U.S.FOREST SERVICE – NATURAL RESOURCE CONSERVATION SERVICE
LARGE WOOD WORKSHOP
(September 2023 Craig, Alaska.)

LARGE WOOD STRUCTURE TYPES, CONFIGURATIONS, AND CONSTRUCTION METHODS



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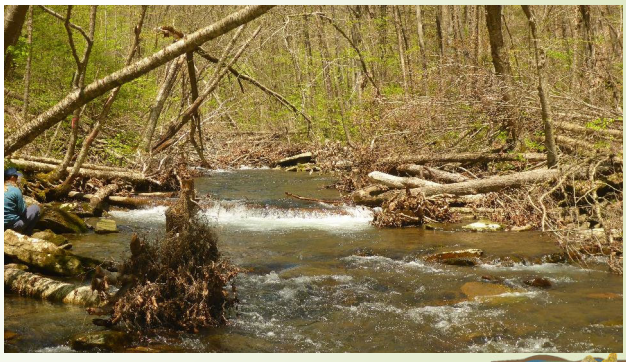
Acknowledgements for Photos

USDA Forest Service (Chad Landress, Bob Gubernick)
Natural System Designs – Tim Abbe & Rocky Hrachovec
Interfluve – Marty Melchior
Santa Fe National Forest
Ian Johnson – Hoonah Indian Association

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Topics

1. Hand Construction & LW Structures
2. Heavy Equipment Construction and LW Structures
3. Helicopter Construction

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Large Wood Reference Conditions in Alaska

Harris River, Alaska

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Placement of Large Wood for Aquatic Habitat Benefit

Table 6-5. Recommendations for Placement of Large Wood in Streams for Aquatic Habitat Benefits

Stream Size	Width (meters)	Large Wood Structure Functions and Risks	Natural Large Wood Configurations
Small	<10	Single or multiple pieces of wood can be effectively used to create habitat, stabilize the channel, dissipate energy, and store sediment. Logs in small streams may be used to create step pools (i.e., plunge pools). Because small streams generally have less energy to move large wood, a greater variety of large wood locations and orientations can be employed without excess risk.	Logs most often lie perpendicular or are angled downstream to flow, but any orientation is feasible. They may span the channel or intrude partway into the channel.
Medium	10–20	Channel-spanning wood structures may be applicable, but the results are less predictable than for small streams and their vulnerability to flood damage is relatively high.	Wood tends to accumulate in jams, but single pieces and small complexes also occur. The outside of bends and the head of natural gravel bars tend to be relatively stable locations for wood jams.
Large	>20	Stabilizing woody debris becomes a significant concern on larger streams. Wood placement in the main stem of the channel is only recommended in the form of anchored structures (i.e., log jams, large wood complexes, and wood trapping structures), unless transport can be tolerated. Key pieces and log complexes can be effectively used in side channels and floodplain habitats.	Lateral jams, as opposed to full-spanning jams, are a common feature. As with medium-sized streams, locations at the outside of bends and the head of natural gravel bars tend to be relatively stable.

Source: Saldi-Caromile et al. (2004); Cramer (2012).

Source: National Large Wood Manual - Engineering With Nature (dren.mil)

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Hand Work Wood Construction Methods

- **Requires minimal design –**
  - Structure location and type flagged in the field. Plan or typical detail may be required for permitting
  - Hydraulic Analysis via Cross section analysis using Mannings Equation
  - Use trees much longer than bankfull width for ballasting
  - Entanglement is the principal anchorage method. Ballasted with extra wood
  - Usable trees should be relatively close to construction site.

Construction

- Trees harvest near site in uplands and on floodplain
- Logs can be skidded longer distances than rootfans
- Root fans can pulled over. If close to the stream away from the bank, part of the roots can be left intact for additional ballast
- Wood moved with grip hoist and timber carriers depending on the size of the stream
- Trees can be cut to a point or wedge and pulled into bank material for partial embedment depending on bank material composition
- Trees are woven together as best as possible to get multi points of contact

- **DON'T REMOVE EXISTING TREES THAT STABLIZE THE BANKS!**

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Hand Work Wood Construction Tools

- Safety equipment – Hard hats, gloves, eye and hearing protection, saw chaps
- Chokers and wire rope (cable)
- Pulleys / Block and tackle, shackles
- Capstan winch and grip-hoist
- Chainsaw, Ax, handsaw







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Hand Built Wood (Structure Examples)

Small wood structures
1. Cost effective
2. Good in areas with poor access
3. Requires minimal design
4. Opportunistic siting. Need trees to entangle and available near the site



