Changes in Debris Fans and Rapids: 21 Years of Monitoring Debris-Flows in Grand Canyon

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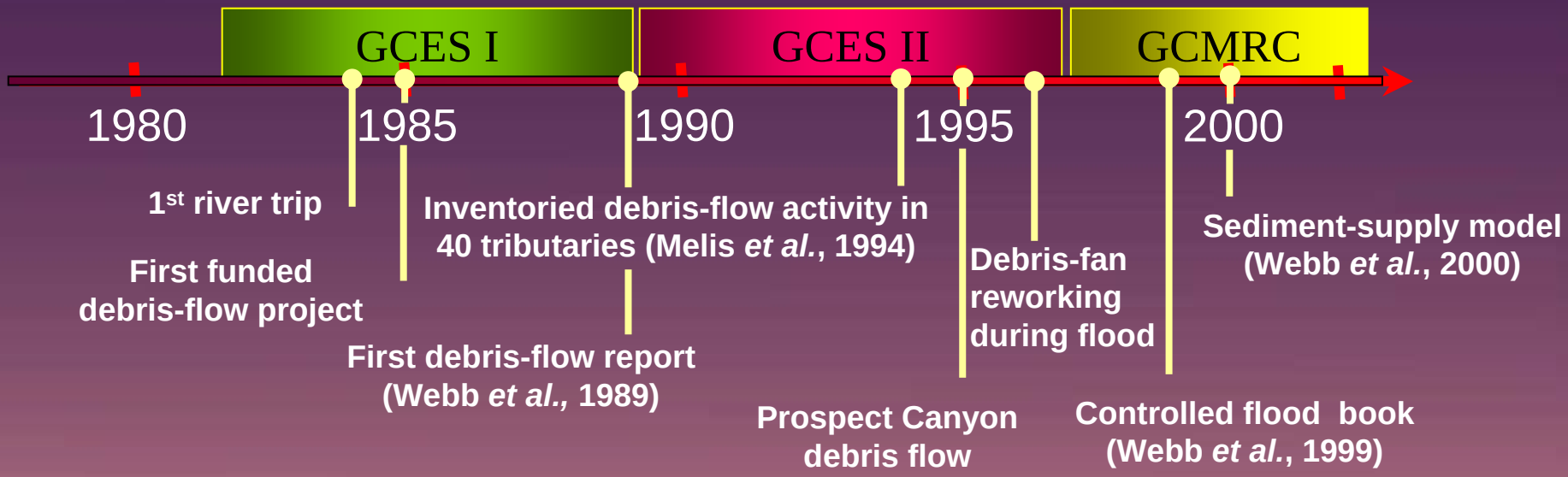
History of Monitoring Coarse Sediment

Monitor and study the contribution of coarse-grained sediment into Colorado River within Grand Canyon from all tributaries and evaluate impact on river.



