Inferential Hydraulics:

Evaluating and Using a 2D Model

New and Evolving Concepts in Indirect Discharge Measurement May 8-11, 2001

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Real-Time Flood Mapping Pilot

USGS

Pilot Goals

- NWS flow forecasts fed to hydraulic model
- Model results to GIS
- GIS products to internet map serving software
- Near-real time

Project Model: TrimR2D

- Developer: Vincenzo Casulli, Univ. Of Trento
- Solves: shallow-water equations
- Method: semi-implicit, semi-lagrangian, finite difference

2-D Flow Equations

$$\frac{\partial \zeta}{\partial t} + \frac{\partial\left[(h+\zeta)u\right]}{\partial x} + \frac{\partial\left[(h+\zeta)v\right]}{\partial y} = 0$$

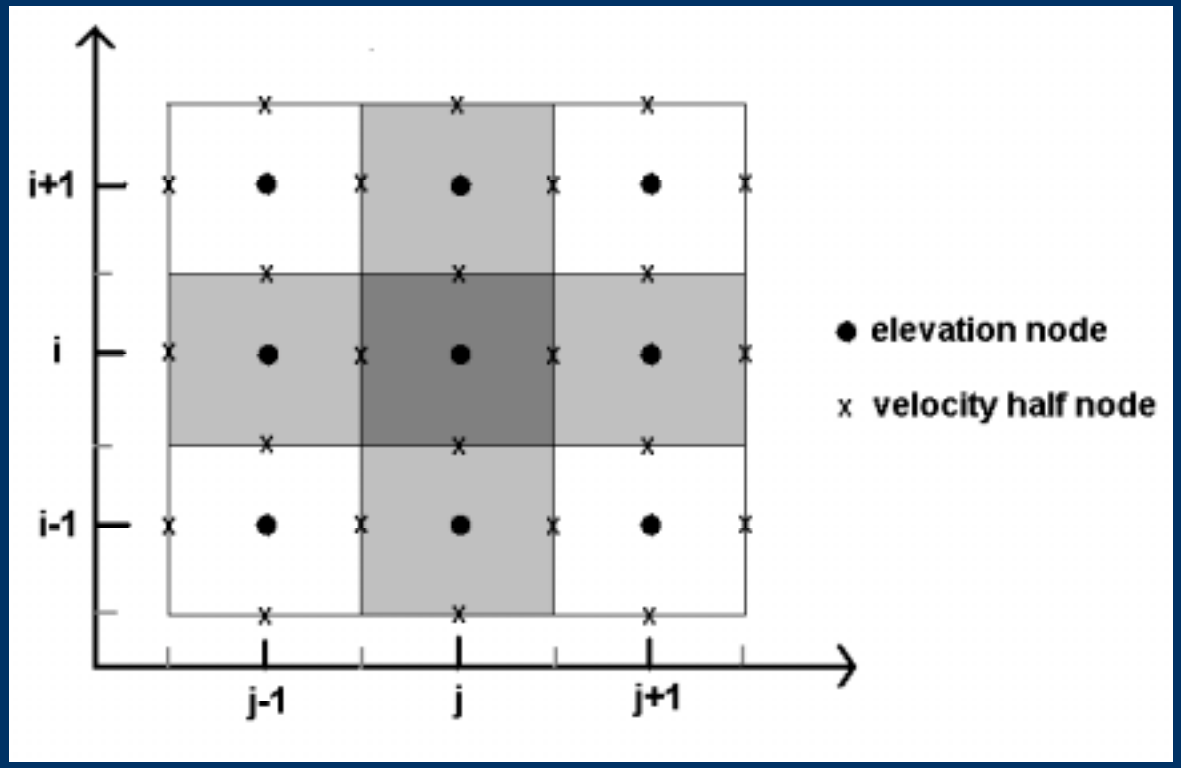
$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -g\frac{\partial \zeta}{\partial x} - \frac{1}{\rho(h+\zeta)}\left(\tau_x^w - \tau_x^b\right) + A_h\nabla^2 u + fu$$

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -g\frac{\partial \zeta}{\partial x} - \frac{1}{\rho(h+\zeta)}\left(\tau_x^w - \tau_x^b\right) + A_h\nabla^2 u + fu$$

Some Numerical Properties

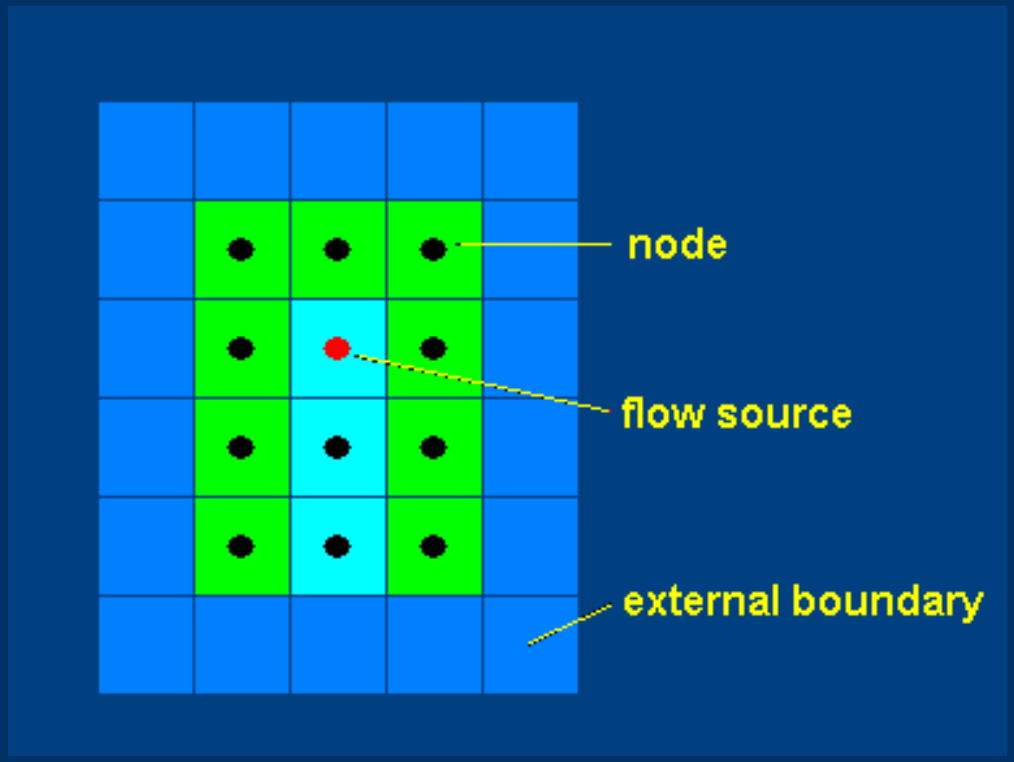
- Convective terms- Eulerian-Lagrangian
- Implicit terms - unconditionally stable
- Discretized equation - properly accounts for positive and zero depths
- Pentadiagonal solution matrix - solved by preconditioned conjugate gradient method

