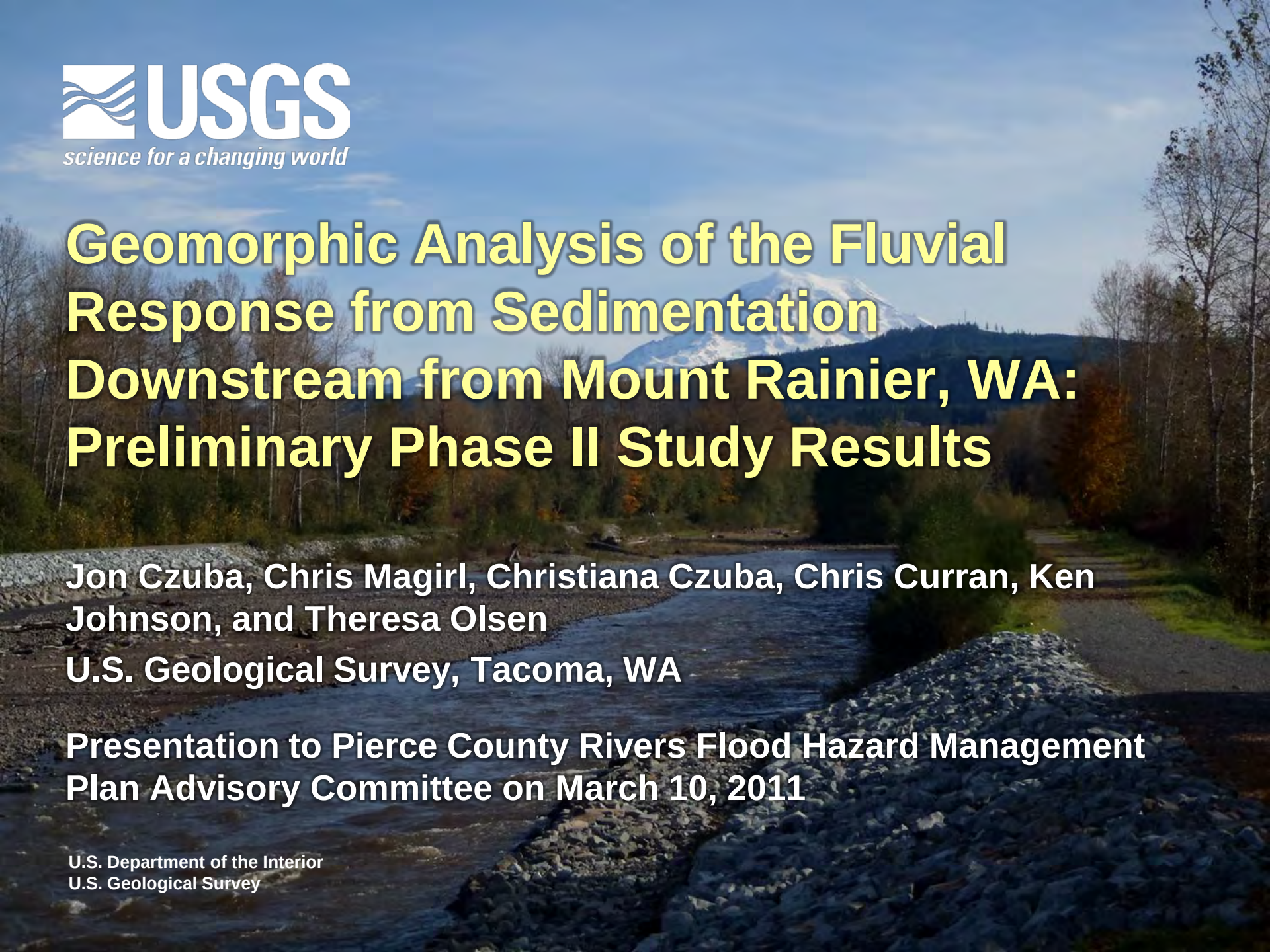

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science for a changing world

Geomorphic Analysis of the Fluvial Response from Sedimentation Downstream from Mount Rainier, WA: Preliminary Phase II Study Results

Jon Czuba, Chris Magirl, Christiana Czuba, Chris Curran, Ken Johnson, and Theresa Olsen

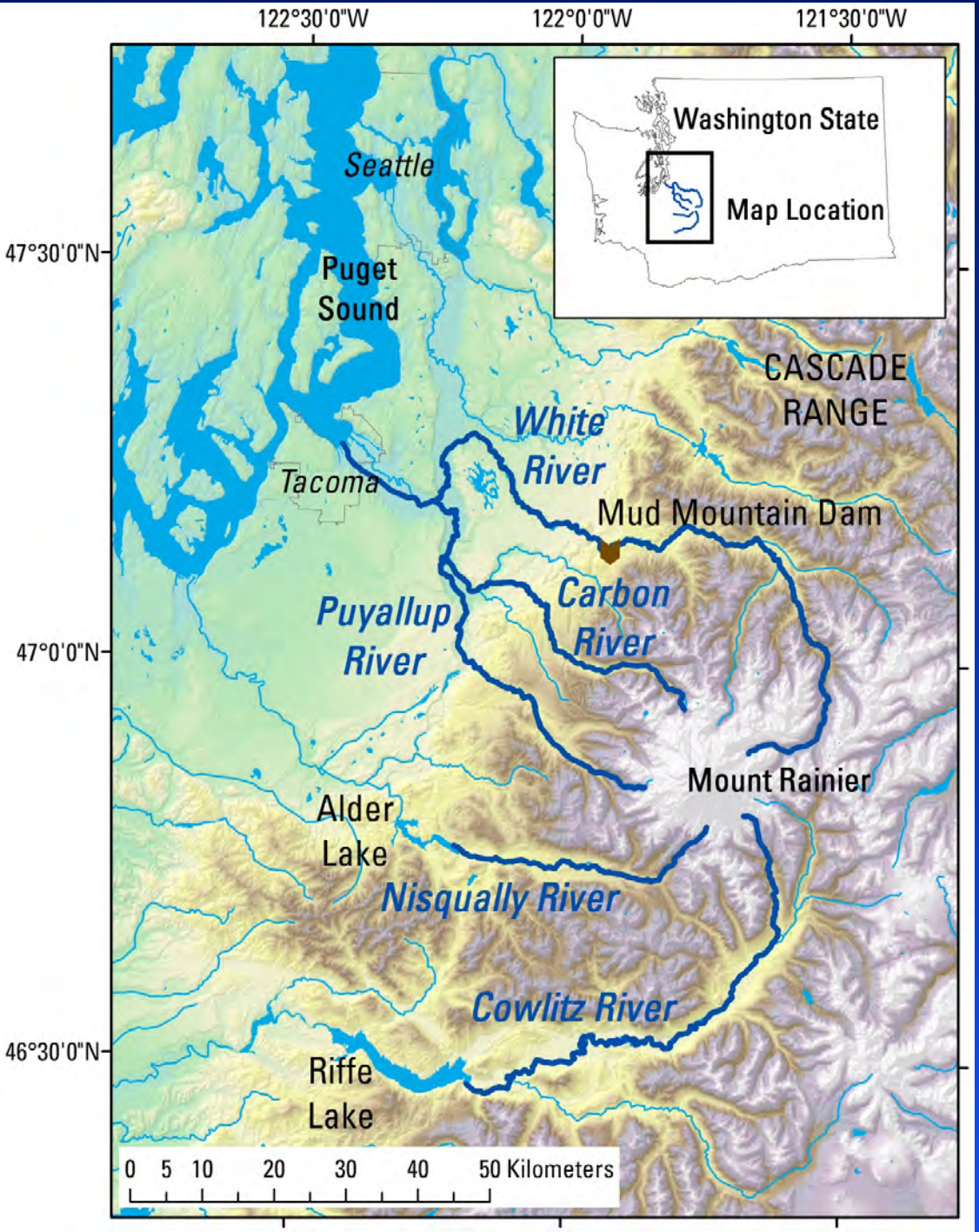
U.S. Geological Survey, Tacoma, WA

Presentation to Pierce County Rivers Flood Hazard Management Plan Advisory Committee on March 10, 2011

U.S. Department of the Interior
U.S. Geological Survey

Overview

- Phase I…
- Phase II…



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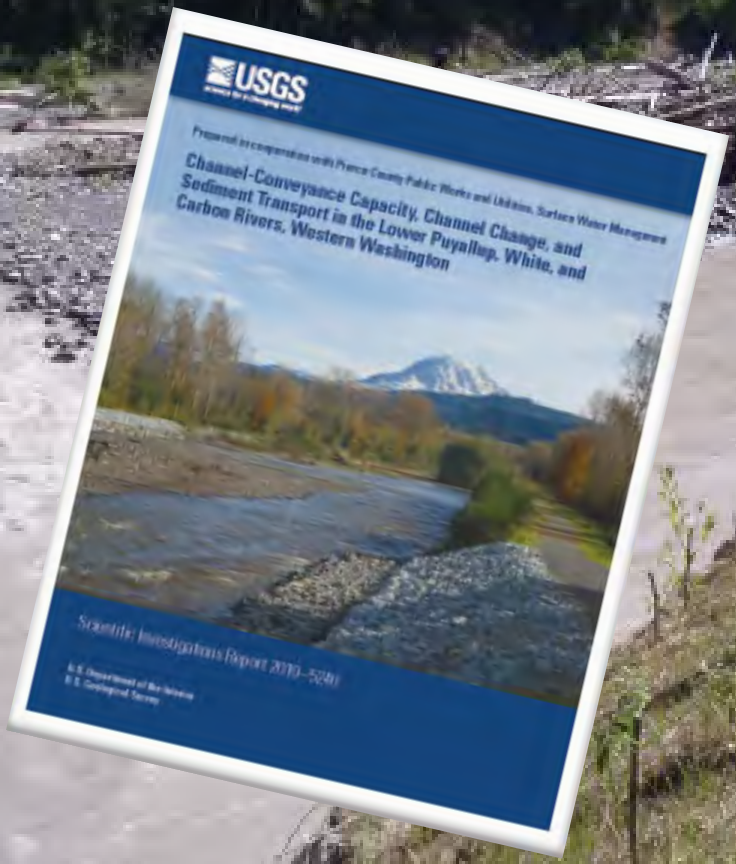
What we know: Summary of Phase I

Czuba, J.A., Czuba, C.R., Magirl, C.S., and Voss, F.D. (2010) "Channel-Conveyance Capacity, Channel Change, and Sediment Transport in the Lower Puyallup, White, and Carbon Rivers, Western Washington," USGS Scientific Investigations Report 2010-5240, 104 p.

