

Posts, PALS, and Pitfalls: Hard-Won Lessons in Low-Tech Restoration



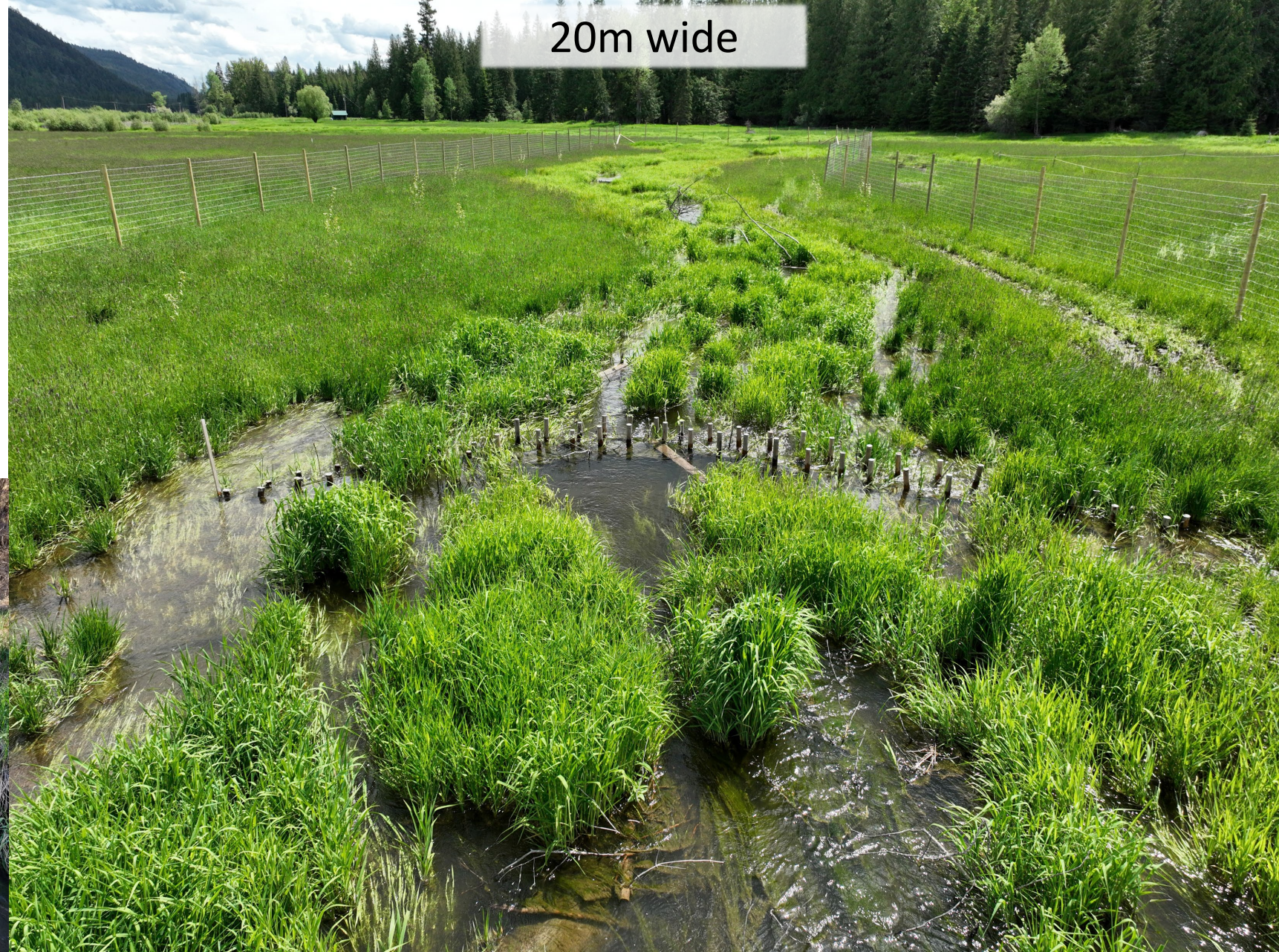
Grassroots movement to empower locals

LTPBR Explorer – Project Locations



pbr.riverscapes.net/projects

Scalable restoration with promising results



Scalable restoration with promising results



Structure benefits



Reach benefits

Sounds like a dream... what is the problem?

- When applied inconsistently, it leads to uneven support

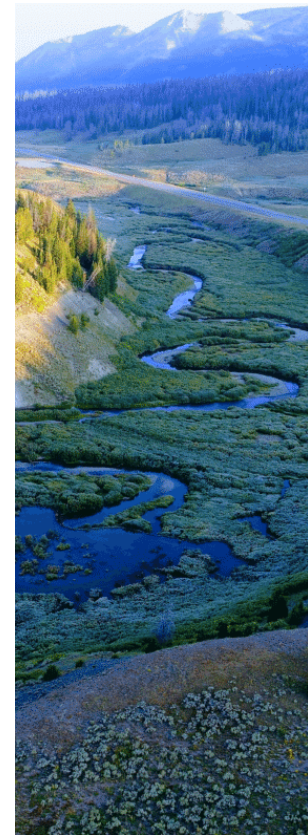
LOW-TECH PROCESS-BASED RESTORATION PRINCIPLES FOR STRUCTURALLY-STARVED RIVERSCAPES

Riverscapes Principles

1. Streams need space
2. Structure forces complexity and builds resilience
3. The importance of structure varies
4. Inefficient conveyance of water is healthy

Restoration Principles

5. It's okay to be messy
6. There is strength in numbers
7. Use natural building materials
8. Let the system do the work
9. Defer decision making to the system
10. Self-sustaining systems are the solution



LOW-TECH PROCESS-BASED RESTORATION *OF* RIVERSCAPES DESIGN MANUAL



Edited by: Joseph M. Wheaton, Stephen N. Bennett, Nicolaas Bouwes, Jeremy D. Maestas & Scott M. Shahverdian

LTPBR embraces uncertainty

- When applied inconsistently, it leads to uneven support

LOW-TECH
PRINCIPLES
RIVERSCAPES

Uncertainty is at the heart of LTPBR

Riverscape

1. Streams
2. Structure
3. The importance of structure varies
4. Inefficient conveyance of water is healthy

Restoration Principles

5. It's okay to be messy
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LOW-TECH
PROCESS-BASED
RESTORATION
OF
RIVERSCAPES
DESIGN MANUAL



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Funders, regulators, legislators, public, etc. all desire certainty

Typical Design Expectations

Basis of design report

- Design drawings
- Goals and objectives
- Site characterization
- Alternatives assessment
- Design considerations
- Permitter consultation
- Technical specifications
- Adaptive management plan
- Construction quantities
- Cost estimate

Balancing certainty with LTPBR principles

- Take advantage of available resources

LOW-TECH PROCESS-BASED RESTORATION RECOMMENDED DESIGN PACKAGE

Project-Scale Map(s)
(Drainage Network) ✓

Shows complex locations on drainage network.

Complex-Scale Map(s)
(One for each complex) ✓

Shows structure locations within each complex, complexes zone of influence, structure types, & valley bottom extents.

Complex Design Tables
(Clear Complex Objectives & Hypotheses) ✓

Location	Structure	Complex	Objective	Structure Type	Structure Size	Structure Cost	Structure Description
Complex 1	Structure 1	Complex 1	Objective 1	Structure Type 1	Structure Size 1	Structure Cost 1	Structure Description 1
Complex 1	Structure 2	Complex 1	Objective 2	Structure Type 2	Structure Size 2	Structure Cost 2	Structure Description 2
Complex 2	Structure 3	Complex 2	Objective 3	Structure Type 3	Structure Size 3	Structure Cost 3	Structure Description 3
Complex 2	Structure 4	Complex 2	Objective 4	Structure Type 4	Structure Size 4	Structure Cost 4	Structure Description 4
Complex 3	Structure 5	Complex 3	Objective 5	Structure Type 5	Structure Size 5	Structure Cost 5	Structure Description 5
Complex 3	Structure 6	Complex 3	Objective 6	Structure Type 6	Structure Size 6	Structure Cost 6	Structure Description 6

Note, structure design tables are possible but not always necessary as during construction not all structures are built exactly as designed, and flexibility is key (e.g. 12-15 structures specified).

Restoring Western Headwater Streams with Low-Tech Process-Based Methods: A Review of the Science and Case Study Results, Challenges, and Opportunities
Version 1.0, November 2022

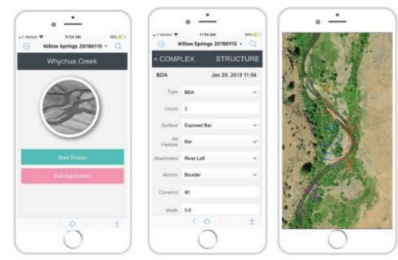


Shows complex locations on drainage network.

Shows structure locations within each complex, complexes zone of influence, structure types, & valley bottom extents.



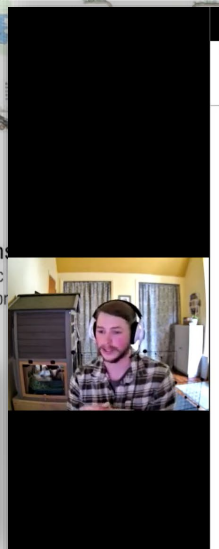
OPTIONAL Field Apps
(Database-driven field design & monitoring Apps can capture above information, quickly & efficiently. But paper forms can work too)



NOT NECESSARY Engineering Con...
(No need for expensive topographic or topographic cross-sections, or Grading Plans on Topo)



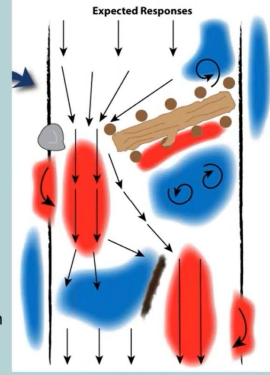
NOTE: Repeat topographic surveys and hydraulic models can be useful monitoring tools.



Preparation – Design

- How to design a low-tech project?
- General steps...
 1. Determine area of impact
 2. Identify structure objectives
 3. Record structure characteristics
 4. Map structure locations

- Purpose of a structure
- Stabilize bank
 - Protect plantings
 - Divert flows
 - Scour pool
 - Overbank flow
 - Trap & sort sediment
 - Widen channel
 - Aggrade streambed
 - Hydraulic complexity
 - Refugia



How will a structure contribute to the reach-level goals?





Was the project constructed as designed and built well?

Construct

Was the project designed with purpose and intent?

Design



Was an adaptive management plan developed and applied?

Steward

Was working at the site and LTPBR technique justified?

Planning



Planning

Lesson: Understand fluvial processes

$$F_c = \frac{mv^2}{r}$$

$$d_s = d_m \left(\frac{V_m}{V_c} - 1 \right)$$

$$\theta = \omega \sin kx$$

$$\tau = k_t Q^{1/3} S^{2/3}$$

$$\theta_r = \frac{\tau_r}{(\rho_s - \rho_w)gd}$$

$$\frac{\partial C}{\partial t} = \omega - \nabla Q_s - k_d \nabla^2 h$$

$$\frac{\partial R}{\partial t} = U - \omega - E$$

$$\tau_{ce} = \alpha \rho_d^b$$

$$W = k_c \sqrt{Q}$$

$$QS \sim Q_s D_{50}$$

$$Q_s = k_s W (\tau - \tau_c) (\sqrt{\tau} - \sqrt{\tau_c})$$

$$V = \left(\frac{K}{n} \right) R^{2/3} \sqrt{S}$$



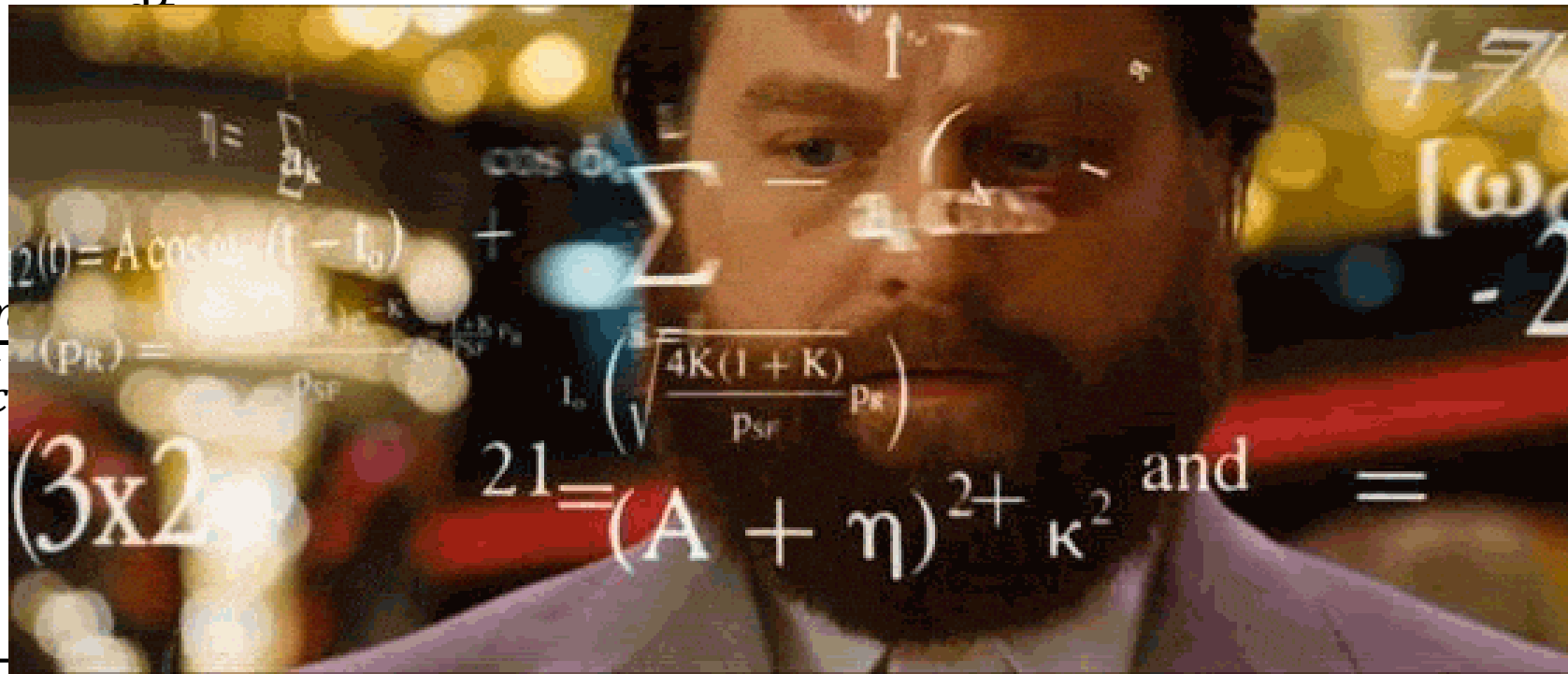
Planning

Lesson: Understand fluvial processes

$$\frac{\partial R}{\partial t} = U - \omega - E$$

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$$W = k_c \sqrt{Q}$$



$$d_s = d_m \left(\frac{V_m}{V_c} \right)$$

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$$\sqrt{\tau} - \sqrt{\tau_c}$$

