

Sediment monitoring and modeling of the Elwha River in preparation for dam removal

Christopher Konrad
USGS Washington Water Science Center
<http://wa.water.usgs.gov>
Tacoma, WA

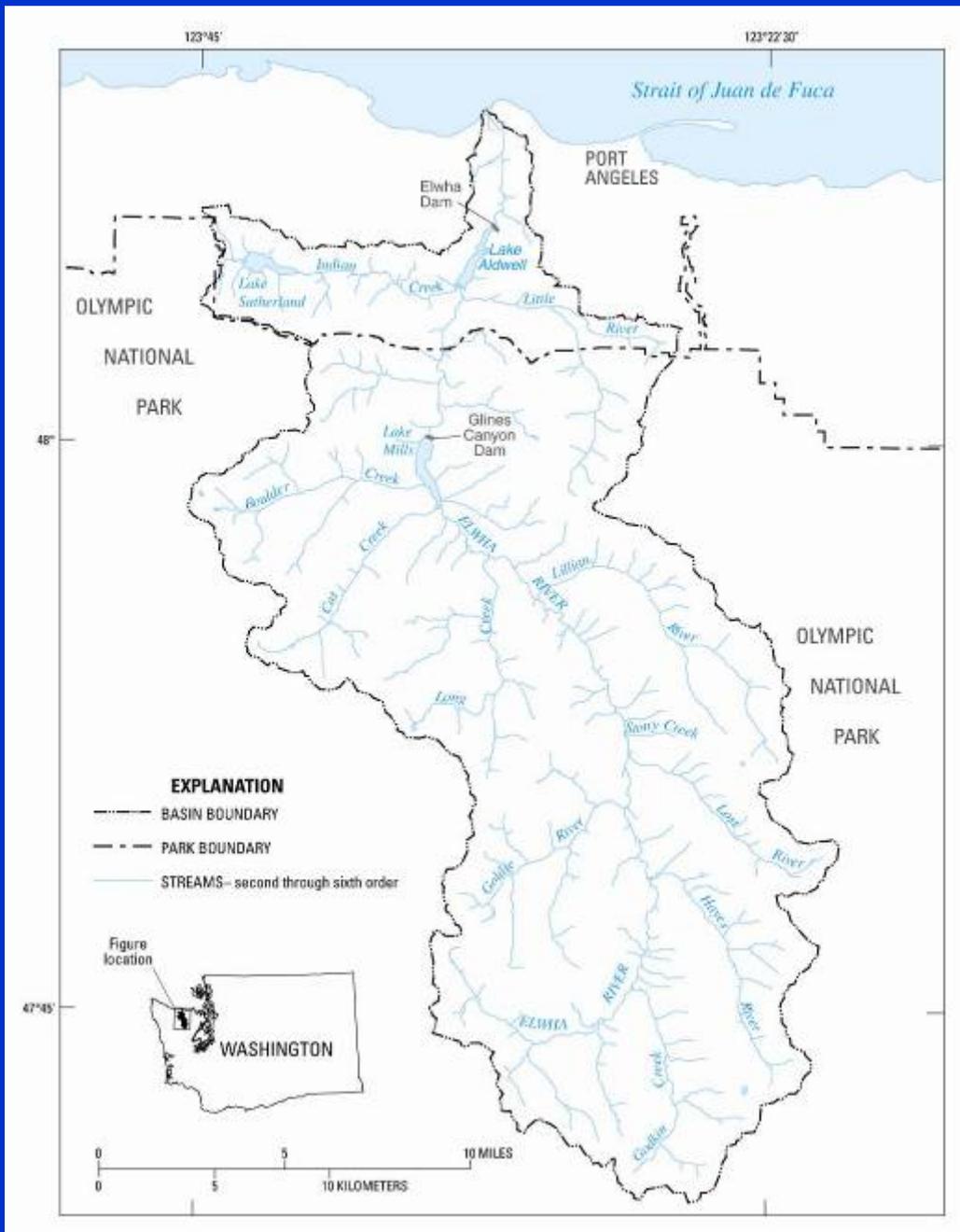
*Washington Hydrologic Society Meeting
January 19, 2005*

Elwha River Restoration Project



U.S. Department of the Interior is planning to remove two dams from the Elwha River beginning in 2008.

Photograph courtesy of the National Park Service



Elwha River
 Drainage area
 ~800 km²

Relief
 ~2000 m

Average basin
 gradient
 ~4 percent

Lake Mills deposits

$\sim 10 \times 10^6 \text{ m}^3$, 50% is coarse material (sand, gravel, cobble) forming a delta with finer-grained lake bed deposits

Lake Aldwell deposits

$\sim 3 \times 10^6 \text{ m}^3$, 30% is coarse material forming a delta with finer-grained lake bed deposits

Sediment load above Lake Mills

- Bed load $\sim 2 \times 10^8 \text{ kg/yr}$ ($0.2 \times 10^6 \text{ m}^3/\text{yr}$) calculated from Lake Mills delta
- Suspended $\sim 3 \times 10^8 \text{ kg/yr}$ ($0.3 \times 10^6 \text{ m}^3/\text{yr}$) based on records for WY 1995-97
- Approximately 95 percent of suspended load is transported in less than 25 days per year



Photograph courtesy of US
Bureau of Reclamation

Sediment Issues Related to Dam Removal

Erosion of the reservoir deltas and lake bed deposits will impact:

- Water quality for water supply and lotic and near-shore ecosystem;
- Channel and near-shore morphology and aquatic habitat quality (channel network and bed material)
- Flood elevations

What will be the magnitude and duration of these impacts?



