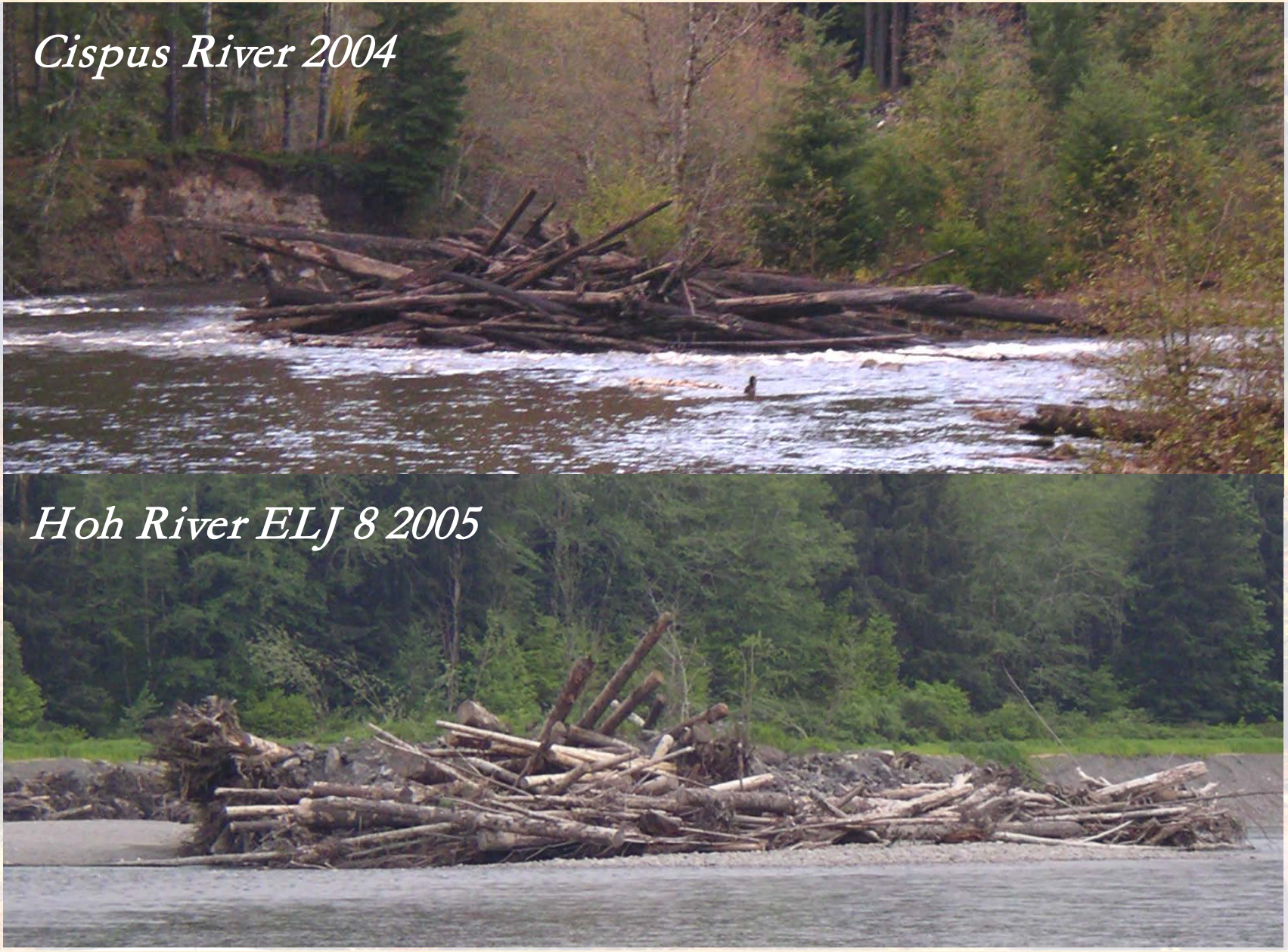
Large Woody Debris and Engineered Logjams

Tim Abbe
Herrera Environmental Consultants, Inc.

Some basic guidelines for building a sound foundation for sustained rehabilitation of fluvial ecosystems:

1. **Know how physical elements and processes have changed and their significance to the system.**
2. **Re-introduce or emulate the key elements which have been lost.**
3. **Understand the consequences of "restoring" natural systems, particularly w.r.t. human development.**
4. **Adapt land management and infrastructure to accommodate recovery of disturbance regimes that sustain ecological communities.**


Cispus River 2004
Hoh River ELJ 8 2005

"Engineered" Logjams Means They are Carefully Analyzed and Designed for a Factor of Safety and a Specified Design Life

- Size, position, and spacing of ELJs based on:
  - Hydraulic analysis of flow behavior near structure(s)
  - Channel response over time
- ELJ architecture & materials based on:
  - Scour analysis
  - Structural stability analysis
  - Material design life analysis
- All structures designed to emulate nature and provide maximum possible benefits to restoring native habitat

Engineered Logjam Design Process

1 Reach Analysis
- Fluvial geomorphology
- Hydrology & hydraulics
- Ecology/Habitat/ESA
- Wood & sediment budgets

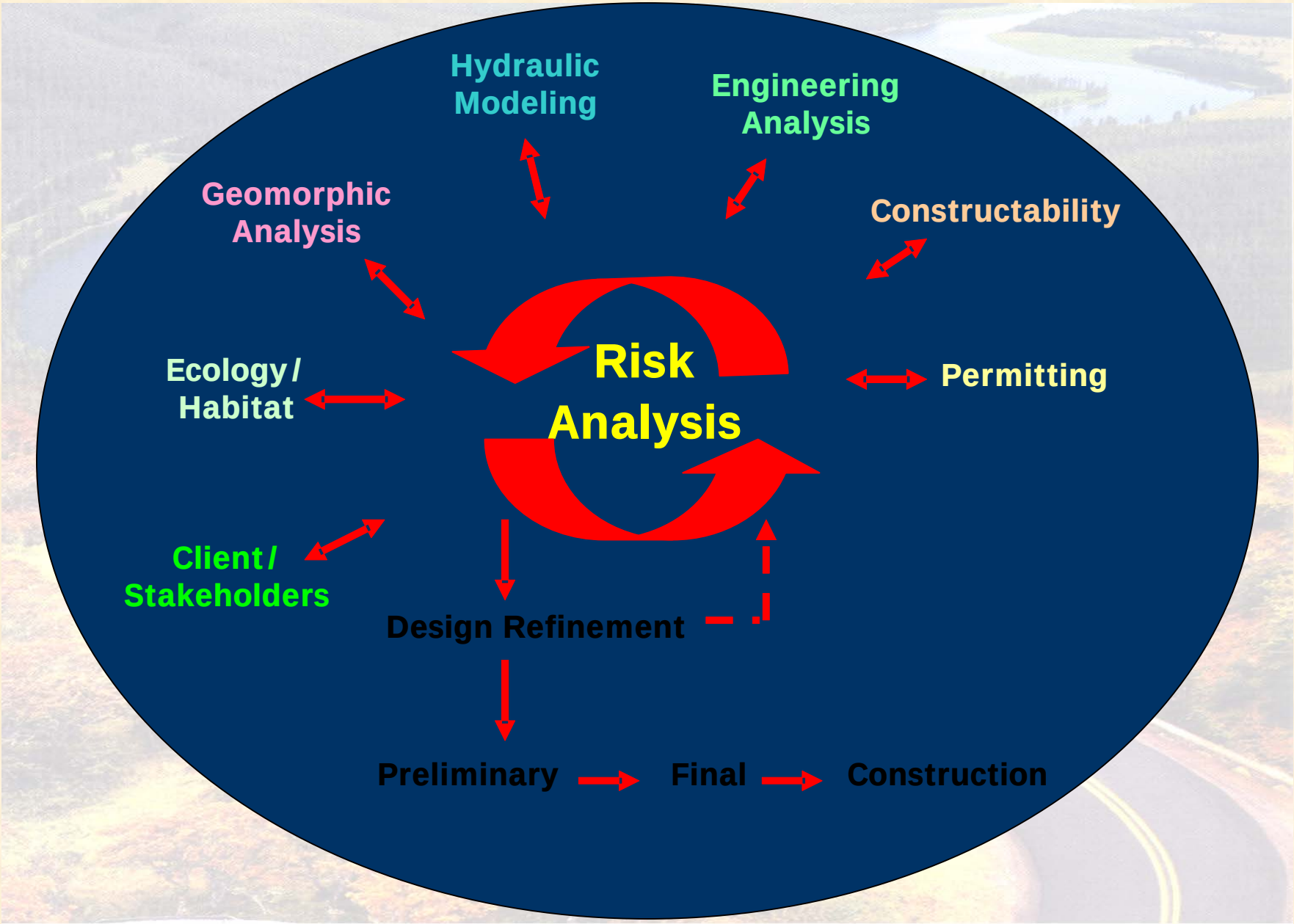
2 Feasibility
- Opportunities/Constraints
- Stakeholder concerns
- Design Alternatives
- Acceptable Risk and Cost
- Cost Benefit

3 Risk Assessment
- Risk to habitat and humans
- Factor of Safety
- Engineering Analysis
- System Response

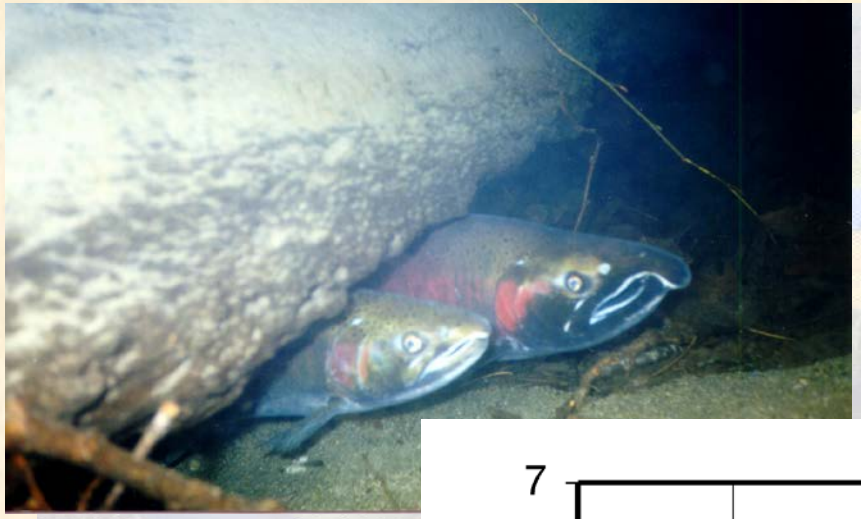
4 Design
- Type of structure and architecture
- Number of structures, size, location
- Force balance
- Scour and deposition
- Channel dynamics

5 Construction
- Materials (trees)
- Access and sequencing
- Flow diversion and de-watering
- Erosion and water quality

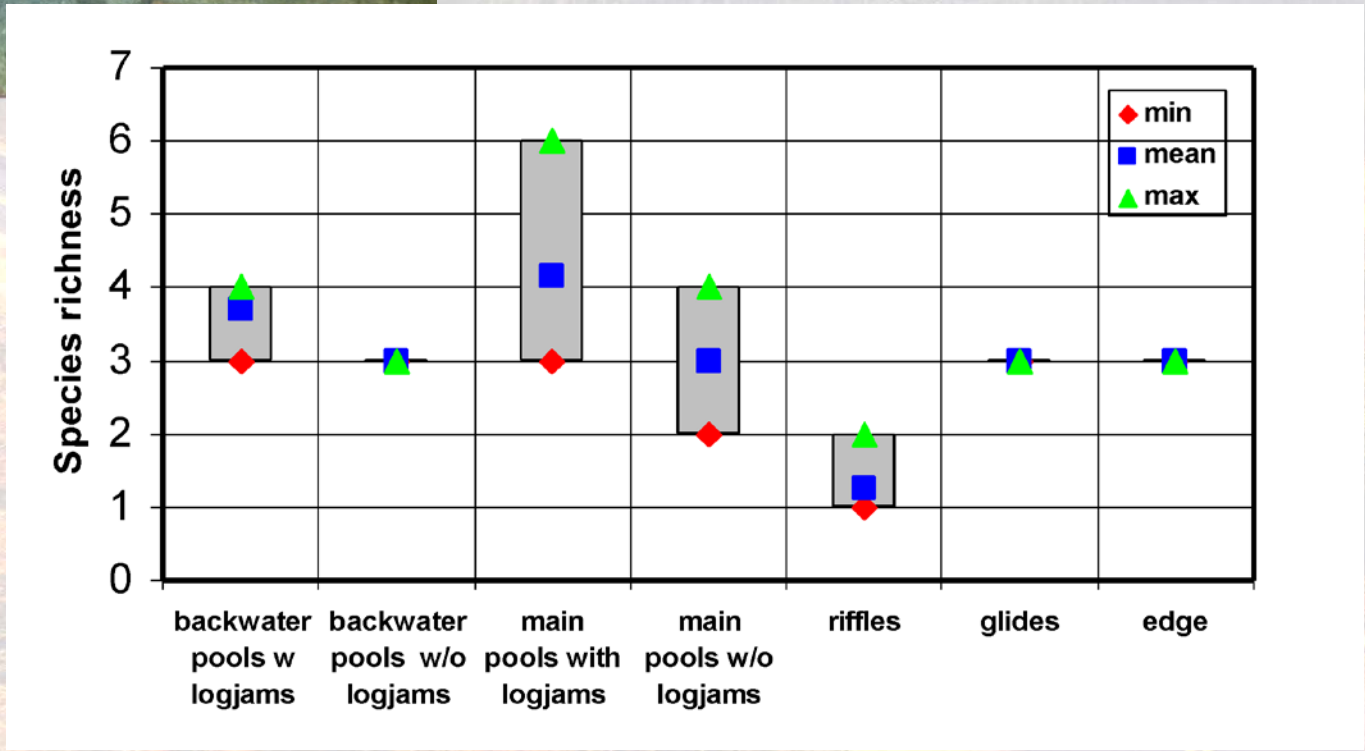
6 Inspection Monitoring
- Culling or repair
- Re-vegetation
- Accumulation/Loss of ballast
- Flotsam accumulation


Hydraulic Modeling
Engineering Analysis
Geomorphic Analysis
Constructability
Ecology / Habitat
Risk Analysis
Permitting
Client / Stakeholders
Design Refinement
Preliminary
Final
Construction