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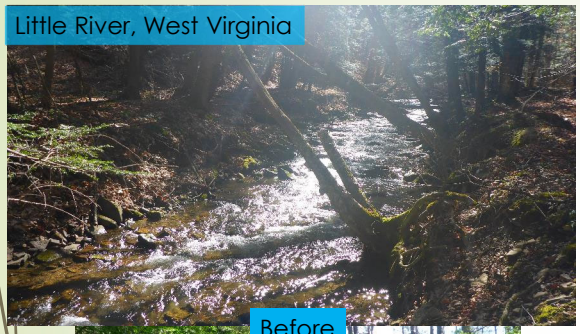
GRF1

Hand Work Wood Structure Examples

Little River, West Virginia



Before

Long Run, West Virginia

After 3 years

Photos by C.Landress Monongahela NF

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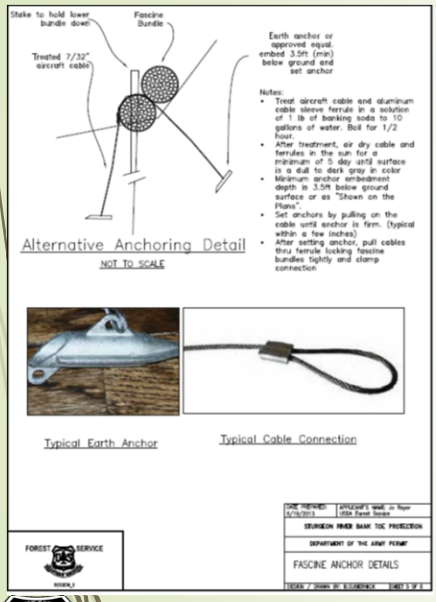
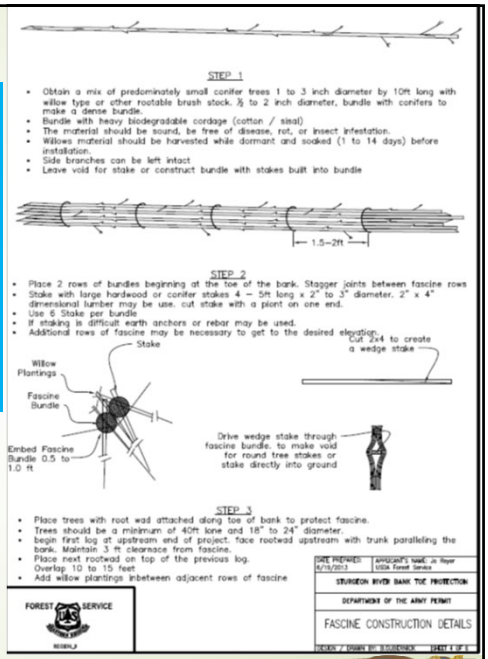
Hand Work - Fascine Bank Protection



Fascine Bank Protection

1. Small wood / branches bundled together
2. Mechanically anchored
3. Work best in sand dominated and stream with heavy suspended sediments
4. Voids fill up with fines
5. Concurrent plant required



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Slide 9

GRF1 Gubernick, Robert -FS, 9/1/2022

Fascine Bank Protection Example

Sturgeon River, Michigan
1 year after construction

Sturgeon River, Michigan
6 years after construction

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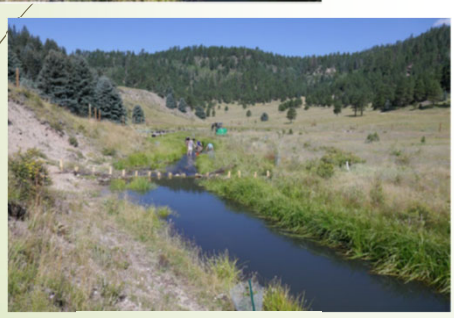
Beaver Dam Analogies (BDA)

Before



After construction

Beaver Dam Analogy

1. Structure intent is to hold water longer on the land and wetlands
2. Small stream application and sites with limited access
3. Typically, very low to low gradient with floodplains
4. Dead small logs are the structural pieces and other materials are woven around them to emulate a beaver dam. Sometime rock (cobbles & gravel are included)

After construction - 2 months

Photos courtesy of the Santa Fe National Forest

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Xmas Tree Revetment

Xmas Tree Revetment

1. For stream narrowing
2. Work well in high suspended sediment load streams
3. Small stream application and sites with limited access
4. Typical siting is in very low to low gradient with floodplains
5. Cells are constructed with wood posts for anchorage. Xmas trees are tied together with cord and the cells filled. Koir fabric added on top (not always needed).

