Salmonid Restoration Federation Large Wood Field School

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

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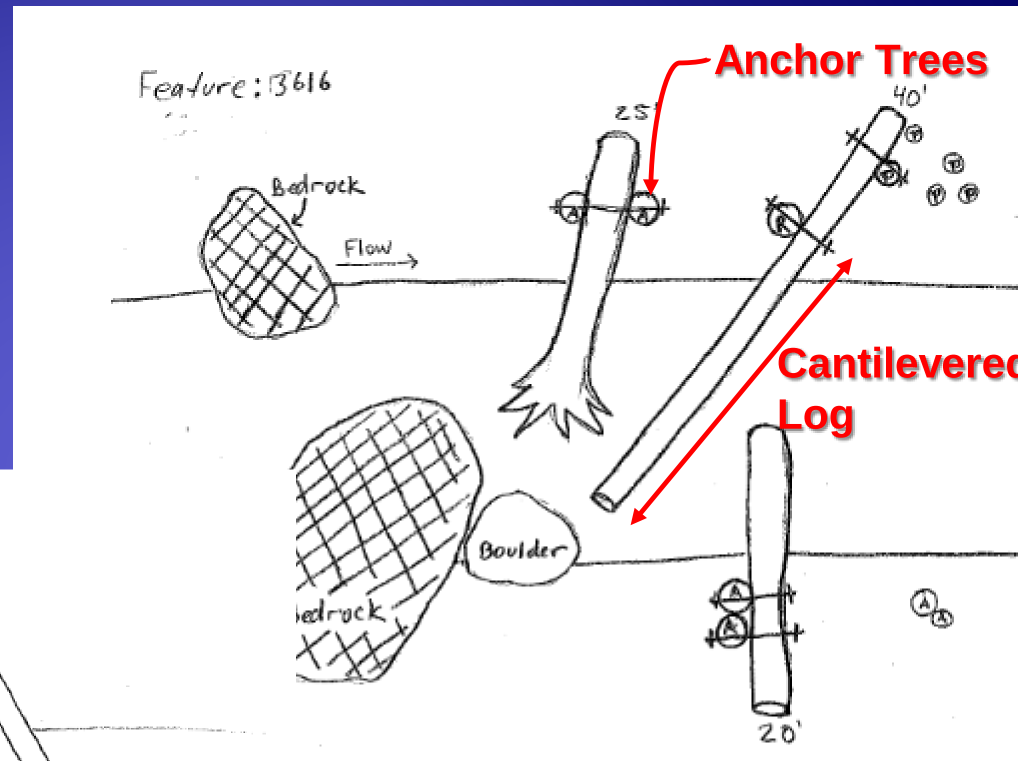
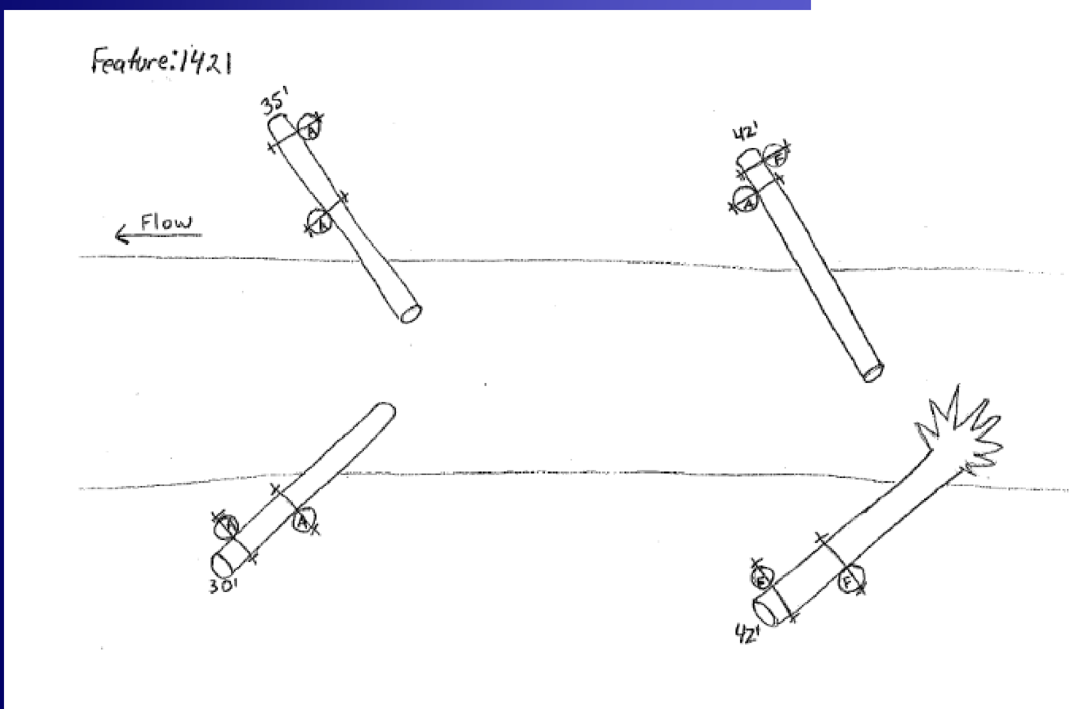
November 2021

Kenny Creek Case Study: Cantilever Log Structure Stability Assessment





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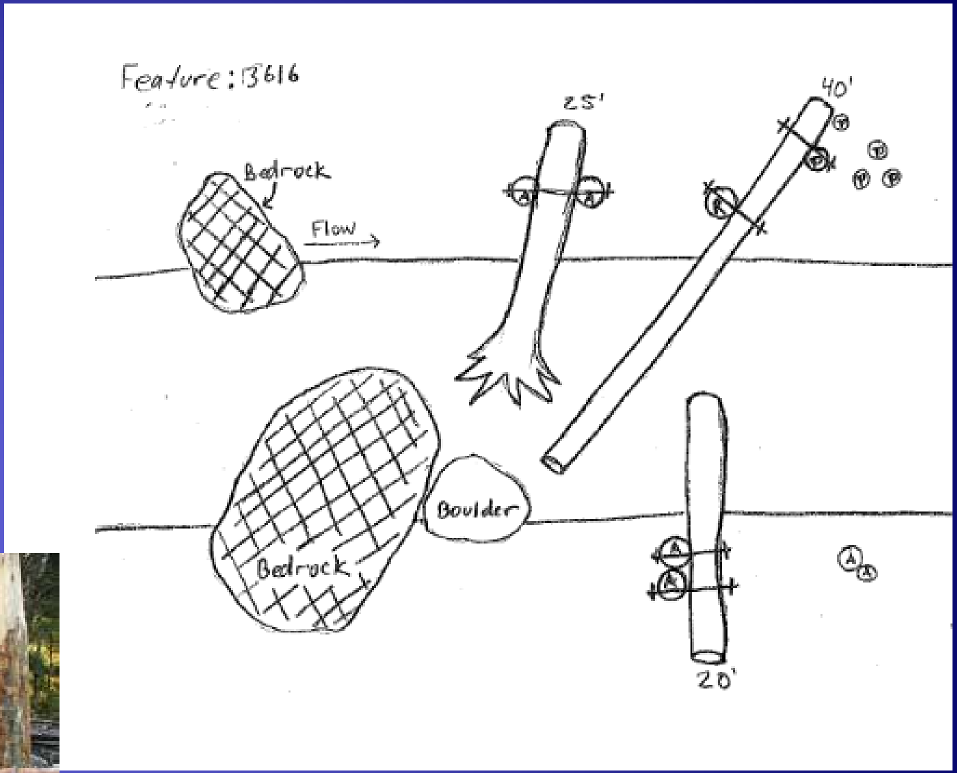
Kenny Creek Case Study

