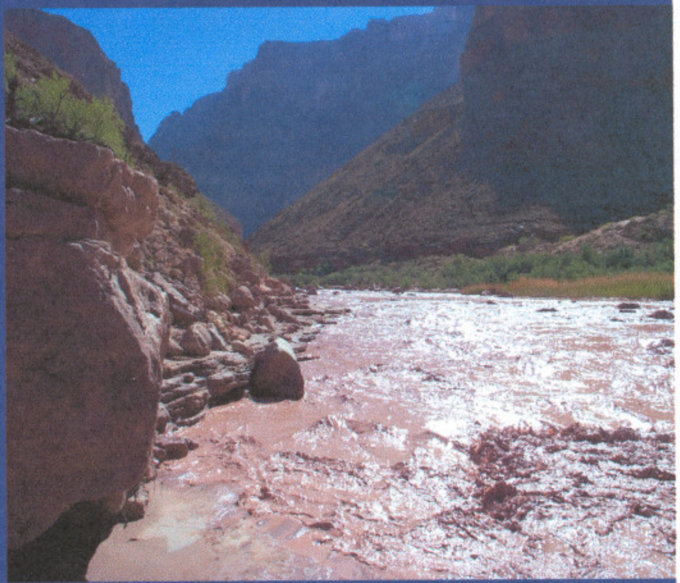
Flow and sand transport models of the Colorado River through Grand Canyon



Stephen Wiele
USGS

Development of a management tool for predicting multi-dimensional and 1-dimensional sand transport in the Colorado River ecosystem

Stephen Wiele (USGS)
Paul Grams (Johns Hopkins and Utah State University)
Josh Korman (Ecometric Research)
Jack Schmidt (USU)
Peter Wilcock (JHU)

Project components

PIs:

Wiele – model development and application

Schmidt/Grams – methods of extrapolating local 2d model results to longer reaches

Wilcock/Grams – sand transport over a rough boundary

Korman – linkages to biological issues

Linkages to other projects

GCMRC:

Mark Gonzales/Kohl – bathymetry

Mike Breedlove – cross sections for 1d model

Melis/Topping – suspended sediment measurements

Melis – underwater video

USGS:

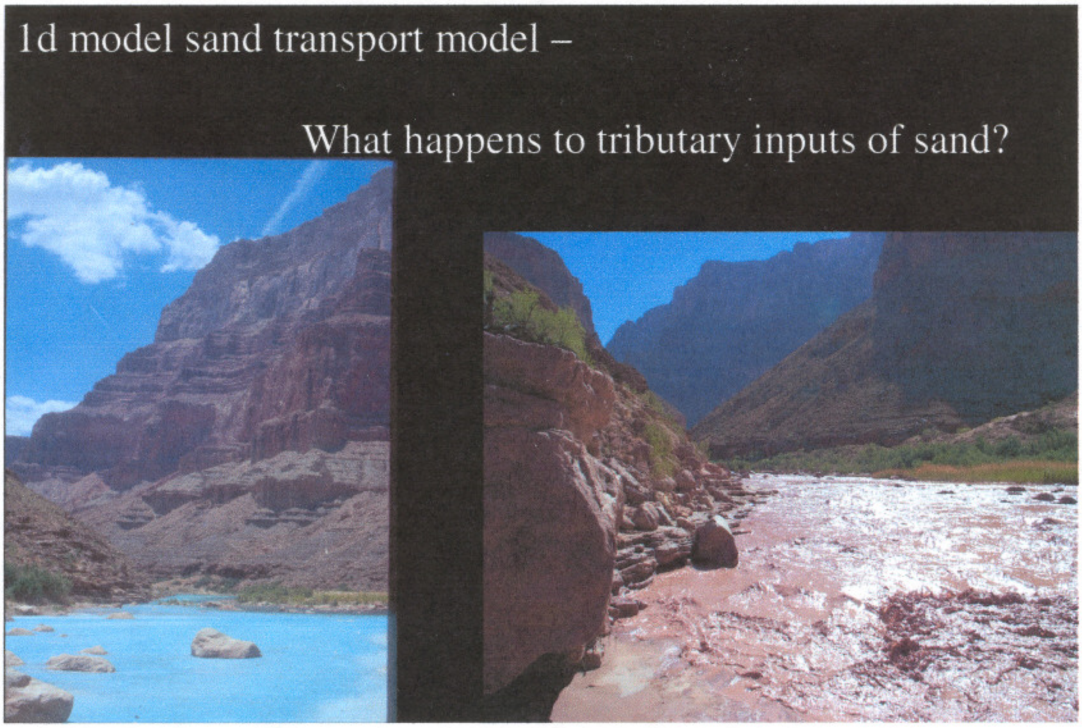
Roberto Anima – maps of channel-bottom textures

