Design Considerations for Large Wood Projects

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Overview

- Uses of wood in rivers
- Design considerations
  - Forces at work
  - Countermeasures

Why wood?

- Wood is a natural component of forested streams and rivers
  - In-stream Density varies
- Wood can provide both habitat complexity and stability elements
- We've removed much of the wood
- We've limited its recruitment

Uses of wood in rivers

- Bank protection at strategic locations
- Creates local scour
- Provides fish habitat
- Wildlife habitat

Uses of wood in rivers

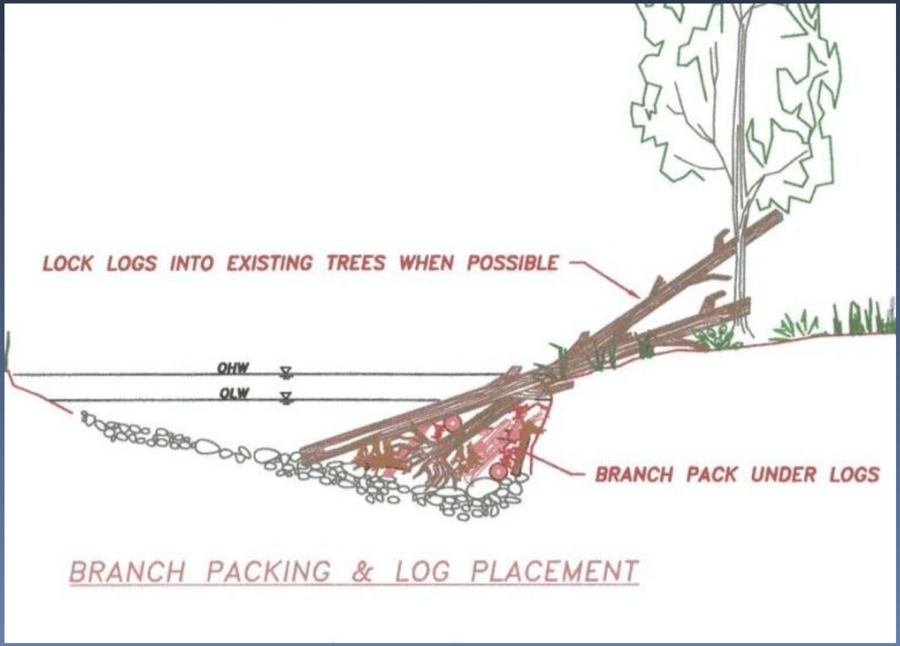
- Stream structure
- Grade control

During construction

Uses of wood in rivers

- Floodplain roughness
- Water training
- Refugia during floods
- Protect critical transitions