http://pubs.usgs.gov/sir/2010/5240/



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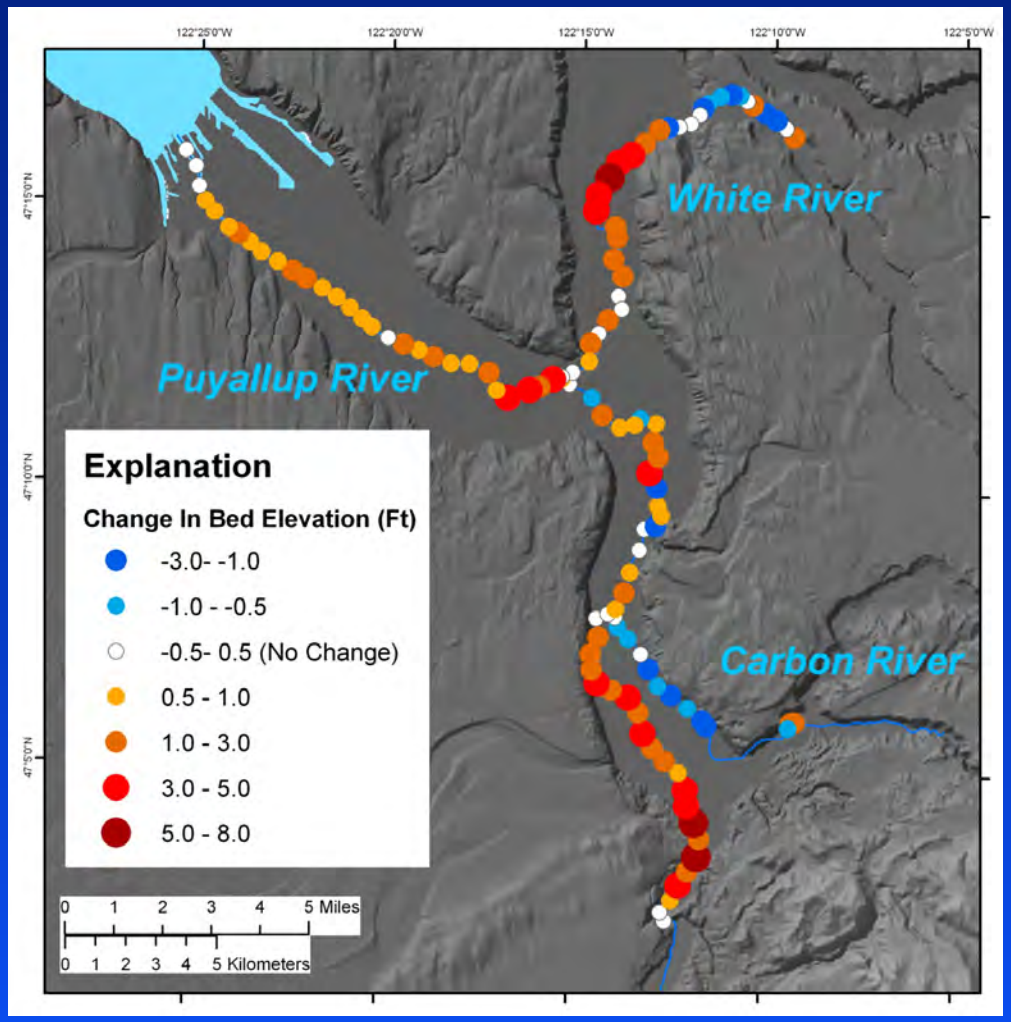
What we know: Summary of Phase I

Rivers in the Puget Lowland are filling with sediment.

(…with large rocks)



From Czuba et al. (2010)

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What we know: Mount Rainier National Park

- Rivers rapidly aggrading in the National Park.
- As much as 30 ft during the 20th century (Beason, 2007)
- Flooding in Nov 2006 caused $36 million in damage and closed the park for 6 months.

The Big Questions of Flood Control in Pierce County:

- How much sediment?
- When will it arrive?
- Where will the sediment accumulate?
- How can Pierce and King Counties effectively manage the sediment?

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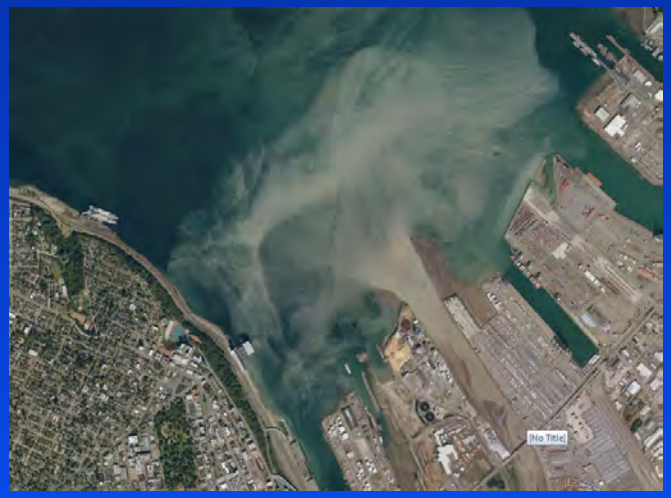
Phase II: Geomorphic response in rivers downstream from Mount Rainier

1. Sediment budgets
2. River conveyor belts (stream power)
3. Tools for predicting future trends



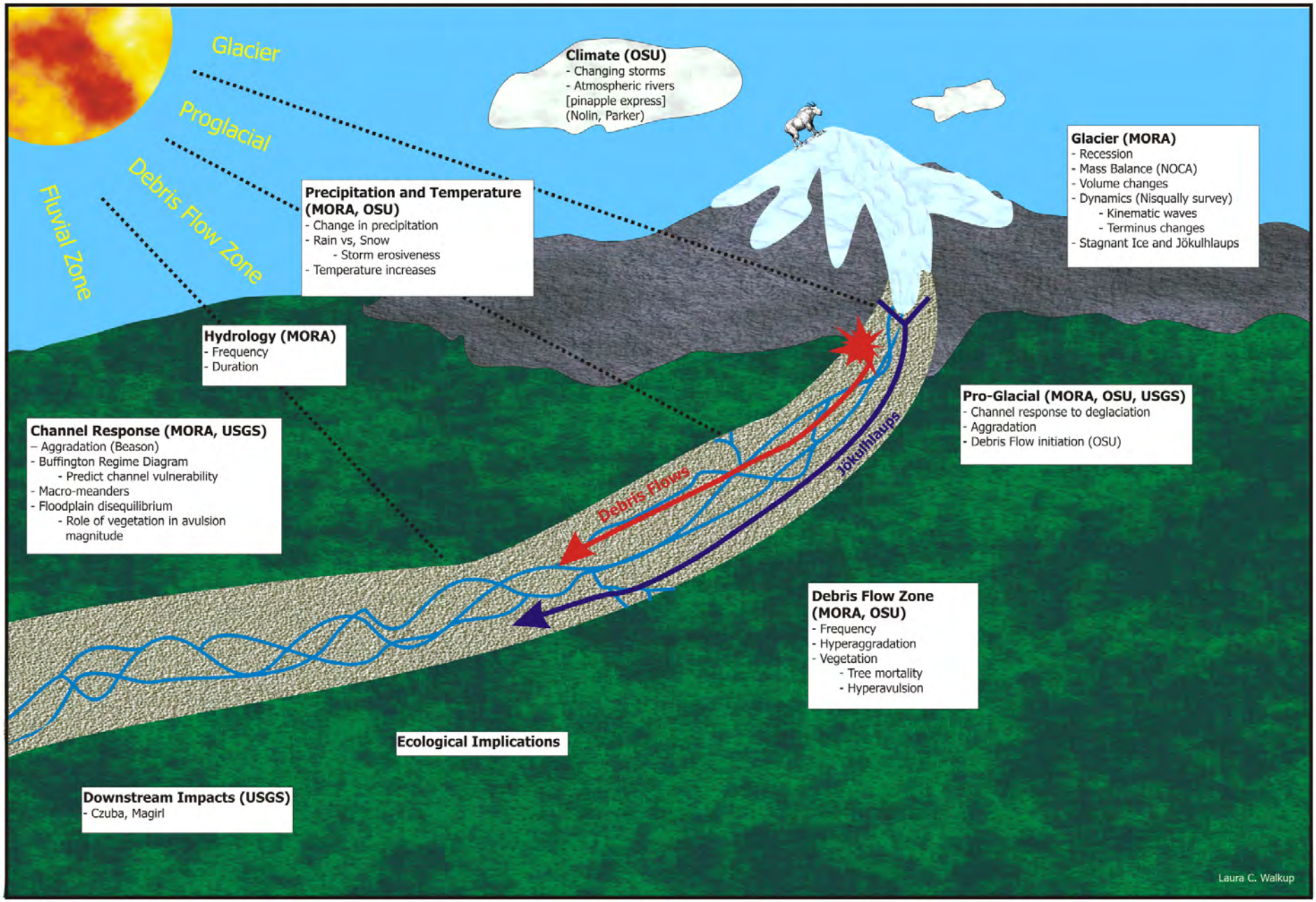
USGS

Cooperation and Collaboration

- Funding provided by Pierce County, King County, and the USGS Cooperative Water Program
- Project also greatly benefits from a close, collaborative relationship with Mount Rainier National Park, Oregon State University, and Cardno-Entrix

