REFERENCE REACHES, LARGE WOOD & OTHER HABITAT FEATURES

MODULE 10 - GARRETT JACKSON, L.G.

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WSDOT

Hydrology Program Manager
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Current duties: Oversees hydrology program support of Chronic Environmental Deficiencies and Fish Passage Programs. Develops Large Wood policy and reviews implementation. Provides technical support to emergency actions. Designs nature-based shoreline stabilization in marine and freshwater. NCHRP panel support.

Background & Experience: Garrett's experience includes 30 years of theoretical and applied hydrology and geomorphology throughout the western United States and overseas. His work includes stream restoration, geomorphic reach assessments, streambank stabilization, wetland mitigation, geologic hazard evaluation, sediment transport studies, erosion control, hydrologic and hydraulic modeling. He has designed numerous streambank stabilization and stream restoration projects. Garrett worked in consulting for 16 years before joining WSDOT. During the last 12 years, Garrett has been conducting reach assessments, designing emergency streambank stabilization, designing large wood structures, hydraulic modeling, fluvial geomorphic studies, channel migration analysis, and project management.

Education: B.S., University of Arizona, 1986, Geosciences; M.S., 1990, University of Arizona, Geomorphology; Certificate in Stream Restoration, Portland State University, 2007.

Personal interests: Garrett is married and has a large cat, lives in Seattle, and loves backcountry skiing, mountaineers, kayaking, and sport climbing,, playing Brazilian music, and singing sea shanties.

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Reference Reaches, Large Wood, and Other Habitat Features

This module will review the most current WSDOT reference reach and habitat features policies. We will discuss the challenges associated with design and implementation of large wood and other habitat features in stream restoration in the WSDOT context.

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Reference Reaches, Large Wood, and Other Habitat Features

Fish Passage and Stream Restoration Training

Garrett Jackson
July, 2020

Outline

WSDOT

- Reference Reaches
- Large Woody Material (LWM)
- Other Habitat/Design Features

Reference Reaches

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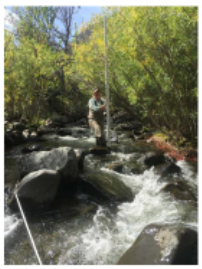
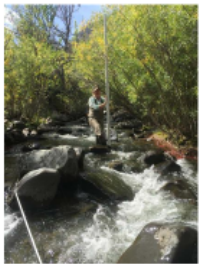
- Important for stream restoration, including fish passage projects
- Helps define appropriate streambed material and channel geometry (slope, width, depth)
- Helps us understand bedforms and contribution of wood



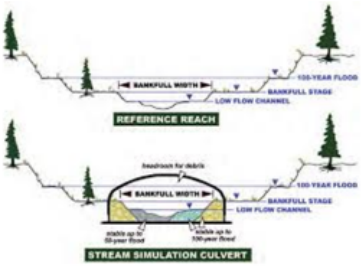
Definitions

- ***Project reach*:** the segment of stream in which the project is located
- ***Reference reach*:** A stable segment of stream with consistent slope, geometry, planform, and sediment load that represents, to the best available knowledge, background condition of the project reach
- ***Stable stream:*** A stream, over time (in the present climate), that transports the flows and sediment produced by its watershed in such a manner that the dimension, pattern and profile are maintained without either aggrading, nor degrading (Rosgen, 1996)
- ***Design reference reach:*** a reach of stream, that matches the geometry of a project reach dictated by constraints



Recommended steps in identifying a reference reach

1. **Examine adjacent reaches OR**
2. **Examine reaches in same watershed farther *upstream* or *downstream* OR**
3. **Examine adjacent watershed with similar conditions THEN**
4. **For selected reach, collect relevant information**



Step 1: Examine reaches immediately upstream and downstream

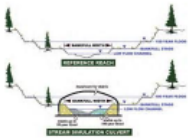
- Does the average stream gradient change *significantly* between upstream and downstream?
- Are there signs of chronic erosion or deposition?
- Are there any man-made features within the active channel? Within the floodplain?
- Are there any sudden changes in sediment size distribution?
- If the answer is "NO" to **all** of the above, then it is appropriate to use as a reference reach.

Step 2. Choose a reference reach based on similar reach characteristics.