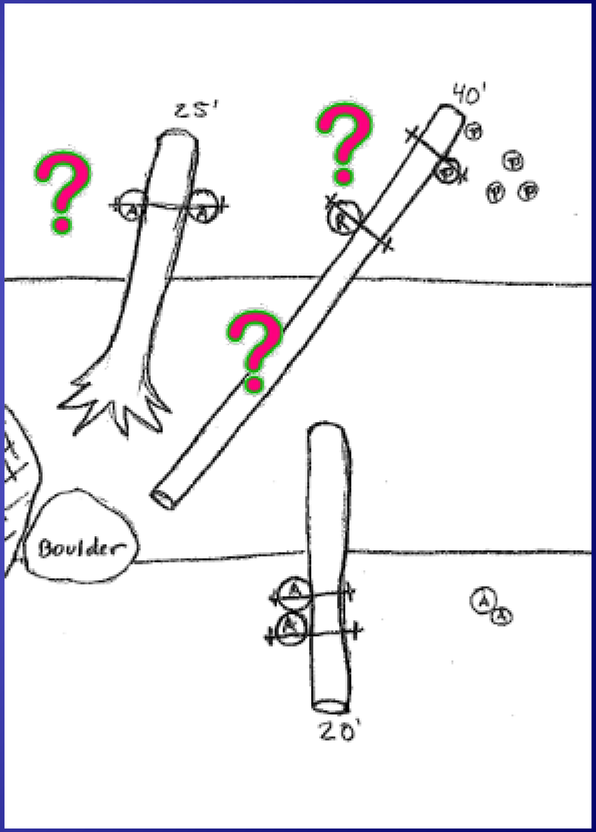
Given the hydraulic properties of a channel

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



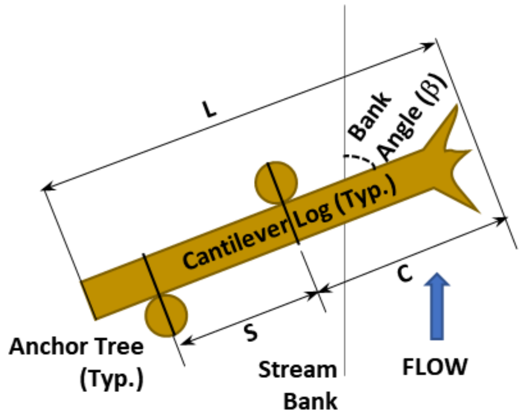
So how BIG can I make it?

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. Are 2 anchor trees better?
7. Do log pitch and bank angle matter?

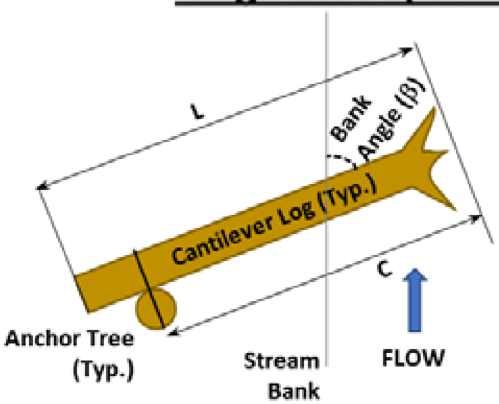


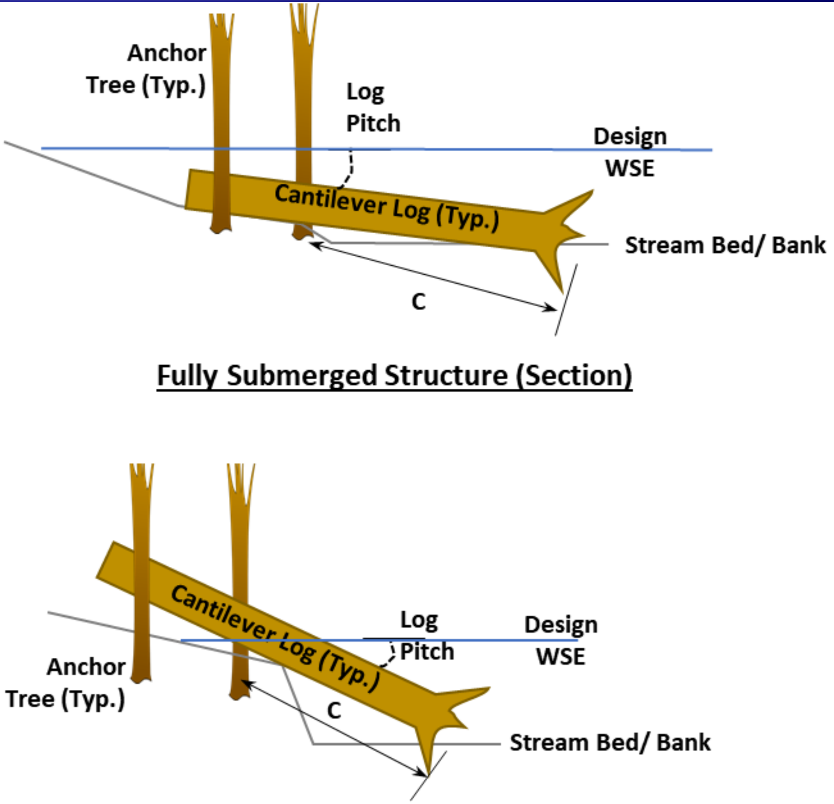
Kenny Creek Typical Structure Layouts

Cantilevered Root Wad Layout (Plan)



Cantilevered Root Wad Anchored to Single Tree (Plan)





Fully Submerged Structure (Section)

Partially Submerged Structure (Section)