Lesson: Understand fluvial processes

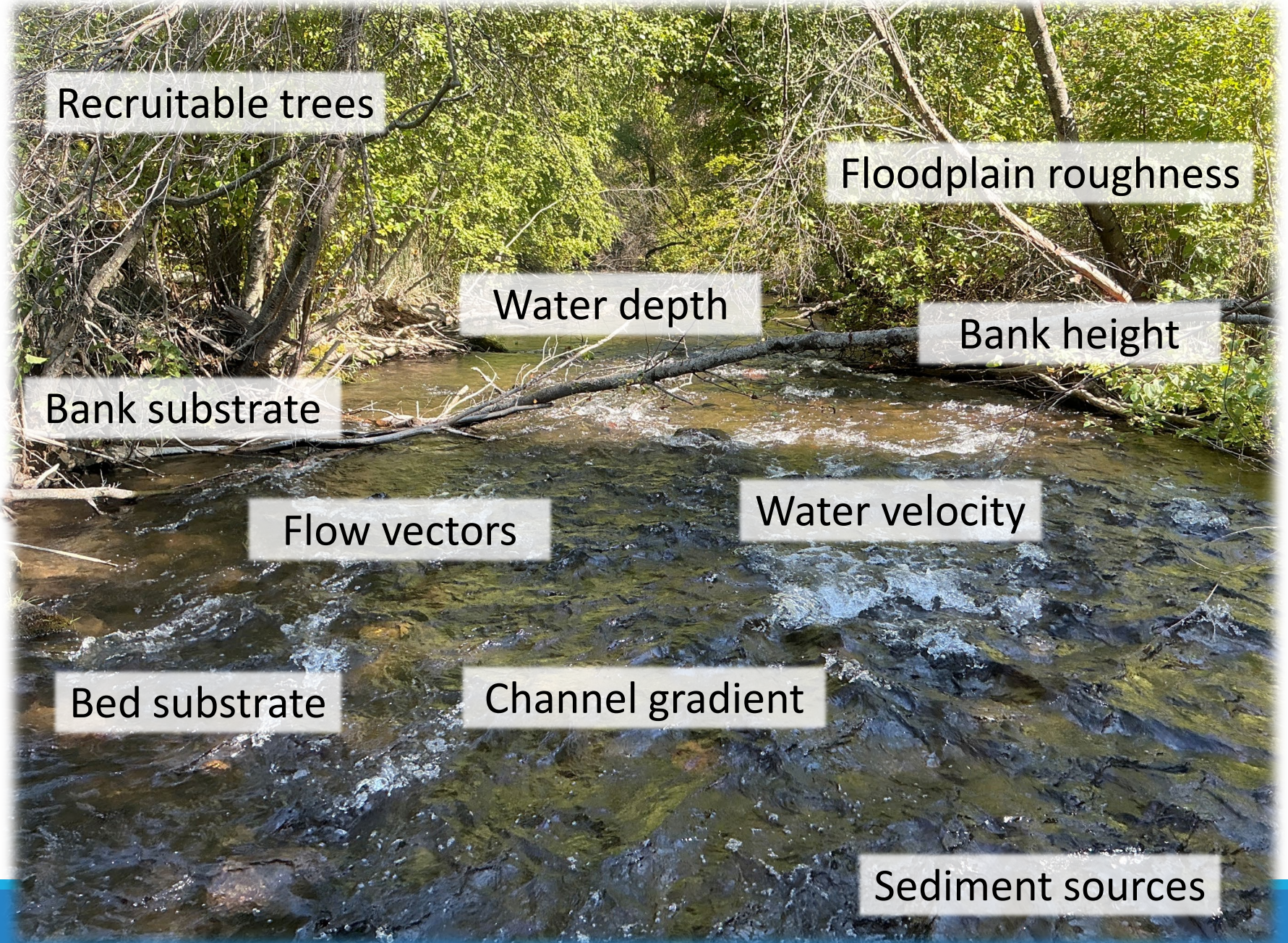
Planning





Planning

Lesson: Understand fluvial processes



Recruitable trees

Floodplain roughness

Water depth

Bank height

Bank substrate

Flow vectors

Water velocity

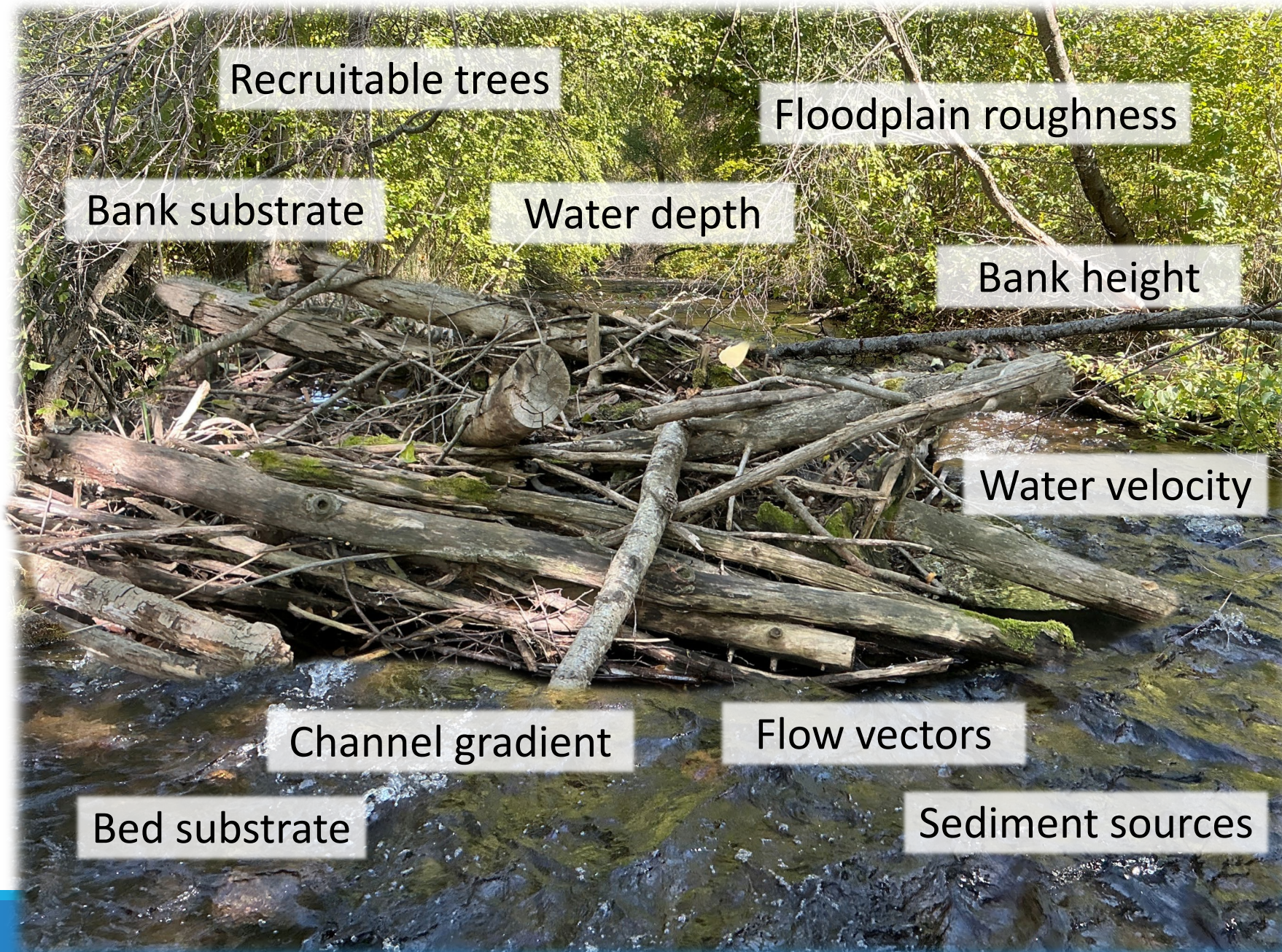
Bed substrate

Channel gradient

Sediment sources

Lesson: Understand fluvial processes

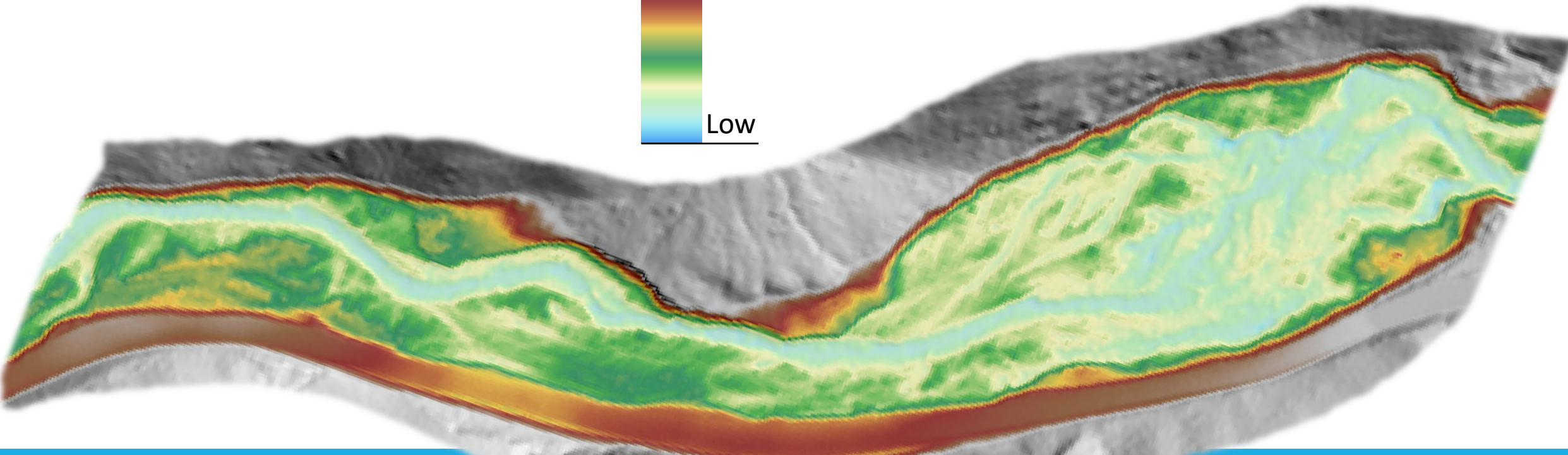
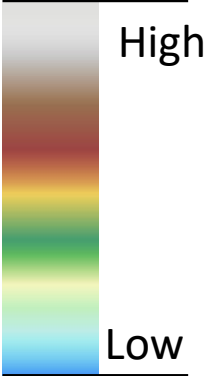
Planning



