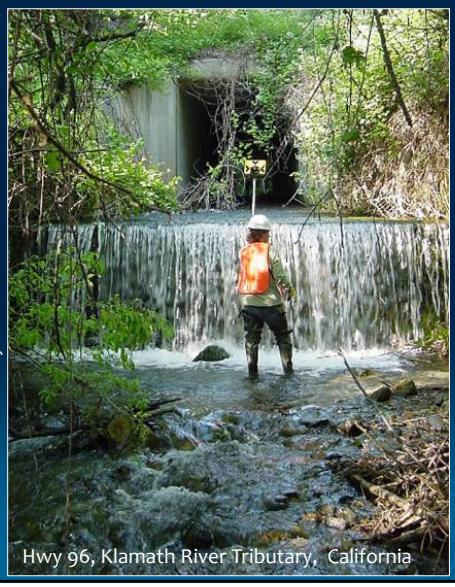
Assessing Geomorphic Risk for Stream Crossing Projects



Hwy 96, Klamath River Tributary, California

Humboldt State University

Michael Love P.E.
Arcata, California
mlove@h2odesigns.com

Michael Love & Associates
Hydrologic Solutions

❿1

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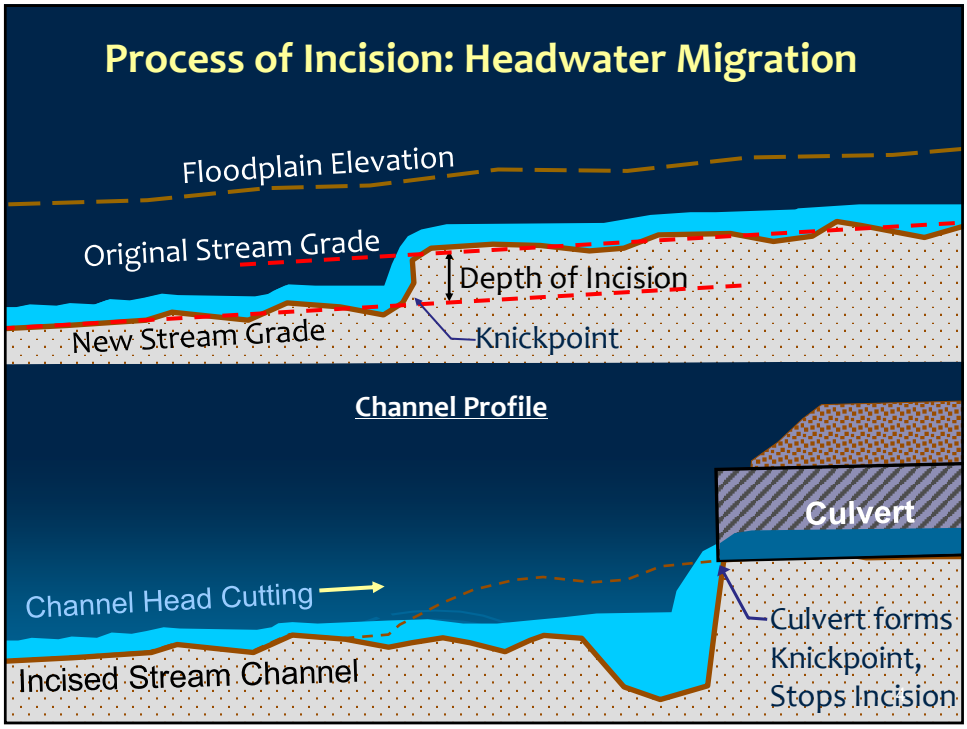
❿2


Photos: Ross Taylor

❿3


Process of Incision: Headwater Migration
Floodplain Elevation
Original Stream Grade
Depth of Incision
New Stream Grade
Knickpoint
Channel Profile
Culvert
Channel Head Cutting
Culvert forms Knickpoint, Stops Incision
Incised Stream Channel

