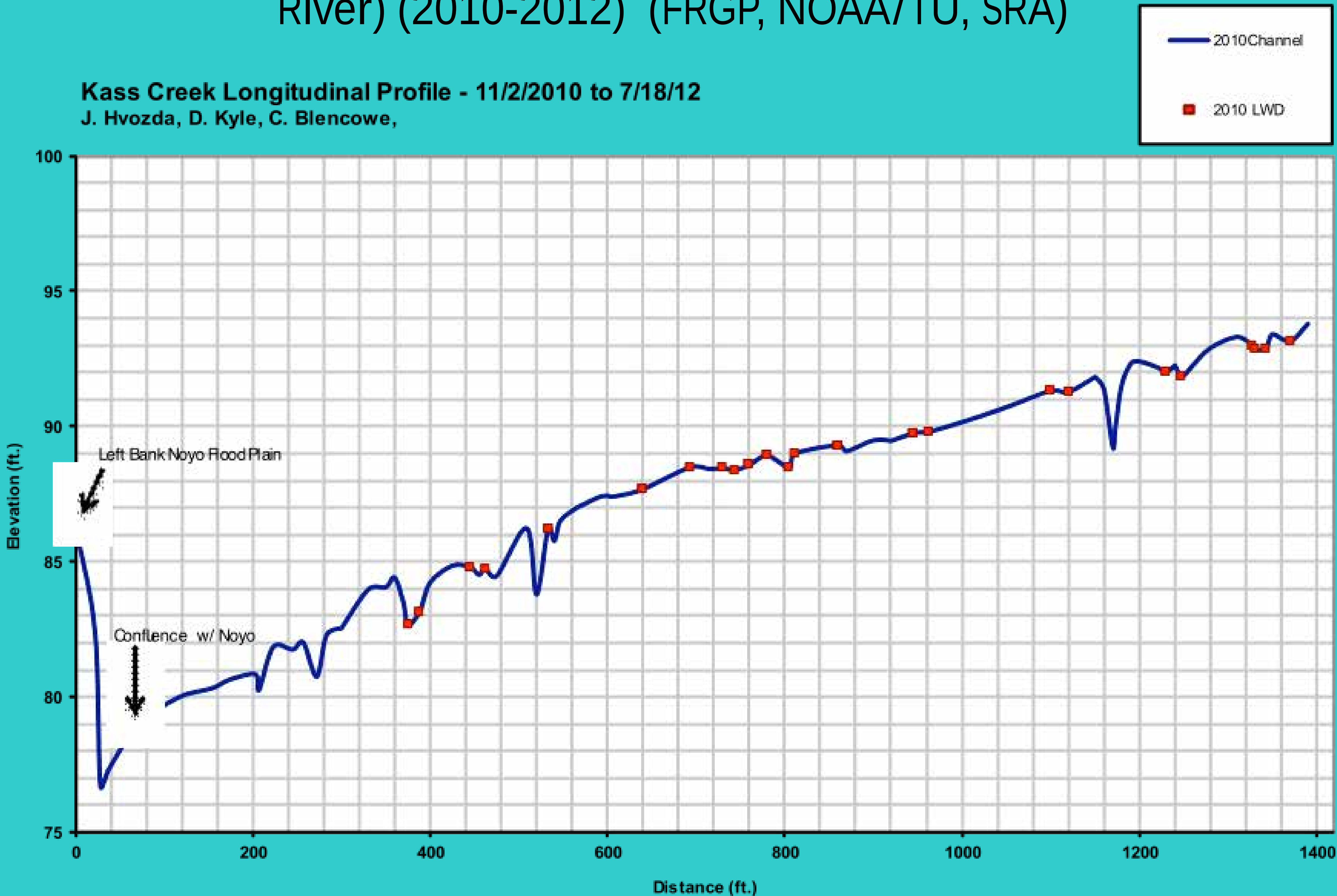
This was a survey of a lower 3.5-mile reach of the 2007 project area by Trevor Lucas et al (2012)