Lesson: Site selection is important



Relative
Elevation



Flow →

<< 600m >>

Lesson: Site selection is important

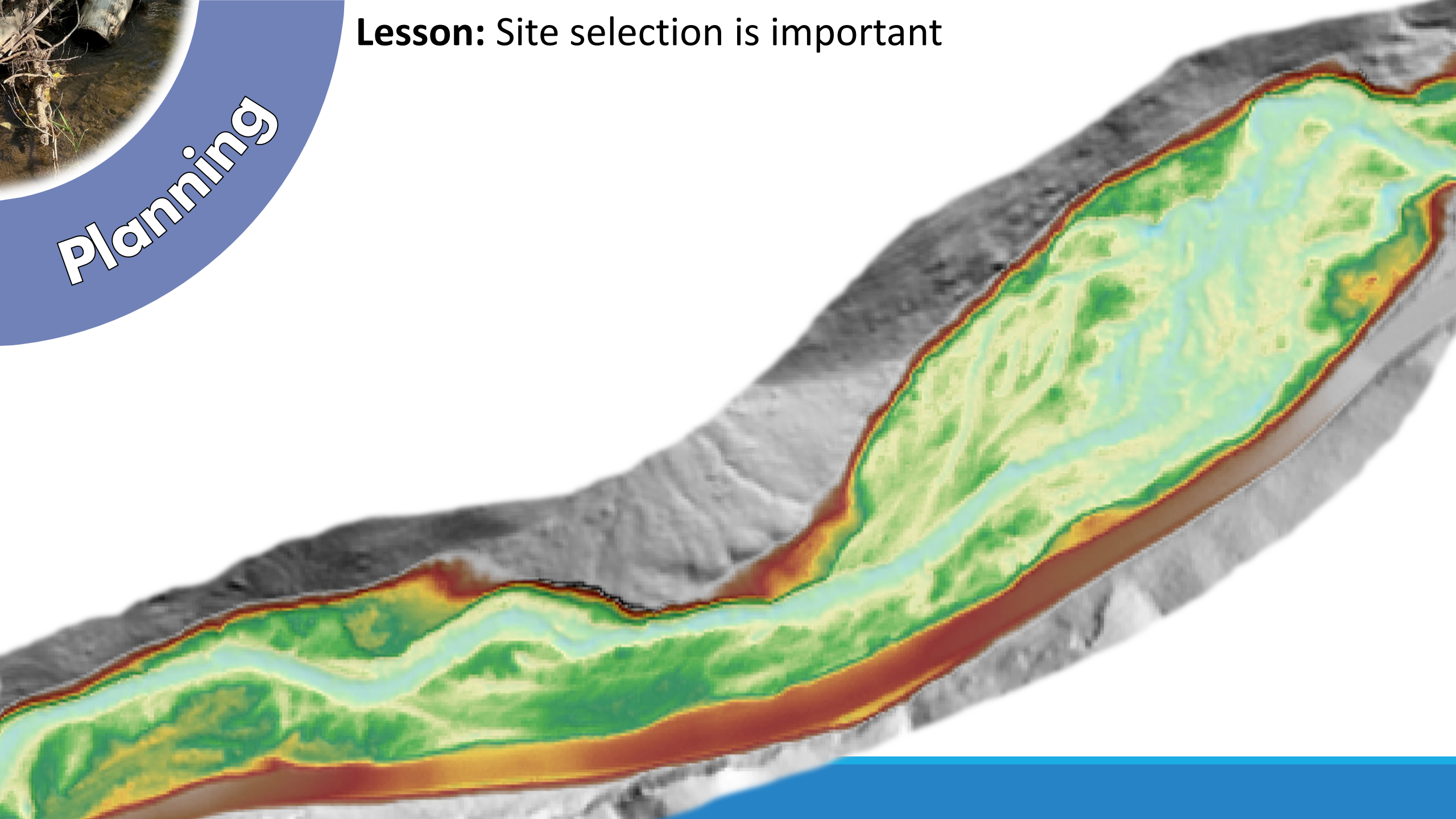
Planning





Planning

Lesson: Site selection is important



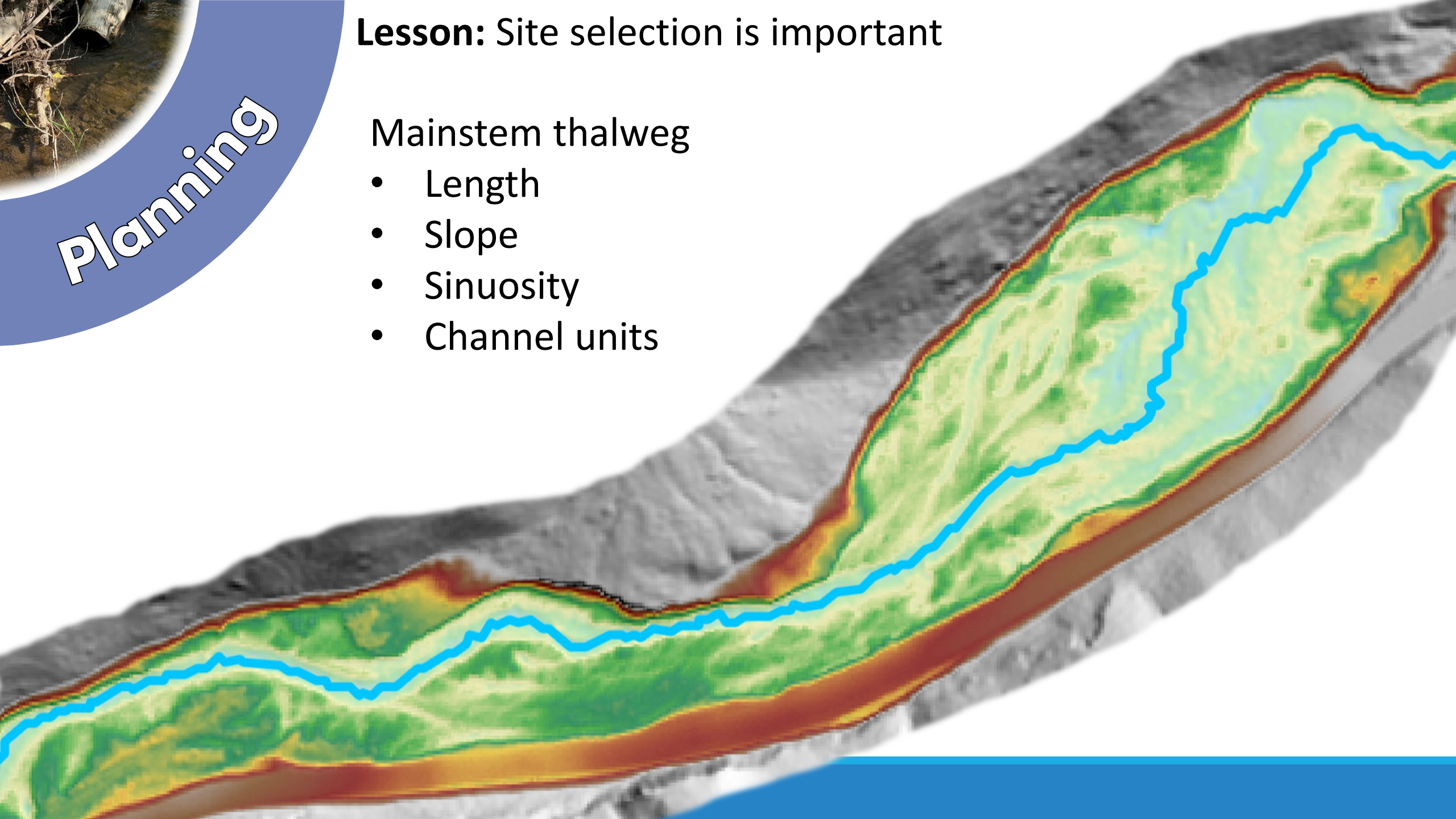


Planning

Lesson: Site selection is important

Mainstem thalweg

- Length
- Slope
- Sinuosity
- Channel units



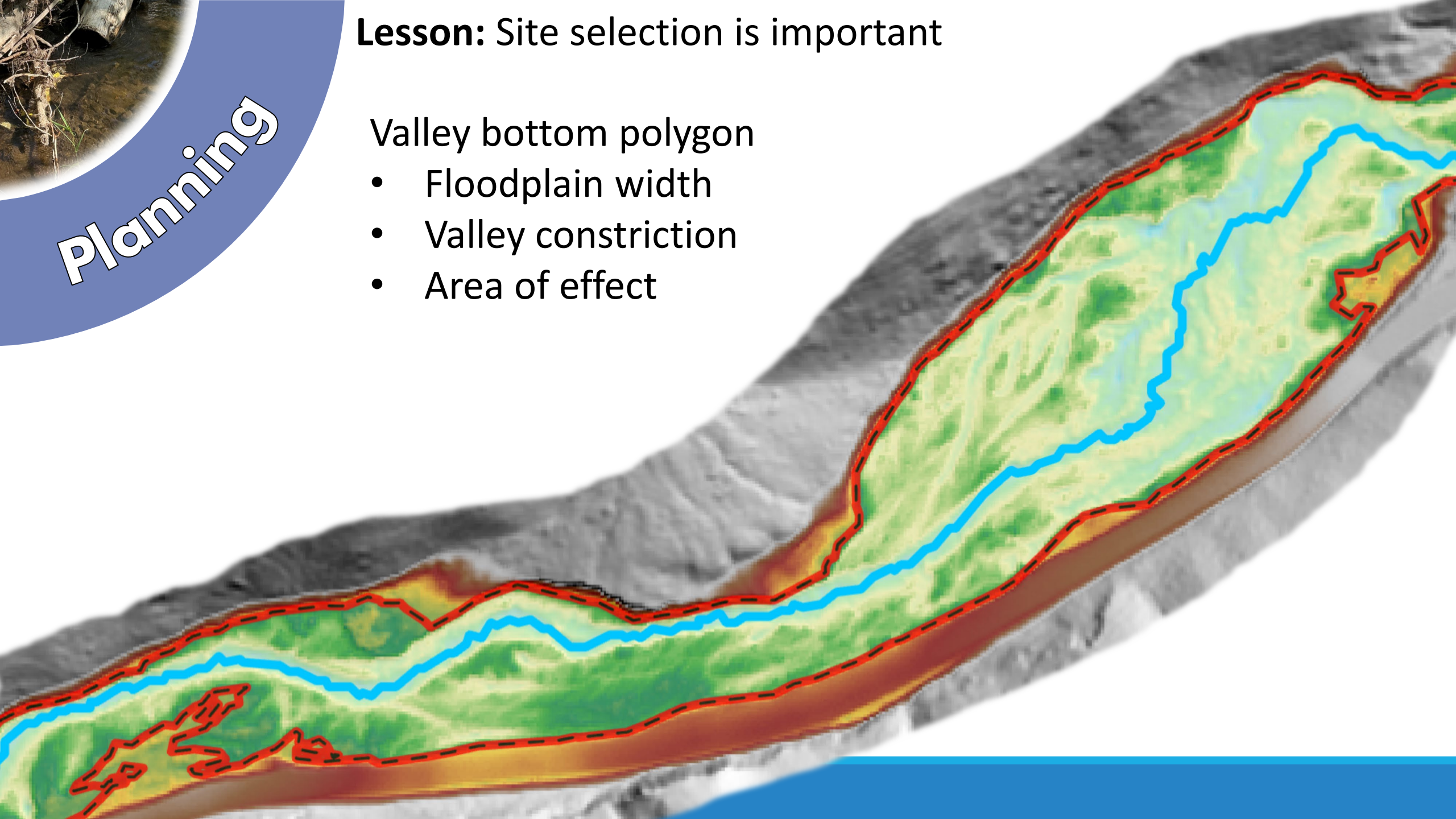


Planning

Lesson: Site selection is important

Valley bottom polygon

- Floodplain width
- Valley constriction
- Area of effect

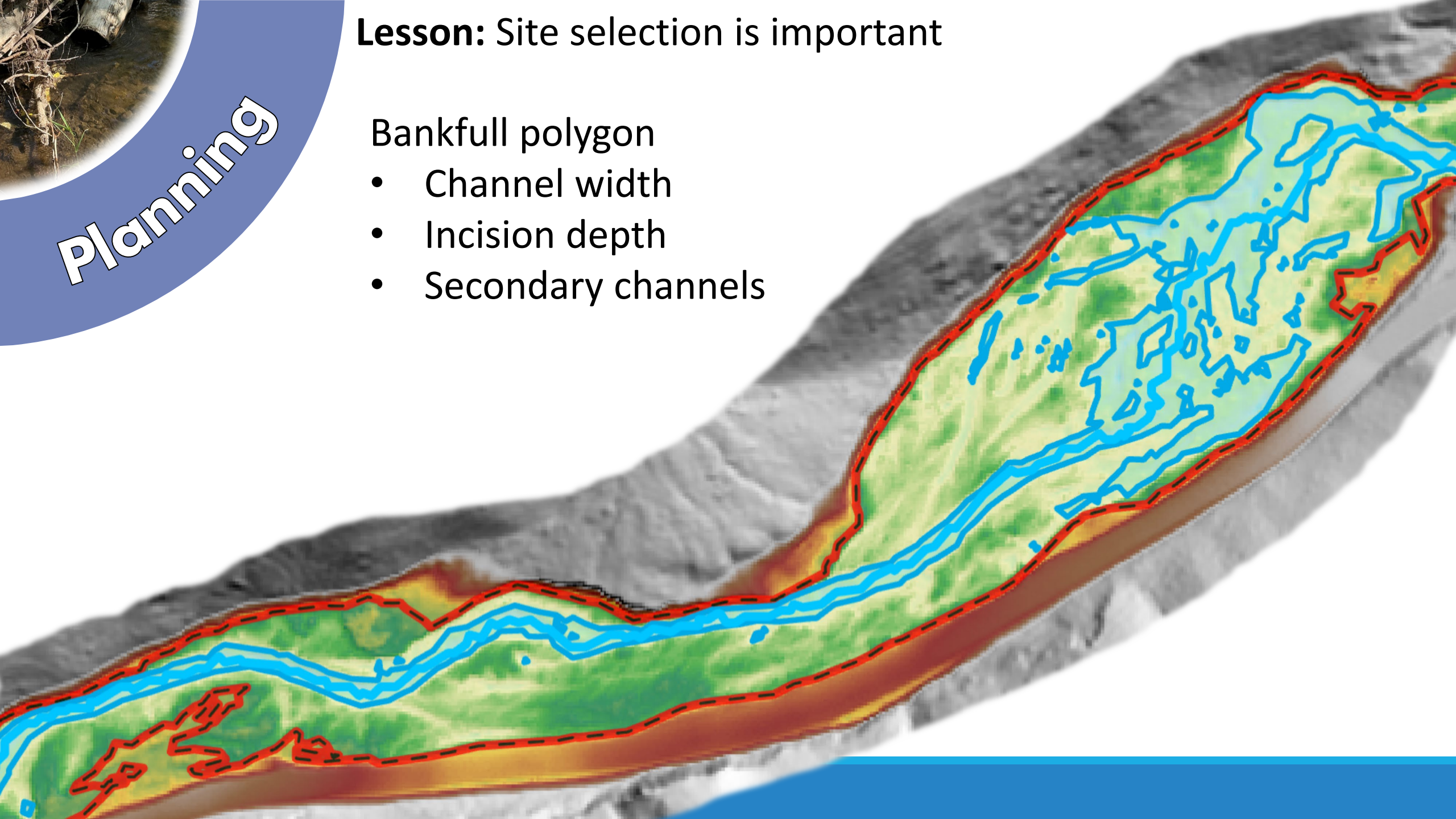




Planning

Lesson: Site selection is important

- Bankfull polygon
- Channel width
 - Incision depth
 - Secondary channels

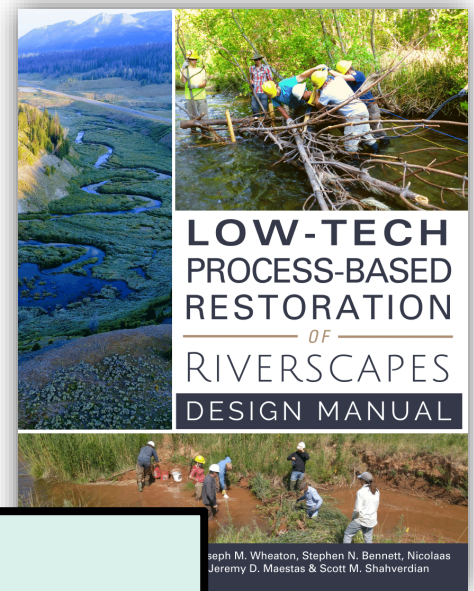




Lesson: Design report is necessary



- Typical Design Expectations**
Basis of design report
- Design drawings
 - Goals and objectives
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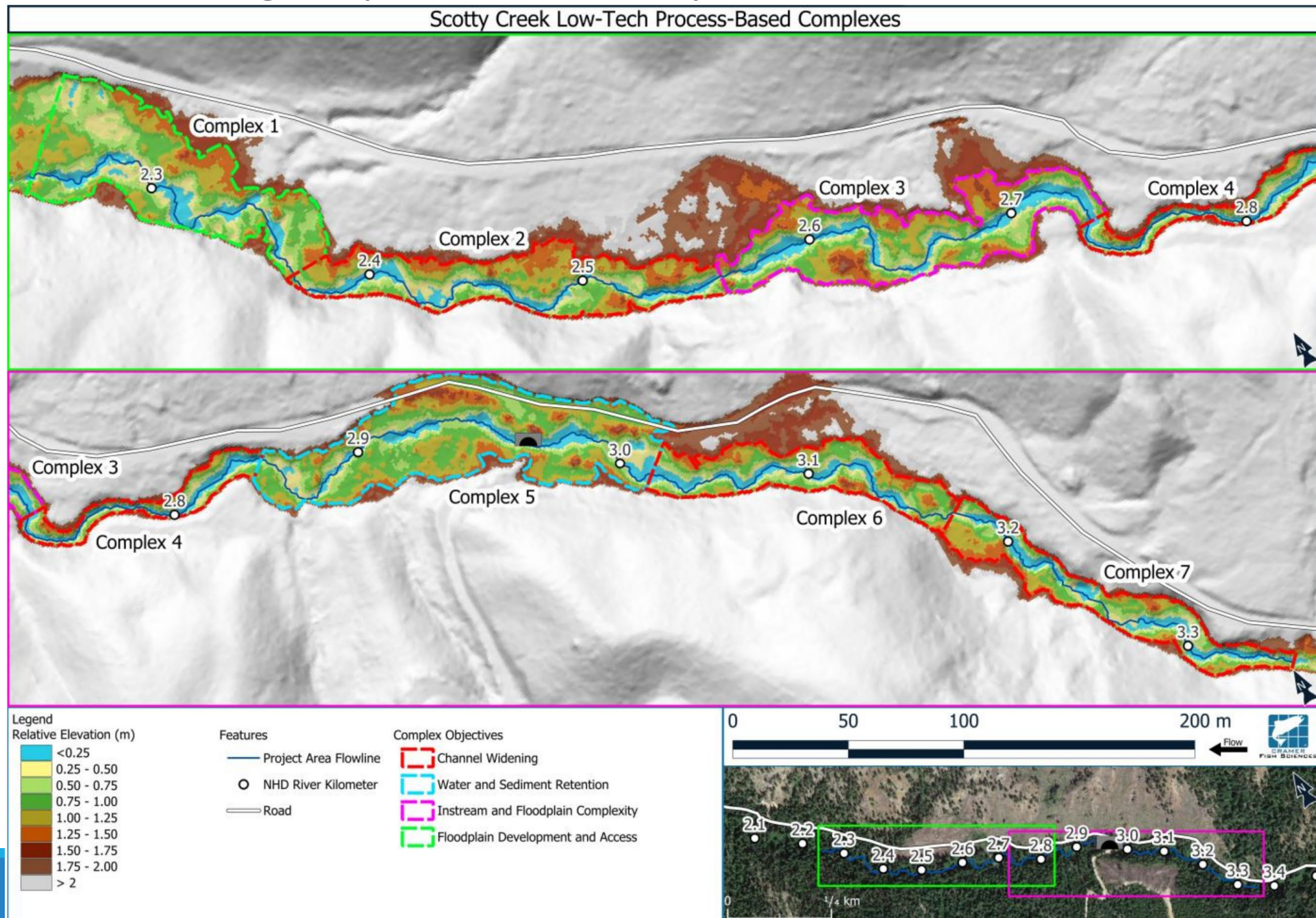


Design

Lesson: Design report is necessary

Complex-Level Design

How do the structures work together to meet reach-level objectives?



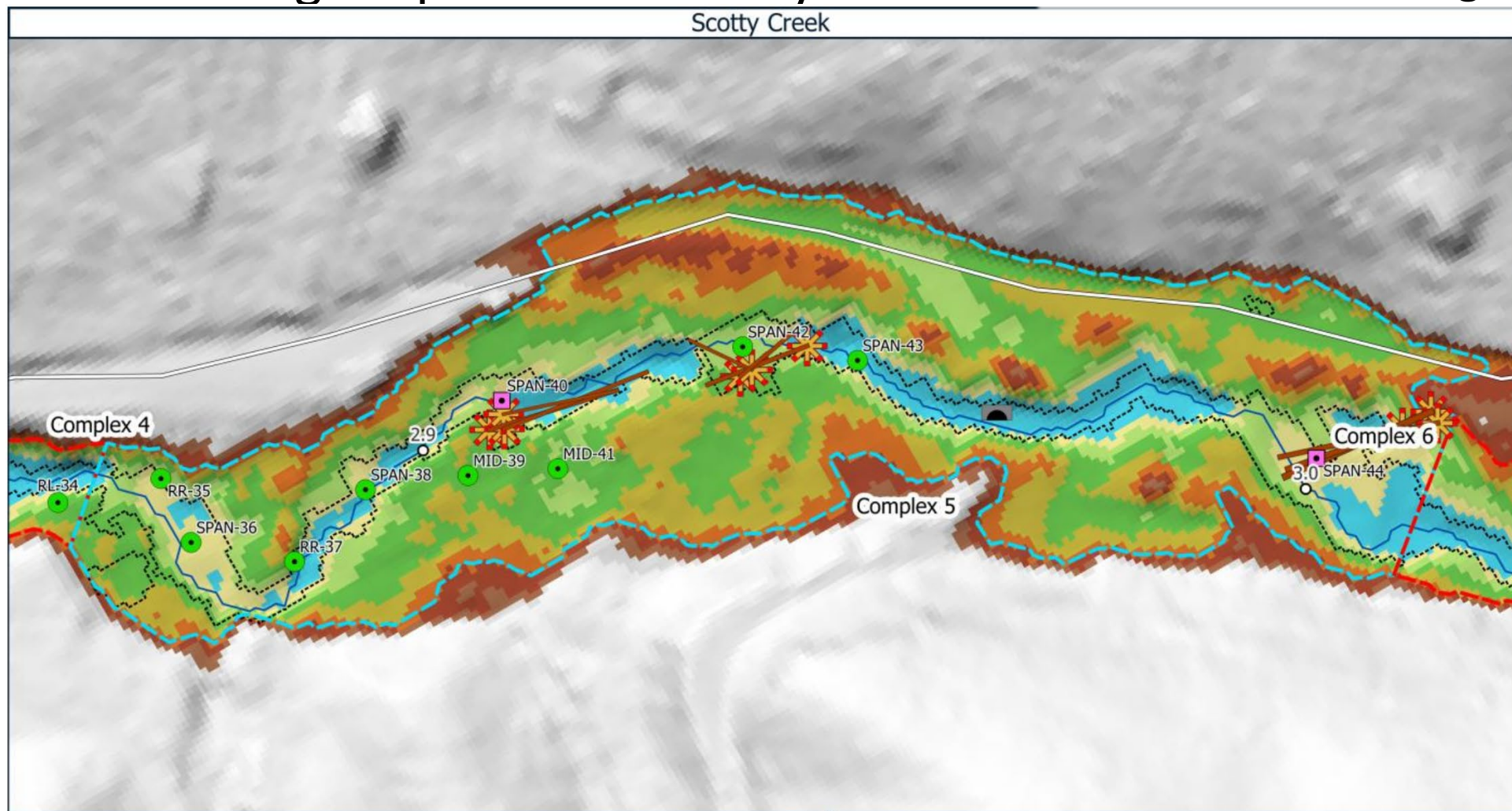


Design

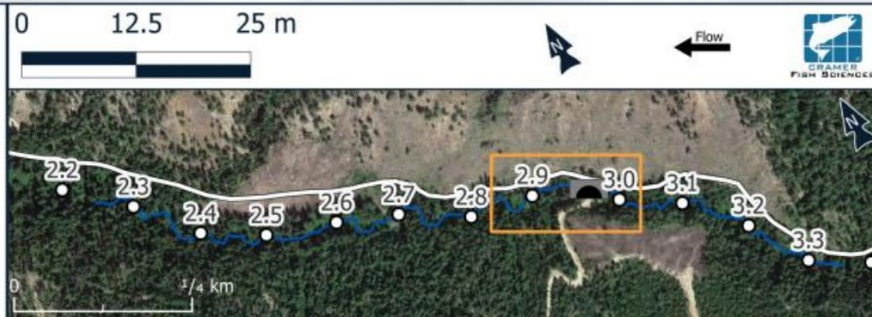
Lesson: Design report is necessary

Reach-Level Design

Where is each structure throughout the project area?



Legend Relative Elevation (m) Color scale: <0.25 (lightest), 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 1.75, 1.75 - 2.00, > 2 (darkest)	Features Project Area Flowline (blue line) NHD River Kilometer (circle with number) Road (grey line)	Structure Type BDA (pink square) PALS (green circle) Infrastructure (yellow triangle) Treatment Type PAS (purple hatched square) SLASH (red hatched square) Direct Fell (red starburst)