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Heavy Equipment Large Wood Construction Methods

- **Requires design –**
  - Full analysis and modeling for large projects. If only a structure or 2 may use less extensive analysis depending on Permitting requirements
  - Tree size is much greater typically
  - Requires access construction to mob trees to sites
  - Embedment, entanglement, piling, mechanical anchor are the principal anchorage methods

- **Construction**
  - Typically need a large and small excavator to construct LW structures
  - Structures can be continuous or discreet structures
  - Anchorage methods depends on site configuration
  - Key ballast trees are usually embedded with other trees woven together
  - May or may not require dewatering

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Ballasting and Anchoring

Ballasting and Anchoring is accomplished by:

- Soil, rock, & wood ballast (weight) over buried key pieces overcoming buoyancy and drag
- Entanglement – wood pieces woven into live trees
- Mechanical anchoring – soil anchors (manta ray or duckbill) or deadmen (buried log) with cable attachment to structure
- Piling

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Heavy Equipment for Large Wood Construction

EXCAVATORS (LARGE & SMALL)

DOZER'S

TRUCKS (LOG,LOWBOY, ROCK)

SKIDDERS / FORWARDERS

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Heavy Equipment Large Wood Construction Methods

Protecting banks during access with logs

Log tongs are mandatory!

If working around bedrock, consider having a hydraulic hammer to remove bedrock knob, gain pool depth, or additional room to place wood when embedding

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Heavy Equipment Large Wood Construction Methods

ACCESS RULES OF THUMB

- Access trail should angle downstream toward the stream
- Minimize travel distances up and down stream
- Keep main access corridors toward the edge of floodplain or in the upland and construct short spurs to central location so 2 to 4 or more sites can be serviced by 1 spur trail
- Put access paths to bed when project is complete. Roughen them and place trees across. These trails can be come flow path during high flows

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Placing and Aligning LW

Log tongs improve efficiency, placement accuracy, and help minimize any wood damage

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Anti Flanking Structures

- Placed on the upstream side of the structure to prevent flanking from removing ballast material
- Begin usually at same depth of scour logs
- Mainly used on meander bend jams
- Comprised of logs battered against bank materials and the main log structure

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Scour Logs

- Placed underneath and behind the face of the LW structure
- Installed to anticipated scour depth
- Can be placed on all types of constructed log jams
- Cabling scour logs together helps facilitate construction. They hold the logs together for easy burial below water surface
- Add slash to the backfill, it helps retain materials

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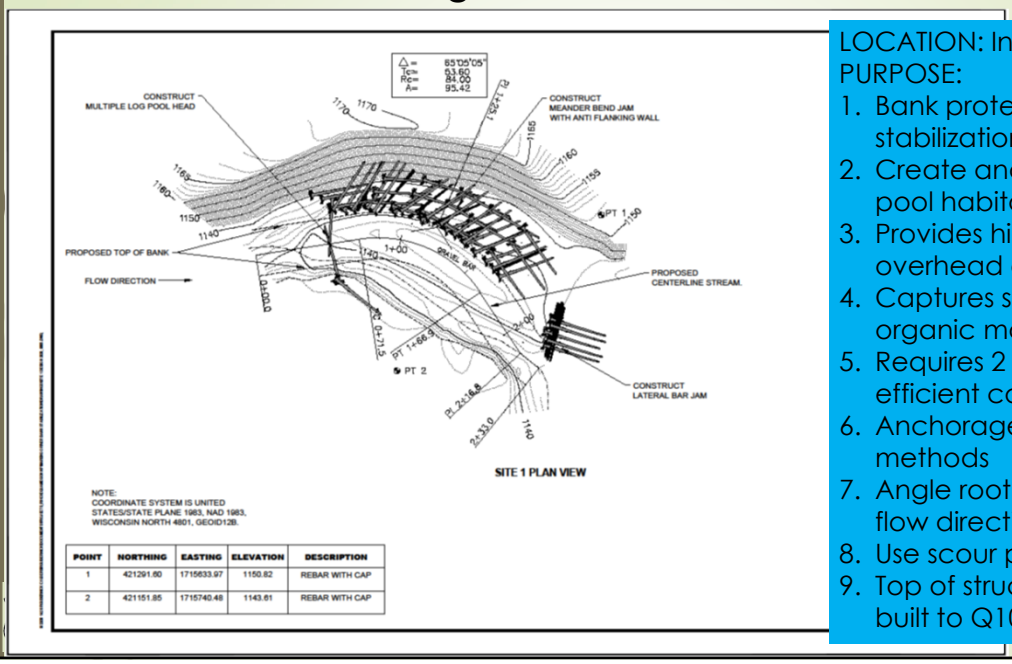
Meander Bend Log Jam



POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
1	421291.60	1715833.97	1150.82	REBAR WITH CAP
2	421151.85	1715740.48	1143.61	REBAR WITH CAP

LOCATION: In meander bends
PURPOSE:

1. Bank protection / stabilization
2. Create and maintain deep pool habitat
3. Provides hiding and overhead cover
4. Captures small wood and organic matter
5. Requires 2 excavators for efficient construction
6. Anchorage by various methods
7. Angle root fans to stream flow direction
8. Use scour protection
9. Top of structure should be built to Q100