Photograph courtesy of J. Higgins



Photograph courtesy of J. Higgins



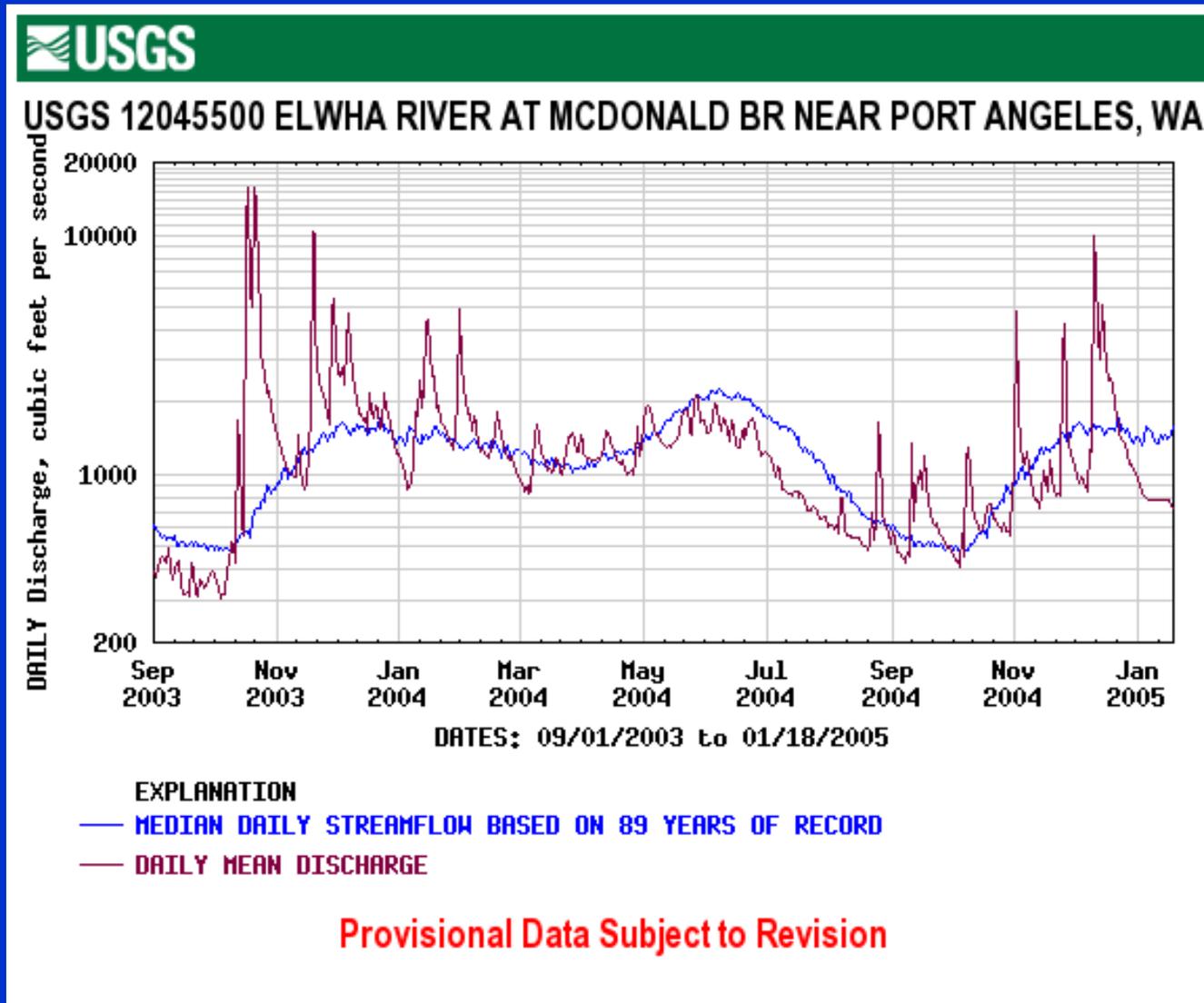








Bimodal hydrograph indicates runoff from rainfall and snowmelt



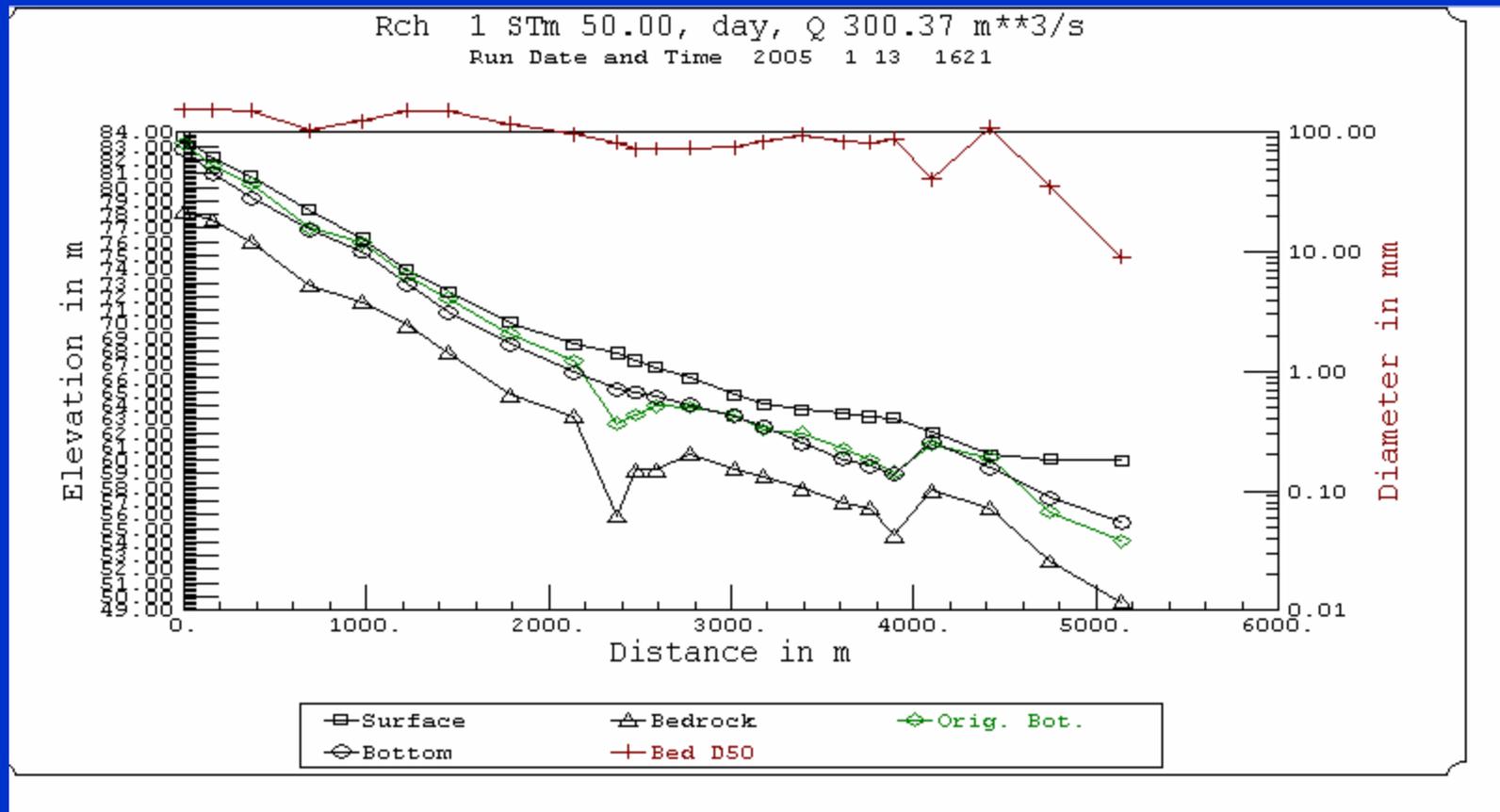
Sediment Transport Model

1-dimensional sediment transport model (Bennett, 2001) for the Elwha River is under development.