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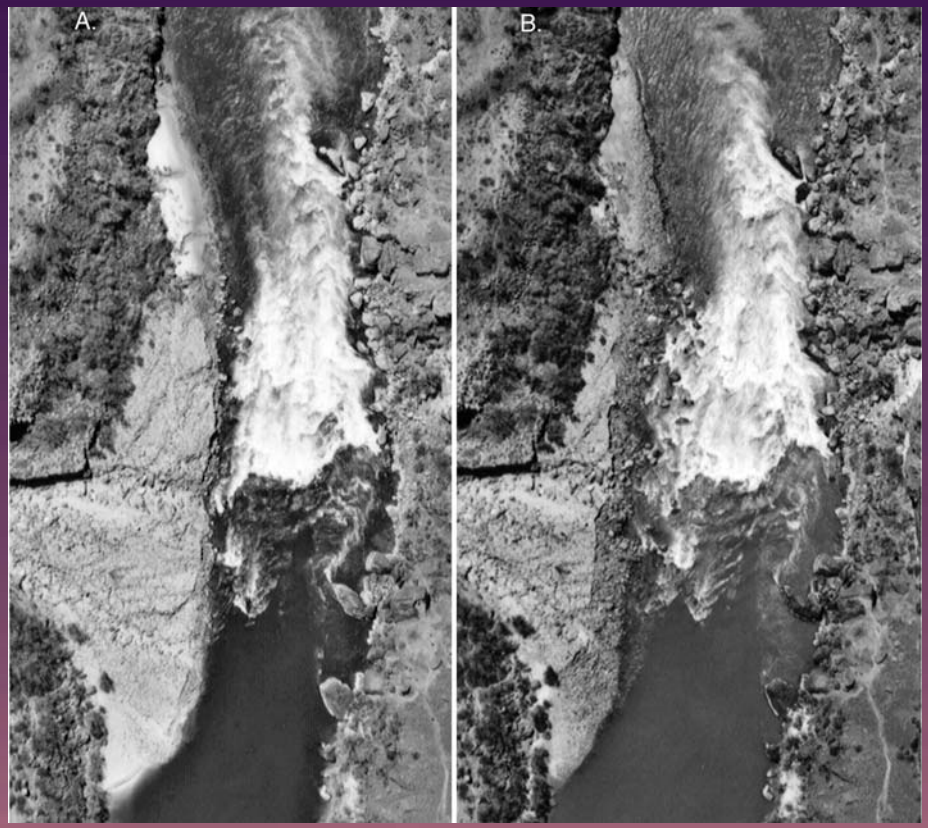
Debris Flows: Frequent and Fundamental



Lava Falls Rapid. A. March 25, 1996. B. April 6, 1996. The river reworked the 1995 debris-flow deposit and widened the rapid by about 20 m.

- We have identified **211** debris flows in Grand Canyon since 1890 (104 since 1983).
- An average of **5** debris flows per year canyonwide.
- Debris flows create and reshape even the largest rapids.
- Debris flows underpin the geomorphic and ecological framework of the river corridor.
- The regulated river has the potential to rework these debris fans.

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Monitoring: Traditional Fieldwork

Since 1984, we have collected:

- 234 topographic surveys
- 225 particle-size samples
- 289 point count surveys

To provide information about:

- area and volume
- particle-size distribution
- fan reworking
- channel constriction and rapid fall

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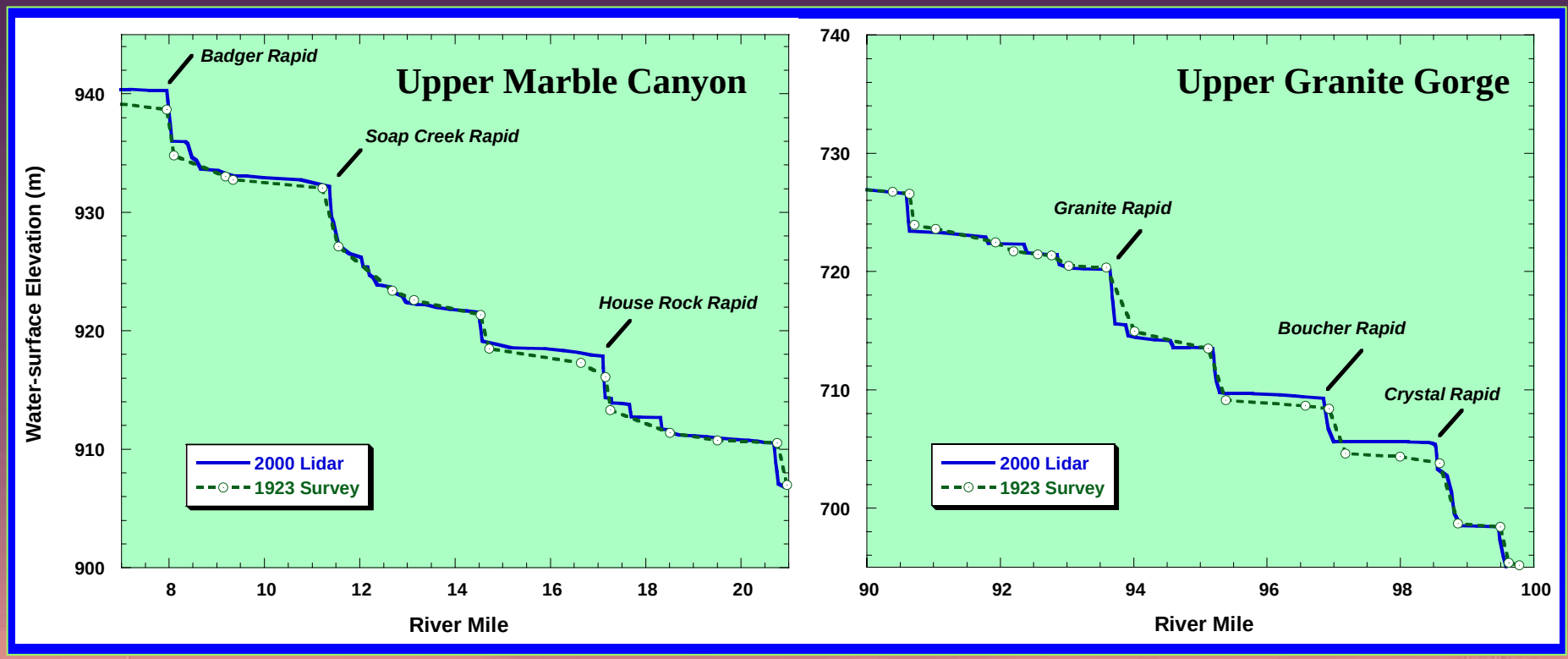
Comparison of 2000 LIDAR and 1923 Survey Data