Fish Benefits

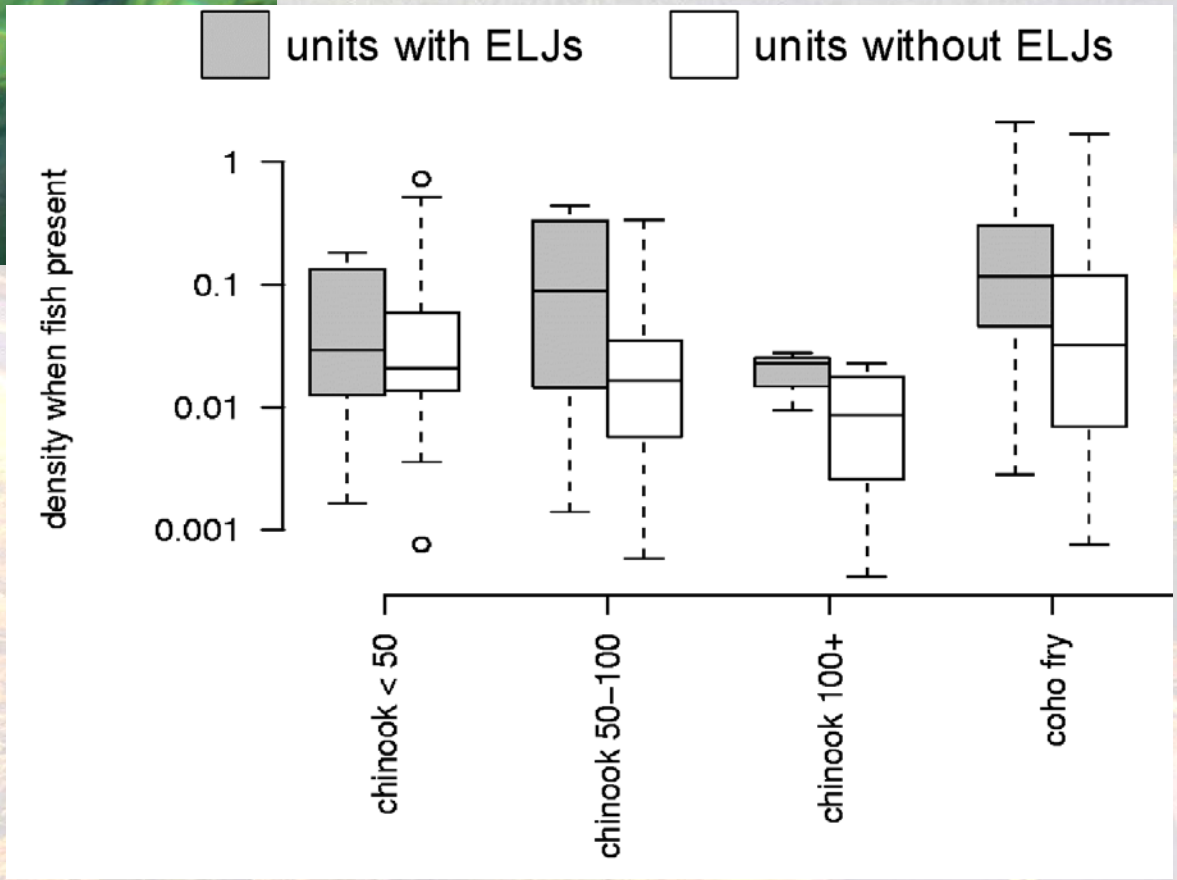


Species richness increases in rivers with the addition of logjams



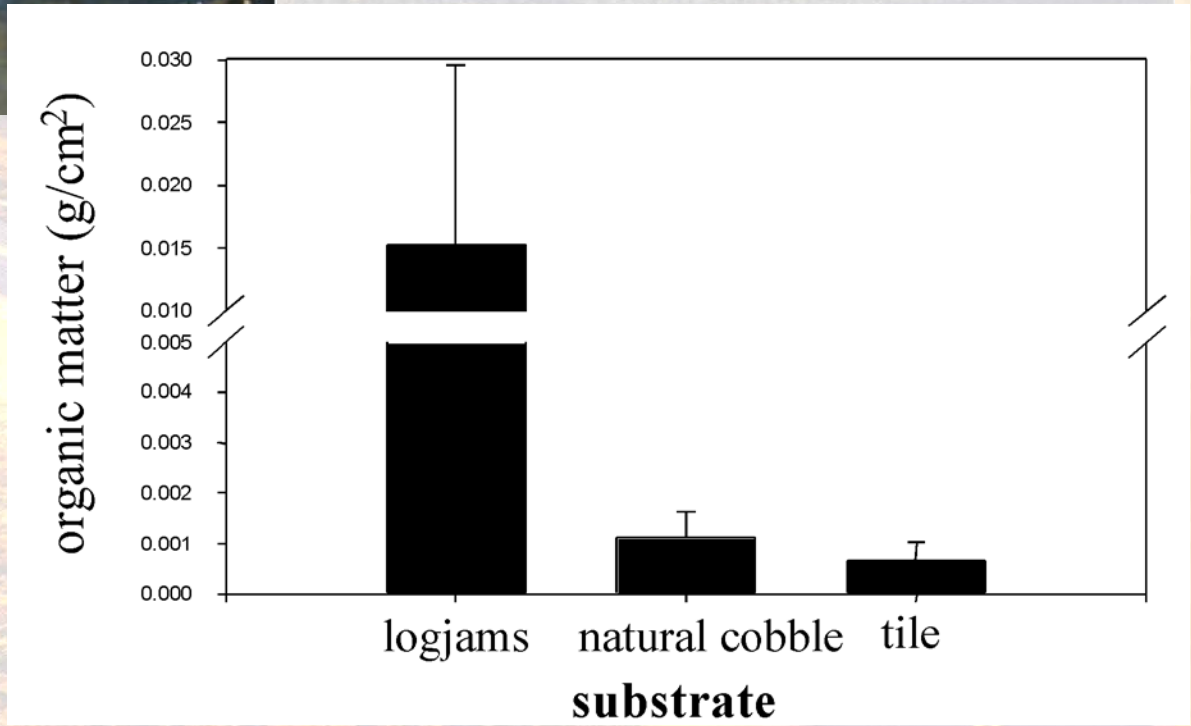
Pess et al. 2002

Fish density increases at logjams



Pess et al. 2002

Organic matter is higher at logjams

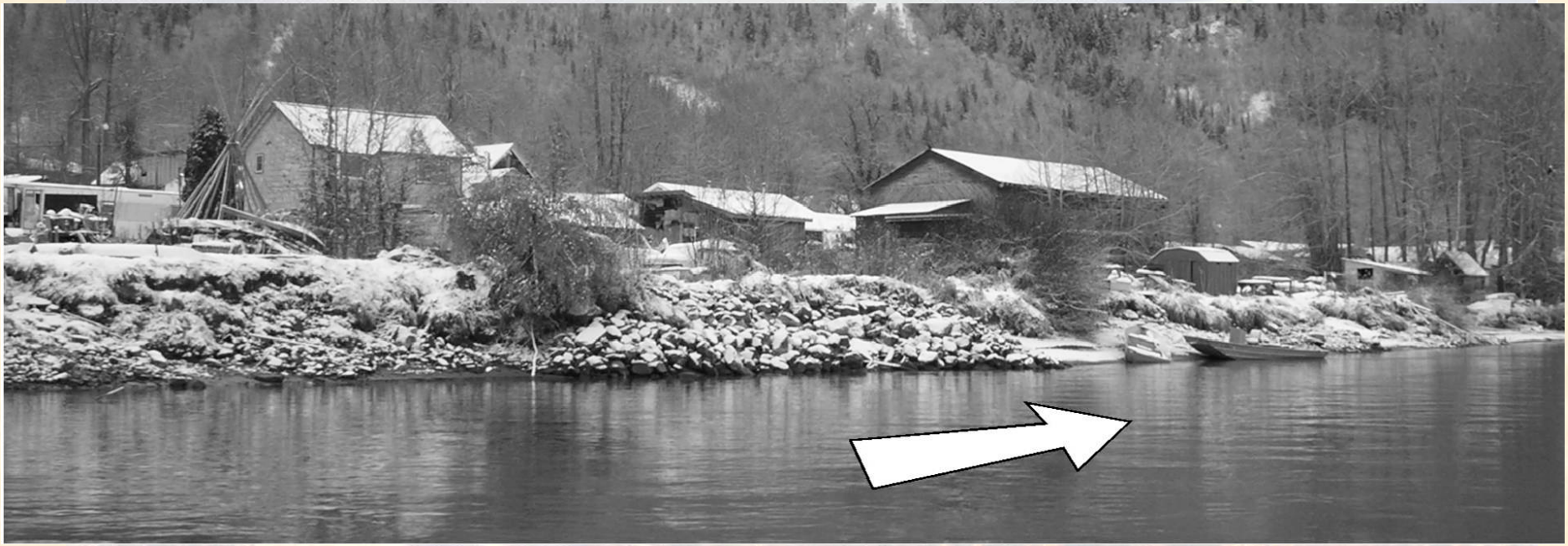


Pess et al. 2002


Logjams also make great
habitat for *Homo Sapiens*

The Many Types of ELJ Projects:

- Bank roughening
- Bank stabilization
- Flow deflection
- Flow bifurcation
- Grade control



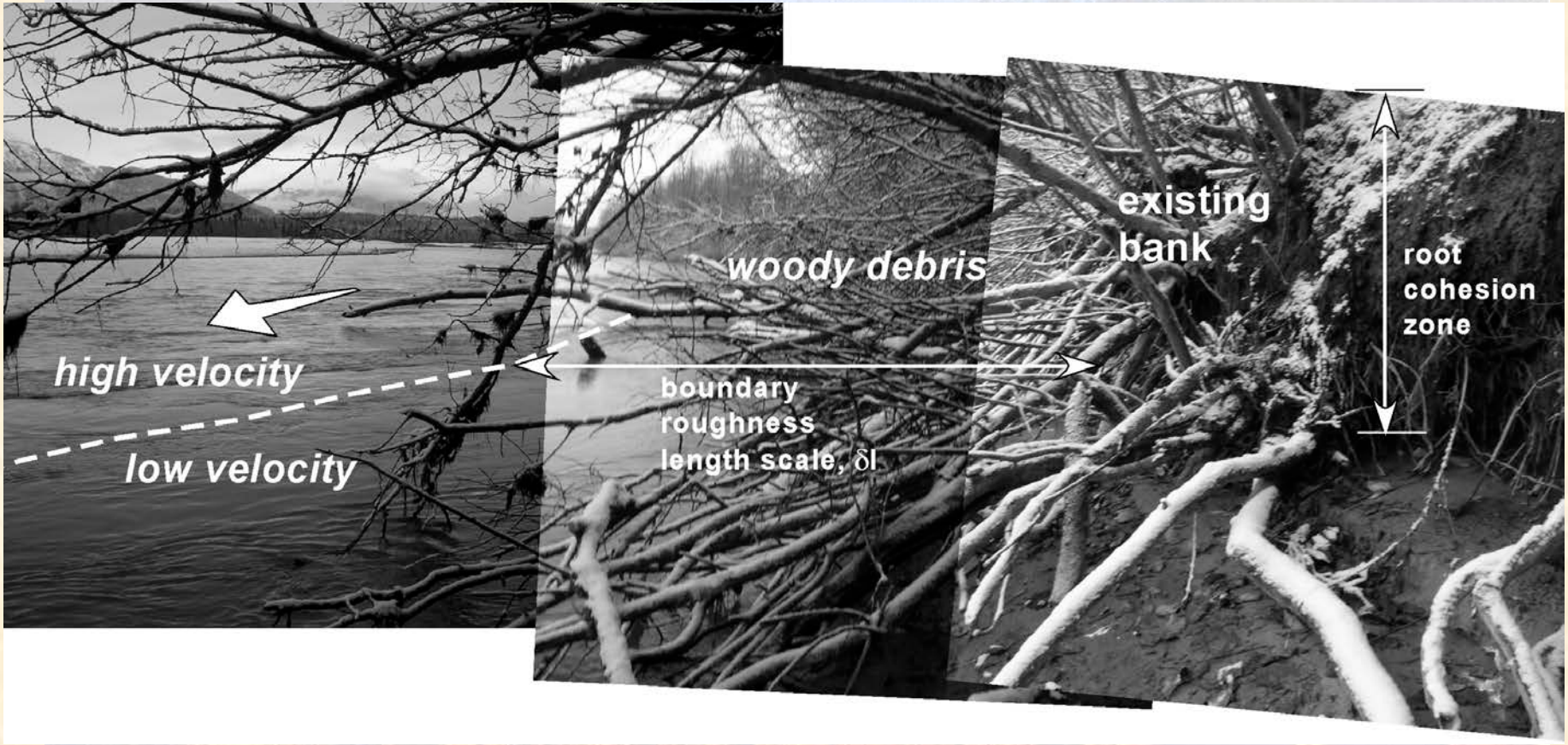
Smooth shoreline:

High velocity flowline hugs shoreline where there is lack of boundary roughness provided by woody vegetation and channel shoreline is subjected to shear stresses.

Rough shoreline:

High velocity flowline is offset by boundary roughness provided by woody vegetation, reducing shear stress along the channel shoreline.

Natural Bank Roughening



Chilkat River, Klukwan, Alaska

Flow Deflection

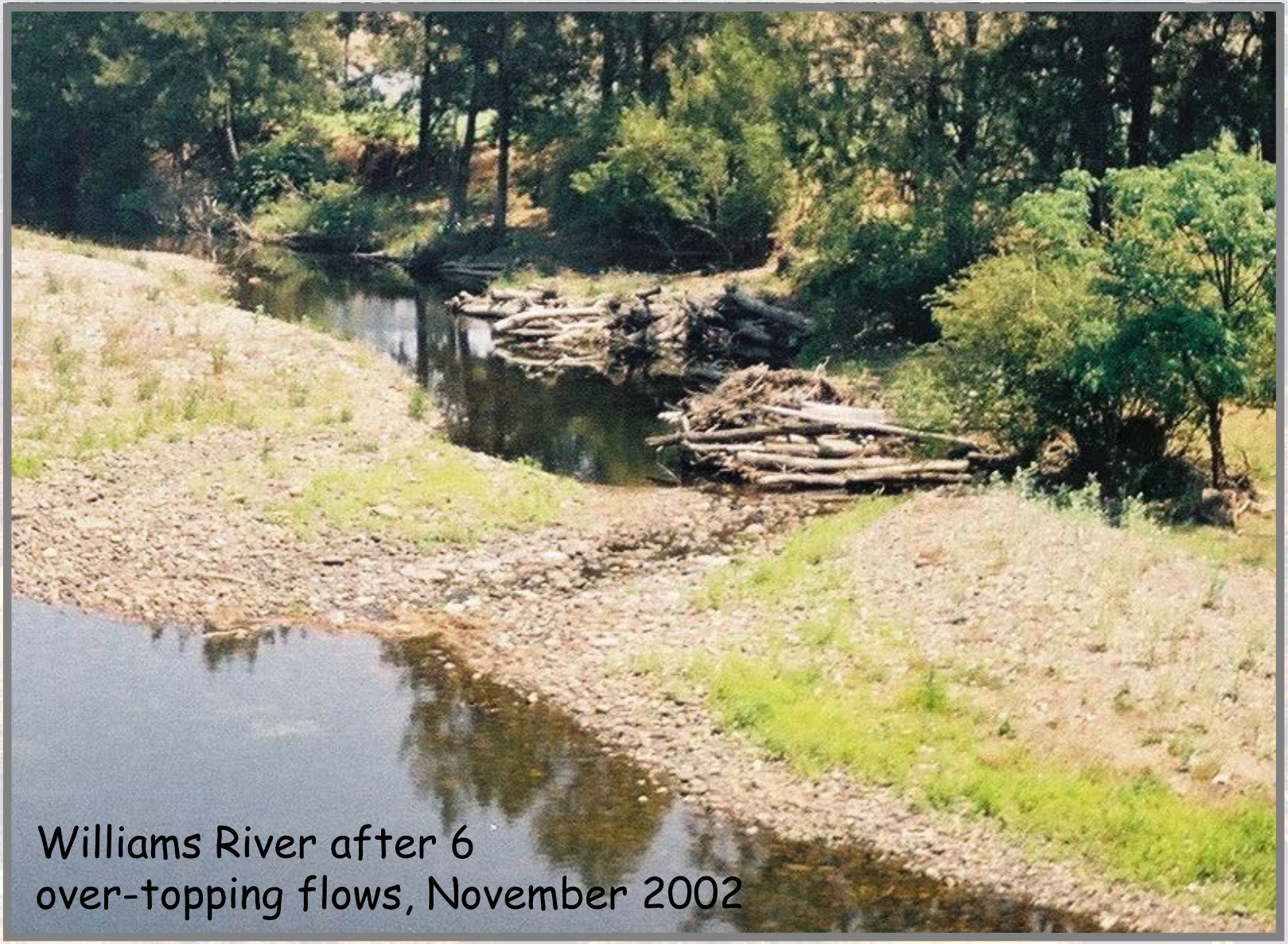
Engineered logjam constructed in 1999 to protect Forest Road 23, Cispus River. November 2004.

Evaluating Design Principles – Examples from Actual Projects:

Williams River, NSW, Australia

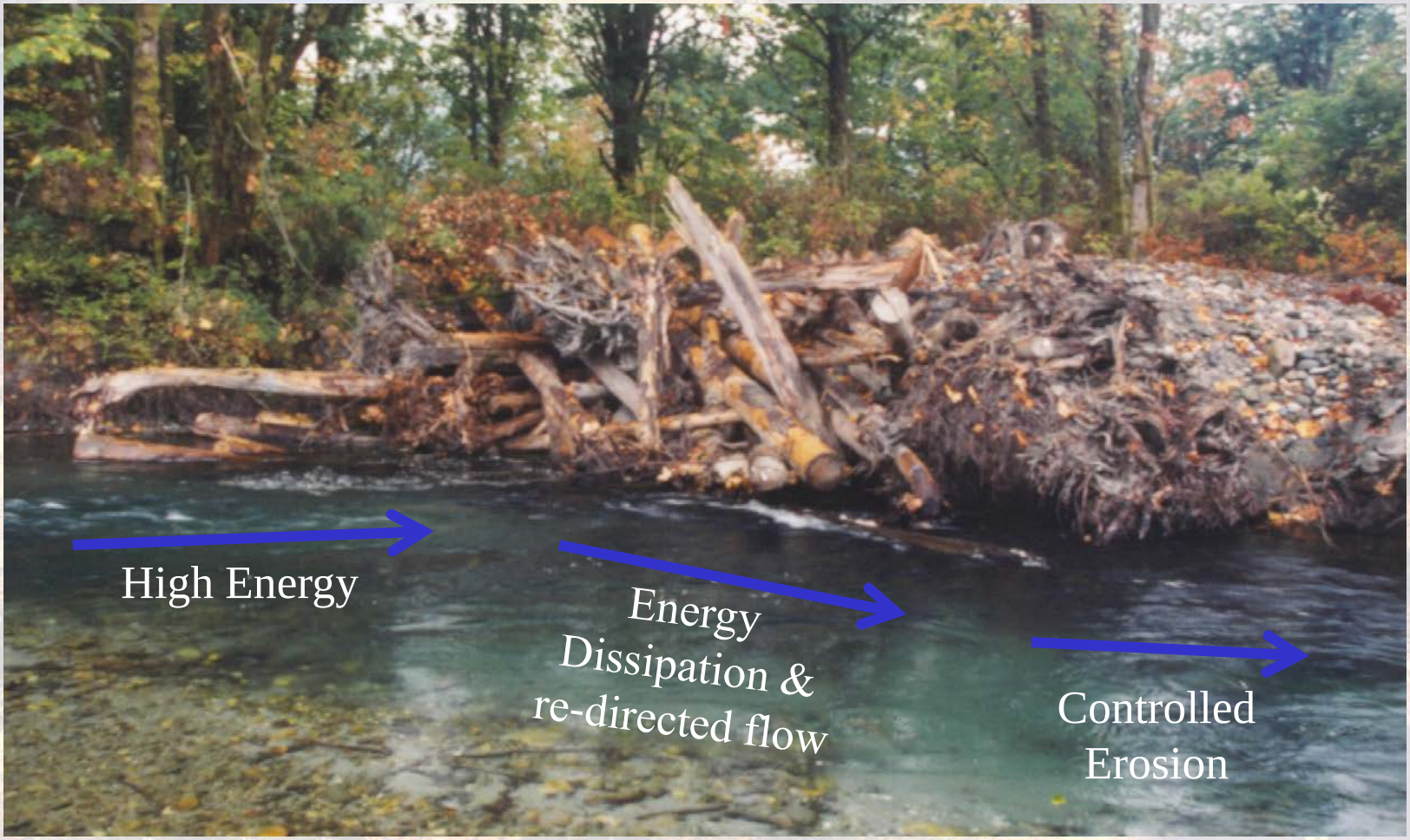

2 m
Williams River ELJ
As-Built Conditions, 2000
SEP 24 2000

Williams River during flow submerging structures by 2 m.