Driving Forces on Acting Logs from Flows

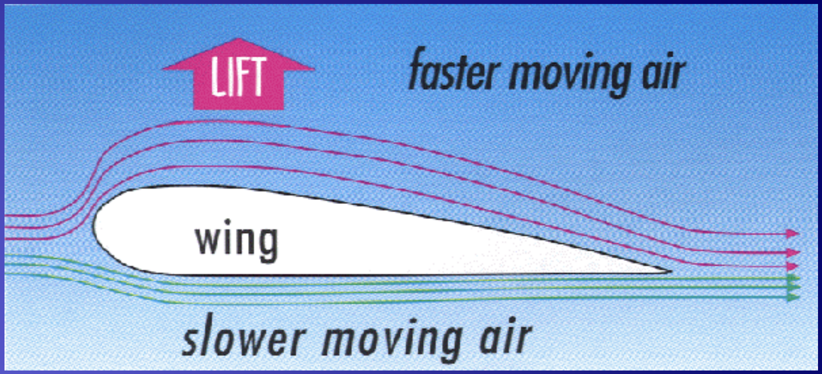
Vertical Forces

1. **Buoyancy**
2. Lift

Horizontal Forces

1. **Drag**

Buoyancy



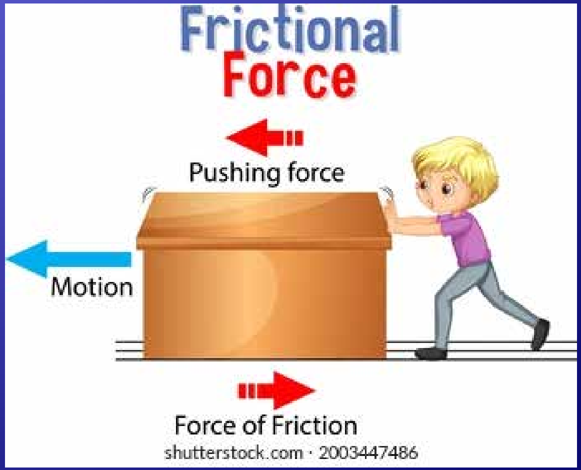
Stabilizing Forces Acting on Logs

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%

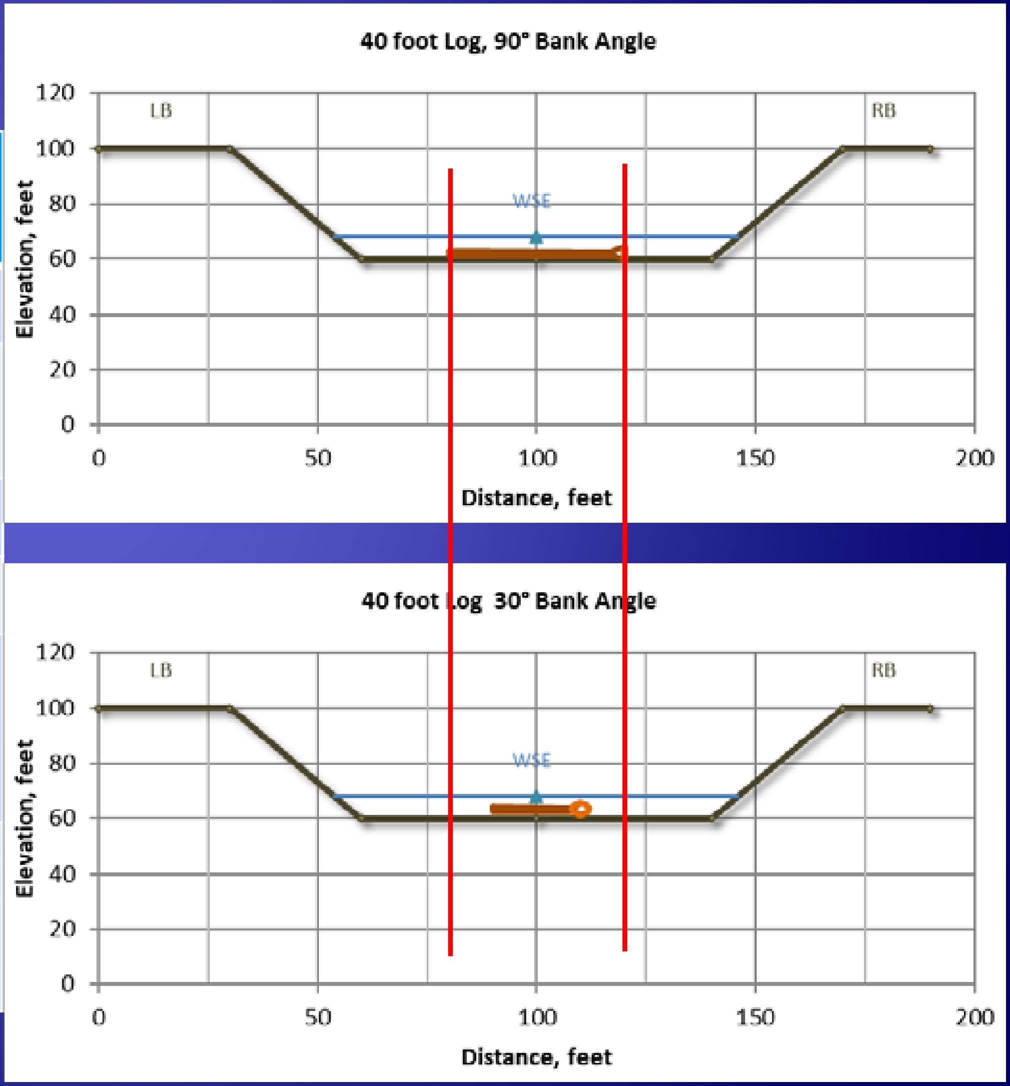
Design Flow Event: 25 Year RP

- **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

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

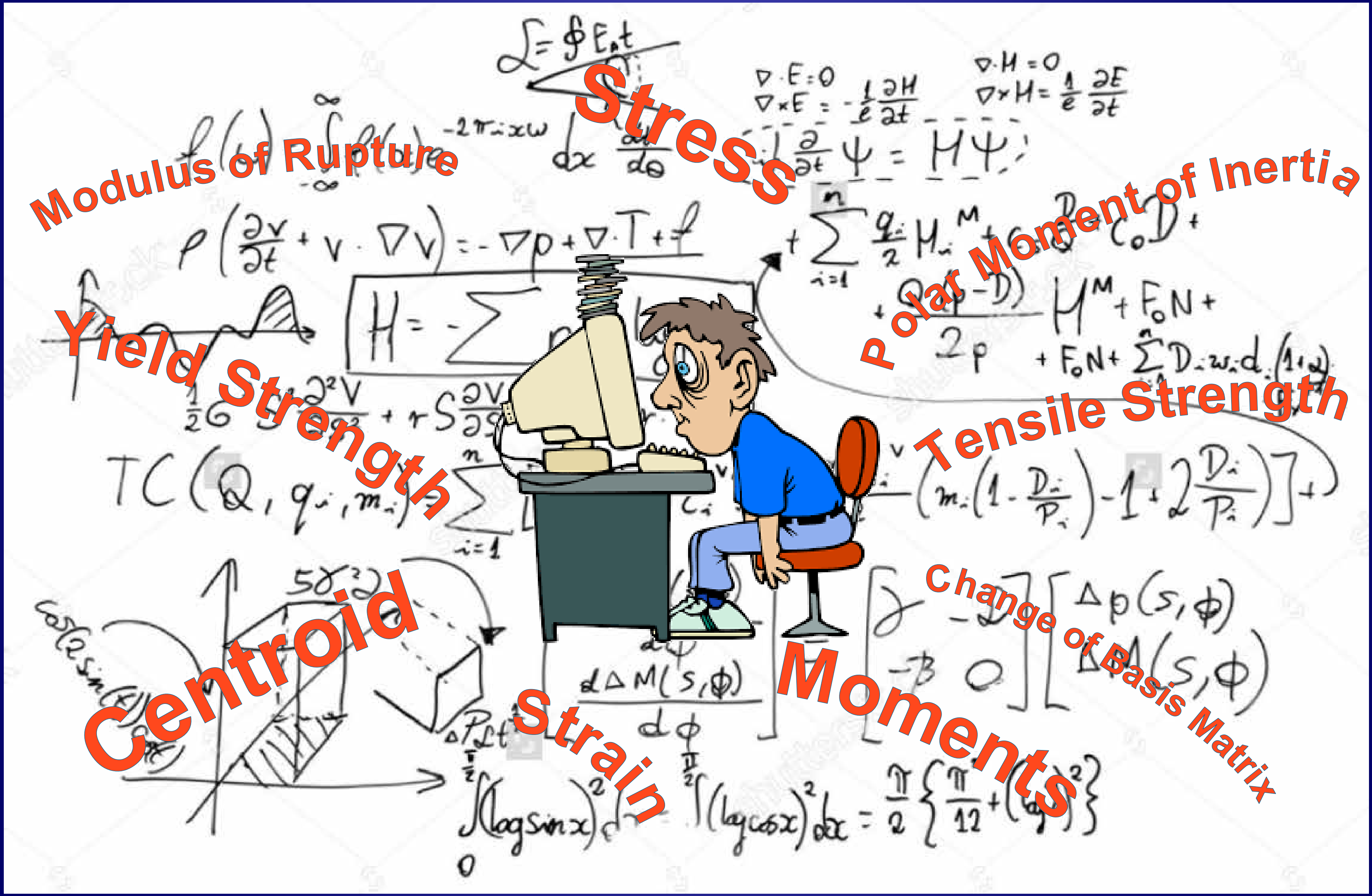
Properties vary with direction of force