	Complex Objectives Channel Widening (red dashed box) Water and Sediment Retention (cyan dashed box) Instream and Floodplain Complexity (magenta dashed box) Floodplain Development and Access (green dashed box)	

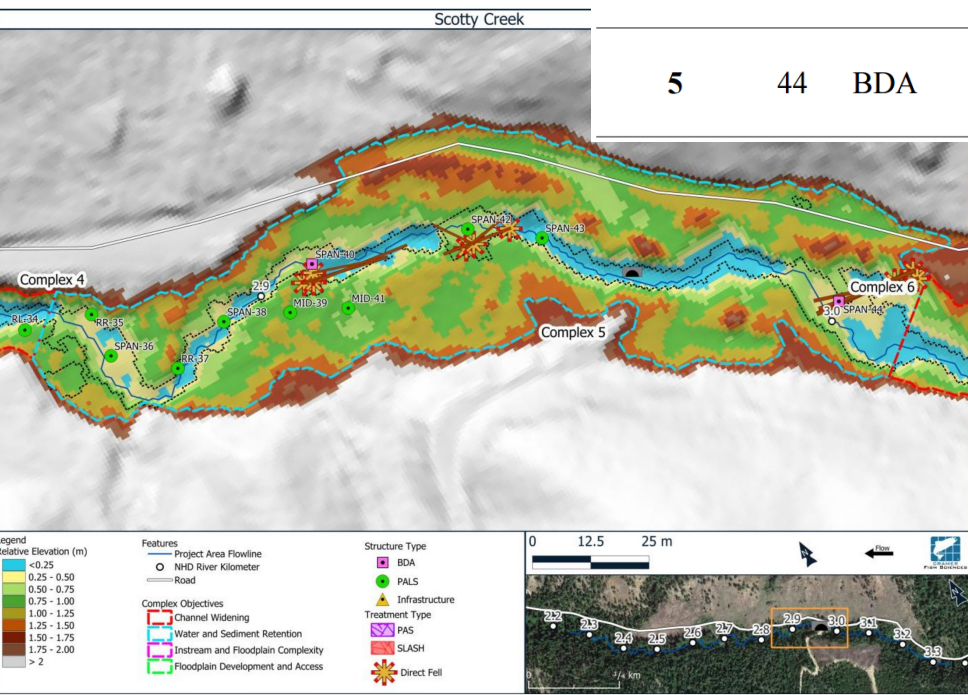




Lesson: Design report is necessary

Structure-Level Design

Complex	ID	Type	Description	# of Posts	Wood Count	Attachment	Objectives	x	y
5	38	PALS	pond water upstream; angle side ways to erode through floodplain on RR and RL	12	10	SPAN	Floodplain Connection, Sediment Storing, Pool Development	1609513.9	738894.1
5	39	PALS	add complexity into floodplain	5	5	MID	Create and Maintain Split Flows	1609557.5	738876.4
5	40	BDA	pond water upstream	28	0	SPAN	Pond Development, Sediment Storing, Floodplain Connection	1609587.9	738898.3
5	41	PALS	add complexity into floodplain	5	5	MID	Create and Maintain Split Flows	1609594.5	738858.6
5	42	PALS	direct flow onto RL and RR floodplain	15	15	SPAN	Floodplain Connection, Sediment Storing, Pool Development	1609695.1	738864.6
5	43	PALS	direct flow onto RL and RR floodplain; be cognizant of road prism	12	10	SPAN	Floodplain Connection, Sediment Storing, Pool Development	1609737.1	738833.3
5	44	BDA	pond water upstream and capture debris prior to culvert	35	0	SPAN	Pond Development, Sediment Storing, Floodplain Connection	1609895.7	738690.2

