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DEVELOPMENT OF AN INUNDATION MAPPING CAPABILITY USING HIGH RESOLUTION FINITE ELEMENT MODELLING

by

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Previous Position

At the time of the last report (June 1996) the new topographic data for the Missouri model reach, between Gavins Point and Maskell, had just been applied to the model. The high quality topographic data and relatively high resolution of the model enabled an accurate representation of the river bed. The process of running the model towards a steady state, a prerequisite for fully dynamic simulations, had just begun.

Current Position

Since the previous report significant progress has been made. This has taken two main forms, firstly large quantities of data have been supplied to Bristol consisting of flow records for long periods and synchronous satellite images. The corrected datum level for the Maskell gauge site has also been obtained enabling the downstream model boundary to be specified accurately. Secondly the modelling study has progressed to the point of running specific simulations, facilitated by the new data.

The flow data consisted of four discrete time periods between 1984 and 1995. The data was recorded hourly by the gauges at Gavins Point (flow), Scotland (flow and stage), Maskell (stage), Yankton (flow and stage) and Gayville (stage). The flow data from Gavins Point and Scotland is used as the upstream boundary to the model and the stage level at Maskell is the downstream boundary. The data from Yankton and Gayville can be used for validation purposes. One satellite image was supplied for each of the four time periods (2 SPOT, 2 LANDSAT TM).The new data is summarised in Table 1, previous data for 1993 is not included.

The different data available and hydrological conditions for each of the four periods affects how it can be used in the modelling study. The lack of stage data in 1984 and not having an image of the model reach in 1995 mean there is little point simulating these records at present as one of the study objectives is model validation using stage values and satellite imagery. The very low flows around the time of the 1991 image could cause some problems with the model therefore the first data set to be simulated was chosen to be that of 1994. The data for this period is almost complete and the image covers the entire reach.

Close inspection of the flow data within several days of the 1994 image revealed there was very little (<2%) variation in the data set. This enabled constant inflows, of 905m3/s at Gavins Point and 45 m3/s from the James River and a constant downstream stage value at

Maskell to be used to simulate the flow regime at the time of the image. The model was run using a 4 second time step until a steady state was achieved where the inflow equals the outflow, taking into account a mass conservation error of less than 1%. The bed friction was represented as a constant value over the whole computational domain.

For this section of the flow record a brief sensitivity analysis has been carried out. This assessed the relative sensitivities of the bed friction, turbulent viscosity and inflow. The parameter with the greatest influence by far on all the levels of model output was shown to be the bed friction (Figure 1). On a very general level the model runs did pick out the coarser features on the satellite imagery, for example large sand banks and the route of the main channel (Figure 2). On a more stringent level comparing the results to the observed stage data at Yankton and Gayville provided a good estimate of how well the model performed. The observed water surface elevation at both points fitted within the range predicted by varying the bed friction parameter within reasonable bounds (Figure 3). The range of the bed friction parameter was used as a simple way to reflect the uncertainty in the modelling system at this time, stemming from small but perhaps cumulative errors in process, topographic and parameter representation.

Given the simplistic representation of the bed friction and fairly coarse resolution of the model this is a very encouraging result. It illustrates the potential of 2D distributed modelling to predict river flows in complex environments. Further detailed study of these results and future model runs should enable the a fuller picture of model performance to be attained and improvements made.

Future Work

The following tasks will be undertaken:

1. Carry out more detailed model calibration and validation against satellite imagery and internal stage values.

2. Assess the influence of topographic data and mesh resolution on the model results.

3. Run simulations for the 1991 and possibly 1984, 1993 and 1995 events.

Table

Year	Duration Of Record	Date and Type of Image	Comments
1984	4 months May - August	June 26th LANDSAT TM	Flood flows. No data for Yankton or Maskell. Gayville only daily stage values. Scotland data stops midway.
1990 - 1991	4 months December 1990 - March 1991	February 8th SPOT	Very low flows. Image covers downstream from Yankton.
1994	5 months April - August	June 6th LANDSAT TM	All data present. Unremarkable flows.
1995	6 months July - December	October 25th SPOT	Image has no overlap with the modelled reach.

Table 1 - Summary of the data supplied recently to Bristol

Figure Captions

Figure 1 - Results from the sensitivity analysis. Relative parameter values are utilised to allow comparison between parameters, 1.0 being the highest value, 0.0 the median value and -1.0 the lowest value of each parameter taken from reasonable ranges for this application. Three different results were looked at in the sensitivity analysis, (a) inundated area over the whole domain, (b) predicted minus observed stage values at Yankton and (c) Gayville. All three clearly show that bed friction is by far the most important parameter, outdoing even a +/- 10% variation in flow rate into the model.