Typical Material Properties

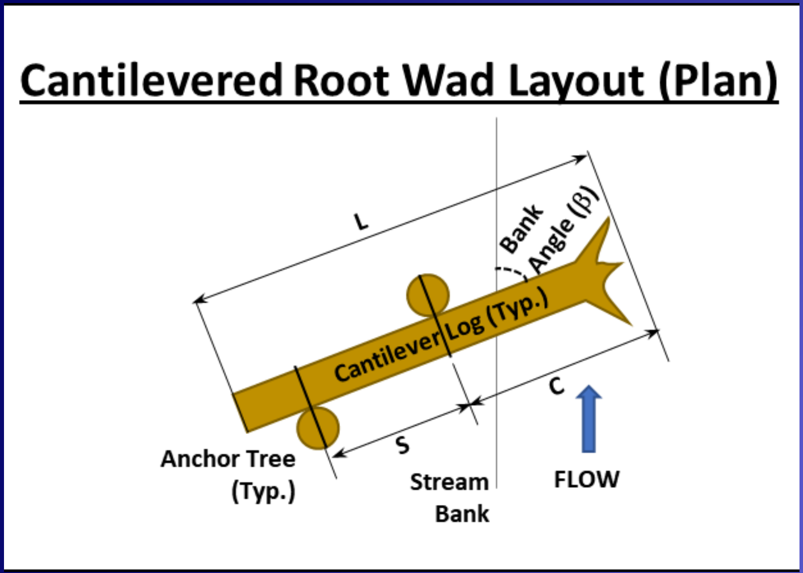
Material Strengths of Wood and Rebar		
Material	Bending Strength (lbs/in^2)	Twisting Strength (lbs/in^2)
Douglas Fir (Dry)	**12,400**	1,130
Douglas Fir (Green, Live)	7,700	900
Redwood (Dry)	**7,900**	1,100
Redwood (Green, Live)	5,900	890
Red Alder (Green, Live)	6,500	770
1” Rebar (Grade 75/80)	75,000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

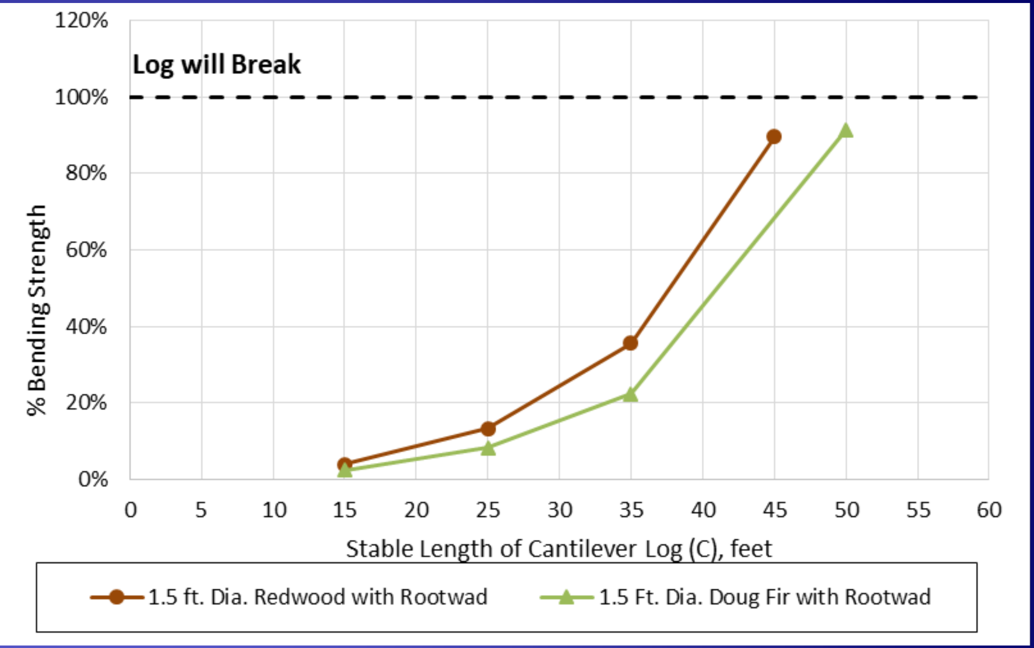
Wood Type	Dry Density (lbs/ft3)
Douglas Fir (Coast)	33.5
Redwood (young)	24.5