- Quantify change in water-surface elevation from 1923 to 2000
- Detect the presence of previously unknown debris flows
- Calculate new set of geomorphic statistics for Grand Canyon



Ref: Magirl et al., 2005

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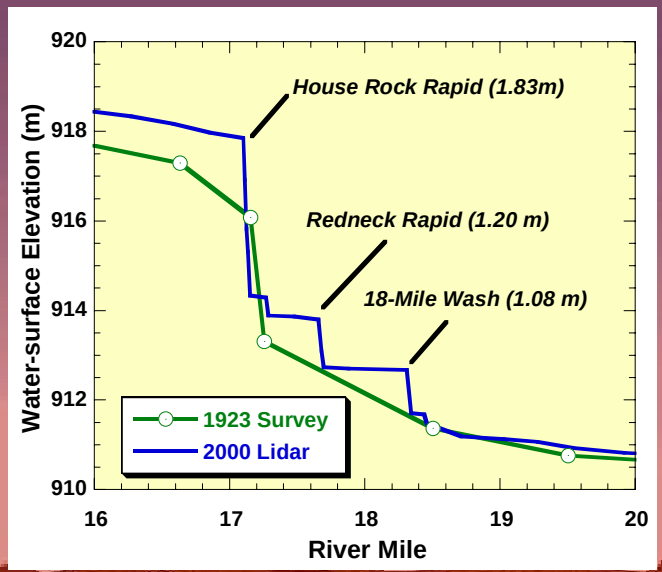
Largest Rise at Head of a Rapid

House Rock Rapid, mile 16.8

1923

1991



Net Rise: 1.83 m

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Photogrammetry on Debris Fans

- Test the use of aerial photography to remotely monitor effects of debris flows and river reworking on debris fans and rapids.
- 75-Mile Wash (3 debris flows) and Monument Creek (4 debris flows) – extensive survey history
- 18 sets of images available between 1965 and 2000, including 14 stereo pairs.
- Supplemented with field survey data through 2005.
- Analyzed changes in fan area, channel constriction, and fan volume using DTMs derived from stereo pairs.