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Meander Bend Log Jam

Monongahela NF West Virginia

Allegheny NF Pennsylvania

Mark Twain NF Missouri

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Meander Bend Log Jam -

Harris River, Ak
Constructed 13 years ago

Wood River, Wy.
Constructed 2019,Upper Photo,
Lower after 2022 Yellowstone flood

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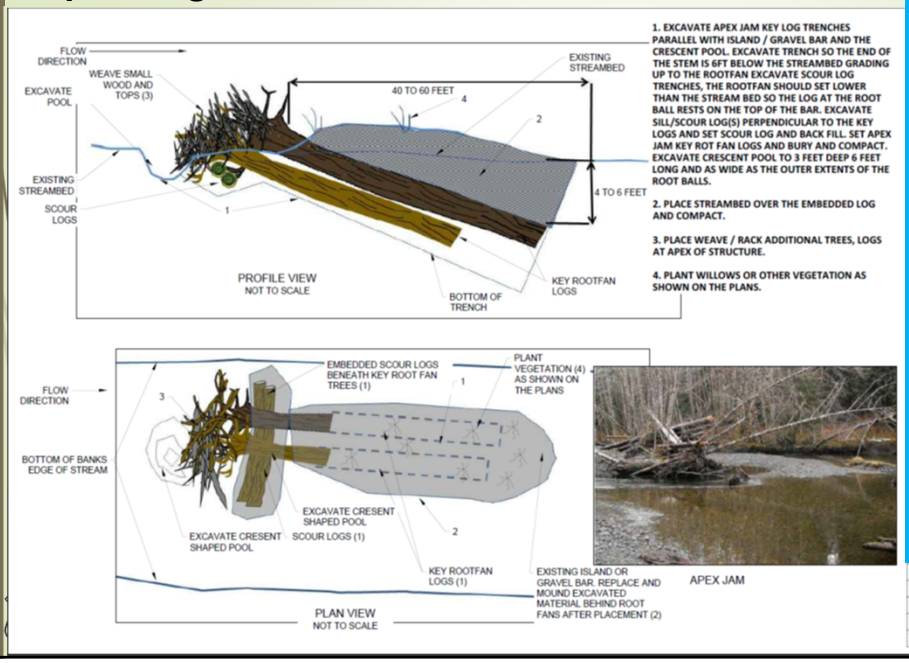
Apex Log Jam



LOCATION: at head of islands and in channel
PURPOSE:

1. Island protection and Island formation
2. Create and maintain pool habitat
3. Provides hiding cover
4. Captures small wood and organic matter
5. Can be constructed with 1 excavator
6. Build face of structure to Q100 Elev if possible
7. Use scour logs.
8. Embed ends of root fans log with 4+ft of sediment over the end of the log

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Apex Log Jam Examples

Trib. To Spasski Creek, Alaska

Harris River, Alaska

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Multiple Apex Log Jams - Lower Harris River, POW
Constructed 14 years ago and still functioning as intended preserving islands

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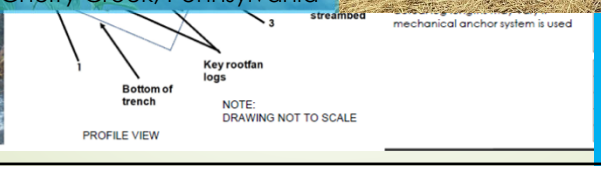
Lateral Bar Jam