Williams River after 6
over-topping flows, November 2002

North Fork Stillaguamish Project

ELJ Functions –
Hard Point Flow Deflectors



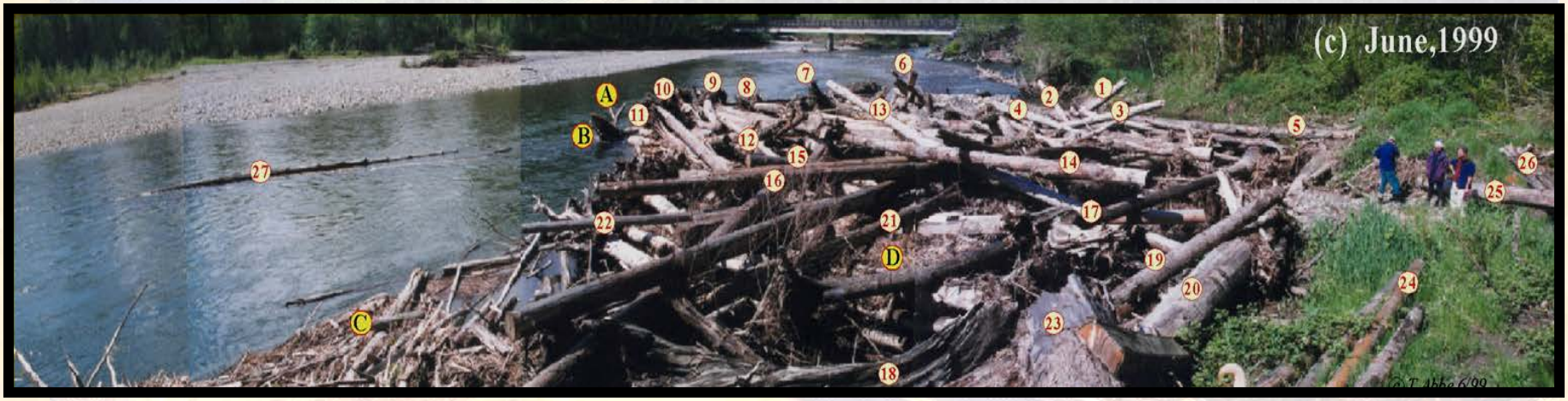
ELJ no.1

ELJ no.1


North Fork Stillaguamish River ELJ #1,
1998-1999.
(a) September, 1998

1998

ELJ no.1


(c) June,1999
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1999

ELJ no.1

2001

ELJ no.1

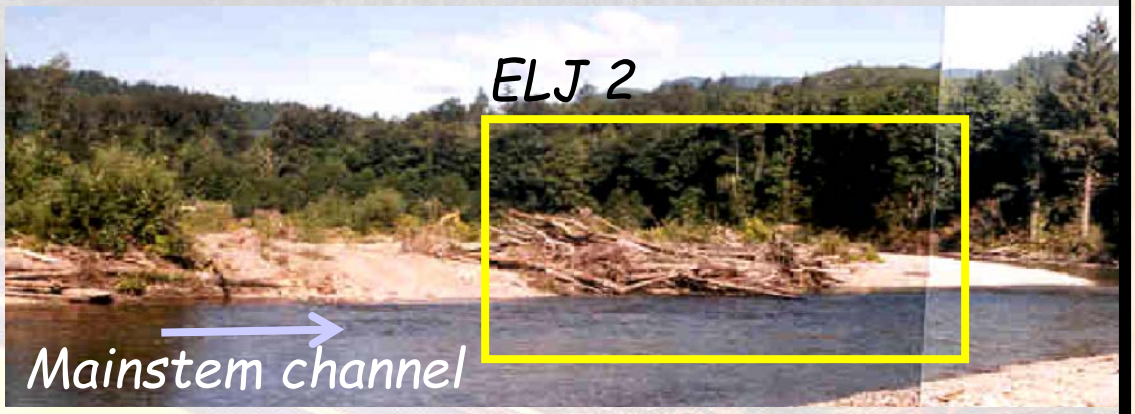
2004

ELJ no.1

2005

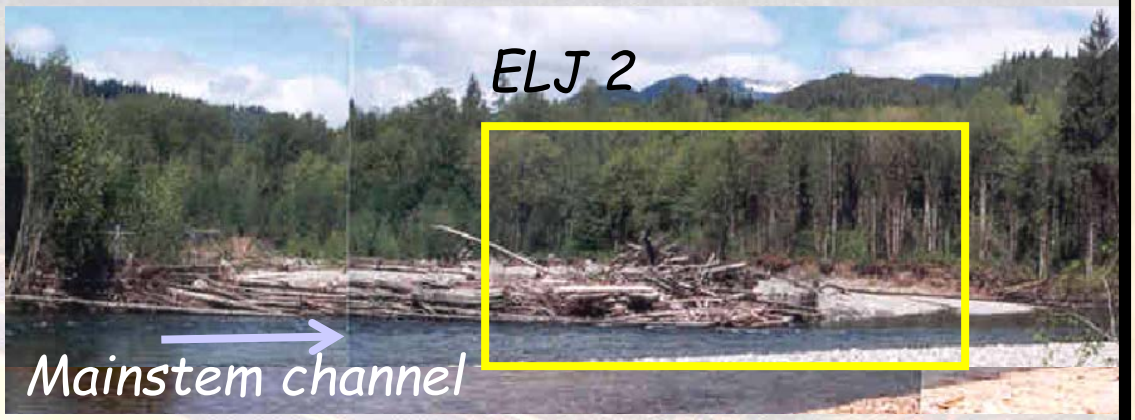

ELJ no.2

ELJ no.2



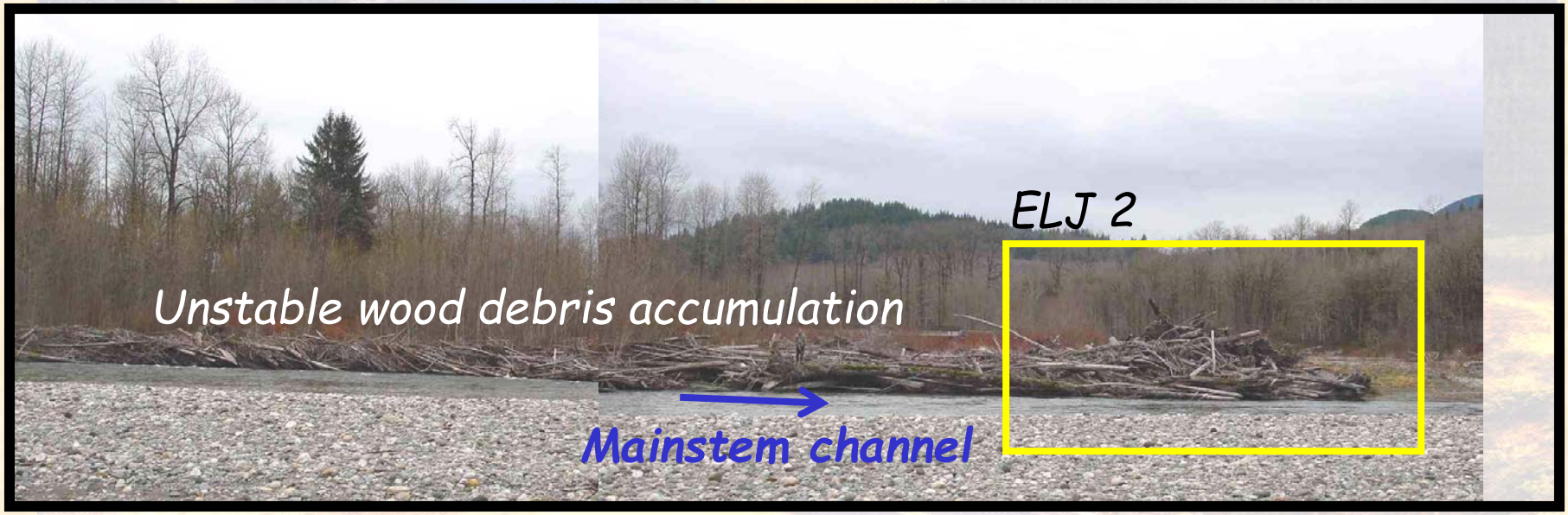
1998

ELJ no.2



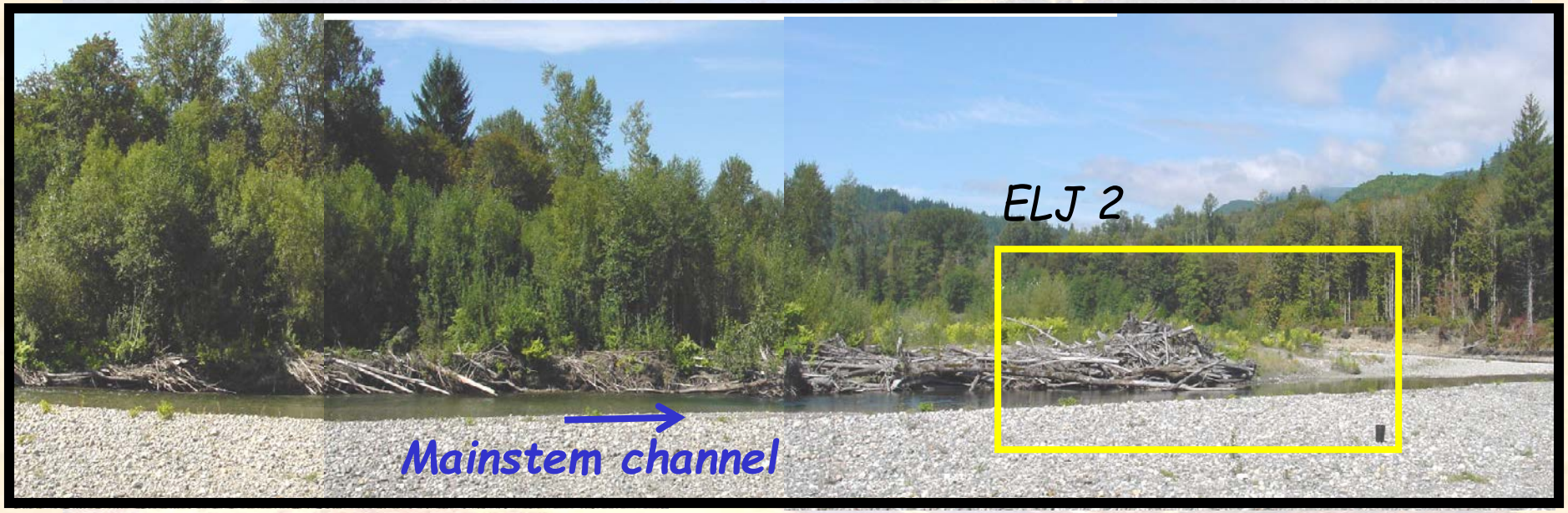
1999

ELJ no.2



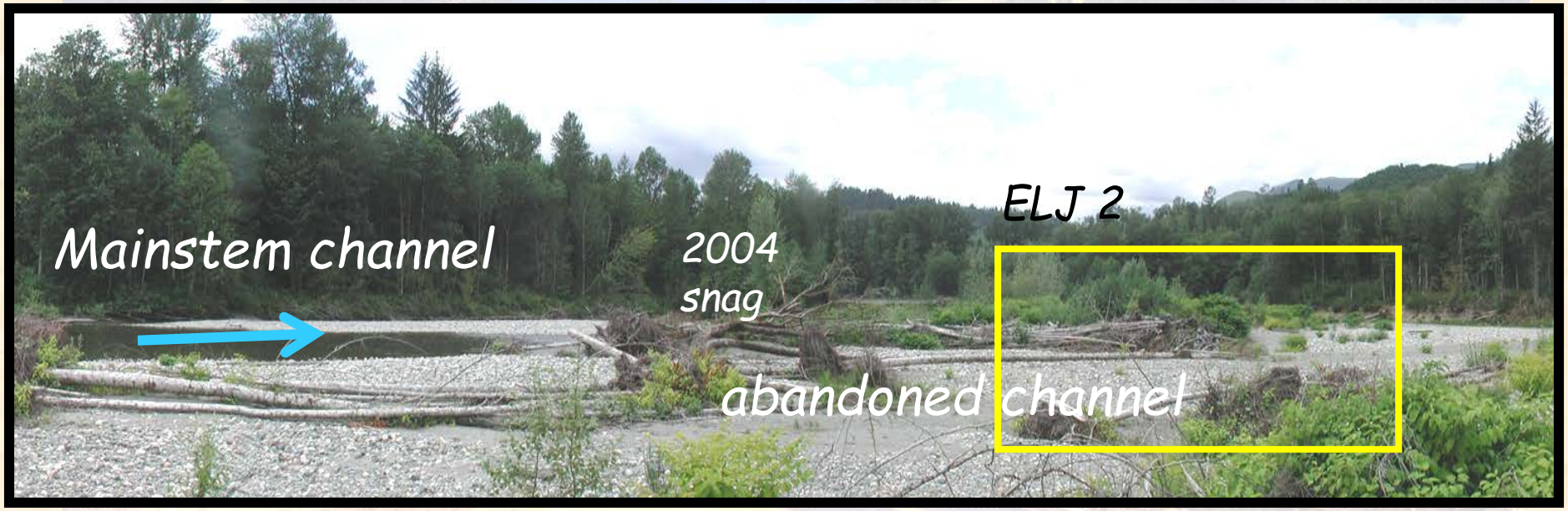
2000

ELJ no.2



2001

ELJ no.2



2004

ELJ no.2

2005

ELJ no.2

2001

3 years after construction, ELJ 2 with racked woody debris and only tips of key member rootwads visible. Main channel has split into 2 channels around the ELJ.

2005

7 years after construction, a significant decrease in racked woody debris has occurred and key member rootwads are much more visible. Main channel flowing entirely to left of ELJ.

