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Managing Water in the West

Rock Ramp Design Guidelines

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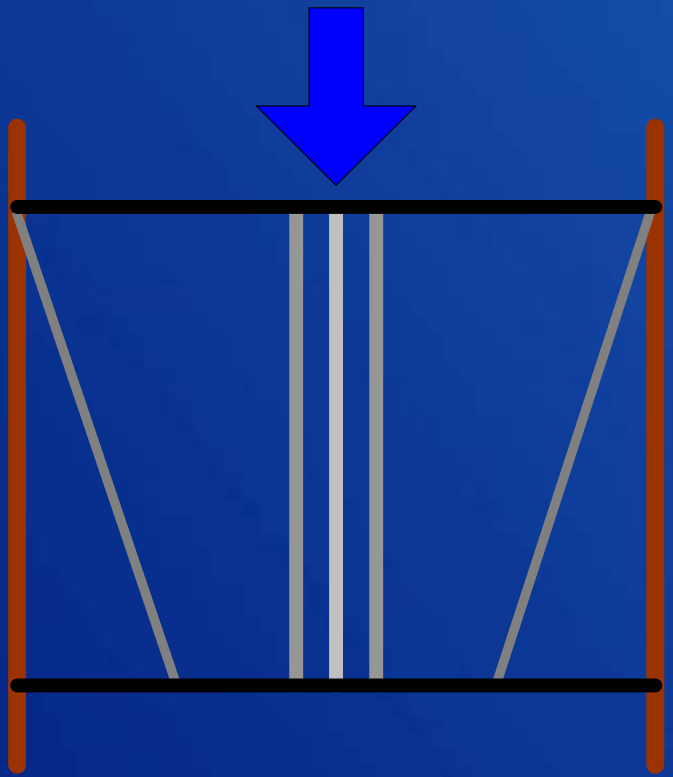
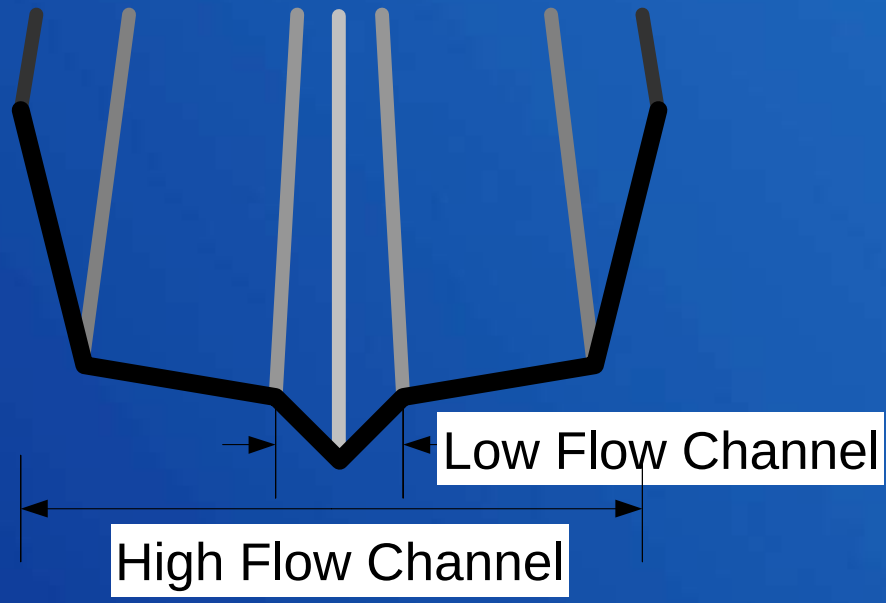
Rock Ramp Design Guidelines

OUTLINE

- Local and System Interactions with Rock Ramps
- Ramp Geometry and Hydraulics
- Riprap Design
- Fish Swimming Capabilities and Passage Criteria
- Design Event and Lifecycle Costs
- Boulder Clusters and Isolated Rocks
- Step Pools
- Future Guidelines Work
- Appendix A – Basic Ramp Design Example