NAU:

Kaplinski/Hazel – bathymetry, long-term beach surveys

Large and local-scale models of flow and sand transport

- one-dimensional unsteady flow model
- multi-dimensional model of flow, sand transport, and bed evolution applied to kilometer-scale reaches
- one-dimensional model of sand transport coupled to unsteady flow model applied to reaches tens to hundreds of kilometers in length



1d model sand transport model

What happens to tributary inputs of sand?

Method

Large-scale model of sand transport

-- multiple grain sizes

-- time-varying flow

-- incorporate new research on near-bed sand concentrations over a rough boundary

-- sand gains and losses calculated with 2d model

one-dimensional model applications

- track major tributary inputs
  - -- predict movement of sand wave and response to dam releases
  - -- predict segregation of grain sizes
- set upstream sediment boundary condition for multi-dimensional model
- optimize dam releases to make best use of available sand

2d model of flow, sand transport, and bed evolution

-- calculate vertically averaged flow field

-- calculate 3d suspended sand field

-- calculate local sand discharge

-- calculate change in bed elevation over a small time step

2d model

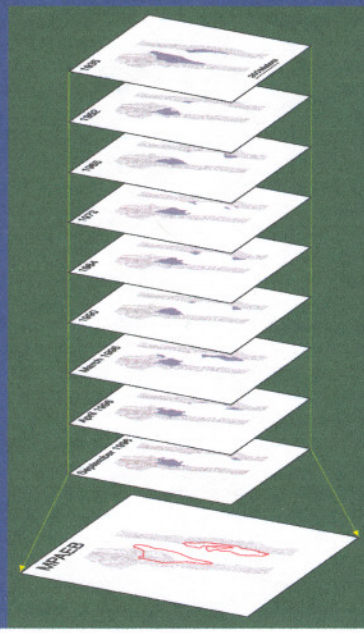
Apply to new reaches for a range of cases, generalize results

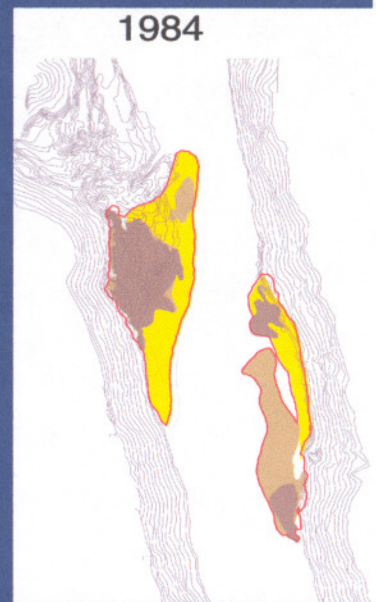
Use results to estimate sand gains and losses in 1d model

USU – use GIS database to develop methods for extrapolation of 2d model results

- define Maximum Potential Area of Eddy Bar (MPAEB)
- scale result from modeled reach by MPAEB
- use NAU data to relate volume to area