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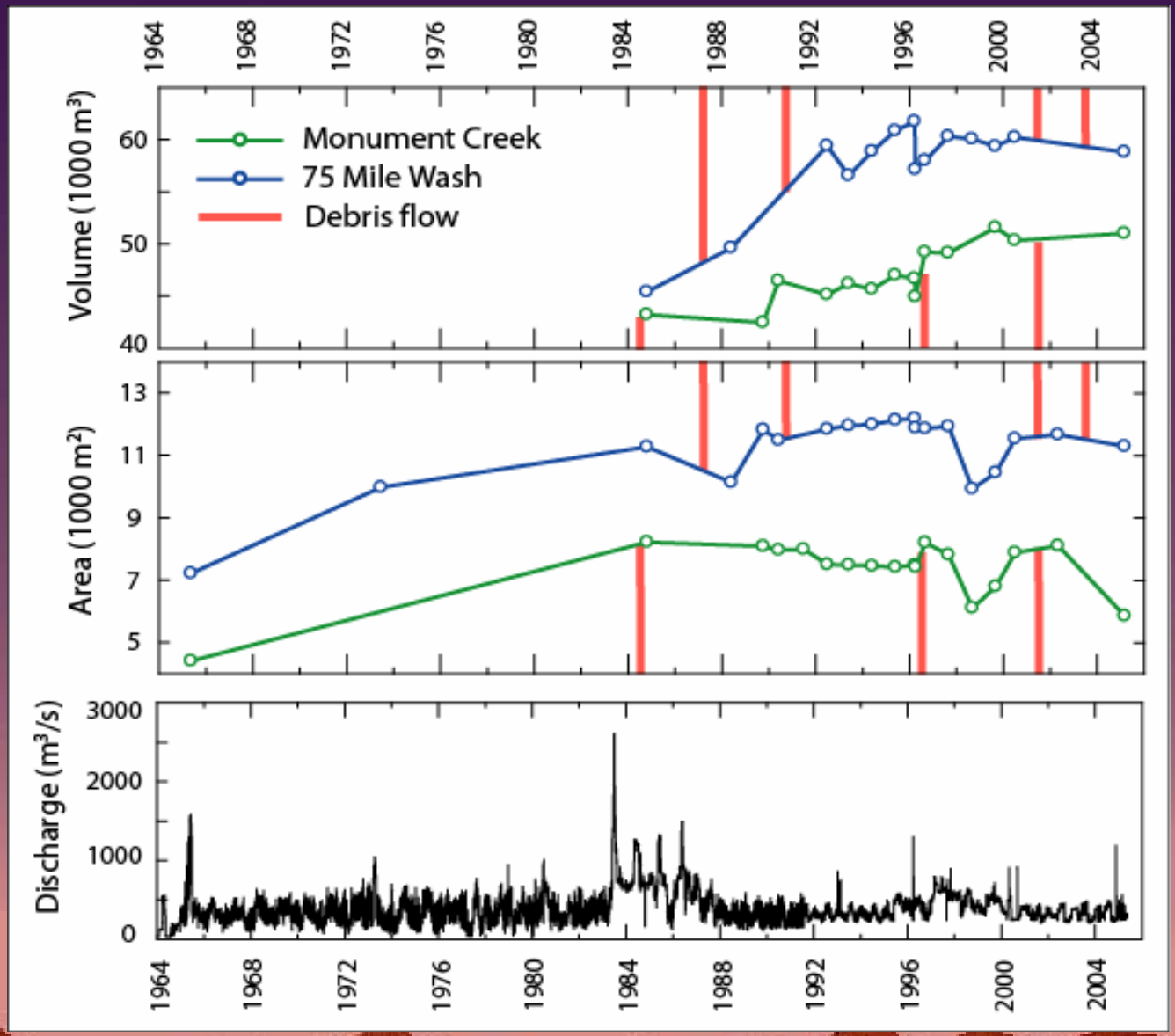
Debris Fan Area and Volume