Ramp Geometry and Hydraulics
Full Spanning Ramp





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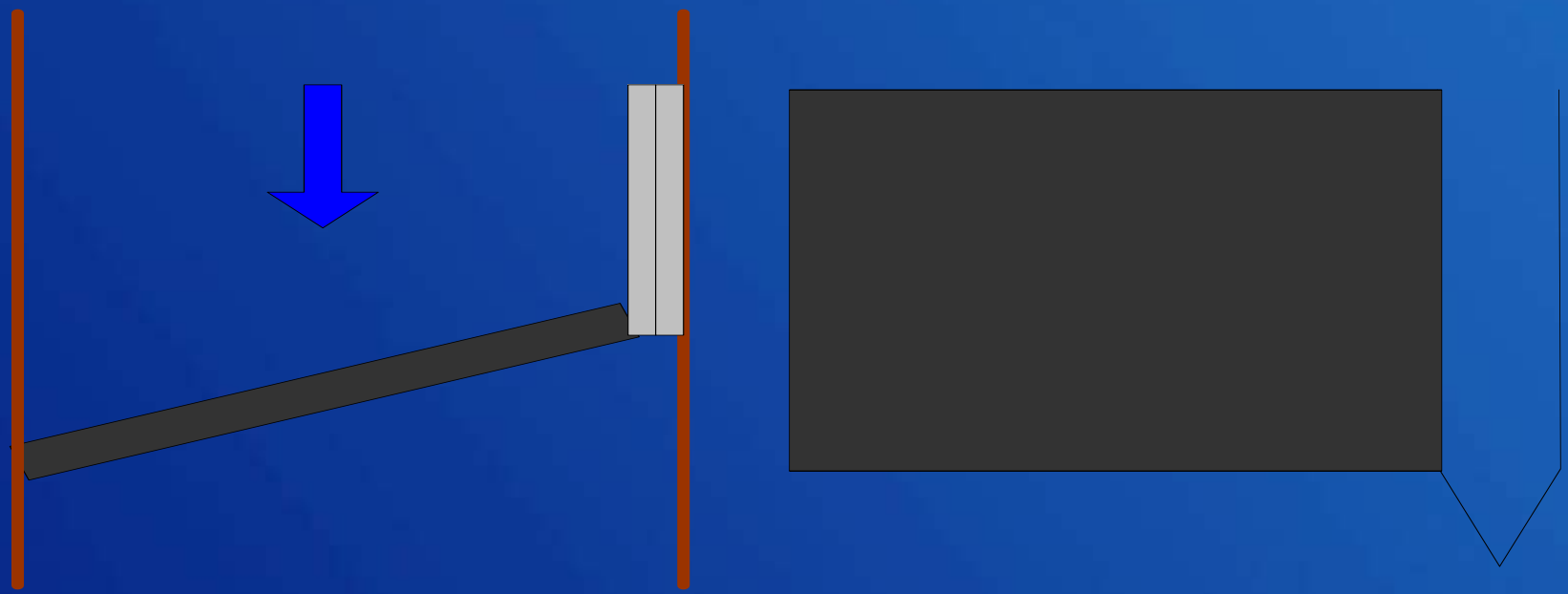
Partial Spanning Ramp



Rock Ramp Geometry Design Procedure

- Evaluate the appropriateness of a rock ramp including local and system interactions.
- Determine the biological fish passage criteria
- Estimate ramp geometric parameters and generate low flow hydraulics to meet fish passage requirements and project constraints. Includes iterating the slope and roughness.
- Determine the high flow design discharge.
- Iterate high flow geometry to provide adequate flood flow passage.
- Design entrance and exit transitions
- Biologic review to validate fish passage characteristics
- Add special features such as boulder clusters or step pools.
- Review the impact from special features on the basic design.