MPAEB





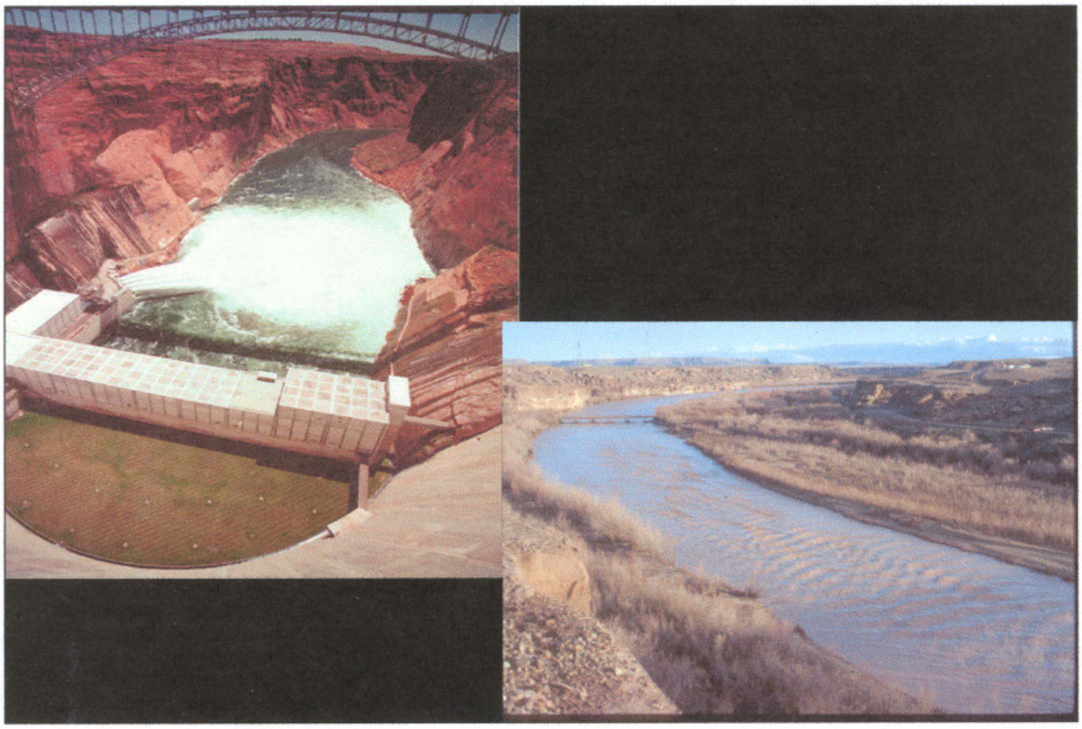
JHU

Develop algorithm for near-bed concentration of suspended sand over a rough bed

-- critical parameter for modeling of suspended sand transport

Ecometric Research

- Output from 1d and 2d models will be used to refine the sand routing and storage components of the physical resources submodel of the Grand Canyon Ecosystem Model
- Predictions of sand storage on the channel bed and depositional patterns on sand bars will be used to refine the aquatic productivity and riparian habitat submodels of the GCM