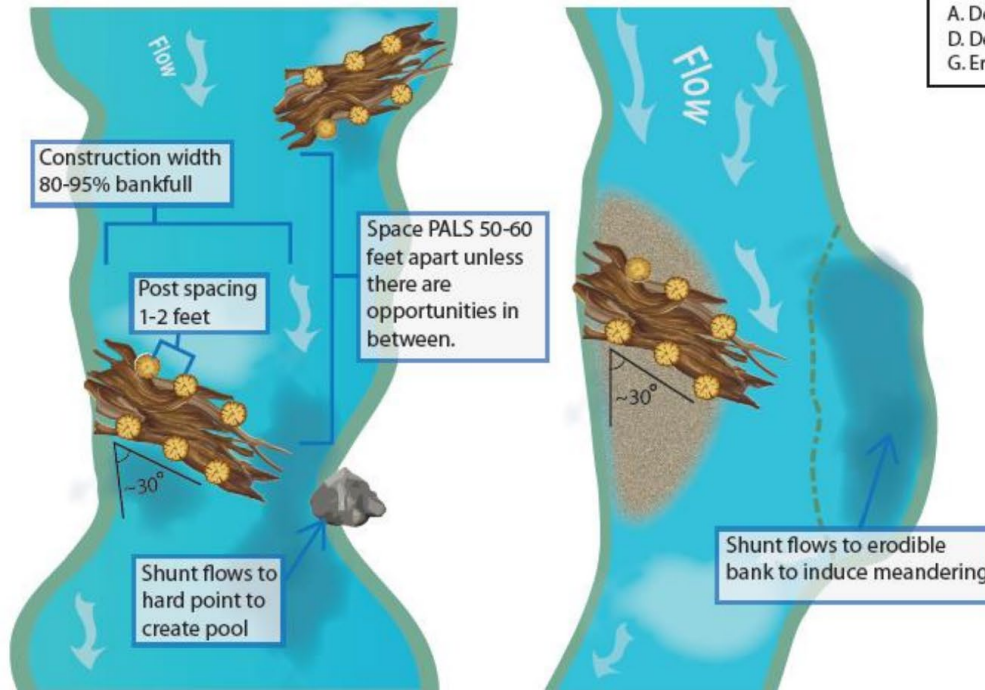




Lesson: Design report is necessary

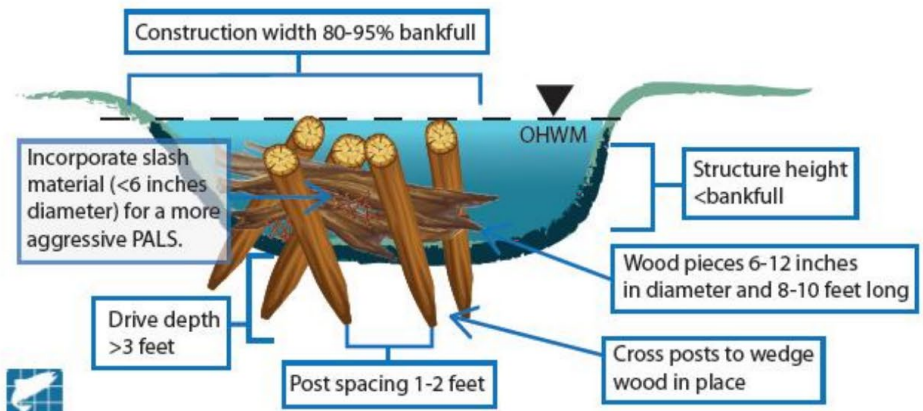
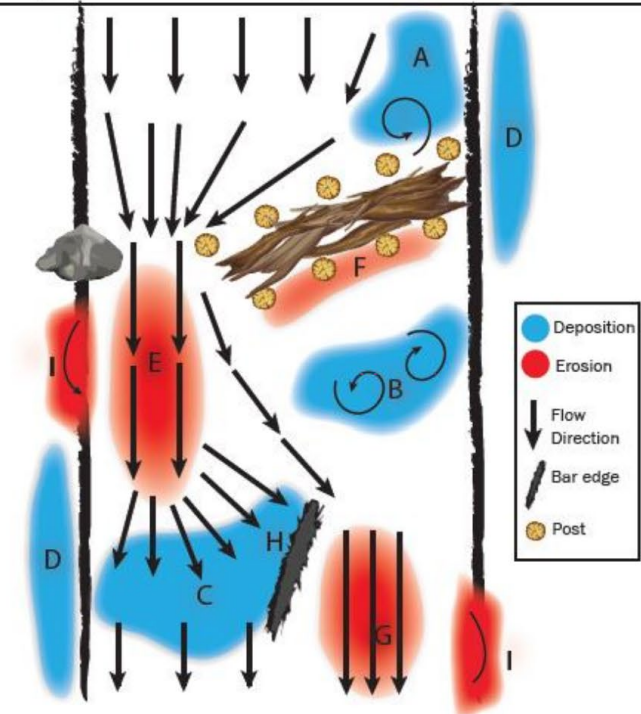
Structure-Level Design

BANK-ATTACHED PALS • INDUCE MEANDERING • DEVELOP POOLS • SORT SEDIMENT • INCREASE HABITAT COMPLEXITY



EXPECTED GEOMORPHIC RESPONSES

A. Deposition Upstream	B. Deposition in Wake	C. Deposition Downstream
D. Deposition Overbank	E. Erosion at Convergent Jet	F. Erosion by Plunge Hydraulics
G. Erosion Forming Chute	H. Erosion of Bar Edge	I. Erosion of Outer Bank

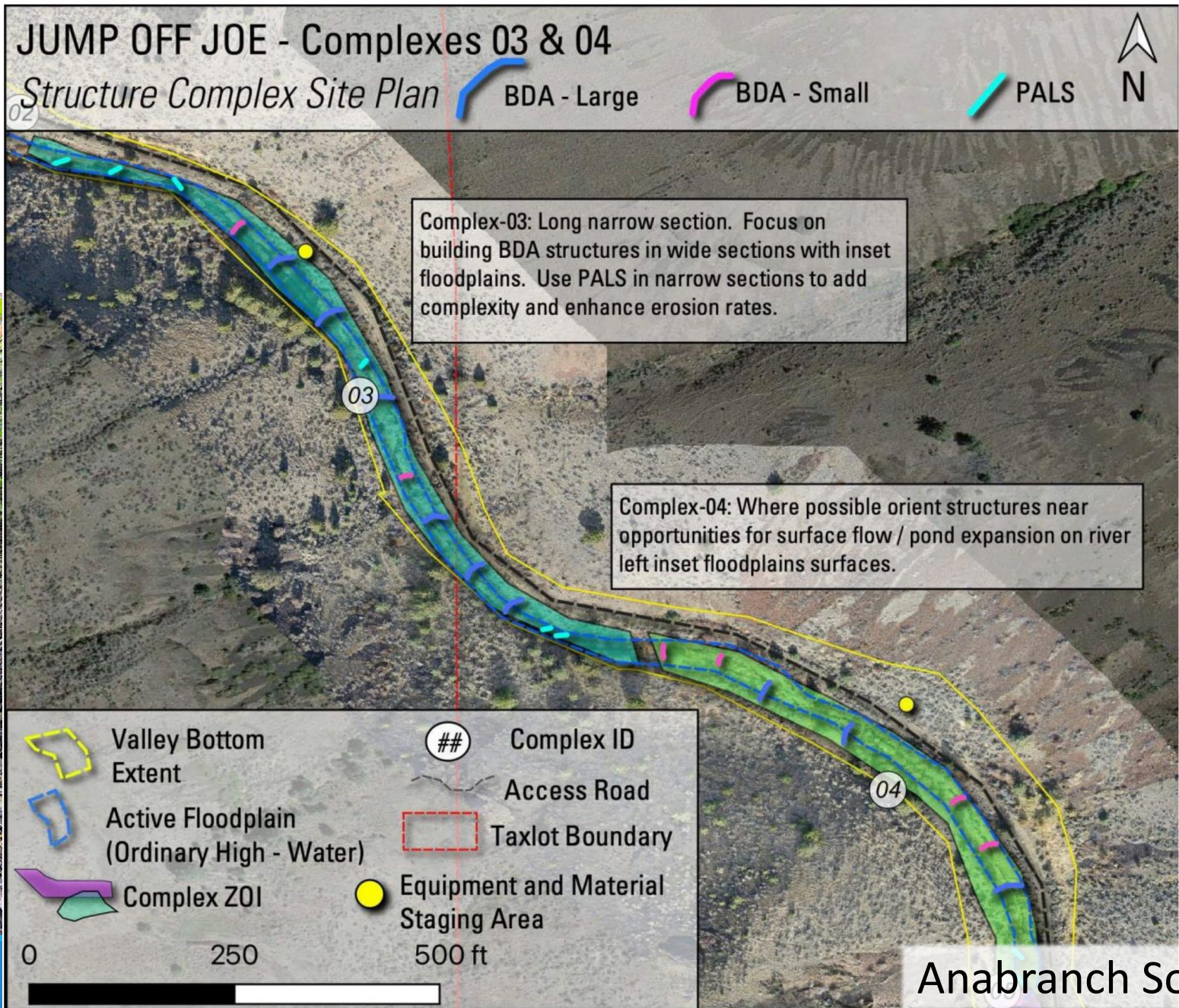


What is each structure intended to do and how do you build it?



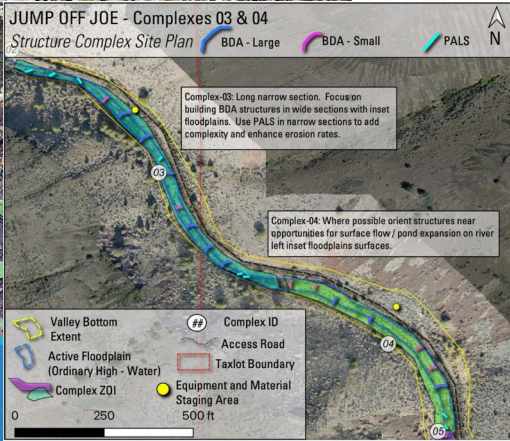


Lesson: Field-fit designs still need justification



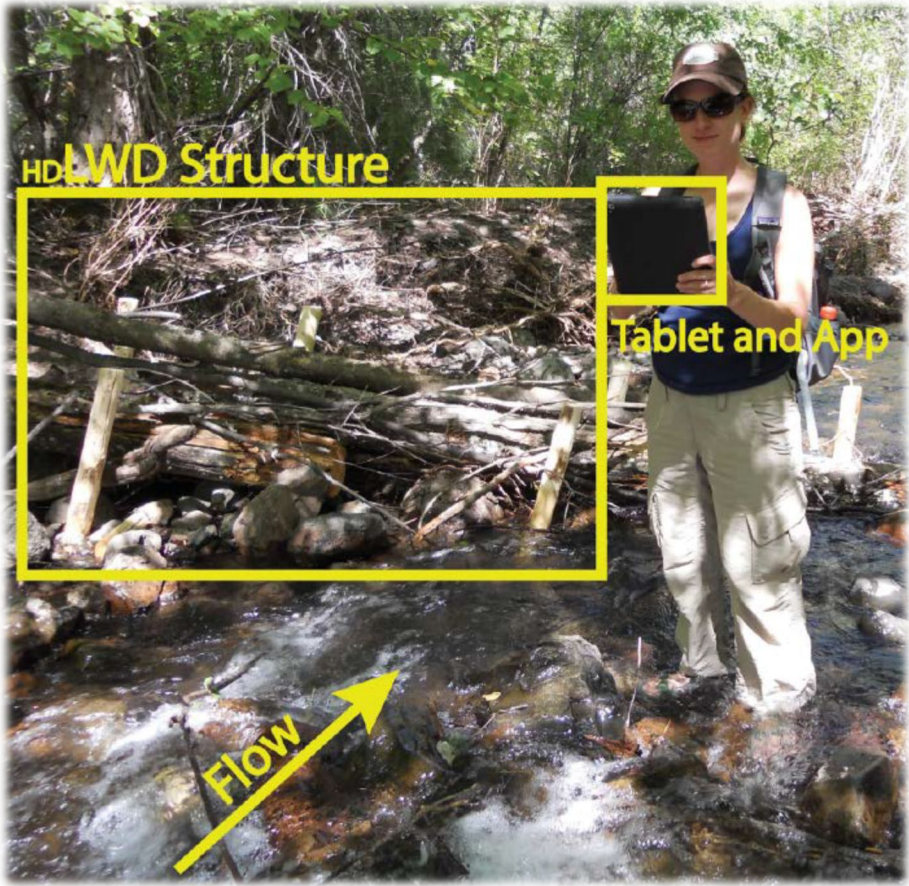
Lesson: Field-fit designs still need justification

Design





Lesson: Field-fit designs still need justification



Back Section Name SF-S1 Visit Crew RC Reid Visit Date 2/13/2014

Structure Number 999

Structure Condition

Structure Integrity: Completely Structure Porosity: Partly Porous Posts Remaining: 7-8 Post Integrity: Mix Solid/ % Channel Constriction: 70-80

LWD Accum.: Probable SWD Accum.: Certain Visit Type: Post High Flow Conditions: Low Flow/No

General Habitat Wood Photos

Unit #	Geo Tier 4	Unit Loc	% Bar Exp	Start Dist	Unit Lgth	Unit Width	Max Depth (cm)	Riffle Crest/Ave Depth (cm)	Dominant Forcing Mechanism	Dominant Substrate
8	Run	DS	.75	3	2	1	200	200	Unknown	Bedrock

Unit #	Geo Tier 4	Unit Loc	Start Dist	Unit Lgth	Unit Width	Unit on RR	UC	RR	RL	UC
1	Run	US	0	1	.5	NA				
2	Forced Bar	US	0	1	.25	3 Stru	6 - Undercut	3 - Structurally Forced Pool	2 - Forced Bar	1 - Run
3	Structurally Forced Pool	US	0	1	.25	NA				
4	Rapid	DS	0	2	.5	NA		4 - Rapid	5 - Run	
5	Run	DS	0	2	.5	NA				
6	Undercut	US	0	.75	0	NA				
7	Dammed Pool	DS	2	1	1	NA		7 - Dammed Pool		
8	Run	DS	3	2	1	NA			8 - Run	



