The First Decade of the Upper Green River Fish Habitat Rehabilitation Project

Examples of adaptive management

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SEATTLE DISTRICT

US Army Corps of Engineers®

TACOMA WATER
TACOMA PUBLIC UTILITIES

Slovenia

Croatia

Rome

Thailand

2005 Upper Green River

North Fork Ponds

Tributary LWD loading

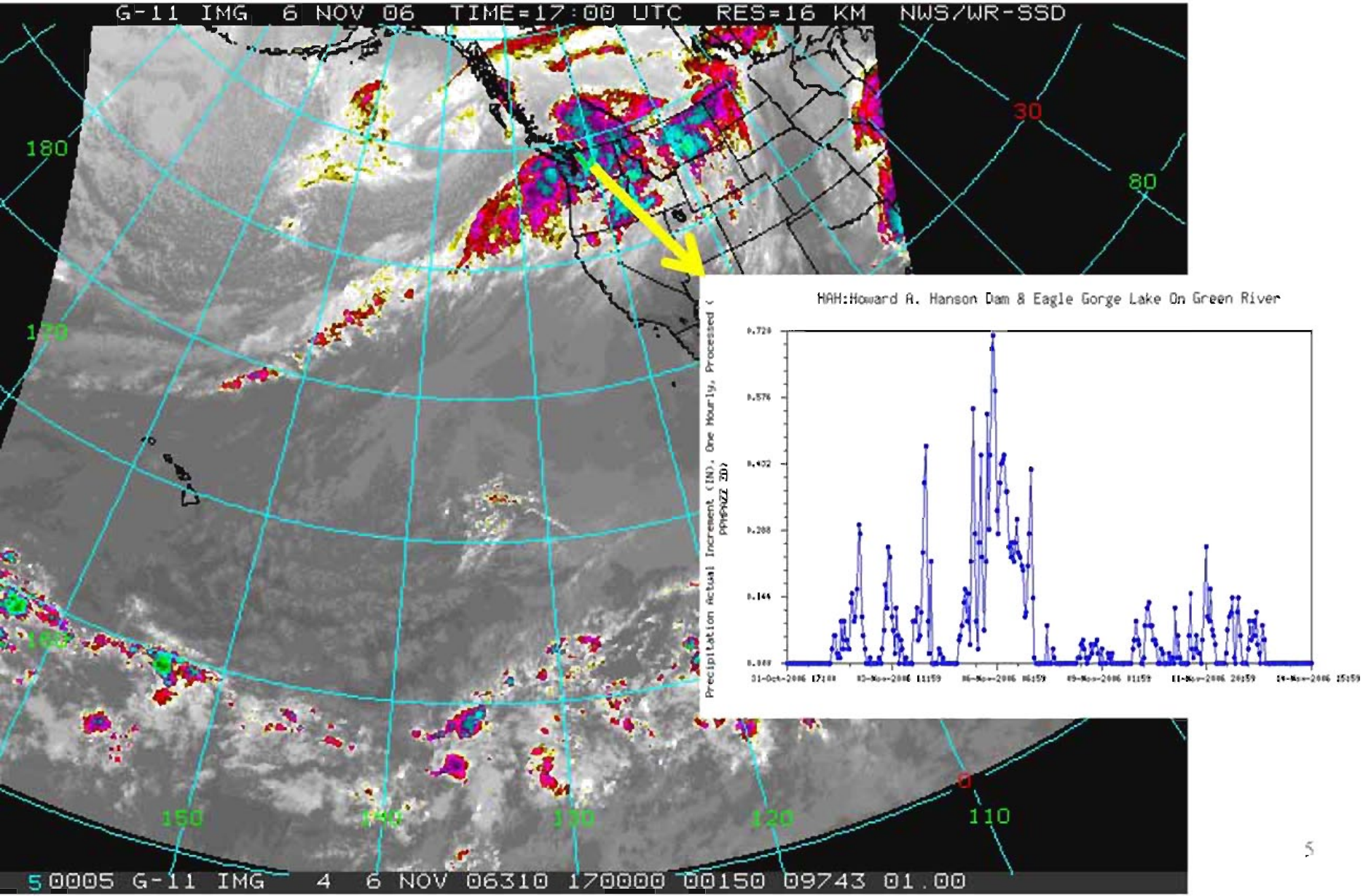
Mainstem Pool Habitat

2006 Upper Green River

Channel spanning LW jam

ELJ

AR =Record rainfall 1 week after project completed

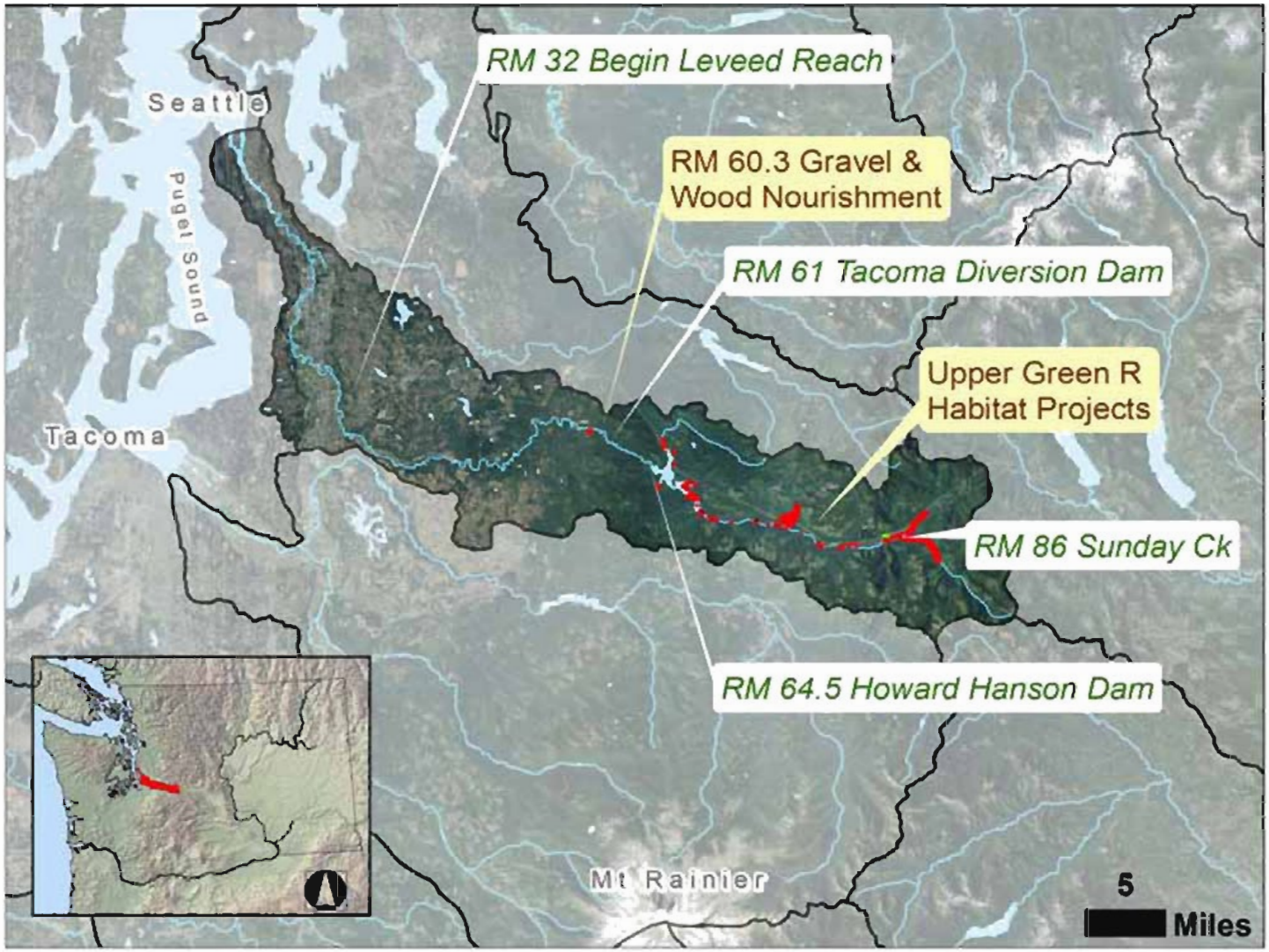


Welcome back! Now figure out how this happened…

Presentation Overview

- Project Purpose & Setting
- Adaptive management – application of lessons learned
  - Zone 1 Green River Pilot Gravel & Wood Nourishment Project
  - Upper Green River LW augmentation
- Thoughts on future efforts

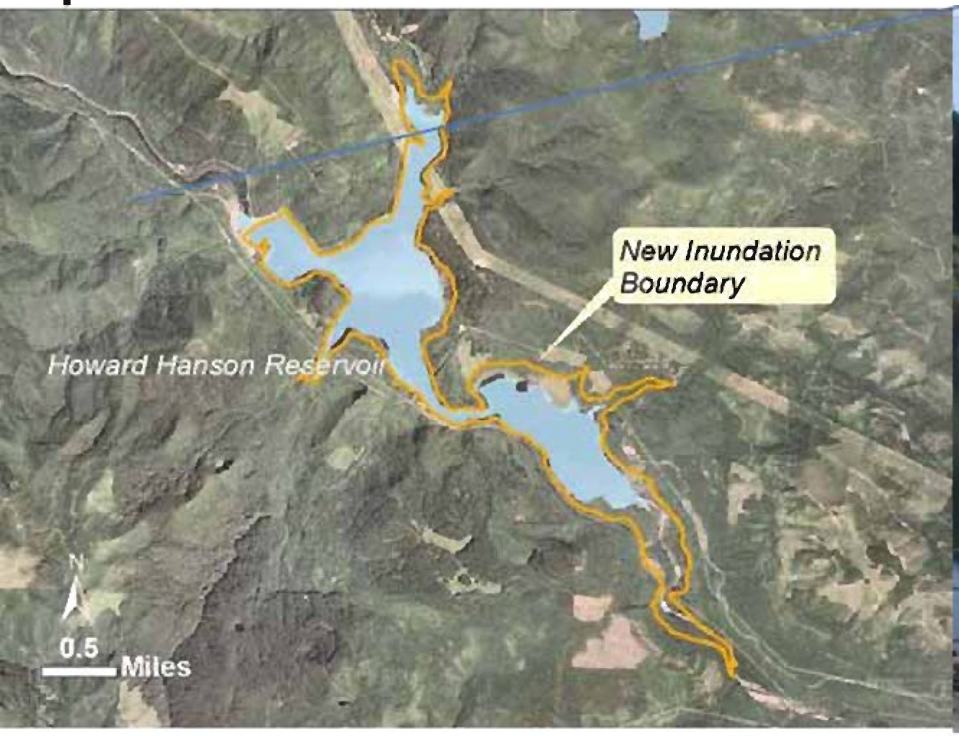
Two Projects, Many Examples of Adaptive Management



Dual Purpose Project

MITIGATION: Address impacts of increased size of reservoir upstream of dam

RESTORATION: Address impacts of construction and operation of Howard Hanson Dam and TPU diversion dam – upstream and downstream of dam