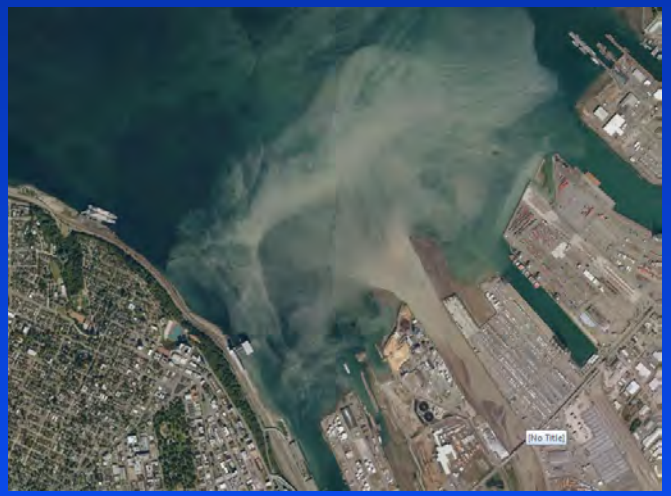
Goats to Geoducks: Research Plan

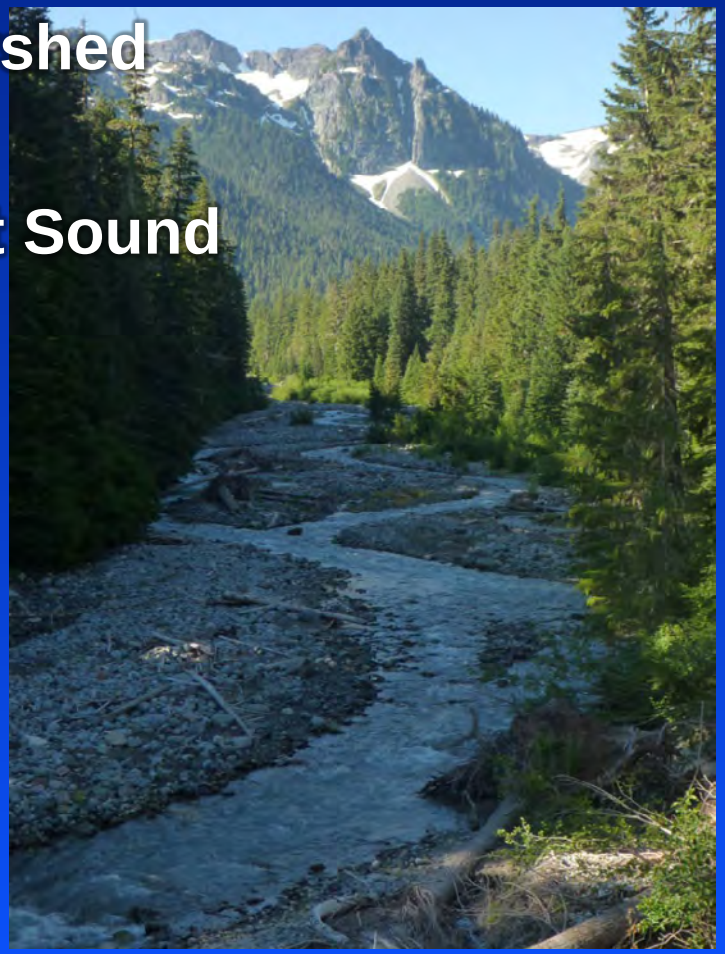
A Mount Rainier National Park, Oregon State University and United States Geological Survey Collaboration



Sediment Budget

- Accounting of the sources, movement, and deposition of sediment in a river network
  - Mt. Rainier volcano and watershed
  - River storage and transport
  - Deposition in lakes and Puget Sound





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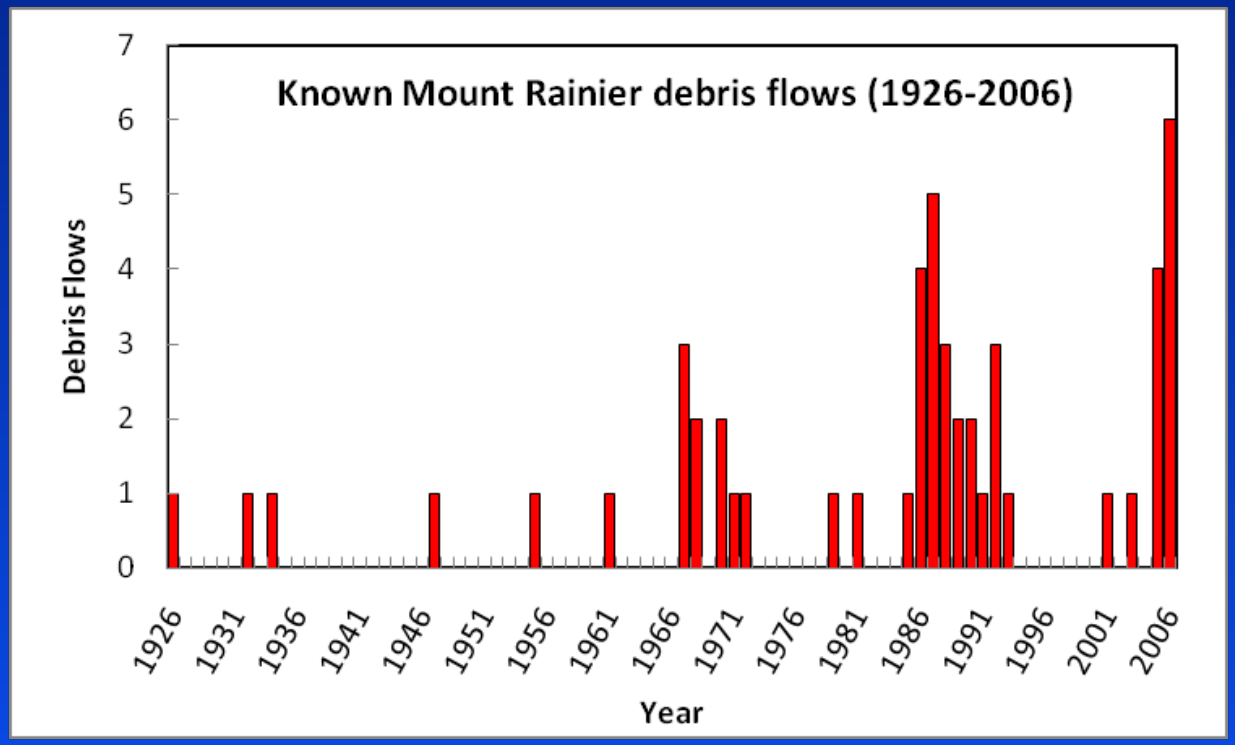
Sediment from Mt. Rainier

Debris-Flow Activity from Mount Rainier

- 51 *known* debris flows from recently de-glaciated regions of Mount Rainier
- Historical debris-flow record incomplete
- Debris flows are prodigious producers of sediment



From Copeland (2008)

USGS

2005 Debris flow at Christine Falls

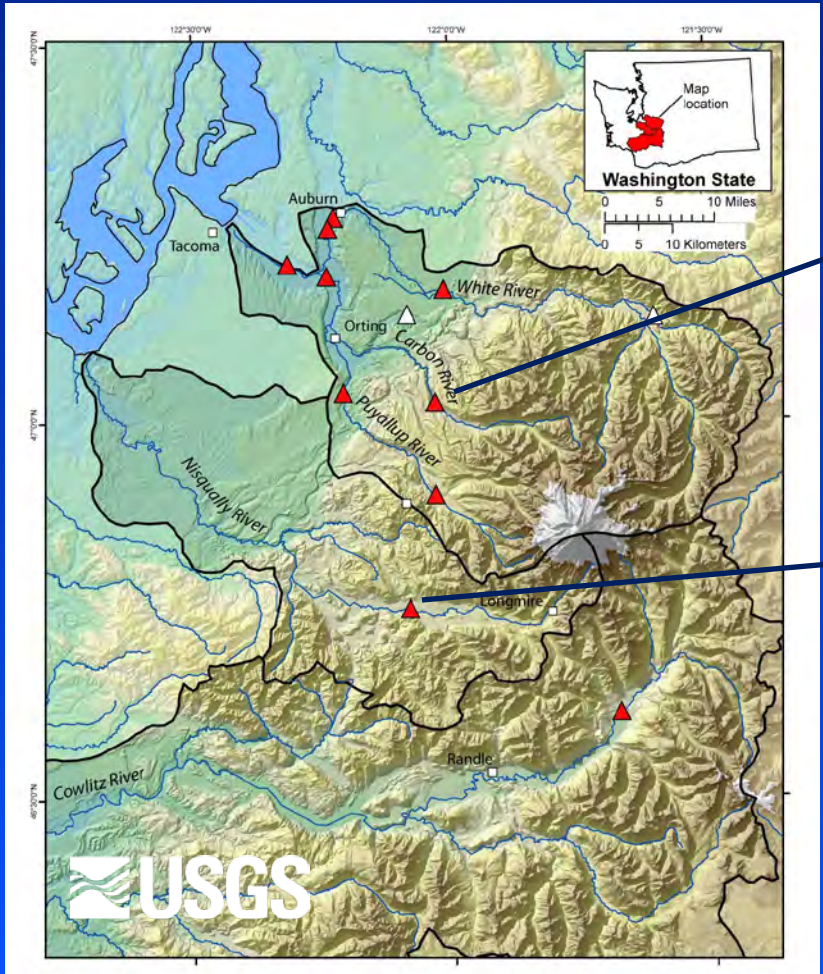
- Movie provided by Paul Kennard of the National Park Service
- Debris flows ~80% sediment by weight; consistency of cement; float boulders like fishing bobbers
- Dominant downstream sediment-transport mechanism

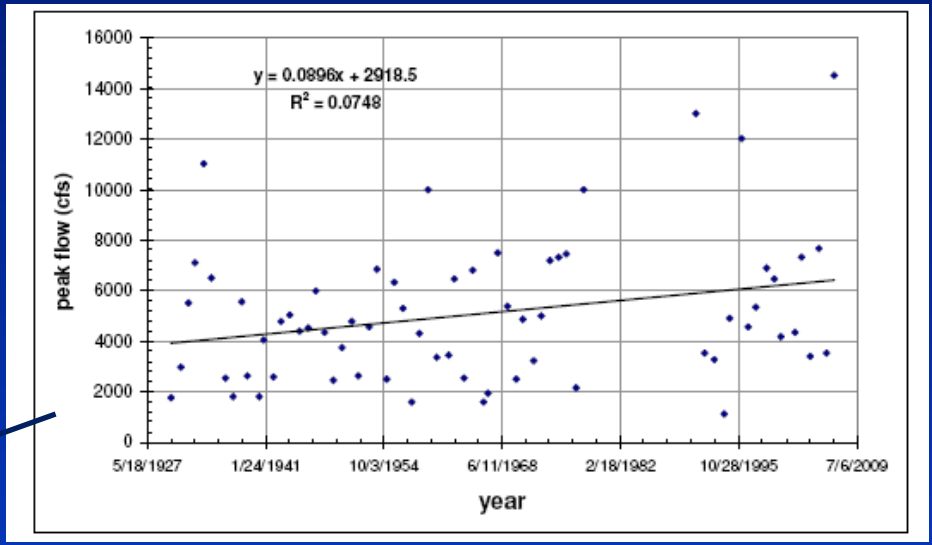
USGS

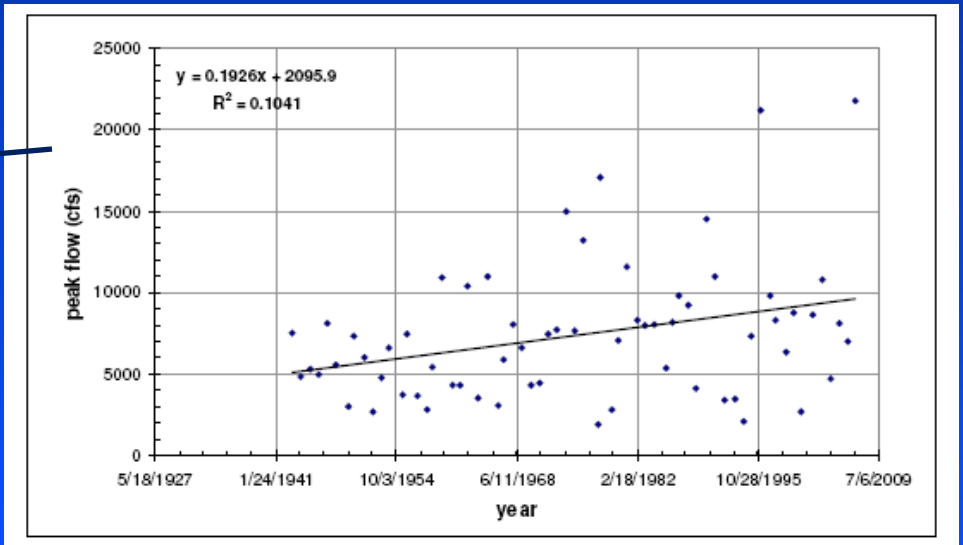
Movie available on YouTube: http://www.youtube.com/watch?v=SrYqJlCuppA&safety_mode=true&persist_safety_mode=1type "Mount Rainier debris flow"

Increasing peak flows?