- Examine a topographic map at the 1:24,000 scale (or finer) for reaches farther upstream and downstream of the project reach.
- When a reach with similar slope and channel confinement is identified, determine the size of the contributing watershed area. Is it similar (+/-20%) to the contributing area above the project reach?
- If "YES", go to Step 3. If "NO", look to adjacent watersheds with similar aspect, elevation, and geology and go back to step 2(a).

Step 3. Gather data on reference reach

a) In what stage of channel evolution is the reference reach?
b) Measure water surface slope during non-flood event
c) Measure bankfull width in at least 3 representative locations;
d) Conduct pebble counts in at least 3 locations on rifles or pool tailouts.
e) If there is more than 10% sand and finer, use bulk sampling and analysis for sediment size distribution.
f) Note riparian zone vegetation, canopy density
g) Note presence (or absence) of LWM, especially key pieces.
h) Record geographic coordinates of reference reach, using GPS unit or similar.



Large Woody Material and Other Habitat Features

- Where and when we work in streams
- Large wood use and design
- Boulders & other features

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Large Woody Material

What is it?

- > 6 feet length
- > 6" diameter
  (DBH – diameter at breast height (4.5')

Why are we discussing it?

- Bank protection
- Channel resilience
- Aquatic habitat benefits
- Required by partnering entities

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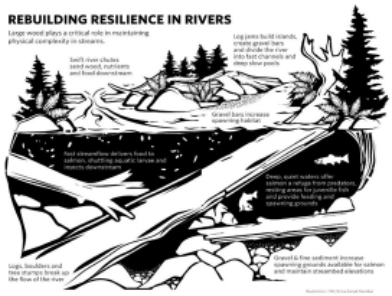
LWM habitat benefits

- Cover from predators
- Contributes to hyporheic flow
- Attenuates stream power
- Cooler water
- Macroinvertebrate habitat
- Gravel retention



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LWM in fish passage program

- LWM concept developed in PHD
  - Determine LWM targets
  - Plan view depiction of concept
  - Description of each structure type & function
  - Any constraints discussed with HQ Hydraulics
- Stability, final sizing and layout in FHD
  - Develop anchor concepts
  - Log orientation and elevation finalized based on stability calculations.
- May need "as directed" notes in design drawings

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Steps in the LWM design process

1. Determine project objectives
2. Conduct a Site and Reach Assessment (PHD)
3. Conduct a Water Safety Assessment (if needed)
4. Determine LWM targets (#key pieces, #total, volume total)
5. Determine LWM structure designs and locations
6. Incorporate LWM structures in hydraulic model (implicitly or explicitly)
7. FHD – finalize LWM design

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Determine Project Objectives

- Habitat functions (cover, shade, refuge - **typical**)
- Bank stabilization (less common)
- Flow Re-direction
- All of the above

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Conduct a Reach Assessment

Is it an alluvial or bedrock channel? Till?

- Evaluate riparian conditions
  - Contribution of LWM to stream function, stability
  - Is the stream lacking wood? If so, why?
- How confined?
- What is the channel gradient?
  - generally we place wood in channels <2%
  - up to 5%
- What tendency for degradation? Aggradation?

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Water Safety Assessment

- Is the stream considered "recreational"?
- Would LWM create unacceptable or unmitigatable risk to the public?
- Place where there is visibility from upstream
- Don't design or place in a situation that prevents circumnavigation
- Design to prevent "straining"
- Don't place near boat ramps or other access points
- Consider signage on a case-by-case basis
- Public involvement/notification may be needed

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Water Safety Assessment

- Is the stream considered
- table or
- ic?
- from
- uation
- on
- or other
- by-case
- on may be needed

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Determine LWM Targets

- Use LWM metrics calculator
- Enter project-specific information:
  - Length of regraded channel section
    - Includes length of crossing structure (even if we can't place wood)
  - Bankfull Width
  - Habitat zone
- Use lookup tables to determine target values
- Enter log dimensions and number
  - Meet key piece volume and number first
- Iteratively add and adjust log numbers and volumes
- Until targets are met or exceeded

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What is a key piece?

