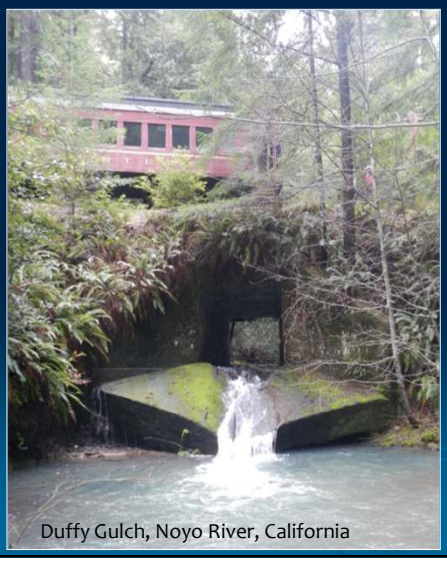
# The Pre-Design Phase
## Geomorphic Based Stream Crossing Projects



Duffy Gulch, Noyo River, California

**Michael Love P.E.**
Arcata, California
mlove@h2odesigns.com
707-822-2411

Michael Love & Associates
*Hydrologic Solutions*

California Department of Fish & Wildlife
*California Salmonid Stream Habitat Restoration Manual*
**Part XII: Fish Passage Design and Implementation (2009)**

Available at:
http://www.dfg.ca.gov/fish/resources/habitatmanual.asp

Primary Authors:

Michael Love P.E.
*Michael Love & Associates, Inc.*

Kozmo Bates P.E.
*Olympia, WA*

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## Other Primary Sources for Pre-Design Guidance

**US Forest Service, 2008**
Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings

https://www.fs.fed.us/eng/pubs/pdf/StreamSimulation/

**NOAA West Coast Fish Passage Guidelines**
Pre-Design Guidelines for
CA Fish Passage Facilities

https://www.fisheries.noaa.gov/west-coast/habitat-conservation/west-coast-fish-passage-guidelines

**CDFW Fish Bulletins**
No. 183: The Use of Log and Boulder Weirs in Stream Habitat Restoration
No. 184: The Use of Large Wood in Stream Habitat Restoration
No. 185: The Use of Low-Tech Process-Based Stream Habitat Restoration

**Washington Department of Fish and Wildlife, 2013**
Water Crossing Design Guidelines

http://wdfw.wa.gov/publications/01501/

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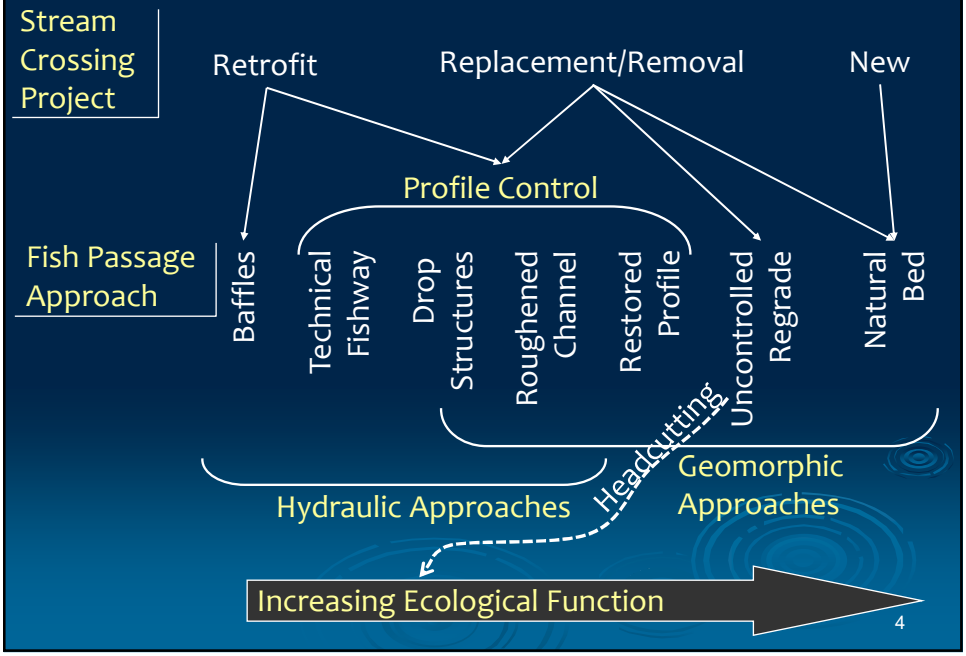
## Design Approaches for Aquatic Organism Passage

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## Passage Design Process

Project Objectives

Engineering Site Plan Map

Geomorphic Site Assessment

Pre-Design Phase

Geomorphic Risk Assessment and Design Objectives

Setting Project Alignment & Profile

Select Suitable Design Approach(es)

Design Phase

Design Development

Final Plans, Specs, Cost Estimate

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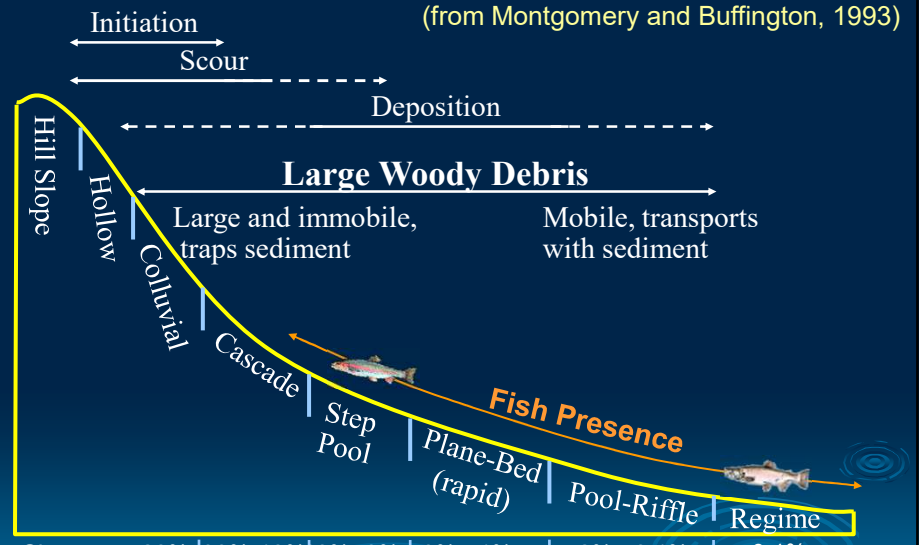
## Site Assessment Objectives

- Gain an understanding of **channel history, stability,** and **adjustment potential:**
  - Channel type (transport vs. response)
  - Floodplain conveyance
  - Historic channel alternations
  - Bed variability (pool depths)
  - Headcut potential
  - Bank stability
- Develop a **channel template:**
  - Shape
  - Approach Alignment
  - **Bed Controls** (embedded wood, large rock, bedrock)
  - Profile
  - Substrate Composition
  - Floodplain Connectivity

## Generalized Stream Classification

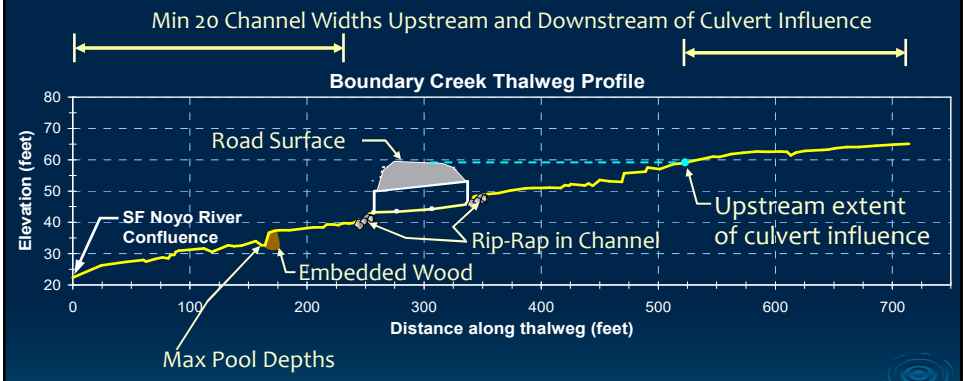
(from Montgomery and Buffington, 1993)



