THE HYDROVISION GRAPHICAL USER ENVIRONMENT

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THE HYDROVISION GRAPHICAL USER INTERFACE

HydroVision was developed to support computational models of free surface flow with transport phenomena and sedimentation processes. In particular, HydroVision was developed to support the family of models developed at the CCHE based on the efficient element method of Wang & Hu (1992). These models all use a structured grid system for the discretization of the study domain. The current version of HydroVision, which is in Beta release, supports the depth integrated unsteady model known as CCHE2D. HydroVision provides graphical support of grid generation, specification of initial and boundary conditions, simulation control/ monitoring, and visualization. Each of these will be discussed further in the following sections.

Grid Generation

HydroVision has been developed to support both near field modeling of hydraulic structures and far field modeling of longer reaches of natural rivers. Because of this, there are two grid generation methods. The first method, for the near field problem, utilizes an automatic grid generator know as FEMesh. In this method, the user specifies the outer boundary geometry and then relates points on this boundary to points in the logical (IJ) domain. The grid generator then fills in the interior grid. In this case, bed elevation may be specified as a collection of random points with elevation, which are used by FEMesh to determine the bed elevation at each computational node.

The second method, for support of the simulation of natural rivers, reads in a series of survey cross section data and bank elevation points. The grid is automatically generated and bed elevation is interpolated between cross sections. This method requires minimal interaction with the user.

For either method, a set of basic grid editing tools are provided. The user can add grid lines, delete grid lines, move grid lines, and move nodes. This is all done through a computer aided design (CAD) interface that allows the user to quickly modify the structured grid system.

Boundary and Initial Conditions

Proper specification of boundary and initial conditions is, of course, critical to obtaining reasonable results. HydroVision currently allows graphical specification of initial bed roughness and free surface elevation. Initial bed elevation can be specified graphically, using a digitized map or photograph, if cross section survey data are not available. Boundary conditions can also be specified graphically allowing the user to visually inspect the inlet and outlet boundaries.

The CCHE2D model implemented with HydroVision currently only allows one inlet boundary and one outlet boundary. The interface allows the inlet and outlet to be set by simply selecting nodes with a mouse pointer. There are currently three types of inlet boundary conditions: the user can specify a specific discharge and flow direction at each node of the inlet section; a total discharge can be specified across the inlet boundary; or a total discharge hydrograph can be specified at the inlet boundary. Two types of outlet boundary conditions are allowed: a free surface profile can be specified across the outlet boundary, or an open boundary condition can be used for unsteady flow conditions.

Simulation Control and Monitoring

HydroVision allows the user to start a simulation and interact with it as it proceeds. The user can select several monitor stations in the study domain, where the time histories of the computations are saved and can be viewed as response vs. time plots during the simulation. The normalized maximum change of velocity and water surface elevation are displayed and automatically updated as the simulation proceeds, as shown in Figure 1. This allows the user to find problems in the results during the simulation, rather than waiting until the simulation is complete to post process the results.

The model can be stopped whenever there is a need to modify the boundary conditions and model control parameters. The model can then be restarted from the last result or from cold start conditions.

Visualization

HydroVision provides some basic visualization capabilities to allow the user to immediately assess the results of the simulation. Scalar quantities are displayed using color filled contours. The gradation of colors facilitates a clear view of the scalar quantity. The computed velocity may be shown as vectors which are colored to indicate the speed of the flow or as single colored lines over laid on a scalar quantity. The user can zoom in and pan around the study domain to examine the results in more detail. Figure 2 shows the interface with the graphics window for a typical case. A postscript image of the graphics window can be produced for presentation purposes.

APPLICATIONS

HydroVision allows full access to the capabilities of the CCHE2D model. A few results are given to illustrate the model's capabilities; these results are taken from the CCHE technical report by Jia & Wang (1997).

Sine Generated Channels

Sine generated channels are used to simulate natural meandering channels. Figure 3 shows the comparison of results obtained by CCHE2D with experiments conducted by A. de Silva (1995). Here there is a general agreement with measurement. The largest difference occurs at the inner bank where the flow is approaching the bend and the outer bank where the flow is leaving the bend. This difference is due to secondary motions caused by the channel curvature which are not currently taken into account by the CCHE2D model.

Natural Channels

The next two figures show application of the model to simulate flow in a natural channel. Figure 4 shows a vector plot of a flow field behind hypothetical spur dikes added to a section of a natural channel. HydroVision allows the user to add features, such as spur dikes, and immediately see the effect on the flow field. Next the simulation of a section of Hotophia creek with a flood wave passing through is shown in Figure 5. This illustrates the application of an unsteady boundary condition. Initially dry areas of the flood plains were inundated and became dry again in the retreating period of the flood.