Phased Implementation

- Biop requirement, 2000 (ESA listing of Puget Sound Chinook salmon)
- Baseline studies 2000-2002
- Design Studies 2002-2009
- Implementation over a 50-year period, beginning 2003
- Lead agency is USACE, partner is City of Tacoma

Hydrologic Setting

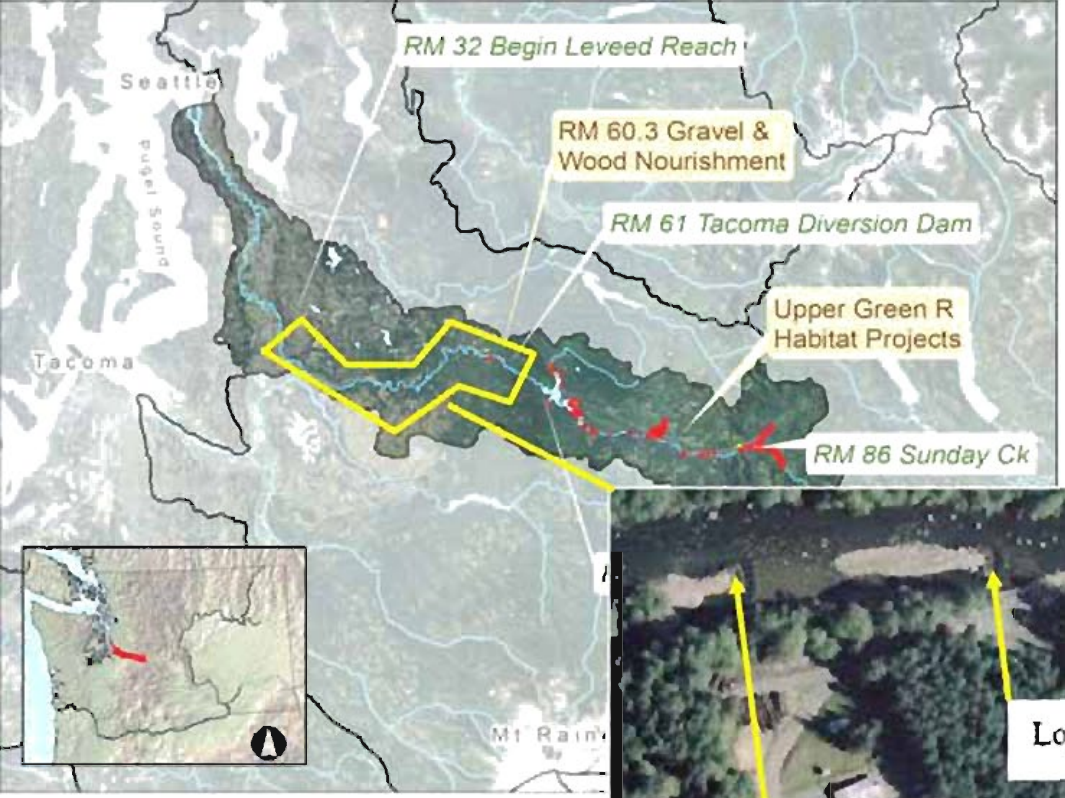
- "Working watershed" closed to public
- Water supply for Tacoma
- No fish passage yet
- Lowest pass over cascades in headwaters – no glaciers
- Basin area above dam 220 mi^2
- Basin avg. precip = 88" (2.2 m)
- Basin avg snowfall= 22-400"
- Qavg = 1200 cfs, Q2 = 12000 cfs, Q50 = 33000 cfs

January 2009 > 90% of Design Q

Avulsion, January 2009, North Fork Green River

Record Flood Pool, Howard Hanson Dam

Zone 1 Pilot Project, 2003-2053



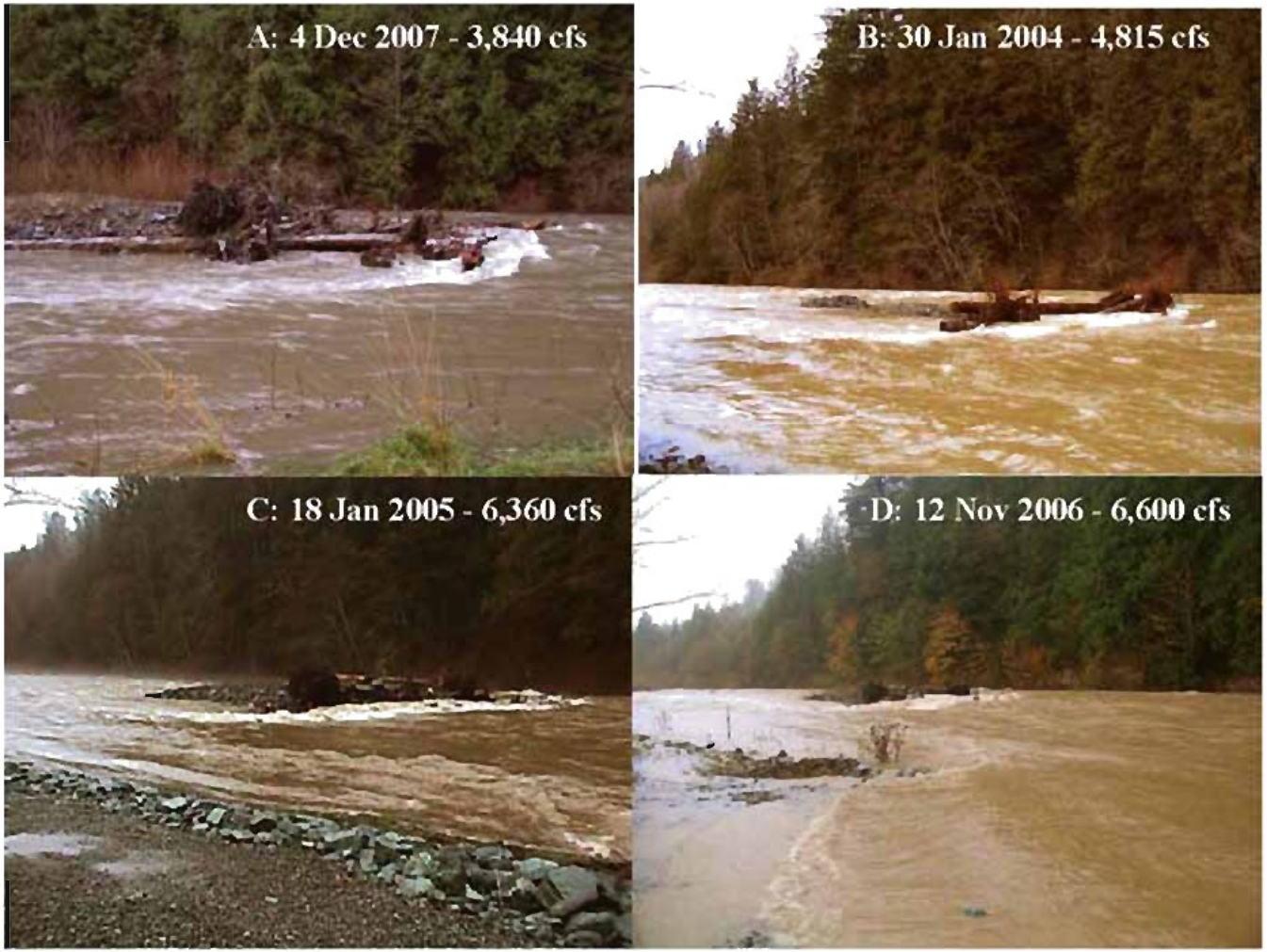
Gravel & Wood nourishment of 30 mile reach

Boater safety & Monitoring

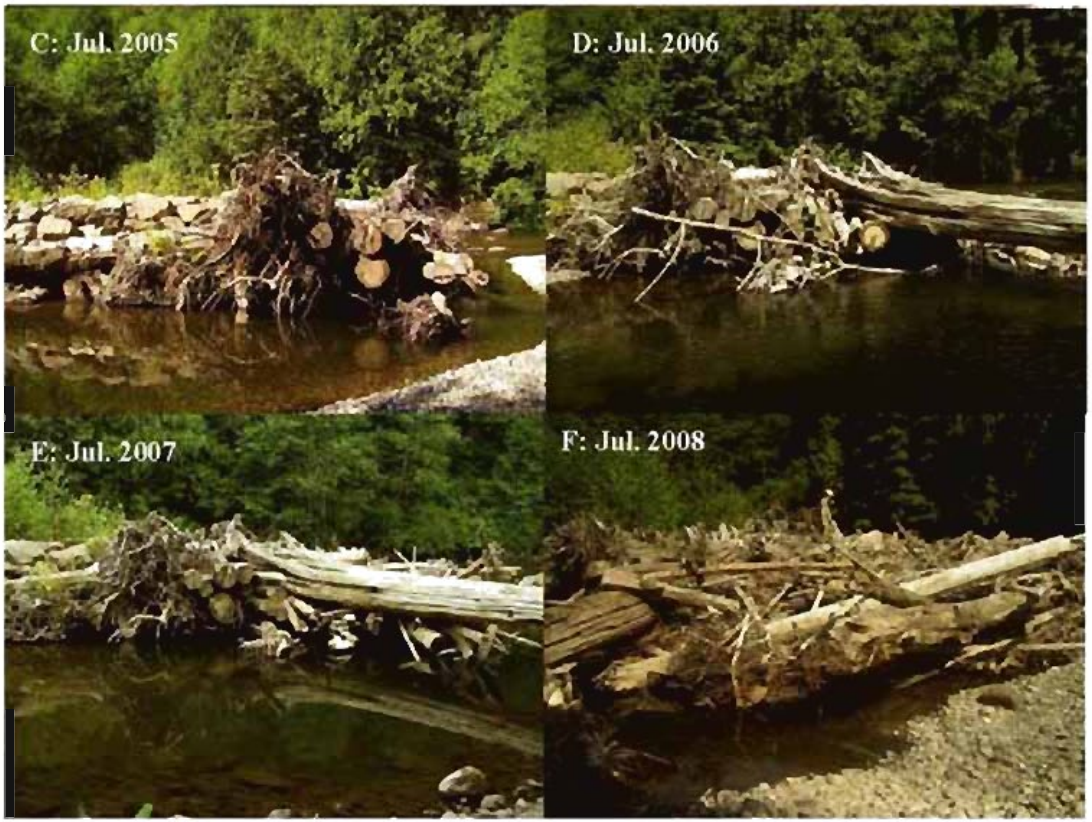
- Jam modification for recreational boater safety & warning signs
- Log ID tags