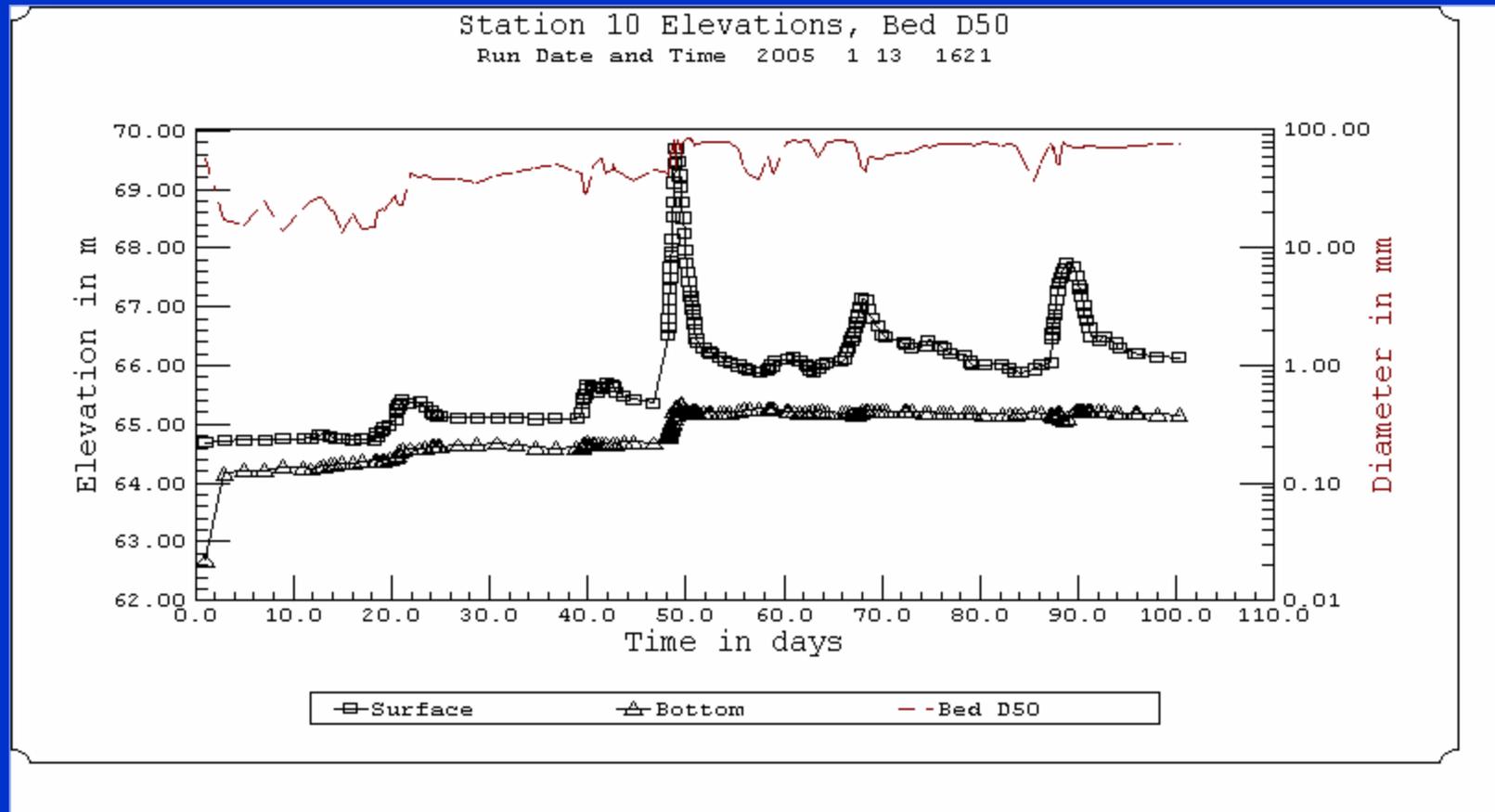
The model simulates:

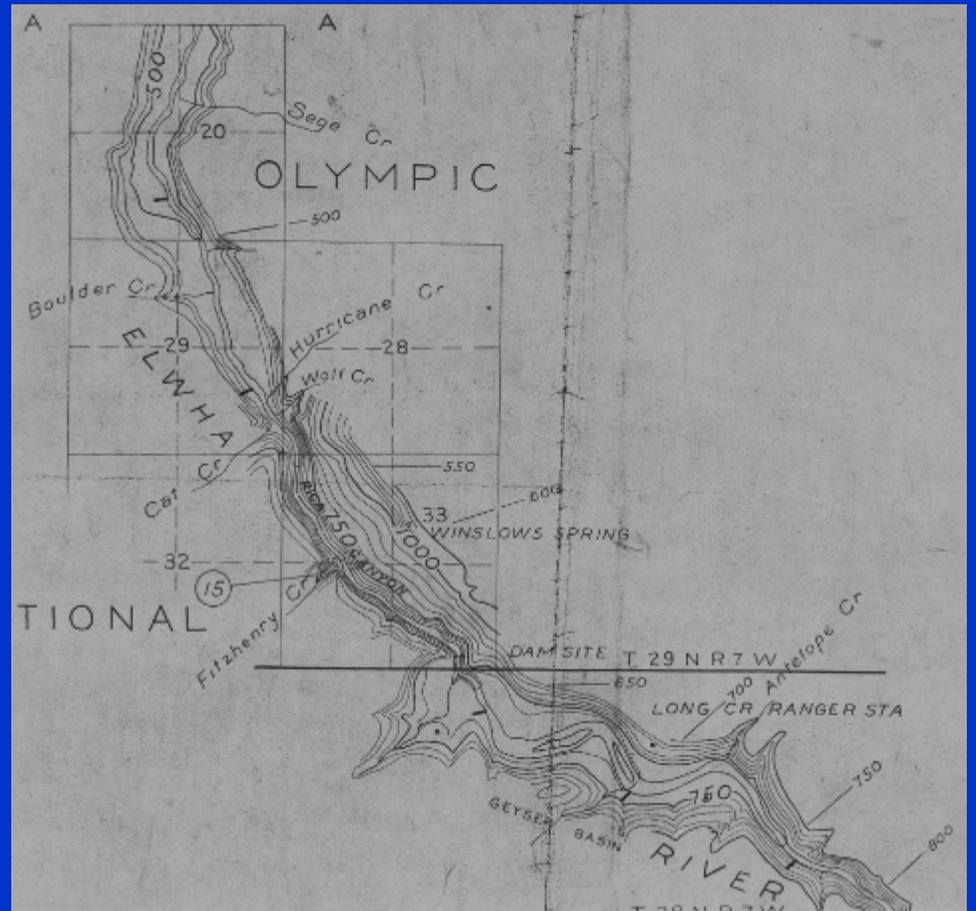
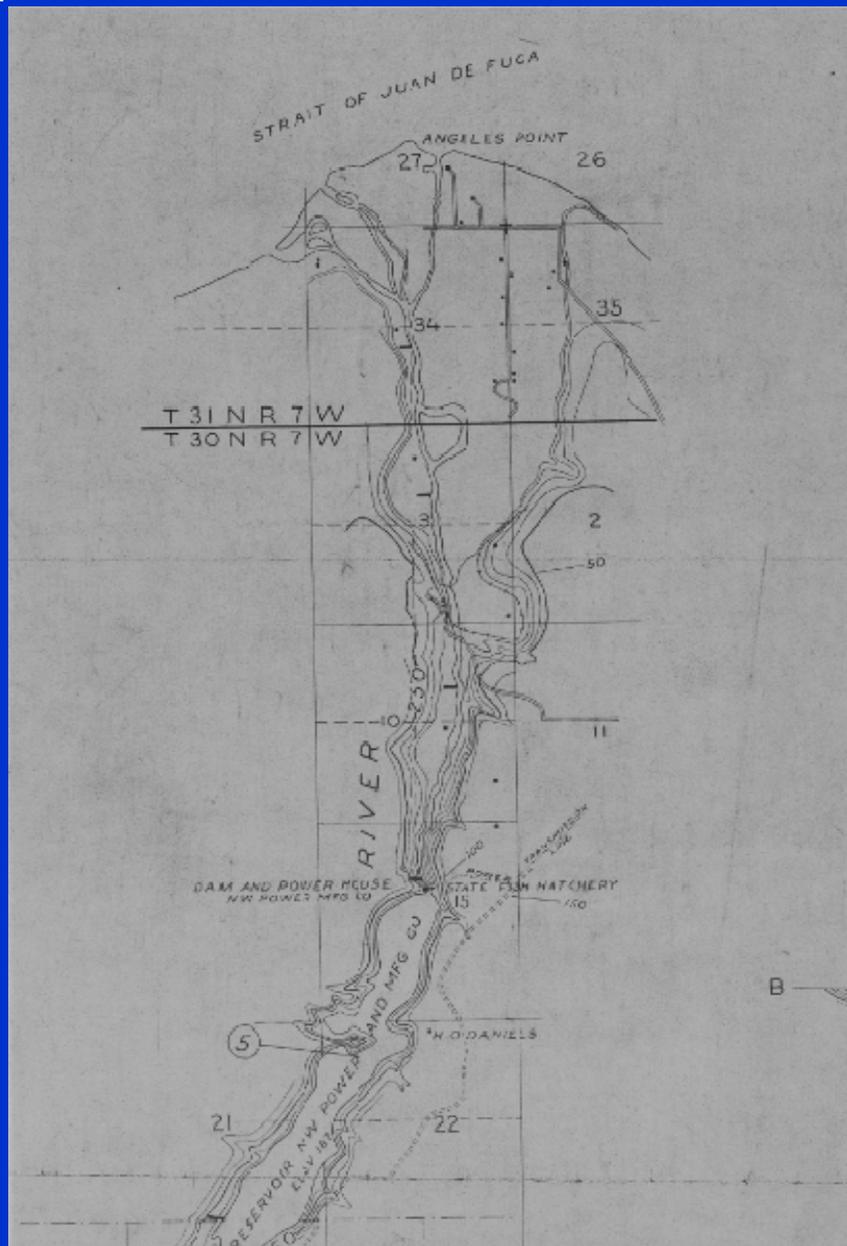
- 1-D hydraulics in channel networks (gradually-varied, steady flow in each time step)
- bed and suspended loads over time,
- vertical changes (deposition and scour) in bed, and
- changes in the particle-size distribution of the bed.