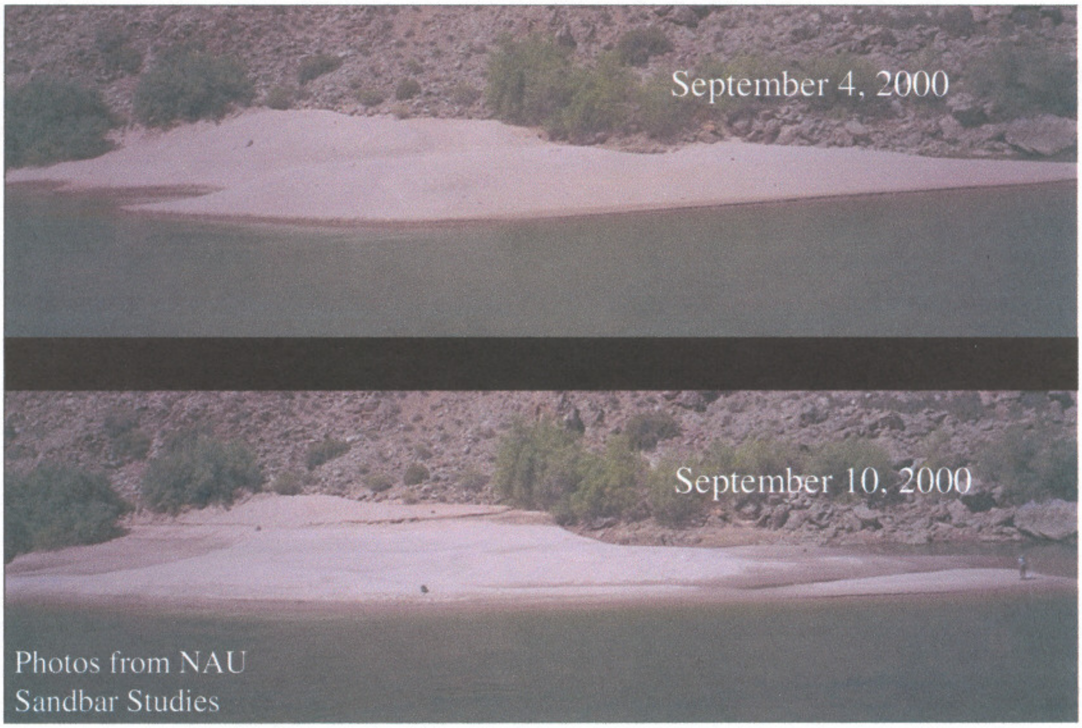


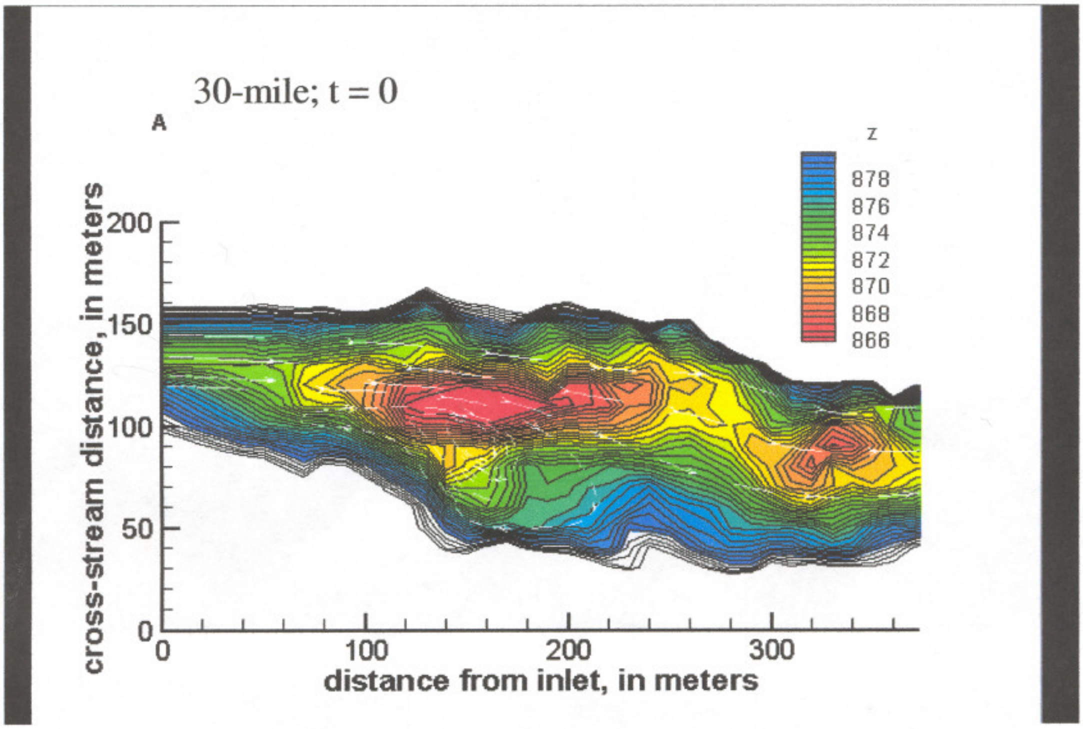
Replenish sand bars with high dam releases