Figure 8. ELJ2 As-Built

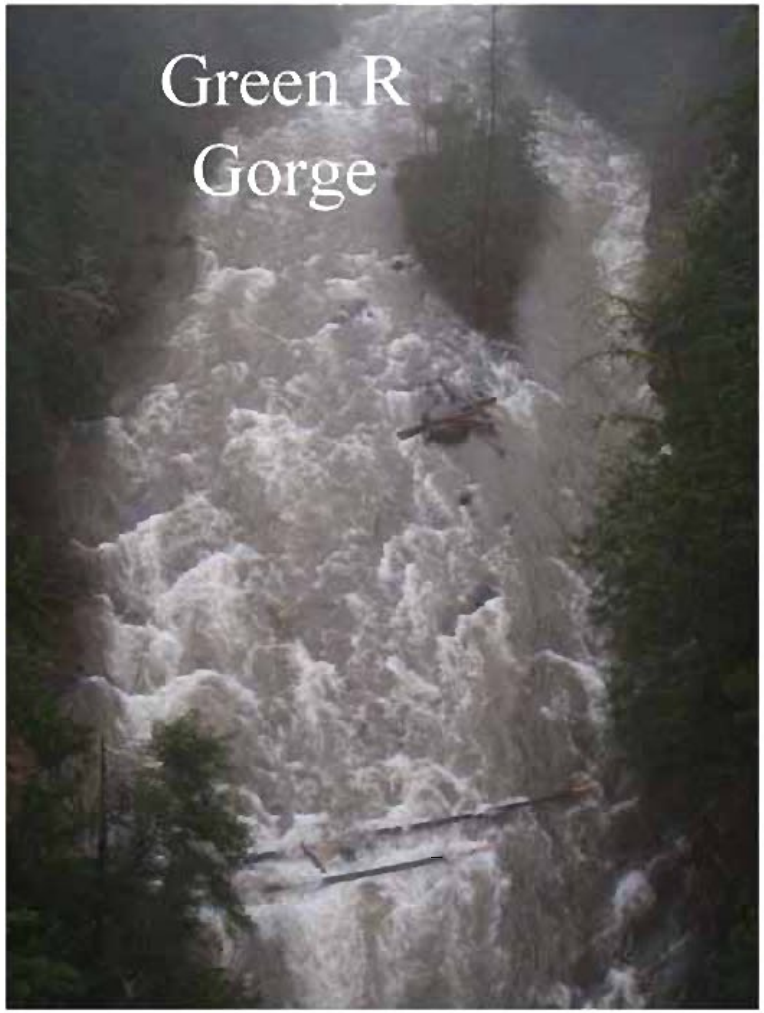
Influence of external factors



Monitoring to assess if recreational navigation hazards need removal

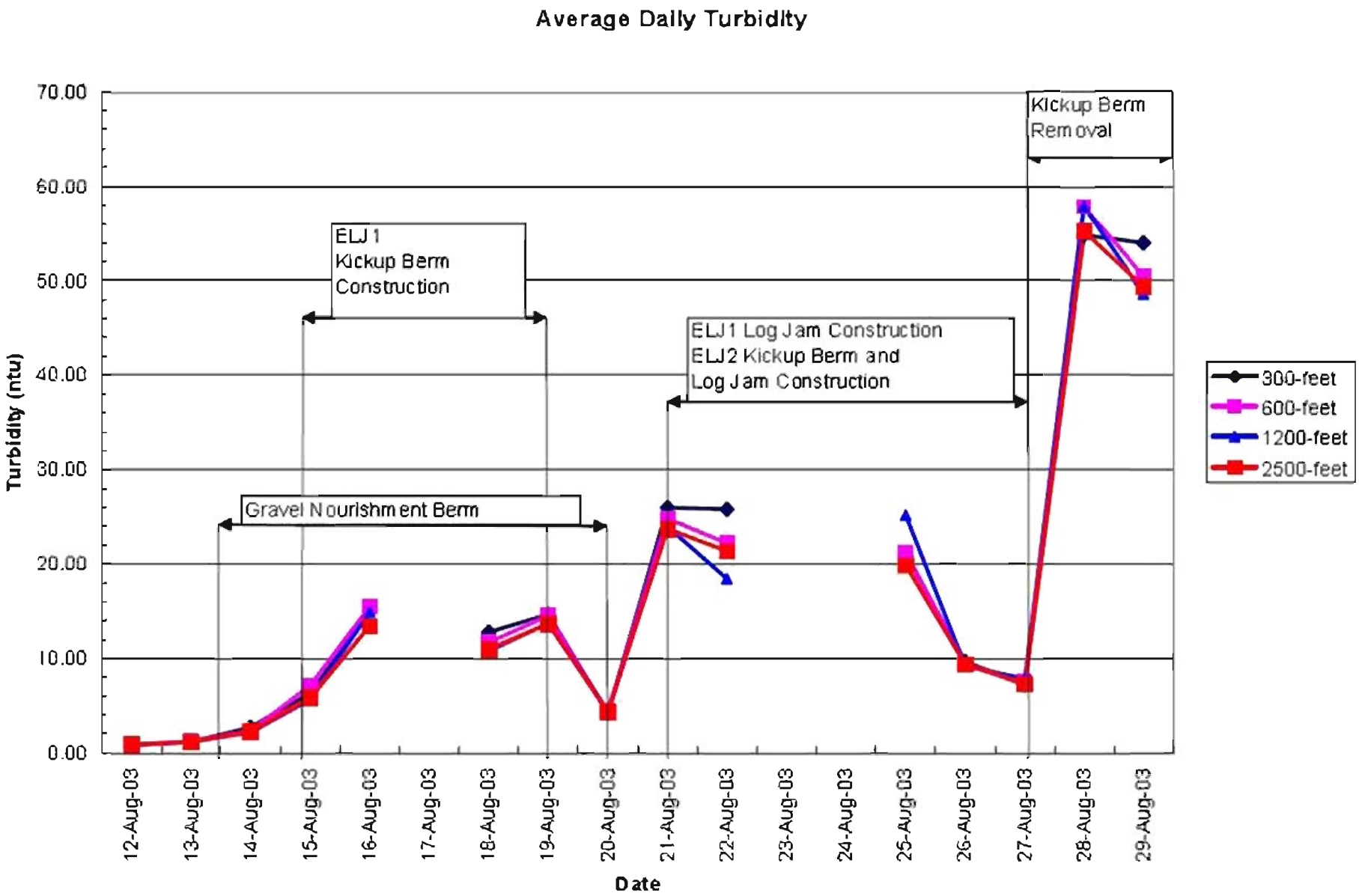


ELJ 1



Water control & permits

- ELJ construction issues – water control & turbidity – can we do this without permit violations?


Average Daily Turbidity
Turbidity (ntu)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Kickup Berm Removal
ELJ 1 Kickup Berm Construction
ELJ1 Log Jam Construction
ELJ2 Kickup Berm and Log Jam Construction
Gravel Nourishment Berm
300-feet
600-feet
1200-feet
2500-feet
12-Aug-03
13-Aug-03
14-Aug-03
15-Aug-03
16-Aug-03
17-Aug-03
18-Aug-03
19-Aug-03
20-Aug-03
21-Aug-03
22-Aug-03
23-Aug-03
24-Aug-03
25-Aug-03
26-Aug-03
27-Aug-03
28-Aug-03
29-Aug-03
Date

LW Nourishment Success

Individual pieces and natural logjams increasing

Table 5-1. Comparison of total LWD counts for the 2001 and 2005-2008 surveys of LWD in the middle Green River, Washington (RM 61.0, Howard Hanson Dam to RM 32, Auburn Narrows).

	Survey Year				
	2001	2005[1,2]	2006	2007	2008
Total LWD Pieces	434	724	1,297	1,140	846
Medium Size Pieces	259	503	777	682	512
Large Size Pieces	110	115	262	229	102
Key Size Pieces	23	34	51	46	30
Rootwads	42	72	207	183	202
Total LWD Jams	24	78	84	66	101
Small Jams	21	60	71	57	80
Medium Jams	1	13	10	7	12
Large Jams	2	5	3	2	9

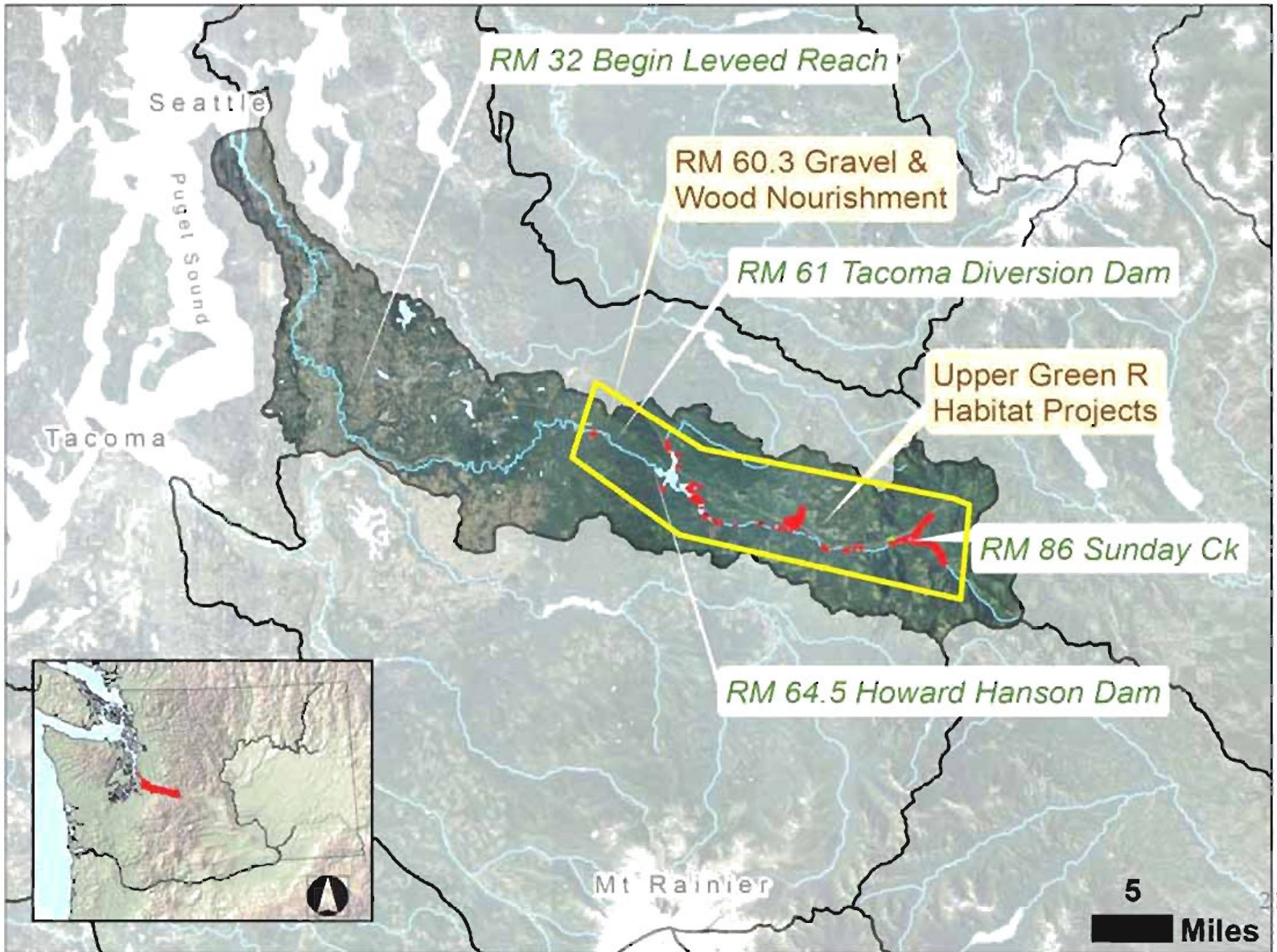
[1]LWD counted in 2005 mainstem and side channel units was not kept in separate tallies.
[2]2005 survey length was 5.3 miles shorter than other years survey lengths.