Summary of Percent Change in Key Habitat Variables in Six Mendocino County Streams

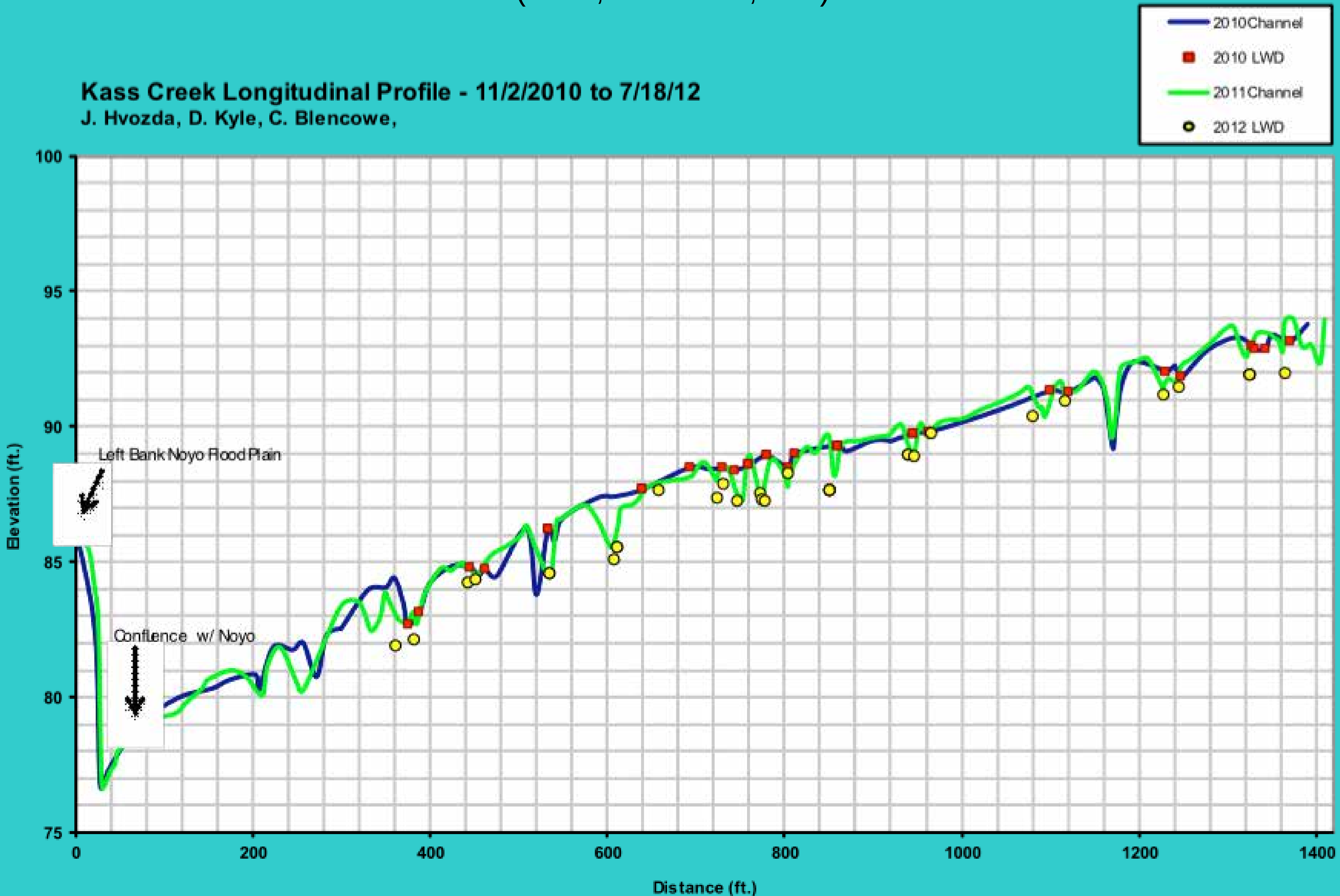
Percent Change in Several Key Variables in Six Mendocino County Streams After Project Implementatio)