Model output: profile of bed and particle-size distribution



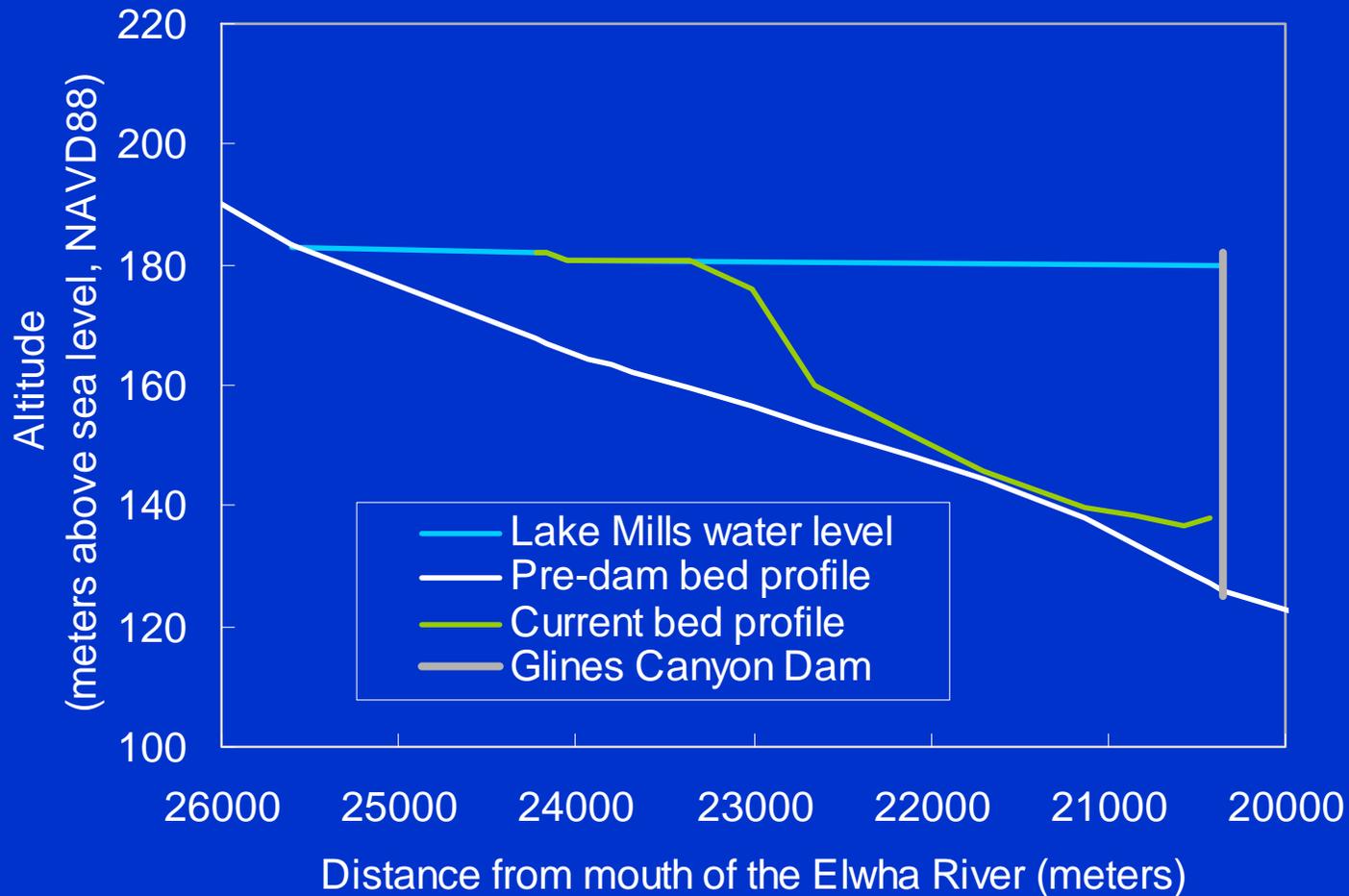
Model output: time-series of bed elevation and particle-size distribution





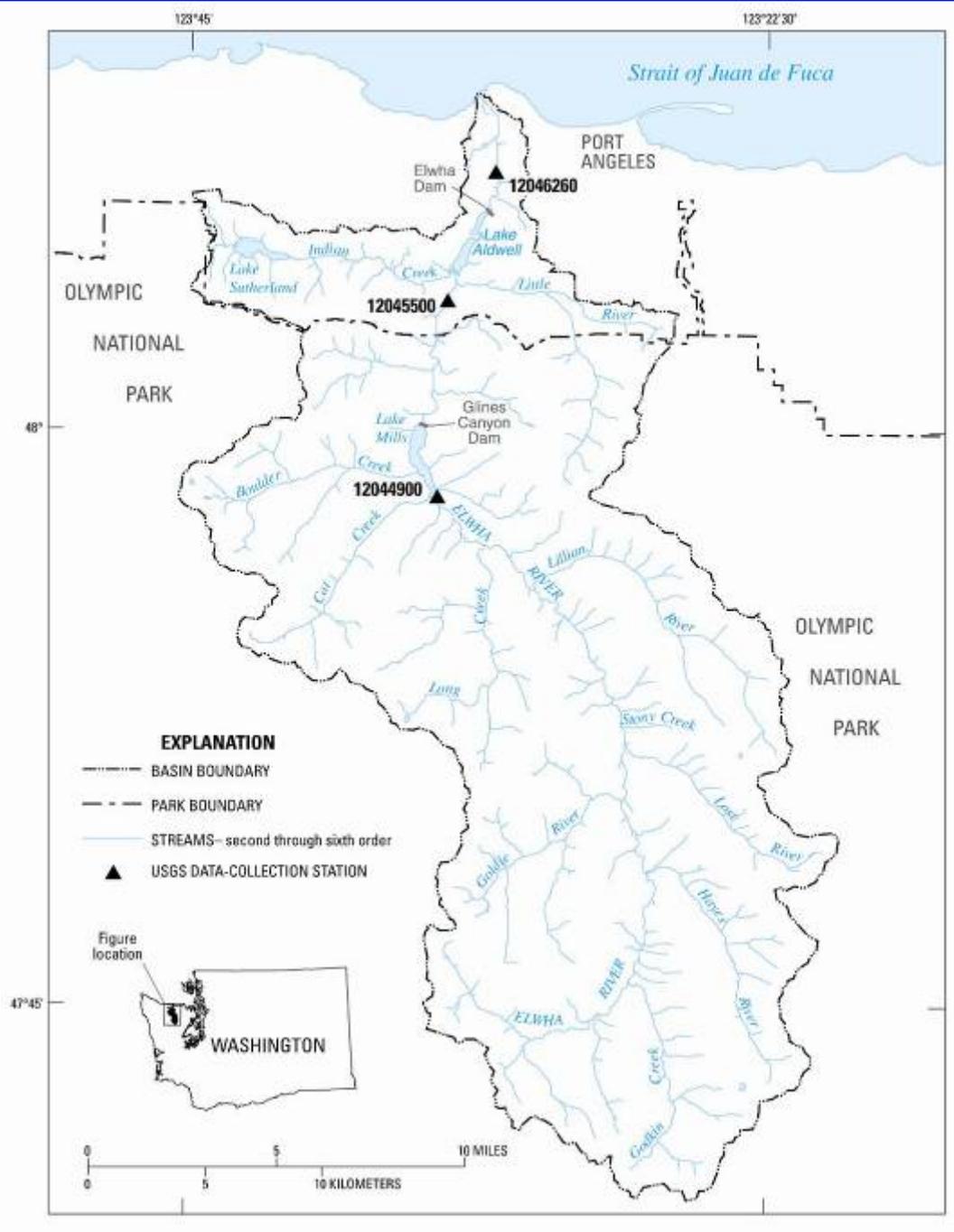
Maps from the 1926 Jones reconnaissance of the Elwha River

Estimating bed load from lake bathymetry



Elwha Fluvial Sediment Data

- Above Lake Mills: suspended sediment record for water years 1994 (partial record) to 1997; and numerous bed load samples collected from 1995-1998, but remain to be analyzed.
- McDonald bridge: suspended sediment record for April 1994 to September 1995; miscellaneous days in water year 1996.