- **400% Increase in total LW jams since initiation - Why make hardened ELJs when you can let nature do it for you?**
- Needs sustainable programmatic efforts to succeed
- Monitoring and risk assessments required

Zone 1 LW & ELJ Summary

- Jams don't need to be huge if they are stable and there is adequate LW load
- Wood nourishment is building and maintaining jams naturally over a 30 mile reach = big ROI
- Designer should be on site to verify critical information received by construction team
- Accounting for sediment in hydraulic studies would be beneficial
- Design with uncertainty in mind

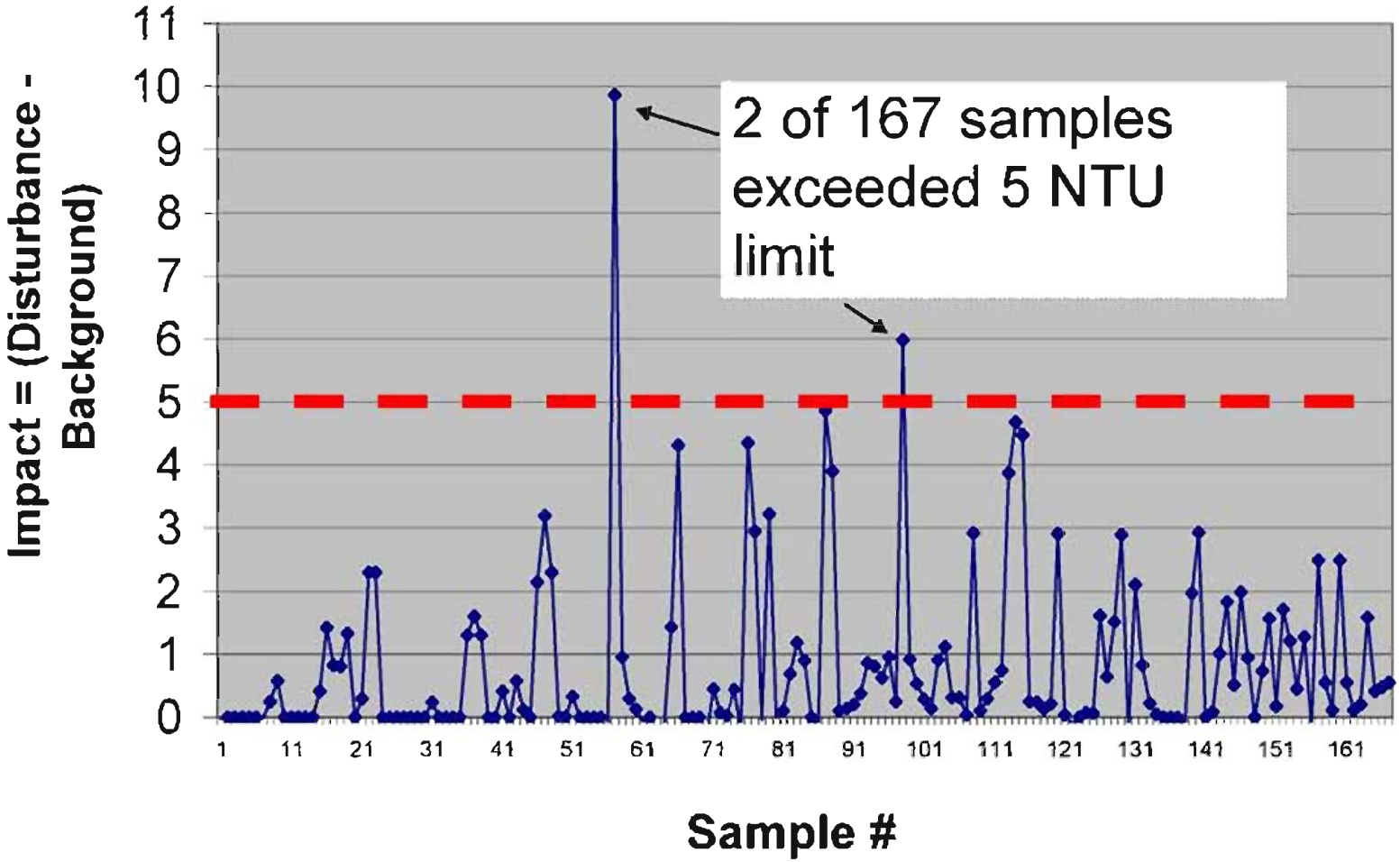
Upper Green River Project Summary 2002 - 2012



Adapting Installation Techniques and Design for Water quality protection

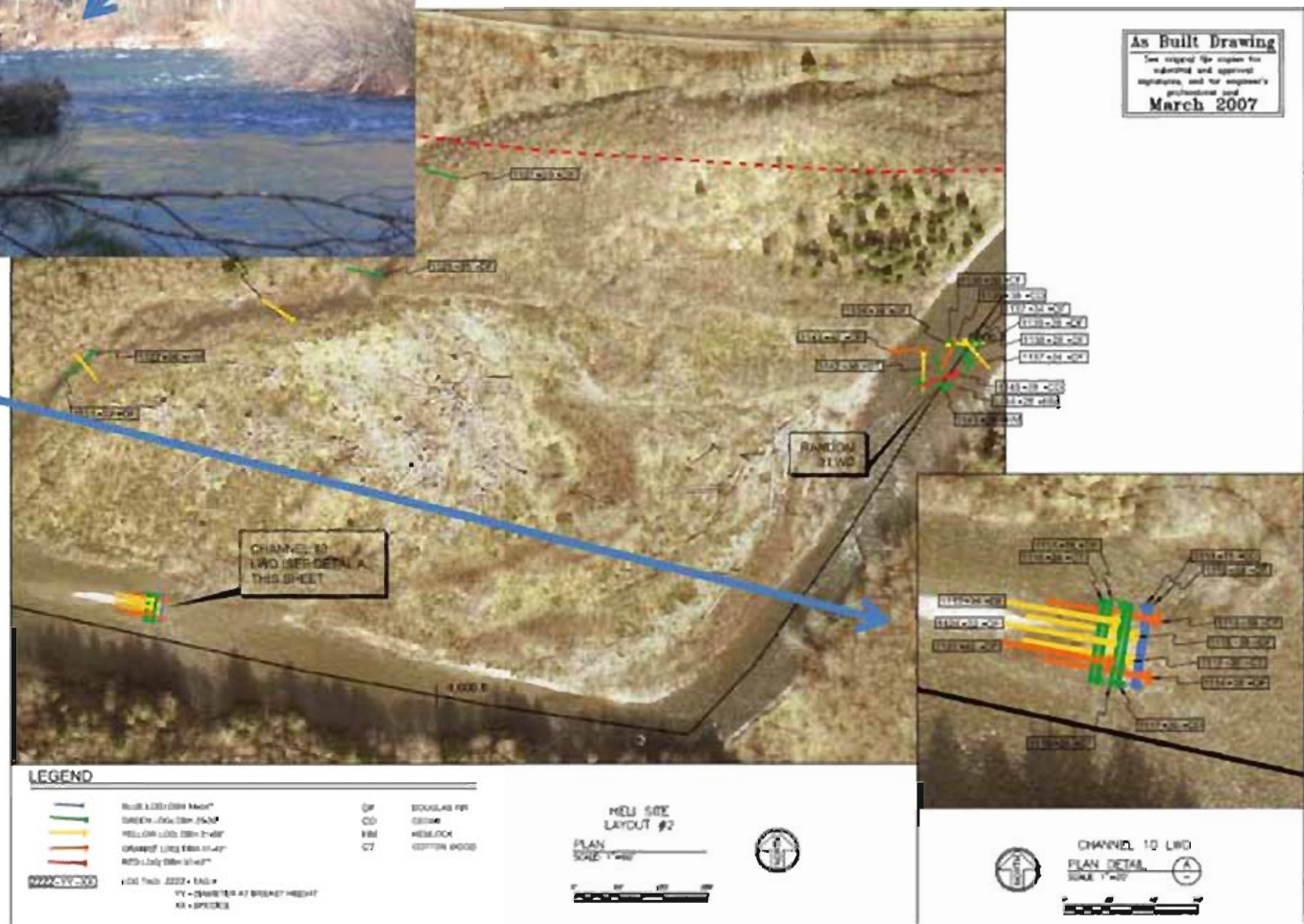
- Careful planning to Minimize crossings,
- Reduce excavation and fill

Water Quality Impact During Construction, 2005



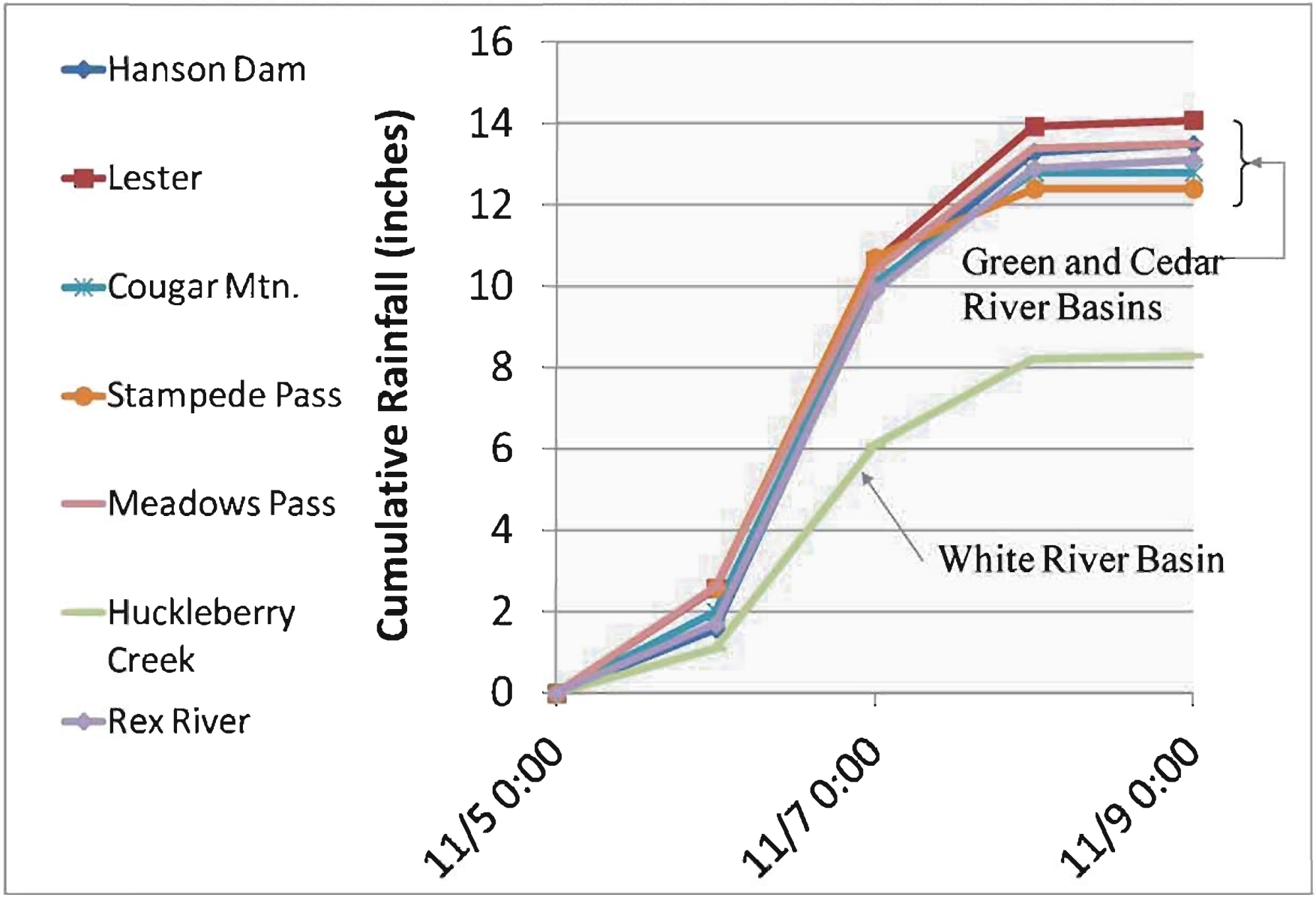
Initial success of mainstem LW loading in 2005,