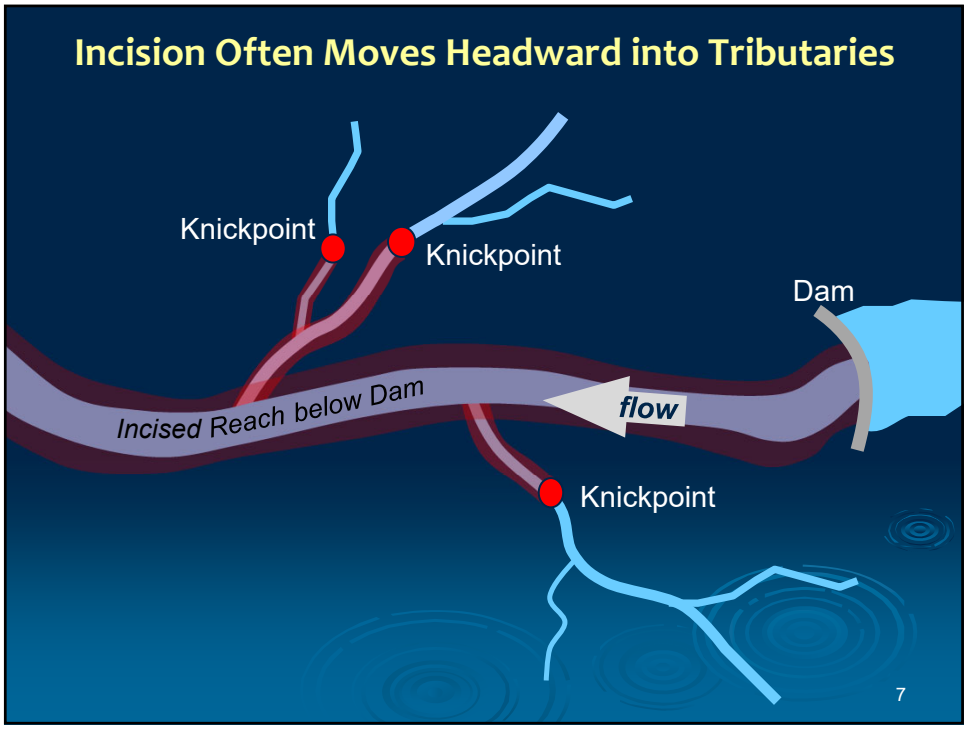
❿4

Channel Incision is a Natural Process, but…

❿5

We Initiate of the Incision More often then Not

❿6

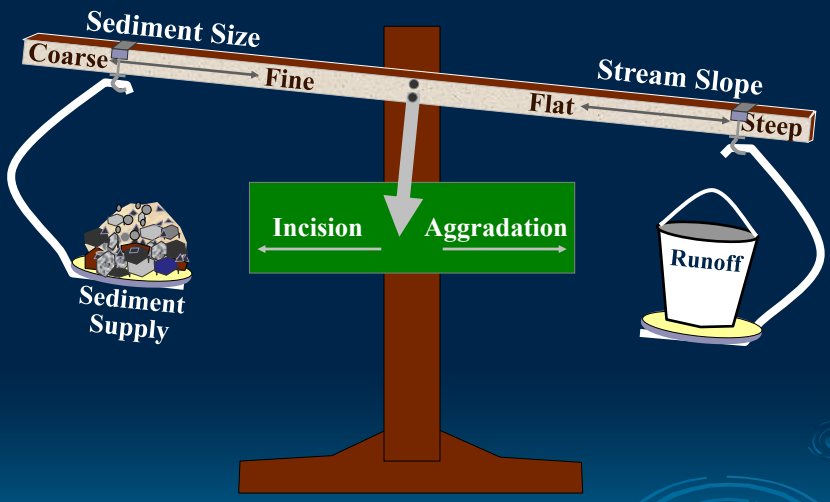

Incision Often Moves Headward into Tributaries
Knickpoint
Knickpoint
Dam
Incised Reach below Dam
flow
Knickpoint
7

⑩7


Knickpoints that Stop Incision but Create Fish Barriers
Harrison Grade Creek, Calif.
Perched Culverts
Alameda Creek, Calif.
Photo: Jon Stead
Armored Utility Crossings
Napa River, Calif.
Perched Bridge Aprons
San Pedro Creek, Calif.
Perched Fishway Entrances
8

⑩8

Dynamic Equilibrium and Causes of Incision



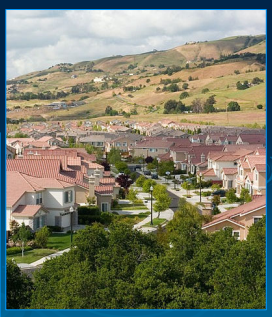
The Lane Relationship (from Lane, 1955)

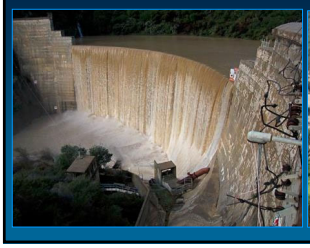
9

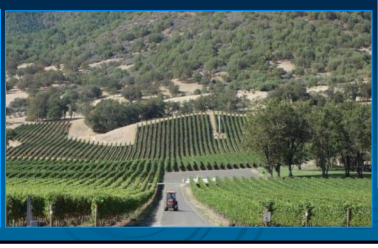
❿9

Causes of Channel Incision

- ✓ Decrease in sediment supply (dams, gravel extraction, urbanization)
- ✓ Channel encroachment (Increase depth of flow, bed & bank shear)
- ✓ Channelization (shortening/steepening the channel)
- ✓ Increase in runoff (urbanization, agriculture, road density)
- ✓ Loss of wood in streams (removal of large wood, beaver dams)
- ✓ Climate change/extreme weather