Interlude for Mind Numbing Math



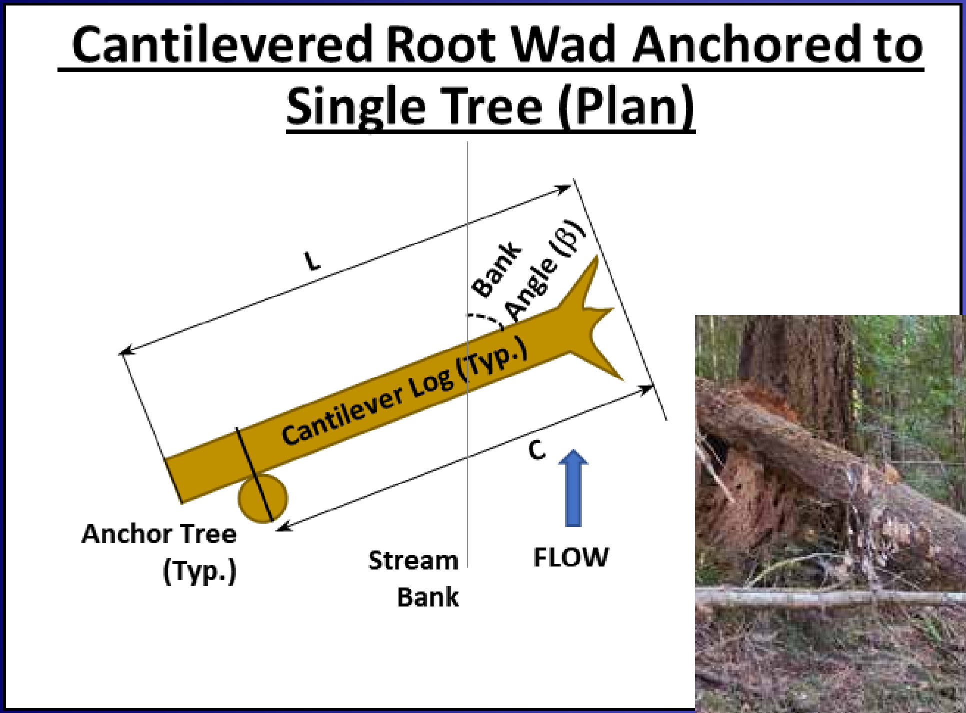
How Far Can I Stick my Cantilever Log into the Channel without it Breaking?





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

Can I get away with One Anchor Tree?
How Big does my Anchor Tree need to be?
Will my Rebar Bend?



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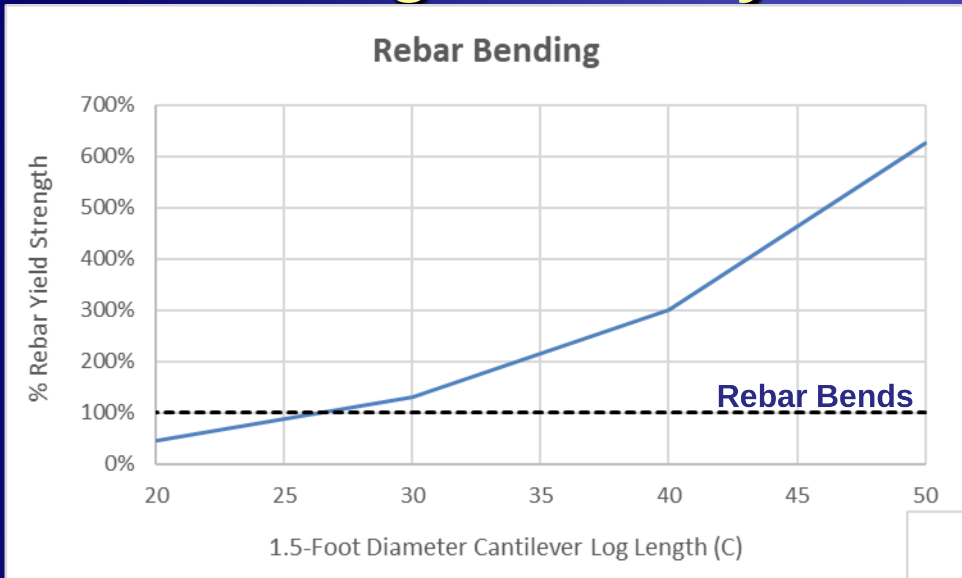
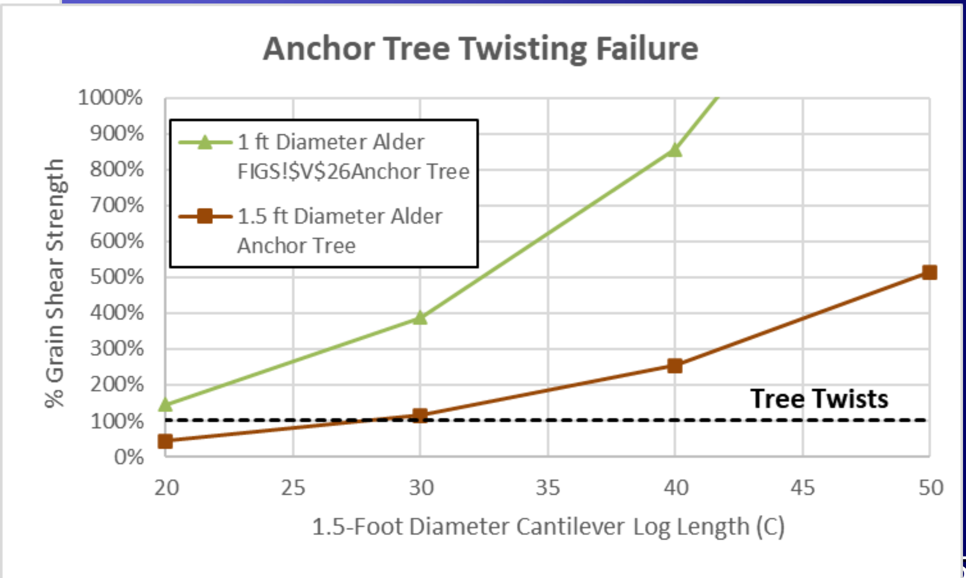
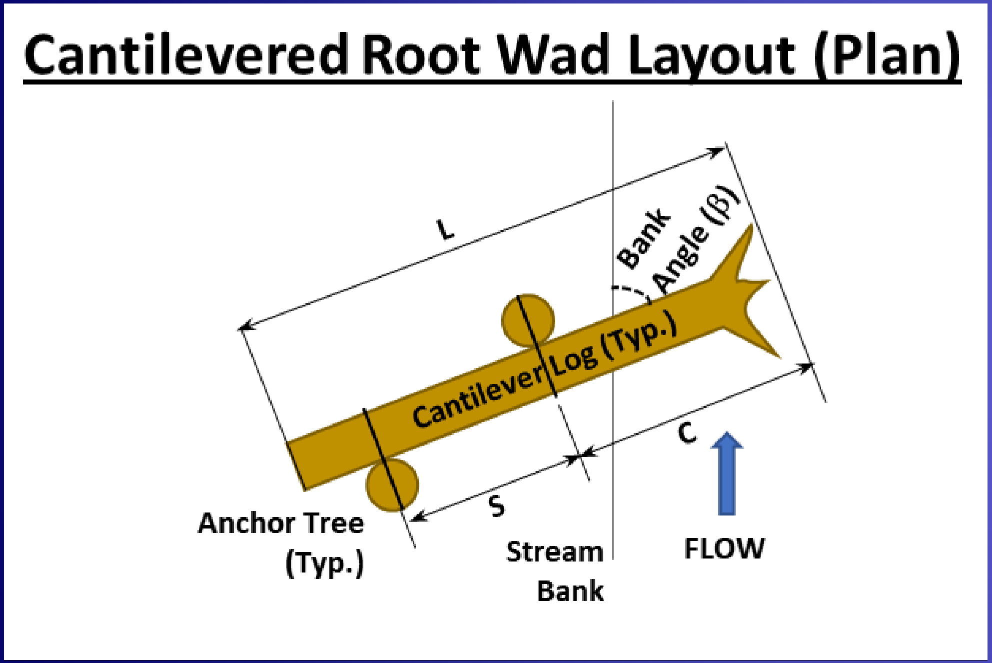