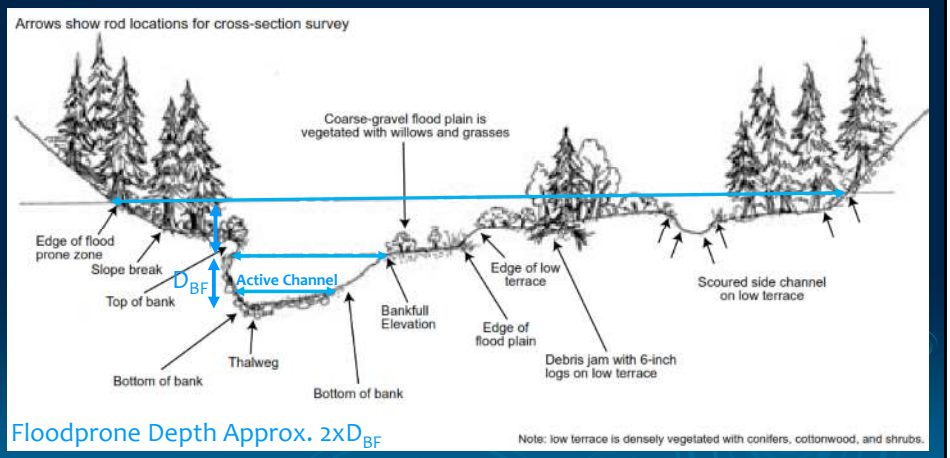

## Longitudinal Profile

- Survey profile along channel thalweg
- Extend survey well past culvert influence
  Recommend Min Profile Length = 20 channel widths
- Survey captures pool depths, riffles,
- Survey "forcing features" controlling grade
  Note long-term stability of each forcing feature
- Survey base and top of features controlling grade
  Bedrock, large colluvium, embedded wood, debris jams, check-dams, culvert inverts, stream confluence…

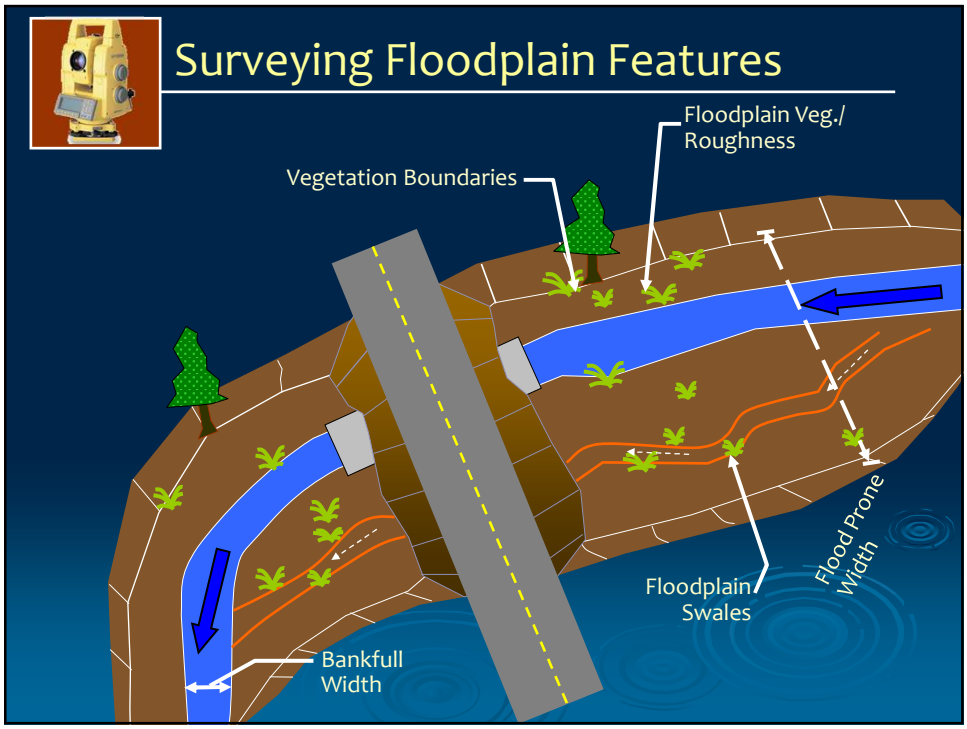
# Longitudinal Profile

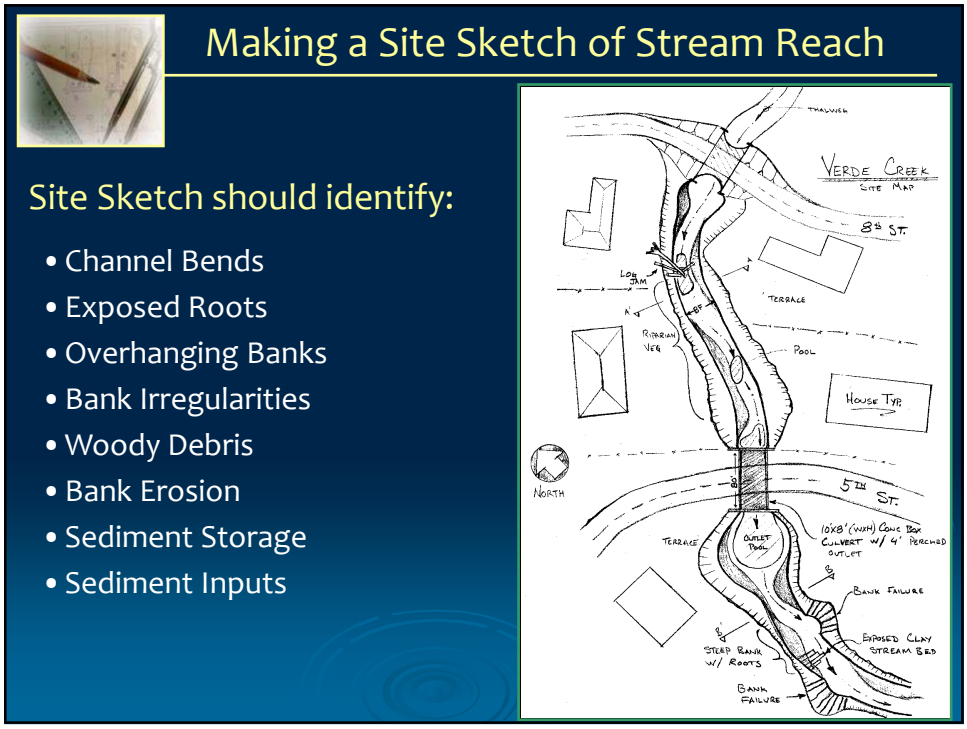


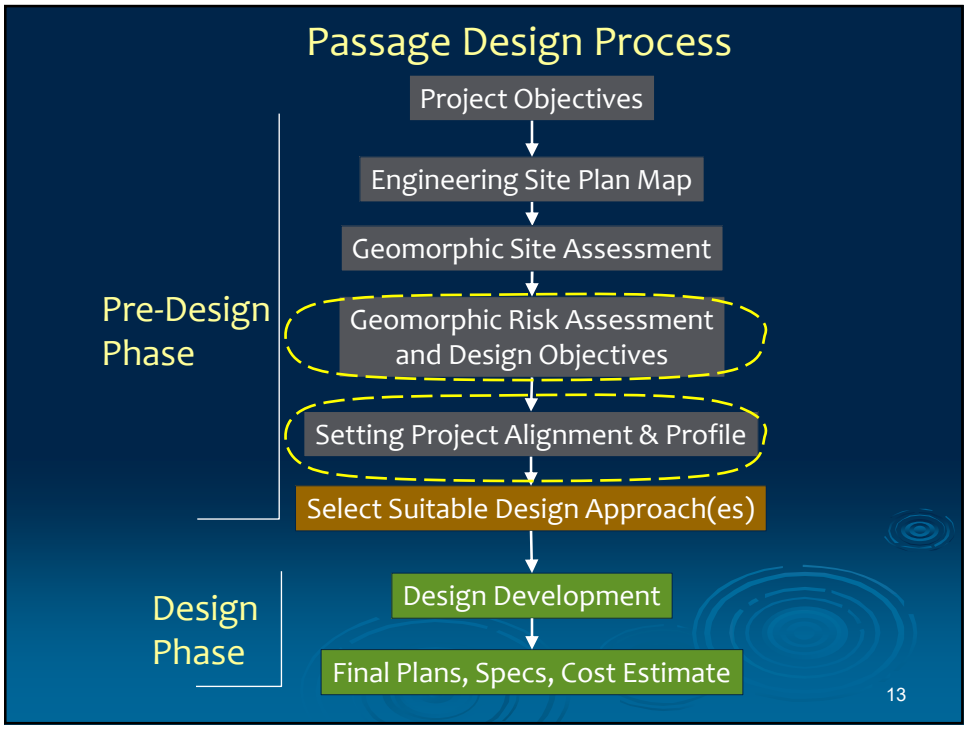

# Surveying Channel and Floodplain Features




*From: USFS 2008 Stream Simulation Design Manual*


Surveying Floodplain Features
Floodplain Veg./
Roughness
Vegetation Boundaries
Flood Prone
Width
Floodplain
Swales
Bankfull
Width