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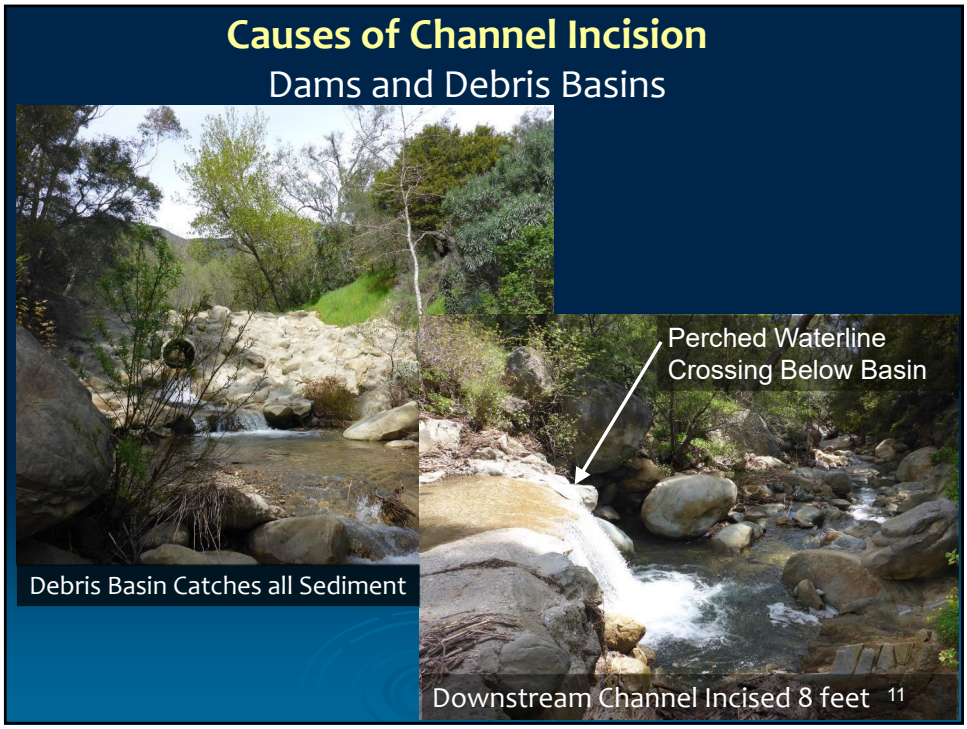
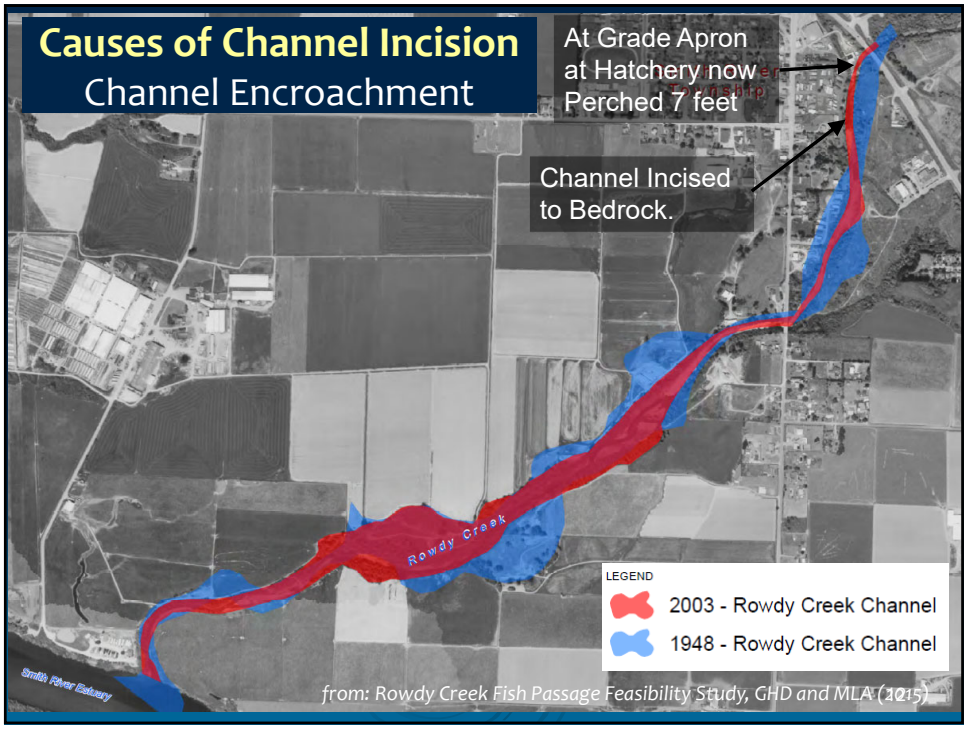
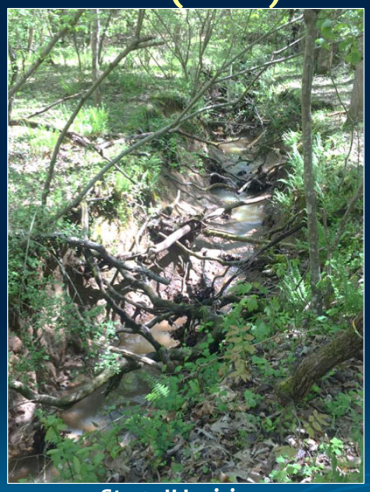

Causes of Channel Incision
Dams and Debris Basins
Perched Waterline Crossing Below Basin
Debris Basin Catches all Sediment
Downstream Channel Incised 8 feet
11

⑩11


Causes of Channel Incision
Channel Encroachment
At Grade Apron at Hatchery now Perched 7 feet
Channel Incised to Bedrock.
Rowdy Creek
LEGEND
2003 - Rowdy Creek Channel
1948 - Rowdy Creek Channel
from: Rowdy Creek Fish Passage Feasibility Study, GHD and MLA (2015)

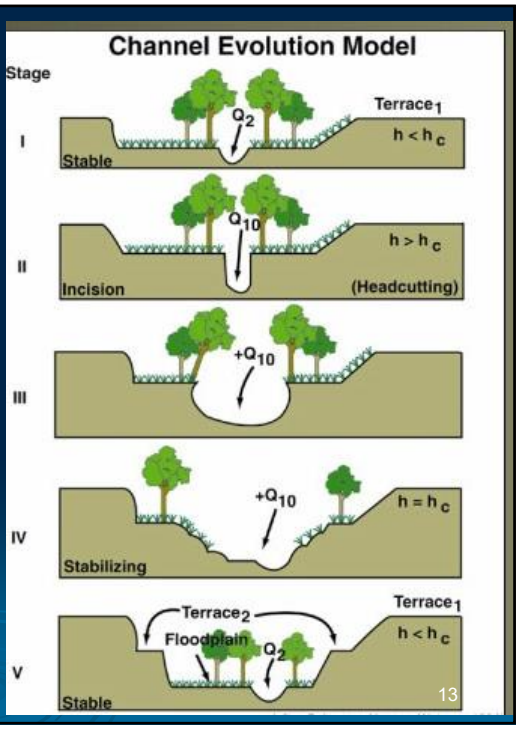
⑩12

Channel Evolution Model (CEM)