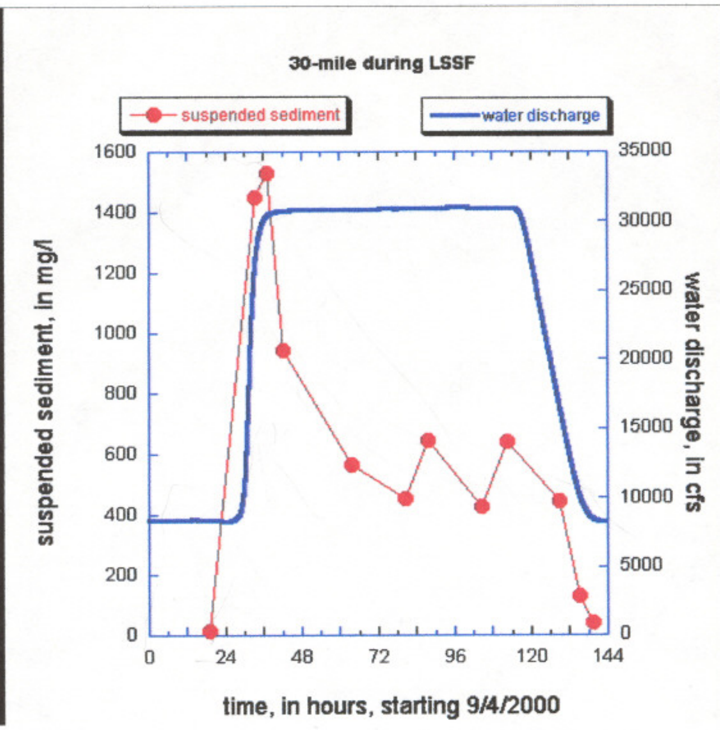
- How high? Are power-plant capacity releases sufficient?
- How long?