Figure 2 - Predicted water depths over the model reach from Gavins Point Dam to Maskell. This plot clearly illustrates how well the model represents large scale topographic features such as the main channel and sand banks. The bed friction parameter for this run was a uniform value of Mannings 'n' of 0.025. As expected alternative parameterizations do create slightly different patterns of inundation.

Figure 3 - Observed and predicted water surface elevations for Yankton, Gayville and Maskell. The upper point at Gavins Point has no observed value and at Maskell, the lowest point, the predicted values are set to equal the observed as a model boundary condition. The low friction run has a uniform Mannings 'n' value 0.01 and the high friction run a value of 0.04.

Figure 1a

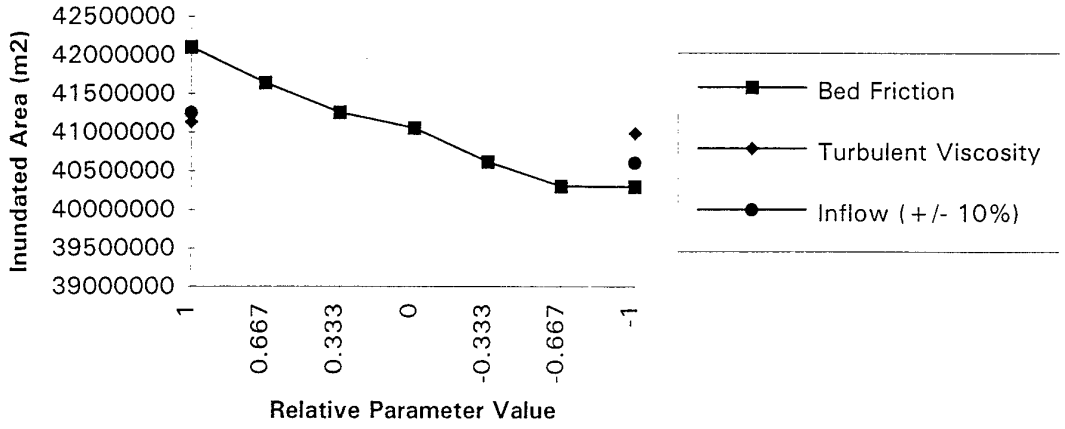


Figure 1b

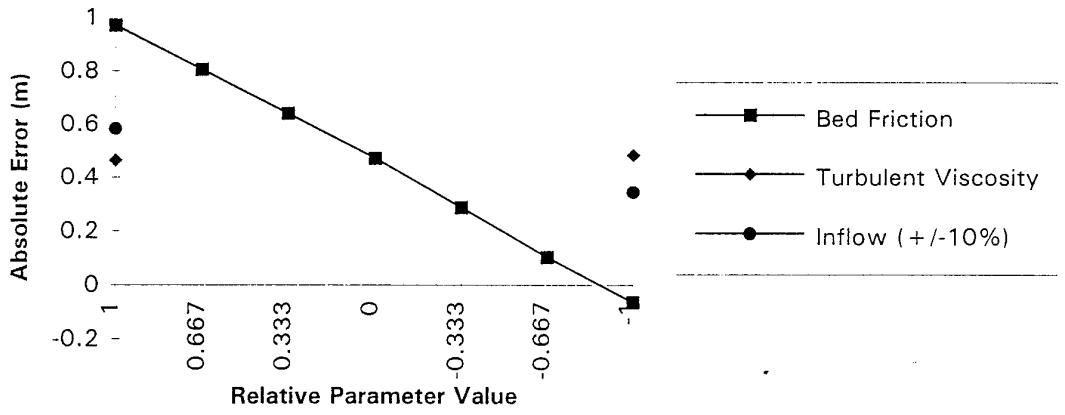


Figure 1c

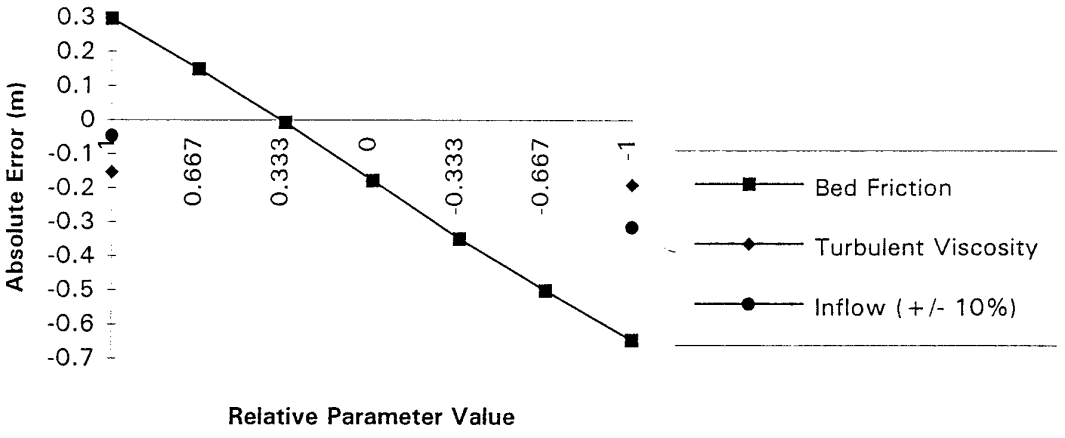


Figure 2