Staggered Grid



- Computational module

Boundary Conditions



- External: water-surface elevation
- Internal: point sources

Simulations

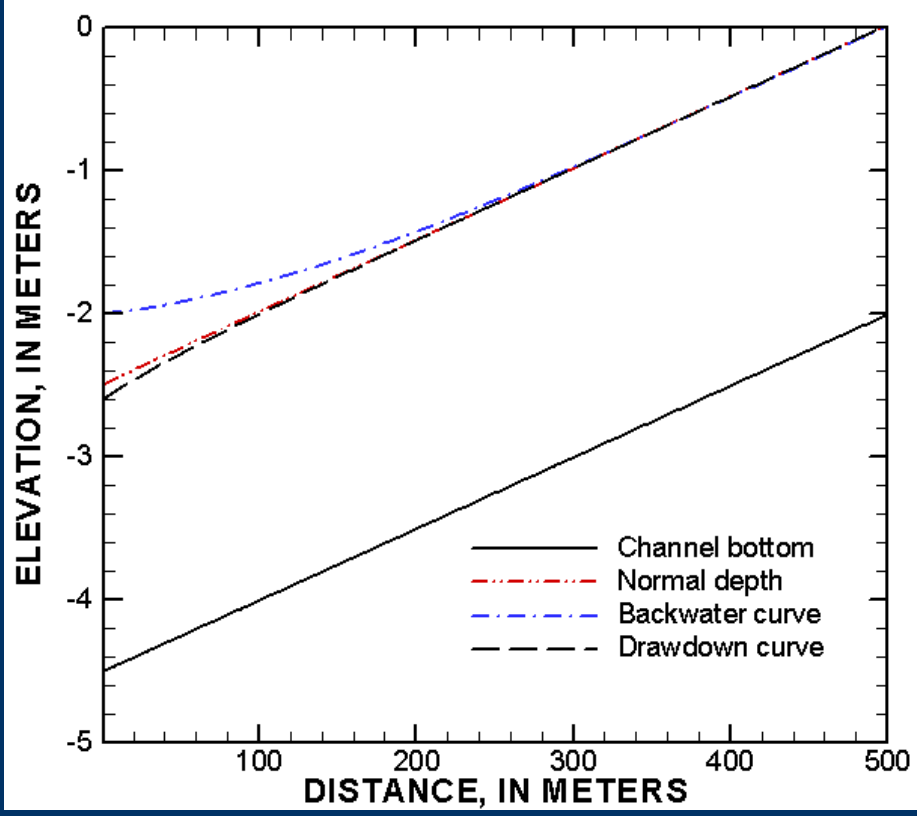
- Uniform flow
- Laboratory dam break
- Chattahoochee river reach

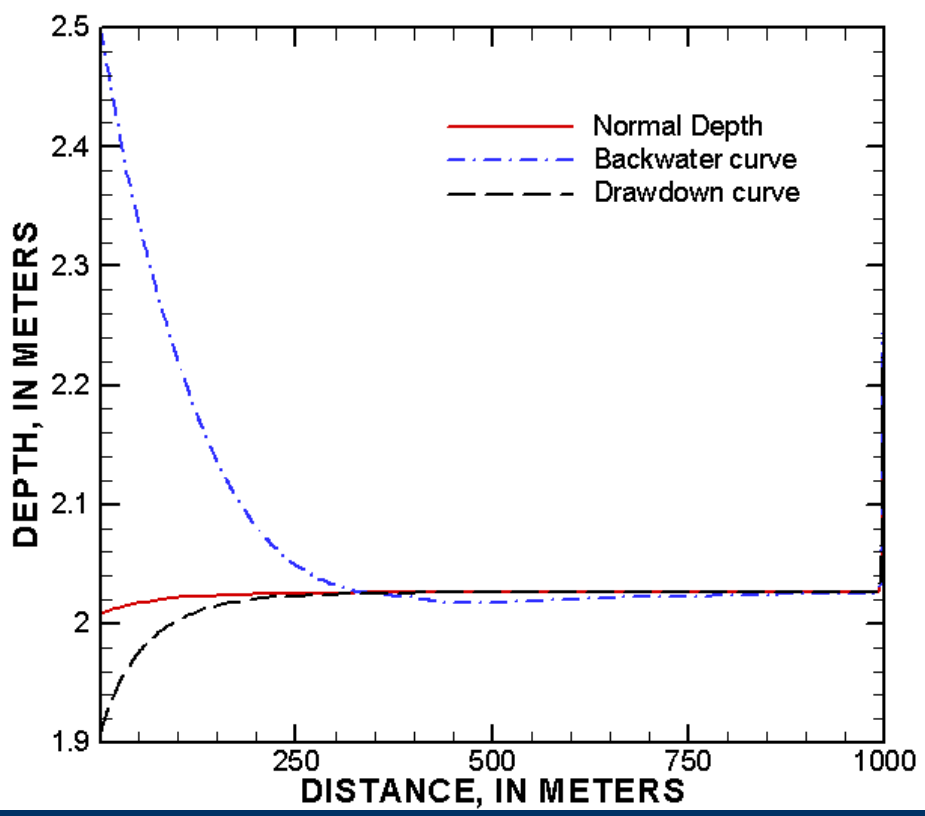
Uniform Flow

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

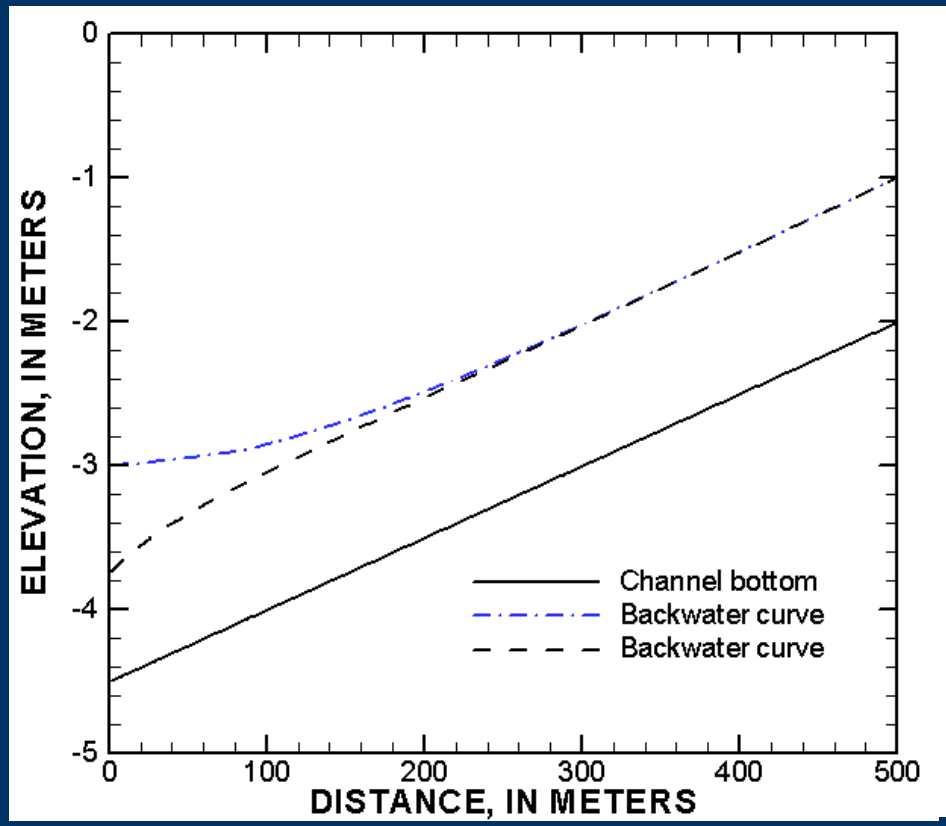
- Rectangular flume
- 4m width x 1000m long
- Channel slope is 0.005
- Model is 6 by 1001 cells