Local and System Interactions

- Degradation
  - Local supply limited cases such as downstream of a dam
  - Downstream base level lowering
- Aggradation
  - rising sediment levels such as from changes in land use or debris flows
- Channel Migration
  - Past temporal and spatial rates of meander migration
  - River bends move laterally as well as translate downstream
  - Evaluate the effects of potentially altering channel migration patterns
    - Place structures in reaches where the potential channel migration is a minimum
    - River migration may cause local flanking of a structure, determine countermeasures if necessary
    - Structures can impede or accelerate migration processes.
- Construction Disturbances
- Geomorphic Thresholds (i.e. alter the water sediment relationship)

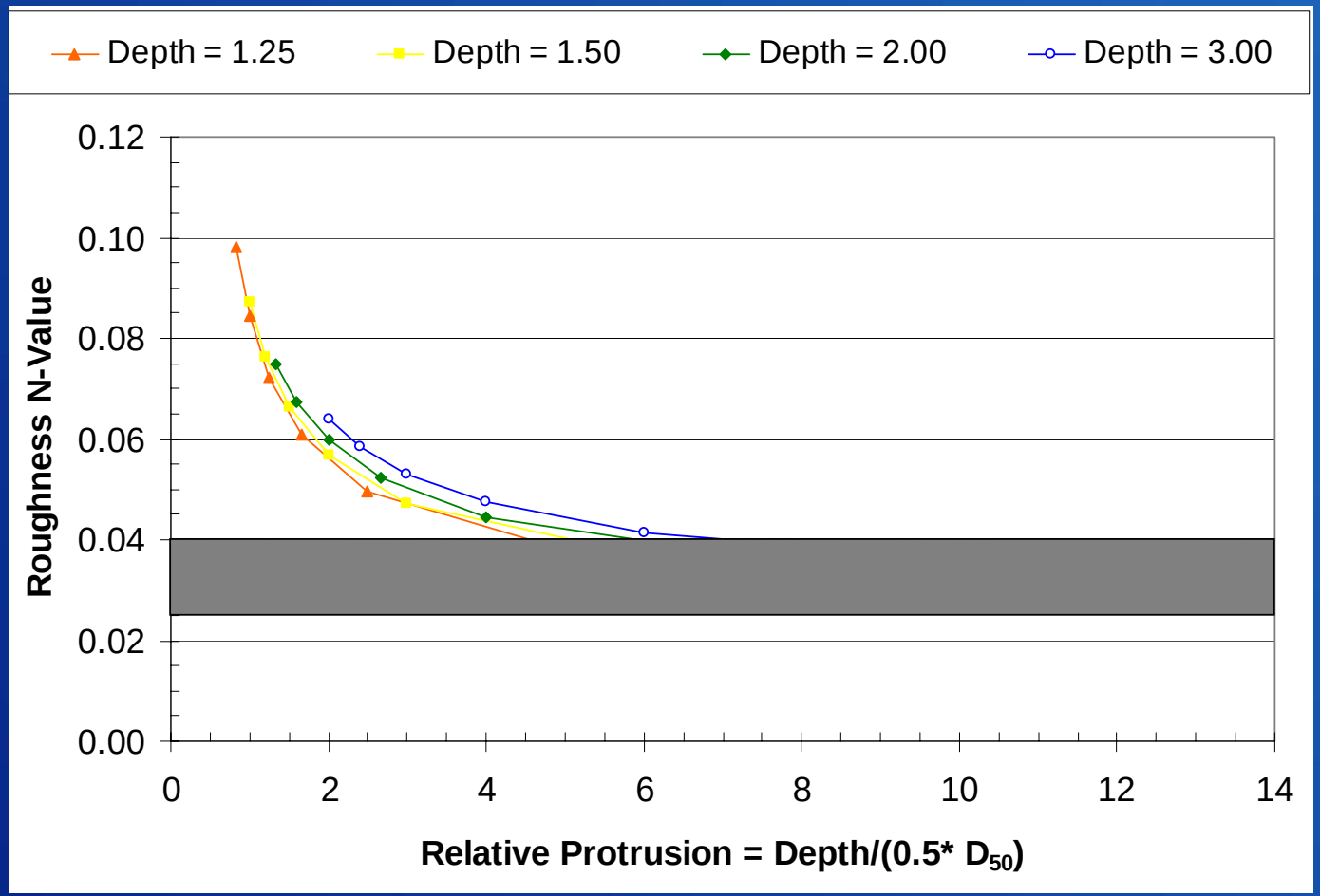
Steep Slope Roughness

- Abt et al. (1987) texted angular rock on steep slopes from 0.01 to 0.20. Rice et al. (1998) performed additional tests (slopes from 0.167, and 0.333).
- Rice et al. (1998) combined Apt et al. (1987) with their data to develop

$$n = 0.029 \cdot \left(D_{50} \cdot S_0 \right)^{0.147}$$

- Where,
  - n = Manning's n-value;
  - D50 = median grain diameter of the riprap (mm); and
  - S_o = slope of the rock ramp.
- Individual stones extending above the rock ramp surface will increase the potential of rock dislodgement

Depth Based Roughness (Darcy-Weisbach)



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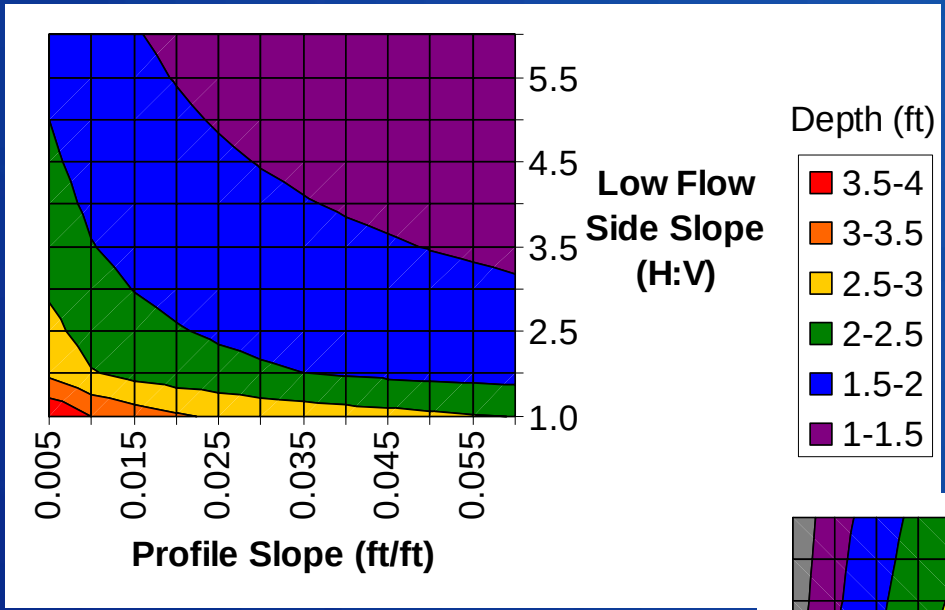
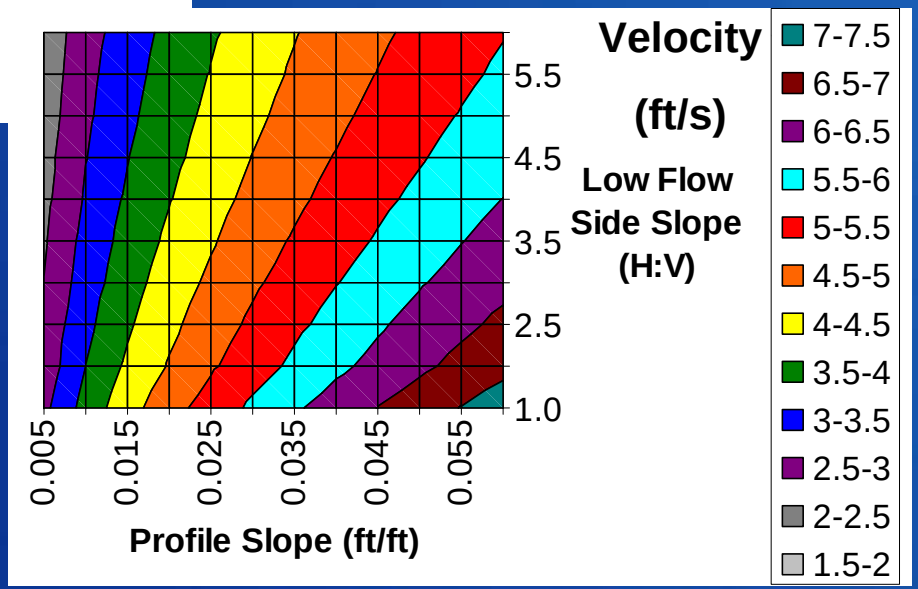
Low Flow Geometry and Hydraulics