	% Pools by Total Length	Total LWD (6'-19')	Total LWD (≥20')	Residual Pool Depths	# of Pools 3.0' - 3.9'	# of Pools ≥ 4.0'	Pool Shelter Rating	% shelter is LW	% shelter is SW
Signal Creek	38.0%	46.0%	113.0%	-4.0%	11.0%	33.0%	5.0%	81.0%	47.0%
SF Big River (Wegner Reach)	25.0%	22.0%	9800.0%	-11.0%	-30.0%	-33.0%	60.0%	1300.0%	2100.0%
LNF Big River	6.0%	10.0%	97.0%	4.0%	14.0%	50.0%	37.0%	12.0%	18.0%
Kass Creek (lower 1400 ft)	24.0%	13.0%	62.0%	0.0%	-100.0%	0.0%	24.0%	49.0%	24.0%
Lower Inman Creek	24.0%	123.0%	327.0%	3.0%	0.0%	100.0%	86.0%	277.0%	587.0%
NF Garcia	10.0%	-7.0%	152.0%	-9.0%	233.0%	0.0%	36.0%	78.0%	76.0%
Mean	21.2%	34.5%	1758.5%	-2.8%	21.3%	25.0%	41.3%	299.5%	475.3%
SD	11.6%	46.7%	3940.6%	6.2%	112.0%	46.8%	28.3%	498.7%	825.6%

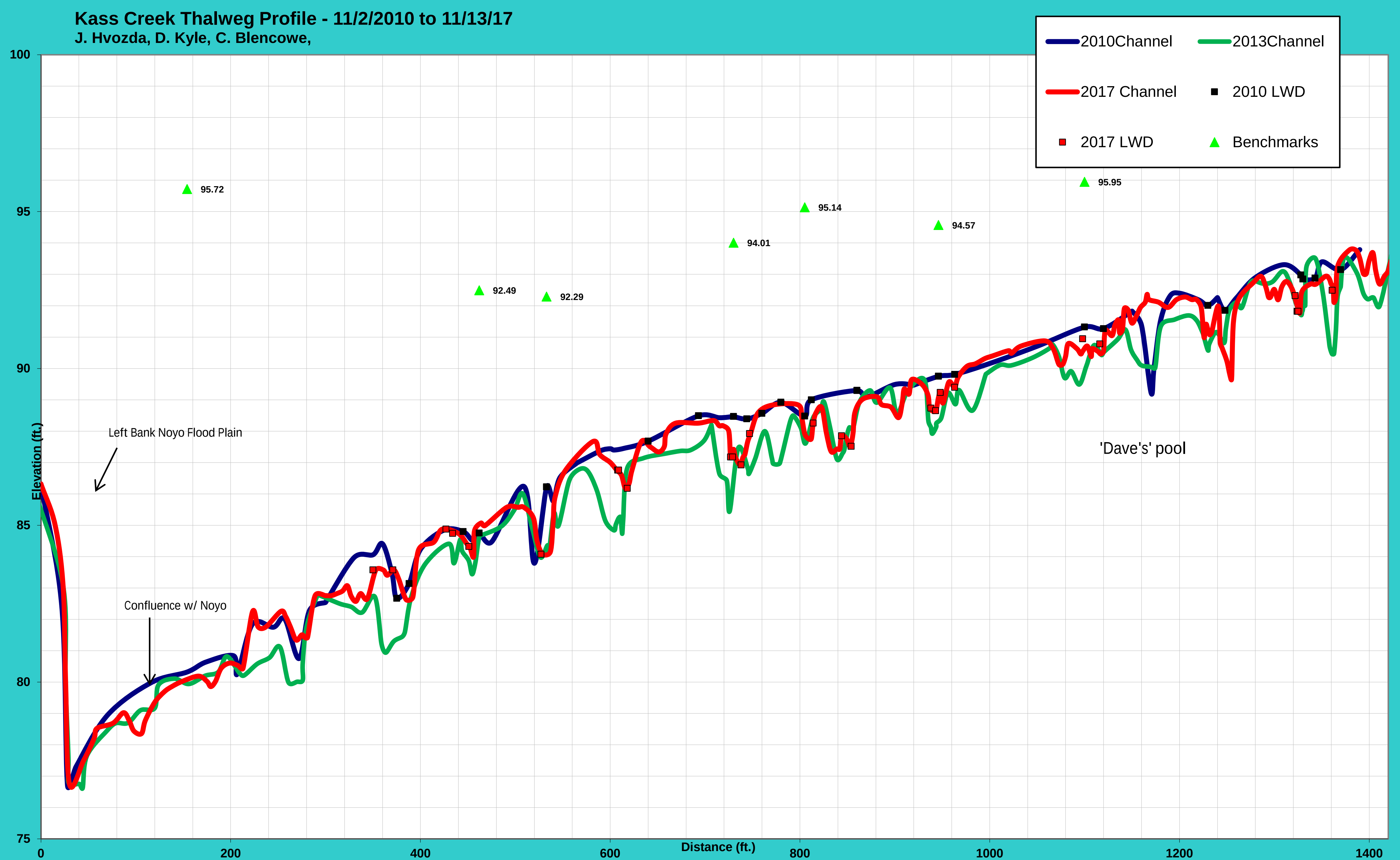
Longitudinal Profile of Lower 1400' Project Reach in Kass Creek (Noyo River) (2010-2012) (FRGP, NOAA/TU, SRA)