Cherry Creek, Pennsylvania

Cherry Creek, Pennsylvania



LOCATION: Channel

5. Build to Q100 elevation
6. Can be built with 1 excavator
7. Anchorage usually by embedment and piling

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Lateral Bar Jam Example

Pennsylvania

Harris River, Alaska

Washington

Harris River, Alaska

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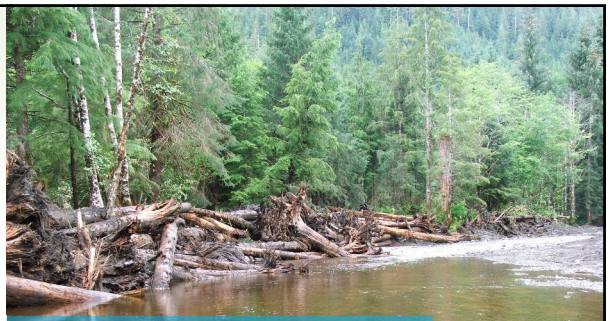
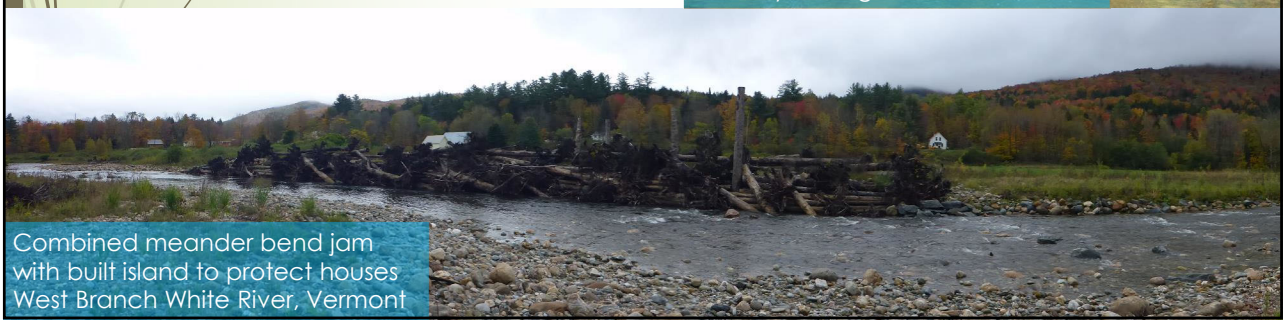
Infrastructure Protection Example

Large Wood Structures Protection Infrastructure

1. High density wood placement
2. Well anchored and ballasted
3. Constructed to Q100 + elevation
4. High FOS, capable of resisting buoyancy and drag at Q100 flows
5. Island type structures or wood levees
6. 2 excavators required



Emulated landslide deposit protecting a State Highway Near Hydaburg Alaska



Combined meander bend jam with built island to protect houses West Branch White River, Vermont

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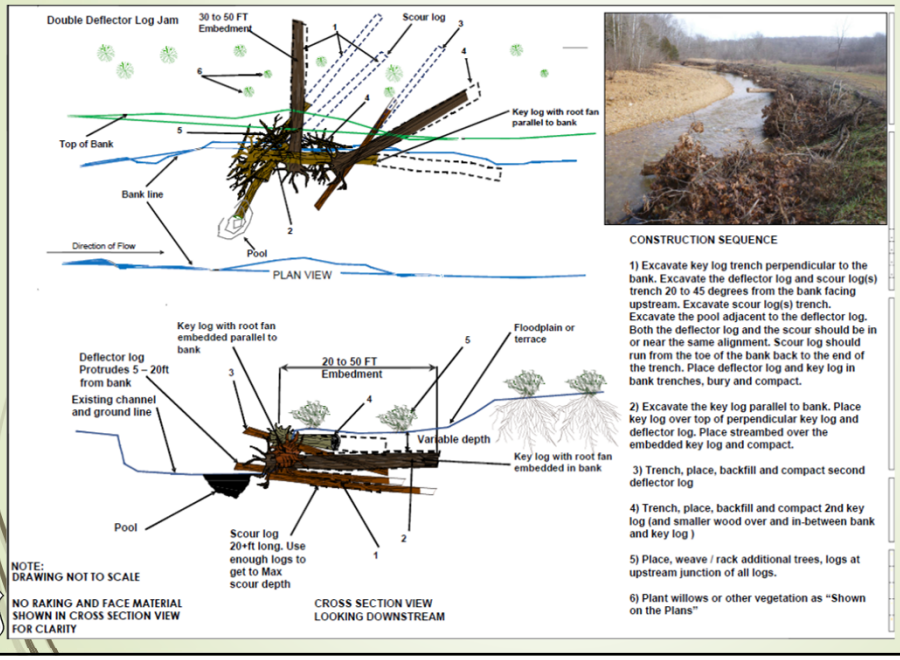
Deflector Jam Example



CONSTRUCTION SEQUENCE

1) Excavate key log trench perpendicular to the bank. Excavate the deflector log and scour log(s) trench 20 to 45 degrees from the bank facing upstream. Excavate scour log(s) trench. Excavate the pool adjacent to the deflector log. Both the deflector log and the scour should be in or near the same alignment. Scour log should run from the toe of the bank back to the end of the trench. Place deflector log and key log in bank trenches, bury and compact.

2) Excavate the key log parallel to bank. Place key log over top of perpendicular key log and deflector log. Place streambed over the embedded key log and compact.

3) Trench, place, backfill and compact second deflector log

4) Trench, place, backfill and compact 2nd key log (and smaller wood over and in-between bank and key log)

5) Place, weave / rack additional trees, logs at upstream junction of all logs.