Streamlining Field Data Collection With Mobile Apps

Camp and Wheaton, 2014

Construct

Lesson: Improvement comes from experience



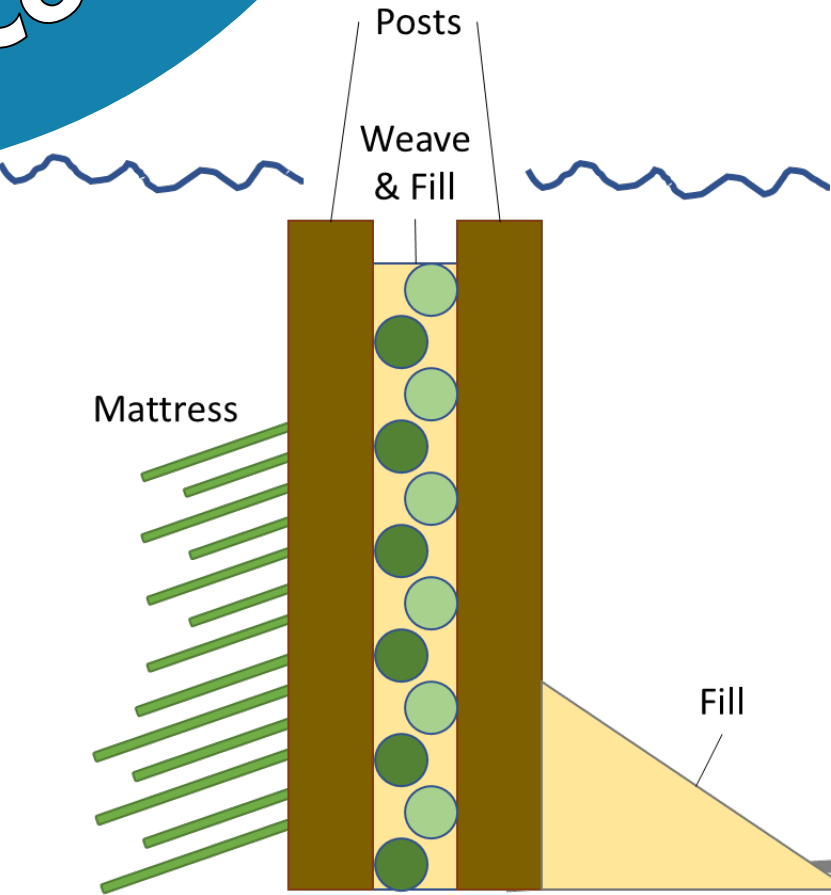
Lesson: Improvement comes from experience

Construct



Lesson: Quality BDAs take a lot of time

Construct





Lesson: Quality BDAs take a lot of time

As Built



Weave choice matters!

Start of 2 Years Later Season



Lesson: A little extra effort leads to a lot more stability

Construct



Chumstick Creek, WA

Charley Creek, WA

Lesson: A little extra effort leads to a lot more stability

Construct



Criss-cross posts to hold wood down

A lot of wood

Crest height \leq bankfull *or* top of bank

Wedge wood into live trees

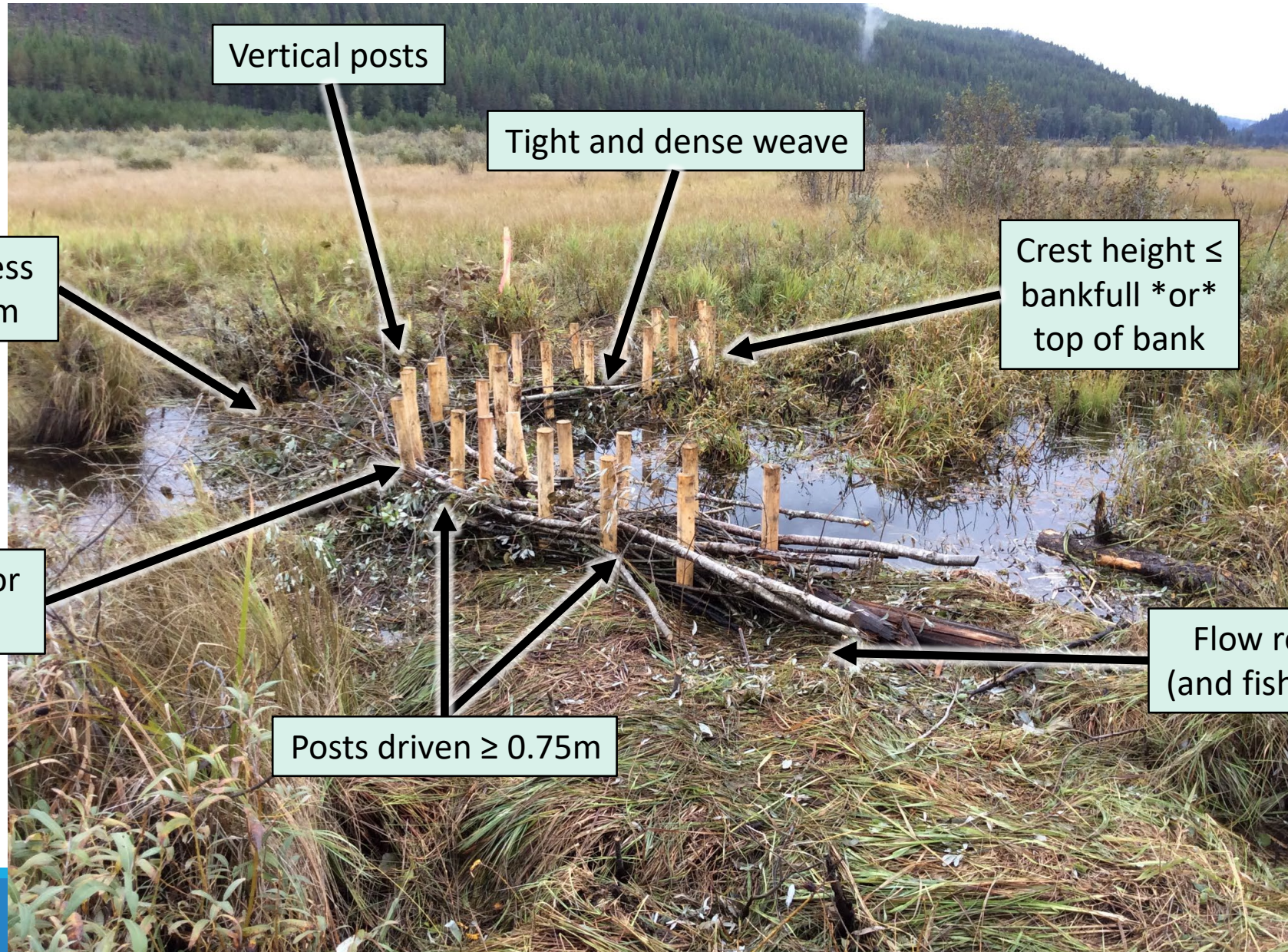
Flow relief valve (and fish passage)

Additional post for every bad post

Posts driven \geq 0.75m

Construct

Lesson: A little extra effort leads to a lot more stability



Vertical posts

Tight and dense weave

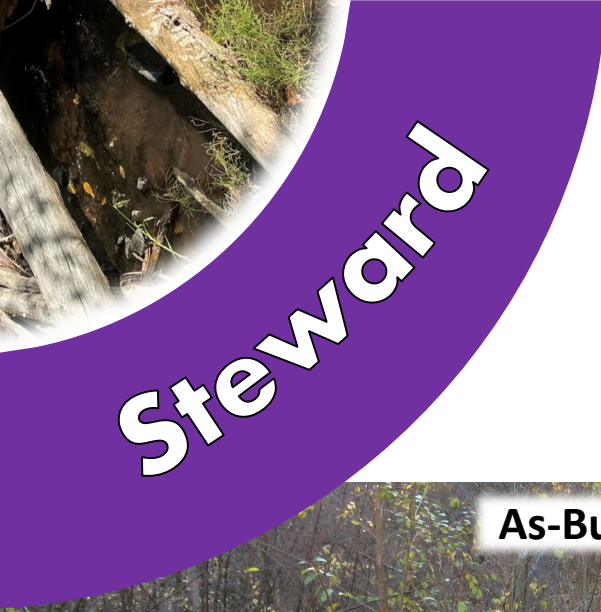
Crest height \leq
bankfull *or*
top of bank

Brush mattress
downstream

Additional post for
every bad post

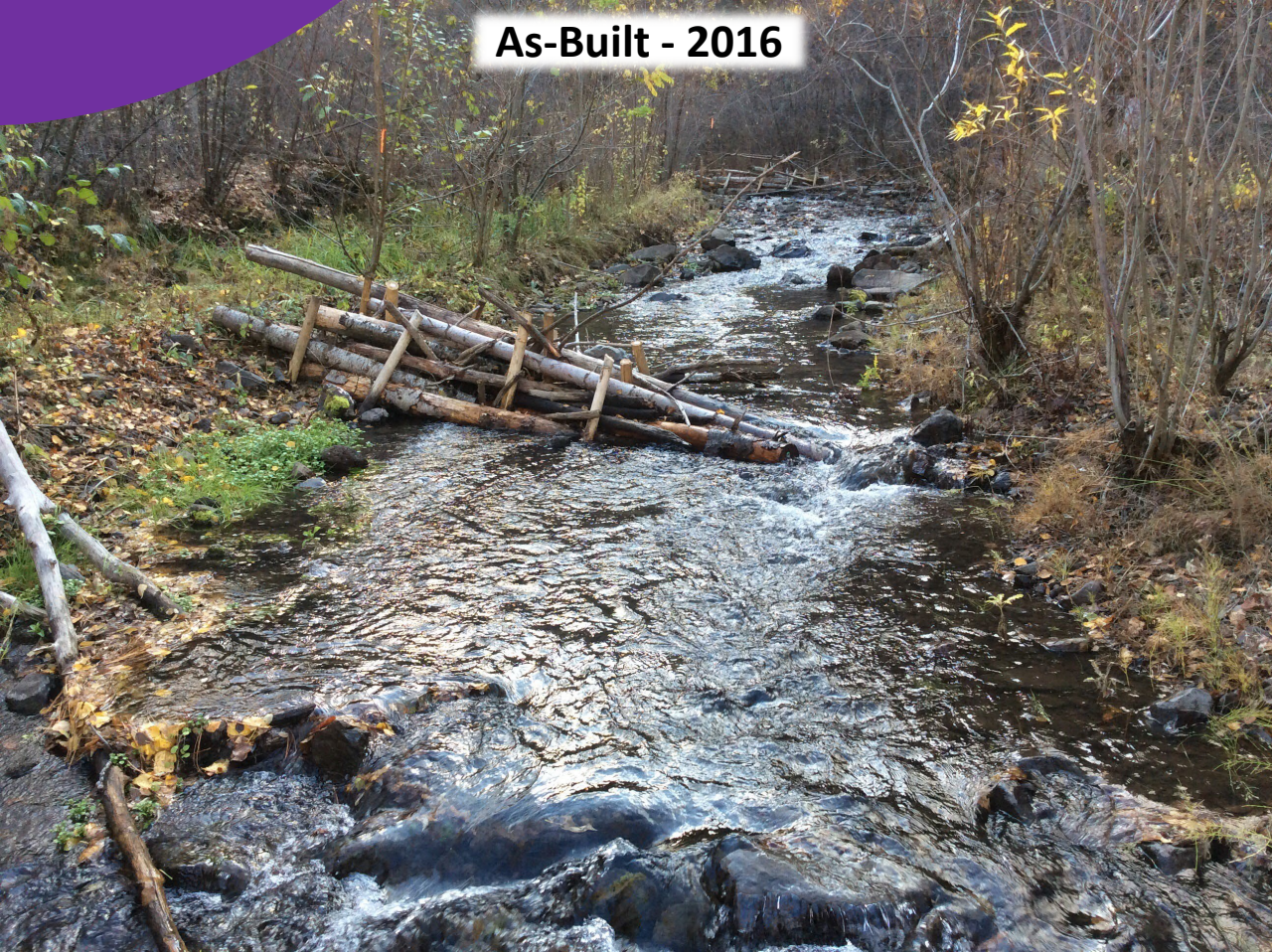
Posts driven $\geq 0.75\text{m}$

Flow relief valve
(and fish passage)



Lesson: Monitoring is essential and can be simple

As-Built - 2016

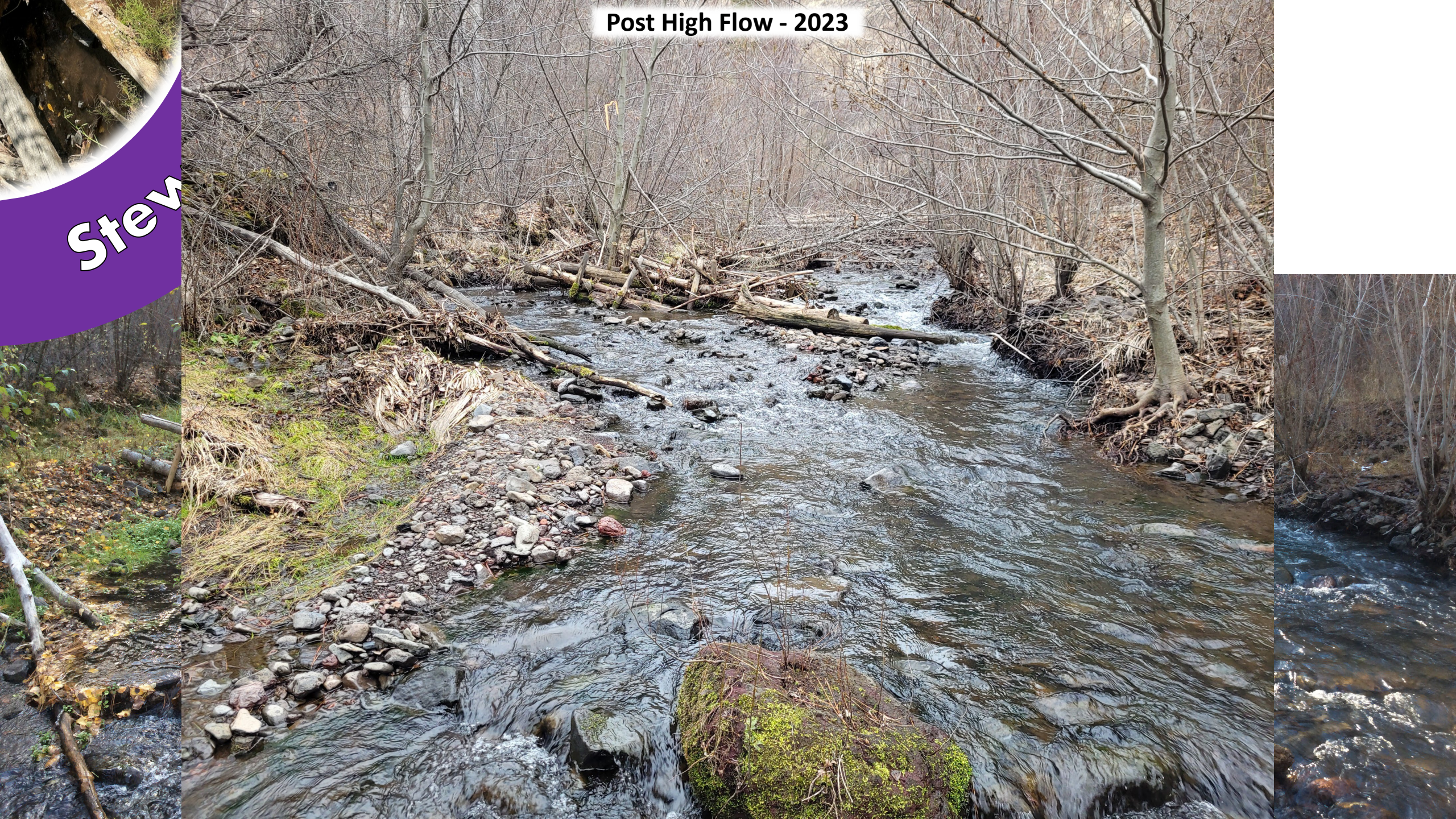


Post High Flow - 2017



Post High Flow - 2023

Step





Lesson: Monitoring is essential and can be simple

Annual Project Monitoring

Questions to consider

- Did individual structures work as intended?
- Is the reach responding as expected?
- What needs to be fixed, replaced, added, or removed?
- Is the project causing harm?
- Are there signs of beavers?
- Am I taking enough photos?