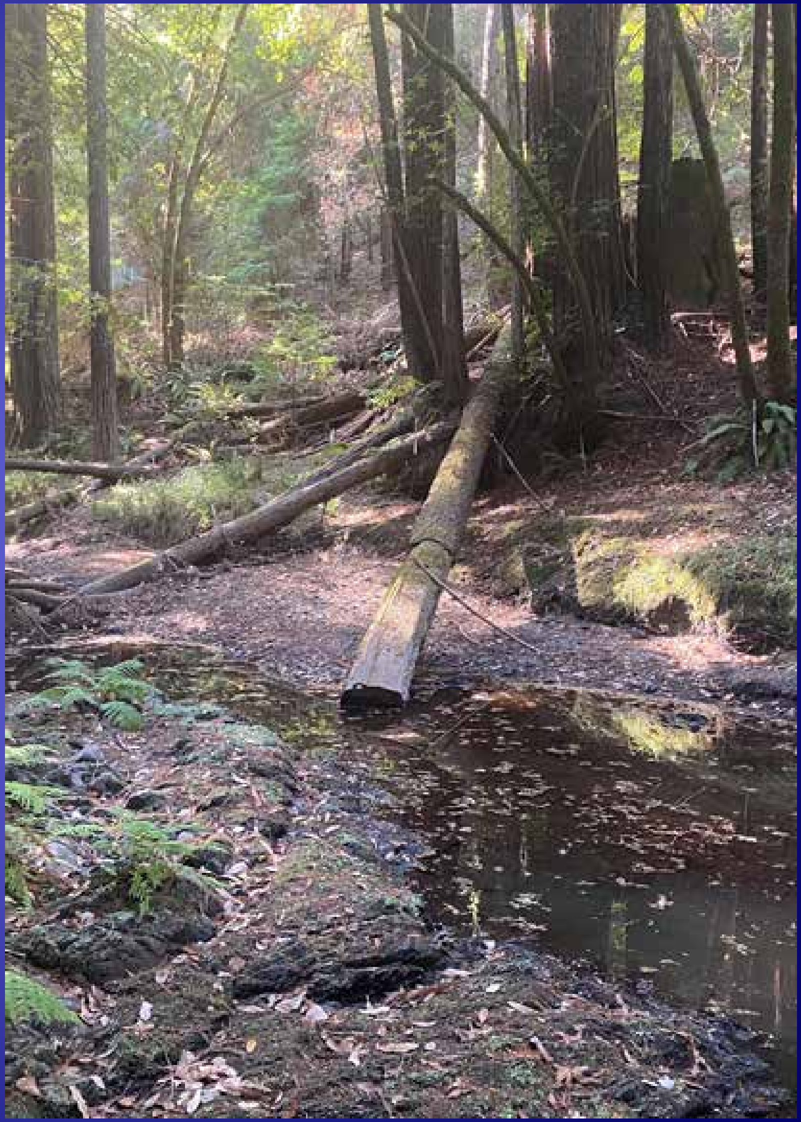
Grain Shear Strength (Twisting) of Live Trees	
Material	Twisting Strength (lbs/in^2)
Douglas Fir (Green, Live)	900
Redwood (Green, Live)	890
Red Alder (Green, Live)	770



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

Are 2 anchor trees Better? How big? How far apart?