Uses of Wood



Combination

- Stabilization
- Fish habitat

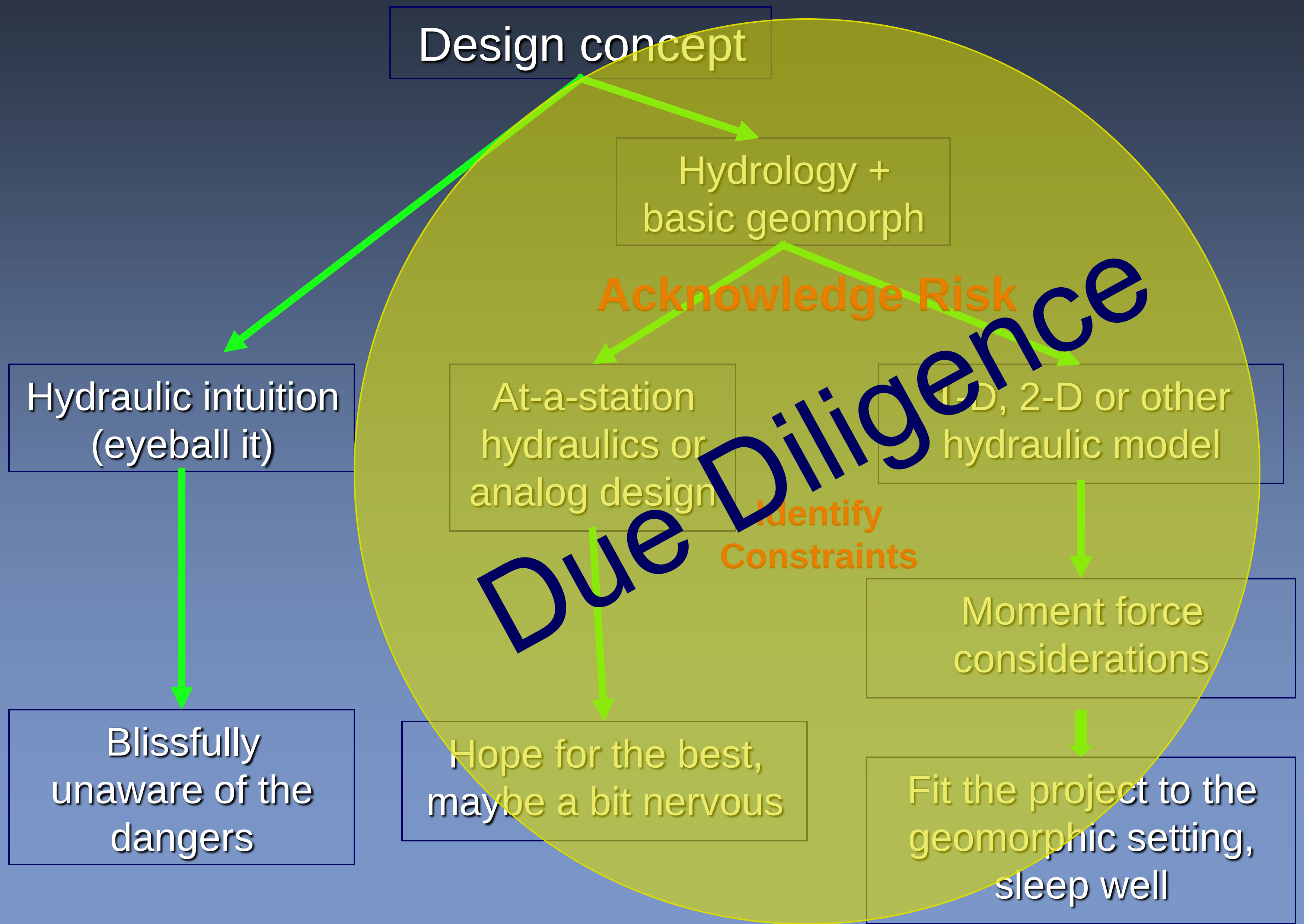
Wood as an integrated treatment

- Hard armored bank stabilization with LWD as an added habitat *component*
- Be wary of void spaces when wood degrades

Risks associated with large wood placement in rivers

- Movement may impact
  - Your habitat improvement goals
  - Your original geomorphic goals
  - Flooding
  - Life and property
    - Recreational boaters
    - Bridges
    - Culverts
    - Houses

The umbrella of due diligence



Design considerations

Forces at work

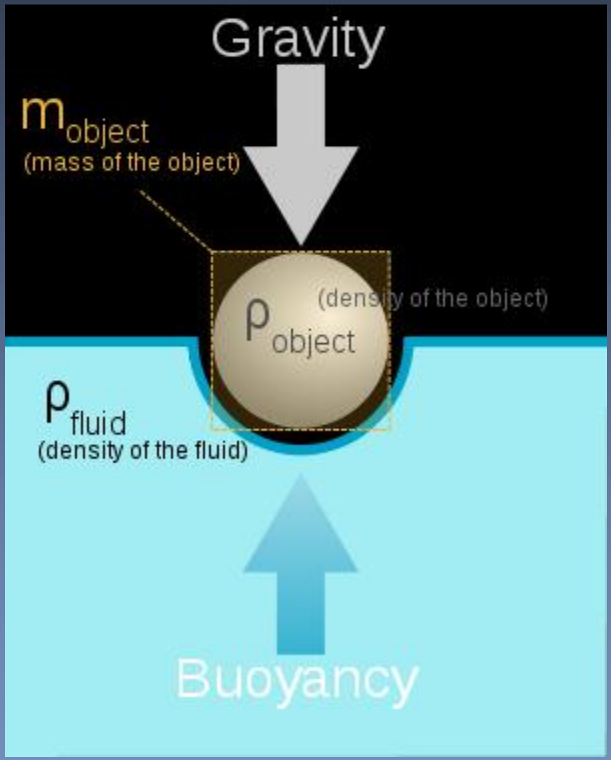
- Drag force
  - Dependent on Area & Velocity
  - High energy channels
  - Larger jams (greater area)
  - Bends