6) Plant willows or other vegetation as "Shown on the Plans"

Deflector Jams

1. Flow re-directive structure
2. Don't use in rivers with heavy canoe and kayak traffic
3. Flow redirection can happen at several elevations
4. Bank stabilization and habitat structure
5. Can capture a lot of wood depending on configuration. Drag force analysis required
6. 2 Excavators required

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Deflector Jam Example

Barney Creek, Missouri

West Branch White River, Vermont

West Branch White River, Vermont

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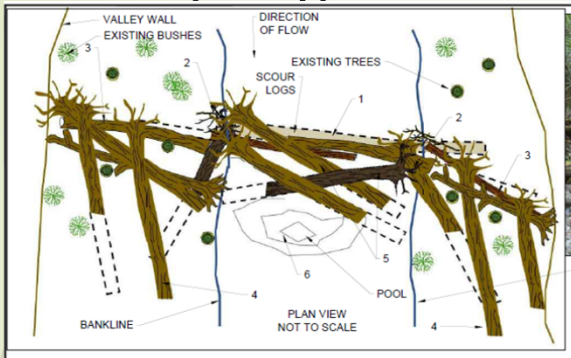
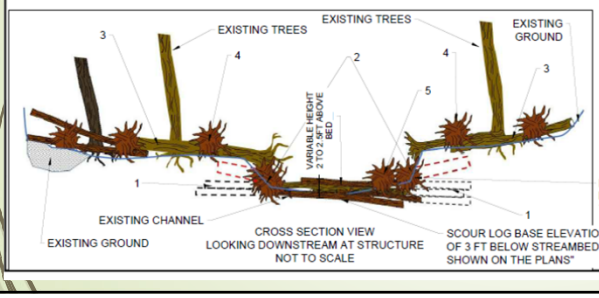
Cross Channel (Valley) Jam with Additional Log Roughness Example





EDGE OF STREAM

NOTES:
1) EXCAVATE KEY CROSS CHANNEL AND SCOUR LOG(S) TRENCHES PERPENDICULAR TO THE BANK. PLACE LOGS, BACKFILL, AND COMPACT TRENCHES. TOP OF OF HIGHEST LOGS IN THE CHANNEL WILL BE A MINIMUM OF 0FT AND MAXIMUM OF 2.5 FT ABOVE THE EXISTING STREAM BED.
2) EXCAVATE THE KEY ROOT FAN LOG ~45 DEGREES FROM BANK. PLACE KEY LOG OVER CROSS CHANNEL LOGS, BACK FILL AND COMPACT TRENCH.
3) PLACE FLOODPLAIN LOG(S) WITH OR WITHOUT ROOTFANS ACROSS THE FLOODPLAIN. STAGGER THE LOGS AND ENTANGLE IN TREES IF POSSIBLE. DON'T BLOCK OFF ACTIVE CHANNELS.
4) PLACE KEY FLOODPLAIN ROOT FAN LOGS, TRENCH, BACKFILL, AND COMPACT IF ENTRENCHED. IF NOT TRENCHED, ENTANGLE IN ADJACENT TREES.
5) PLACE ADDITIONAL ROOTFAN TREES OVER THE KEY CROSS CHANNEL LOGS AND EMBED THE END OF STEM AT LEAST 1.5FT OVER THE CUT LOG ENDS. PLACE REMAINING ROOT FANS TREES AND EMBED.
6) REVEGETATE DISTURBANCE AS "SHOWN ON THE PLANS" AND EXCAVATE POOL

EMBED CROSS CHANNEL LOGS A MINIMUM OF 50% OF THEIR LENGTH INTO THE BANKS. MULTIPLE LOGS REQUIRED

Cross Channel Log Jam

1. Aggradation structure and grade control
2. Cross channel or valley wide structure
3. Typically forms step / drop at construction or over time if grade log is used. Can be a short series of channel roughness
4. Configuration needs to take into consideration possibility of avulsion

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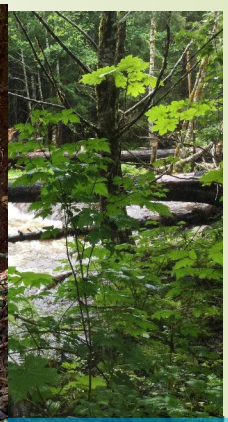
Cross Channel (or Valley) Jam with Additional Log Roughness Example