- Fox and Bolton (2007)/WFPB:
  - A log and/or rootwad that is (1) independently stable in the stream bank-full width (not functionally held…by another log, buried, trapped against a rock or bed form) and (2) retaining or having the potential to retain other pieces of organic debris.
- In fish passage/stream restoration projects:
  - A log with rootwad that meets the 75th percentile of the key piece volume for the appropriate bankfull width and habitat zone

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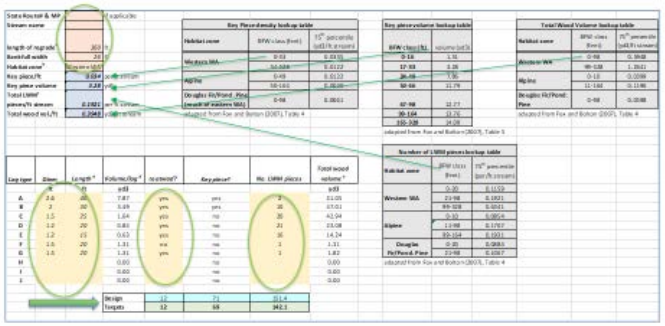
LWM metrics calculator



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Determine LWM structure designs and locations

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Determine LWM structure designs and locations

- Design for the identified objectives (usually habitat)
- Incorporate diversity of structure

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LWM diversity

- LWM sizes (don't rely on key pieces only)
- Orientation
- Elevation
- Angle (0-360 degrees)
- With/without rootwads (non-key pieces)
- Groupings of logs
- Degree of flow deflection
  - OK to be farther out than centerline!

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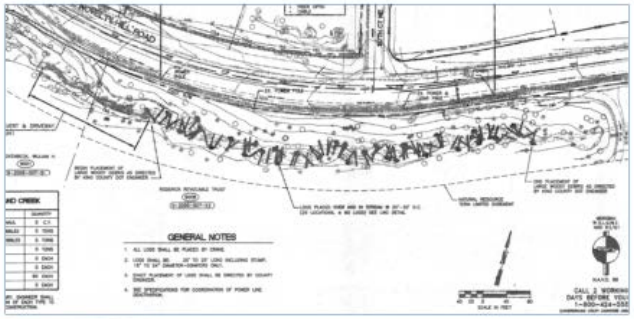
Examples



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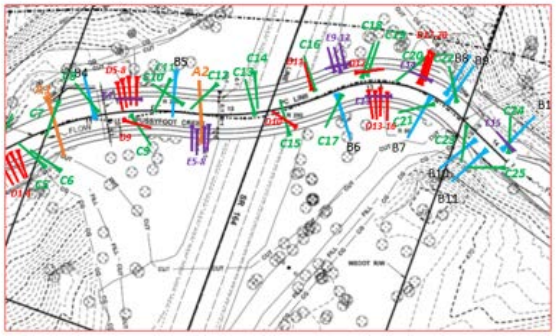
Examples



Determine LWM structure designs and locations

- Design for the identified objectives (usually habitat)
- Incorporate diversity of structure
- **Minimize anchors**

Avoiding anchors

- Use topography to our advantage
  - Steep slopes easier to use for self-ballasting
- Use existing features (trees, mostly) and lashings
- Factor of Safety flexibility?
  - Downstream of crossing
  - What is downstream of the reach?
  - Possible to design for less than 100-year flow
  - 'Mobile wood'

Self-ballasting LWM

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Self-ballasting LWM

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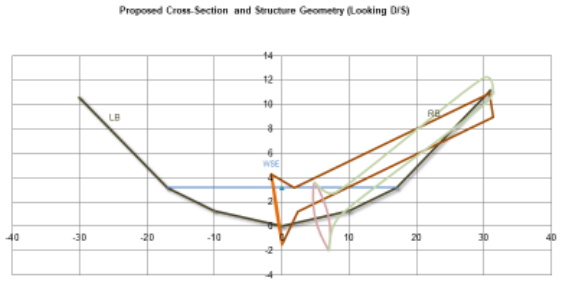
Example – Pussyfoot Creek



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Existing Features as Anchors

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Determine LWM structure designs and locations

- Design for the identified objectives (usually habitat)
- Incorporate diversity of structure
- Minimize anchors
- **Key pieces engaged with all flows**
- **Non-key pieces engaged with flow as much as possible**