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Riprap Design Methods

- Sizing Methods Account for Overtopping Flow
  - Abt and Johnson (1991), Ullman (2000), Ferro (1999), Robinson et al. (1998), USACE (1991), Whittaker and Jaggi (1986), Stevenson (1979), and more.
- Gradation
  - $D_{100} < 2 * D_{50}$
  - $1.25 < D_{60} / D_{10} < 2.4$
- Filter Criteria
- Upstream and Downstream Transitions
  - Cutoff Wall
  - Downstream Scour Protection

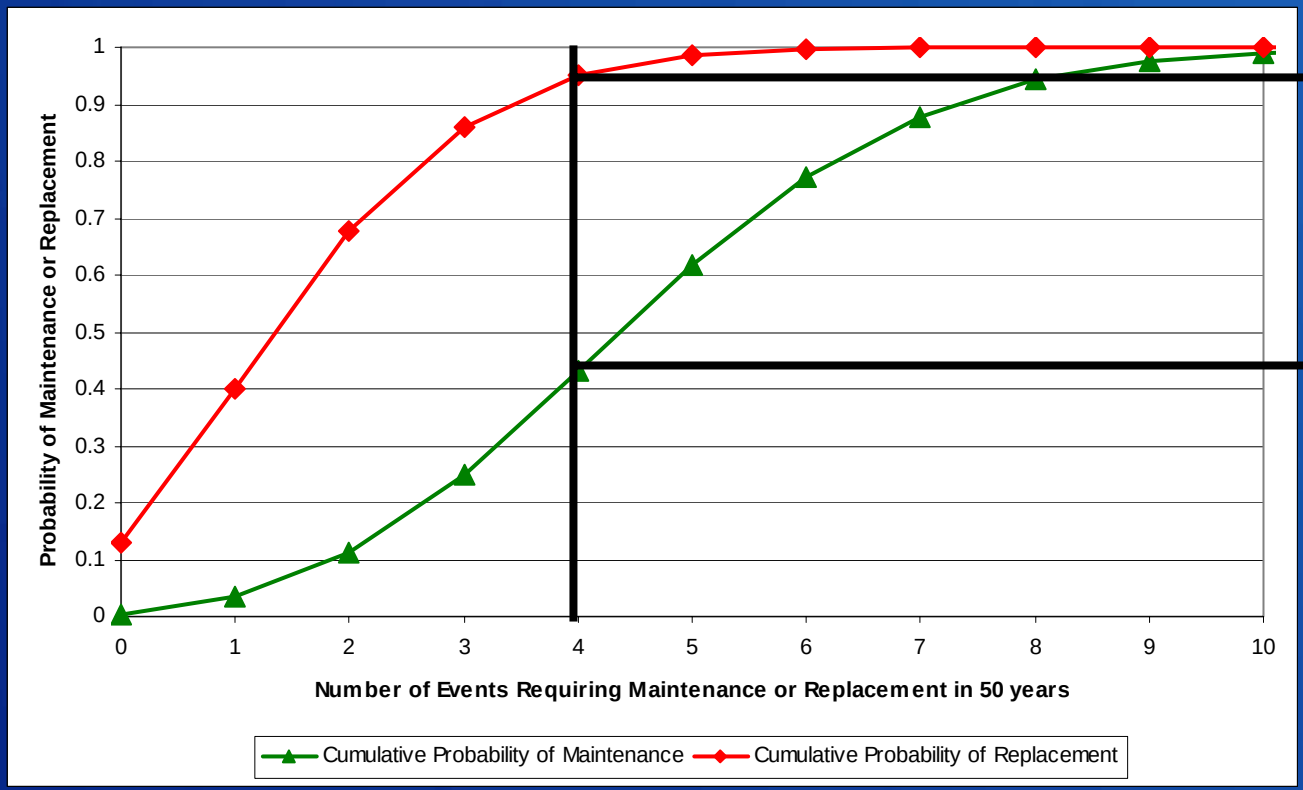
Design Flow and Lifecycle Costs

- Selection of a design event balances the cost of initial construction versus the cost, effort, and probability of replacing or repairing weaker structures if larger flow event occurs.
- Design Flow's Determined by
  - Regulatory Requirements
  - Land owner Requirements
  - Stake holder Requirements
  - Economics