Drove design approach in 2006



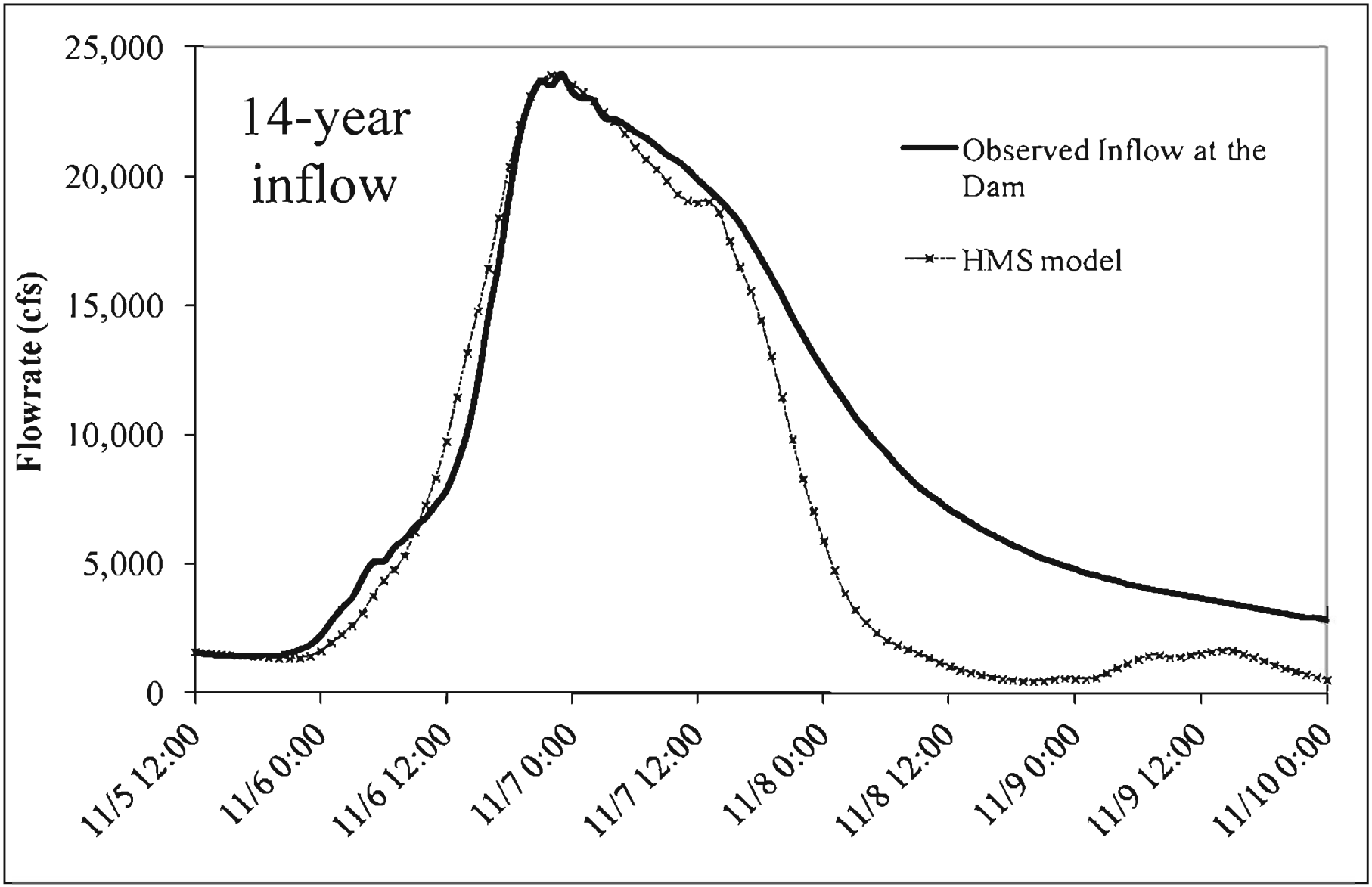
2006 light touch projects – lots of unanchored wood loading

November 2006 Flood Event



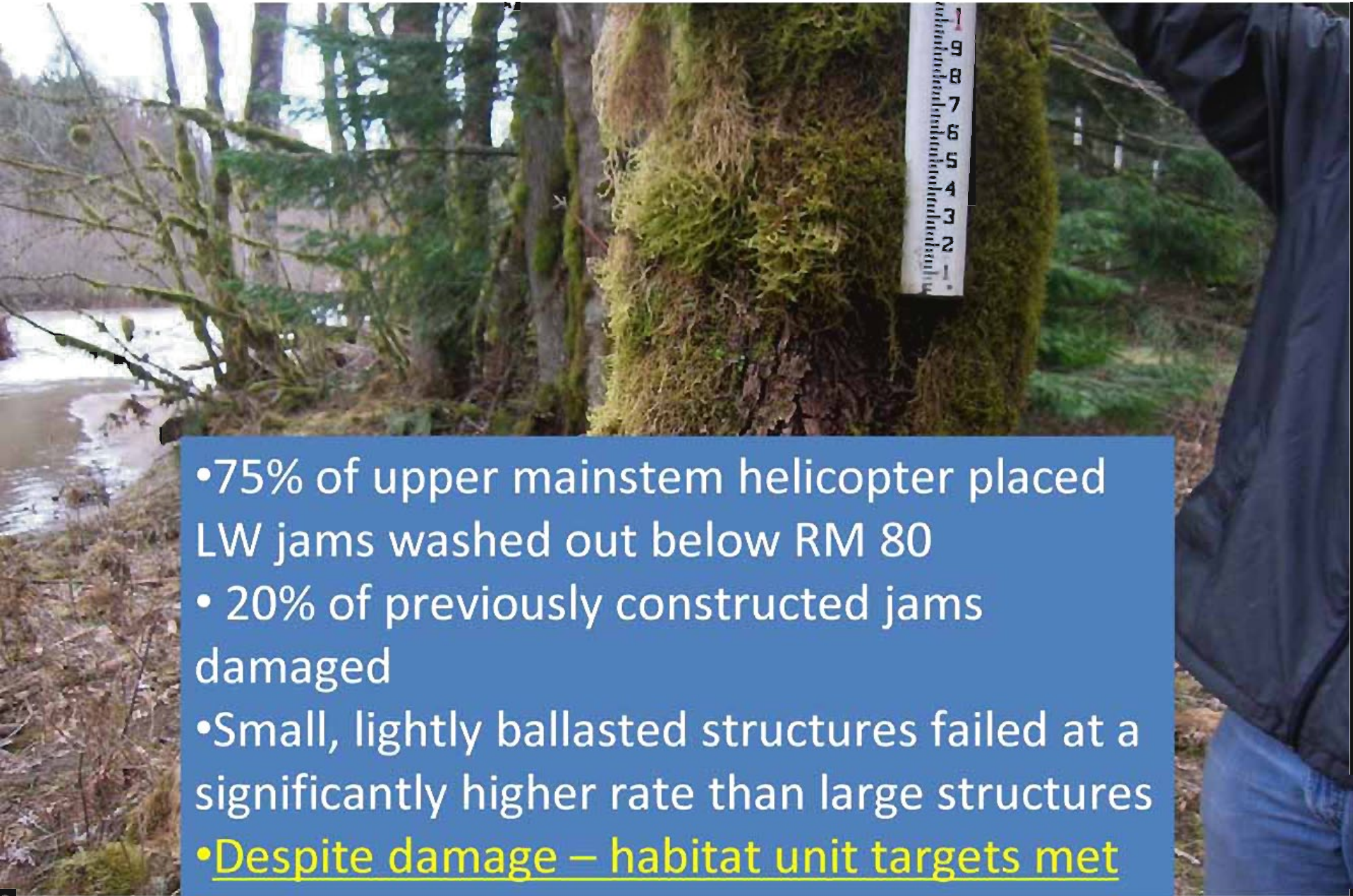
Basin Storm Total Precipitation 12-14 inches

November 2006 Flood Event



Simulated flood peak compared well with observed peak

November 2006 Flood Event



- 75% of upper mainstem helicopter placed LW jams washed out below RM 80
- 20% of previously constructed jams damaged
- Small, lightly ballasted structures failed at a significantly higher rate than large structures
- Despite damage – habitat unit targets met

Findings: Pile failure mode verification – lateral load and ultimate bending capacity exceedance – not pull out

Findings: ELJ stability and ballast retention benefit from higher, less permeable structures, permanent lashing, and multiple anchoring systems.

Flood revealed persistence of buried large wood, resilience of mechanical anchors

November 2006 Flood Event: learning opportunity

POST FLOOD INSPECTIONS

- What survived? How high did the flows get? How much debris was recruited?

AERIAL PHOTOGRAPHS

- What are the reach scale changes, pool area changes?