Making a Site Sketch of Stream Reach
Site Sketch should identify:
• Channel Bends
• Exposed Roots
• Overhanging Banks
• Bank Irregularities
• Woody Debris
• Bank Erosion
• Sediment Storage
• Sediment Inputs
Verde Creek
Site Map
8th St.
5th St.
North
Terrace
Pool
House Typ.
Bank Failure
Exposed Clay
Stream Bed
Steep Bank
w/ Roots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Final Plans, Specs, Cost Estimate
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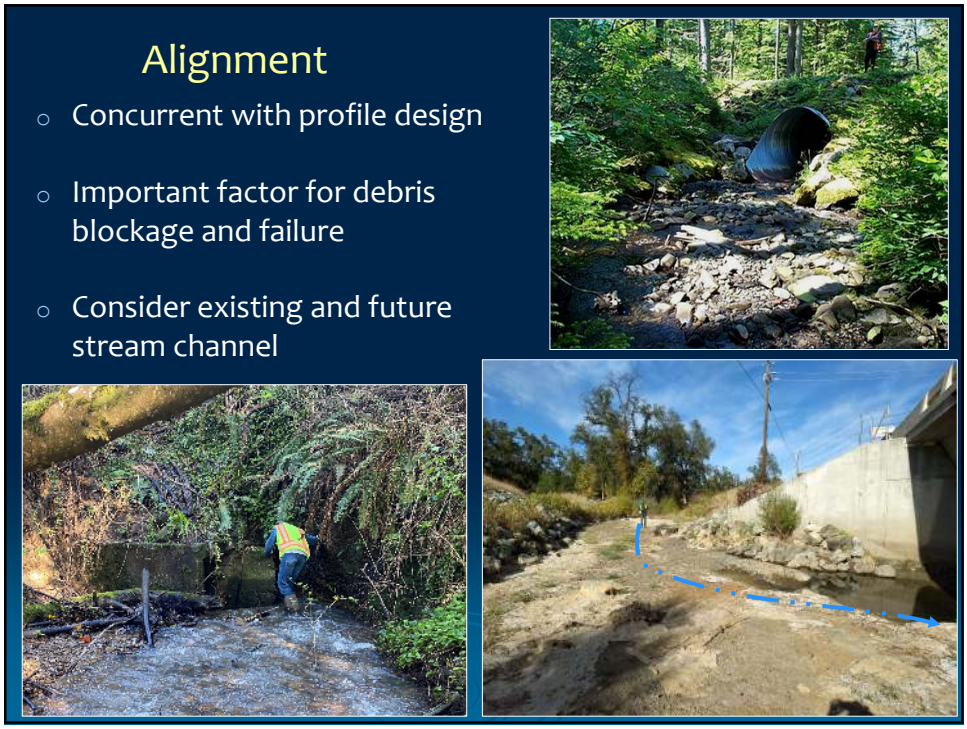
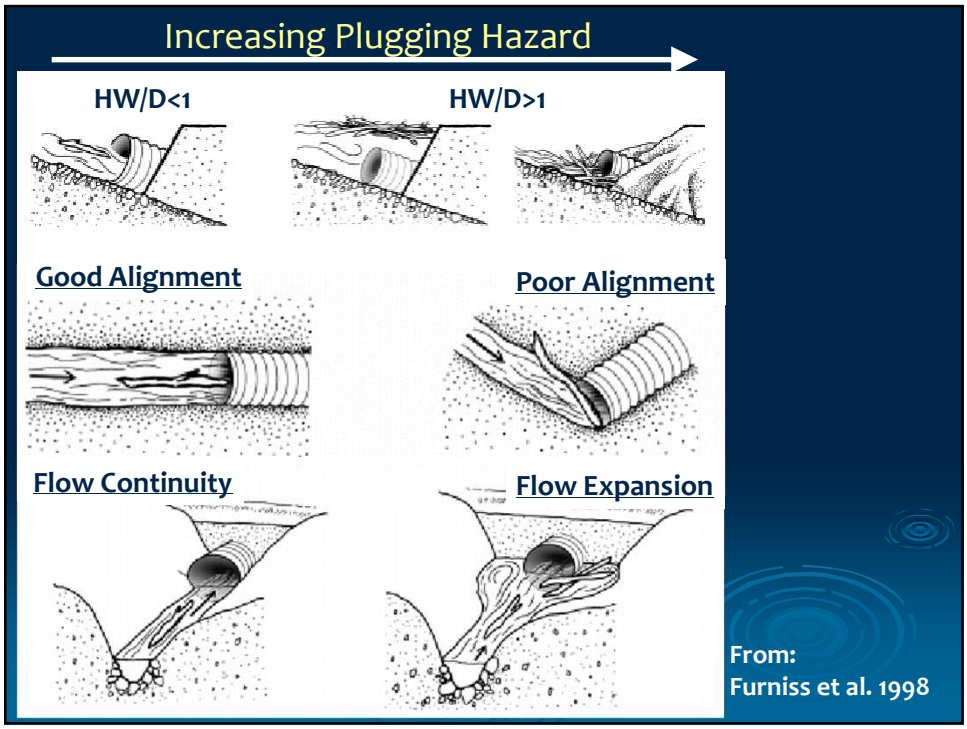
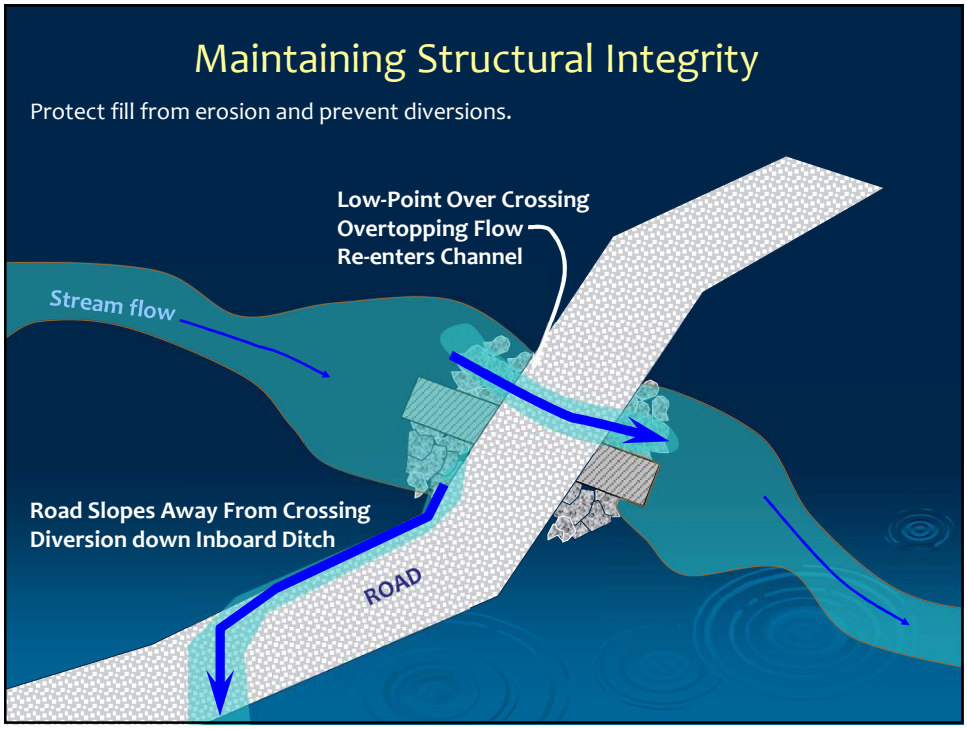

Alignment
Concurrent with profile design
Important factor for debris blockage and failure
Consider existing and future stream channel

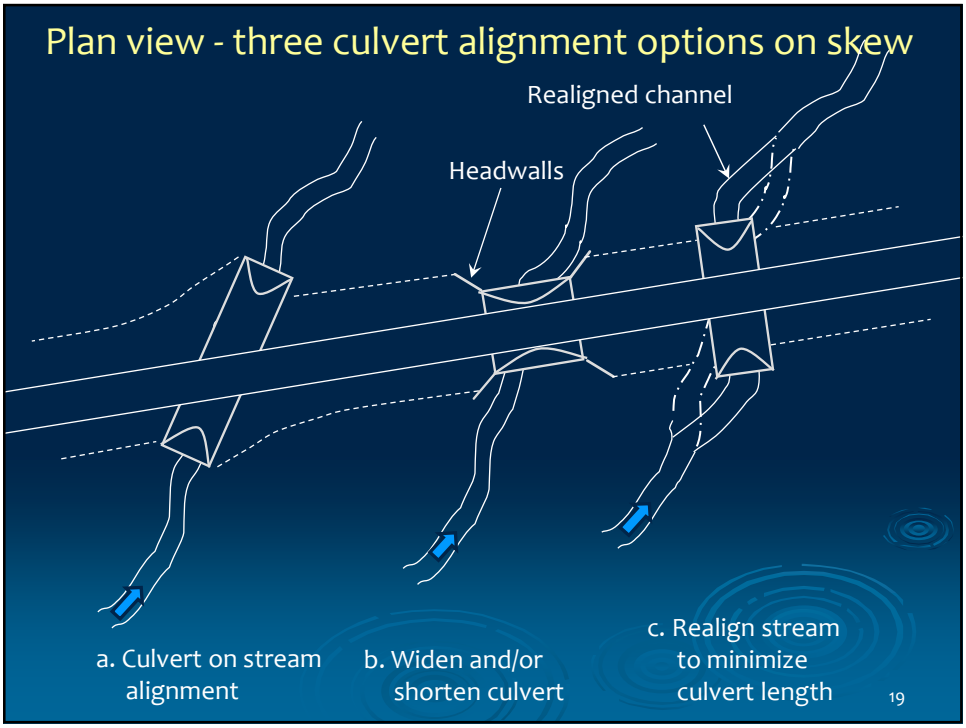

Increasing Plugging Hazard
HW/D<1
HW/D>1
Good Alignment
Poor Alignment
Flow Continuity
Flow Expansion
From:
Furniss et al. 1998