ELJ no.3

ELJ no.3

1998

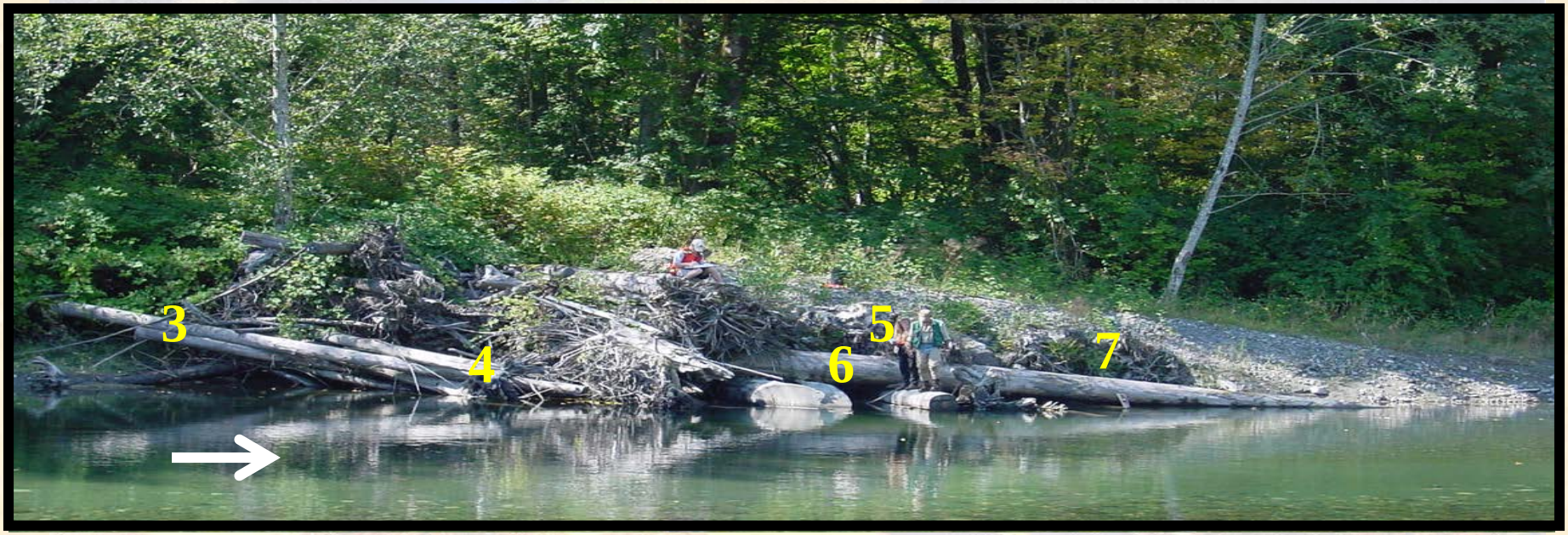
ELJ no.3

1999

ELJ no.3

2000

ELJ no.3



2001

ELJ no.3

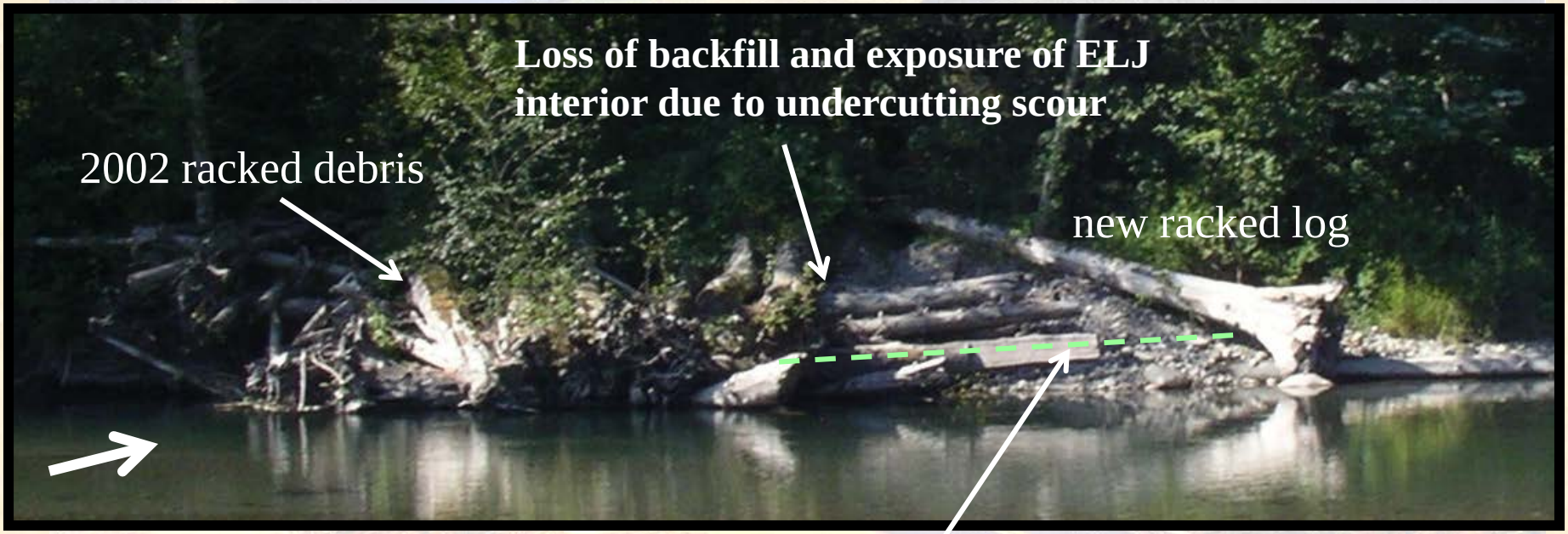
2002

ELJ no.3

Note pitch of broken log:
downstream tip is pointed down

2004

ELJ no.3

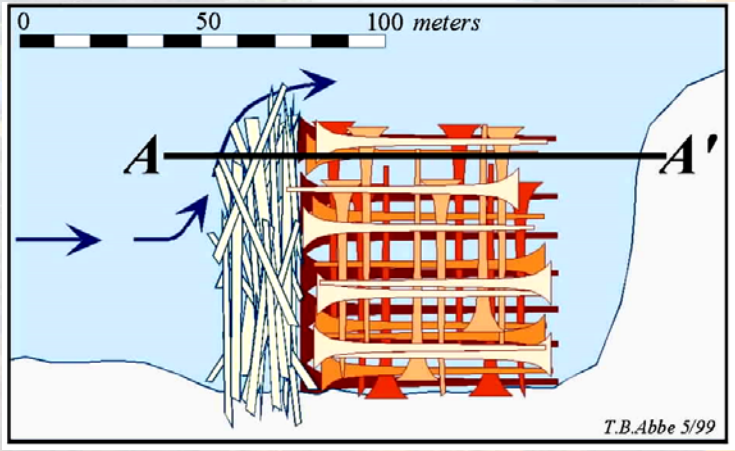


2005

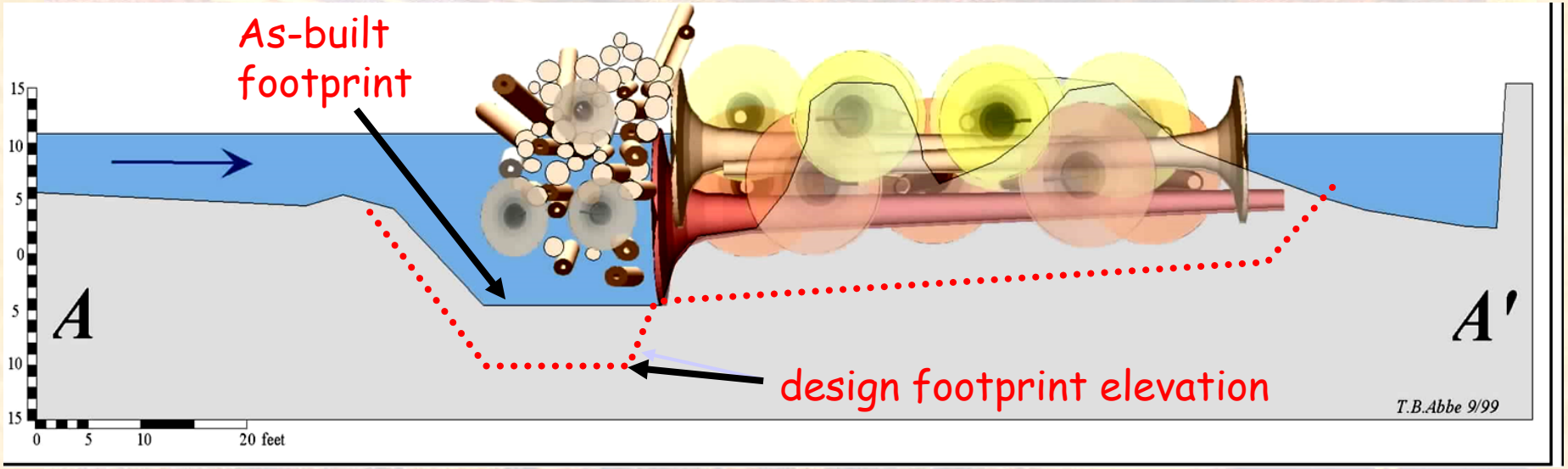
Note that pitch of broken log has reversed, with downstream tip pointed up, indicated upstream corner of structure has settled (~1 m) due to undercutting scour.

Effect of Scour on Structural Integrity

Plan



1998 As-built profile

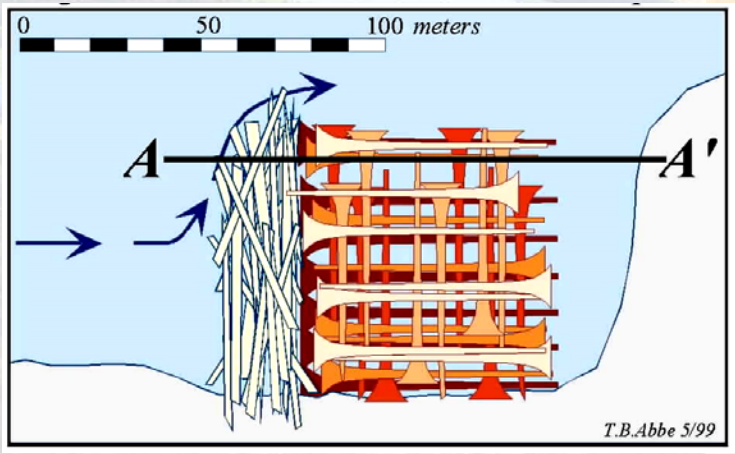


North Fork Stillaguamish ELJ #1, Log #5

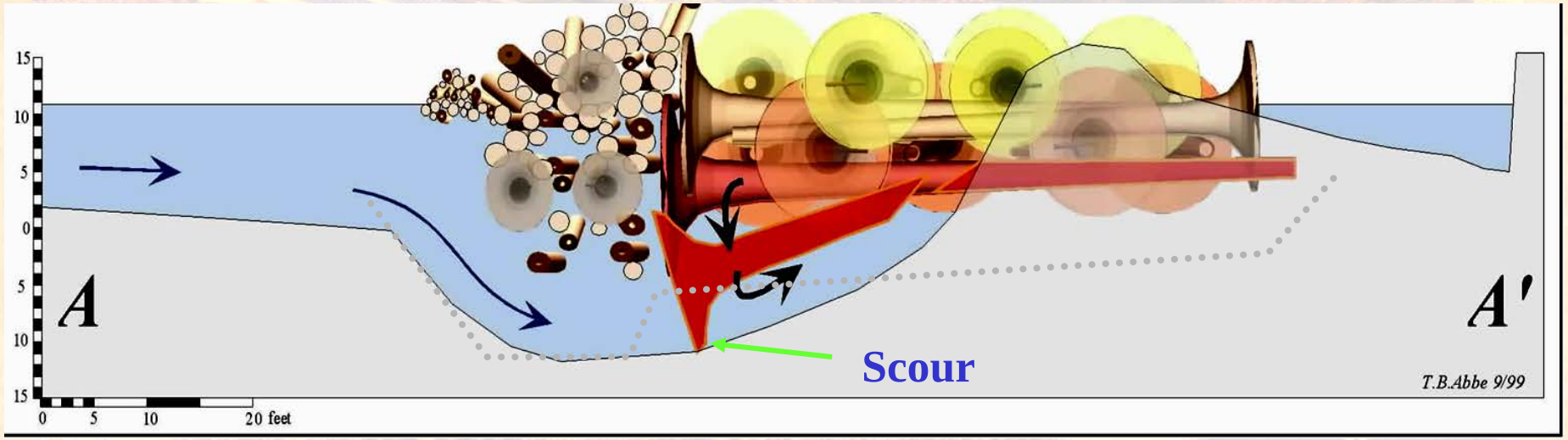
Effect of Scour on Structural Integrity:

Logs sink

Plan



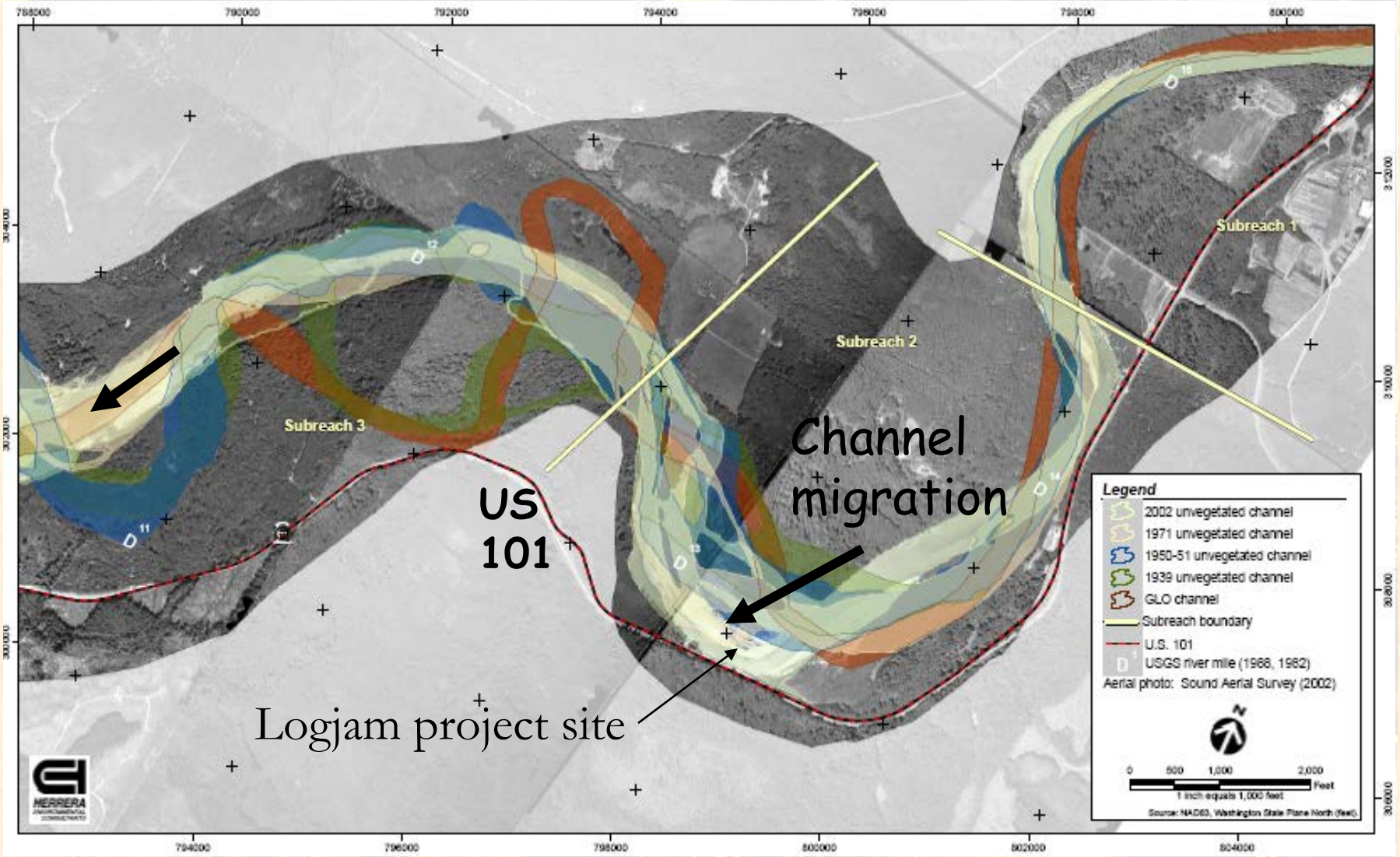
1999 Profile (after 8 overbank flow events)



North Fork Stillaguamish ELJ #1, Log #5

The Hoh River Project

The Hoh River moves at rates up to 30 m/yr (100 ft/yr)

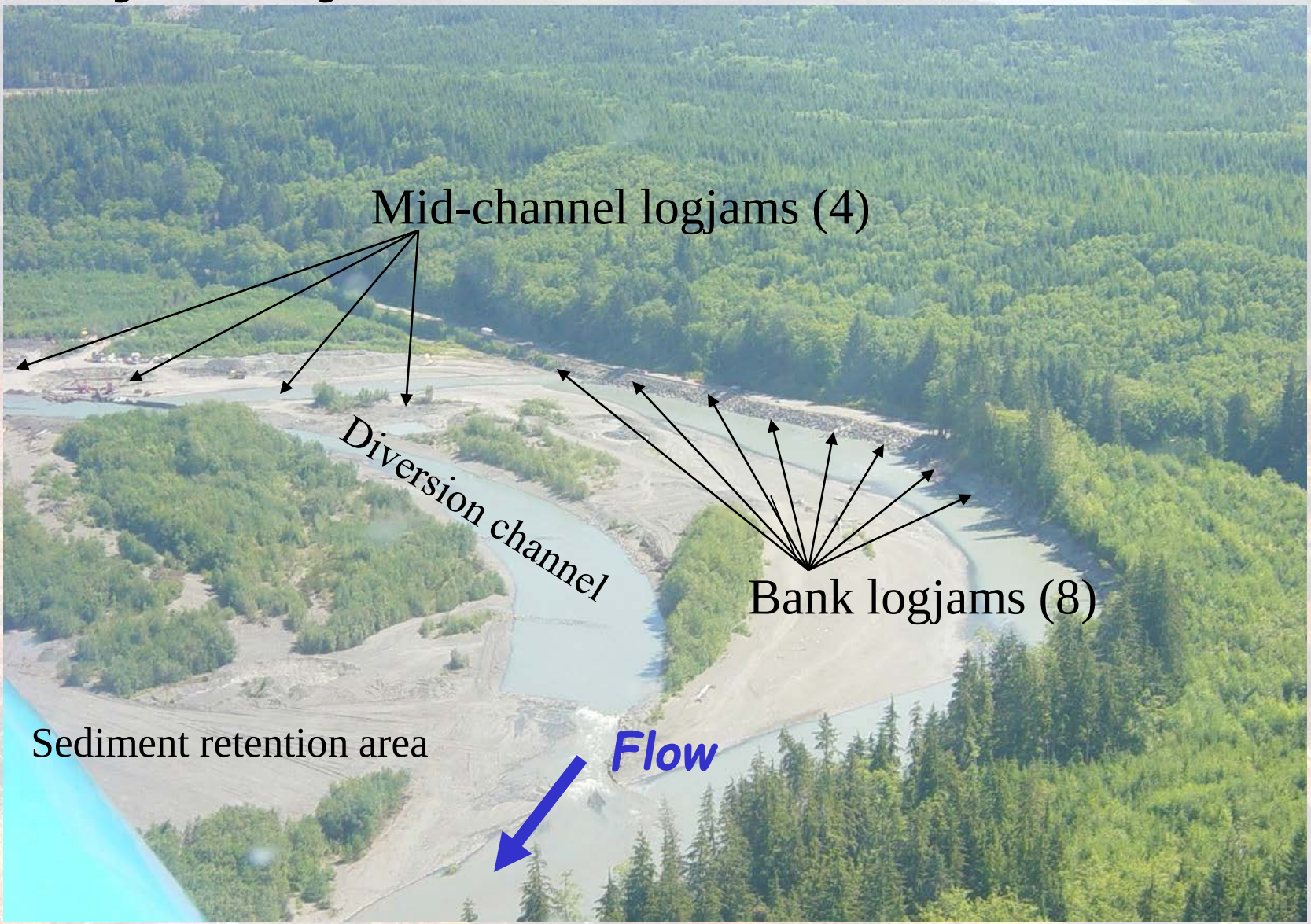


"Natural Analogs"