Changing atmospheric conditions?
- Higher freezing levels and more rain
- Possibility of stronger winter storms

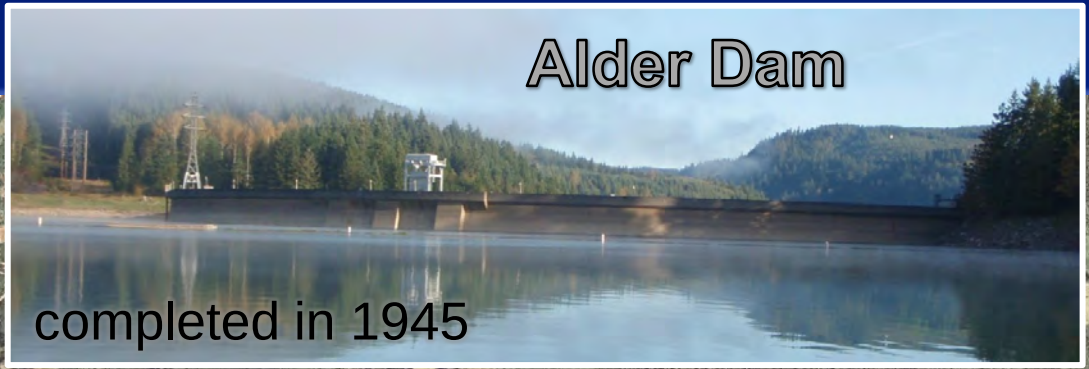


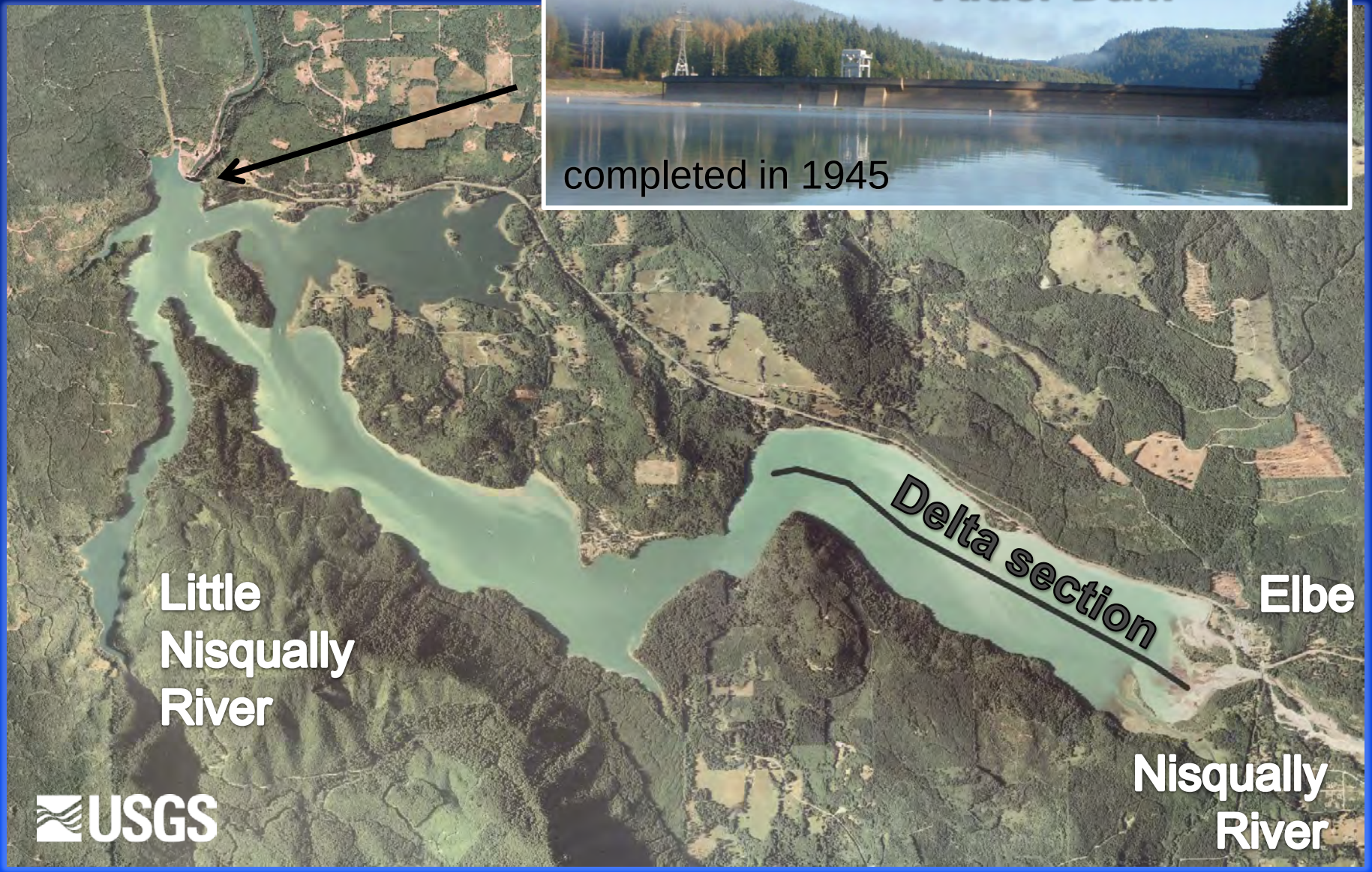




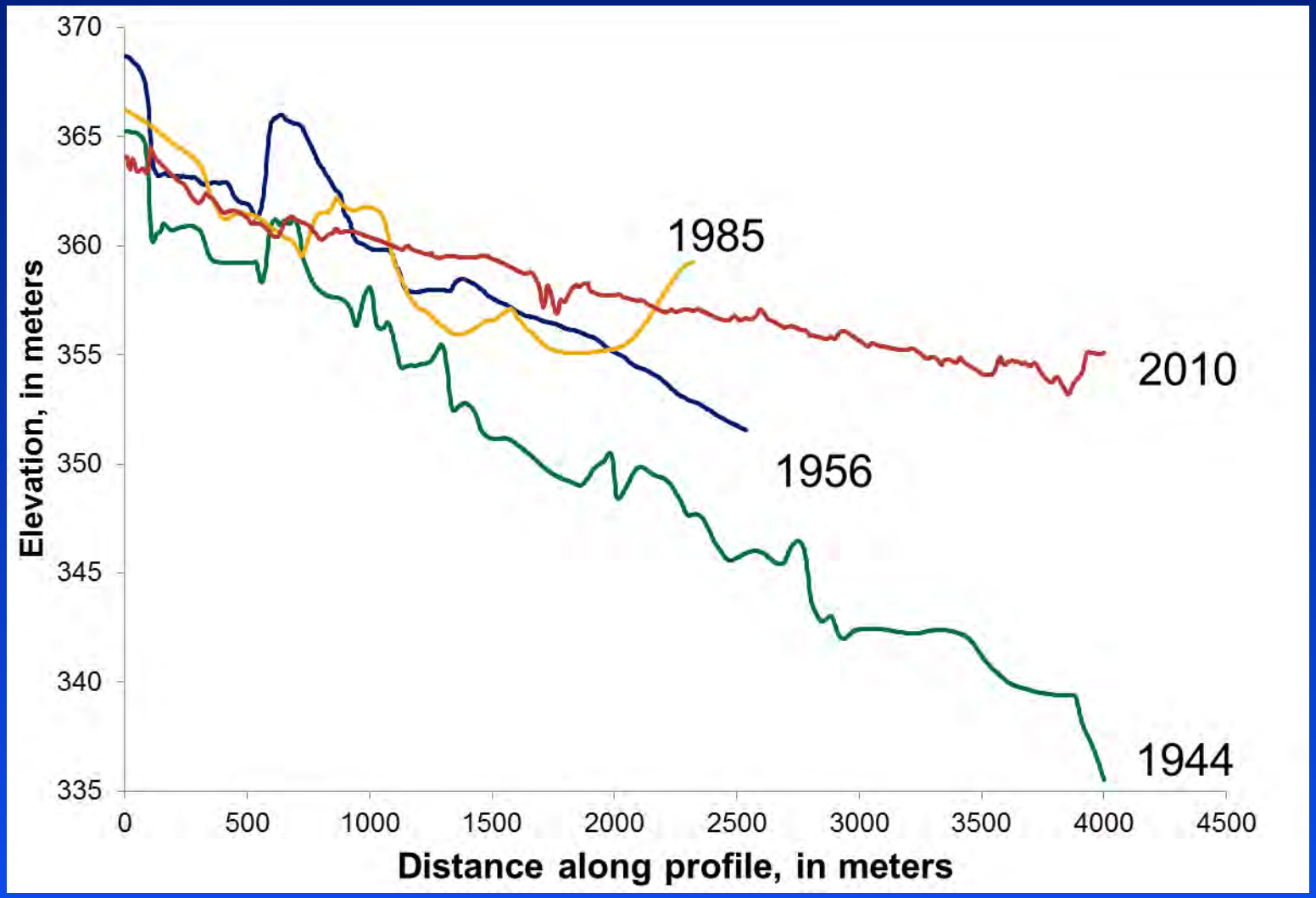
Preliminary results subject to change

Alder Lake


Alder Dam
completed in 1945


Little
Nisqually
River
Delta section
Elbe
Nisqually
River
USGS

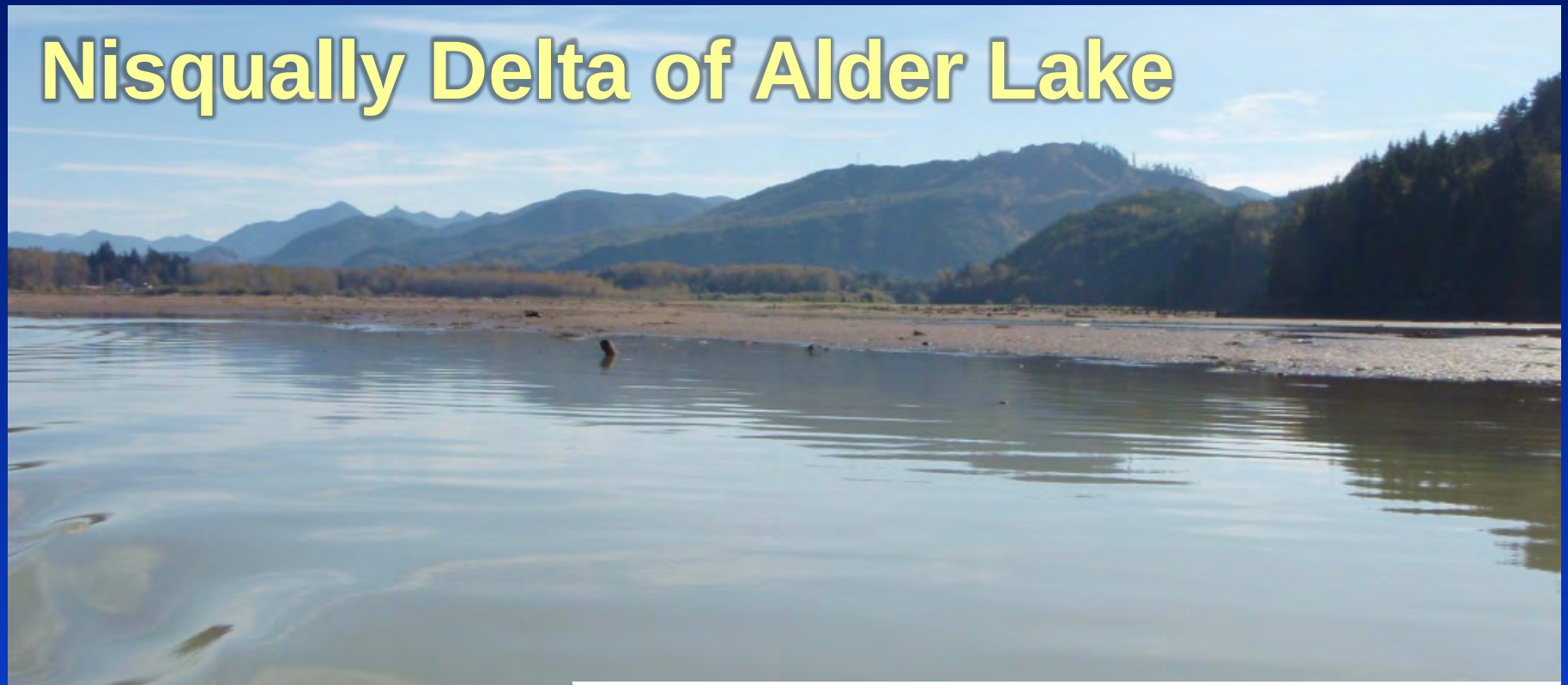
Nisqually Delta of Alder Lake



1944, 1956, and 1985 surveys provided by Tacoma Power