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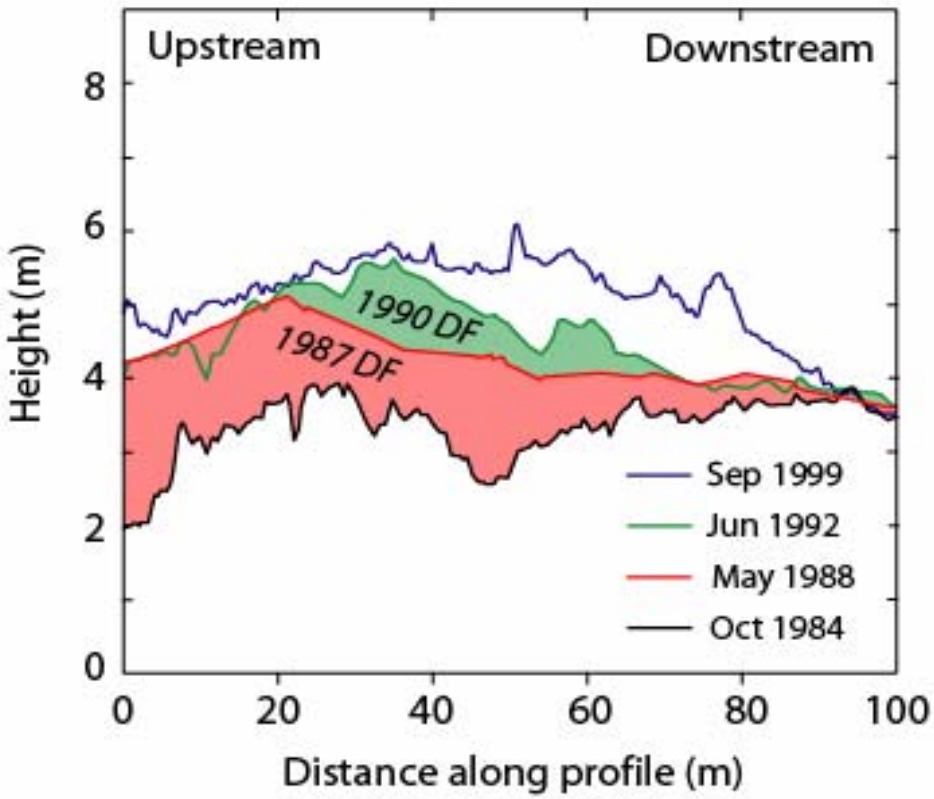
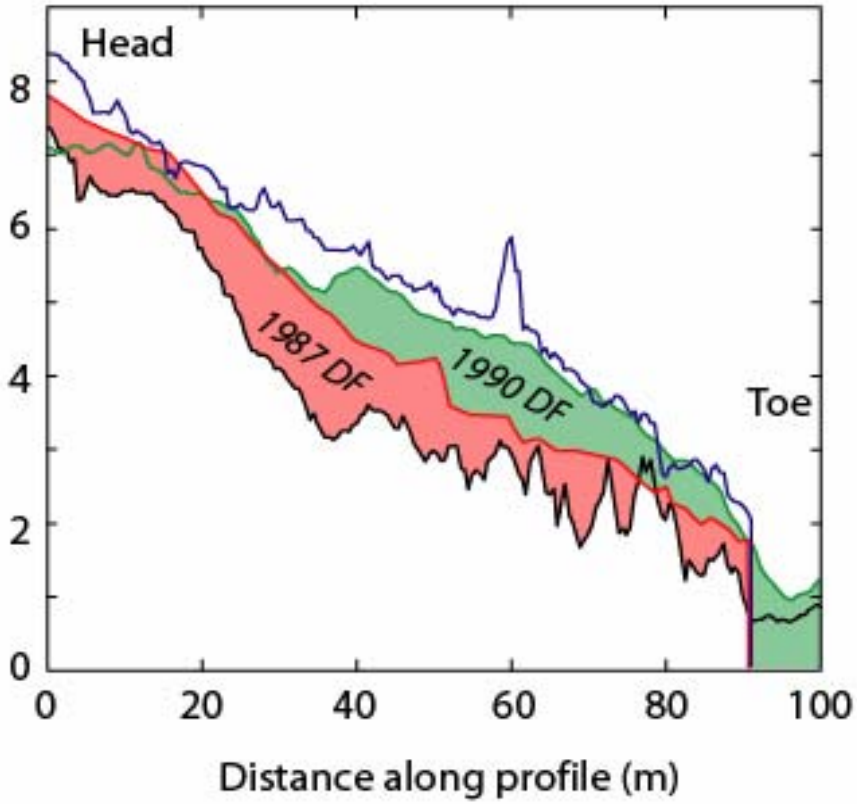
Debris-Fan Profiles at 75-Mile Wash





- Most aggradation occurs in middle of fan, away from the river.
- Fan topography has shifted from concave to convex.