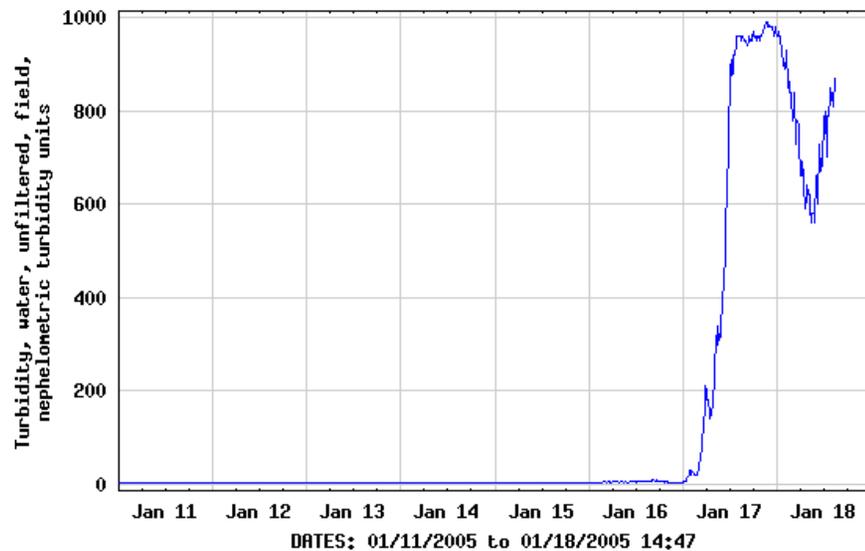
Three USGS hydrologic and sediment monitoring sites:

- 12046260, below Elwha Dam
- 12045500, McDonald Bridge
- 12044900, above Lake Mills