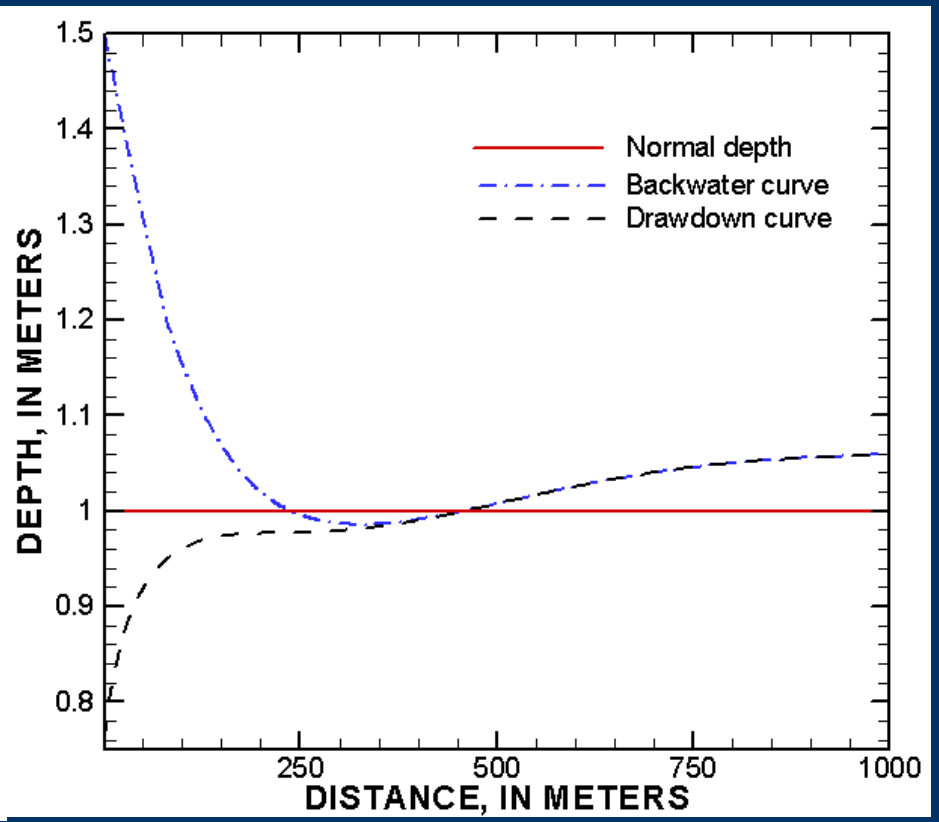
Manning's n=0.035 Uniform depth = 2m



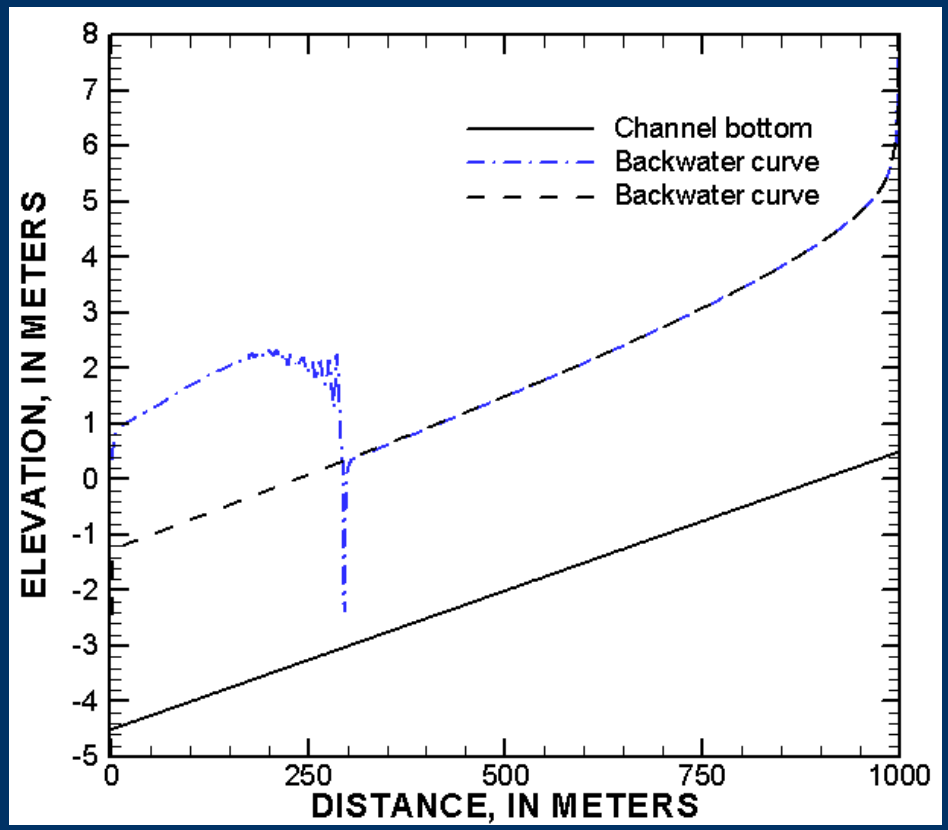


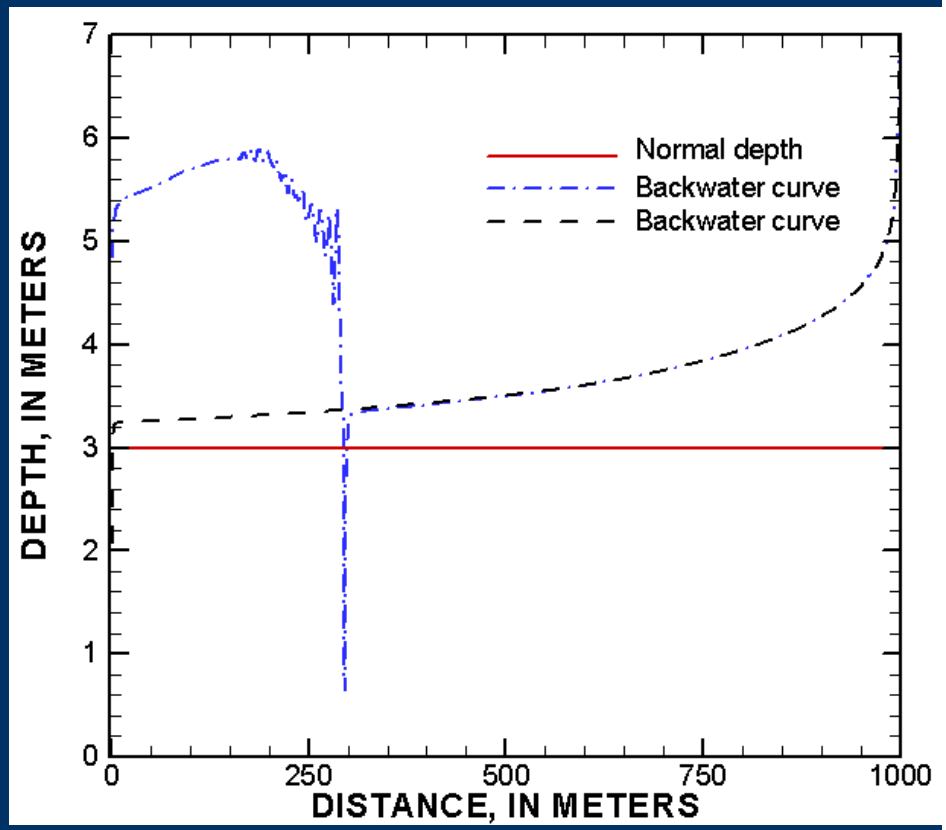
Manning's n=0.075 Uniform depth = 1m





Manning's n=0.012 Uniform depth = 3m