Sediment Transport

Figure 6 shows comparison of computed results obtained using CCHE2D with channel aggradation flume experiment data (Soni 1981) and channel degradation experiment data (Newton 1951) . In both cases the trends of channel bed change agree with those observed in physical experiments.

CONCLUSIONS

This paper reports the results of a research project for the development and application of a graphical user interface, HydroVision to a numerical simulation program, CCHE2D. It is intended to be a general utility software package. When a command line simulation code is integrated into HydroVision, it becomes part of a graphically user interactive simulation environment. Nowadays, this capability has become a standard requirement for all simulation codes. As described in detail in the previous sections of this paper, the HydroVision interface provides its users with the capabilities of generating and perfecting a numerical grid to discretize the simulation domain, specifying physical and numerical parameters of the system considered, prescribing boundary and initial conditions, monitoring the solution at critical locations and numerical accuracy/convergence over the entire simulation domain, allowing the halt of the simulation process for modifying/correcting parameters and restarting the simulation, and selecting the means for scientific visualization of the final results. It has made the hydroscience and engineering investigation using CCHE2D a truly user-interactive and enjoyable experience. The CCHE2D with HydroVision package is currently under beta-testing. It shall be released to the U.S. federal agencies first, and the general users shortly thereafter.

With this encouraging initial success, it is currently being integrated with the CCHE3D simulation code to model near-field highly complicated three-dimensional flows and local scour development phenomena around in-stream hydraulic control and bank protection structures. Furthermore, the level of sophistication of HydroVision will be continuously enhanced.

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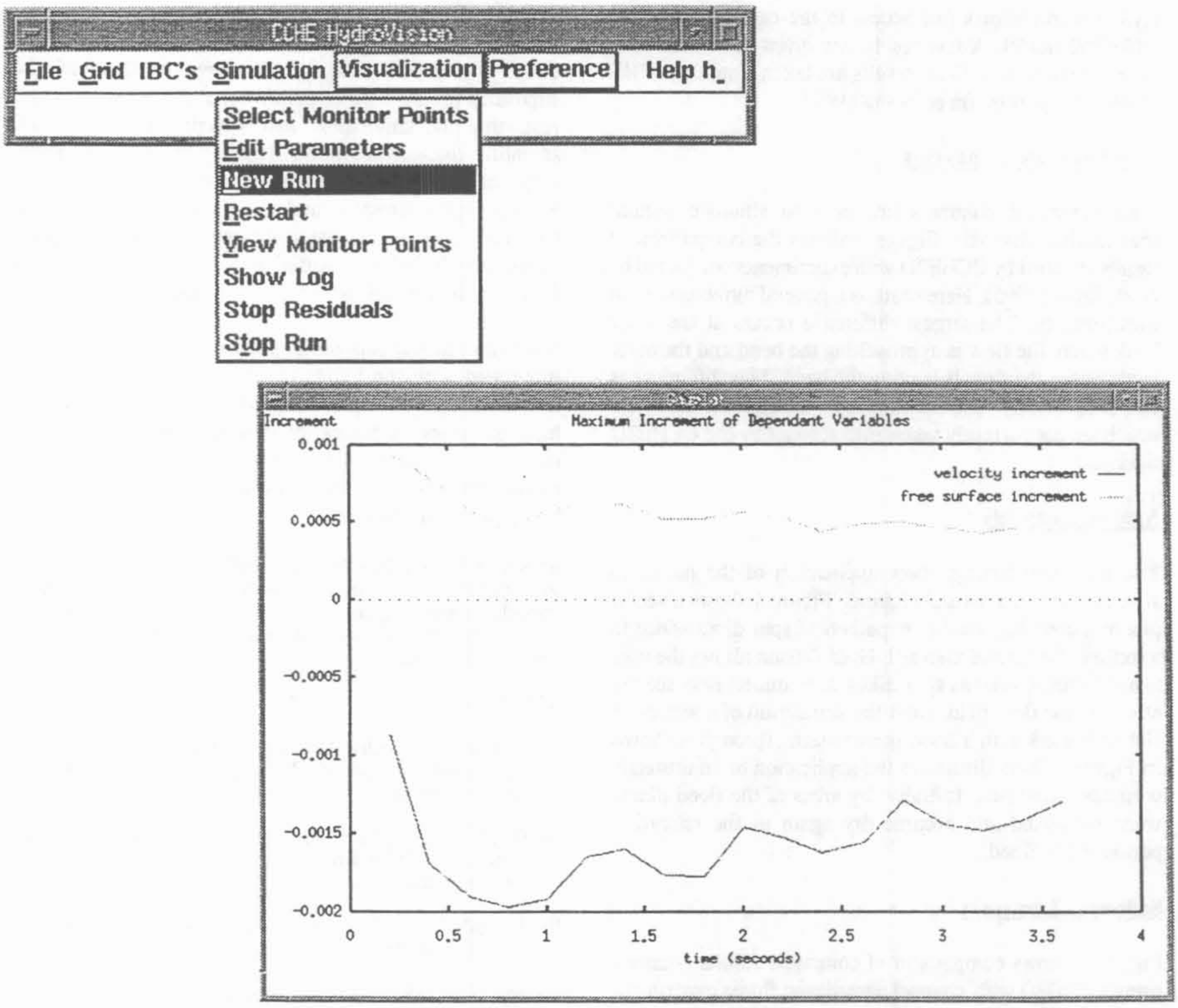