Real-time, continuous turbidity data from the Elwha River



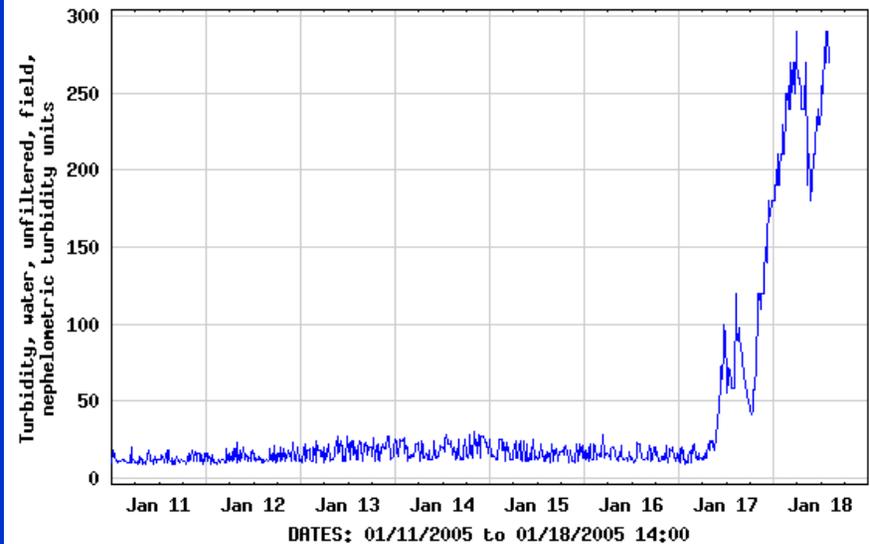
USGS 12044900 ELWHA RIVER ABOVE LAKE MILLS NR PORT ANGELES, WA



Provisional Data Subject to Revision

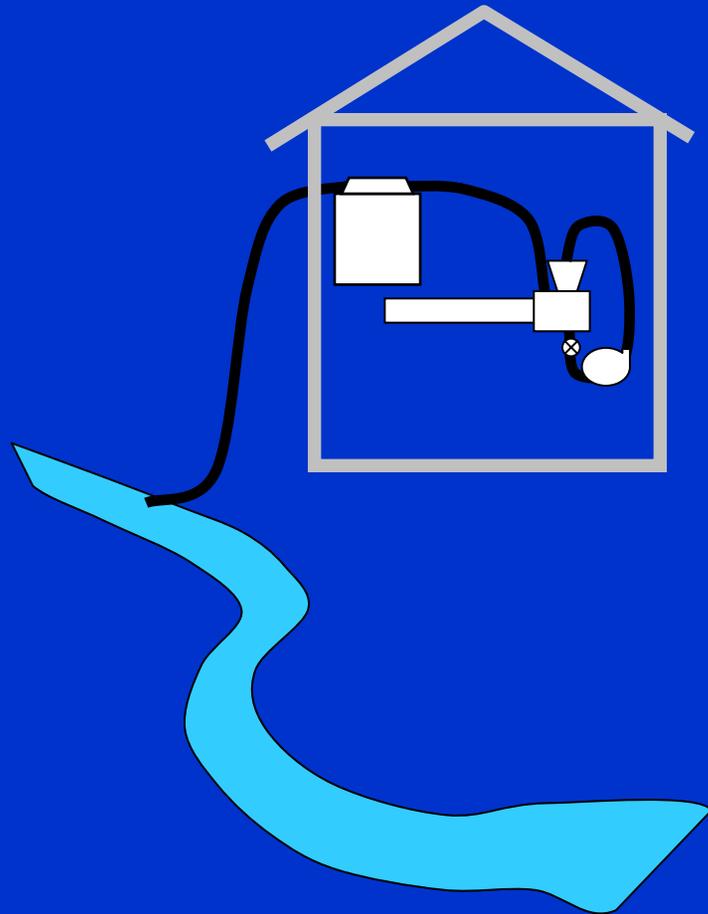


USGS 12045500 ELWHA RIVER AT MCDONALD BR NEAR PORT ANGELES, WA



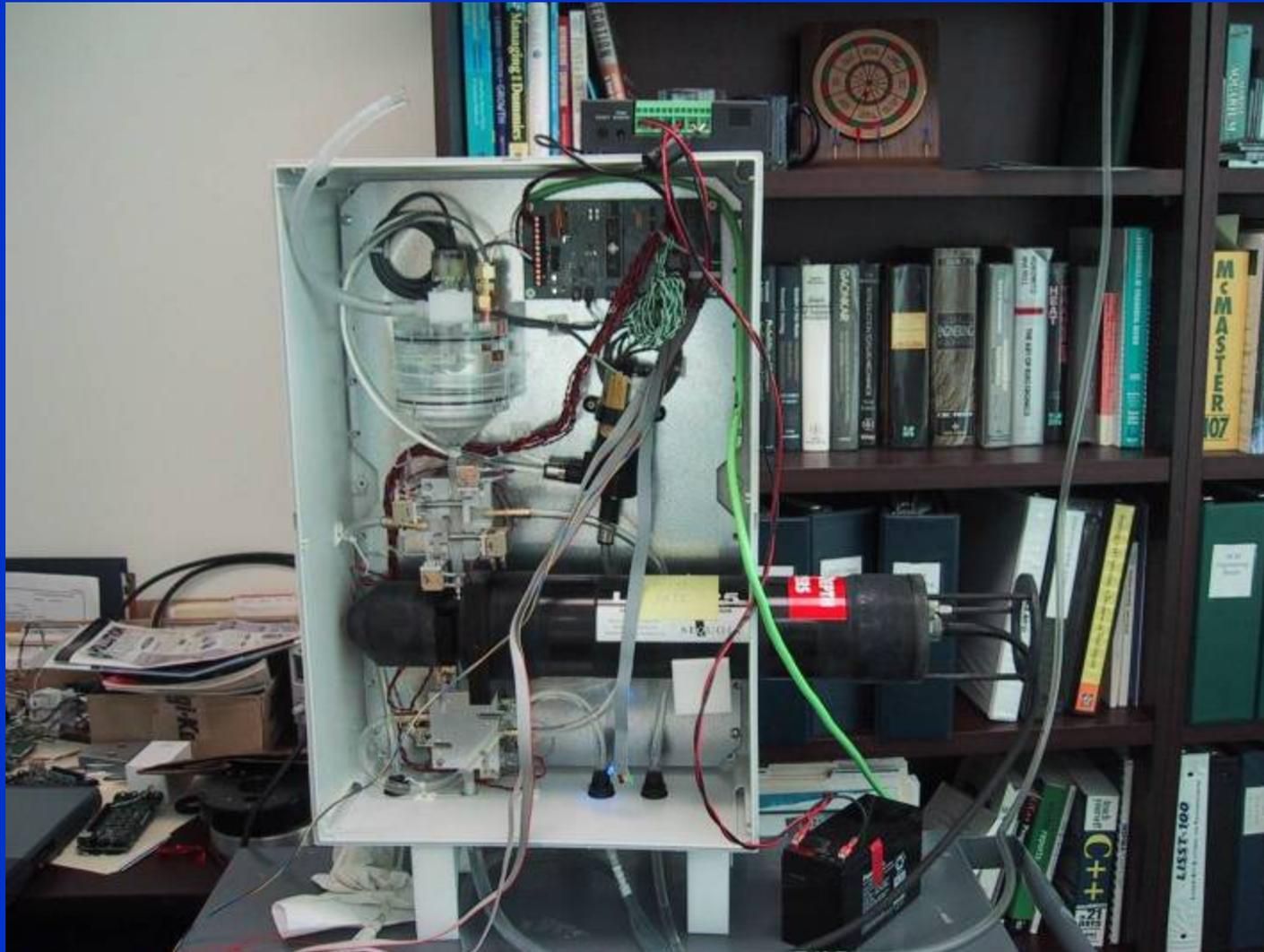
Provisional Data Subject to Revision

Development of new suspended sediment monitoring technology



GOAL: continuous, real-time analysis of sediment over an unlimited range of concentrations

LISST* - Infinite



* Use of a product name does not constitute an endorsement by the U.S. Geological Survey