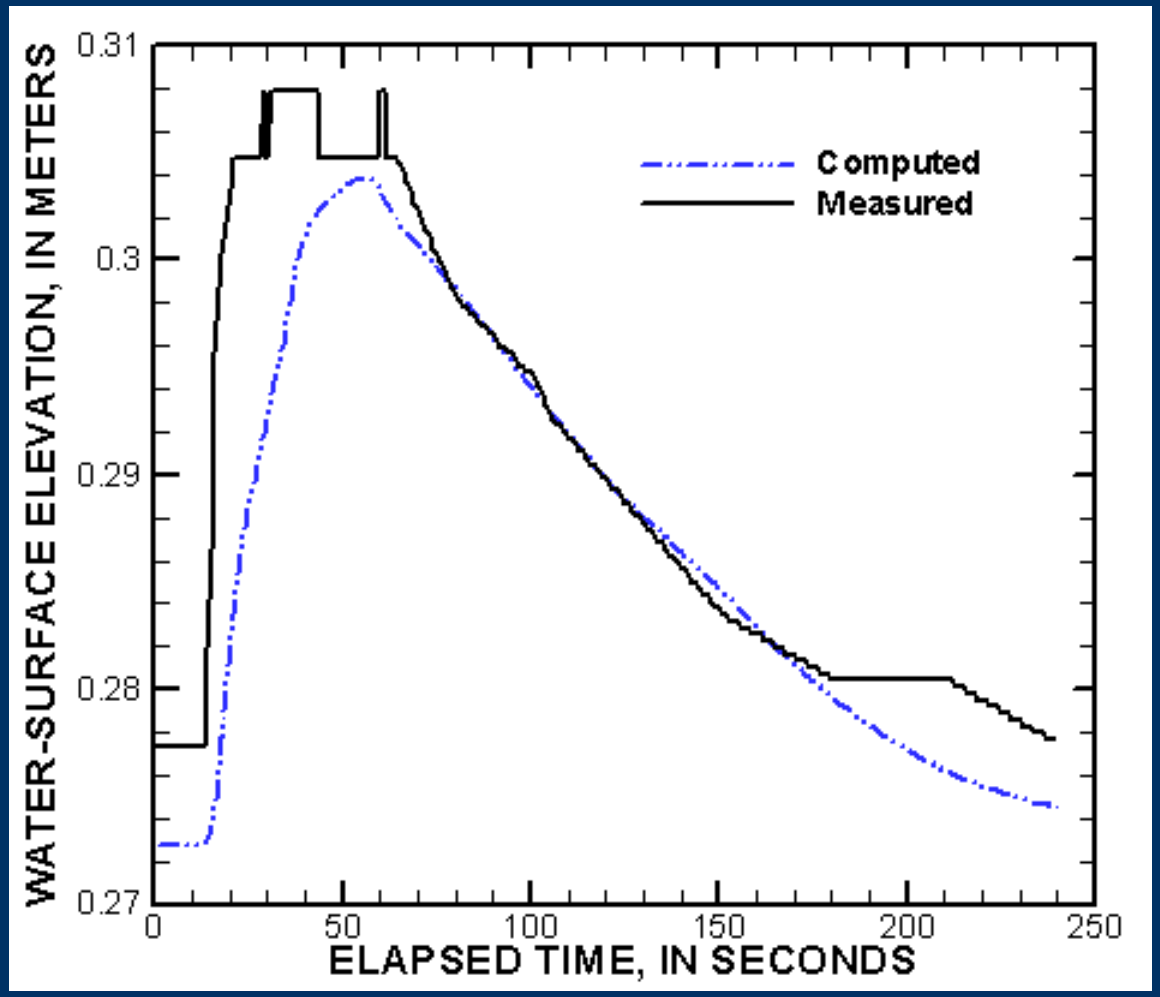
Laboratory Dam Break
(U.S. Army Corp of Engineers)

- 1.219m wide rectangular flume
- Dam is 45.72m from outflow boundary
- Flume slope is 0.005
- Dam is explosively removed
- Time period of 240 seconds