sski Creek, Alaska

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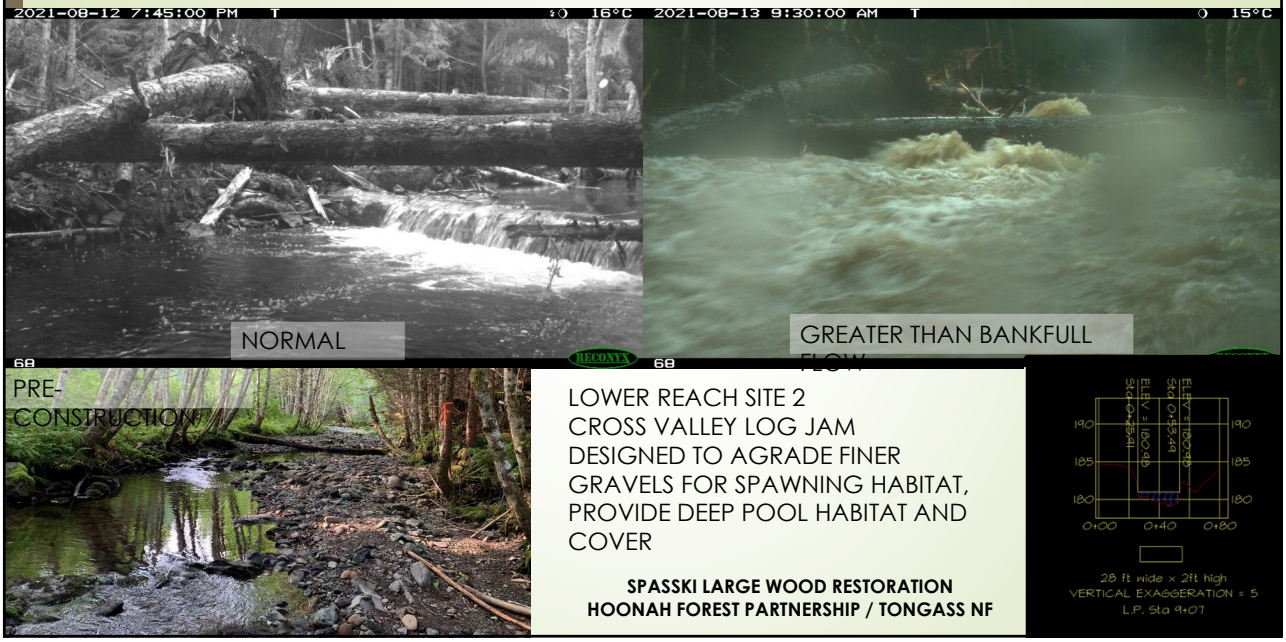
Cross Channel Jam with Additional Log Roughness Example



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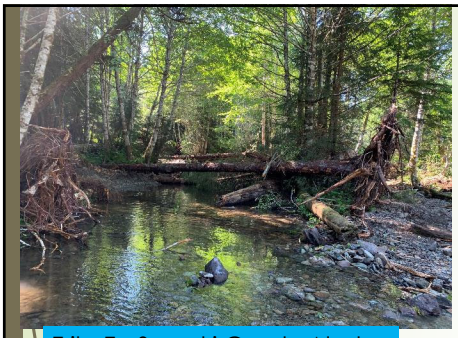
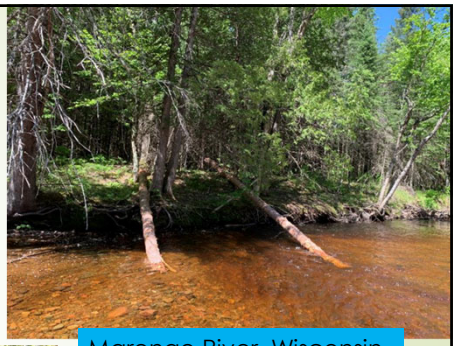
Single Logs/trees and clusters of single logs or trees



Trib. To Spasski Creek, Alaska



Marengo River, Wisconsin

Jemez River, New Mexico

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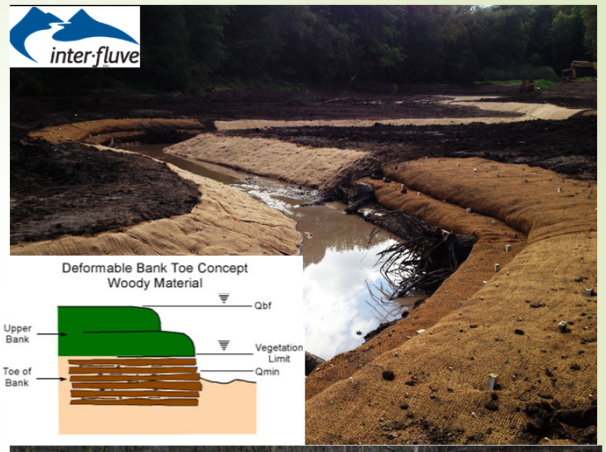
Toe Wood (Small stream)



Toe wood bench
1. High density wood placement
2. Footer logs
3. Constructed bench at bankfull elevation
4. Sub-bankfull benches may be subject to sediment accumulation