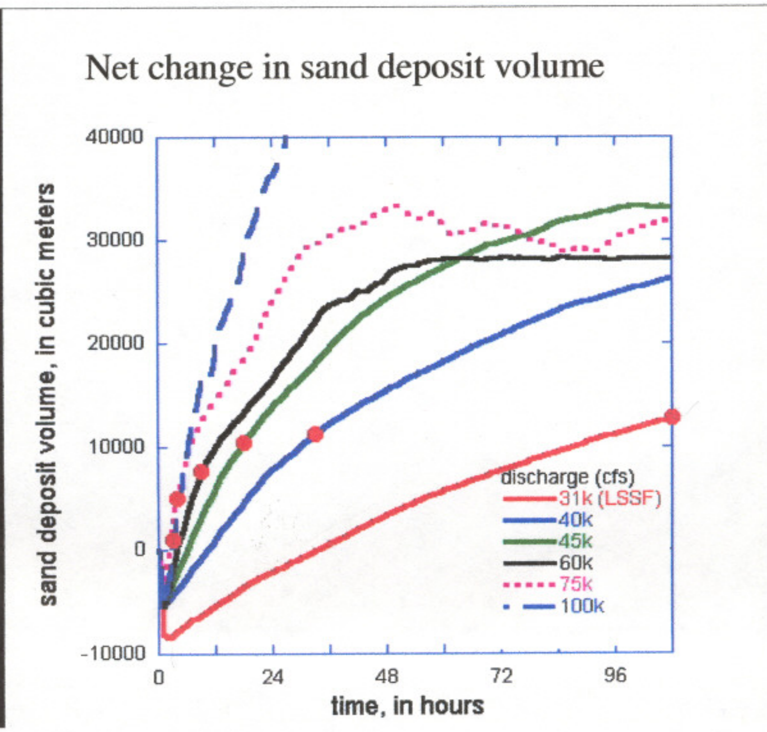
Modeling

Compute deposition over range of sand supplies and water discharges

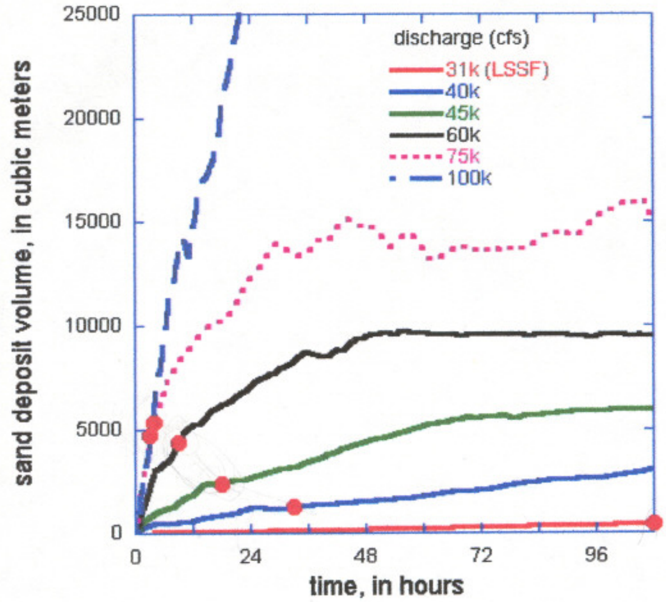

September 4, 2000
September 10, 2000
Photos from NAU
Sandbar Studies


30-mile; t = 0
A
z
878
876
874
872
870
868
866
cross-stream distance, in meters
distance from inlet, in meters
0
50
100
150
200
0
100
200
300

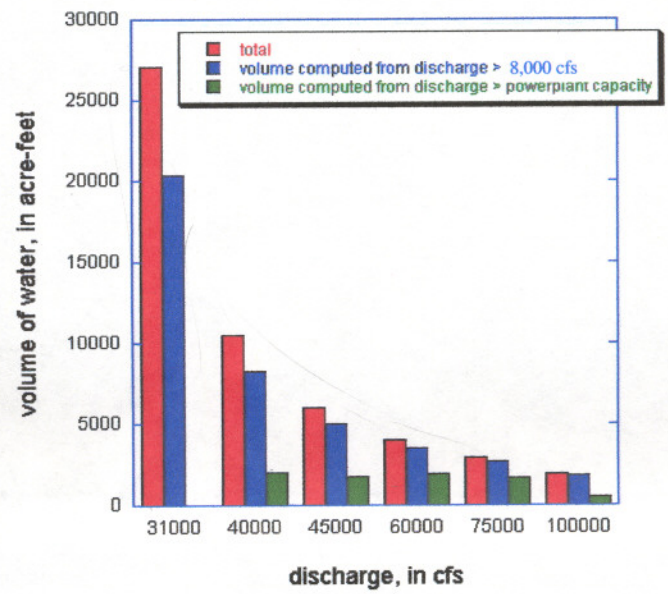

30-mile during LSSF
suspended sediment
water discharge
suspended sediment, in mg/l
water discharge, in cfs
time, in hours, starting 9/4/2000


Net change in sand deposit volume
sand deposit volume, in cubic meters
time, in hours
discharge (cfs)
31k (LSSF)
40k
45k
60k
75k
100k

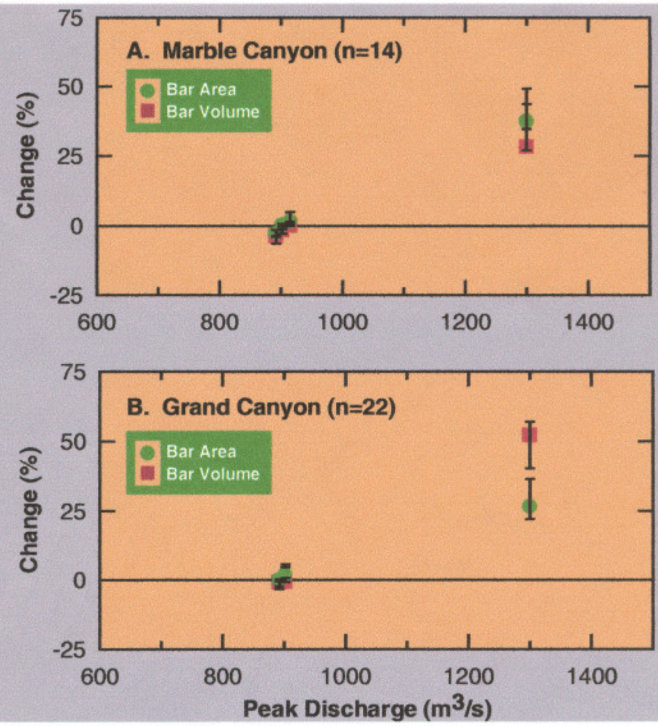
Net change in sand volume above 25k cfs stage



Volume of water required to transport volume of sand transported during the LSSF at 30-mile



NAU
survey data



Conclusions

Power-plant capacity flows are ineffective at building
Sand deposits

Discharges around 45,000 to 60,000 cfs make best use
of sand and water