Preliminary results subject to change

Nisqually Delta of Alder Lake



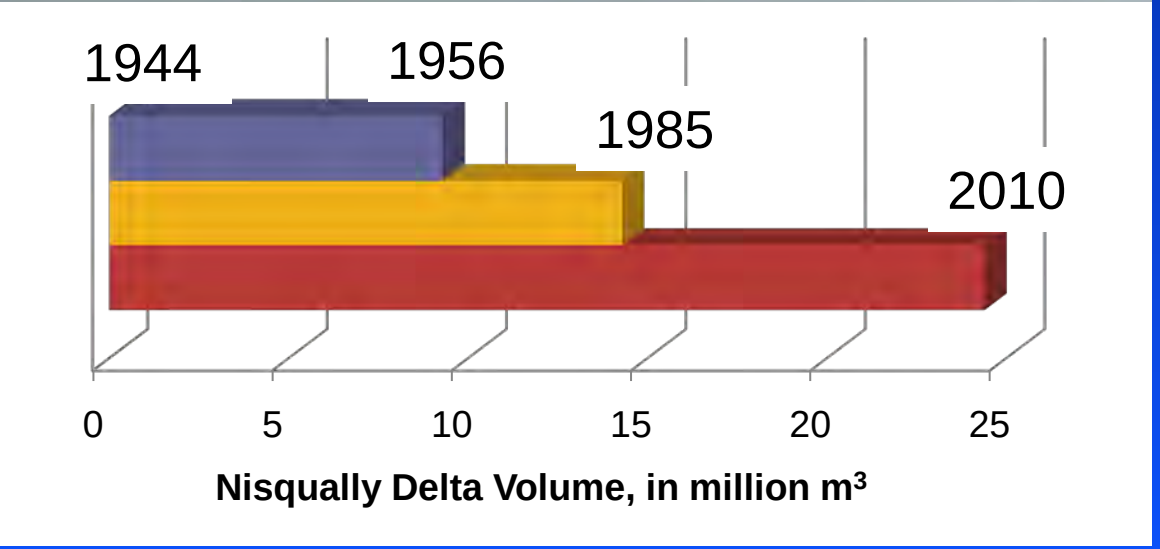
>1,160,000 tons/yr

>520,000 tons/yr

>550,000 tons/yr

Preliminary results subject to change

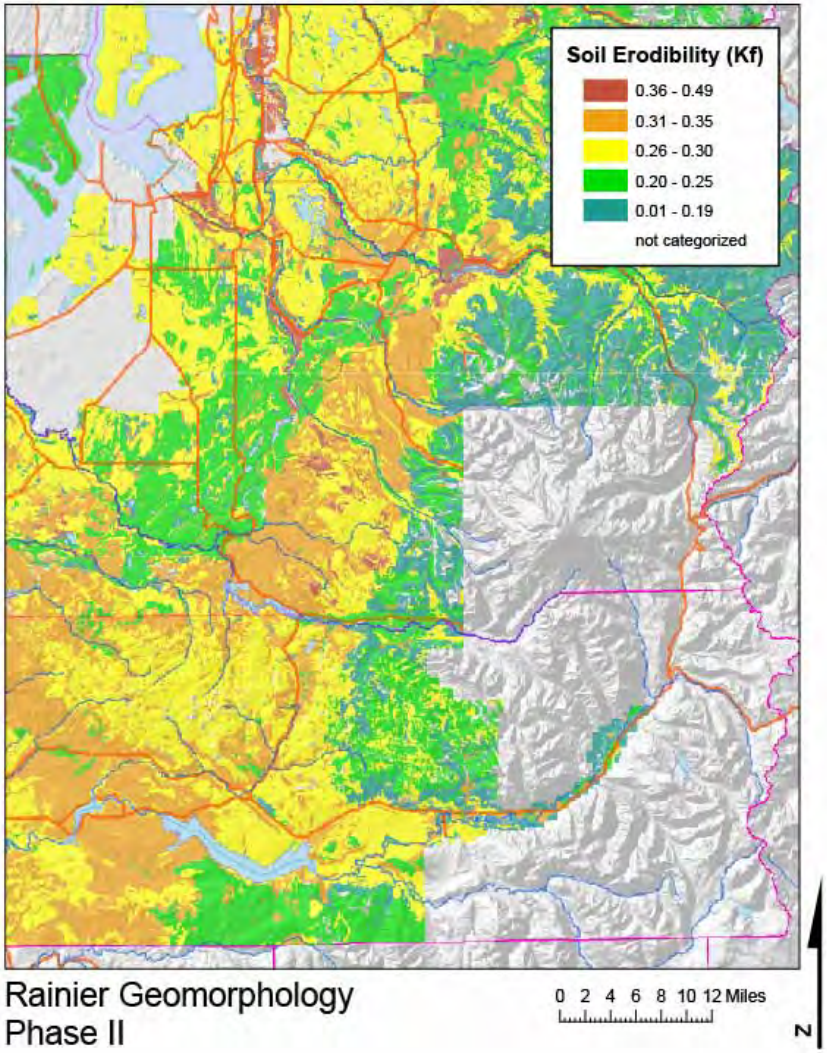
USGS



Watershed Sediment Budget

Estimate soil erosion loss from the drainage basin based on:

- Rainfall
- Soil
- Slope
- Land use
- Land practice



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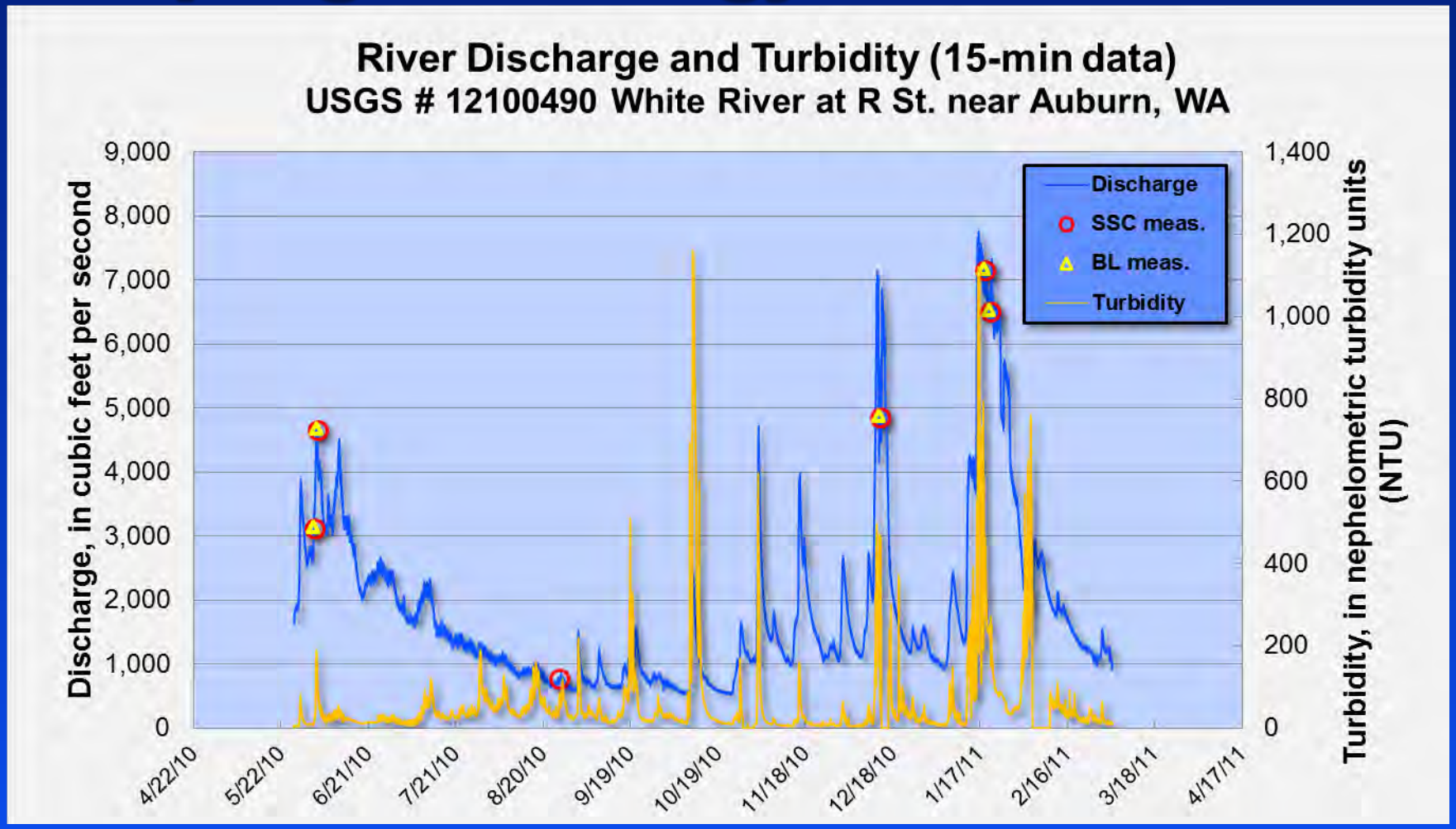
Preliminary results subject to change