**MIXING
CHAMBER**



**LASER
DIFFRACTION
CELL**



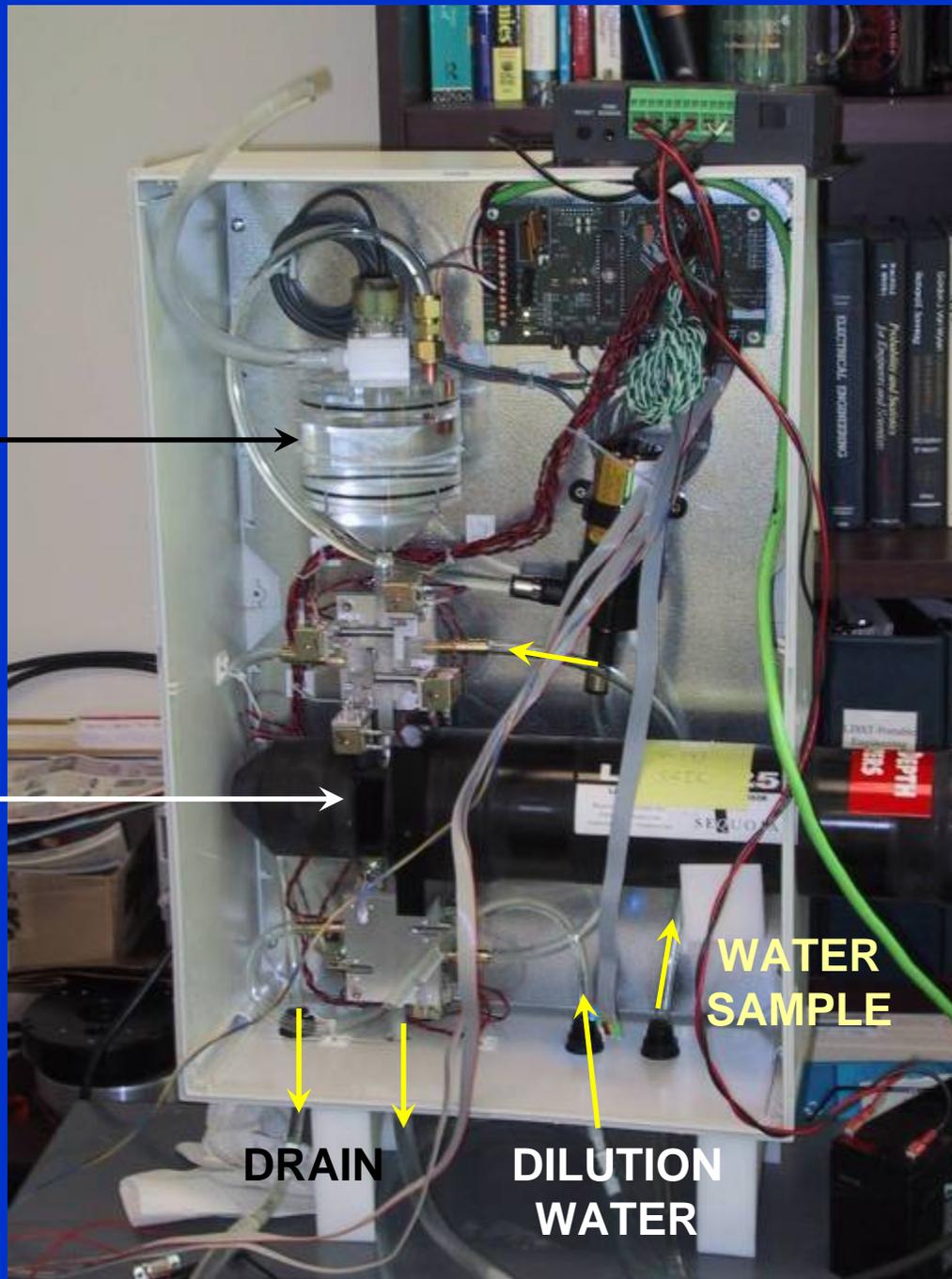
**WATER
SAMPLE**

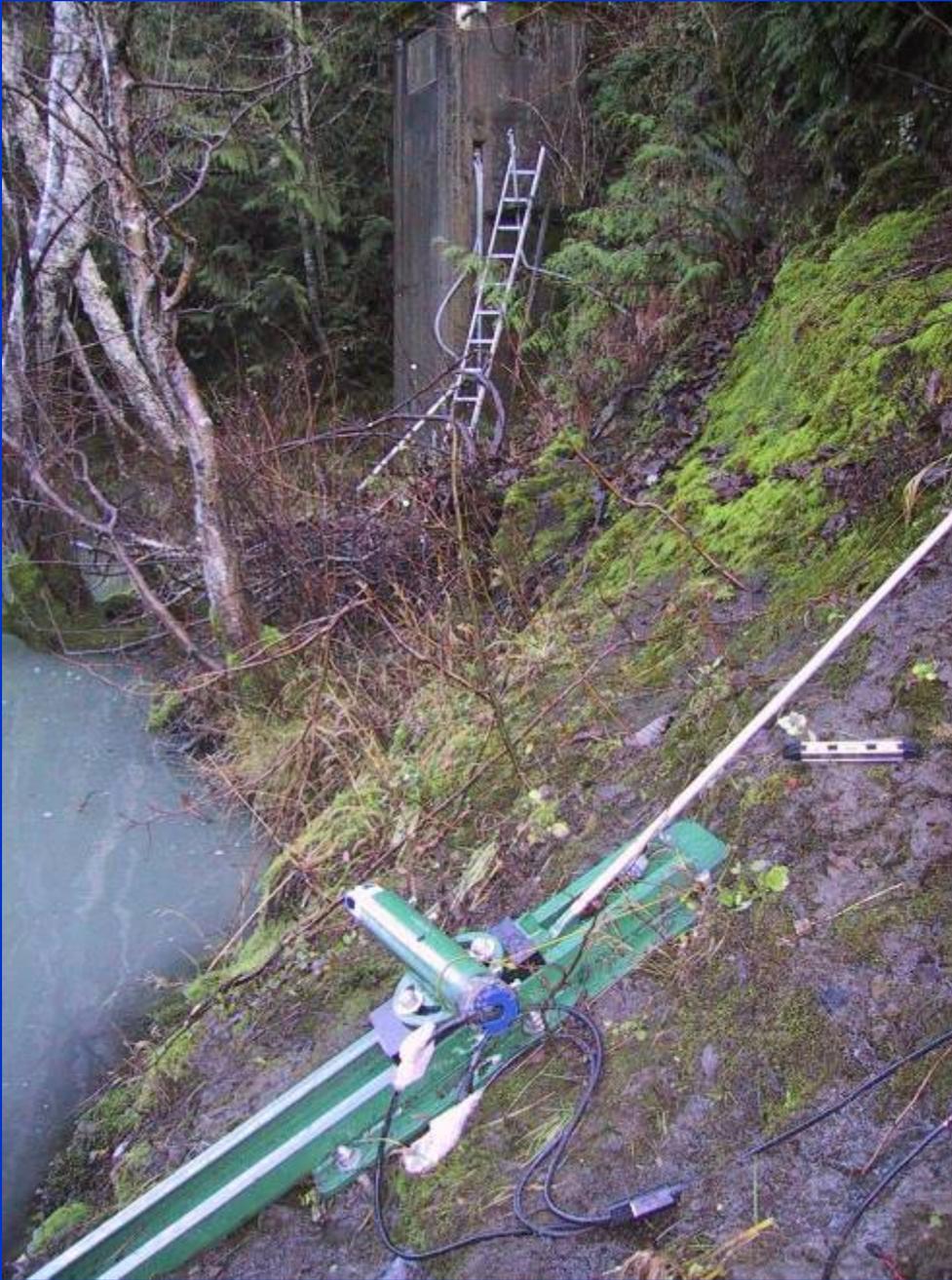


DRAIN



**DILUTION
WATER**





Acoustic Doppler Current Profiler

Typically used for
velocity and stage
measurements,
But also provides an
index of suspended
load for a wide (10 m)
parcel of water.

Next Steps

- Calibrate sediment model and run simulations of dam removal with various streamflow time-series
- Install the LISST-Infinite and evaluate performance by comparing to conventional suspended sediment samples
- Calibrate the ADCP with conventional suspended sediment samples