Is the project meeting its goals and objectives?



Lesson: Most projects require maintenance

Steward





Lesson: Most projects require maintenance



Rebuild? Replace?



Steward

Lesson: Most projects require maintenance

Increase crest height with new post line?





Lesson: Most projects require maintenance



Extend to maintain constriction?



Constriction is gone!



Construct



Design

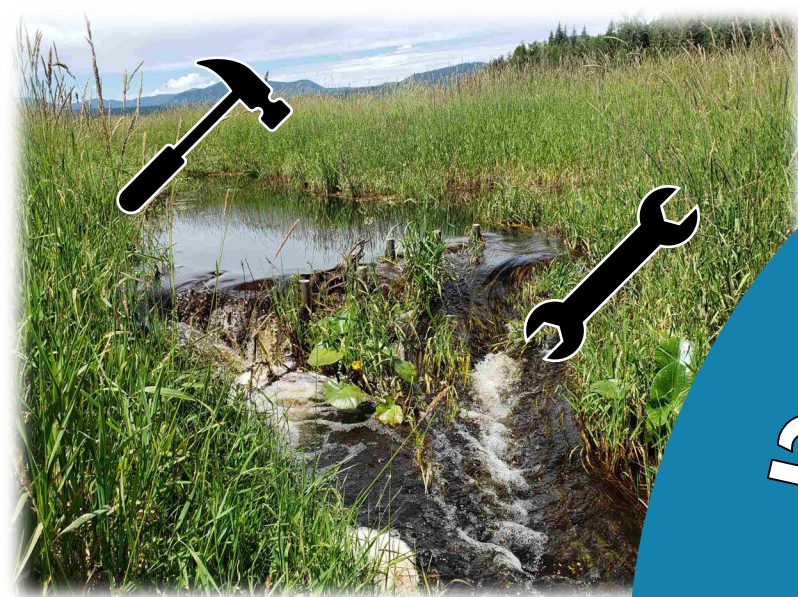


Steward



Planning





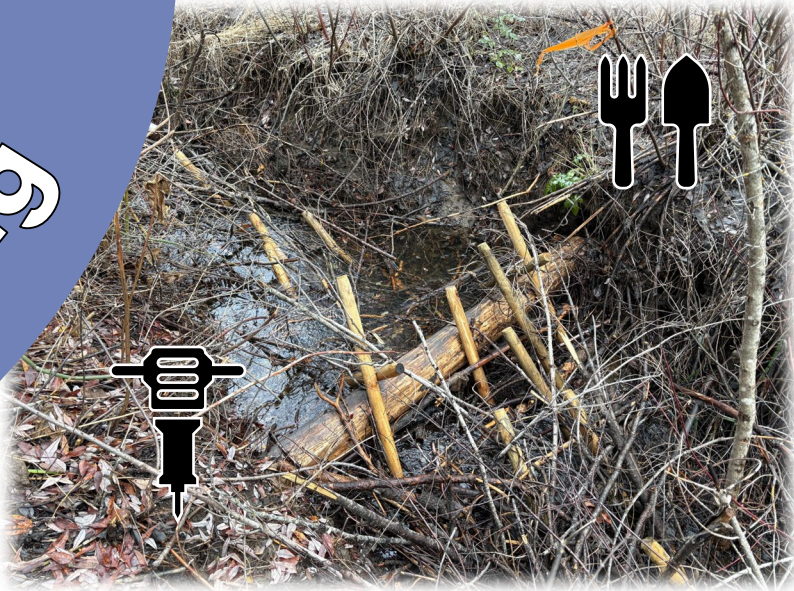
Construct



Design



Steward



Planning



Construct



Design



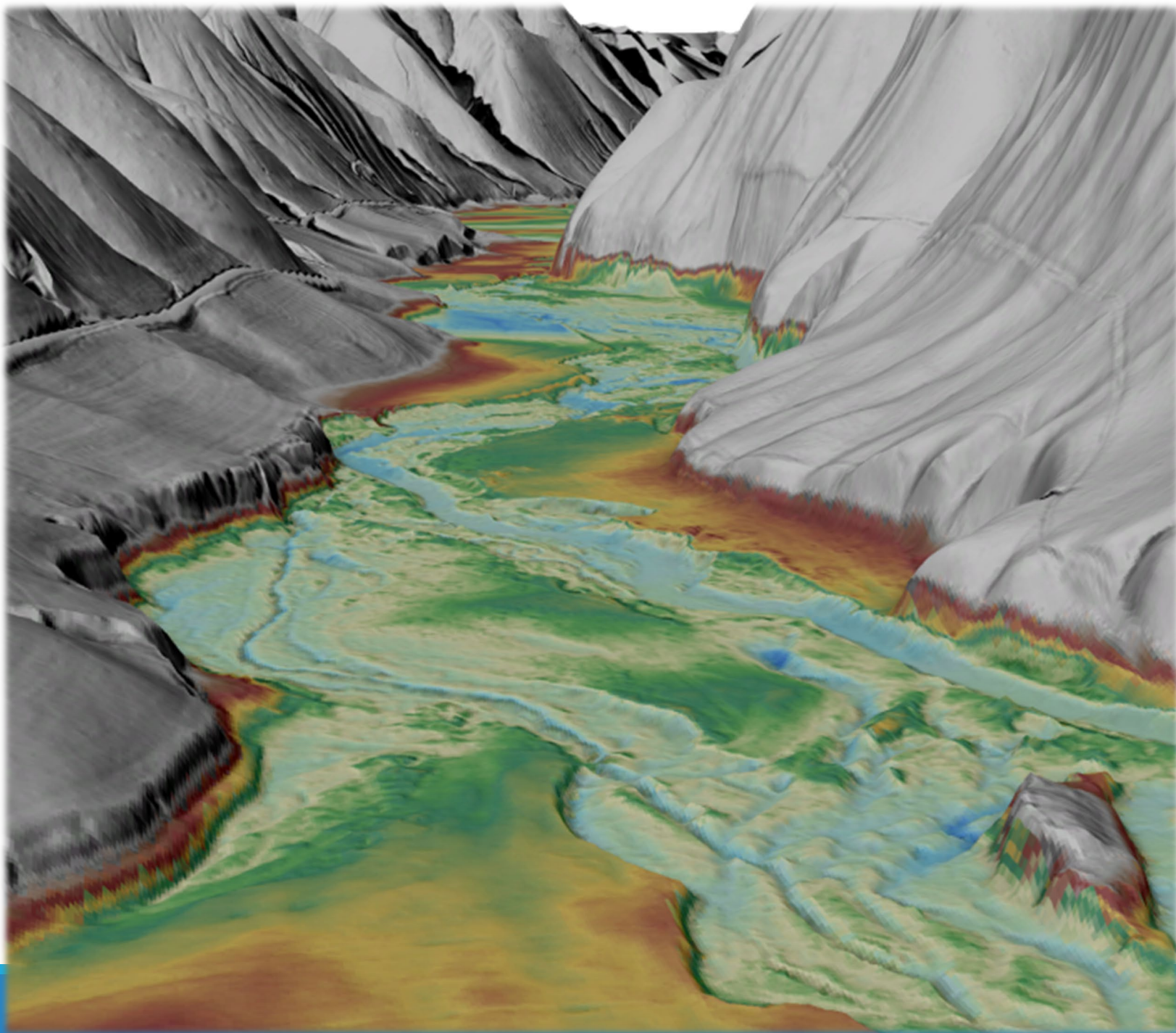
Steward



Planning







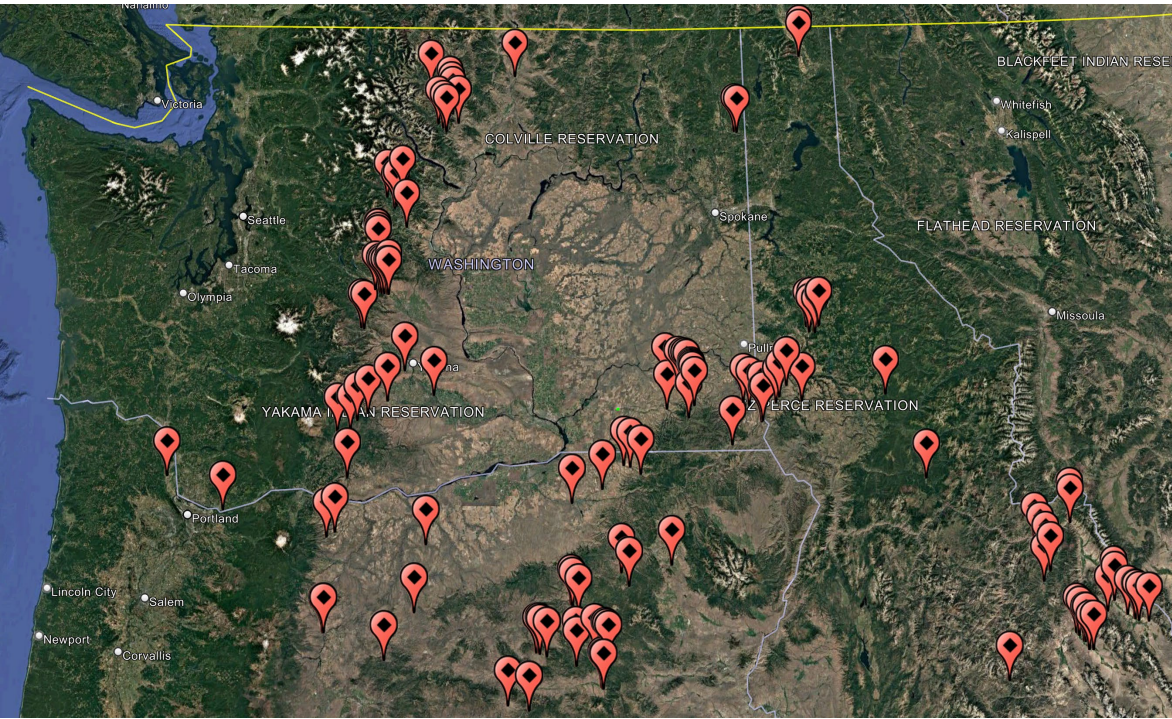
Thank you!

Reid Camp
Science and Technical Coordinator
Snake River Salmon Recovery Board
reid@snakeriverboard.org



LTPBR Project Evaluation

BPA projects with low-tech elements



Bonneville
POWER ADMINISTRATION

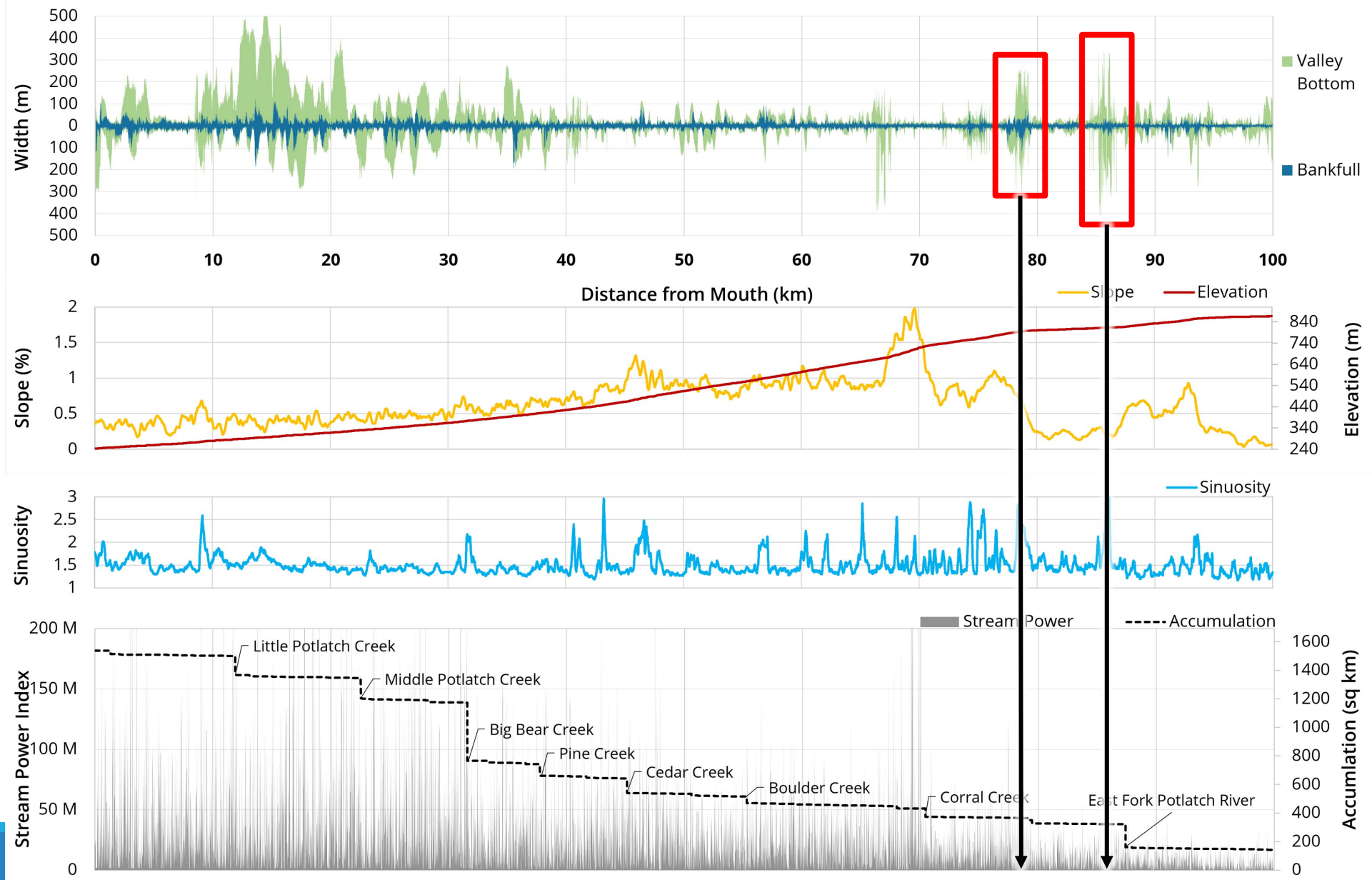


Planning

Understand your watershed!