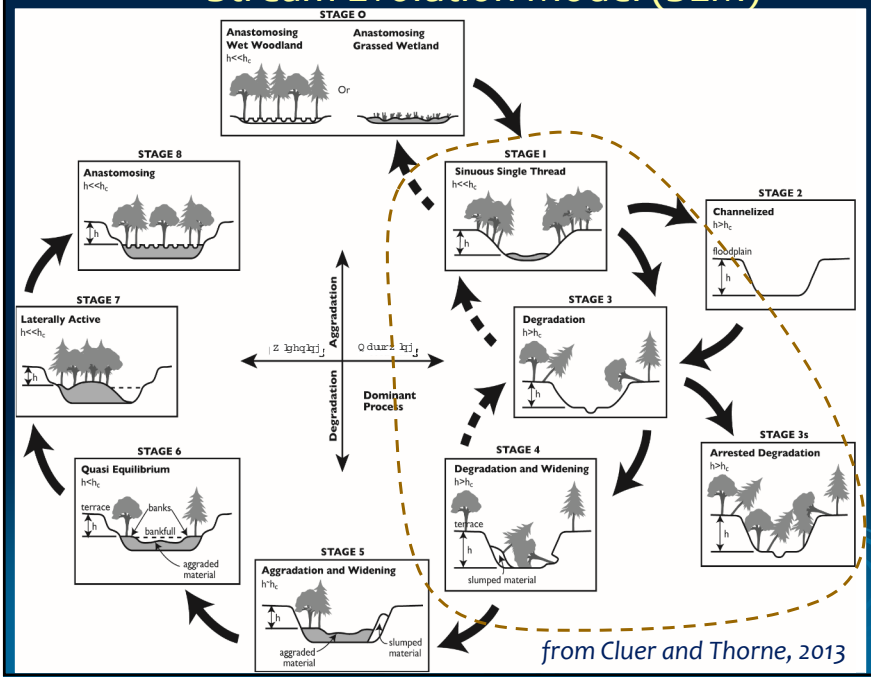
Stage II Incision

from Schumm, Harvey, and Watson. 1984.



⓭13

Stream Evolution Model (SEM)



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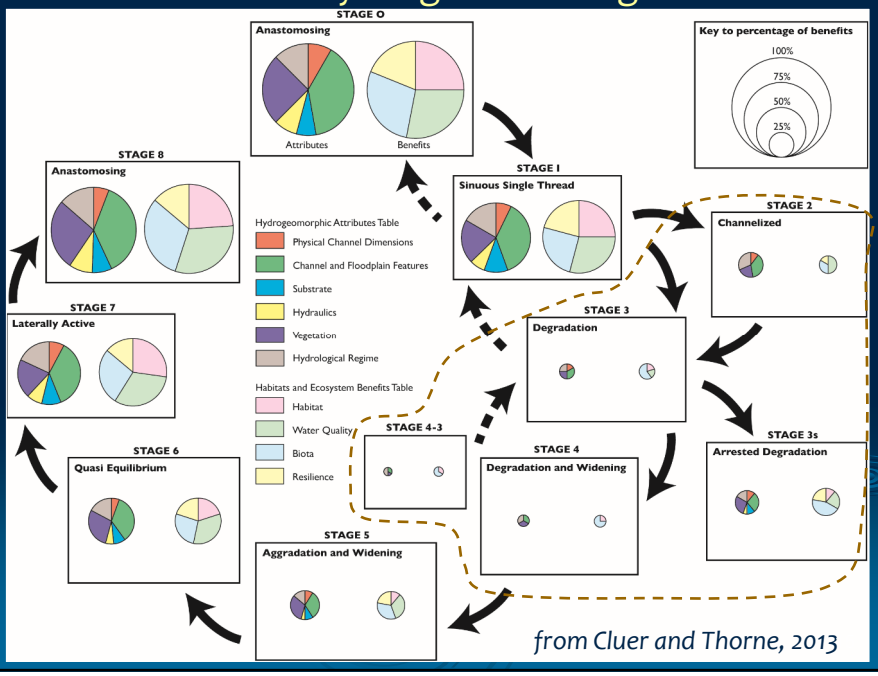
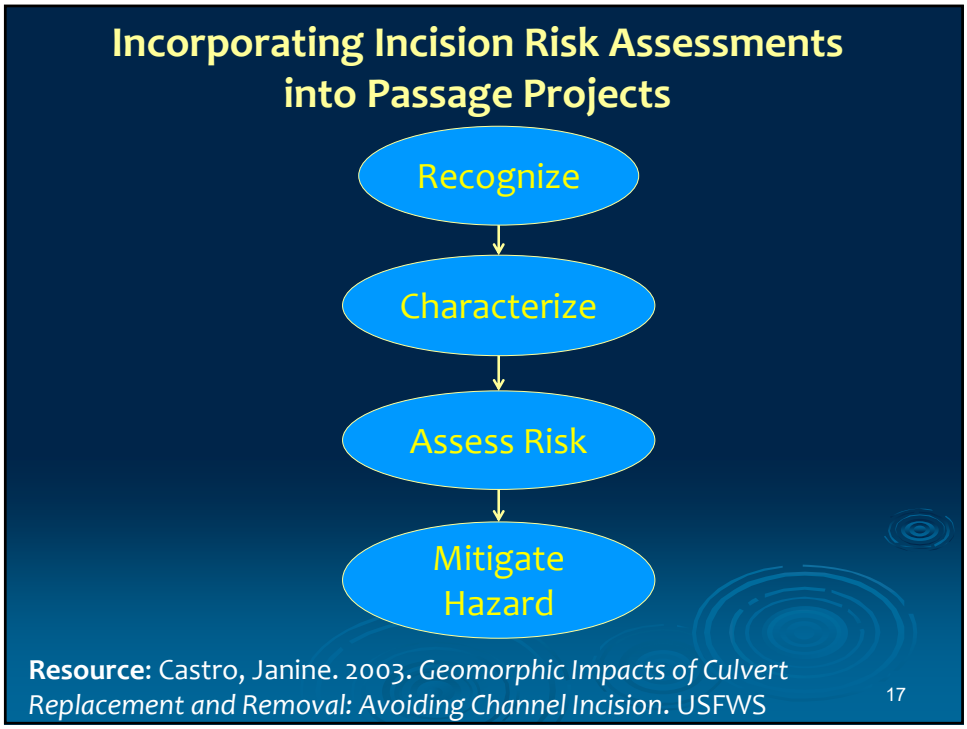
Stream Evolutionary Stage vs. Ecological Benefits