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Nevills Rapid at 75-Mile Wash: Debris Fan Aggradation

1890 (R.B. Stanton)

2005 (S. Young)

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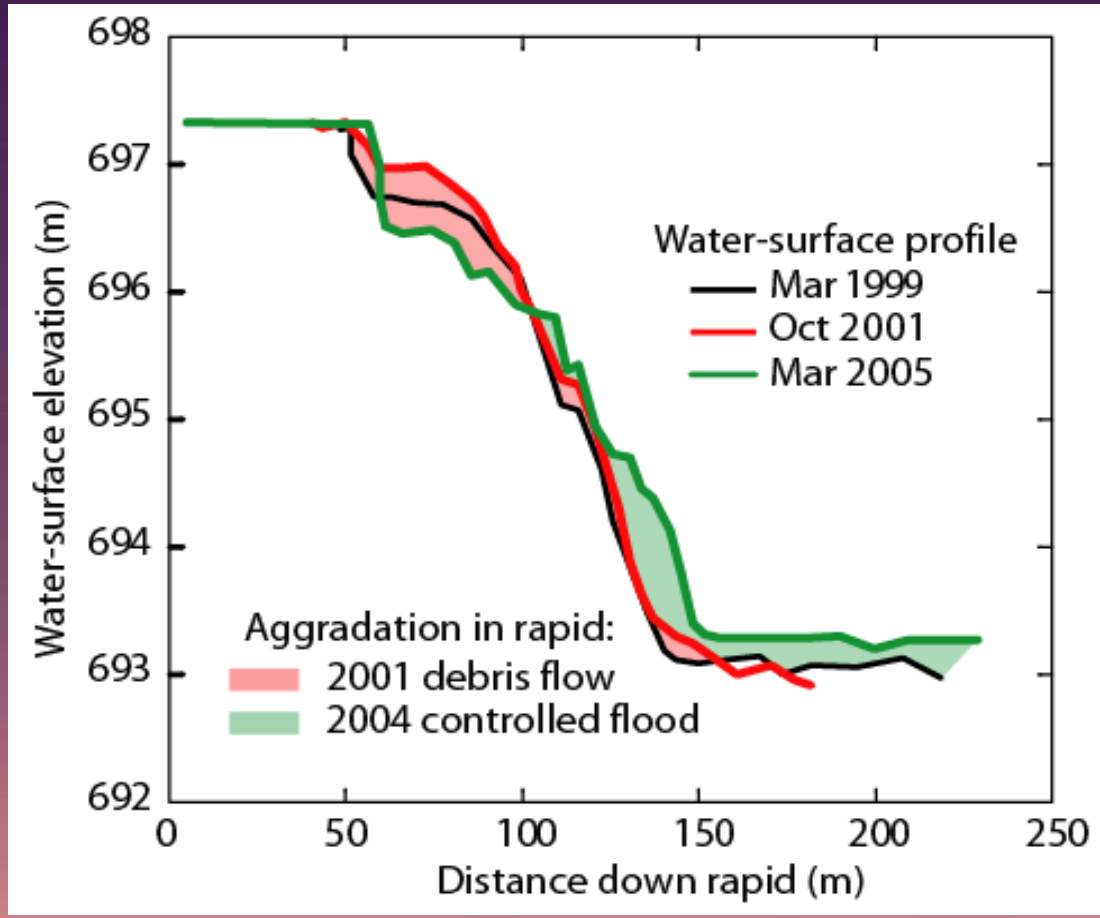
Granite Rapid: Water-surface Profile

- Some data must still be collected in the field.
- 2001 debris flow aggraded only the top of the rapid.
- 2004 flood reworked material into the lower half of rapid and the upper pool