Maintaining Structural Integrity
Protect fill from erosion and prevent diversions.
Low-Point Over Crossing
Overtopping Flow
Re-enters Channel
Stream flow
Road Slopes Away From Crossing
Diversion down Inboard Ditch
ROAD

## Culvert Failure – Debris Plugging
*No Diversion - Minimal Erosion*

## Culvert Failure – Diversion

## Plan view - three culvert alignment options on skew

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## Flow Expansion at Inlet Transitions Turns Debris and Leads to Plugging

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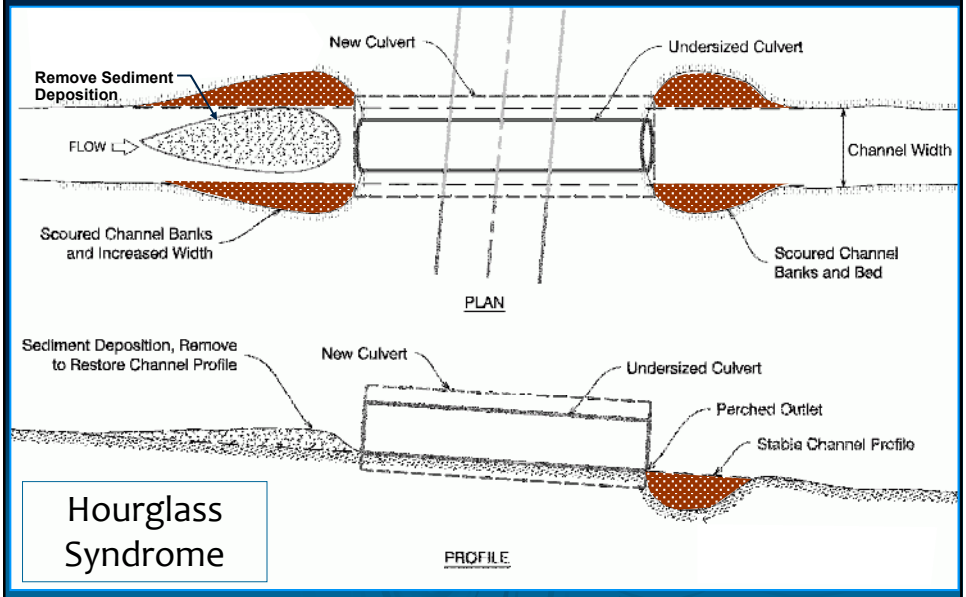
## Restoring Channel Geometry at Transitions




Hourglass Syndrome

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## Examples of Restored Channel Geometry at Inlets

Wood and Rootwads

Encapsulated Soil Lifts

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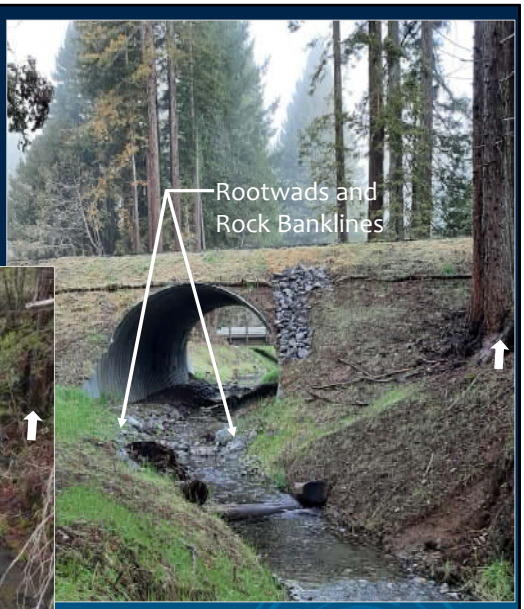
## Example of Restored Channel Geometry at Outlet

Before - Outlet Scour Pool




After – Restored Streambanks at Outlet

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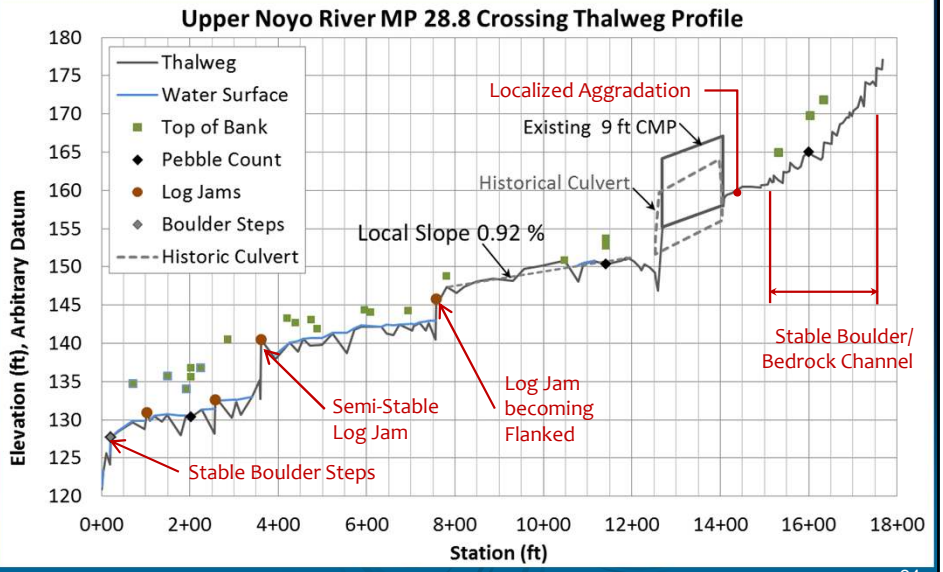
## Channel Profile Analysis

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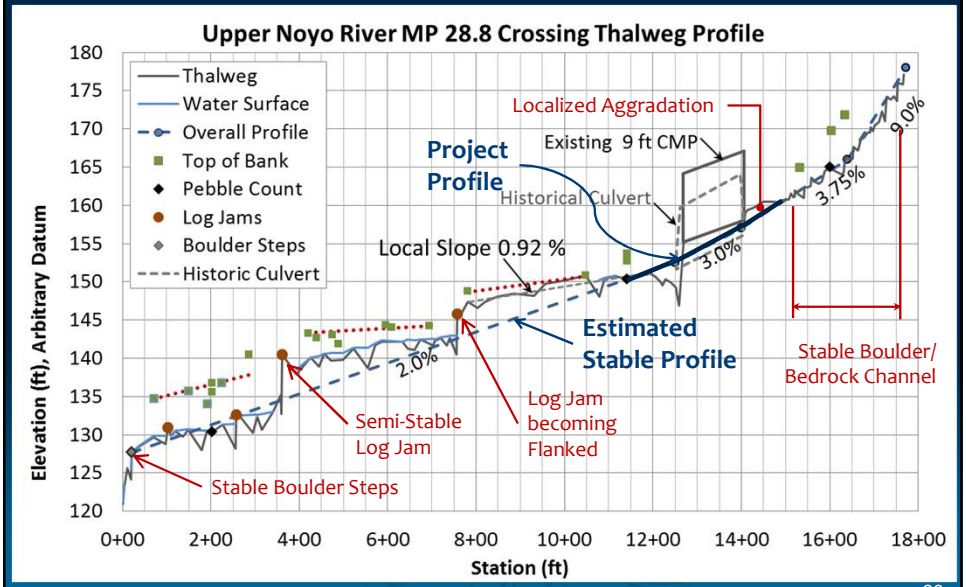
# Estimating Channel Bed Structure Stability