Figure 1 Maximum Error Status Window During a Typical Simulation

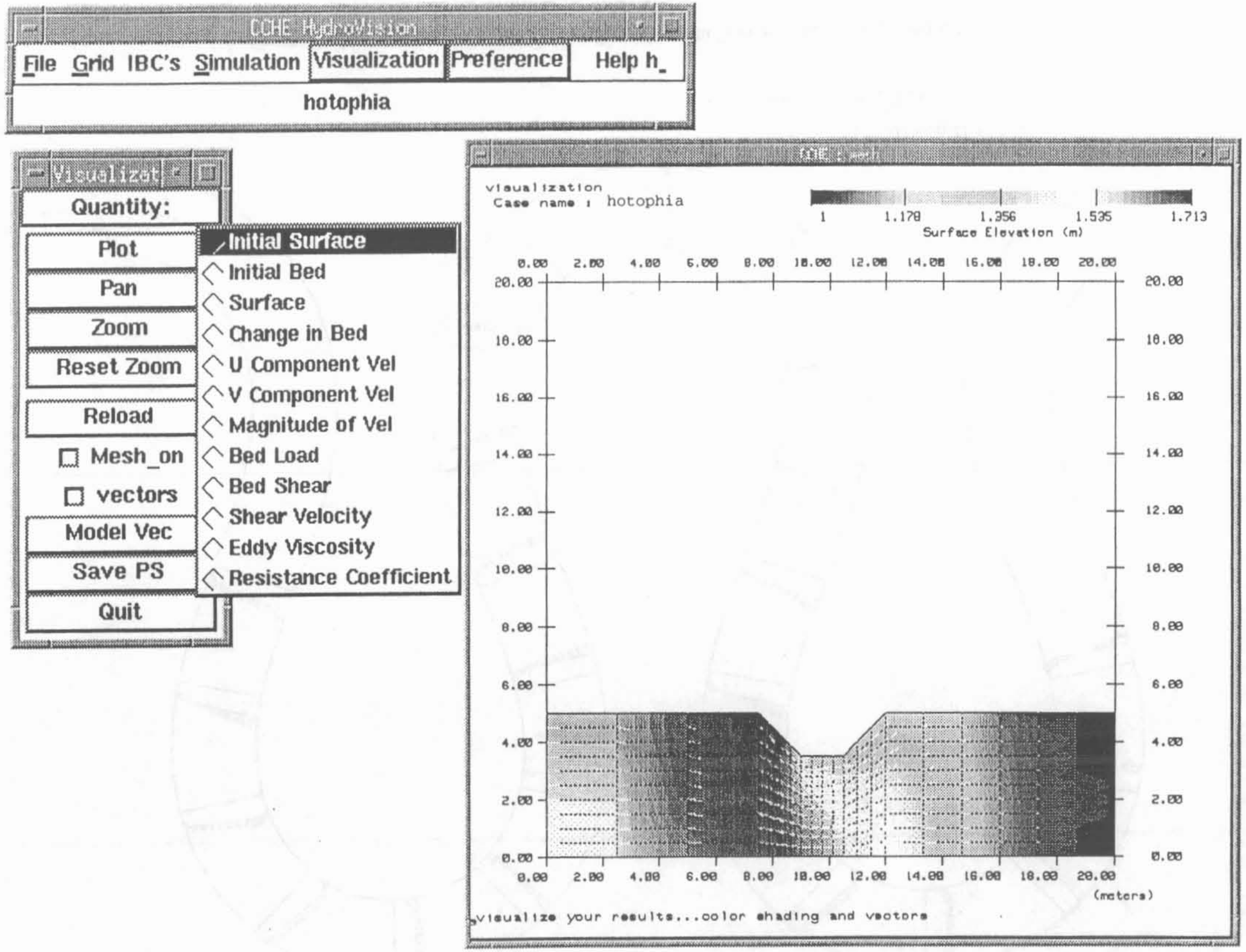

Figure 2 A Typical Visualization