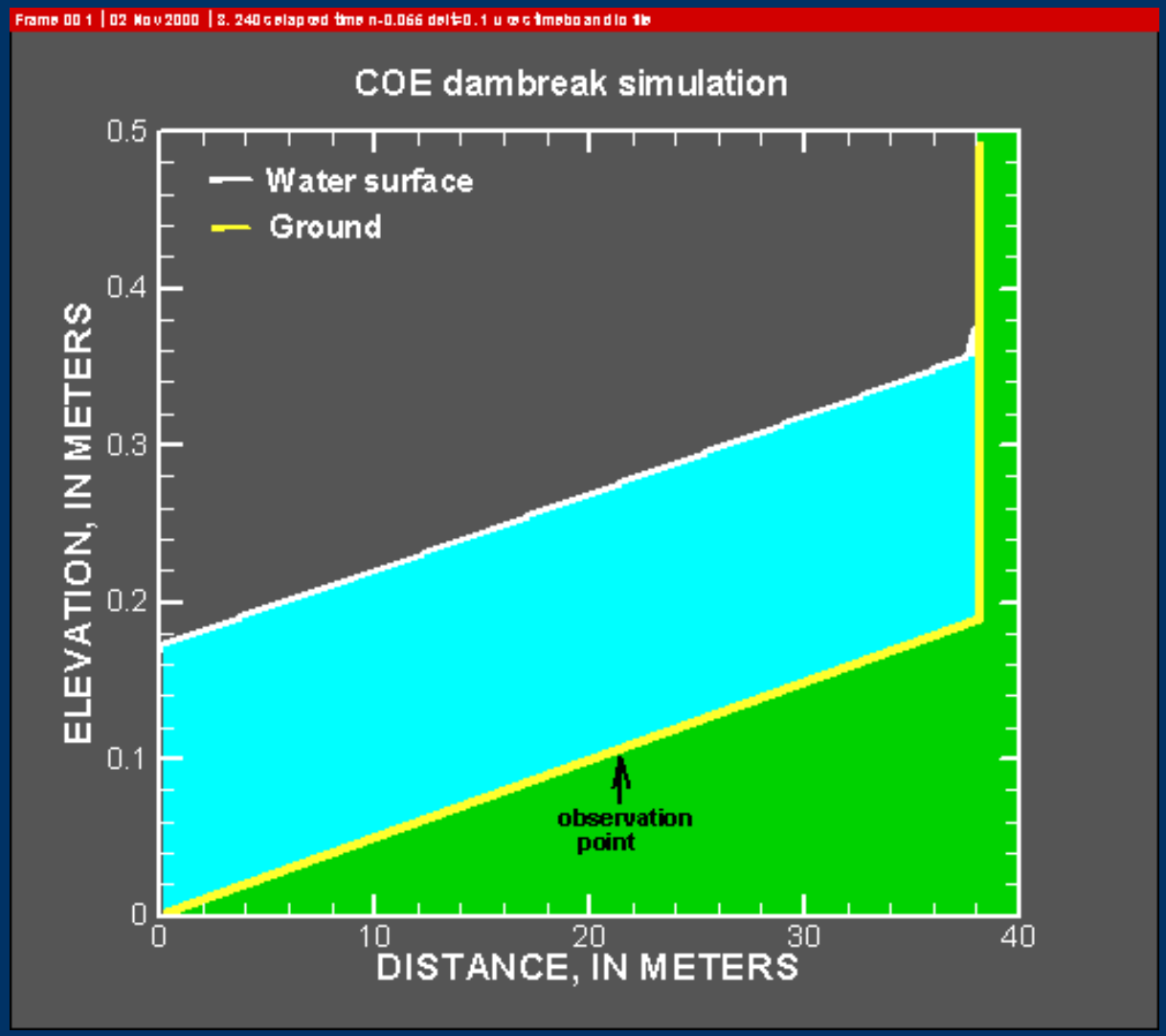
Dam Break Simulations

- Model cells are 0.3048m square
- Two scenarios are simulated:
  - 38.1m reach downstream of dam
    - 6 x 125 cells with time step of 0.1 sec
  - Impoundment and downstream of dam
    - 6 x 314 cells with time step of 0.01 sec

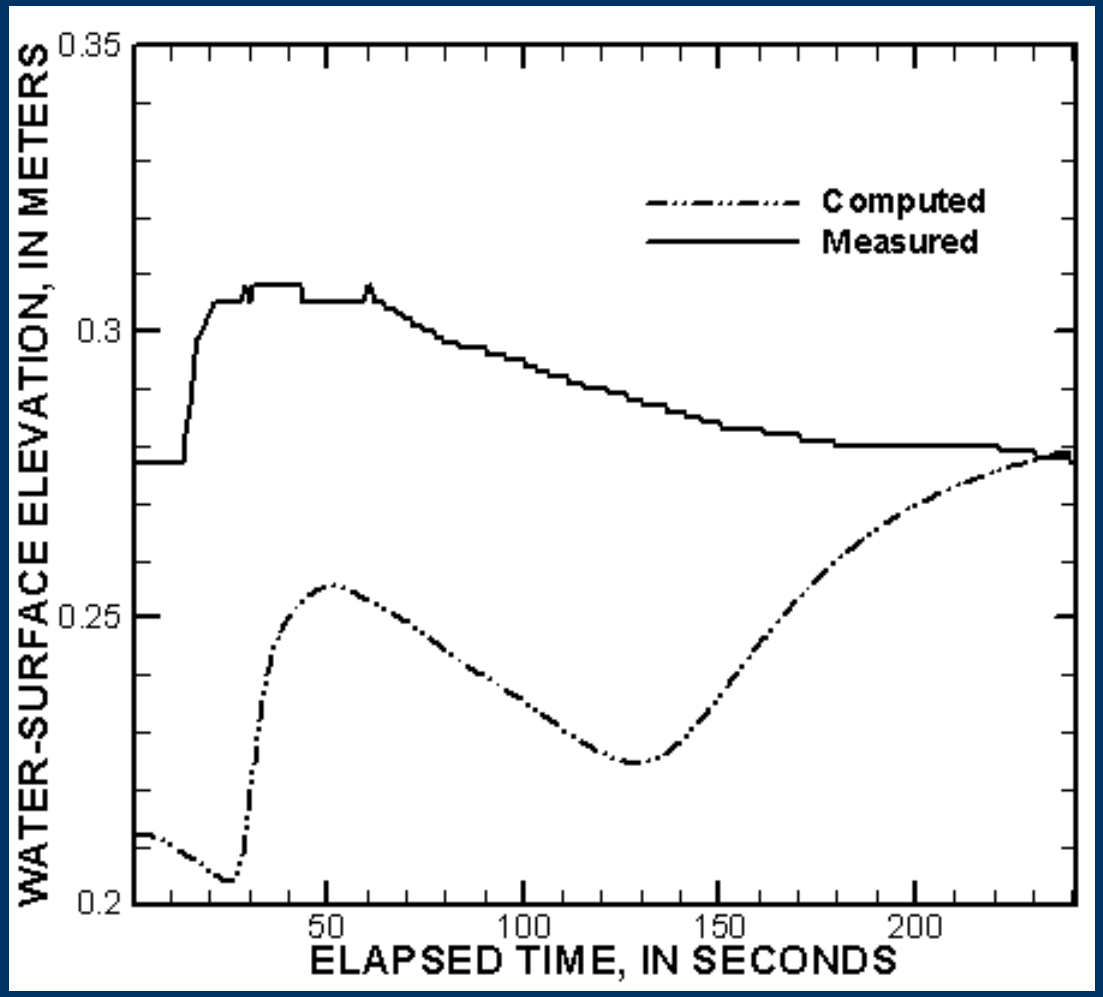
Hydrograph 70ft from outflow
(reach downstream of dam)