*Table 5.3—A qualitative method for determining channel-bed structure stability.* (USFS Stream Simulation Manual)

| Structure composition | Stability Rating | Structure Characteristics |
|---|---|---|
| *Bedrock* | *High* | *Bedrock ledges or falls span entire stream width* |
| *Boulder-cobble steps* | *High* | *Boulder-cobble steps span entire width of stream. Rocks are tightly keyed in place, and keyed-in material extends below base of scour pool below step.* |
| *Cobble-boulder or cobble-gravel pool tail crests or riffle crests* | *High* | *Cobble-boulder or cobble-gravel pool tail crests or riffle crests span the entire width of stream. Particles are tightly packed, embedded into the channel bed, and coarser than the remainder of the channel bed.* |
| *Log* | *High* | *Wood is sound and well anchored, spanning entire stream width.* |
| *Composite log and rock* | *High* | *Wood is sound and well anchored, may or may not span entire stream width. Rock pieces are well keyed in place and bridge gaps so that composite structure controls width from bank to bank.* |
| *Boulder-cobble steps, cobble-gravel steps* | *Moderate* | *Steps do not span entire width of stream or are loosely keyed in place. Keyed-in rocks may not extend below base of scour pool below step. Alternatively, step key pieces are not in contact with each other.* |
| *Cobble-boulder or cobble-gravel pool tail crests or riffle crests* | *Moderate* | *Pool tail crests span entire width of stream, but the largest particles are similar in size to those elsewhere observed along the channel bed. Alternatively, particles are moderately packed and/or moderately embedded into the channel bed.* |
| *Log* | *Moderate* | *Wood is rotten and punky. It may span entire stream width, but anchoring is susceptible to bank scour and movement during high flood events.* |
| *Cobble-gravel steps or pool tail crests* | *Low* | *Steps do not span entire width of stream, and/or are composed of loosely packed materials. Pool tail crests are constructed of material no coarser than rest of stream bed.* |
| *Log* | *Low* | *Wood is very rotten and punky, may or may not span entire stream width, and anchoring is poor and susceptible to bank scour and movement during bankfull flood events. Indications of movement are visible where pieces are anchored into the bank.* |
| *Composite log and rock, beaver dams* | *Low* | *Wood is very rotten and punky, or structure is made of loosely packed pieces that are poorly anchored. Structure does not span entire stream width. Rock is small in size and subject to movement at bankfull flood events. Beaver dams are poorly constructed or old and inactive. Large key logs are not present.* |

# Channel Profile Analysis

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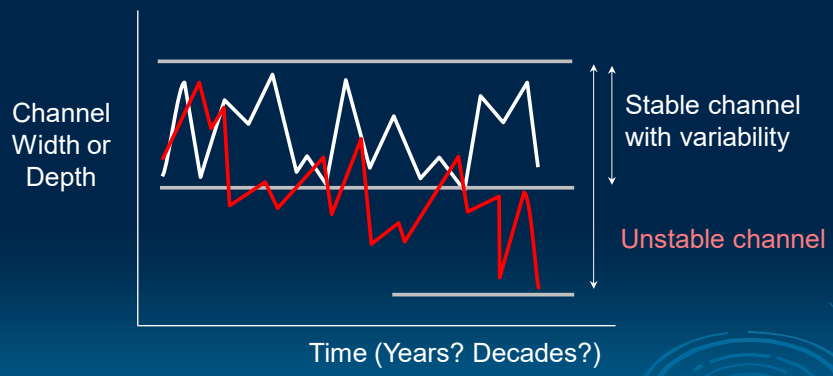
## Estimate Channel Adjustments for Life of Project

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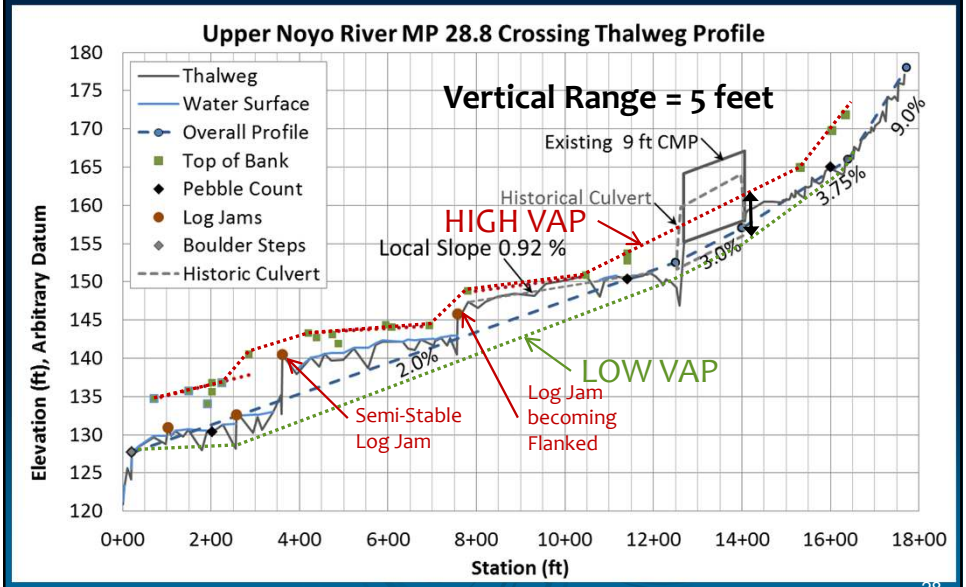
## Vertical Adjustment Potential (VAP) Profiles

Estimates the range of possible channel profiles for life of project

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## Vertical Adjustment Potential (VAP)

Develop VAP with long profile and field investigations:

- ✓ Channel slopes
- ✓ Stability/mobility of channel type/material
- ✓ Channel controls and anticipated longevity [bedrock, large wood, colluvium, hard infrastructure]
- ✓ Knickpoints, evidence of active incision (downcutting) or aggradation
- ✓ Pool scour depths (low VAP)
- ✓ Bankfull and floodplain elevations (high VAP)
- ✓ Historical information (existing invert elev. and slope)

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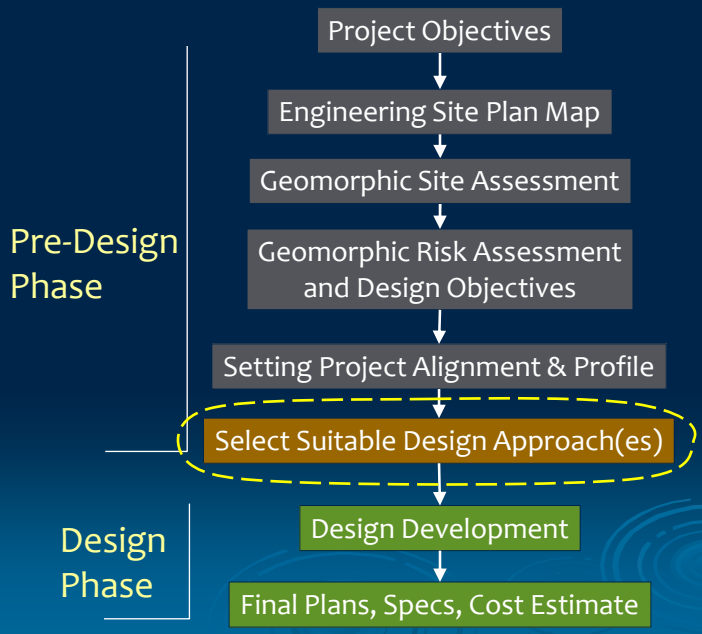
## Passage Design Process