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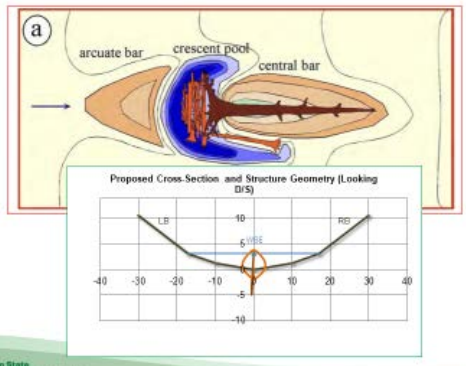
Center of stream



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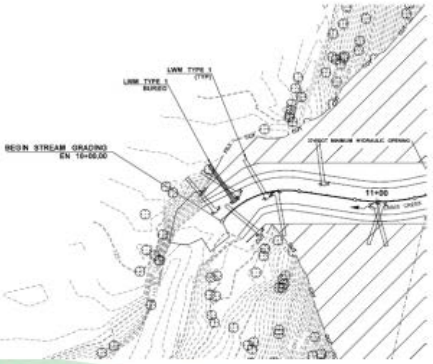
Projecting



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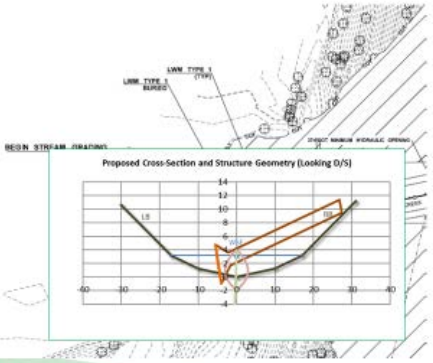

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Channel spanning

- Higher risk to structures, property
- Potential barriers
- Can span above the design flow

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Determine LWM structure designs and locations

- Design for the identified objectives (usually habitat)
- Incorporate diversity of structure
- Minimize anchors
- Key pieces engaged with all flows
- Non-key pieces engaged with flow as much as possible
- **Working with Constraints**

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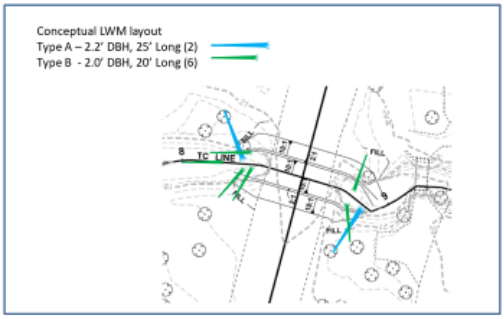
Working with constraints

- 

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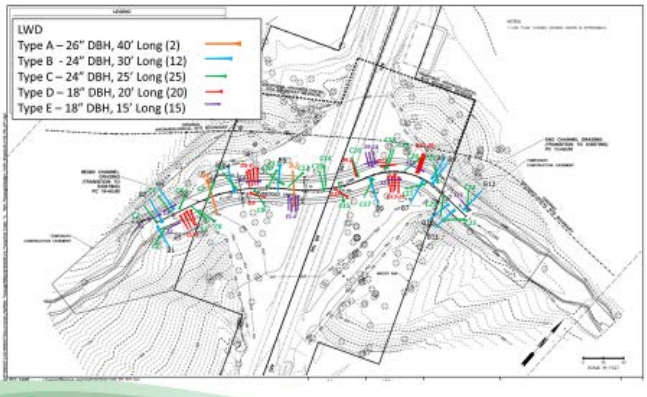

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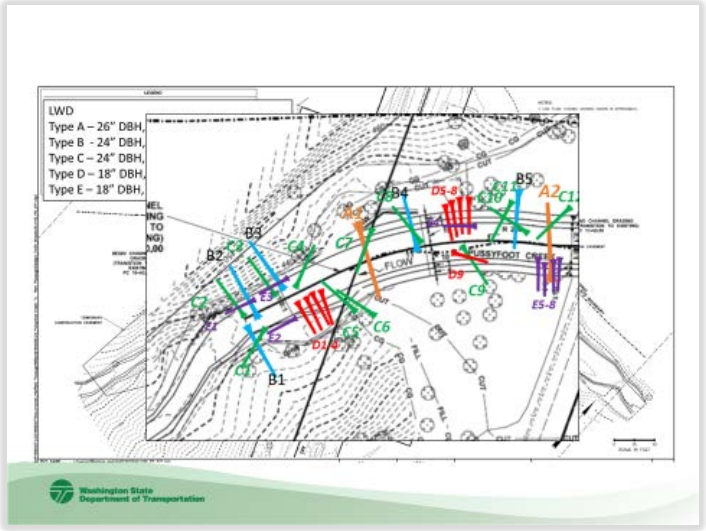