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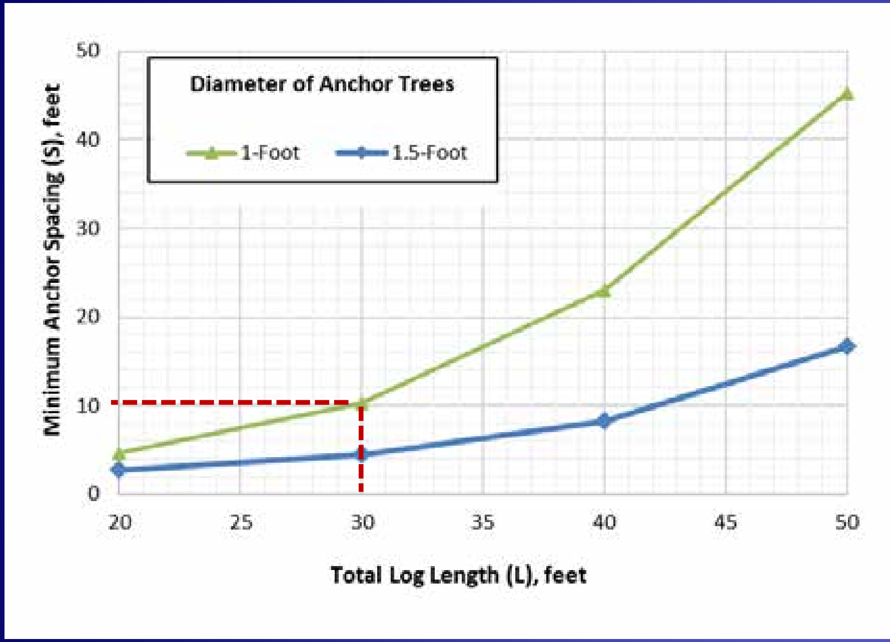
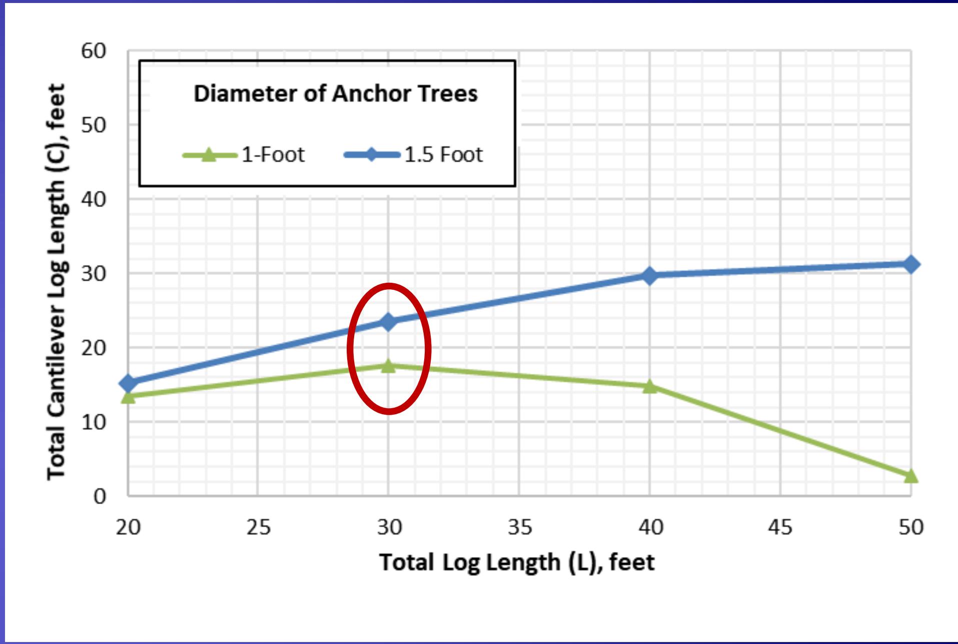
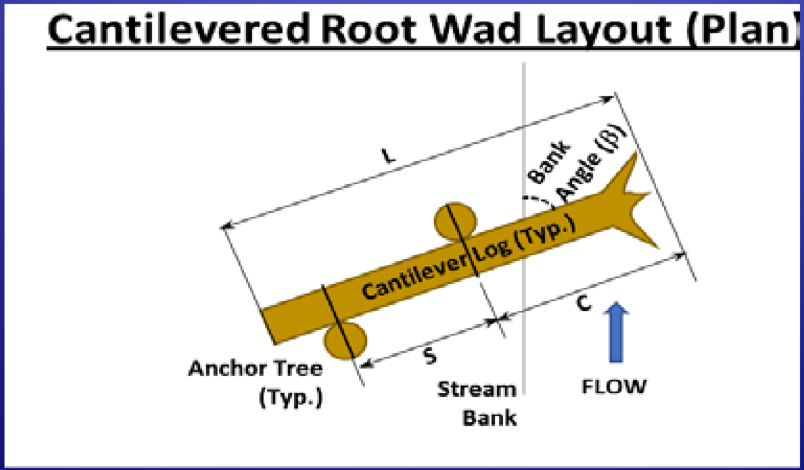
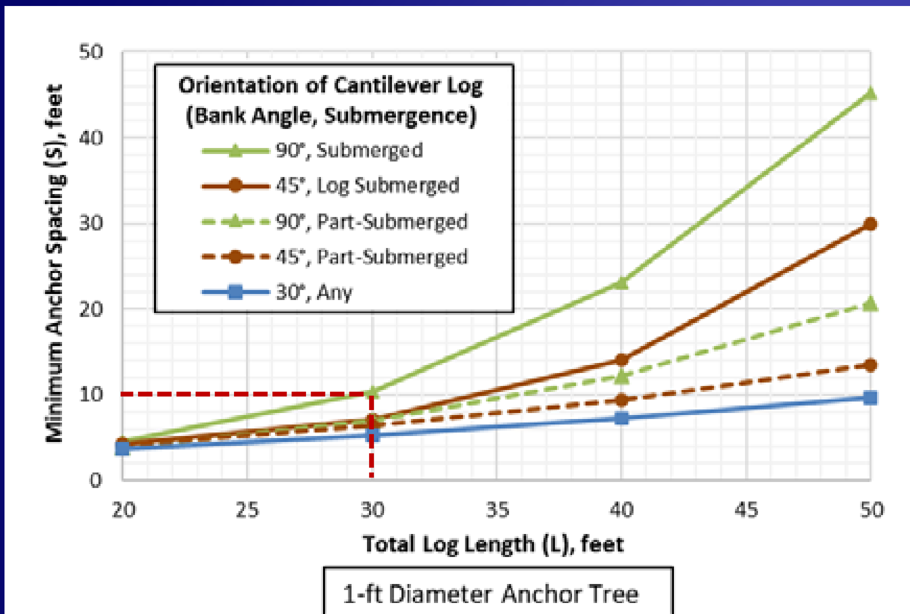
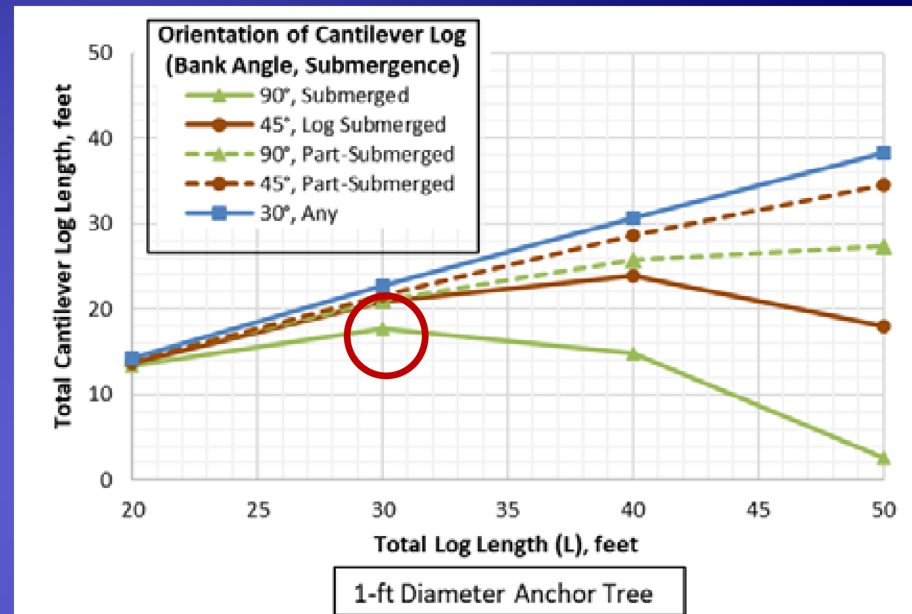