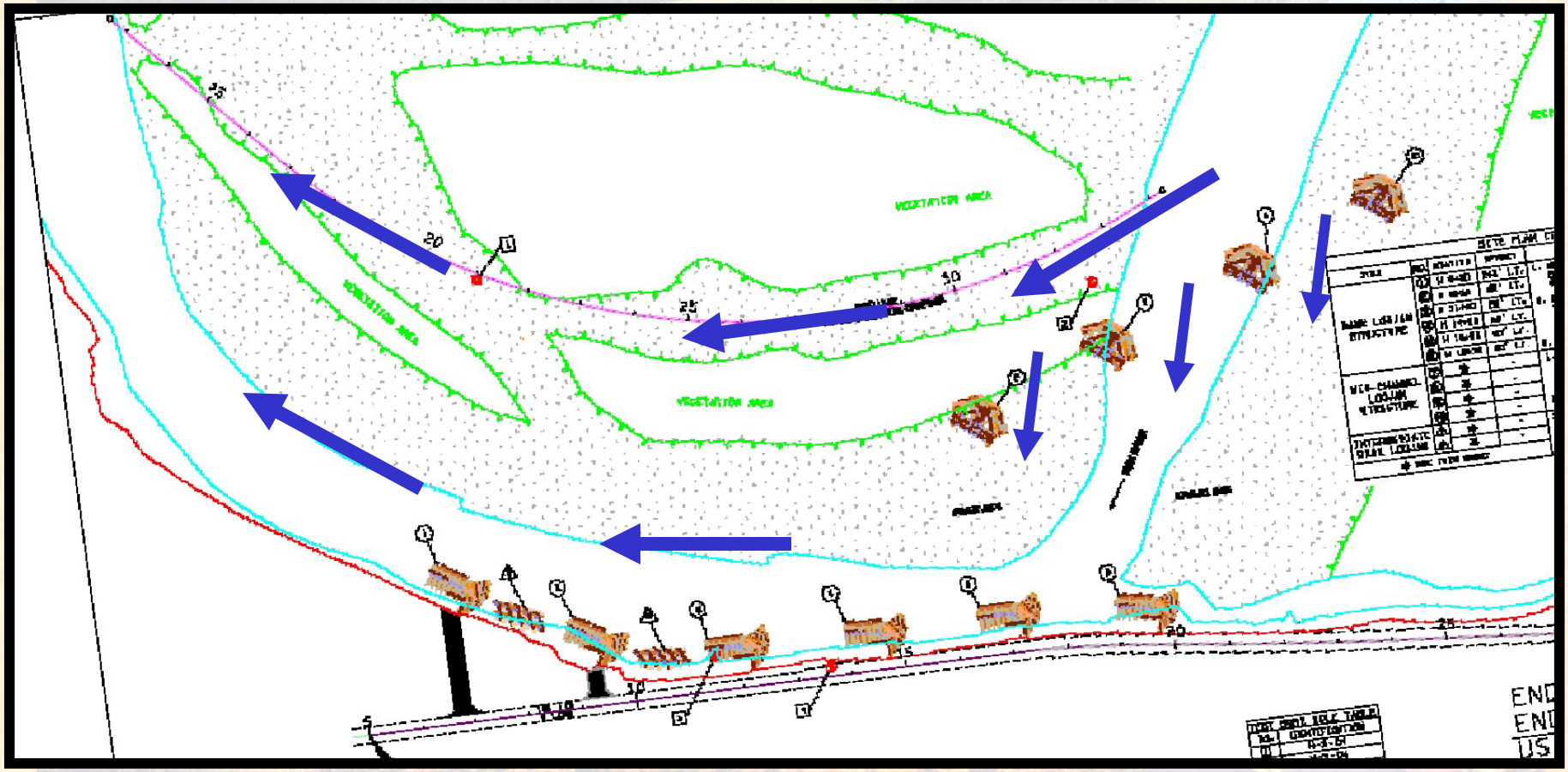
The Hoh River at Nolan Creek provides a current analog for Hoh Project concept of "chute" meander cut-off:

March 29, 2004

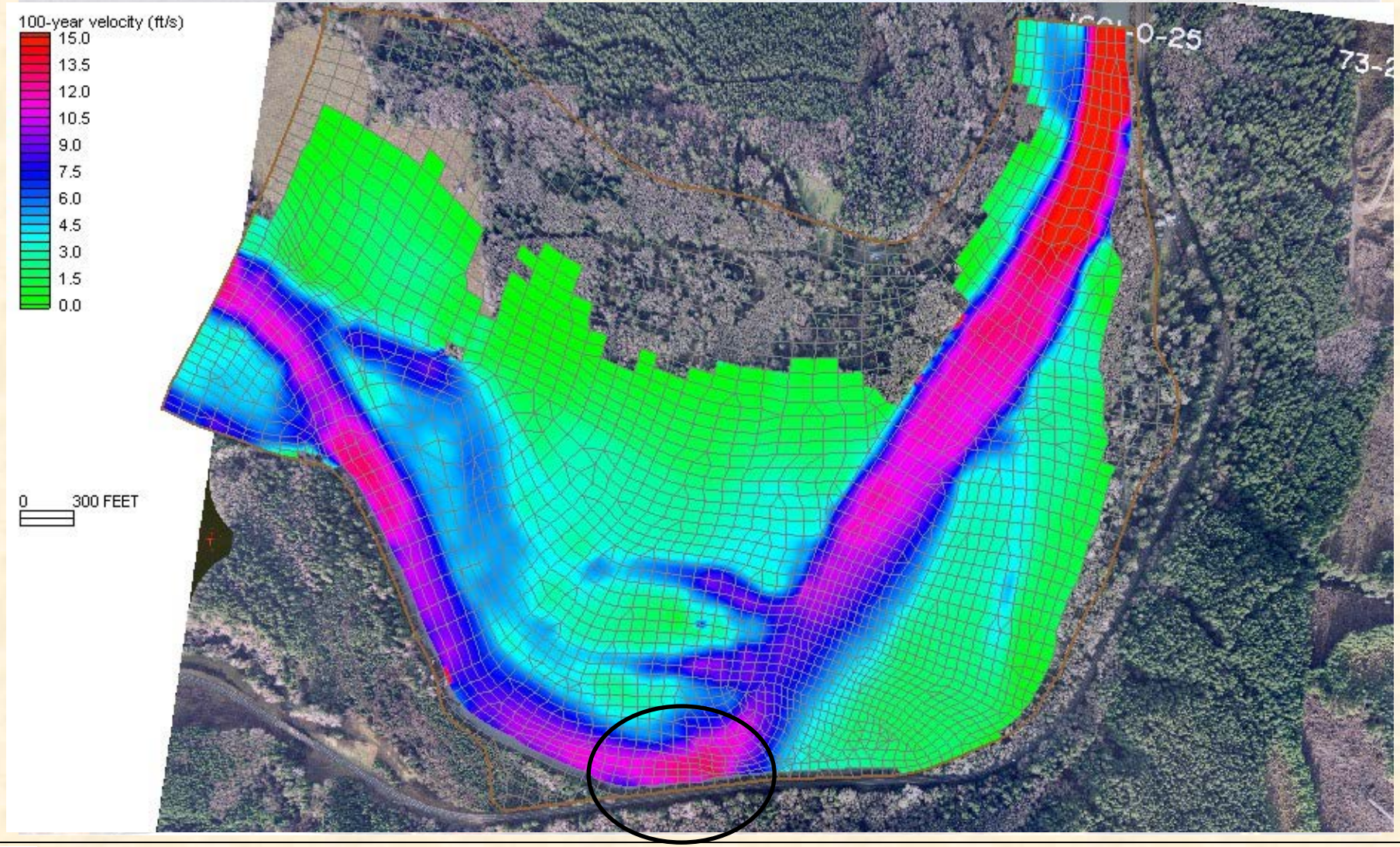
Major Project Elements



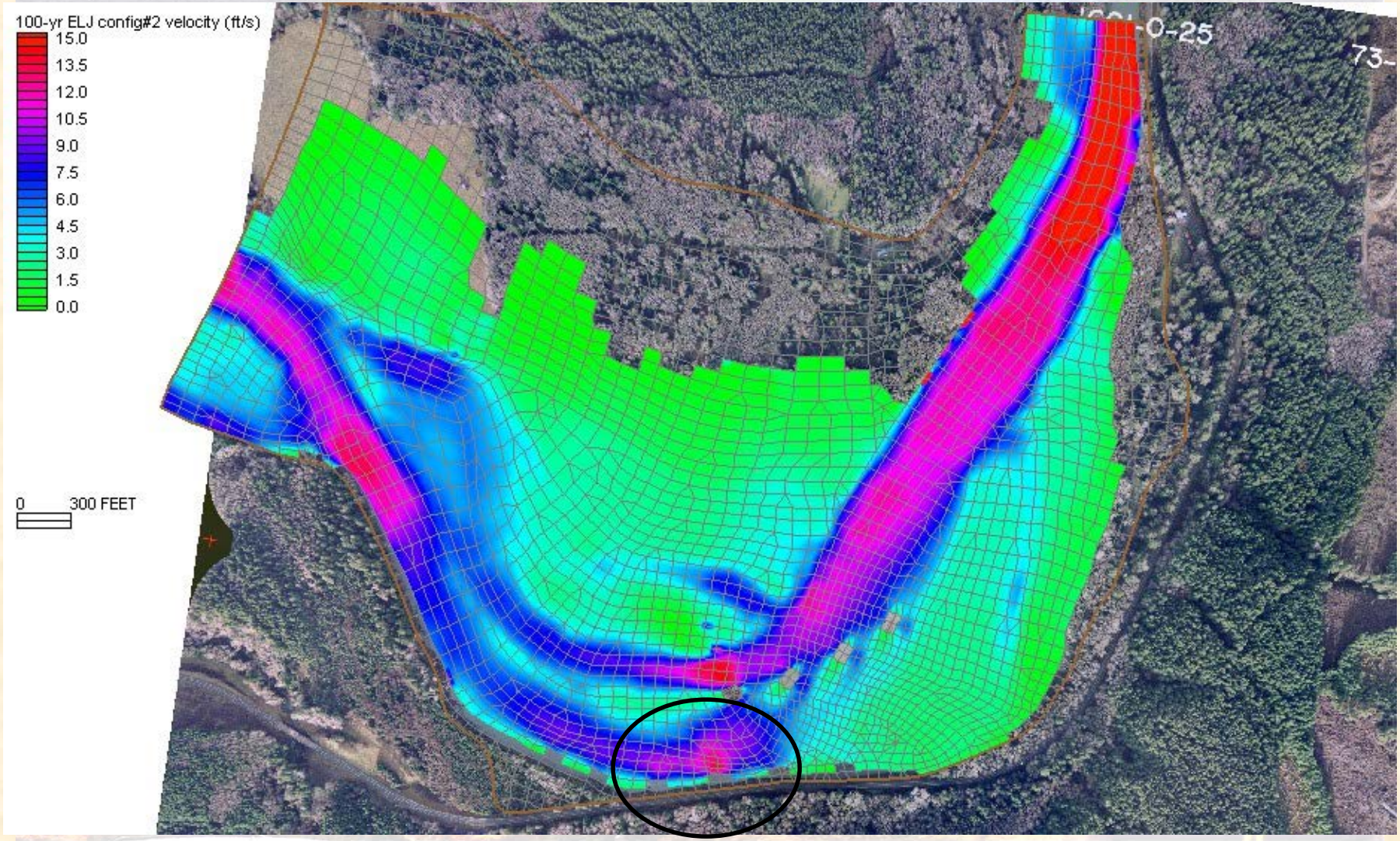
Hoh project objective: get river away from Highway 101



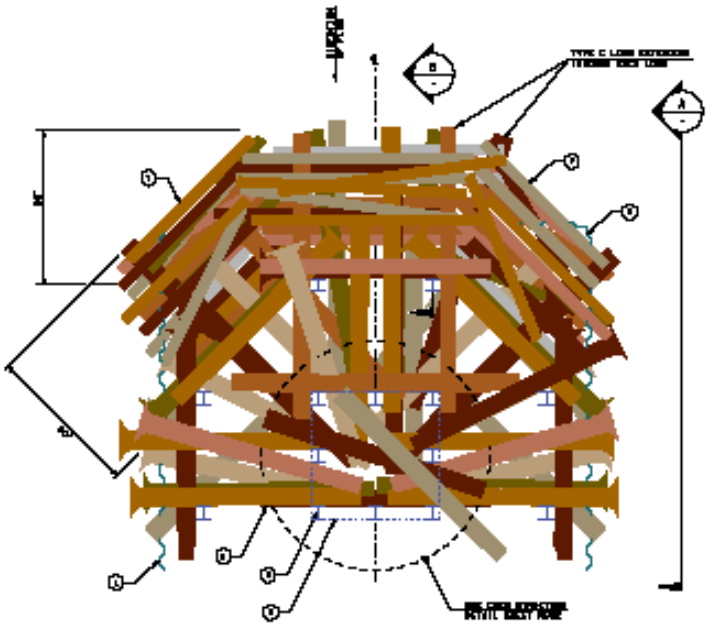
Depth averaged velocity (ft/s) output from FESWMS for existing conditions during 100 yr peak flow event (67,000 cfs)



Depth averaged velocity (ft/s) output from FESWMS for proposed conditions during 100 yr peak flow event (67,000 cfs)

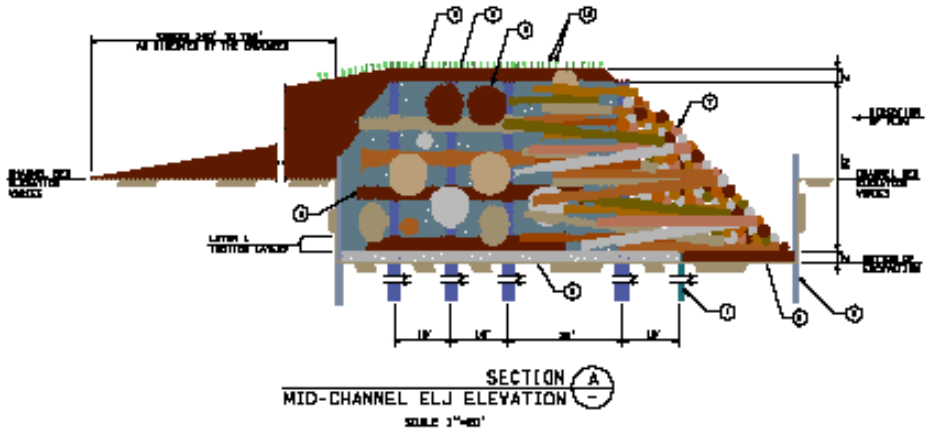


Mid-channel ELJ plan and section view

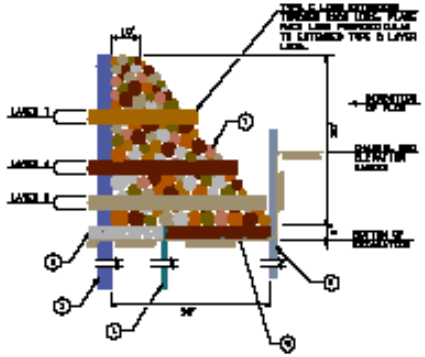


MID-CHANNEL ELJ PLAN VIEW

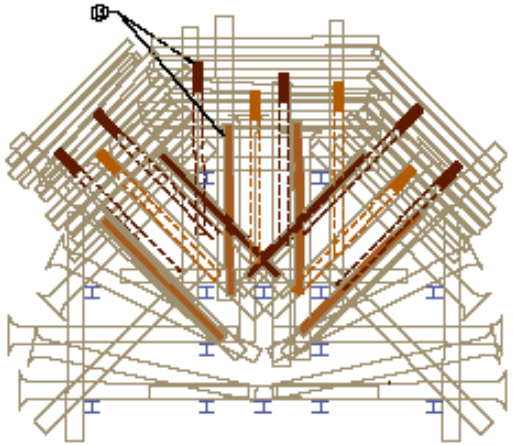
MID-CHANNEL STRUCTURE CONSTRUCTION NOTES