Drag force

- Drag force
  - $F_d = C_d A \gamma_w (V^2)(0.5) / g$
    - C = drag coefficient (0.6-0.9)
    - A = Area of the structure exposed to current
    - V = Expected stream velocity
    - γ_w = Density of water
    - g = gravitational acceleration
    - ERDC recommends multiplying by a factor of 4 to account for debris

Forces at work

- Buoyant Force
  - Typically the biggest problem for smaller jams in Midwestern streams
  - F_b = weight of water displaced by the LWD
  - Fb stays the same, but logs change over time (dry, decay)

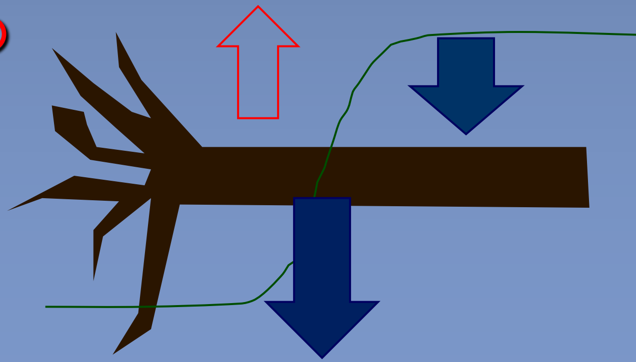


Any floating object displaces its own weight of fluid.
– *Archimedes of Syracuse*

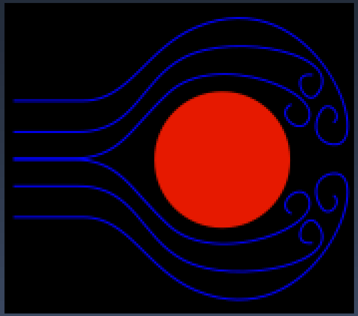
Buoyancy and drag countermeasures

- Calculating ballast needed (Example 35 ft log x 1ft diameter, with 25 feet exposed):
  - Buoyant force of the wood = 1,225 lb
  - Downward force of the wood itself = 1,715 lb
  - Downward force of the soil on top of the log assumes burying 10 feet of a 35 ft log = 2,850 lb

- If FS of 2.0, additional ballast is not needed: 1,715 + 2,850 = 4,565 lb > 2 x 1,225 lb



Drag force



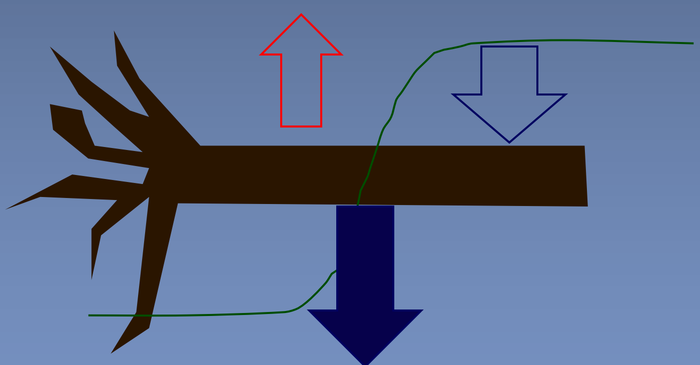
- Compare the buoyant force to the Drag force in this case:
  - 25 foot long exposed log, 1 ft dbh = 310 lb
  - The buoyant force of 1,225 is far in excess of the drag force – so design for the larger