Longitudinal Profile of Lower 1400' Project Reach in Kass Creek (Noyo River) (2010-2012) (FRGP, NOAA/TU, SRA)



Longitudinal Profile of Lower 1400' Project Reach in Kass Creek (Noyo River)
2010 and 2013 and 2017
(FRGP, NOAA/TU, SRA)



Limitations/Applicability

- Direct falling best in 20’-30’ bankfull
- Low gradient alluvial streams
- Willing, supportive landowners
- Unique design considerations in entrenched, flashy high volume channels
- Bankfull widths up to +/-50 feet

Limitations/Applicability

- Landowners with large holdings, lots of trees and little risk to infrastructure
- The 18 largest landowners own 81% of the properties in Mendocino County's CCC ESU Coho Core Areas

Lessons Learned

- Successfully falling trees into channel zone is much more difficult then expected
- Need to design for highest flow events, including buoyancy factors and racking capabilities, “Throttle the channel”
- All LWD is not created equal, design important
- Onsite wood is often the best ie. length
- SWD/MWD often difference between good/great structure
- Realistic structure designs for local conditions
- Size wood/anchors appropriately
- Good operators is critical to success

Techniques through Experience

- 14 years placing wood
- 60+ number of unique projects
- 3100+ structures
- 6500+ pieces of LWD
- No professional training in engineering or similar.
- Re-imagining why/where we move big wood in the woods
- This is just one tool in the restoration tool box

Big Questions:

- How much wood is good?
- How much wood can we reasonably add to these watersheds without causing problems to the channels and without depleting the still young riparian corridor?
- Does wood actually make more fish? The biological component is missing.
- Retreatment?

The Pudding Creek Project: a BACI Study

- A partnership between Lyme Timber, CDFW, TNC, TU
- Six years of baseline data on coho life history metrics
- Approximately 80% of the fish bearing habitat will be treated using accelerated recruitment
- Caspar Creek, a similar watershed with a similar monitoring history, will be the control stream
- Changes in biological (e.g., spawner to smolt) and physical indices will be closely monitored for six years after treatment