⑩15

Allowing Incision to Migrate Upstream without Considering Risk

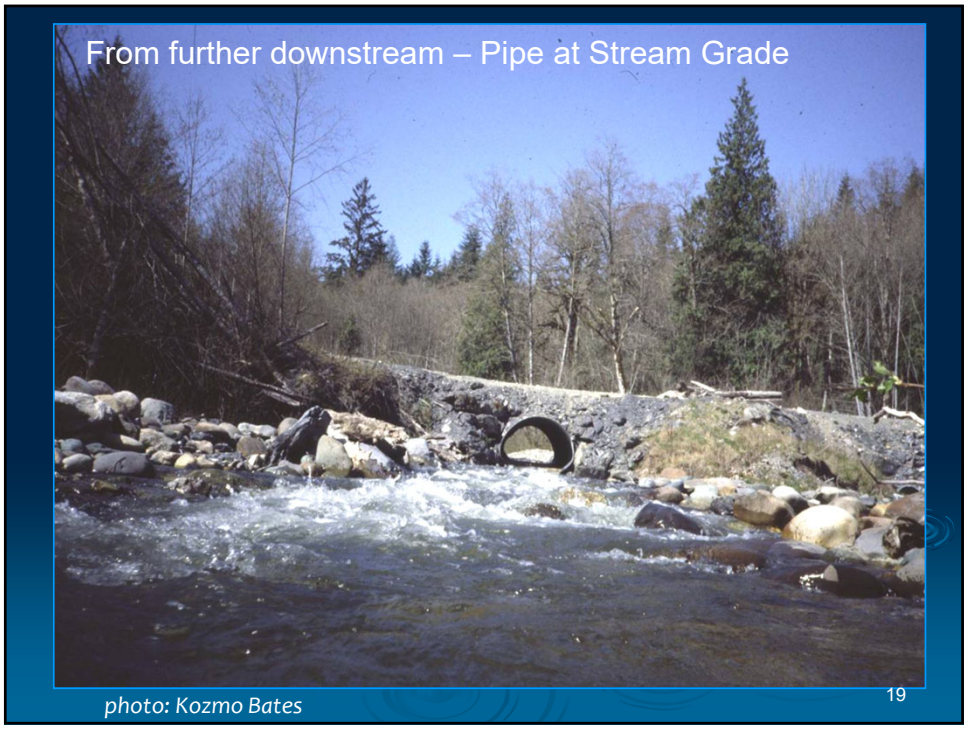
⑩16


Incorporating Incision Risk Assessments into Passage Projects
Recognize
Characterize
Assess Risk
Mitigate Hazard
Resource: Castro, Janine. 2003. Geomorphic Impacts of Culvert Replacement and Removal: Avoiding Channel Incision. USFWS
17