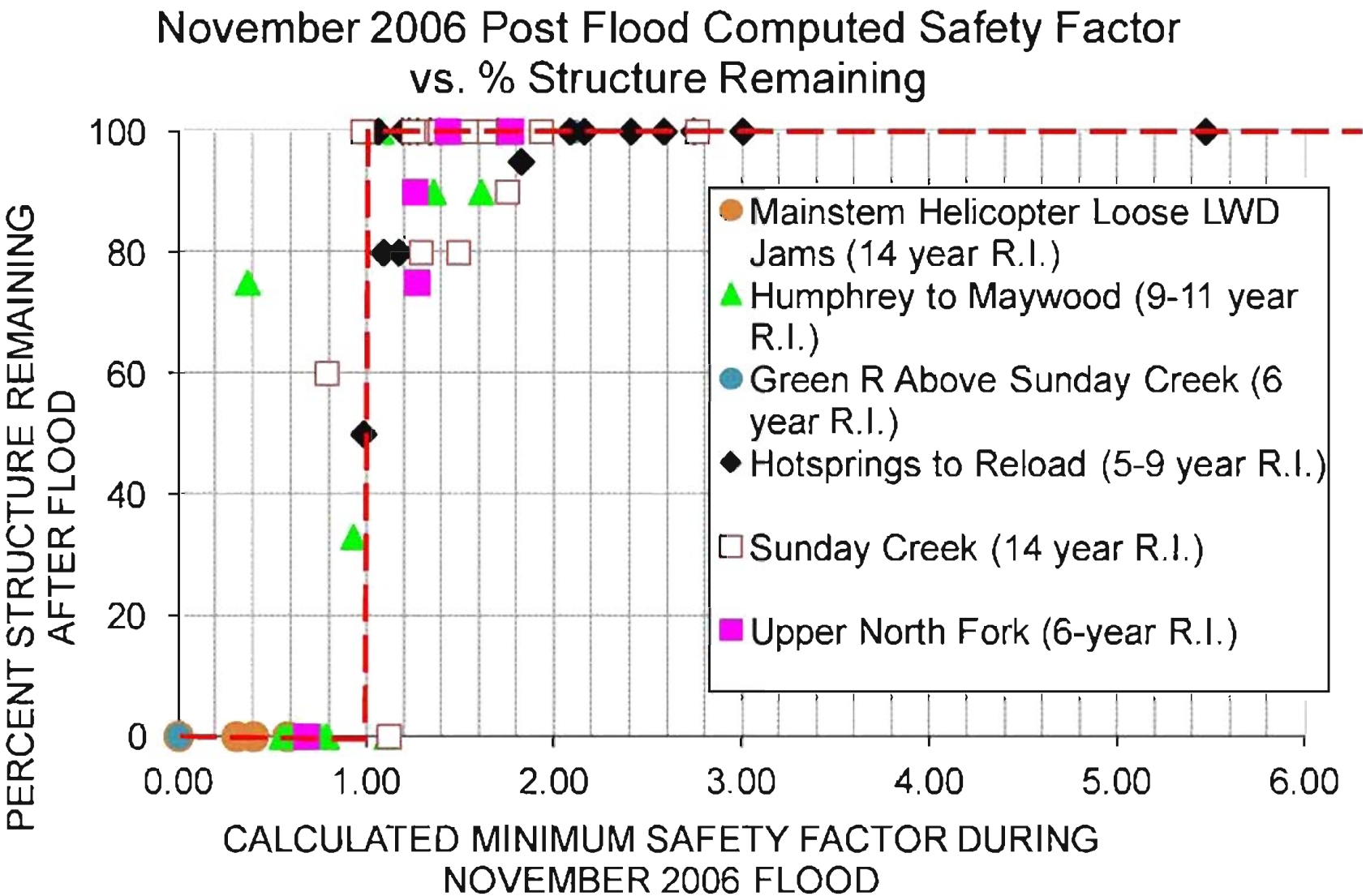
FORENSIC ANALYSIS OF DAMAGED STRUCTURES

- Use observed rainfall and dam inflow to reconstruct flood in upper basin
- Re-run hydraulic models, compare with surveyed high water marks
- Estimate safety factors during flood peak
- Compare to post-flood condition of logjams

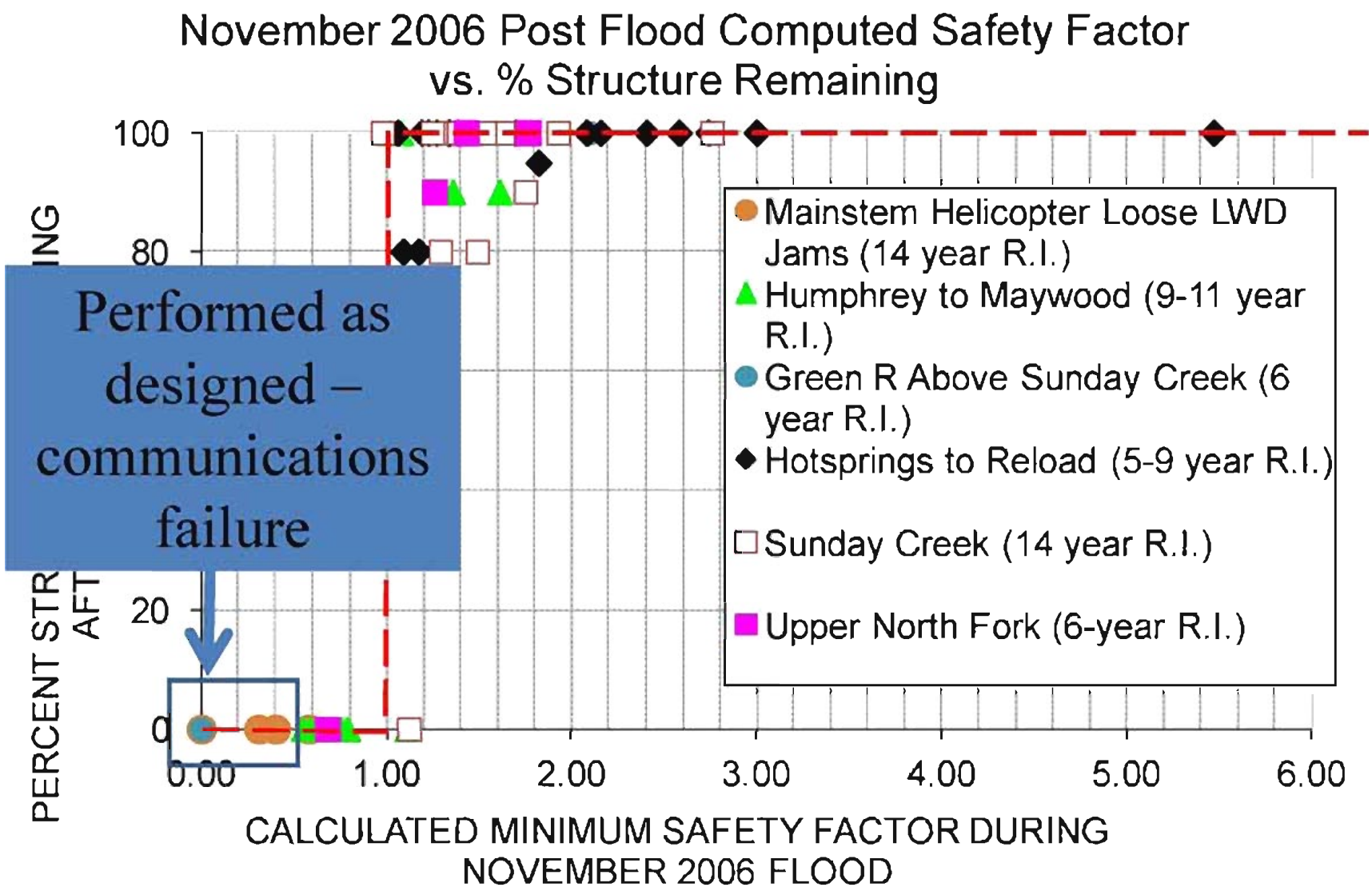
POOL AREA MEASUREMENTS

- Measure in field, compare with aerial photos

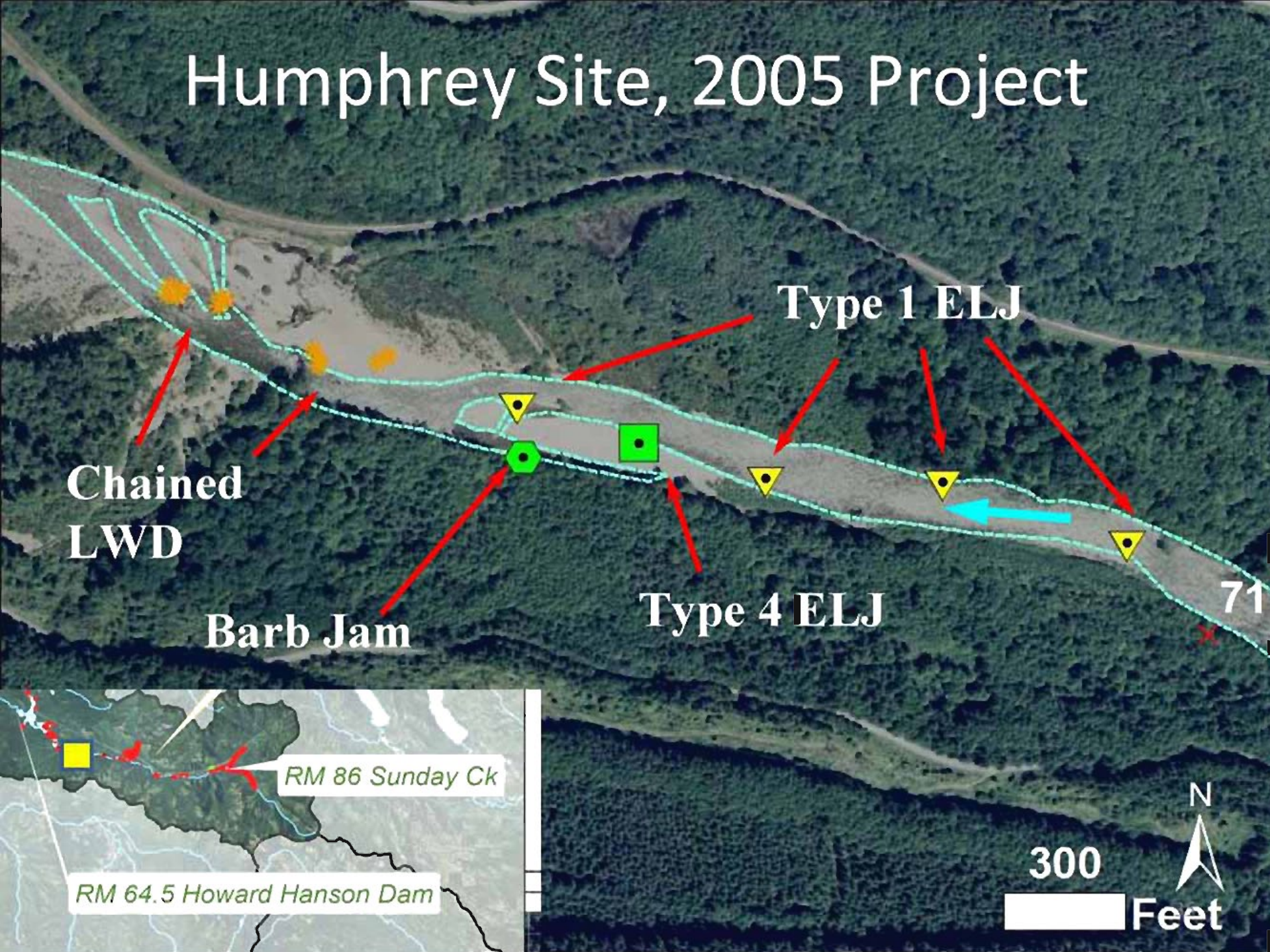
Post-Flood Forensics – backcheck and validation of analysis tools

