Modeling updates and next steps
FY09 Work Plan

8 April 2008 1:30 pm
GCDAMP TWG Meeting, PHX
Physical modeling goals

- Develop and apply predictive models of stage and discharge
- Develop and apply predictive models of mainstem and nearshore temperature dynamics
- Develop apply predictive models of mainstem sediment transport and sandbar dynamics and stability
- Evaluate “what if” scenarios for dam operations
- Eventually, provide input to ecological models
Applications – Stage and discharge

- Peak flow arrival and departure times along the river during high flow releases
- Inundation maps for campsites during high flow releases
- Estimation of inundation levels for a range of flows
- Provide hydraulic variables (velocity, cross-section area, bed shear stress) to other transport models
Applications – Temperature

- Evaluate the effects of release temperatures and volumes (i.e. hydrology, TCD) and daily patterns (i.e. level of fluctuation) on downstream mainstem and nearshore/backwater temperature dynamics

![Graph showing average mainstem water temperature over last 5 years (°C)](image)
Applications – Sediment transport

- Evaluation of the potential for a given operation to result in long-term positive mass balance of sand in Grand Canyon
- Evaluation of the effects of ramping rates on bar stability
- Design of high flow hydrographs to optimize sandbar deposition while minimizing sand export
Recent progress – Stage and discharge

HEC-RAS model (steady, uniform flow) to predict stage profiles for a given discharge

USES SYNTHETIC BATHYMETRY

Recent progress – Temperature

1D mainstem dynamic model: Predicts hourly temperatures at any location below the dam for a given release temperature and discharge hydrograph

Model was used in SPG Options analyses


Recent progress – Temperature

1D mainstem simplified model:
Predicts monthly average temperatures at any location below the dam for a given release temperature and release volume.


Recent progress – Temperature

Progress on nearshore models has been limited by lack of data – thus, we have implemented nearshore (primarily backwaters) temperature monitoring. Also using meteorological data from weather stations installed by Cultural program.
Recent progress – Temperature

We're developing two types of nearshore temperature models

Multi-dimensional models of eddies

Well-mixed “pond” models of defined backwaters
Recent progress – Sediment transport

Sand routing model for the reach from Paria confluence to Phantom Ranch

Event-based simulations – time scales of weeks to months

Still has some calibration issues

Recent progress – Sediment transport

Simplified sand routing model for simulating the fate of tributary inputs over annual to decadal time scales

Shifts the relationship between sand concentration and discharge based on the supply conditions in a reach

Need to test with recent data

Recent progress – Sediment transport

Review panel recommended “updating” Wiele 2D eddy model (mid 90s), as new tools have become available

In the first stages of applying Delft3D model to sandbars (as well as temperature)

As with temperature, progress is limited by lack of data in eddies (lots of surveys, not much velocity and concentration data)
Recent progress – Sediment transport

To address this data gap, we made detailed bathymetric, velocity, and sediment measurements at Eminence and Willie Taylor during 2008 HFE PROJECT 1B
Task 1 - Multi-dimensional modeling of flow, temperature, and sediment transport using Delft3D*

- Calibrate hydrodynamics using velocity data from 2008 high flow
- Calibrate temperature dynamics using nearshore data
- Calibrate sediment transport using data from 2004 and 2008 high flows
- Through calibration, evaluate the complexity of model required (i.e. 2D, 3D, number of grain-sizes, turbulence model)
- Begin applications to study nearshore warming and sandbar response to high flows

* Recommended by review panel
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Task 2 - Sandbar stability modeling and experiments at Arizona State University (ramping rate studies)*

- Ongoing work led by Mark Schmeeckle to study effects of ramping rates on sandbar stability
- Physical model studies at ASU lab
- Numerical model development and applications

* Recommended by review panel
Task 3 - Update and publish "shifting rating curve" model*

- Apply model to recent dataset (summer 2006 through March 2008) as an additional test of the algorithms
- Update manuscript as necessary and submit to Journal of Hydraulic Engineering
- Construct a simple user-interface (Excel)
- Provide support for LTEP simulations?

* Not reviewed by modeling panel, but recommended by PEP-SEDS panel
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Task 4 - Document and develop user manual for Wiele et al 1D sand routing model*

- In order to continue to improve this model (recommendation of review panel), more extensive documentation is needed

- Work with Wiele to document the code (and potentially port to other programming languages) and develop a user’s manual for existing version (facilitating further calibration)

* First step toward following the review panel recommendations (continued calibration and improvement of model formulations)
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Task 5 - Begin development of integrated 1D unsteady flow and stage model*

- Our existing flow (UNSTEADY) and stage (HEC-RAS) models do not incorporate recently collected bathymetric data (UNSTEADY uses a single x-section, HEC-RAS uses synthetic bathymetry)
- We now have bathymetry for much of Marble Canyon, and Goal 8 Core Monitoring will eventually survey the entire river
- With this bathymetry, HEC-RAS can be used for unsteady flow (i.e. wave routing) and stage predictions, in a single package, with improved predictive capabilities
- This task will begin the development of this capability for reaches where bathymetry is available

* Review panel recommended updating HEC-RAS with new bathymetry
Work plan and budget

- **Task 1** – Multi-dimensional modeling
  
  FY09 - $196,574  
  FY10 – continuing, potentially scaled back

- **Task 2** – Sandbar stability modeling
  
  FY09 - $26,523  
  FY10 – potentially continuing, uncertain

- **Task 3** – Shifting rating curve model
  
  FY09 - $31,419  
  FY10 – zero, completion in FY09

- **Task 4** – Sand routing model user’s manual
  
  FY09 - $25,129  
  FY10 – zero, completion in FY09

- **Task 5** – Integrated 1D hydrodynamic model
  
  FY09 - $28,241  
  FY10 – continuing

Travel and publications costs: $12,100

FY09 total: $319,986
FY10 ~ 70% of FY09
Future of modeling project

- Modeling project should not be considered “over” once ongoing model developments are finished (likely in the next 2-3 years)

- Development will result in a “toolbox” of models. The “tools” require maintenance and updating, and staff who know how to use them.

- For example, as new monitoring and research flow data become available, models should incorporate improved understanding of system dynamics

- Thus, modeling project should continue in a scaled back version alongside the Core Monitoring project