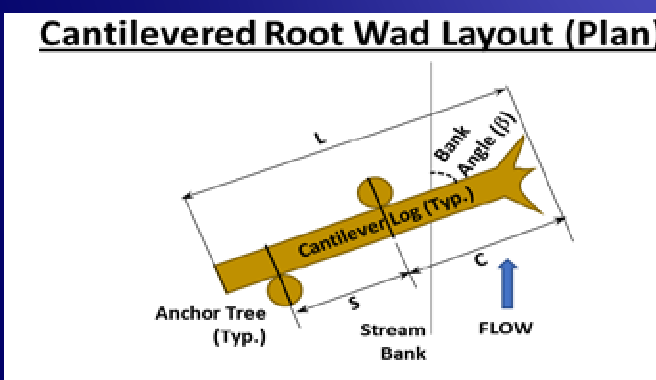


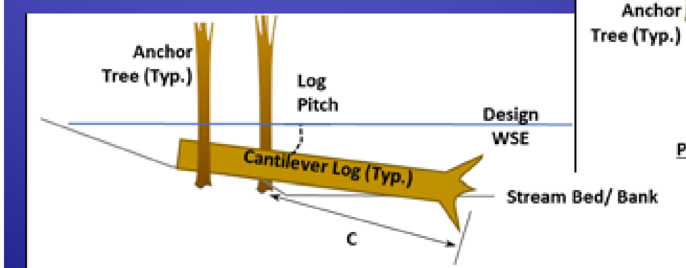


Are 2 anchor trees better? How Far Apart? Do log pitch and bank angle matter?

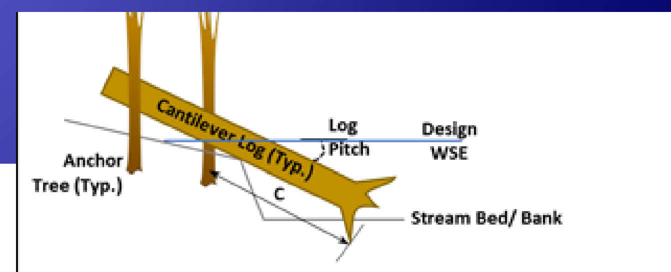








Fully Submerged Structure (Section)



Partially Submerged Structure (Section)

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

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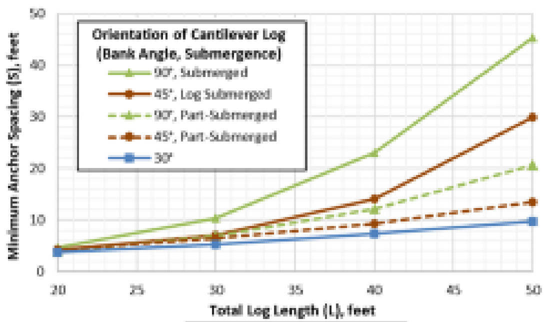
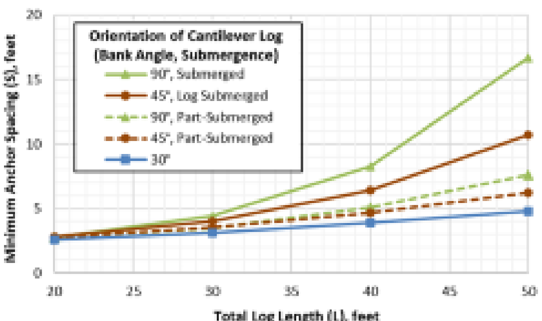
Kenny Creek Cantilevered Log Layout Sheet

Eel River Watershed Improvement Group

ANCHOR TREE SPACING AND TOTAL CANTILEVER LOG LENGTH

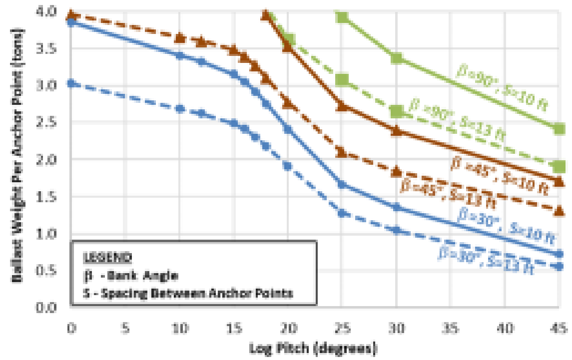


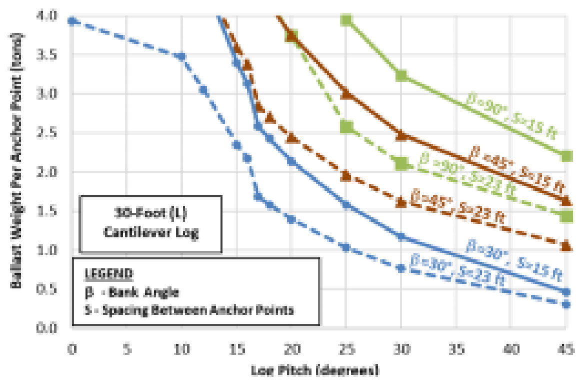
1-ft Diameter Anchor Tree

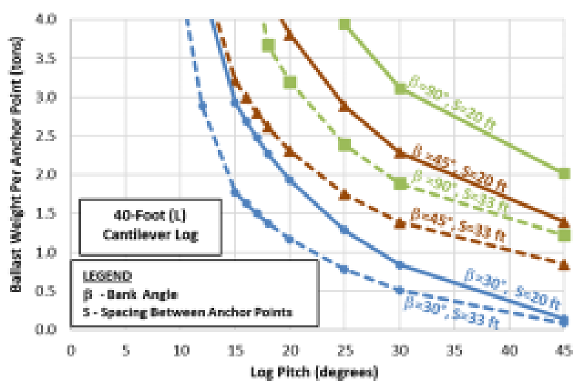


1.5-ft Diameter Anchor Tree

MINIMUM BALLAST WEIGHTS FOR EACH ANCHOR POINT

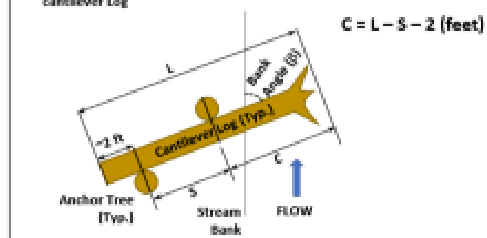




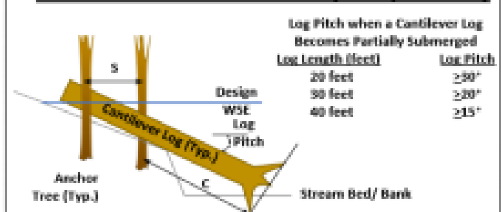


Cantilevered Root Wad Layout (Plan)

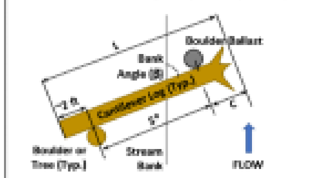
*NOTE: Anchor Trees can be located upstream of downstream of cantilever Log



Cantilevered Root Wad Layout (Section)



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

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)