Working with constraints

- Space constraints – what about in/under structures?
- Culverts – not inside (rare exceptions)
- Bridges – as a rule, "NO"
  - If no other way to accommodate wood, and there is a strong justification, must undergo risk assessment

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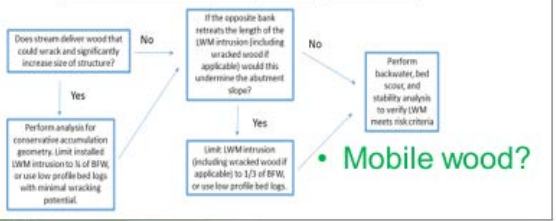
LWM under bridges

All LWM designs under bridges shall address the following risks:

- Undermining of abutment slopes – see decision tree below for allowable LWM intrusion into channel
- Backwater - demonstrate adequate freeboard with a hydraulic model that reflects obstructive effects of LWM
- Bed Scour - foundations should be deep enough to accommodate increase bed score. This will typically be only a few feet for single logs in gravel beds, but will be much more significant in sand beds or with wracked structures.
- Stability – minimum Factor of Safety of 2 for buoyant and drag forces

Decision tree for allowable LWM geometry to avoid bridge abutment erosion:



- Mobile wood?

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FHD – finalize LWM design

- Conduct stability calculations
- Factor of Safety
  - >1.5 generally, for buoyant force, shear force, moment
- Adjust elevation, orientation, angles to minimize anchors while meeting factor of safety
- Determine anchor style based on site conditions

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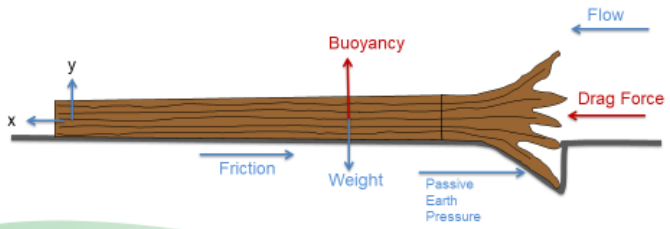
Force Balance on a Log on the Streambed

- Factor of Safety of 1.5 or greater for: Buoyancy, Shear, Moment



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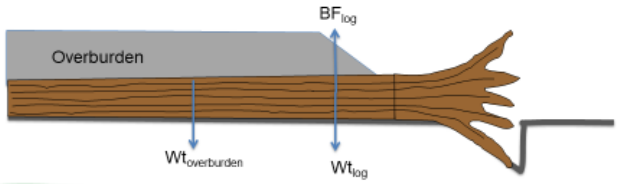
Anchoring by Burial

- Buoyant forces resisted by weight of overburden (rocks, soil, slash)
- Risks: insufficient overburden, flanking by bank erosion.



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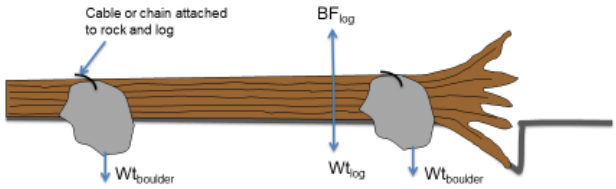
Anchoring with Boulders

- Buoyancy and drag resisted by weight of boulders
- Attach boulders with chains or cable
- Risks: failure of cable attachments (slack in cable)
- Benefits: as scour happens, structure can settle as a unit



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Stability Calculations

- FHD stage (typically)
- Use tool such as Rafferty (2016)
  - Gather inputs
- If cannot be stable to a reasonable Fs
  - And no natural anchors available
- Turn to artificial anchors

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Incorporate LWM structures in hydraulic model

- Obstruction?
- Porous?
- Roughness?
- Sensitivity analysis

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When is LWM not appropriate?