⑰17


Step 1 - Recognition: Incision or Local Scour?
photo: Kozmo Bates
18

⑱18


From further downstream – Pipe at Stream Grade
photo: Kozmo Bates
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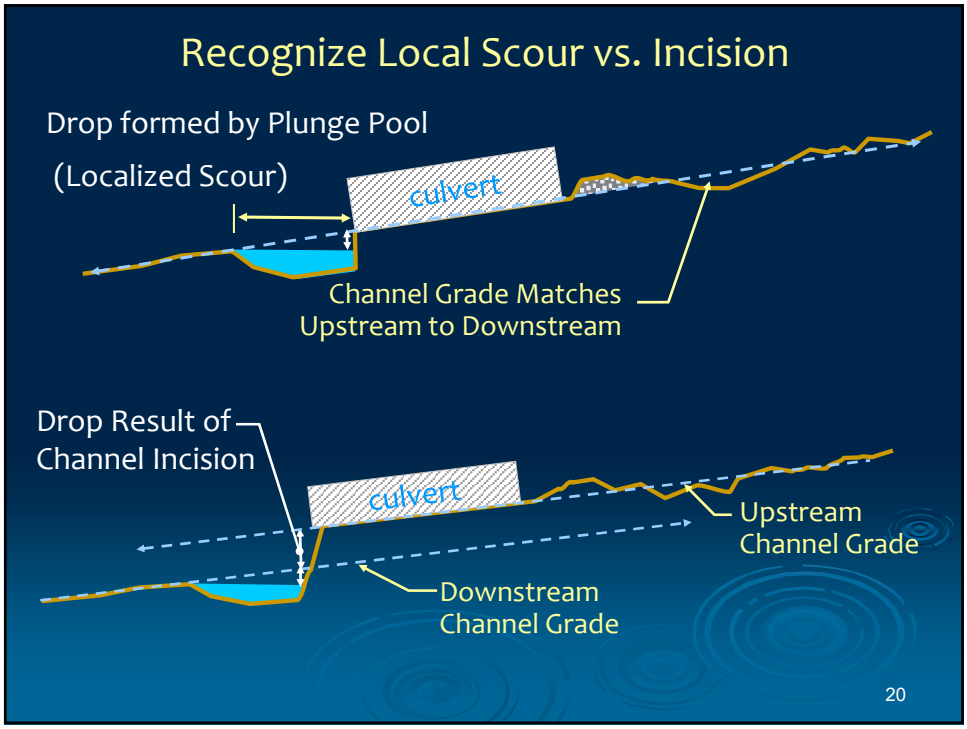
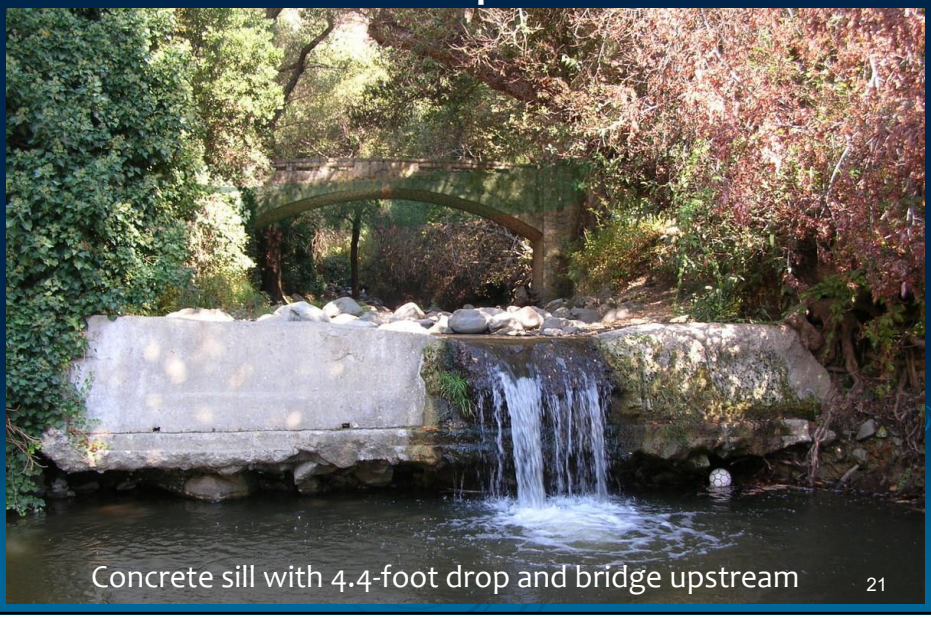
⑩19


Recognize Local Scour vs. Incision
Drop formed by Plunge Pool
(Localized Scour)
culvert
Channel Grade Matches
Upstream to Downstream
Drop Result of
Channel Incision
culvert
Upstream
Channel Grade
Downstream
Channel Grade
20

⑩20

Channel Profile Interpretation
Incision Knickpoint or Not?



Concrete sill with 4.4-foot drop and bridge upstream

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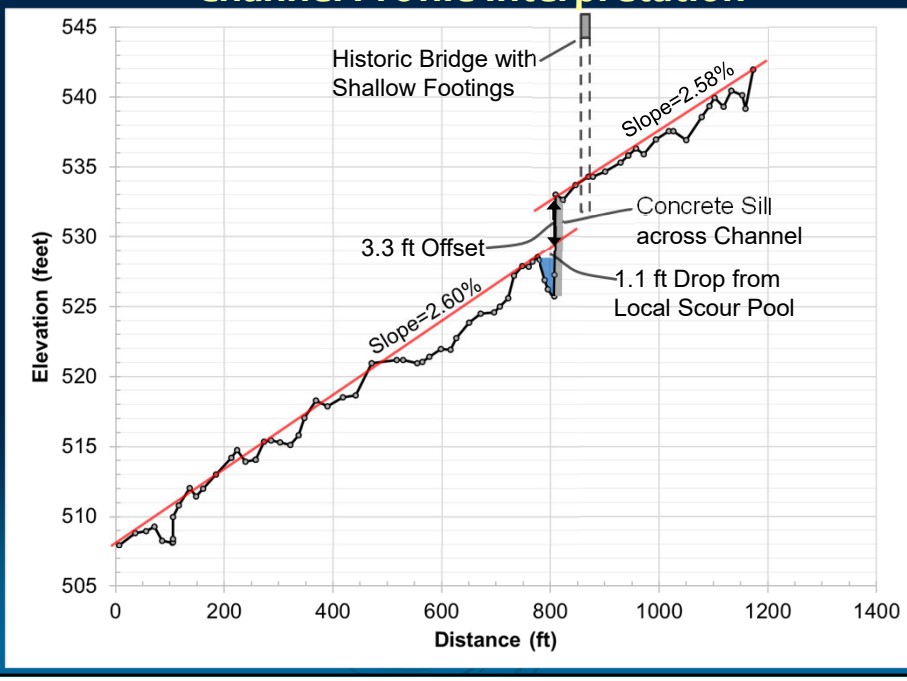
⑩21