  - Management Decision
- The methods do not account for lost delivery opportunities and assume all structures are maintained when required.

Fish Swimming Capabilities

- Literature review of fish capabilities
  - swimming speeds including sustained, prolonged, and burst
  - Leaping capabilities
  - Life stage specific criteria
- State and Federal fish passage criteria
- Example installations of “nature-like” fishways
- Biological criteria planning processes

Replacement and Maintenance Frequency



Less than a 95% chance we must replace a structure more than 4 times

Less than a 50% chance (less certain) that we must repair a structure more than 4 times

Frequencies indicate the likelihood of no more than a given amount.

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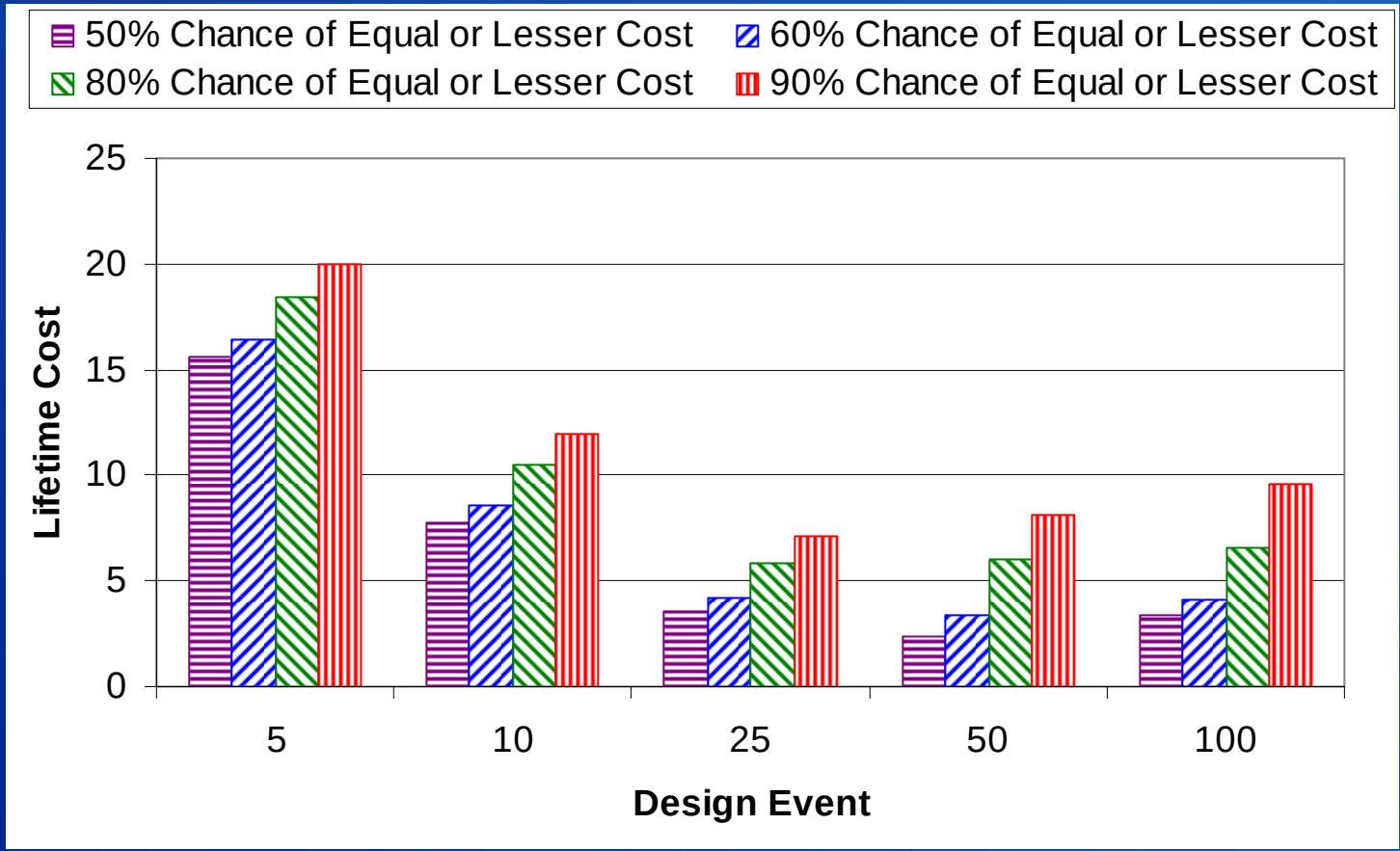
Design Flow Event