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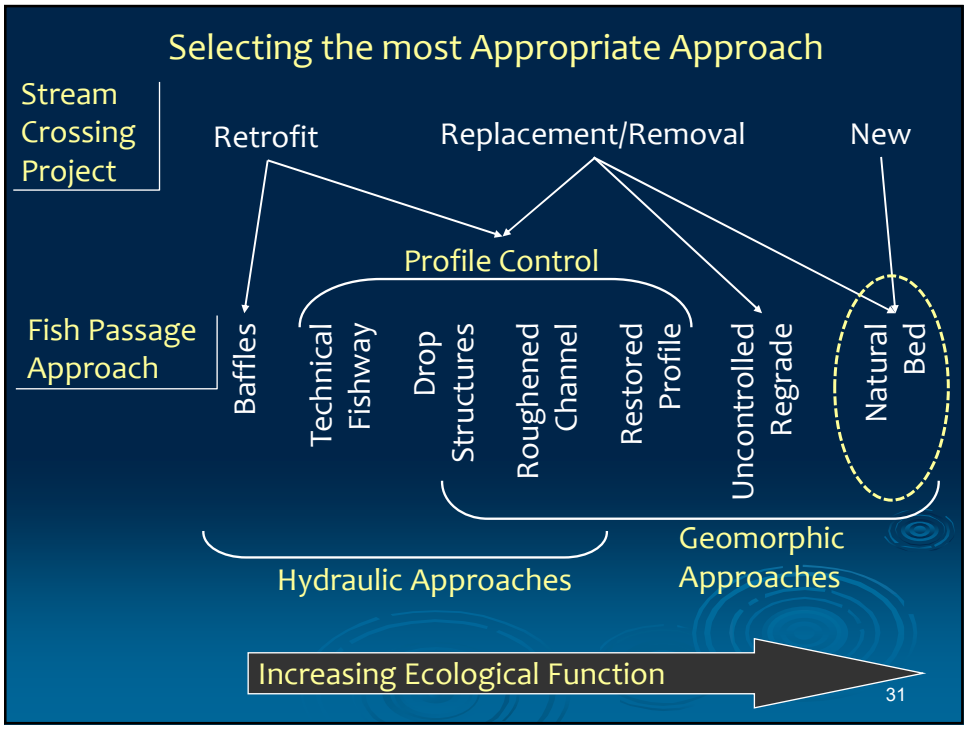
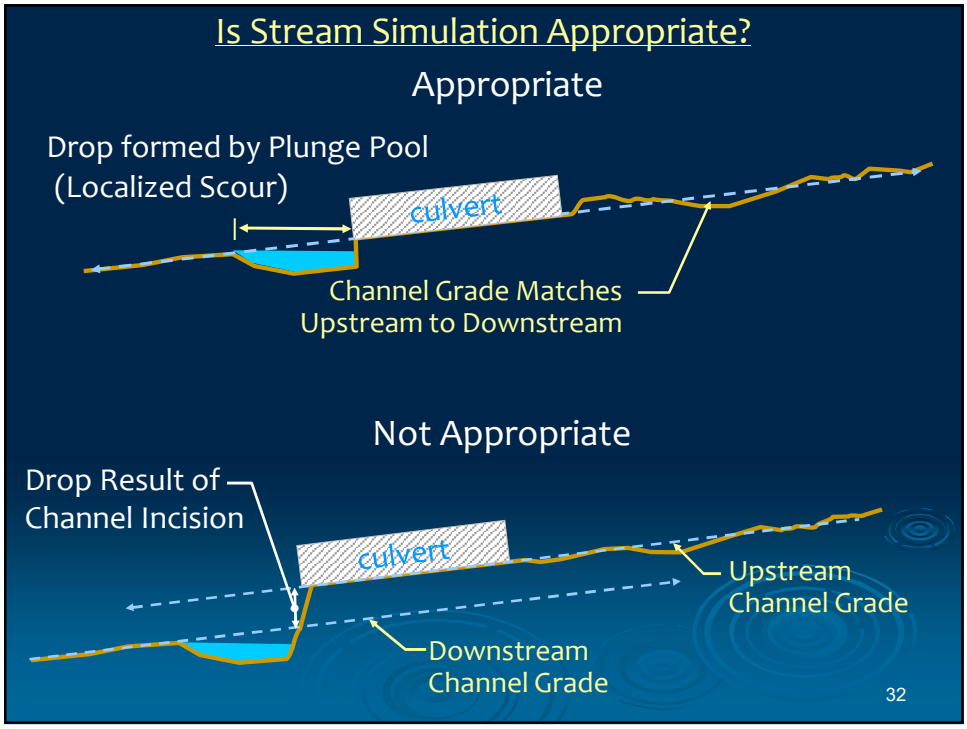
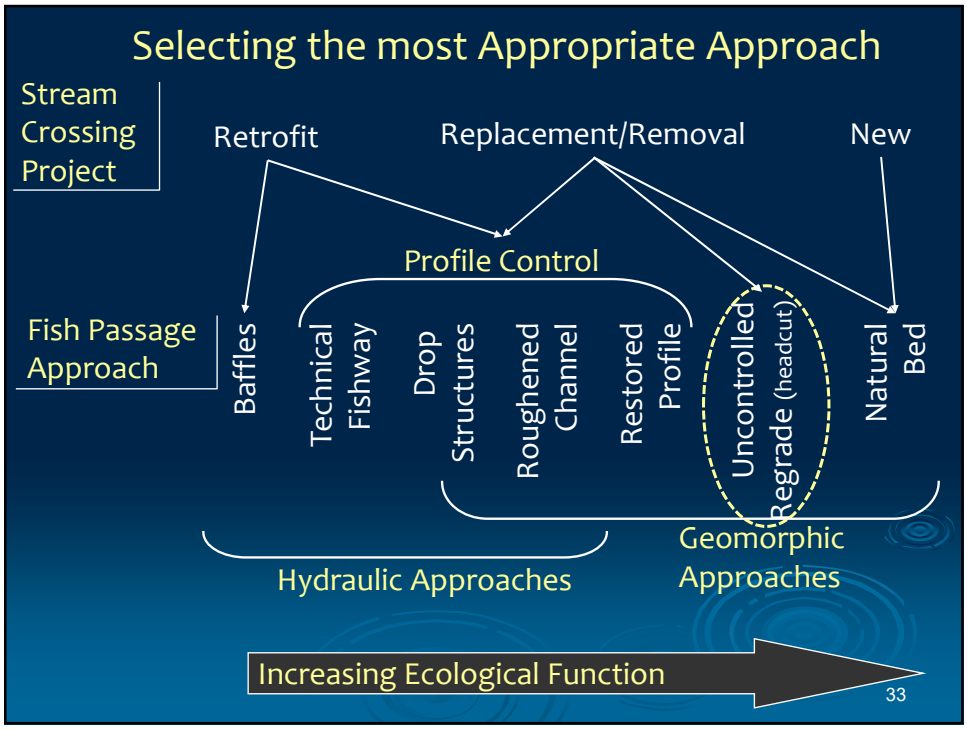

Selecting the most Appropriate Approach
Stream Crossing Project
Retrofit
Replacement/Removal
New
Profile Control
Fish Passage Approach
Baffles
Technical Fishway
Drop Structures
Roughened Channel
Restored Profile
Uncontrolled Regrade
Natural Bed
Hydraulic Approaches
Geomorphic Approaches
Increasing Ecological Function
31


Is Stream Simulation Appropriate?
Appropriate
Drop formed by Plunge Pool (Localized Scour)
culvert
Channel Grade Matches Upstream to Downstream
Not Appropriate
Drop Result of Channel Incision
culvert
Upstream Channel Grade
Downstream Channel Grade
32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Uncontrolled Regrade (headcut)
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Uncontrol Regrade
Upstream of Crossing Before Incision
Wynoochee trib – 2002
Channel regraded to bedrock
Upstream of Crossing After Incision
Example from Kozmo Bates
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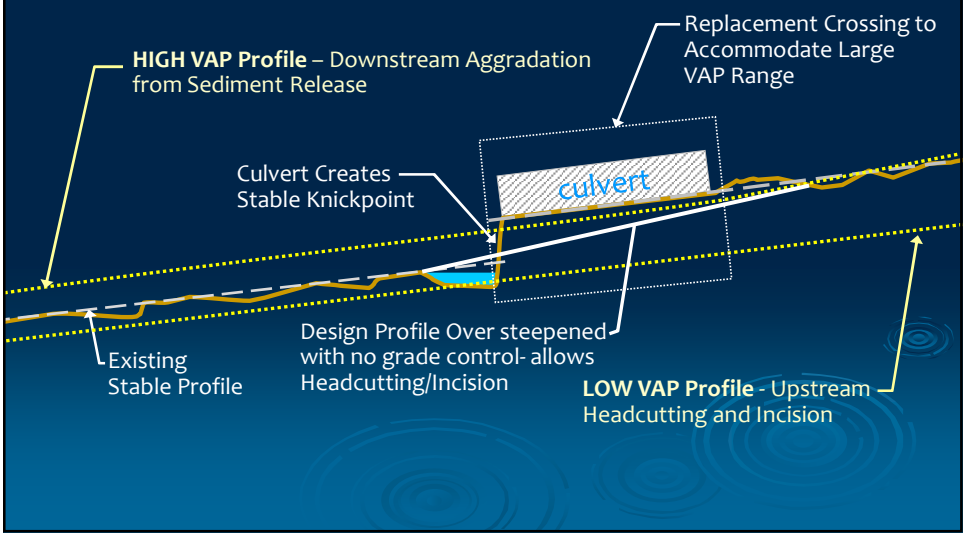
## VAP Profiles for Incised Channels
## (no grade control – "Uncontrolled Regrade")