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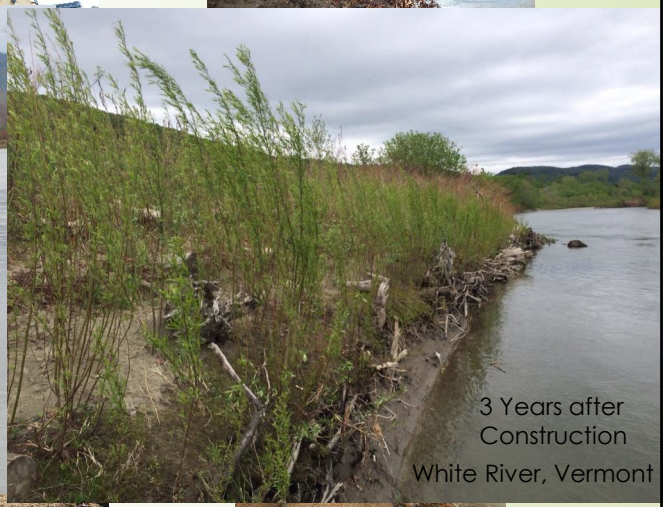
Toe Wood (Large River Variant)

Completed Construction
White River, Vermont



3 Years after Construction
White River, Vermont

Placing Koir fabric.
Soil lift is next

Placing live fascines and ice fenders on first lift

Completed Toe Wood

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Floodplain Wood Examples

Floodplain wood
1. Added for floodplain roughness
2. Use both root-fan and regular logs
3. Typically entangled with existing trees or partially embedded for anchorage
4. Opportunistic siting. Need trees to entangle.
5. Can be used for shadow structures to protect vegetation

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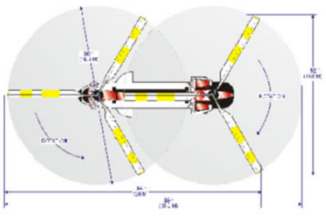
Helicopter Log Jam Construction

- **Can Access places where equipment access is prohibitive**
- **Fast but expensive. $2,500 to $5,000 per hour**
- **Mobilization is spendy so partner up if possible**
- **Requires 200 to 400 gallons per hour fuel consumption**
- **Variable size helicopters available 3,000 lbs to 26,000 lbs capabilities**
- **Grapple configuration is faster than chokers and requires less workers**
- **Difficult getting large helicopters these days due to fire**
- **Can move a lot of trees in a day if stockpile to site distance is 1 mile or less**
- **Safety is key – You can be KILLED!**

BOEING 234 "CHINOOK" - UTILITY - SPECIFICATIONS

Maximum Gross Weight	51,000 pounds *(23,133 kilograms)*
Maximum Hook Weight (precision work) at sea level, standard day	26,000 pounds *(11,793 kilograms)*
Range, Utility (30 minute reserve)	240 nautical miles *(445 kilometers)*
Engines: 2 Lycoming AL-5512 Turbines	4,355 shaft-horsepower max each
Fuel Capacity:	1,000 gallons *(3,785 liters)*
Fuel Consumption: (Jet A)	400 gallons *(1,514 liters)* per hour
Cruise Speed:	120 knots (222 kilometers) per hour



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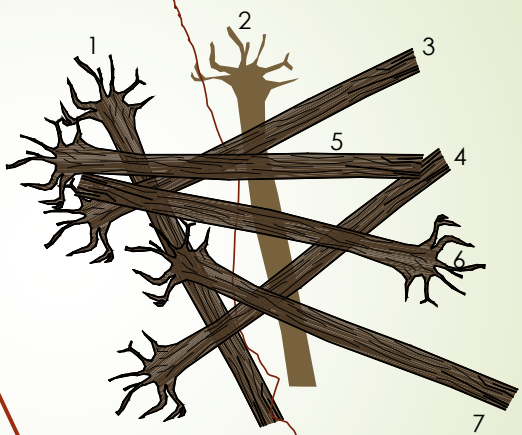
Helicopter Log Jam Construction Plan

Helicopter Construction
1. Log jams are simple configuration
2. Use both root-fan and regular logs
3. Typically entangled with existing trees and extra wood for ballast
4. Least control on log placement (they get pretty close !)
5. Simple plan for layout for pilot and Heli foreman
6. Placement may be limited by canopy closure
7. Fast but expensive construction



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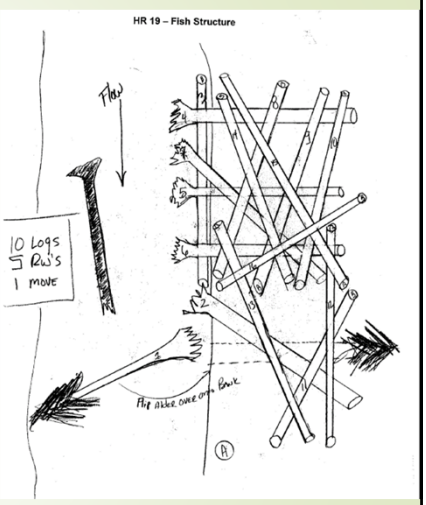
Placing Trees with Helicopters



Design layout for helicopter pilot and ground foremen

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??? Questions???
GEOLOGISTS
WERE CREATED BECAUSE
ENGINEERS
NEED HEROES TOO

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