Site specific lifecycle costs for different design events

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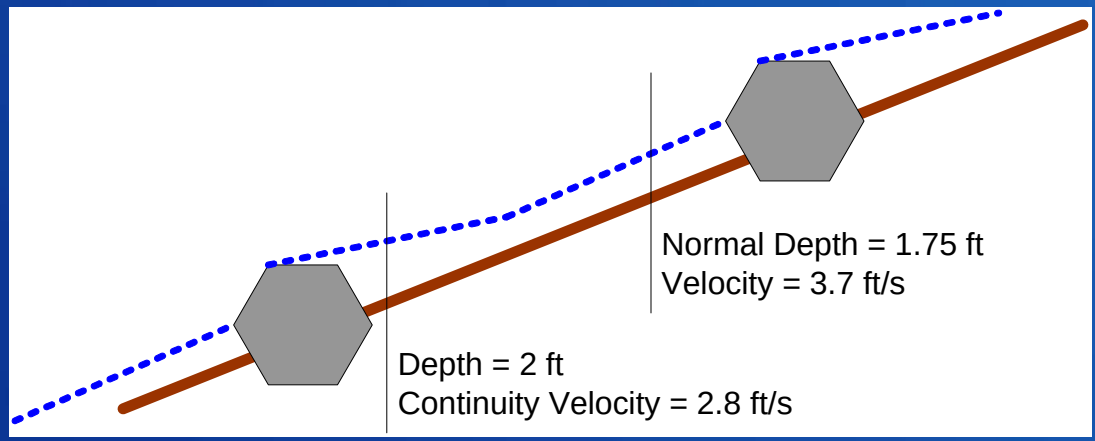
Boulder Cluster Additions



- Cluster sizing, layout, and spacing
- Hydraulic Impacts
- Ramp Interactions
- Construction concerns

Step-Pool Additions

- Range of applicability
- Hydraulics Parameters
  - Step height
  - Step frequency
- Design Parameters
  - Rock size
  - Scour pool dimension
- Rock ramp interaction

Guidelines Software

- An analysis software package can facilitate detailed computations
  - Low flow hydraulics require iterative computations
  - Riprap design uses multiple equations
  - Lifecycle costs requires iterative calculations
- Charts and graphical displays assist in conveying information to support decision making
- Validated software standardizes methods