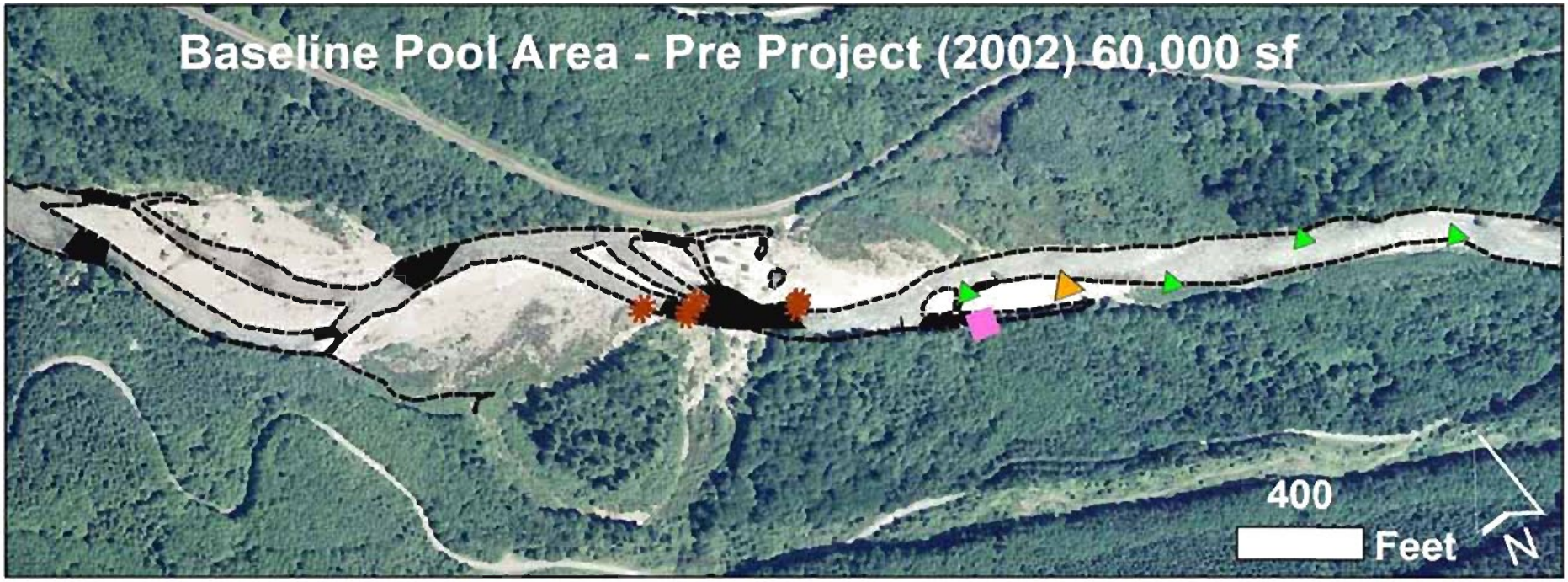


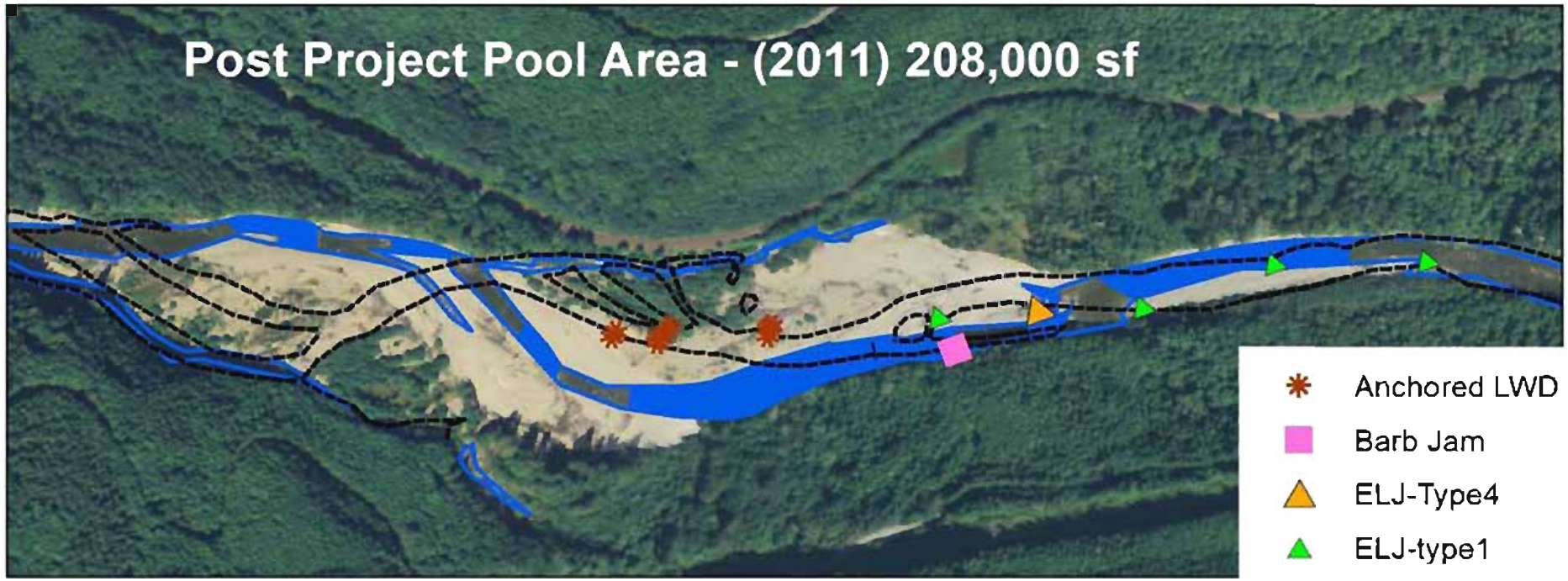
SF = 1.7 (min) for "stable" design?