SECTION A
MID-CHANNEL ELJ ELEVATION



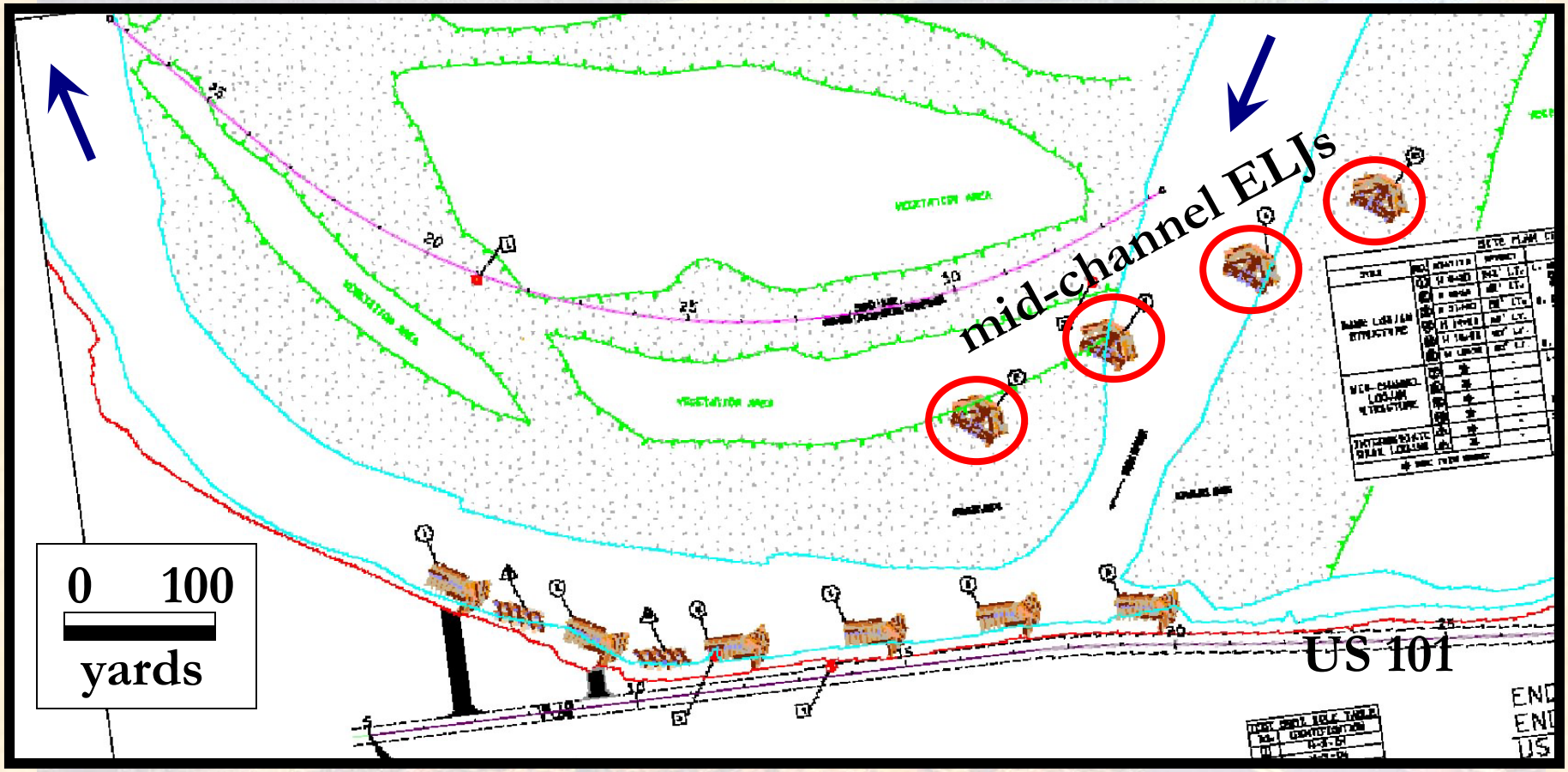
SECTION B
TYPICAL RACKED LOGS ELEVATION



TYPICAL MID-CHANNEL ELJ SUPPORT RACK LOG DETAIL

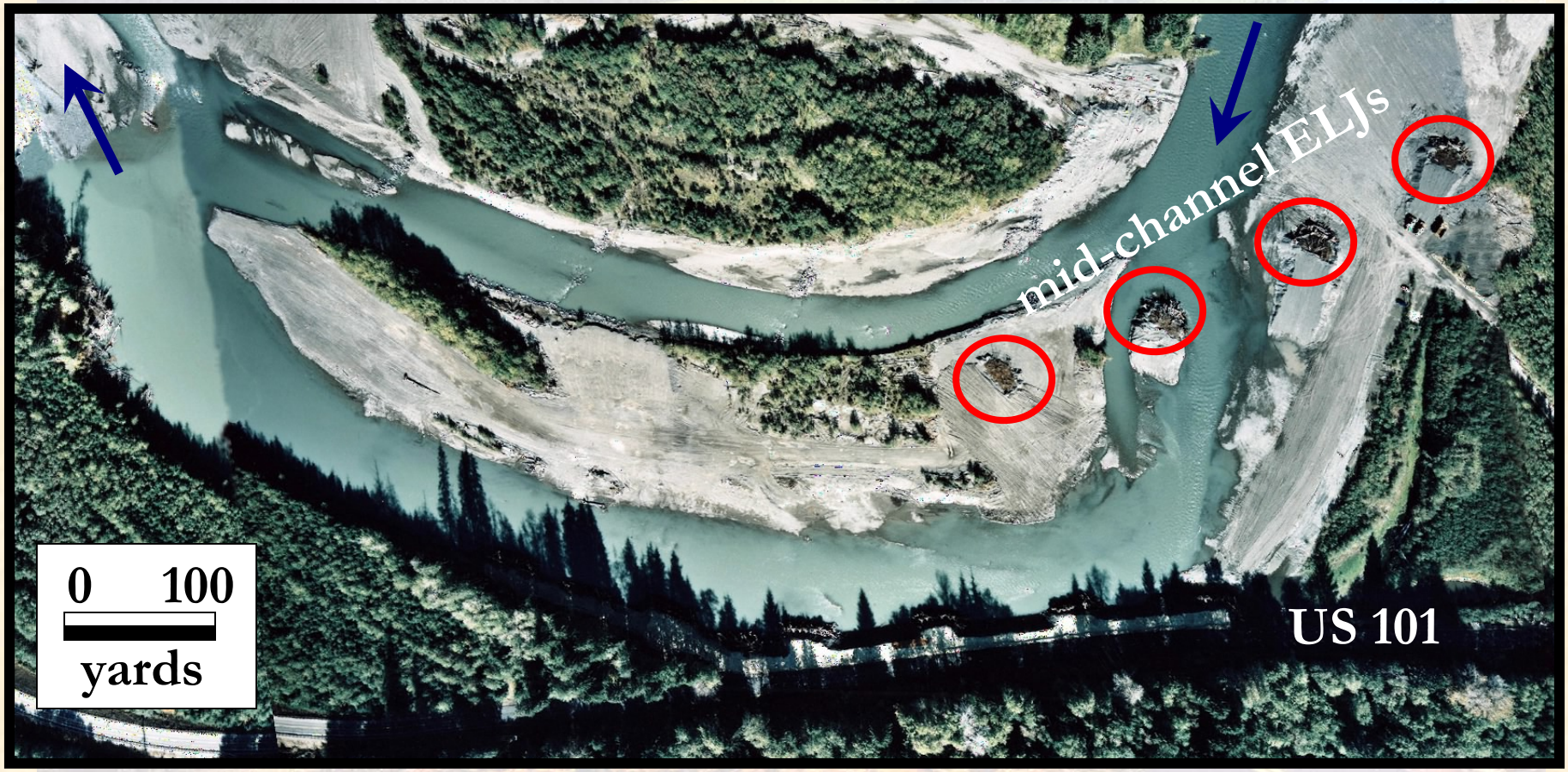
Almost done, October 2004

Hoh River project site in Spring of 2004 prior to construction.

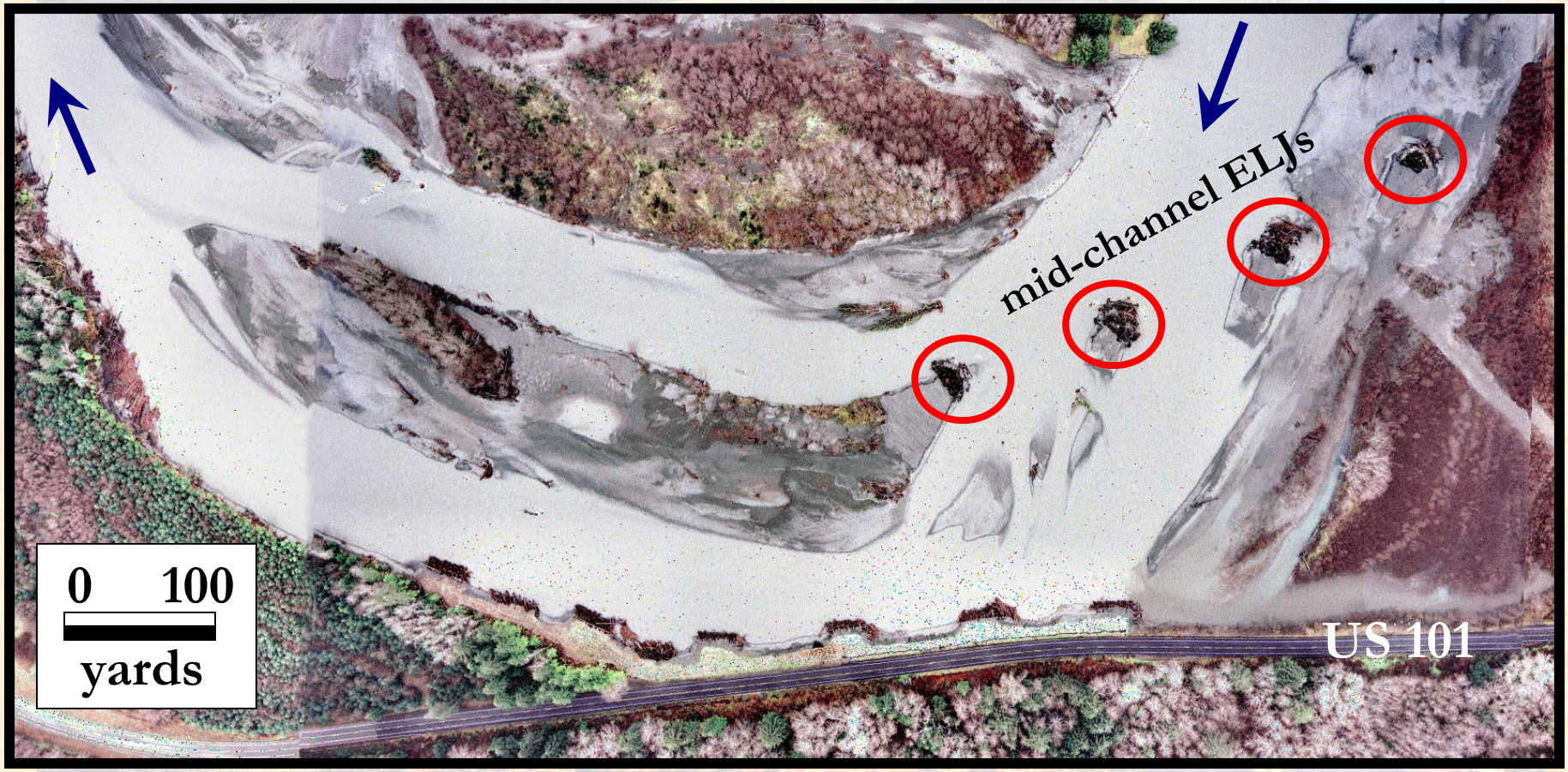


Hoh project site design layout

Herrera concept figure of how we predicted the project site would look in 2005.



Hoh project site as-built conditions in October 2004.



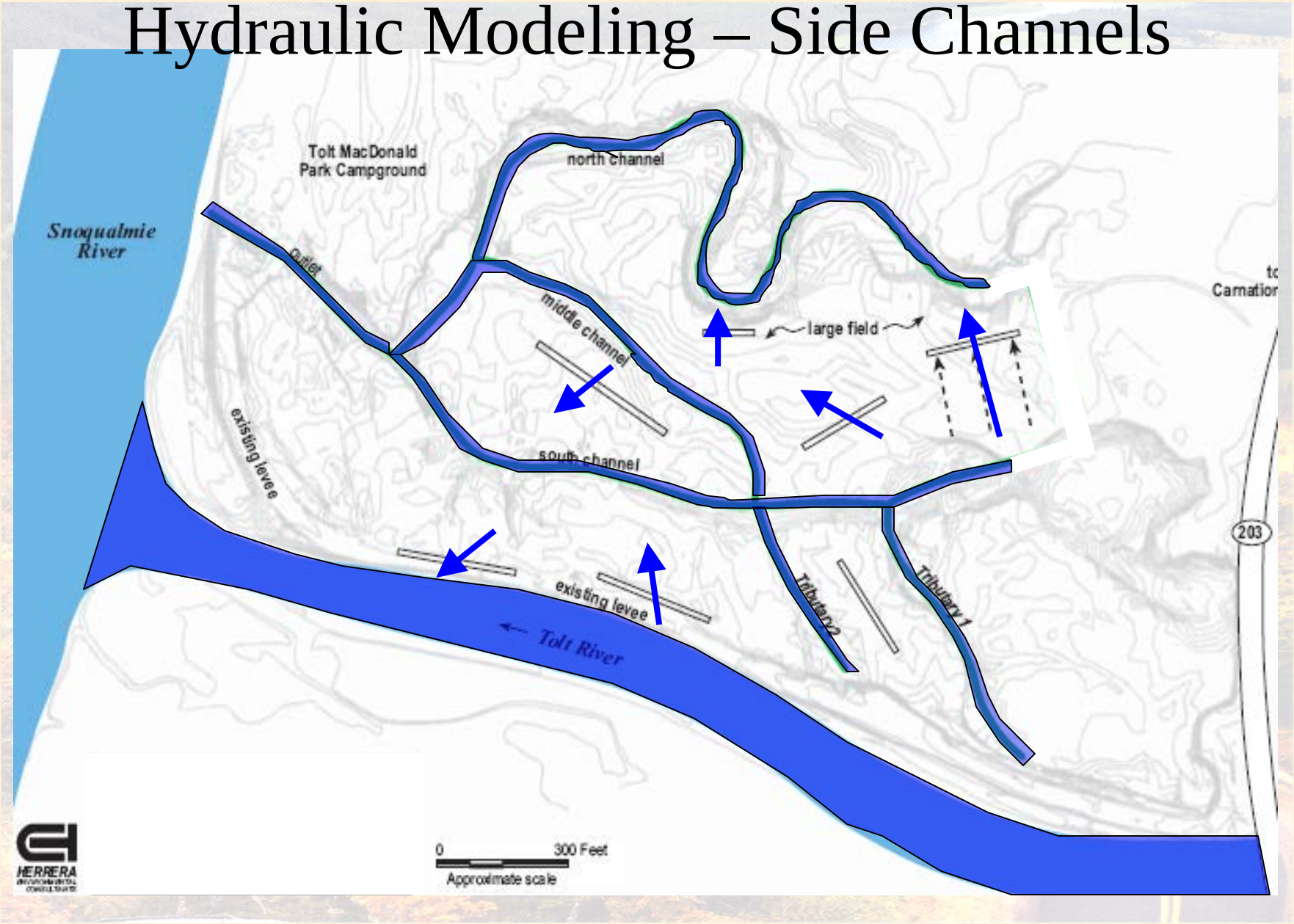
Hoh project site 12-15-04,
after a 30,000 cfs peak flow (~2 yr recurrence interval).

Hoh project site 02-01-05,
after two peak flows of ~30,000 cfs.