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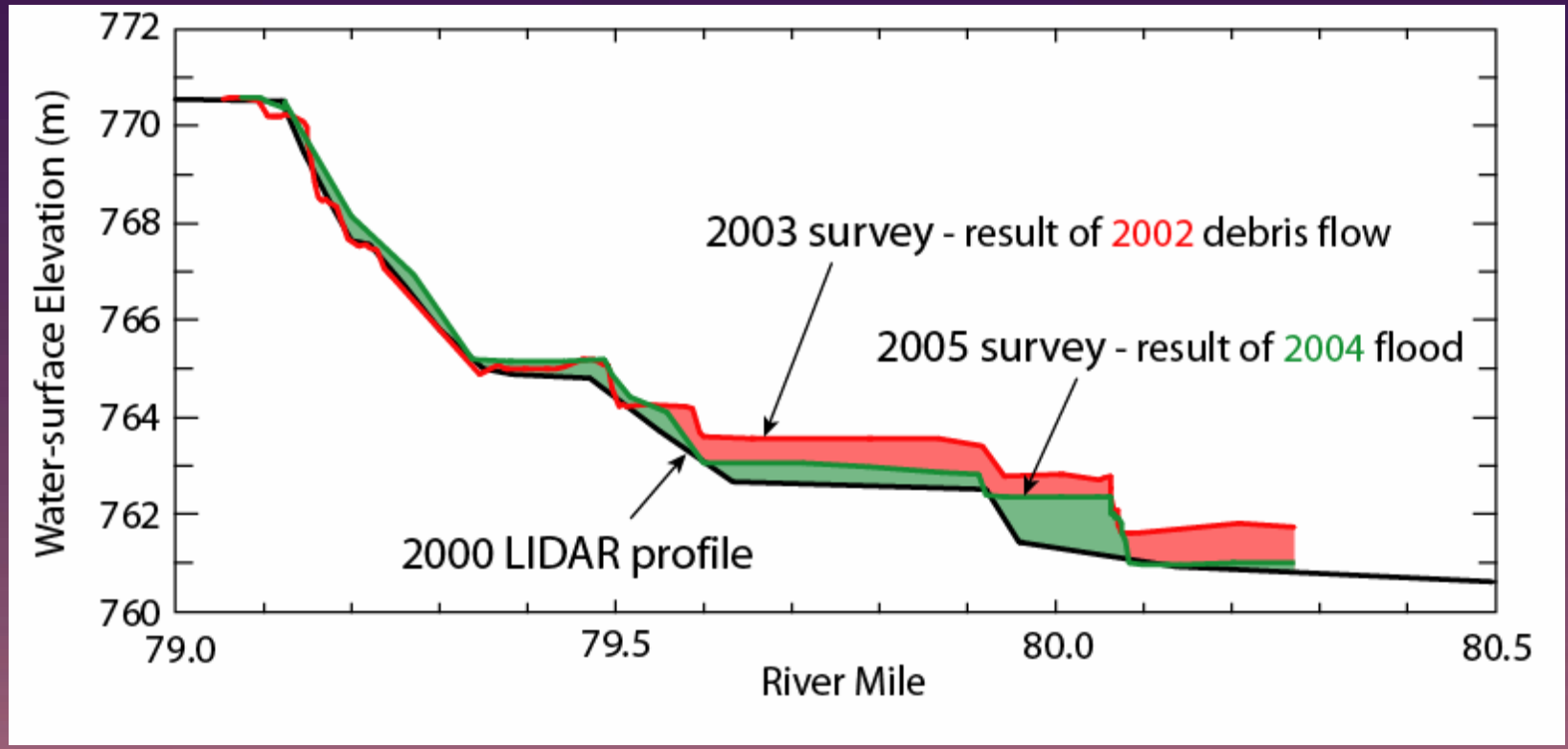
Sockdolager Rapid: Long Profile



- use of LIDAR data for WSP possible for longer reaches
- 2002 debris flow aggraded secondary rapids and created a new one
- 2004 controlled flood only partially reworked new deposits

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Summary

- 21 years of monitoring debris flows have demonstrated that:
  1) debris flows continually create, maintain, and reshape the basic geomorphic framework of the Colorado River
  2) debris flows occur frequently – 5 / year

- Recent evidence indicates that the combination of continued debris flow deposition and reduced flow on the regulated river is resulting in net aggradation of coarse sediment throughout the river corridor.

- Modern remote sensing products such as LIDAR and high quality aerial photography can be effectively used to monitor the continuing interaction between debris-flow deposition and river reworking in the Grand Canyon.

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