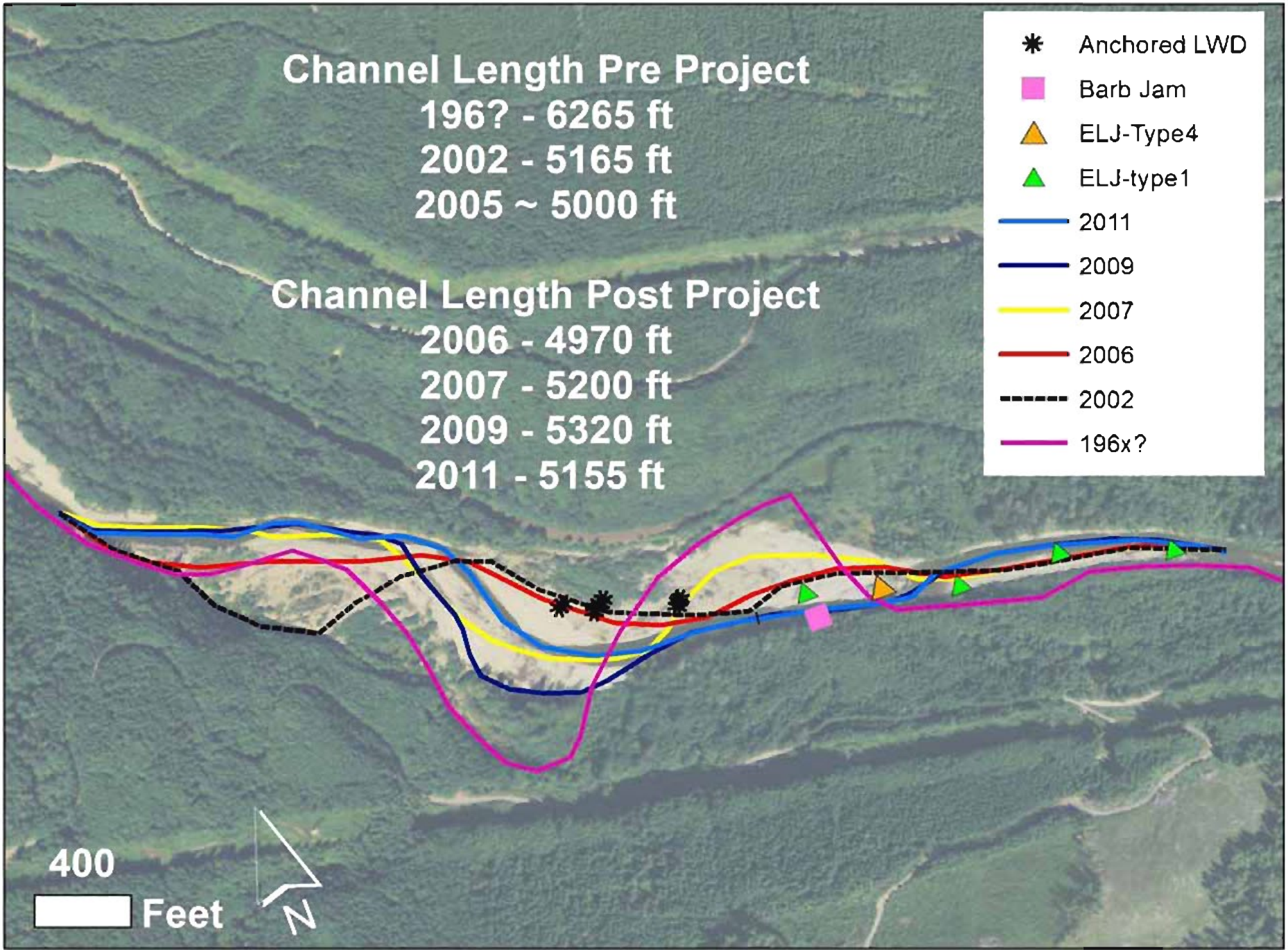


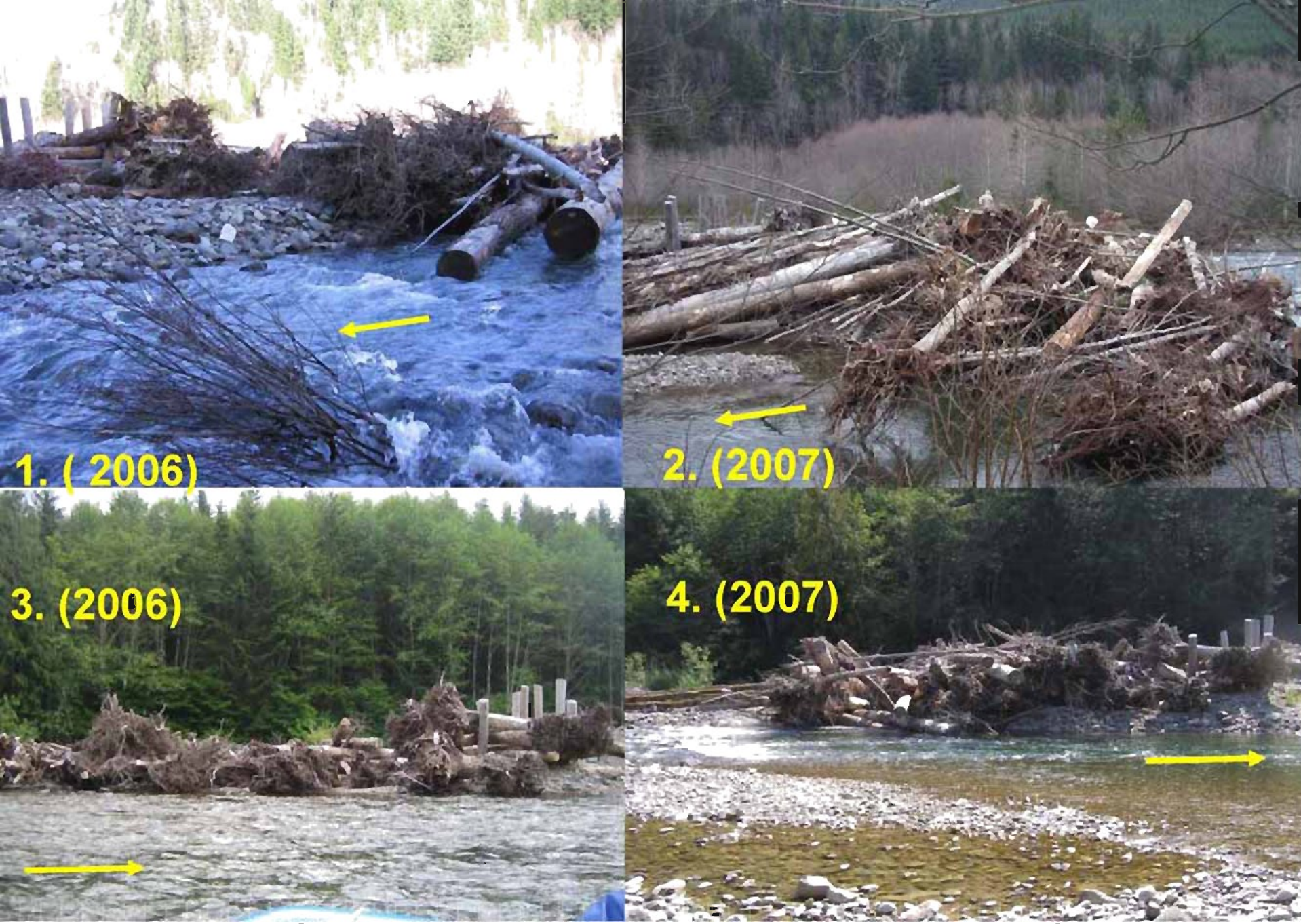
Humphrey Site, 2005 Project



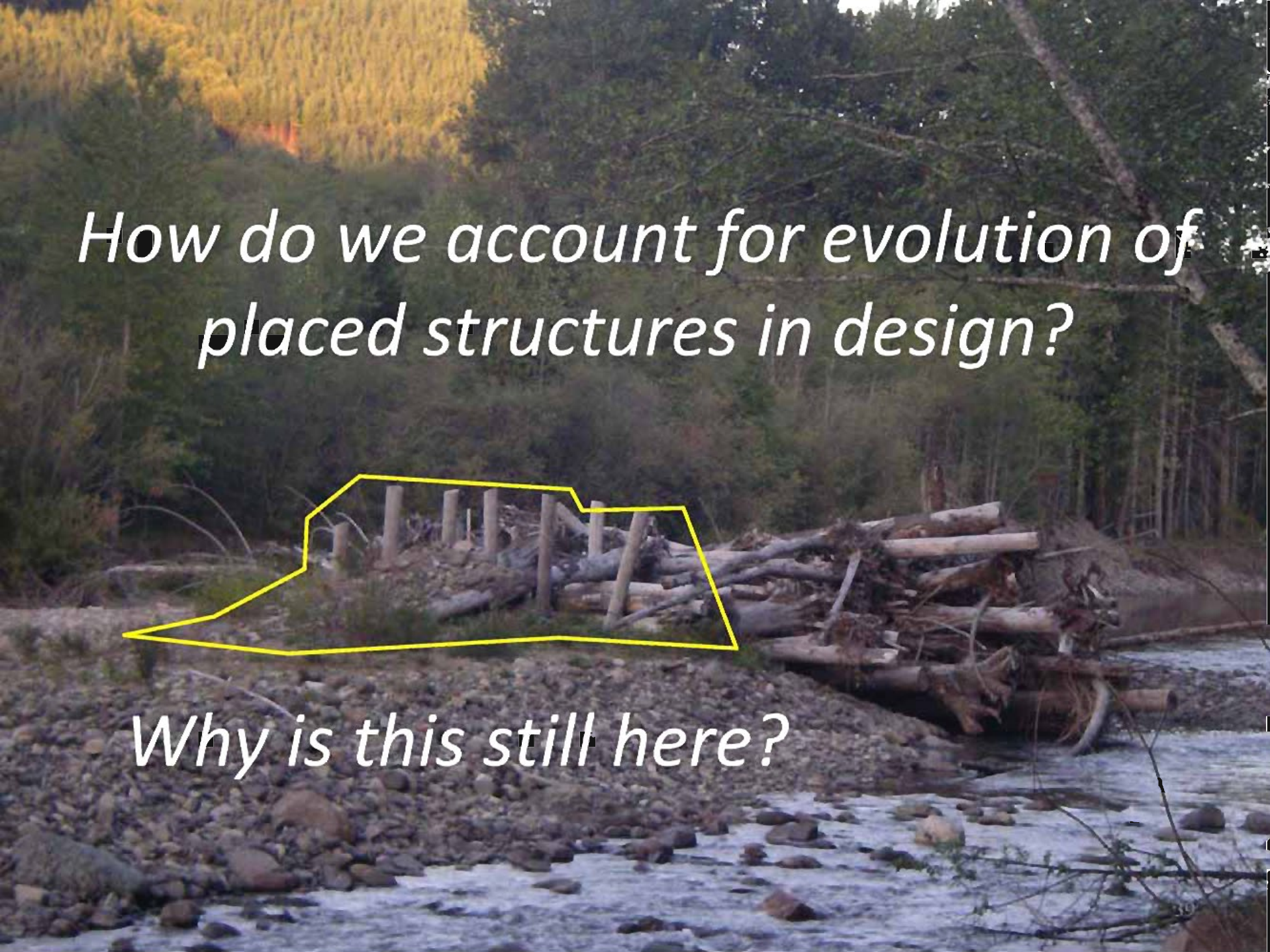

Baseline Pool Area - Pre Project (2002) 60,000 sf
400
Feet
N


Post Project Pool Area - (2011) 208,000 sf
Anchored LWD
Barb Jam
ELJ-Type4
ELJ-type1


Channel Length Pre Project
196? - 6265 ft
2002 - 5165 ft
2005 ~ 5000 ft
Channel Length Post Project
2006 - 4970 ft
2007 - 5200 ft
2009 - 5320 ft
2011 - 5155 ft
Anchored LWD
Barb Jam
ELJ-Type4
ELJ-type1
2011
2009
2007
2006
2002
196x?
400
Feet
N



MAINSTEM NEAR RM 70-HUMPHREY SITE


How do we account for evolution of placed structures in design?
Why is this still here?

Upper Green R Adaptive Management Summary

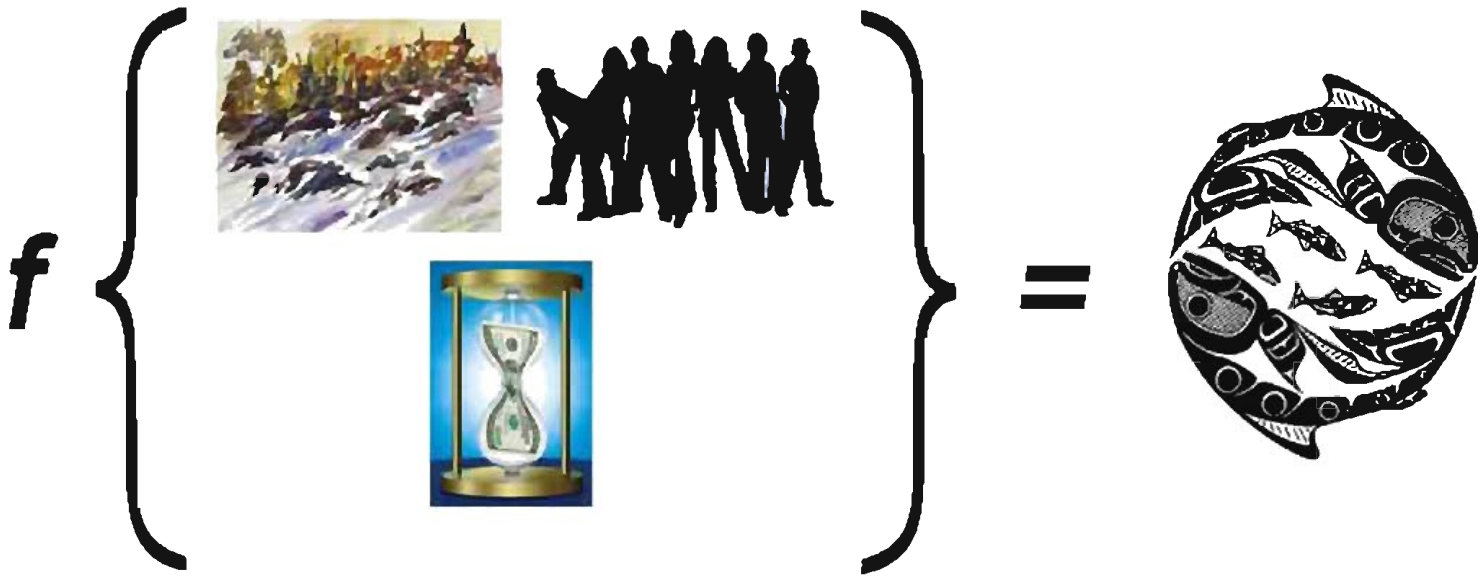
- Assess risks to adjacent infrastructure – design accounted for periodic loss of structures & uncertainty
- Design with reality of field in mind– include alternate materials and foundations as optional items with pre-determined costs
- Conduct pilot projects to test unproven techniques (ELJs, pile driving, gravel nourishment berms)
- Phase construction and routinely monitor to improve outcomes
- Set clear goals informed by science. Redefine success from forms to processes

Where we're headed

- Continue wood nourishment below dam
- Continue wood and gravel monitoring below dam
- O&M phase for upstream LW projects
- Periodic inspection and monitoring to determine what is most cost effective in long term-plan for O&M
- Full fish passage 10 years out

Considerations for a more optimal outcome

Objective: *Optimize this function*



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