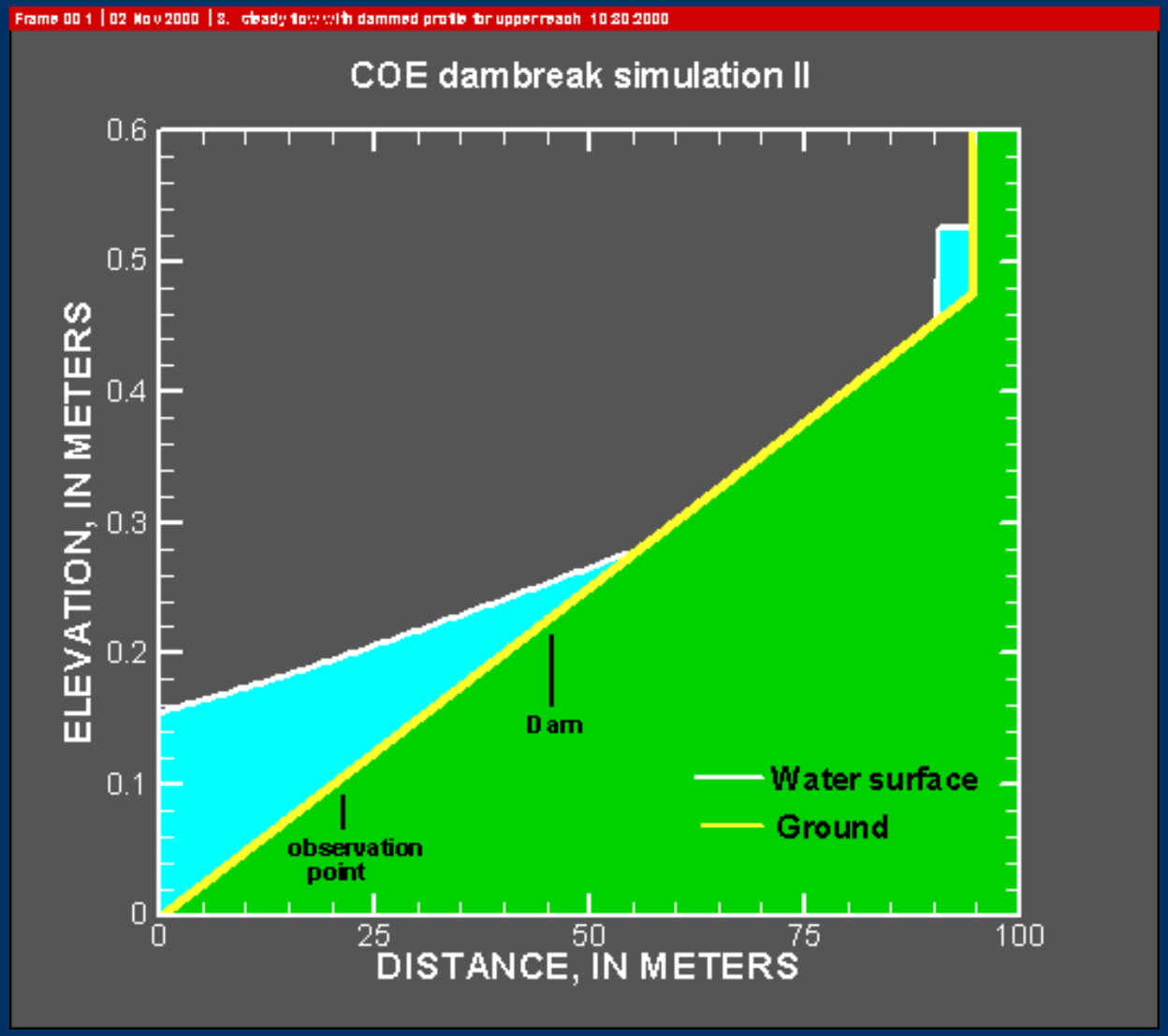
Dam Break Animation #1



Hydrograph 70ft from outflow
(impoundment and reach downstream of dam)



Dam Break Animation #2



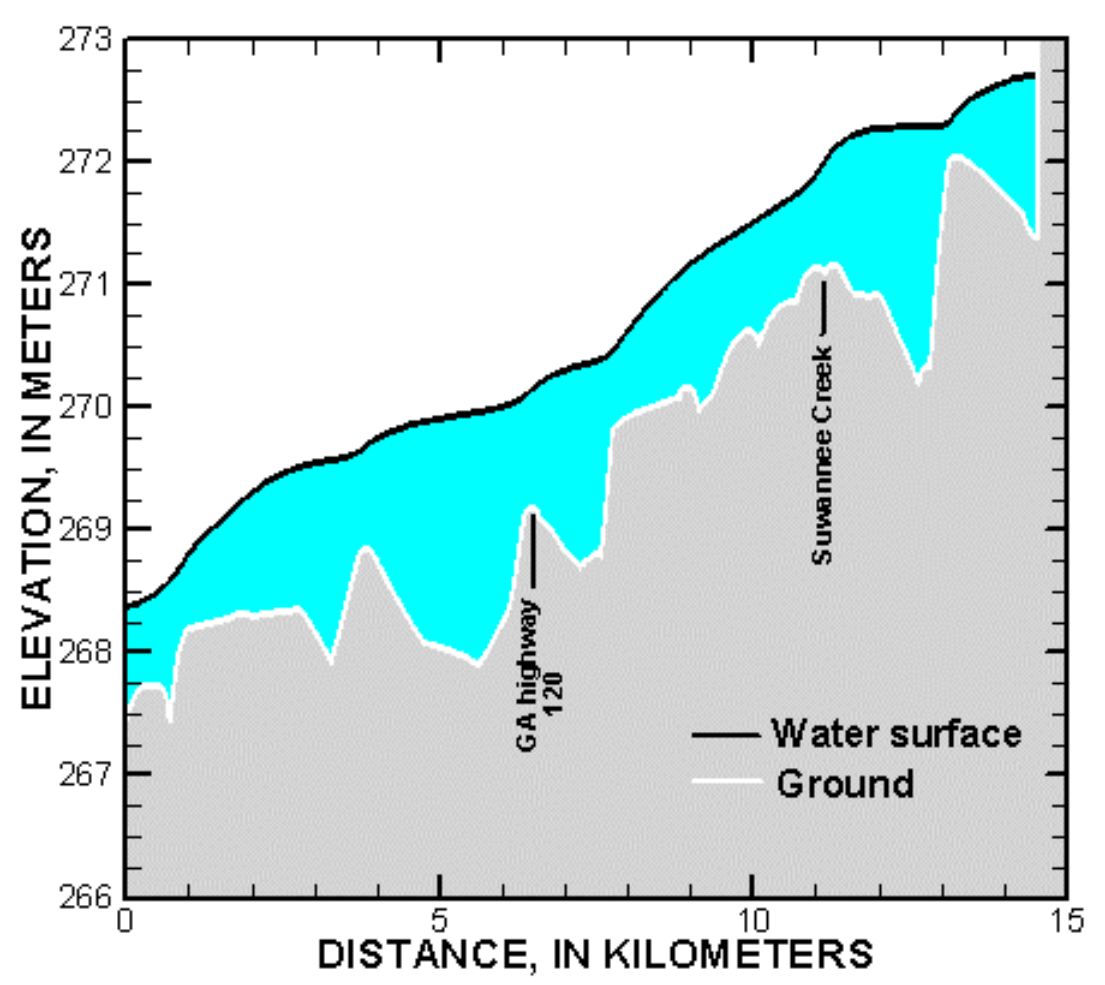
Chattahooche River
(U.S. Geological Survey)

- Reach is from Littles Ferry Bridge to GA Highway 141 (15 kilometers)
- Time period is March 22-23, 1976 (2250 minutes
- Two peaks occur, broad and sharp