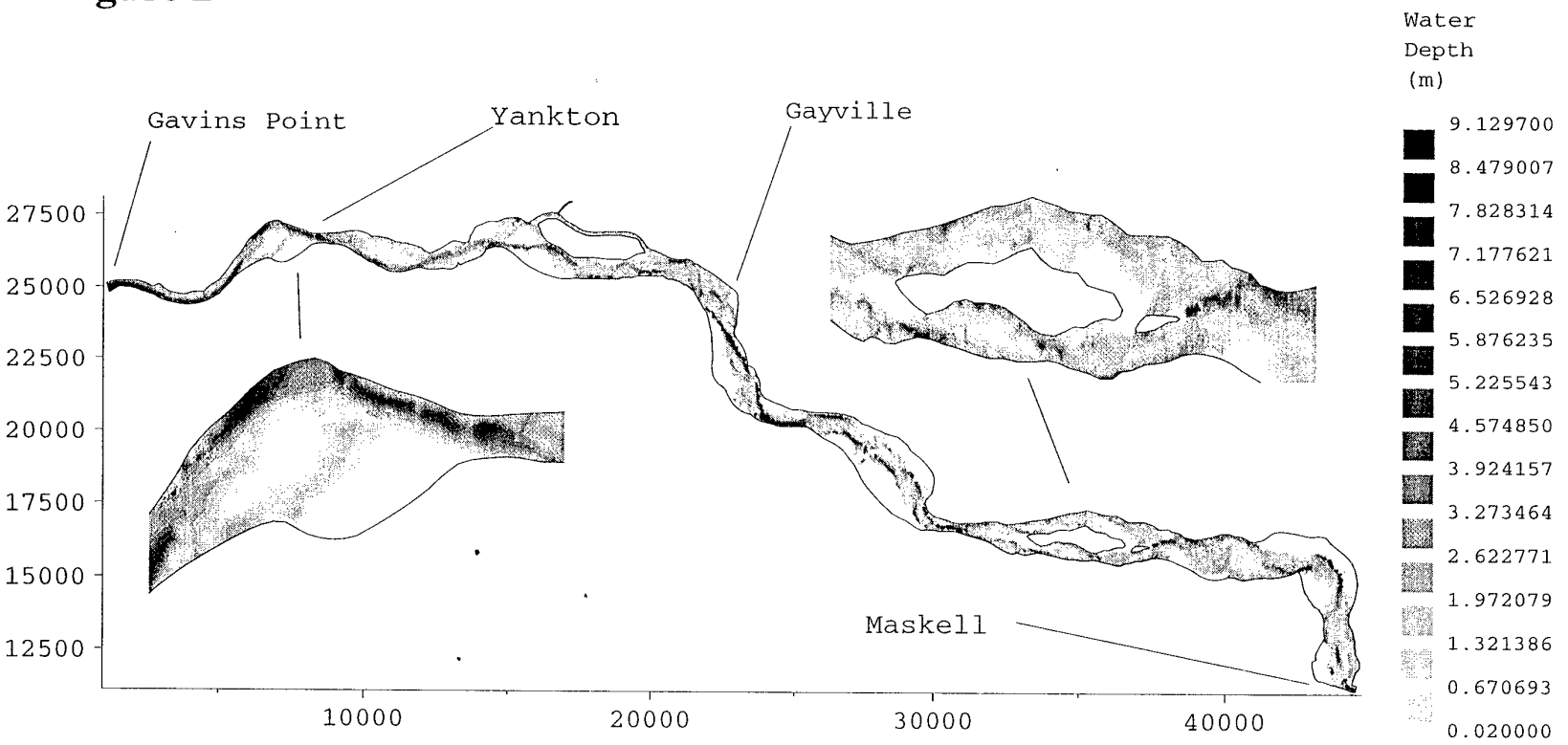
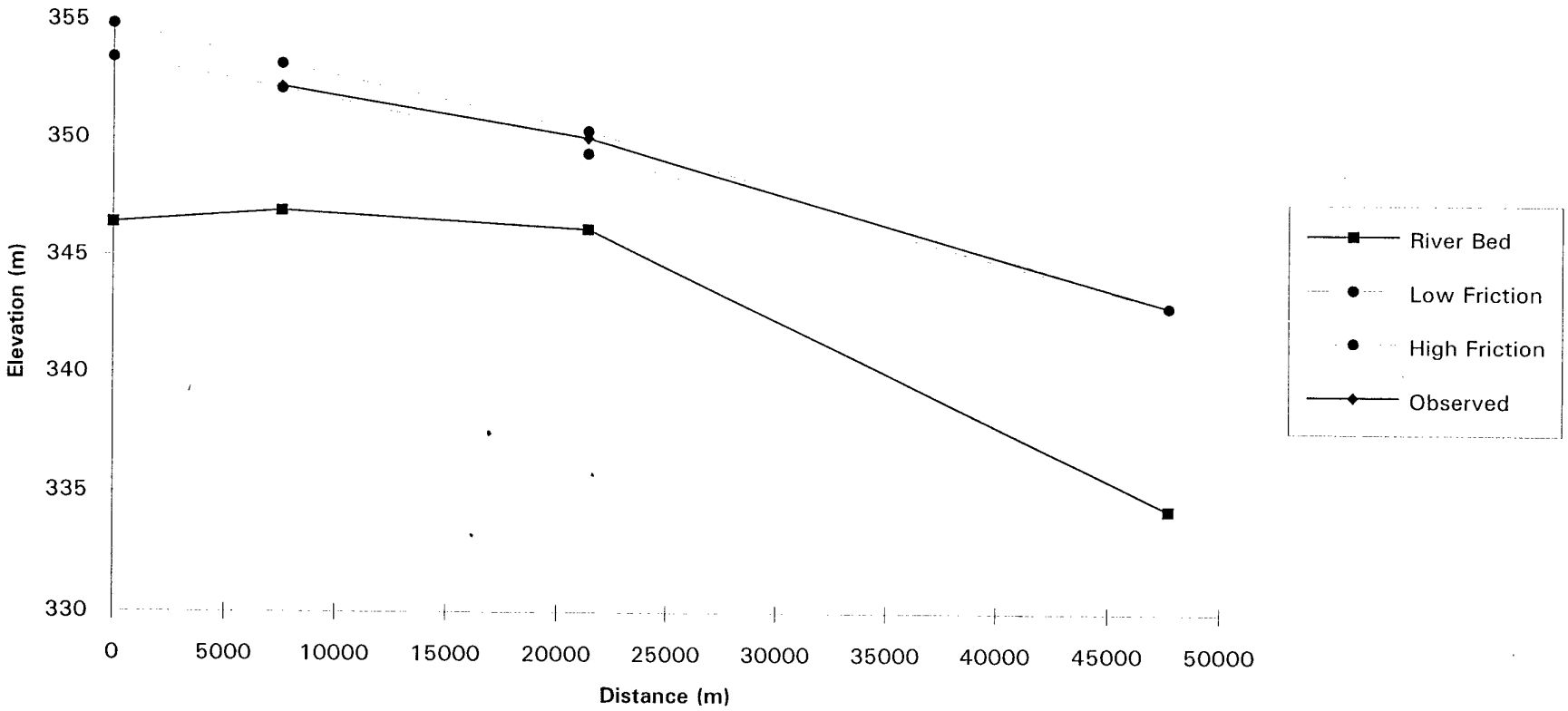

Gavins Point
Yankton
Gayville
Maskell
27500
25000
22500
20000
17500
15000
12500
10000
20000
30000
40000
Water
Depth
(m)
9.129700
8.479007
7.828314
7.177621
6.526928
5.876235
5.225543
4.574850
3.924157
3.273464
2.622771
1.972079
1.321386
0.670693
0.020000

Figure 3


355
350
345
340
335
330
Elevation (m)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Distance (m)
River Bed
Low Friction
High Friction
Observed