Channel Profile Interpretation



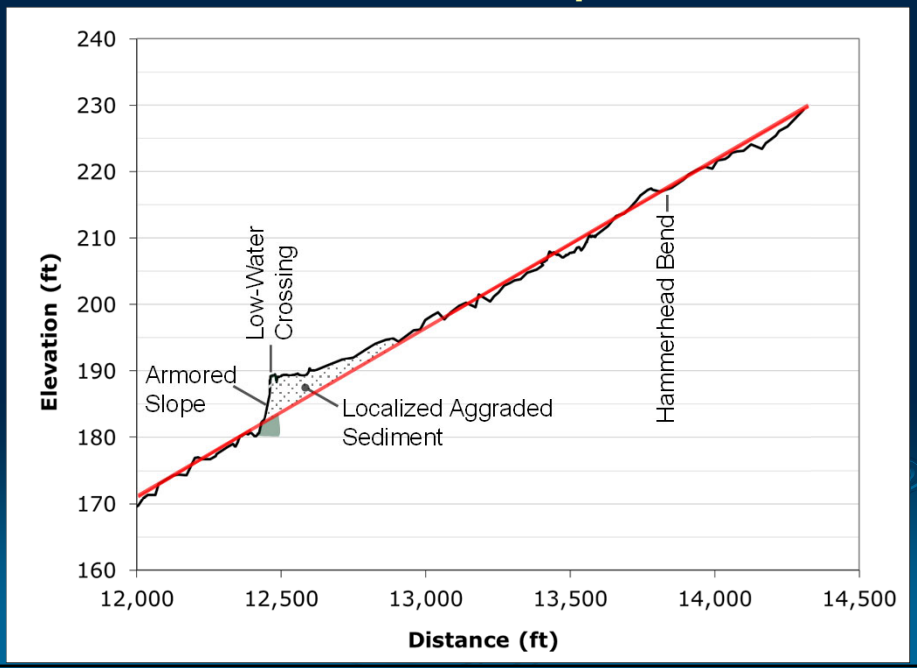
⑩22

Channel Profile Interpretation
Incision Knickpoint or Not?

Vented low-water crossing (ford) with 8.7 feet of drop. 23

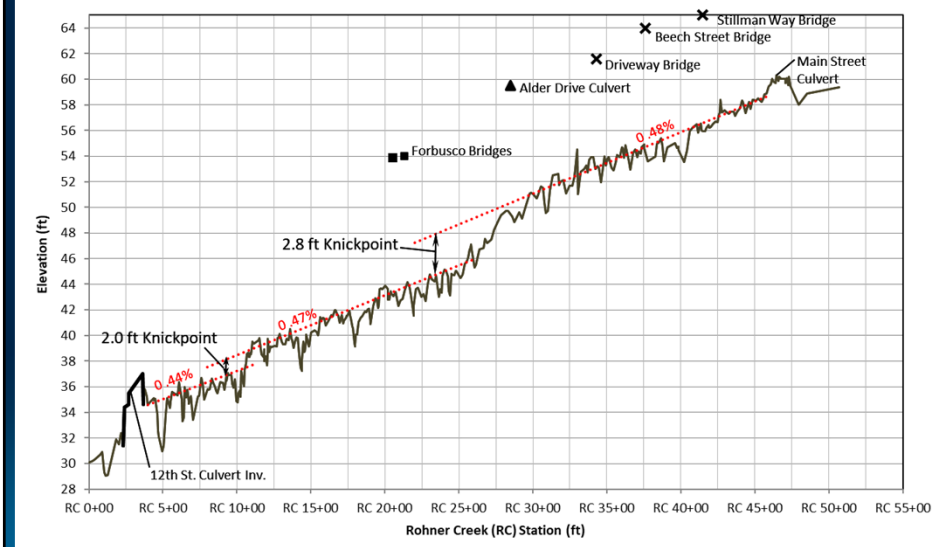
⑩23

Channel Profile Interpretation



⑩24

Channel Profile Interpretation



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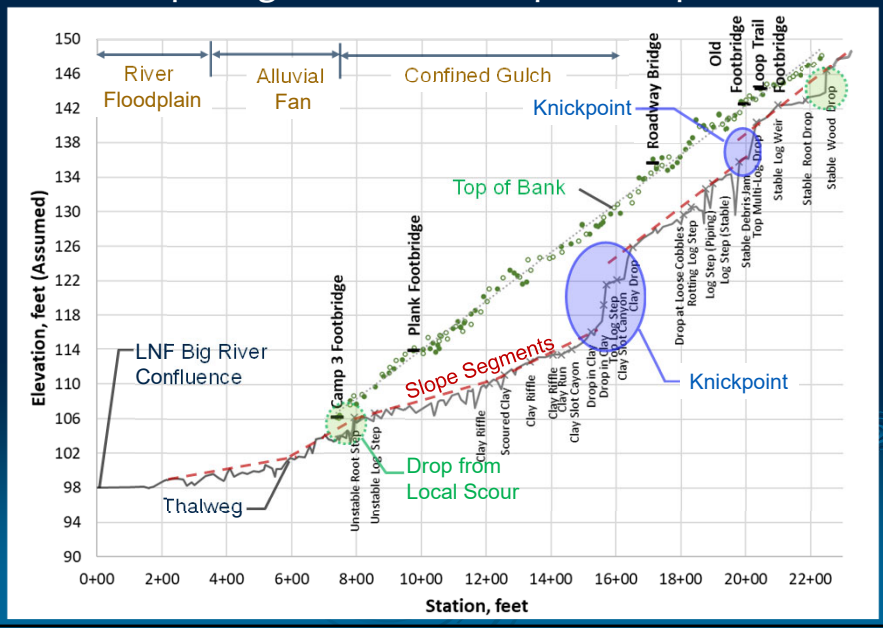
❿25

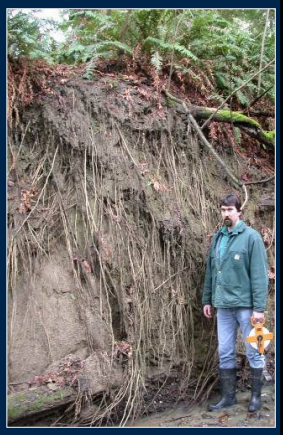
Channel Profile Interpretation
Slope Segments and Multiple Knickpoints