## Uncontrolled Regrade – Sediment Slug

Downstream channel overwhelmed by sediment slug from headcut.
Crossing not sized to accommodate High VAP profile.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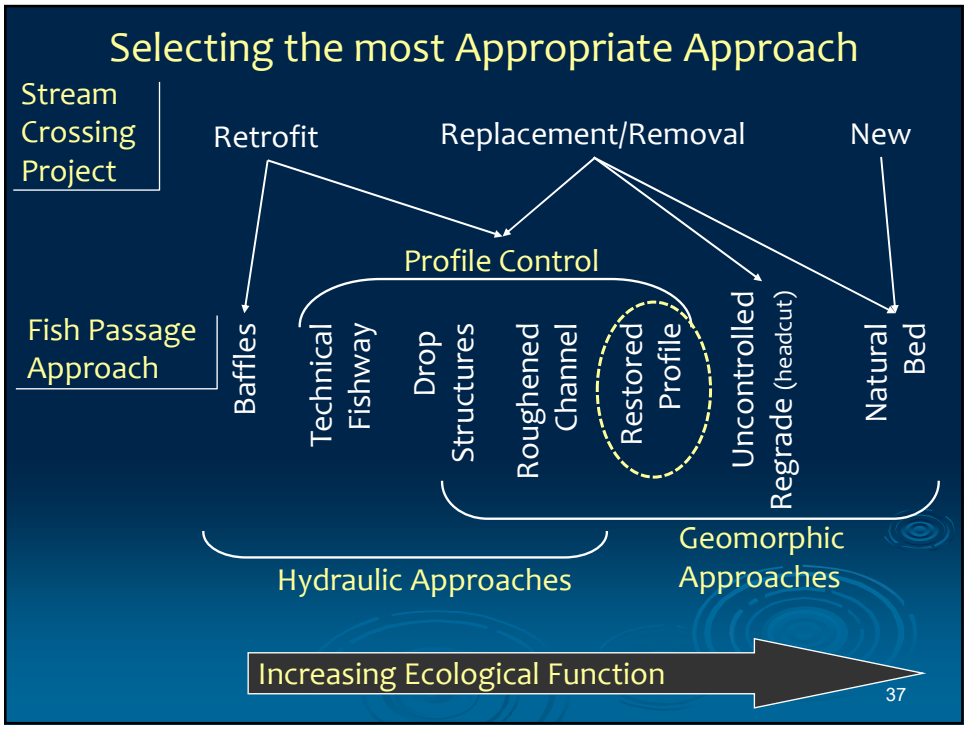
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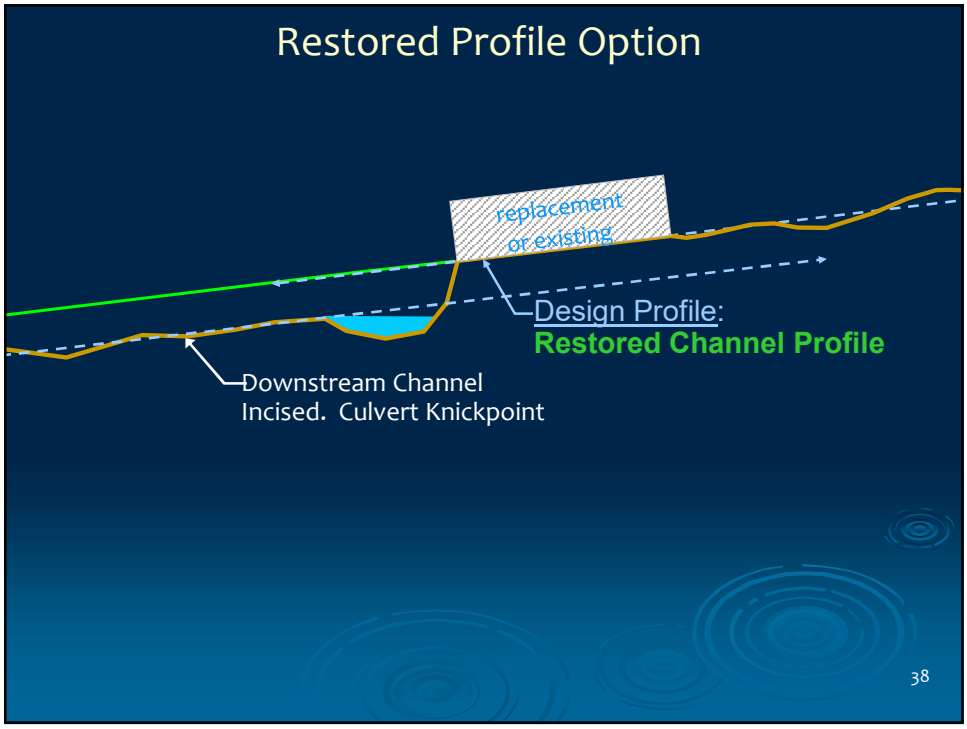
Restored Profile Option
replacement or existing
Design Profile:
Restored Channel Profile
Downstream Channel Incised. Culvert Knickpoint
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## Restoring Incised Channels and Connectivity

### Placing Wood - Profile Restoration

Neefus Gulch
Photo: Ross Taylor

Baker Creek
photo: Sam Flanagan, BLM

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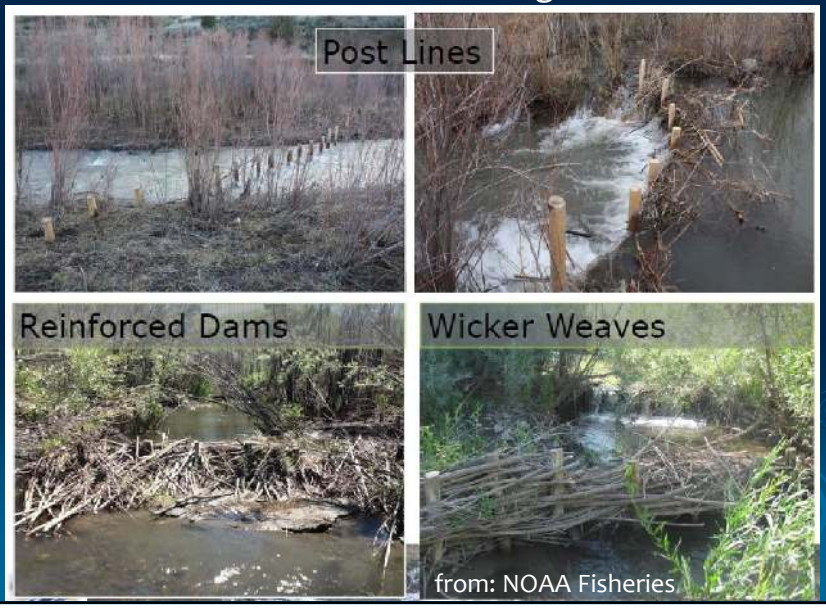
## Restoring Incised Channels and Connectivity