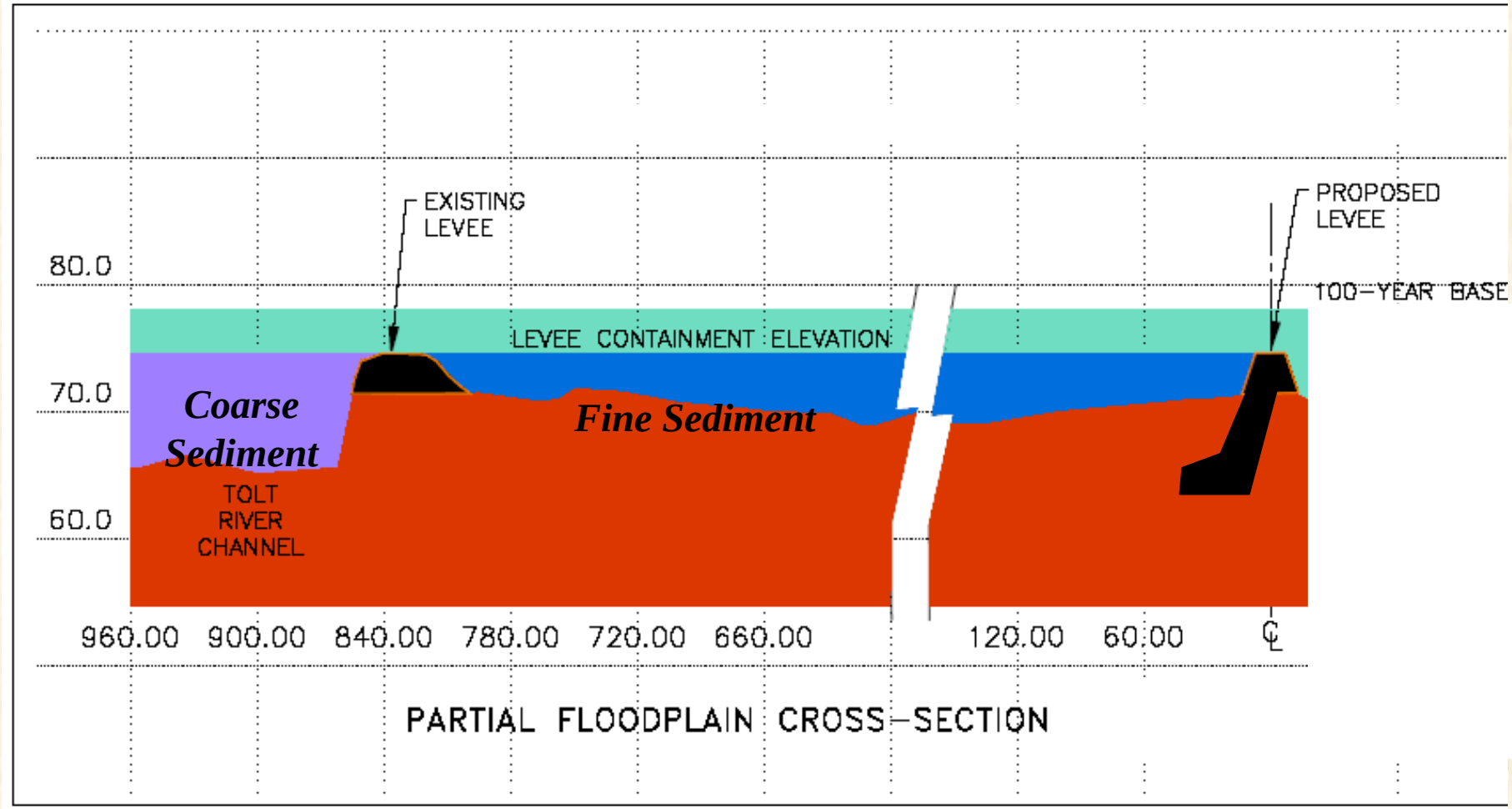
South Fork Tolt

Floodplain Reconnection of Lower Tolt River Delta

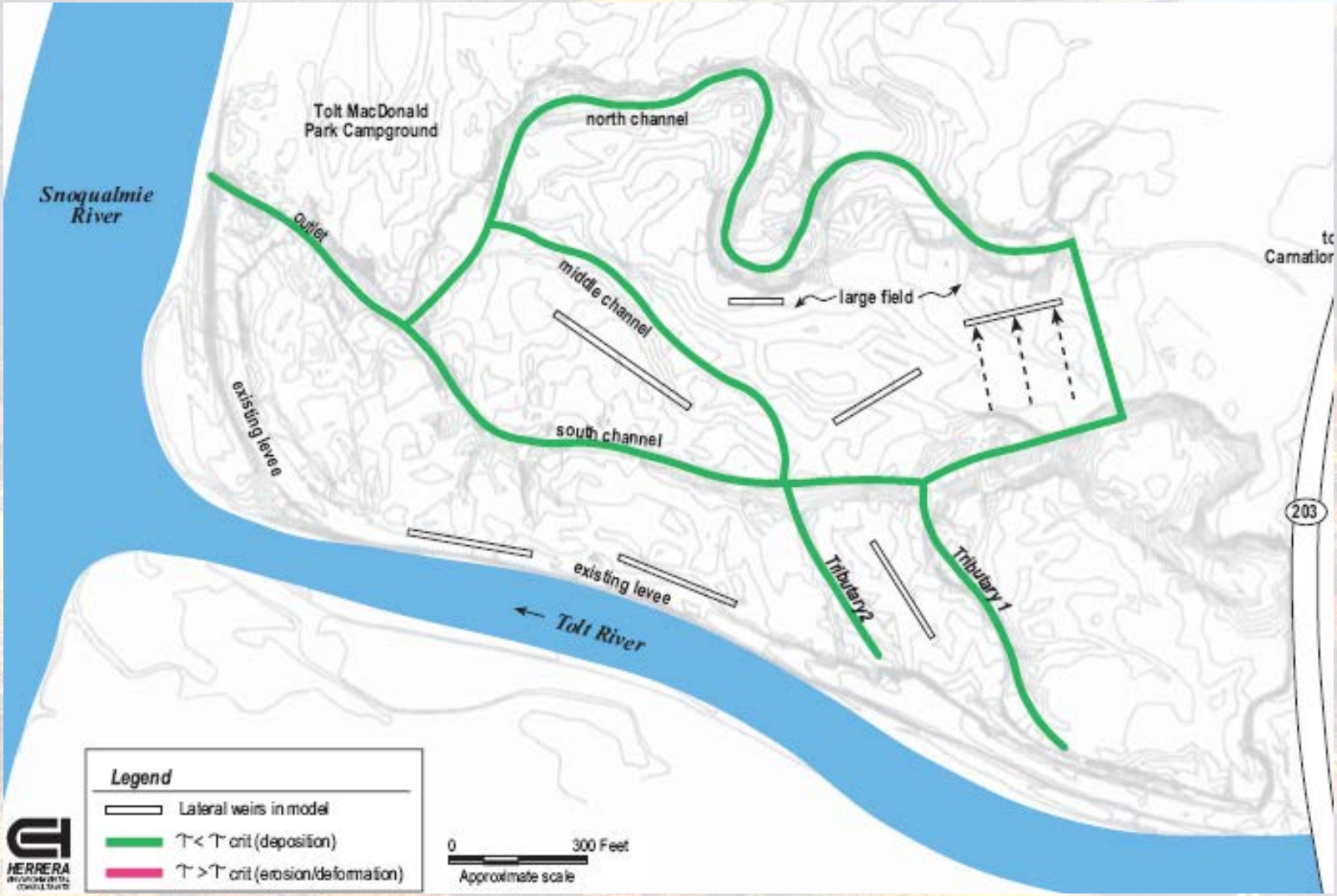
Hydraulic Modeling – Side Channels



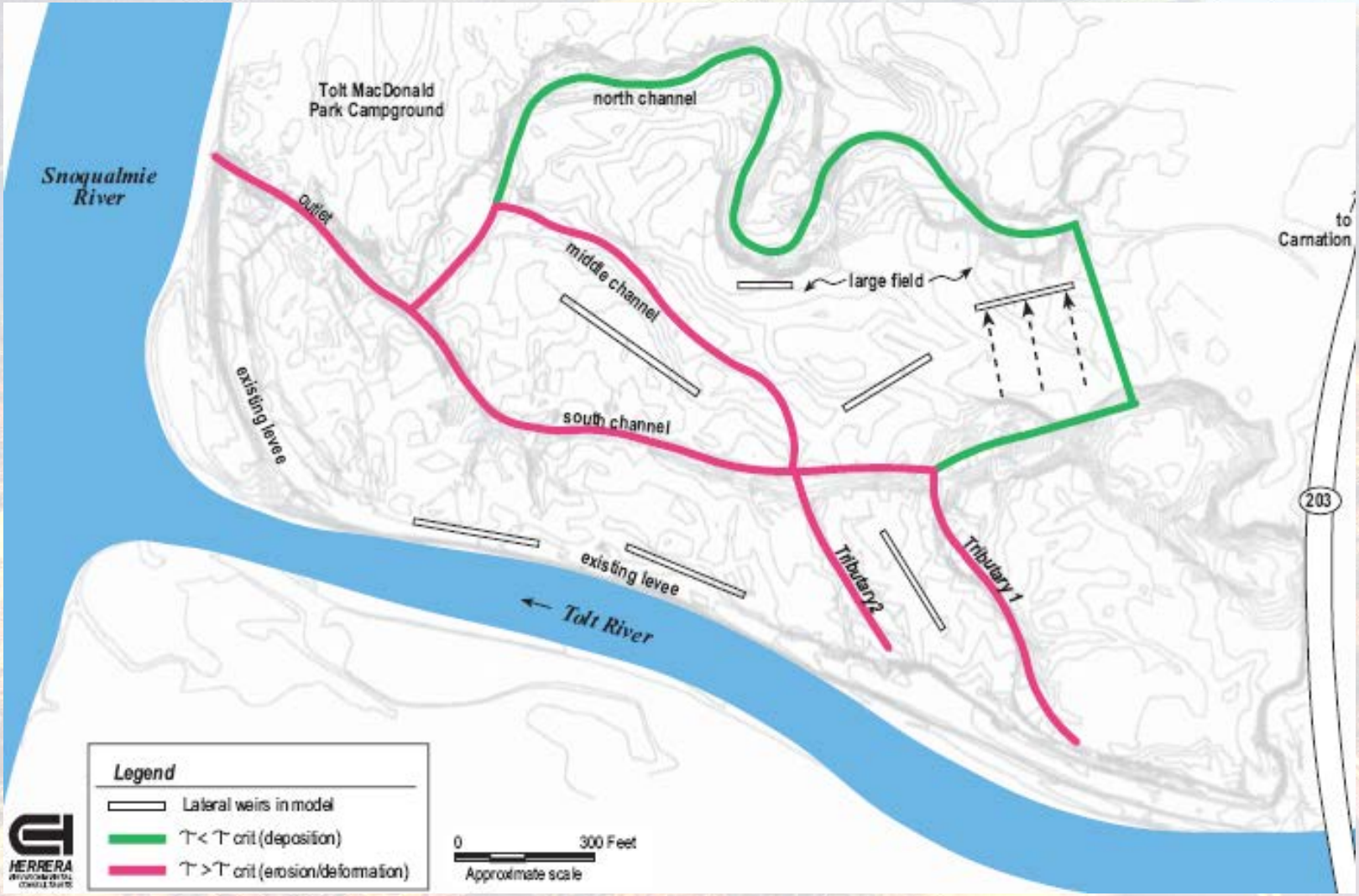
Hydraulic Modeling – Scour and Erosion



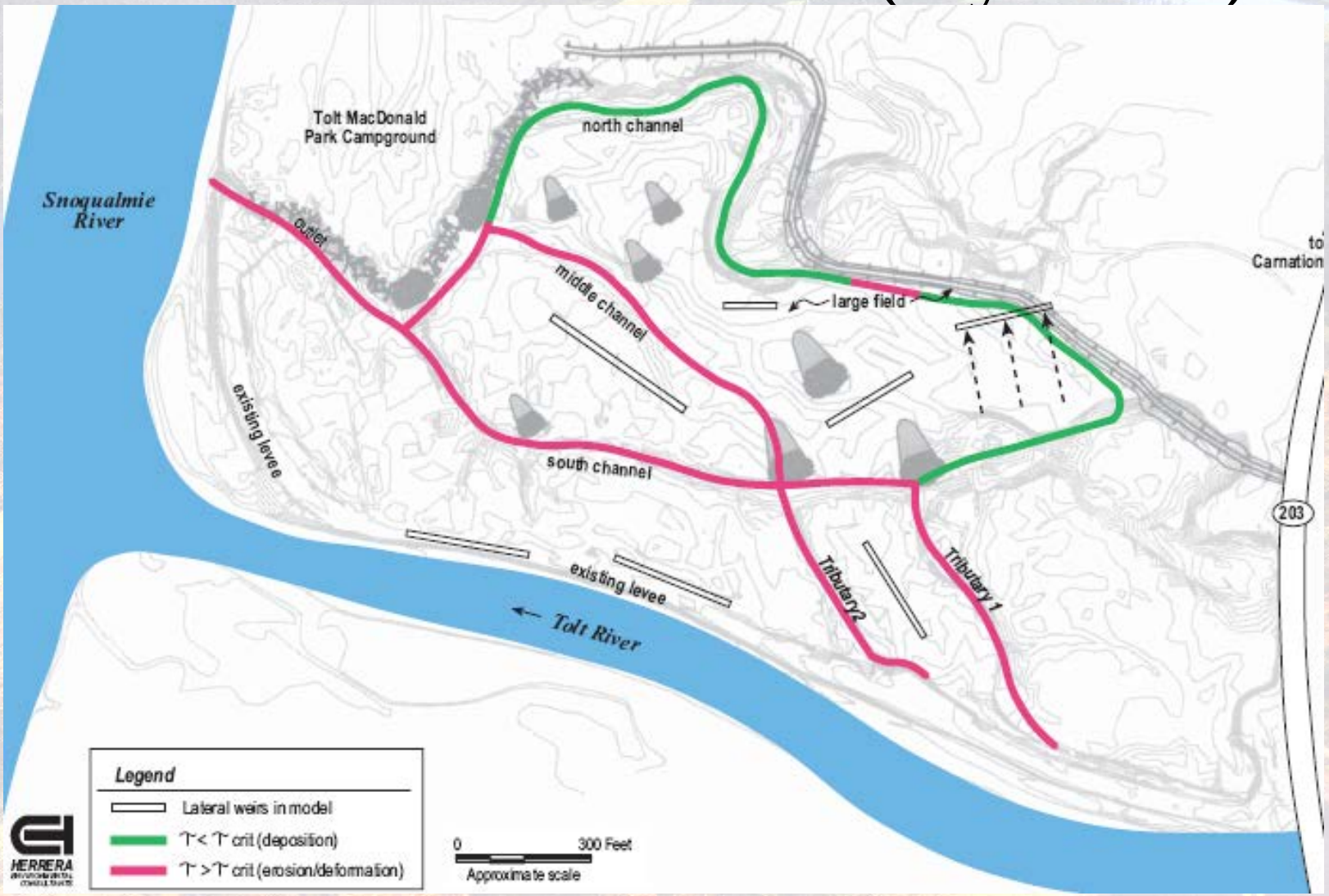
Existing Erosion (2-yr flood)



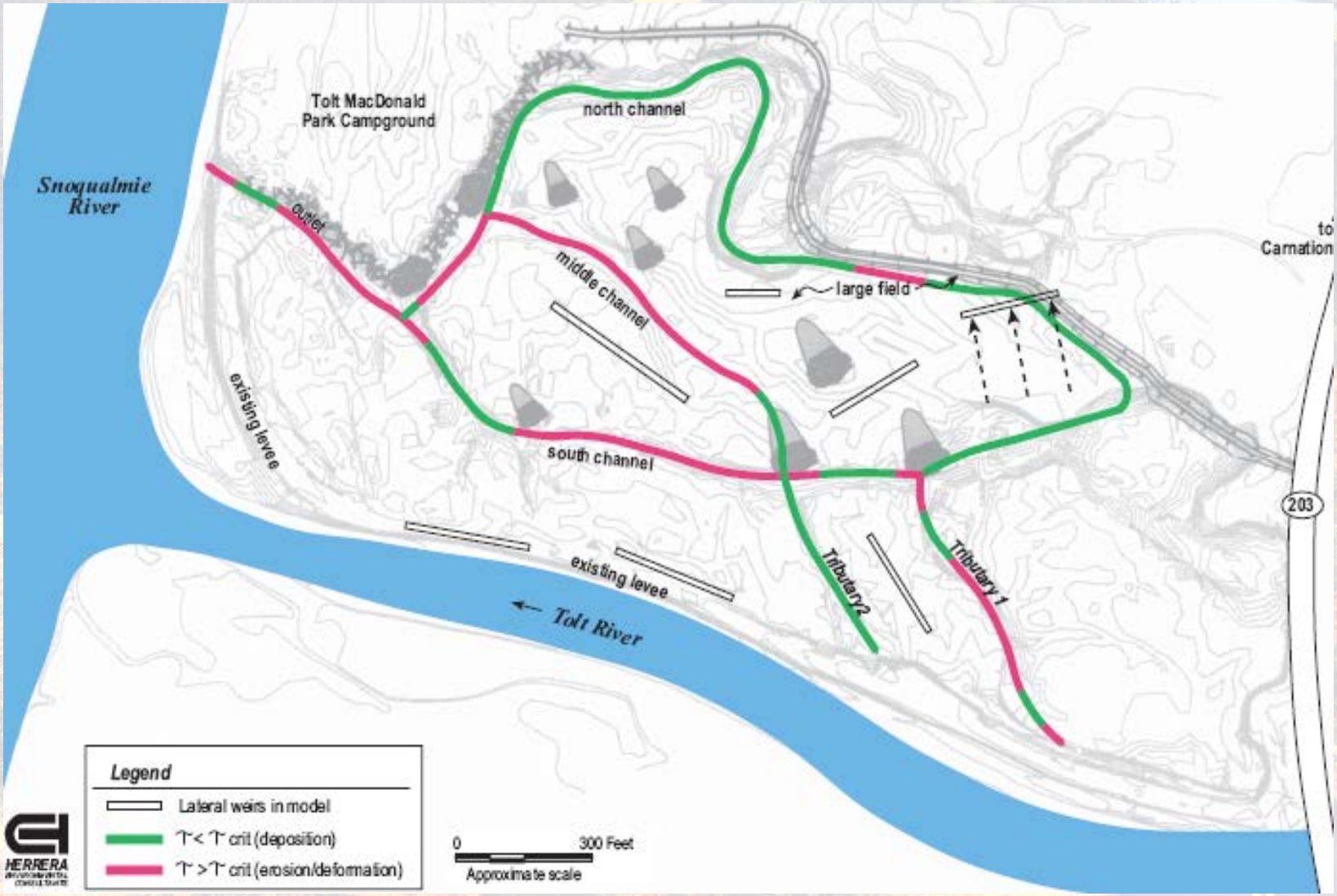
Existing Erosion (10-yr Flood)



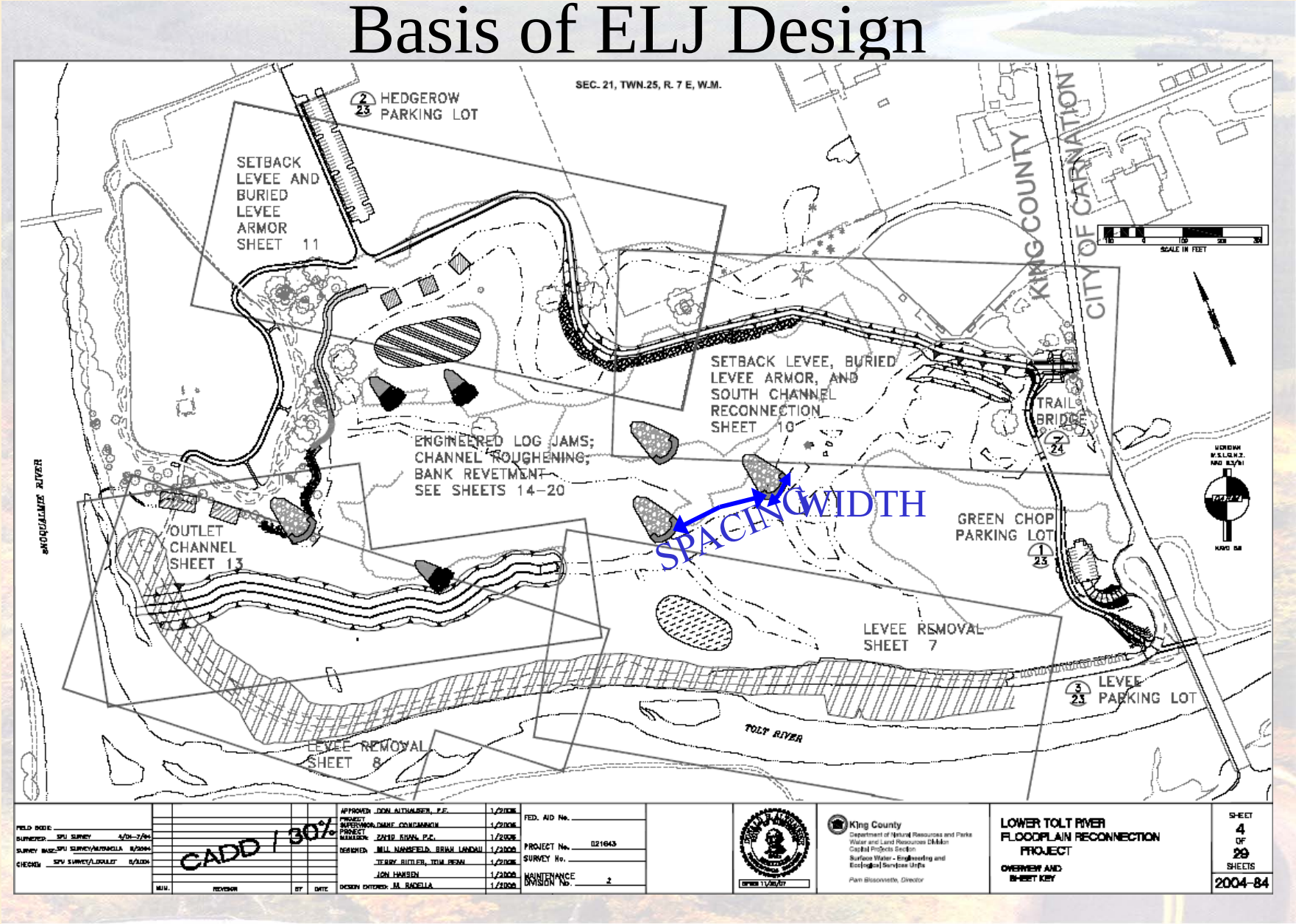
Levee Removal Erosion (2-yr flood)