White River Sediment Sampling

USGS

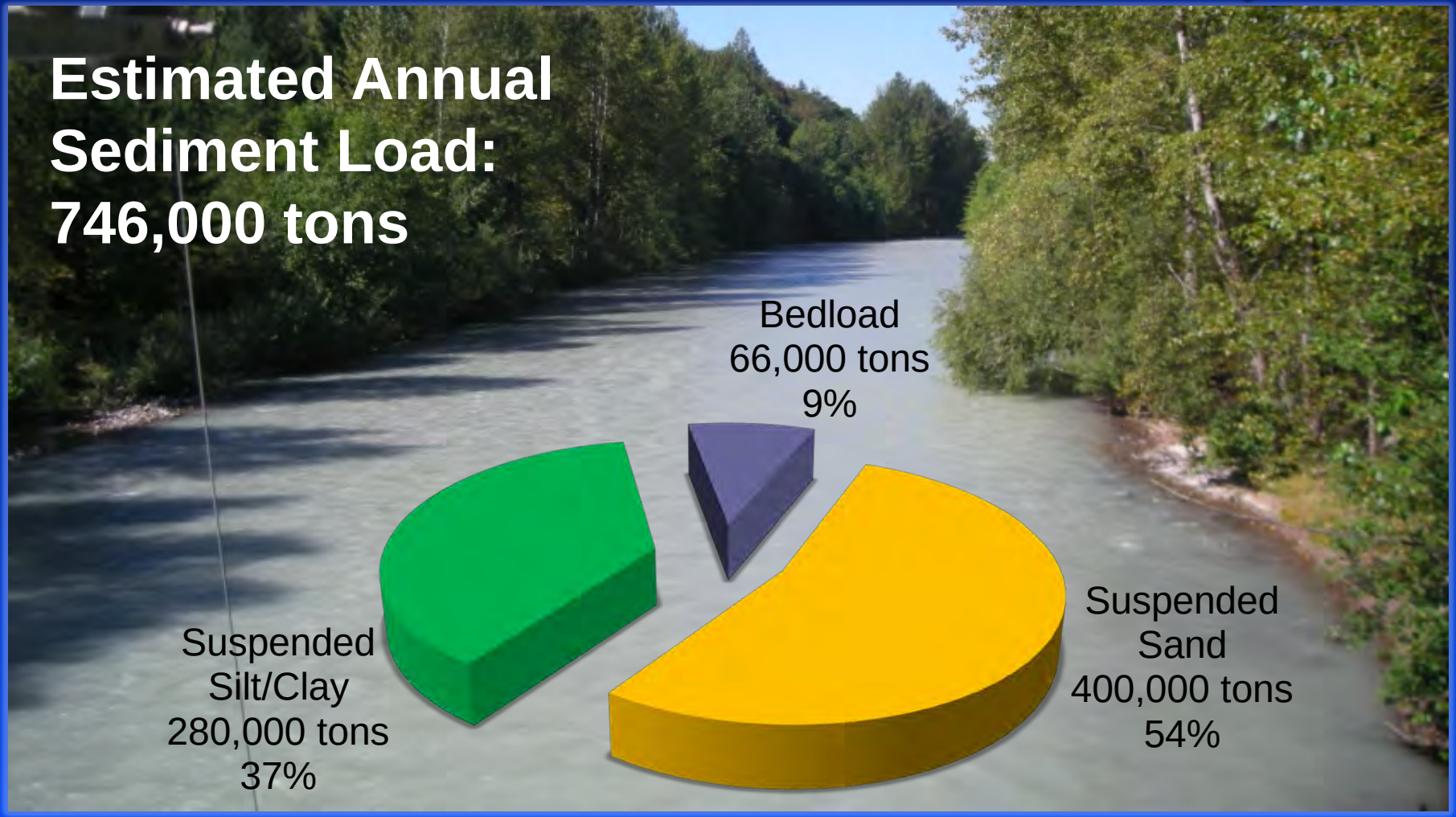
Testing the latest in sediment sampling technology



USGS

Preliminary results subject to change

Sediment Load:
White River at R St. near Auburn, WA



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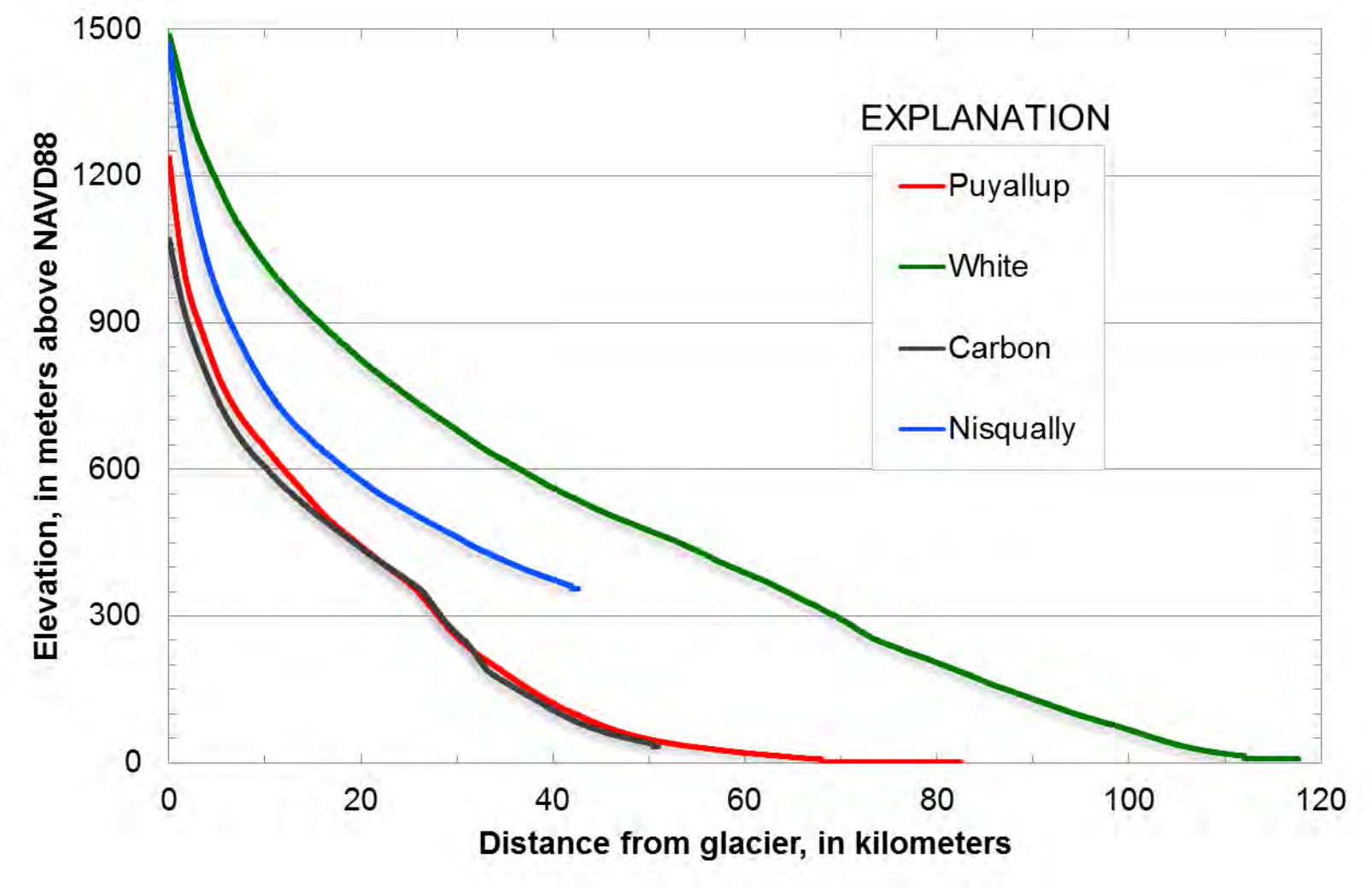
Preliminary results subject to change

Rivers as Conveyors of Sediment



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Gain insight into sediment transport by rivers

Preliminary results subject to change

Unit Stream Power: ω

- Rate of energy dissipation against bed and banks of river per unit width of river.