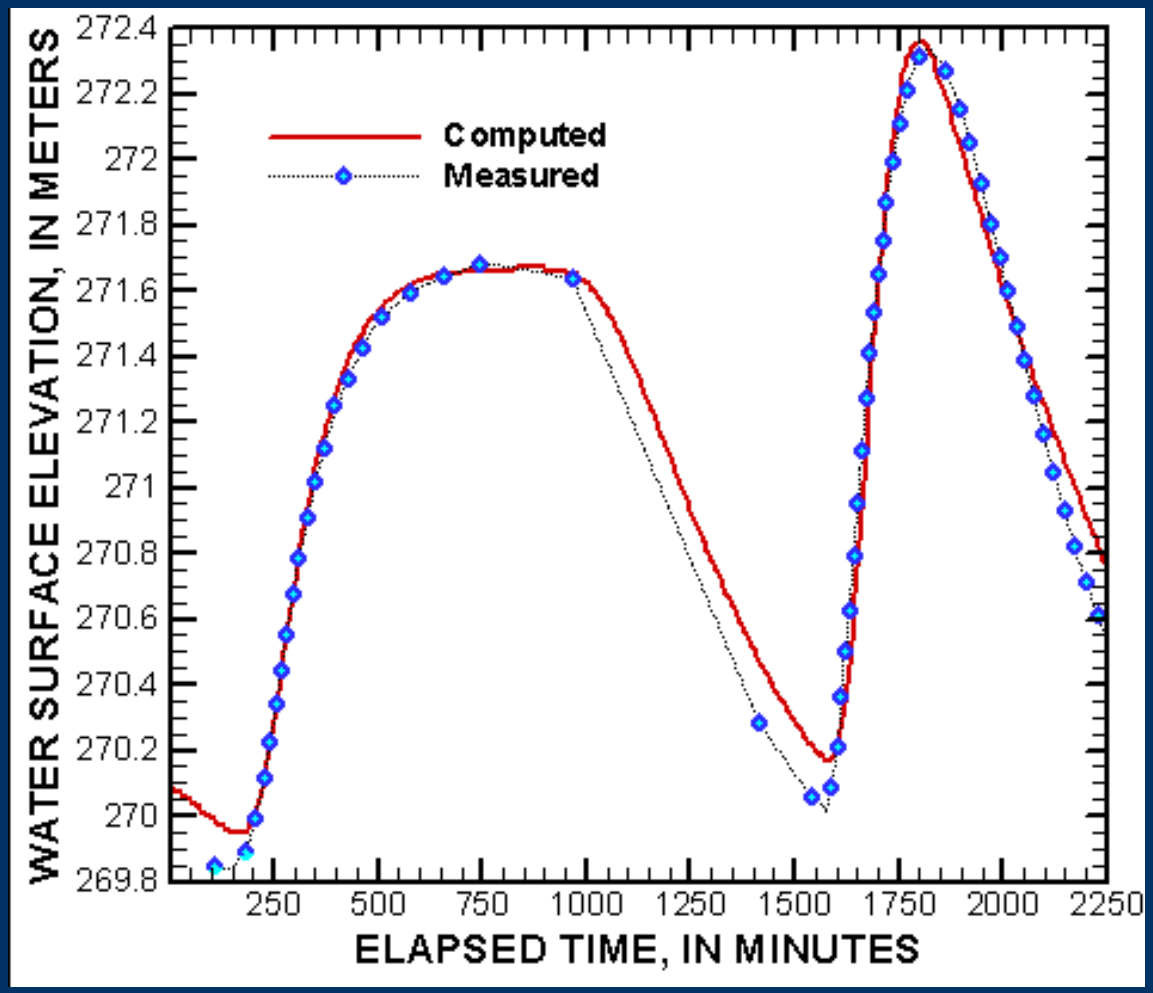
Chattahooche River Simulation

- Model is 22 by 2999 cells
- Cells are 4.8768m square
- Time step is 2 seconds

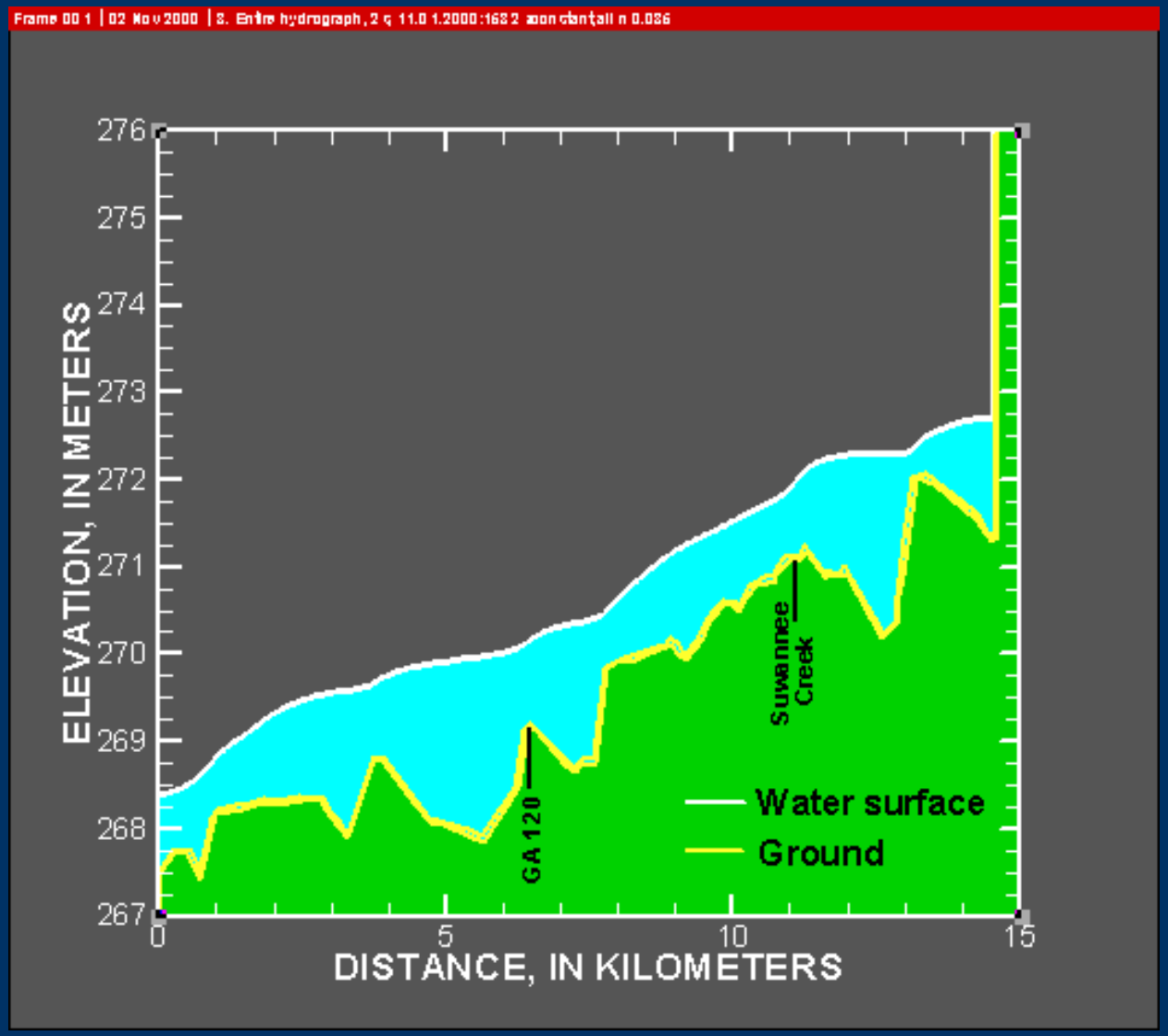
Initial Water-Surface Elevations



Hydrograph at GA Highway 120



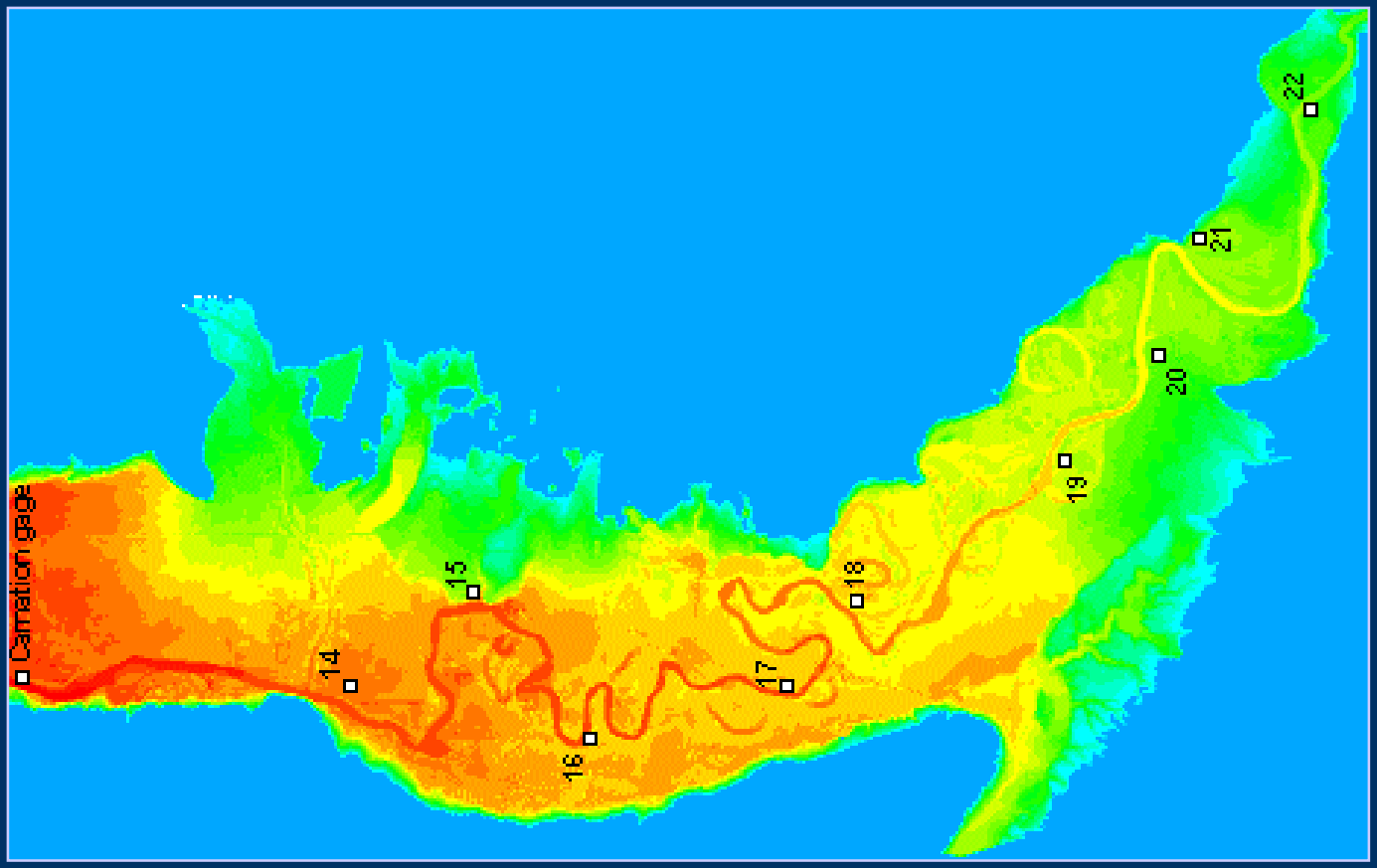
Chattahooche River Animation



Summary of Testing