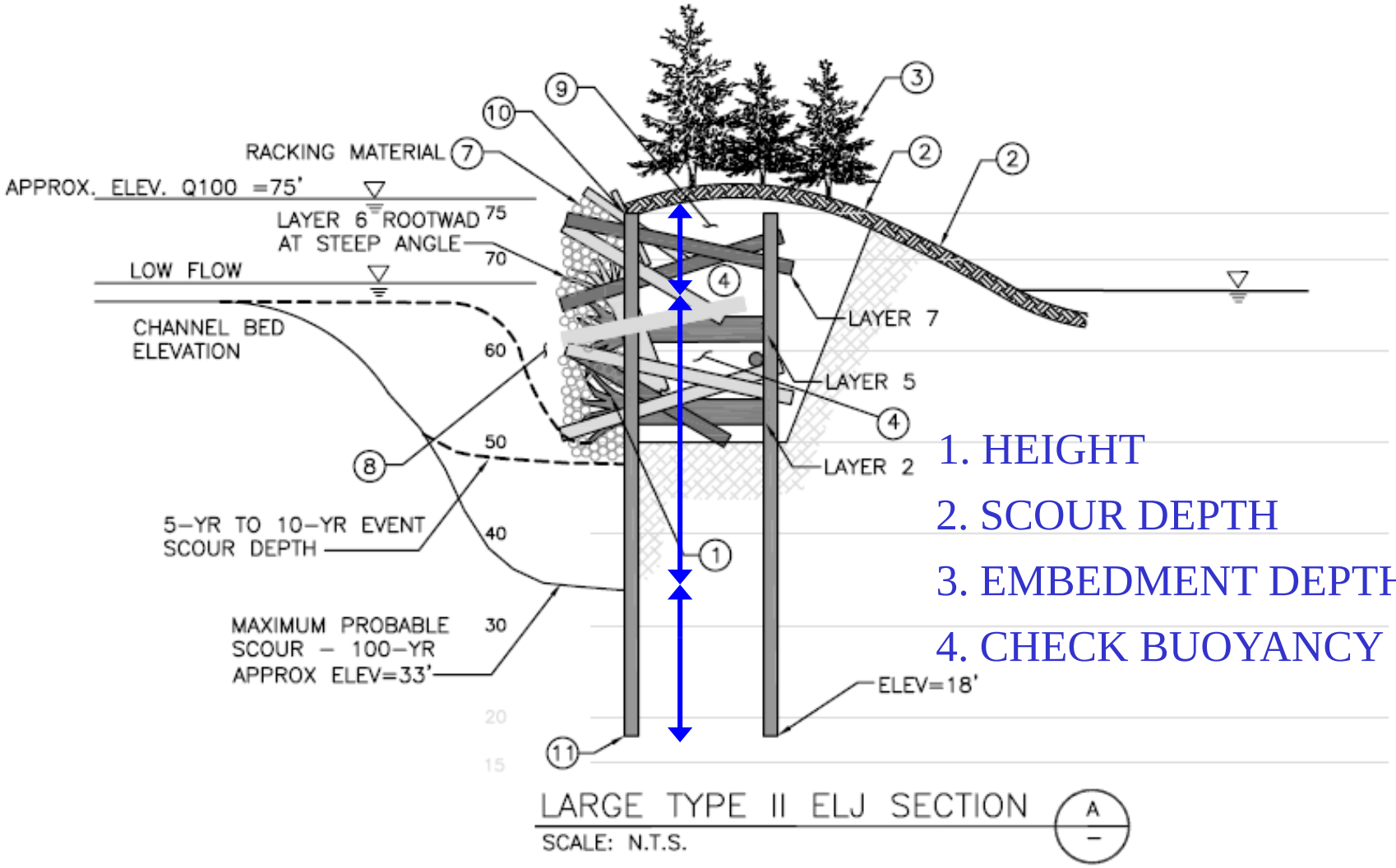
Erosion over time (10-yr Flood)



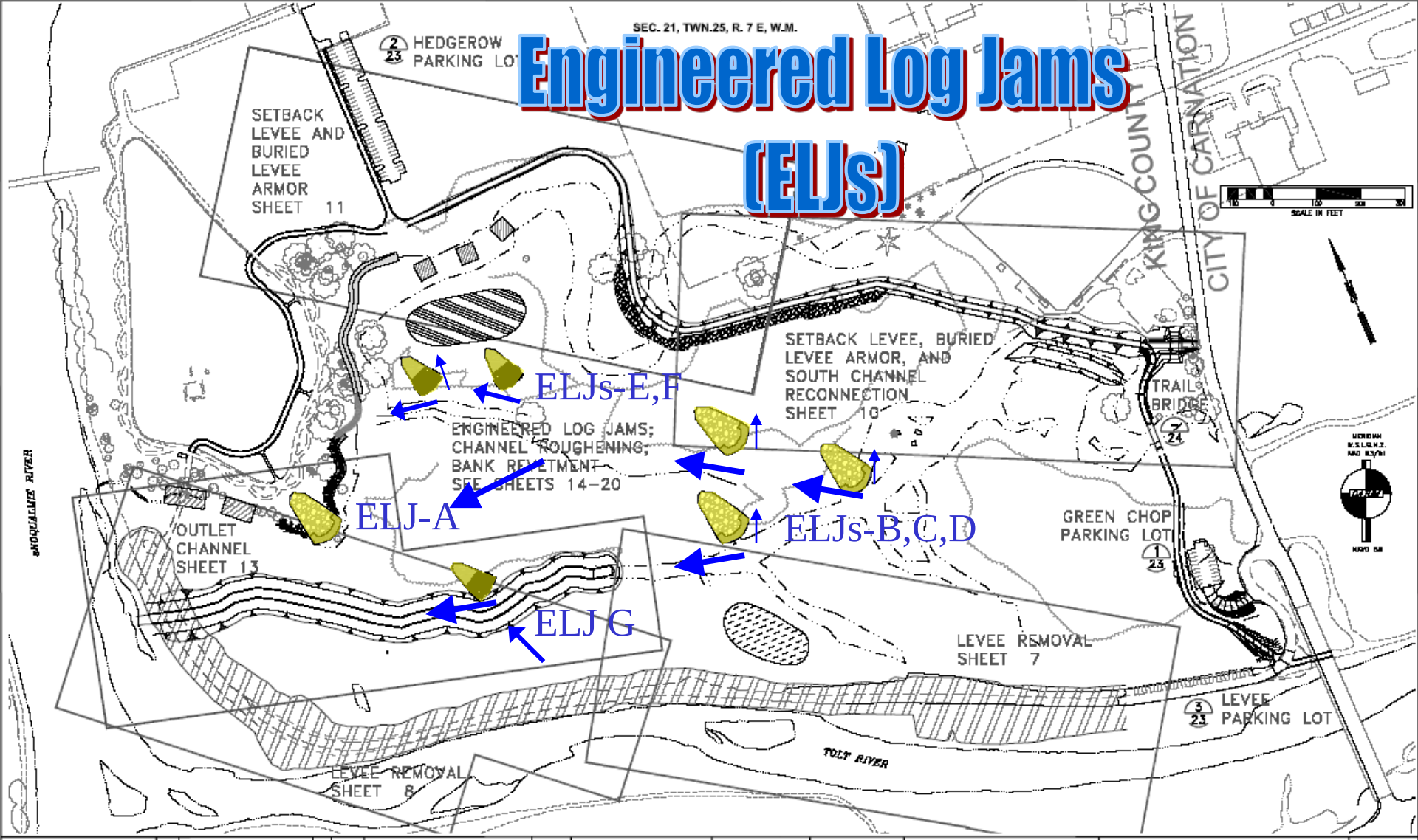
Basis of ELJ Design



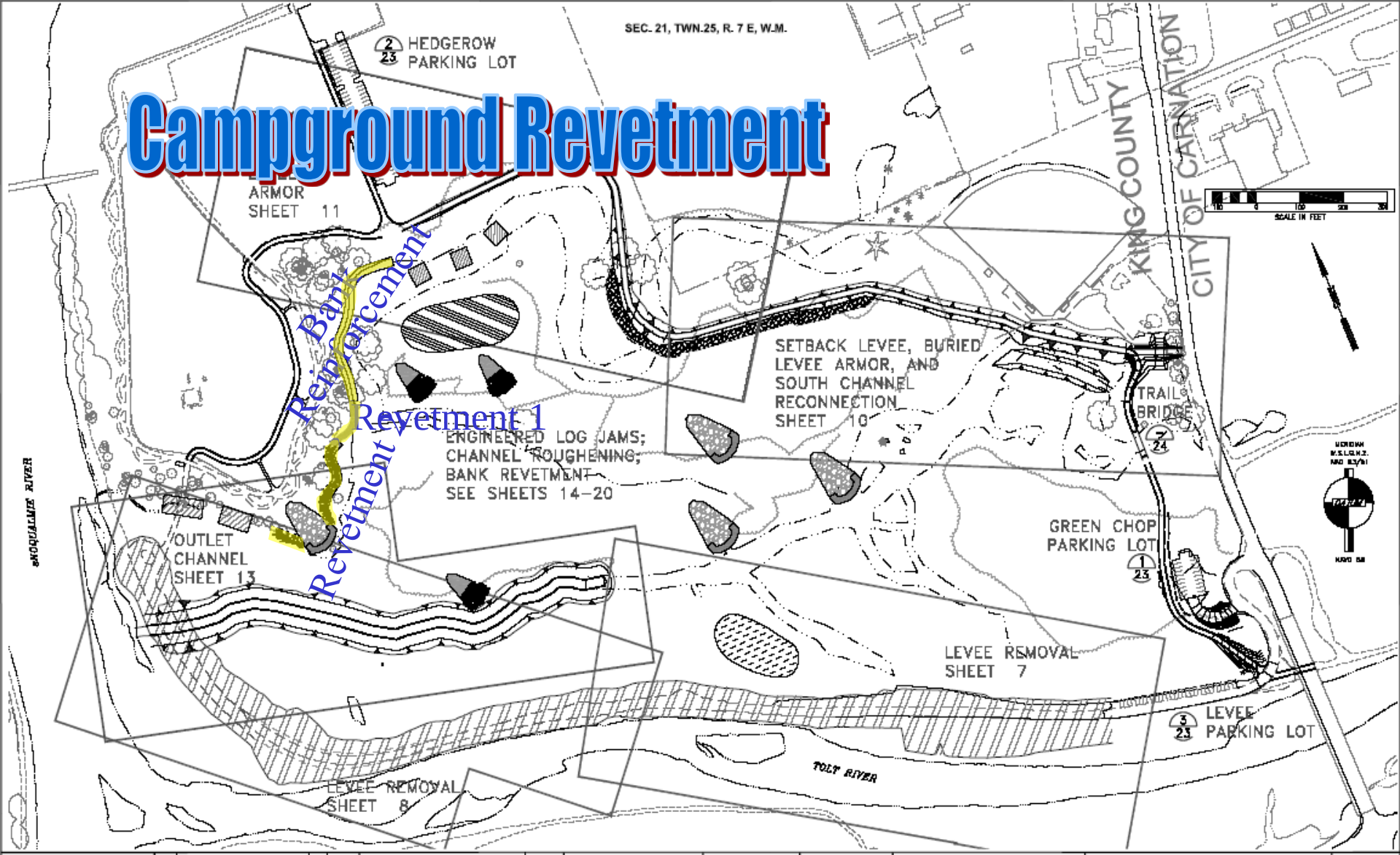
Basis of ELJ Design



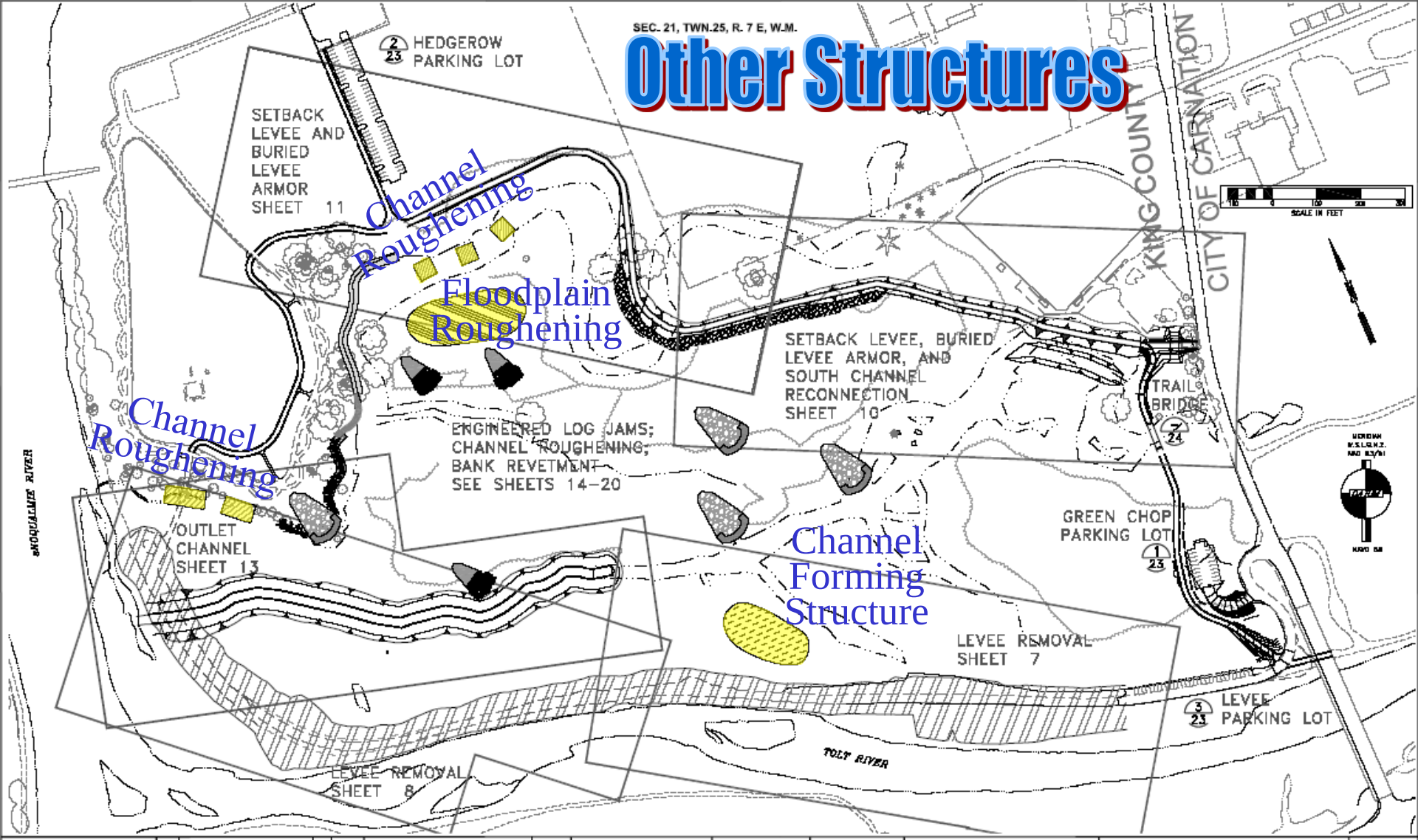
Engineered Log Jams (ELJs)



Campground Revetment



Other Structures



CADD / 30%

King County
Department of Natural Resources and Parks
Water and Land Resources Division
Capital Projects Section
Surface Water - Engineering and Ecological Services Units
Pam Bissonnette, Director

LOWER TOLT RIVER FLOODPLAIN RECONNECTION PROJECT
OVERVIEW AND SHEET KEY

SHEET 4 OF 29 SHEETS
2004-84

Mendenhall River, Juneau, Alaska: A simple log crib revetment

Complex ELJ Bank Crib – Mendenhall River, Juneau, Alaska, 2006

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