Other considerations

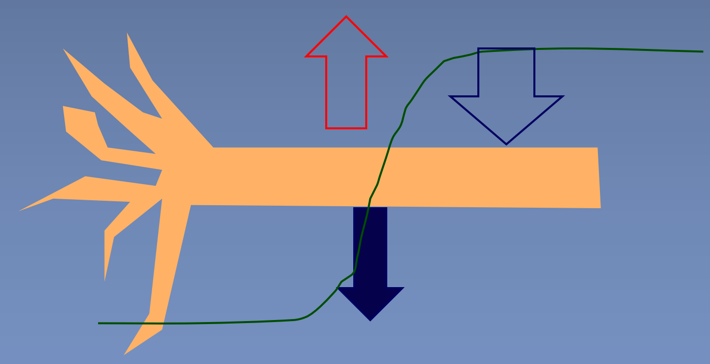
- Remember that drag and buoyant forces don't need to exceed the countermeasures to dismantle your project
  - Vibration
  - Pumping of soils
  - Soil loss or lubrication reduces friction
  - Soil loss decreases your ballast
  - Sliding of loose pieces
  - Jenga

Other forces at work

- Drying
  - Dry wood weighs less, and so the downward force component of the wood decreases as it dries



$F_B < F_{log} + F_{soil}$



$F_B > F_{log} + F_{soil}$

Countermeasure options

No ballast

- Length is an important consideration
- Mobile wood can be OK if the risks are low

Soil ballast

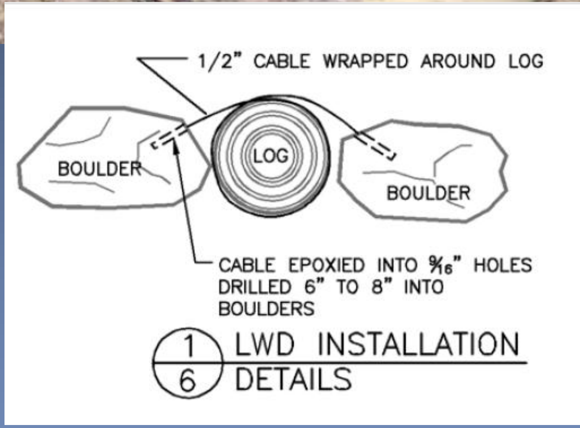
Bank stabilization

- Embedment length
- Buoyancy calculations
- May need other measures to prevent soil loss and thus loss of ballast

- Post Anchor/pile ballast
  - When trees are scarce
  - As trapping element
  - Ballast
  - Flexible wood mat anchor

- Structural ballast
  - Cable
  - Threaded Rod
  - Rope

- Rock ballast
  - Embed within jams
  - Cable directly to logs
  - Aesthetic issues



Fitting the wood to the geomorphic setting

- How is wood functioning in the system now?
- Mobility is related to length
- Mobility related to channel morphology

Wood properties

- How long will your wood last
- Density ≠ decay resistance
- Resistant woods
  - Lignin content
  - Resin content
  - Cedar, Douglas fir, white pine, oak, other pines

Tree Species	Density *(lb/ft^3)*
Cedar, red	23
Cottonwood	25
Aspen	26
Poplar	27
Pine, white	28
Redwood, American	28
Willow	29
Spruce	30
Alder	32
Ash, black	33
Douglas Fir	33
Elm, American	35
Walnut, Amer Black	38
Locust	43
Maple	43
Oak, American Red	45
Oak, American White	47
Cherry	50

Wood properties

- *Preferred Trees*
  - Cedar
  - White pine
  - Oak
  - Maple
  - Elm
  - Black willow (special)
  - Cottonwood (special)
  - Red pine (submerged)
- *Secondary Trees*
  - Aspen/Poplar
  - Balsam fir
  - Hemlock (brittle)
  - Basswood
  - Black willow (brittle)
  - Cottonwood


Recreational boating and wood
Risk to recreational boaters
Risk to anglers

Take home message

- Treat each situation individually
- Properly assess risk
- Conduct the appropriate amount of due diligence
- Match the wood to the geomorphic setting
- Be safe

Thank you

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