Lesson: Site selection is important

Potlatch River



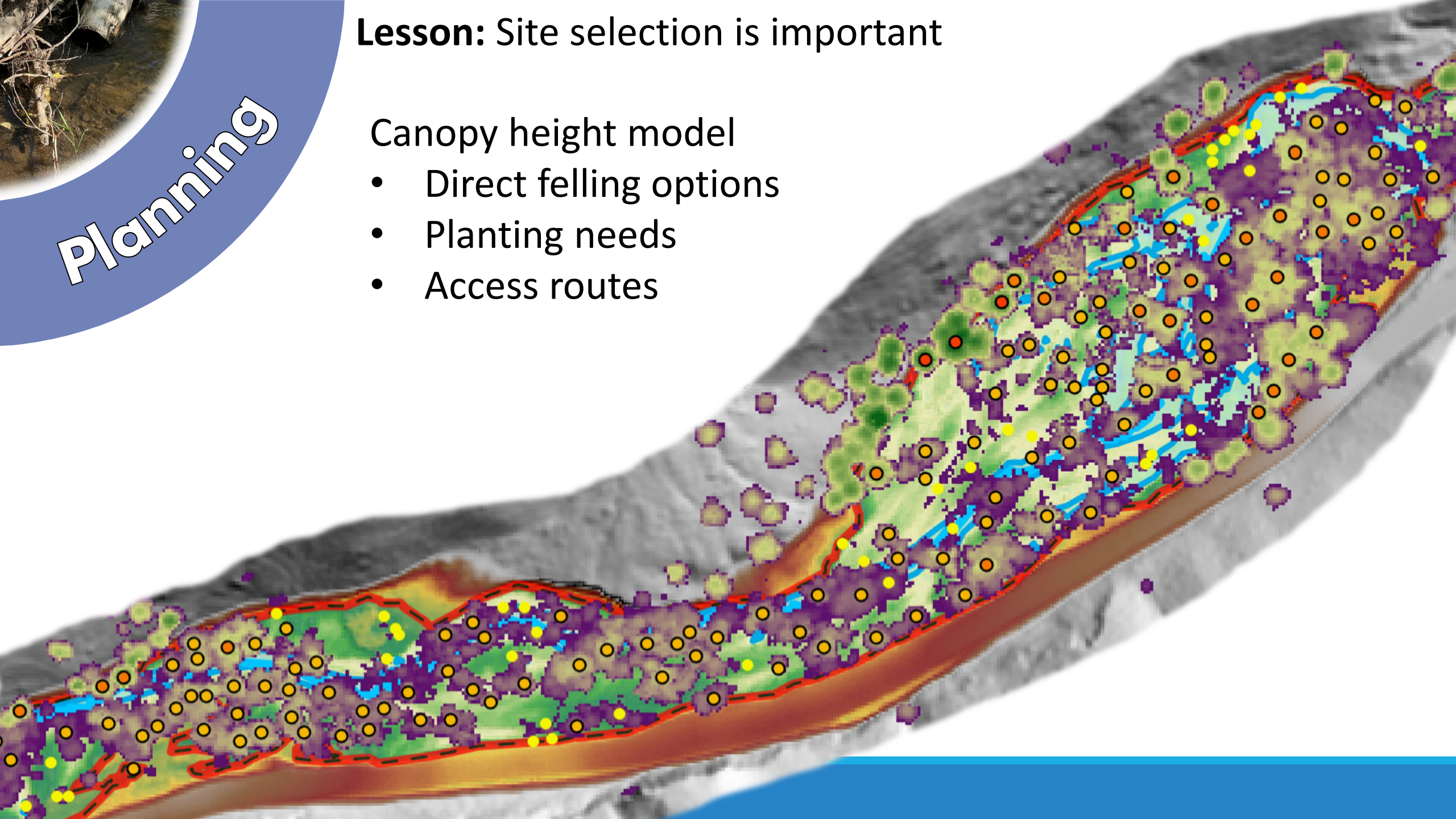


Planning

Lesson: Site selection is important

Canopy height model

- Direct felling options
- Planting needs
- Access routes



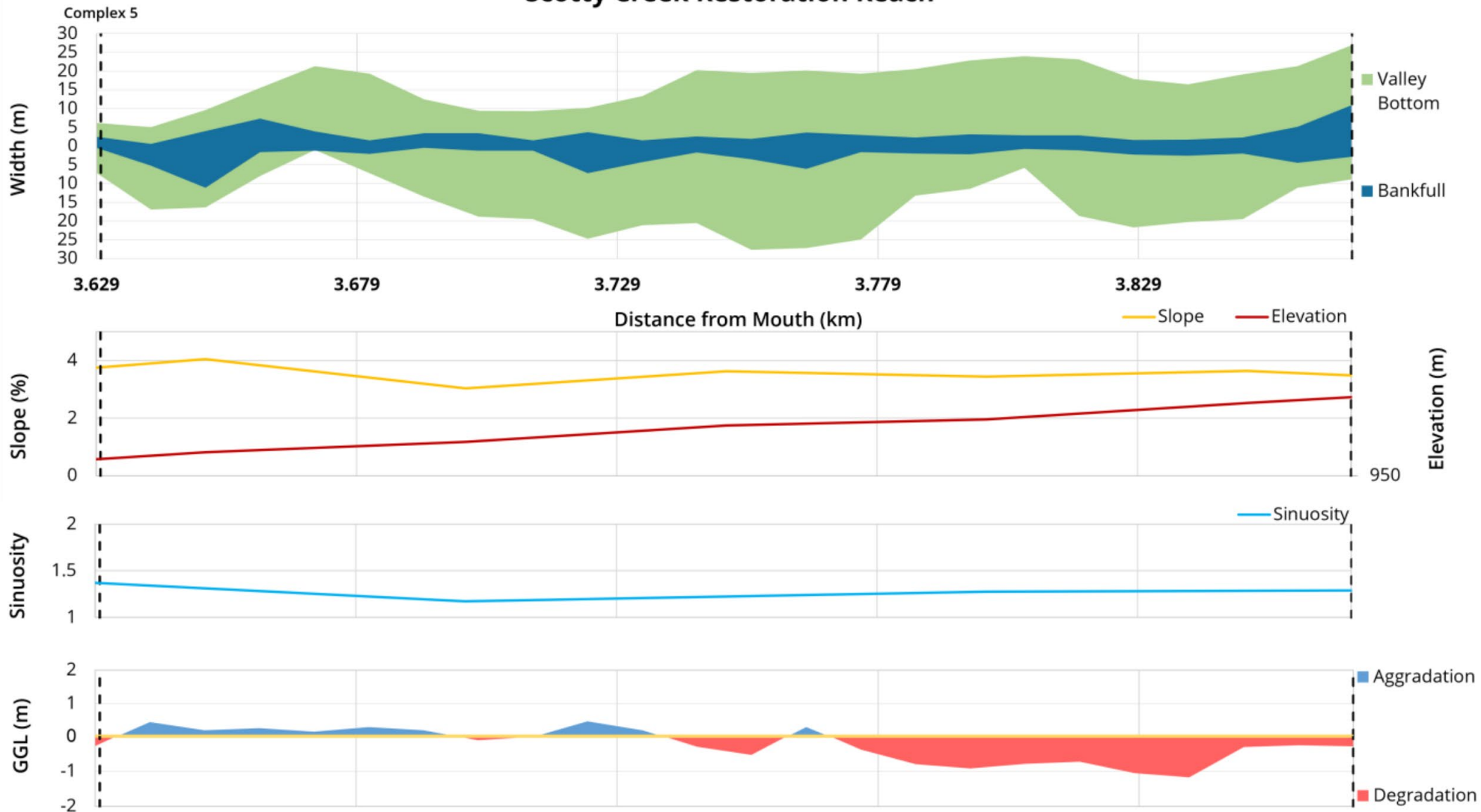


Lesson: Design report is necessary

Complex-Level Design

Complex 5: Water and Sediment Retention

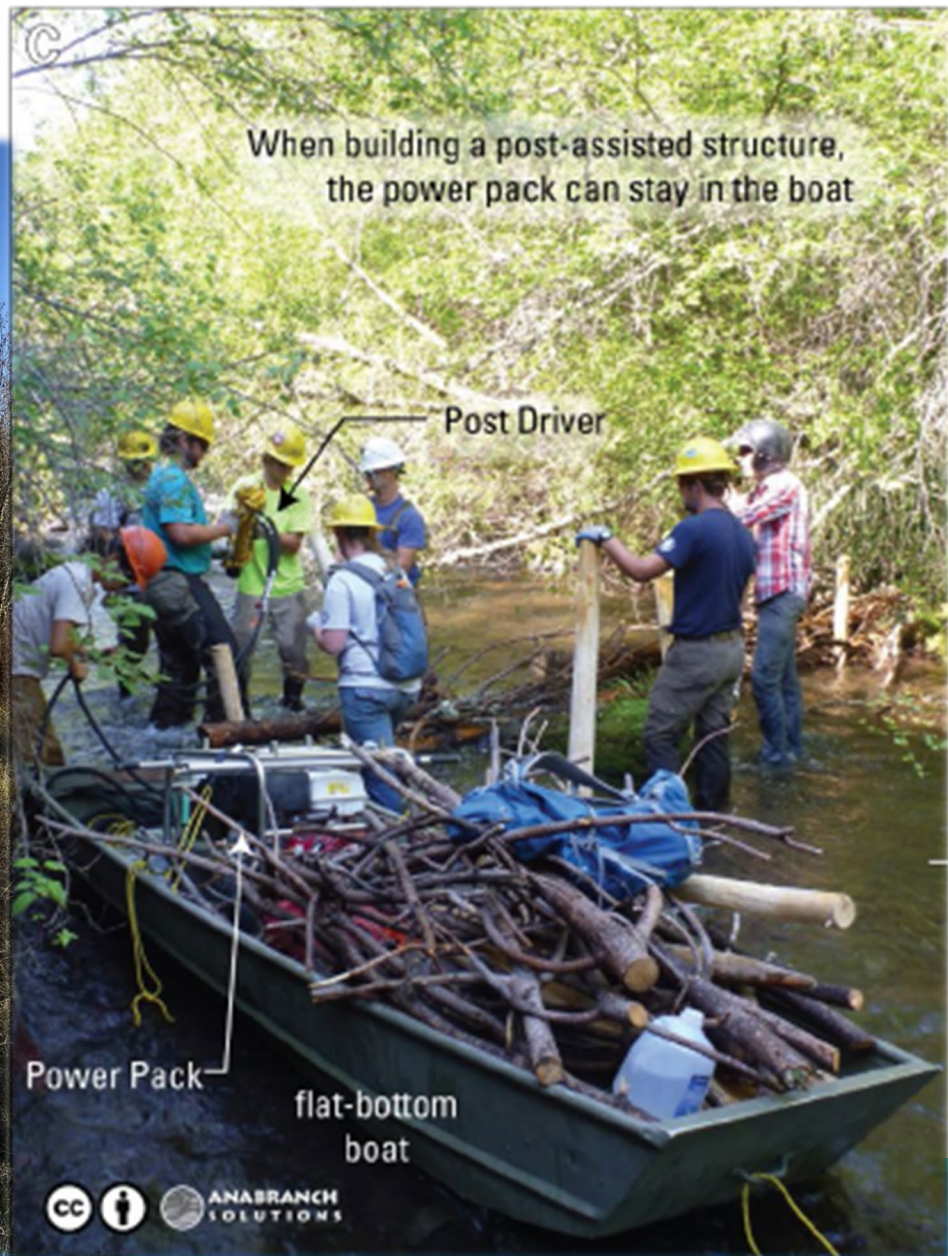
Scotty Creek Restoration Reach



How do the structures work together to meet reach-level objectives?

Construct

Lesson: Improvement comes from experience





Lesson: Quality BDAs take a lot of time

Weave choice matters!



Cottonwood, dogwood, willow, etc.



Alder?!?!



Lesson: Most projects require maintenance

As-Built

Post High Flow

Mid-channel PALS becomes bank-attached





Lesson: Monitoring is essential and can be simple