acceleration due to gravity

discharge

density of water

$$\omega = \frac{\rho\, g\, Q\, S}{B}$$

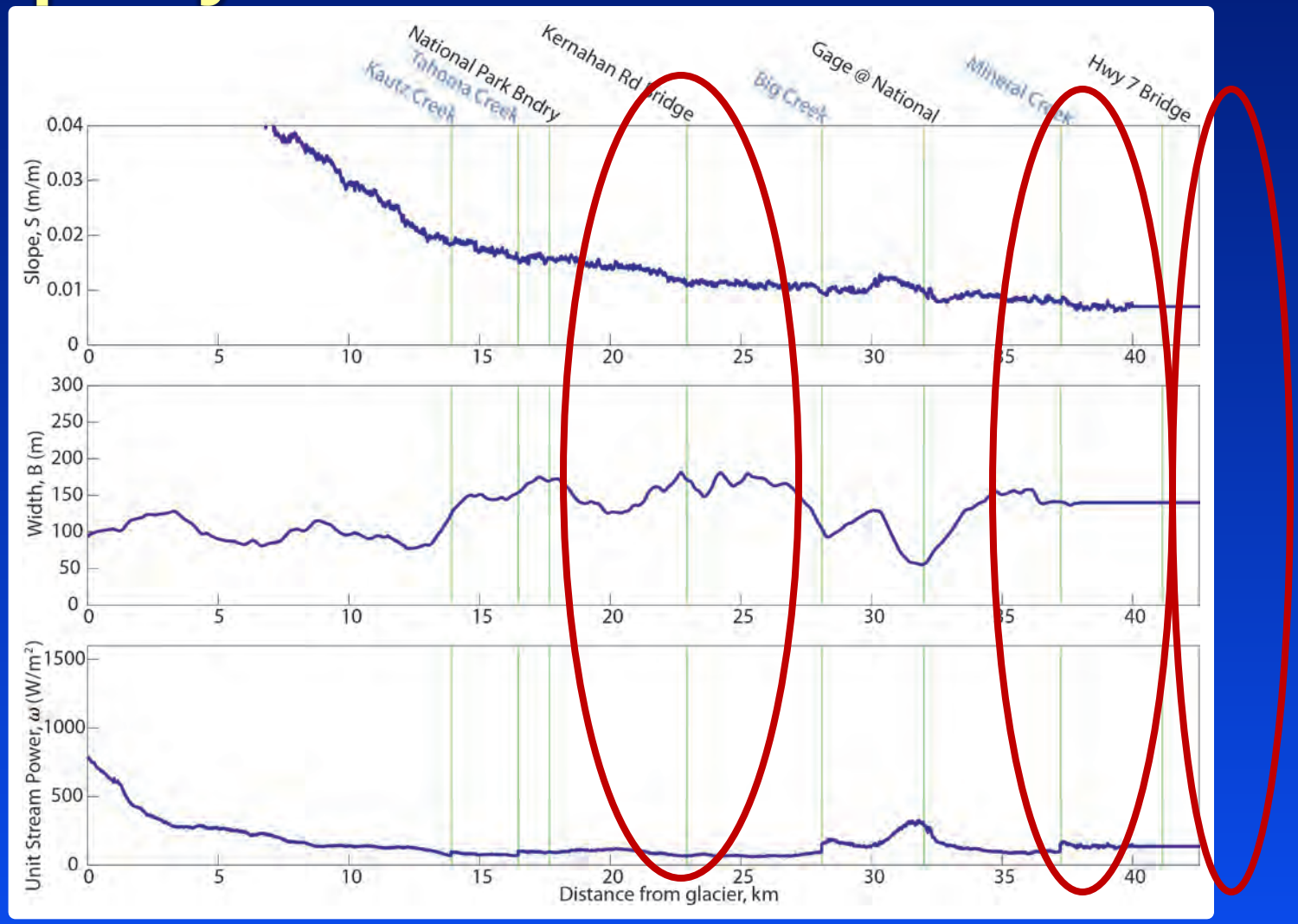
slope

Indicator of sediment-transport potential

width

USGS

Nisqually River



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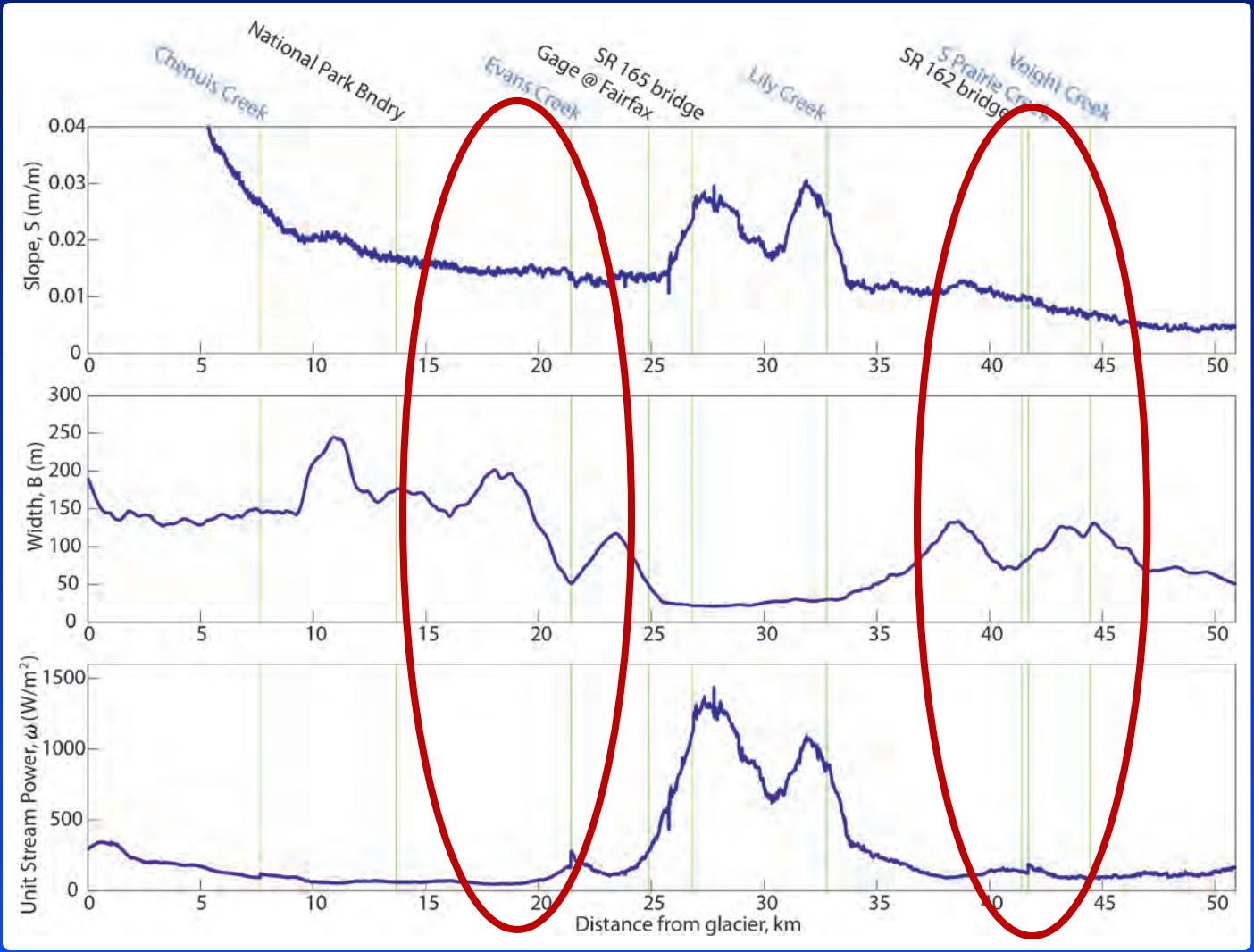
Preliminary results subject to change

Carbon River



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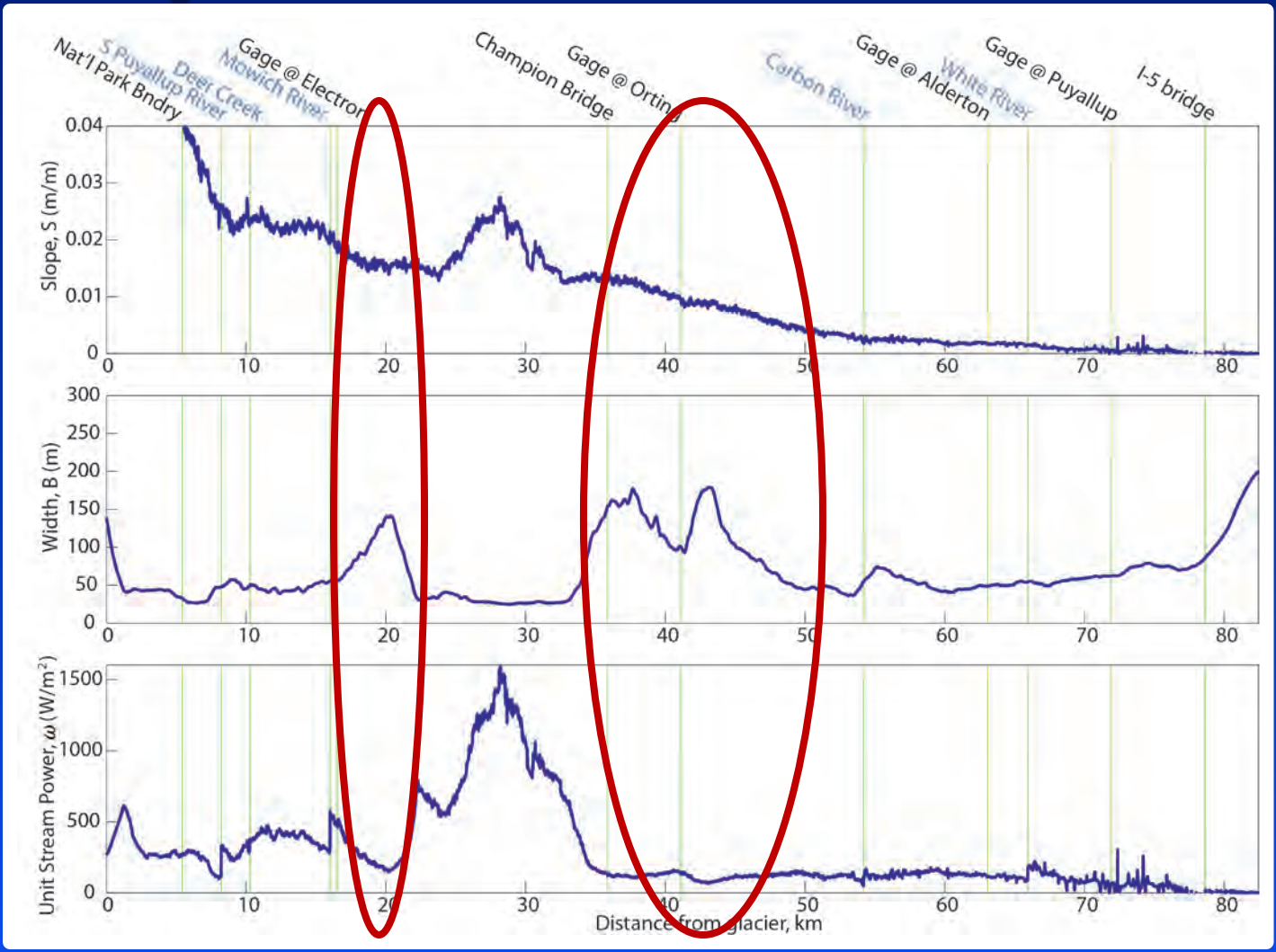
Preliminary results subject to change