- Under a low bridge
- Buried structures
- Where debris flows might be expected
- Backwatering
- Excessive scour as other LWM racks (think fire)

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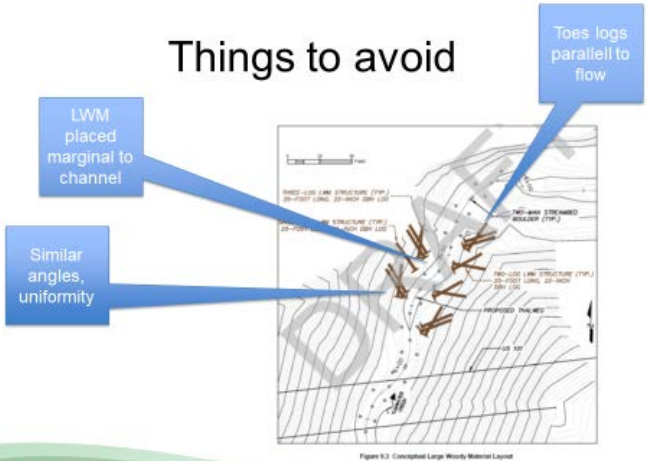
Things to avoid



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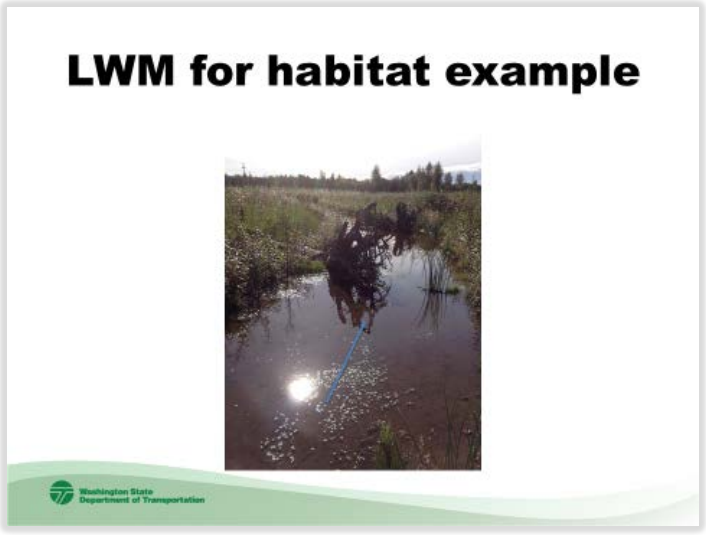
LWM for habitat example

LWM for habitat example

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LWM Examples – Flow re-direction

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LWM Examples – Multi-log

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LWM for bank protection

- Many *recent* designs reflect legacy of using this style
- This uses wood to provide flow re-direction, lateral support, without rock
- Not best for habitat

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Other channel habitat features

- Mobile Wood
- Buried Wood
- Boulders
- Beaver Dam Analogs
- Step Pools
- Bioengineering banks

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Mobile Wood

- Design flow less than 100 year
- Stability is project-specific
  - Mobile with as little as 2-year flow
- Consider downstream constraints carefully
- Can meet LWM volume targets
  - Not for key piece targets

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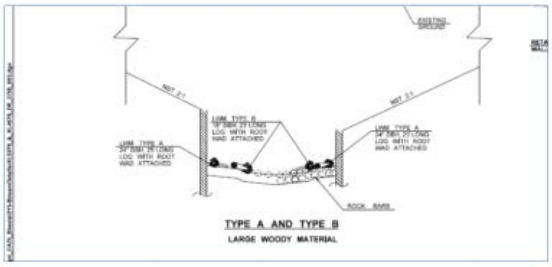
Mobile wood example



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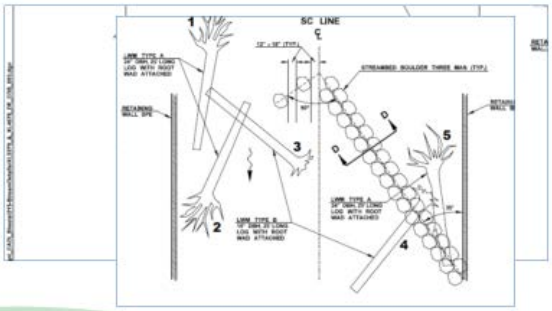
Mobile wood example