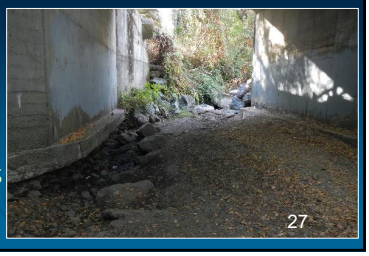


❿26

Other Channel Incision Indicators

- **Toe of Bank is Vertical**
  Exposed roots, lack of sediment layering at streambed-banks interface
- **Actively Widening (Stage III)**
  Active bank failures, low depositional bars
- **Cultural Features Exposed**
  Perched culverts or exposed bridge footings, aprons, and pipelines
- **Lack of Sediment Deposition**
  Erosion of channel bed down to bedrock or other resistant soil layers
- **Lack of Pools**
  Long reaches of riffles/runs without pools





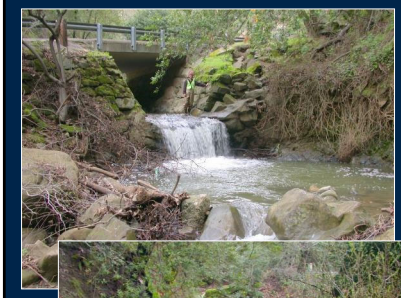
List adapted from J. Castro, 2003

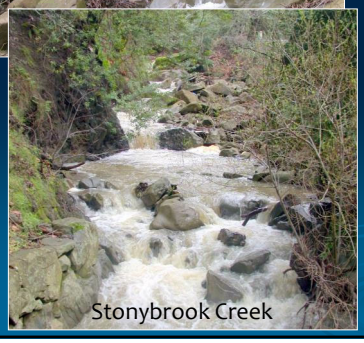
⑩27

Risk Assessment - Rate of Headward Incision

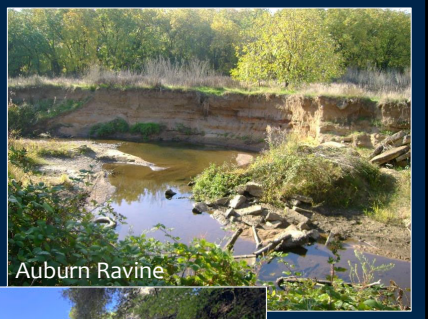
More mobile the bed material, more rapid the channel regrades.

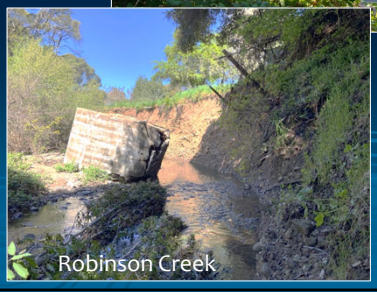
Boulder Channel





Fine Grain Bed and Banks





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⑩28

Risk Assessment for Removing Knickpoints in Incised Channels

- **Anticipated magnitude and extent**
  Depth of incision and length of channel at risk
- **Risk to upstream property and infrastructure**
- **Impact to existing riparian/wetland vegetation**
  Will water table lower with incision and rootzone become dry?
- **Change in connectivity to side-channels and floodplain**
- **Rate of incision, bank widening, and sediment release**
  Mobility of bed, erosivity if banks, wood controls, bedrock
- **Ability of channel to recover**
  Will bank material and land-use permit channel evolution (widening)?

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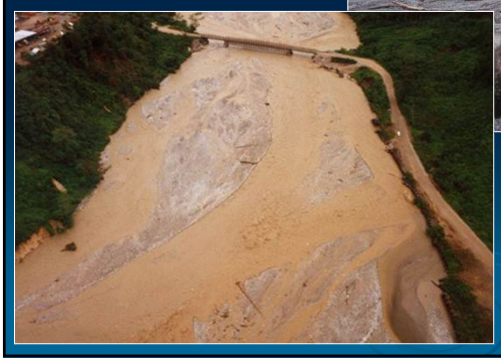
⓾29

Channel Aggradation

Increased sediment loads combined with large flood can cause entire streams and rivers to aggrade.



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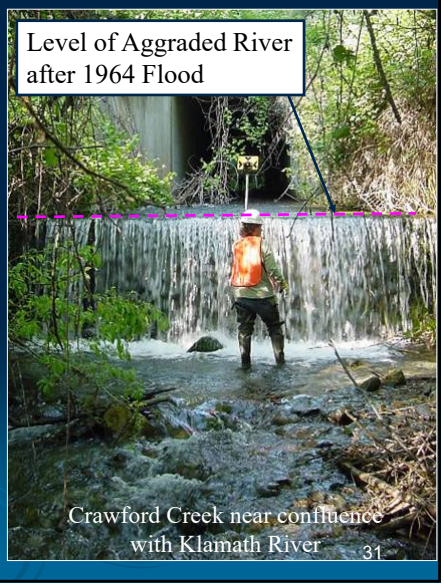
⓾30

Channel Aggradation and Culverts

Culvert replacements after flood events have added complexity and risk:

- Anticipating future regrade.
- Determining vertical placement of culvert invert or arch-footings.
- Providing enough flood capacity in aggraded state.



⑩31

Backwater Influences

Sultan Creek Bridge
Influenced by Debris Jamming from High Flow Backwatering by Smith River

Little Mill Creek Bridge
Depositional Bar from River Backwatering

⑩32


Fluctuating Levels of Beaches and Coastal Lagoons
Solstice Creek Outlet Discharging onto Beach
Arroyo Hondo Lagoon Breaching
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