Puyallup River



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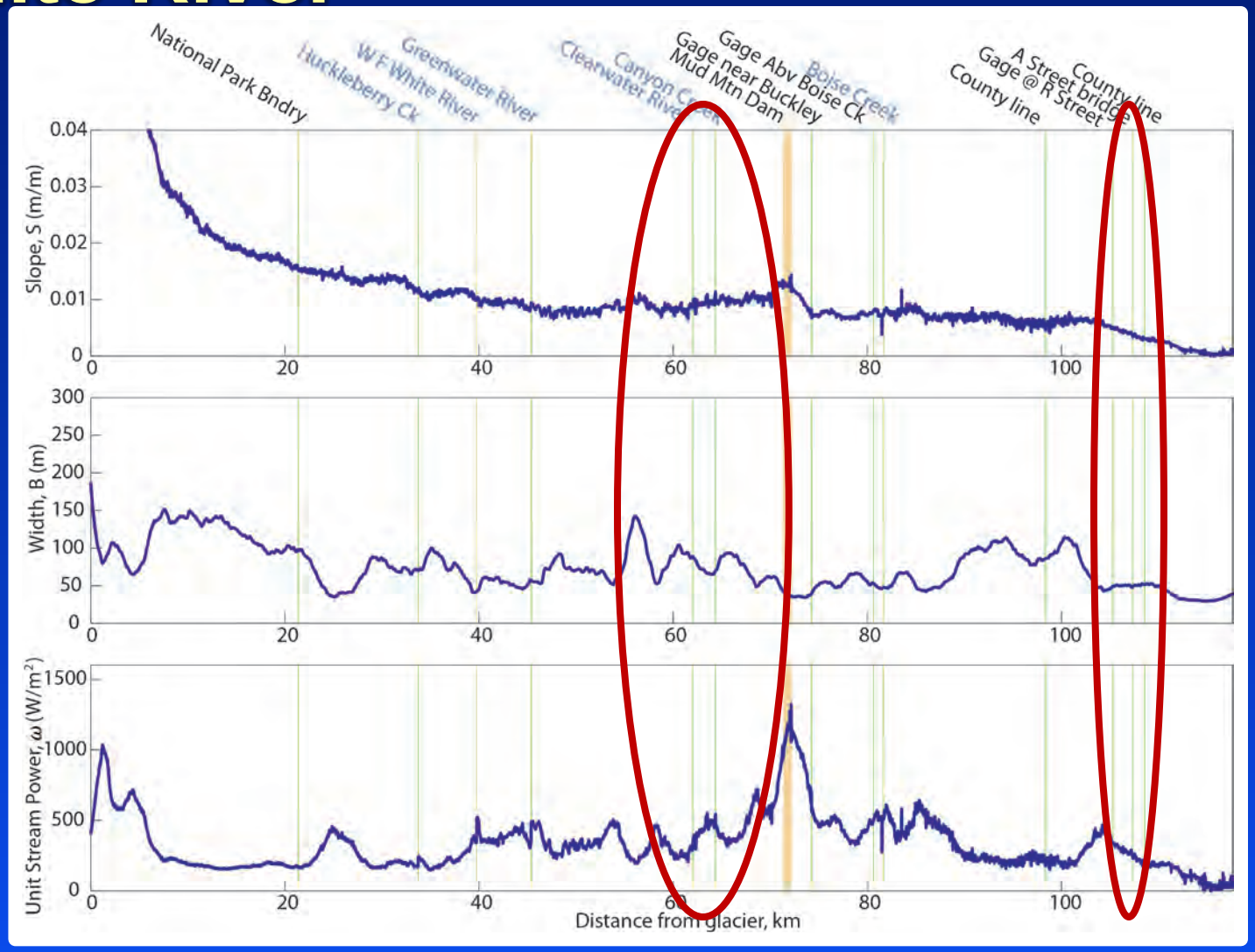
Preliminary results subject to change

White River



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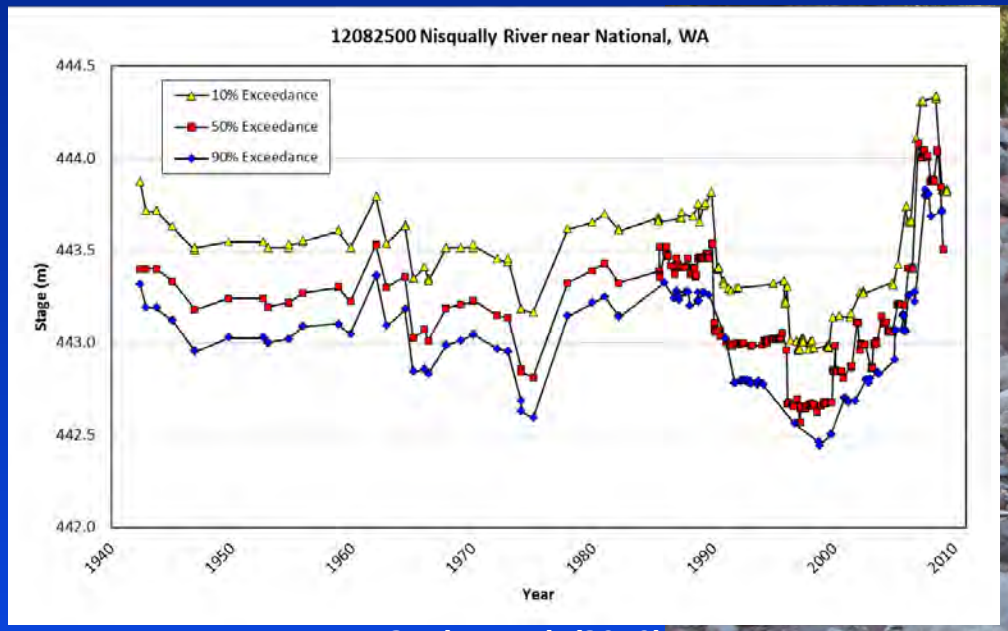
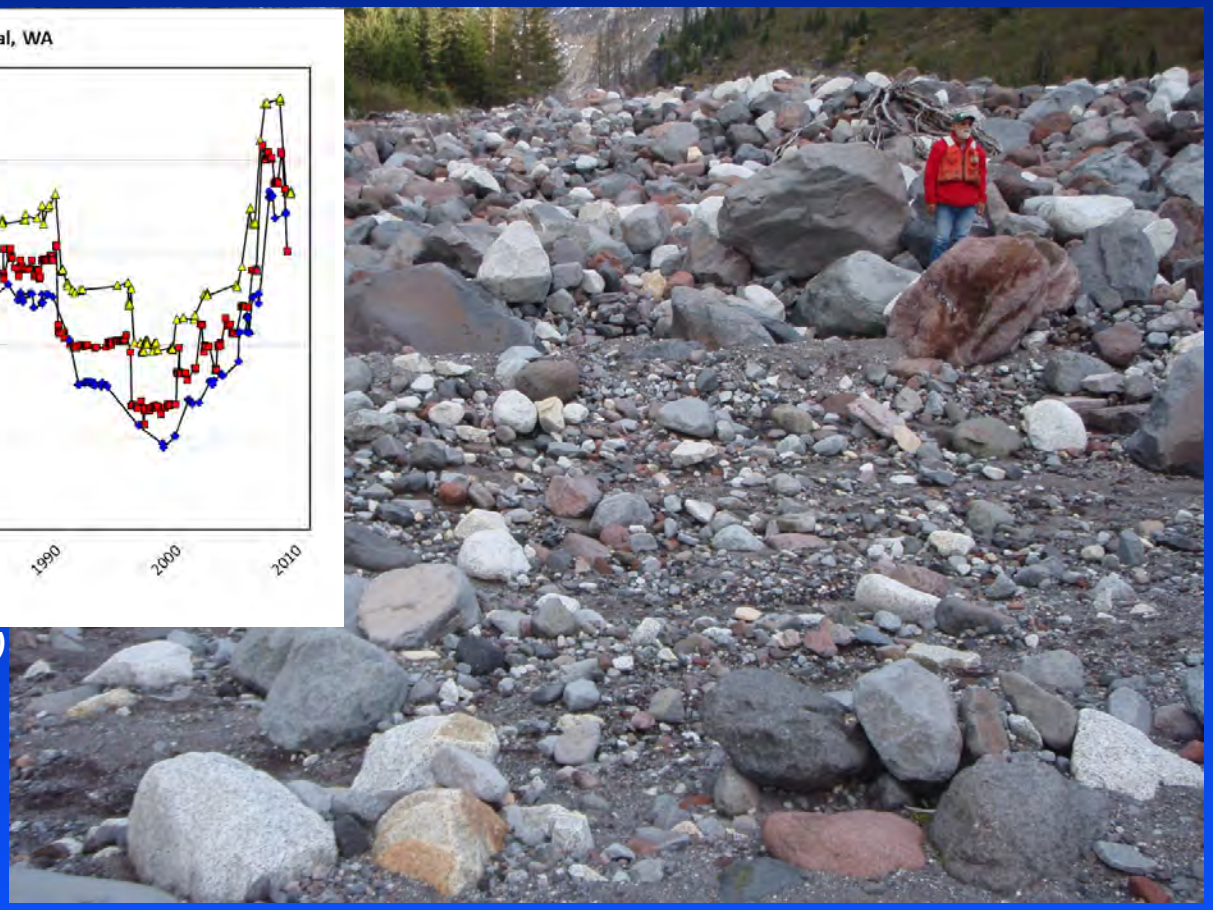
Preliminary results subject to change

1-D Sediment-Transport Modeling

- **Predict amount and timing of arrival of Mt. Rainier sediment**



From Czuba et al. (2010)



Based on Yantao Cui's *TUGS* model (Wilcock & Crowe, 2003)

USGS

How is this useful to managers?

- Increase sediment load
- Increase peak flows

- How long and how much sediment will arrive downstream?

USGS

Key Take-Aways So Far

- Nisqually River sediment load
  - ~1 million tons/yr
- White River sediment load
  - ~0.75 million tons/yr
- Over supply of sediment
- Identified reaches prone to sedimentation
  - Possible candidates for management

USGS

What's Next?

- These slides will be made available to the public by March 31, 2011
  - http://wa.water.usgs.gov/projects/puyallupseds/
- Draft report of final study by June 30, 2011
- Final report by December, 31, 2011

USGS

USGS Tacoma Seminar Series

Larry Schick

US Army Corps of Engineers – Seattle District

WA

"Atmospheric Rivers and their Impacts on Recent Historic Flood Events in Western Washington"

Wednesday, April 27 @ noon

Information and directions at:

http://wa.water.usgs.gov/seminar/seminar.html

USGS

Neiman et al. (in press)

Acknowledgments

- Paul Kennard, Scott Beason, Laura Walkup (National Park Service)
- Gordon Grant, Anne Nolin, Beth Copeland (Oregon State University)
- Sarah Henneford (USGS)

Questions?