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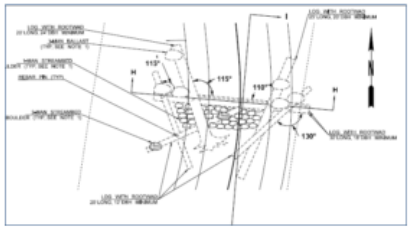
Buried Wood

- Used as tool against degradation uncertainty
- Designed carefully – avoid barrier potential



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Boulders and other features

- When present in reference reach
- Added for "hydraulic diversity"
- May consider for increasing roughness
- Meander bars
  - Meant to maintain low flow channel
  - Sinuosity
  - Scour

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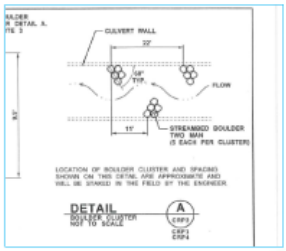
Boulders Clusters

- A way of creating habitat diversity within a buried structure
- Can't simulate root strength of riparian zone
- Want to maintain low flow channel
- Keep flow off structure walls



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Boulders Clusters

- A way
  within
- Can't
  zone
- Want
  flow cl
- Keep
  structu

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Things to avoid

"grid" of boulders

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Things to avoid

"grid" of boulders

Low flow velocity barrier

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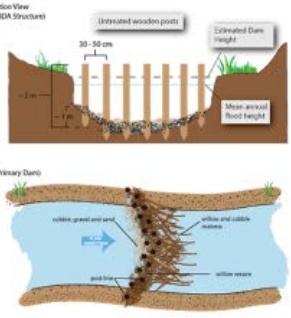
Beaver dam analogs



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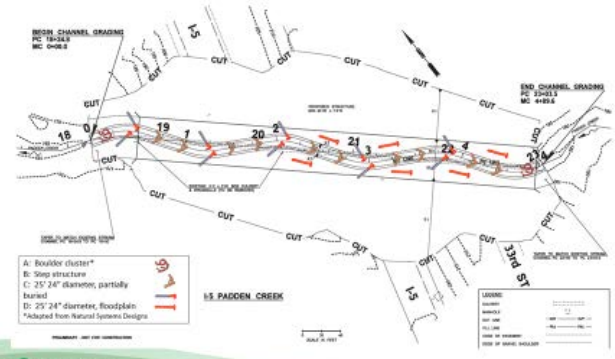
Step pools



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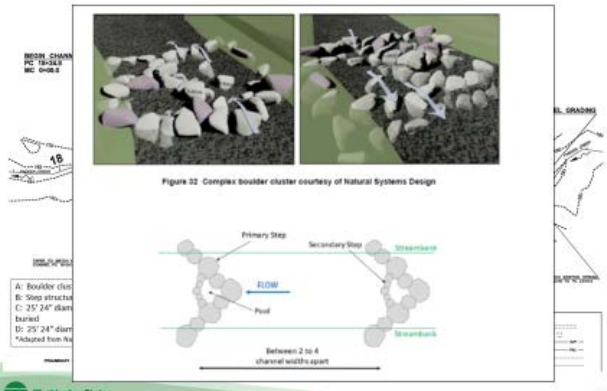

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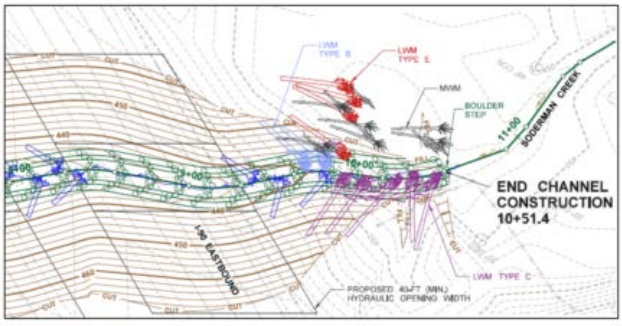

Bioengineering streambanks

- Fabric wrapped soils
- Brush mattresses
- Coir logs and cuttings

- Need to be integrated at the PHD level
  - Need to retain bank form for several years until plants establish

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Bioengineering streambanks

- Fabric w
- Brush m
- Coir log

- Need to b el
  - Need to rs until pla

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Bioengineering streambanks

- Fabric w

- N

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Bioengineering streambanks

- N

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Questions?

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Resources

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