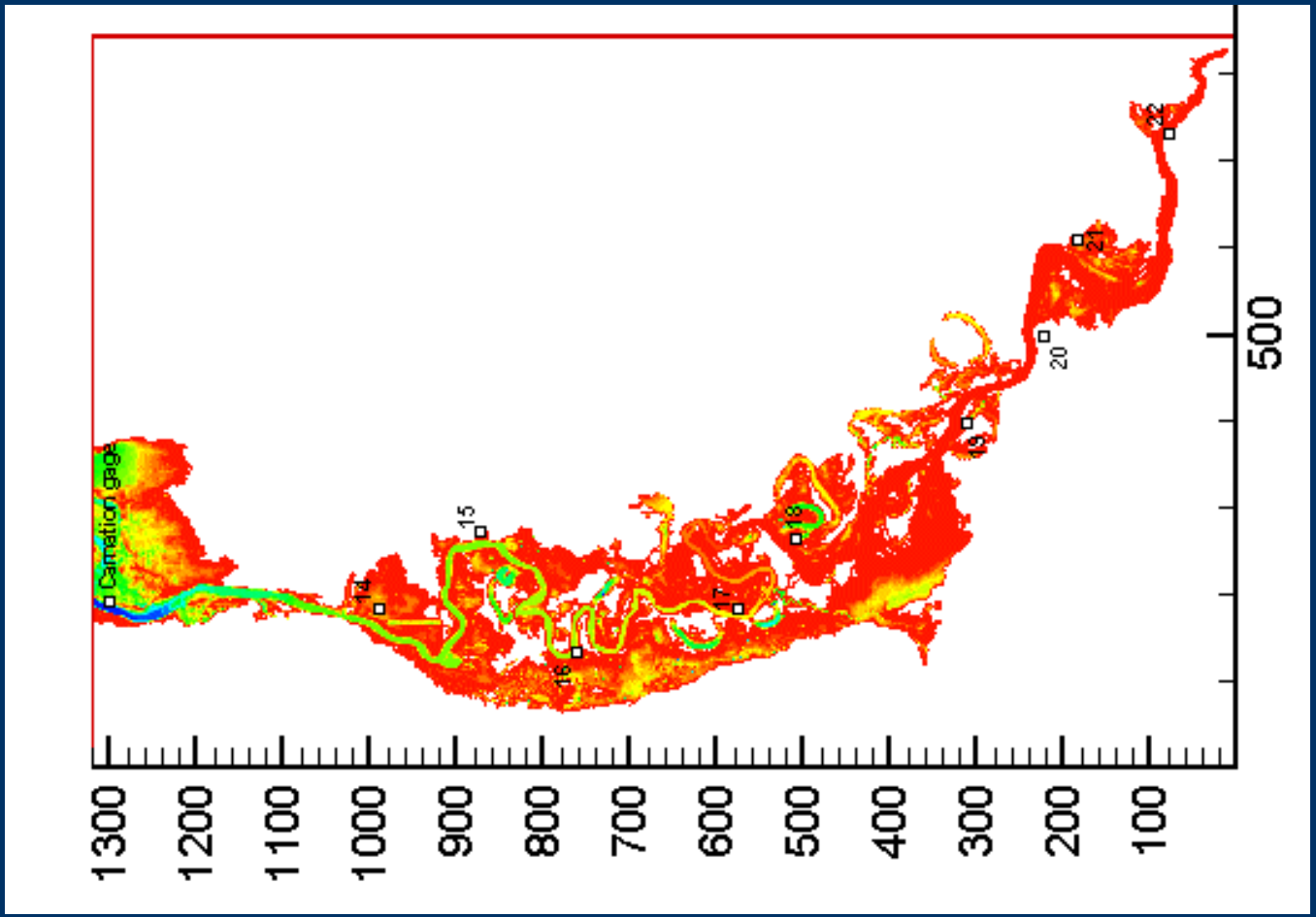
- Friction effects handled appropriately
- Doesn’t crash easily
- Wets and dry cells easily
- Compares well with measured data for real rivers
- DEM data should work well for grids

Application: Snoqualmie River



Lidar topography

Application: Snoqualmie River



Calibration status

Indirect Discharge Tool

Discussion

- PROS and CONS