### Beaver Dam Analogs




from: NOAA Fisheries

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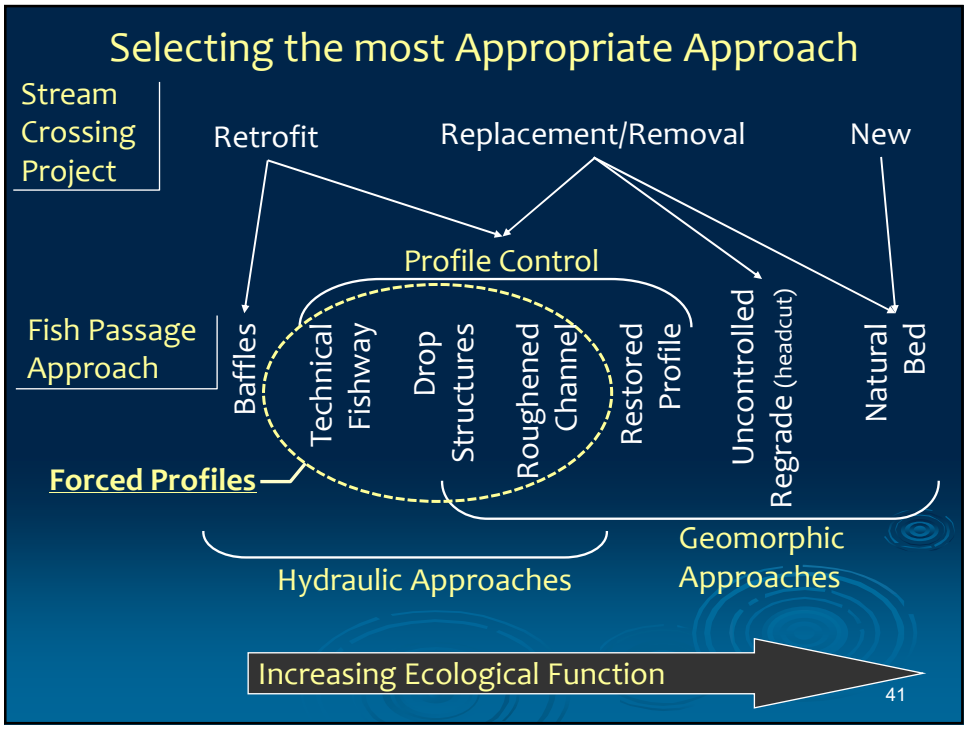
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Forced Profiles
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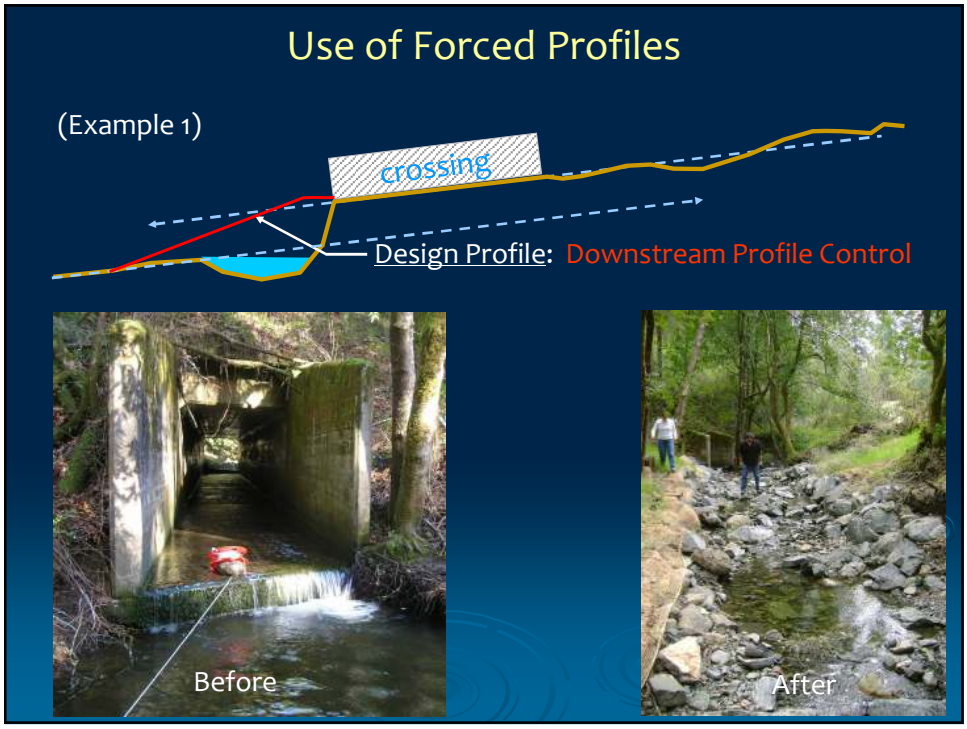
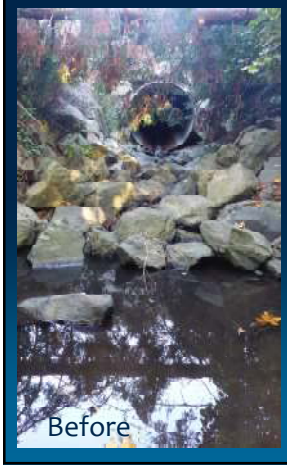
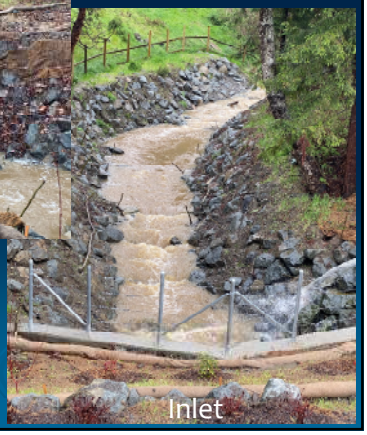

Use of Forced Profiles
(Example 1)
crossing
Design Profile: Downstream Profile Control
Before
After

## Use of Forced Profiles

(Example 2)

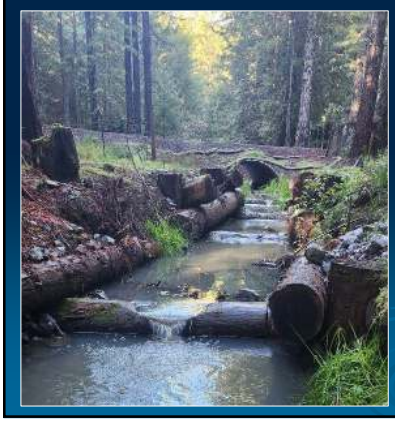





After
(roughened channel)

## Use of Forced Profiles

(Example 3)

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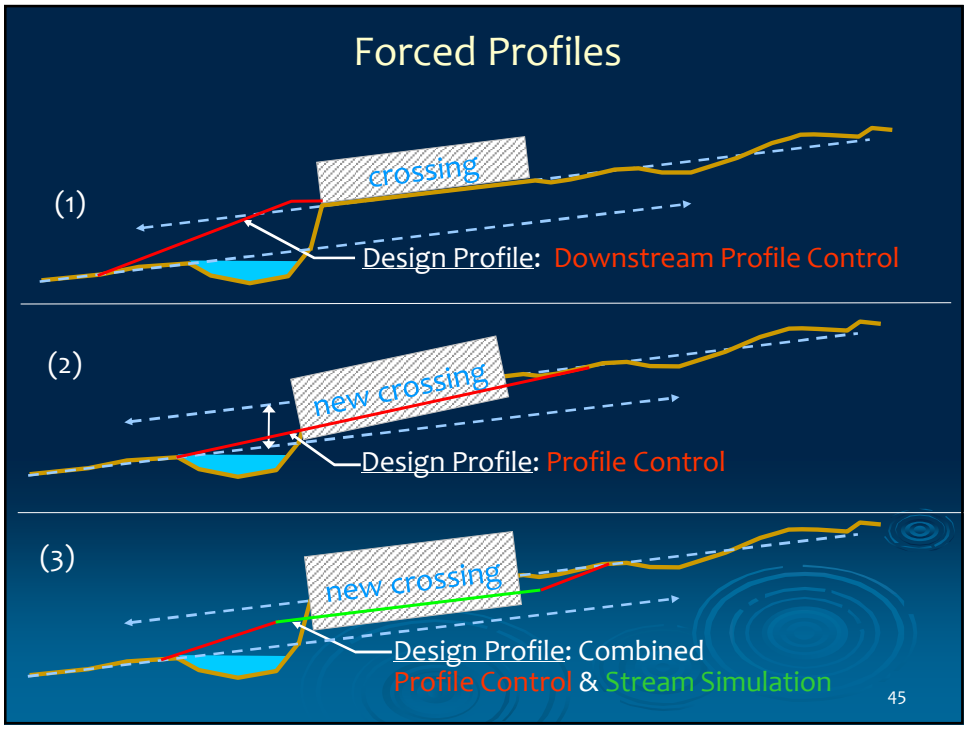
Forced Profiles
(1)
crossing
Design Profile: Downstream Profile Control
(2)
new crossing
Design Profile: Profile Control
(3)
new crossing
Design Profile: Combined
Profile Control & Stream Simulation
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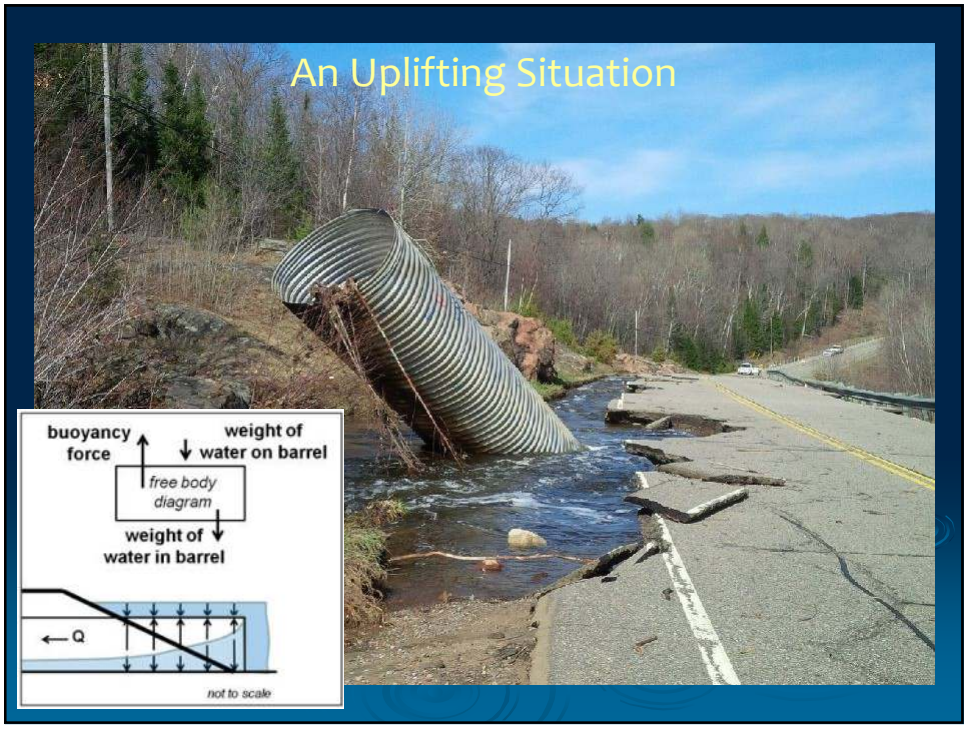
An Uplifting Situation
buoyancy force
weight of water on barrel
free body diagram
weight of water in barrel
Q
not to scale