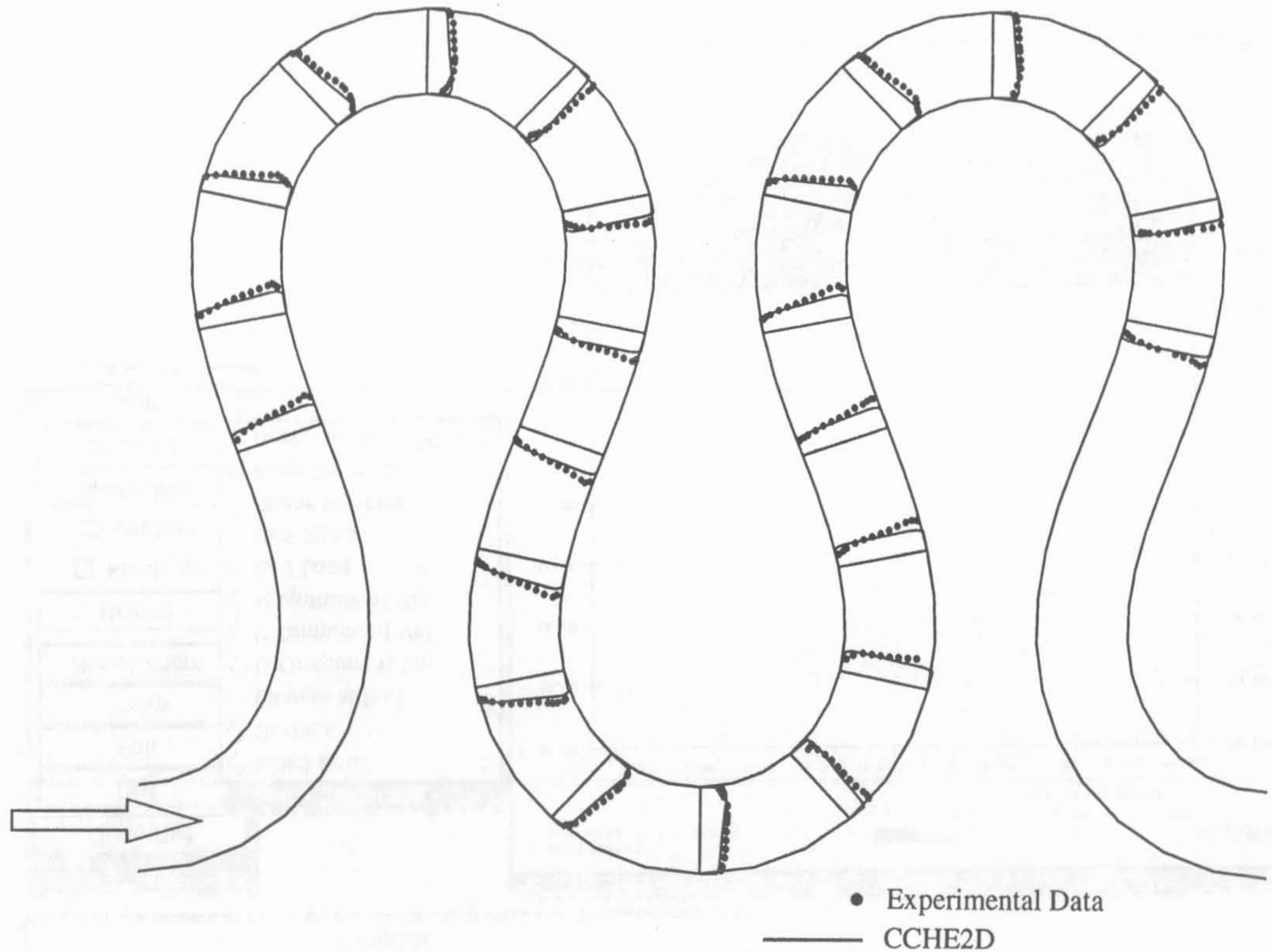

Figure 3 Comparison of CCHE2D with Experimental Data in a Sine Generated Channel

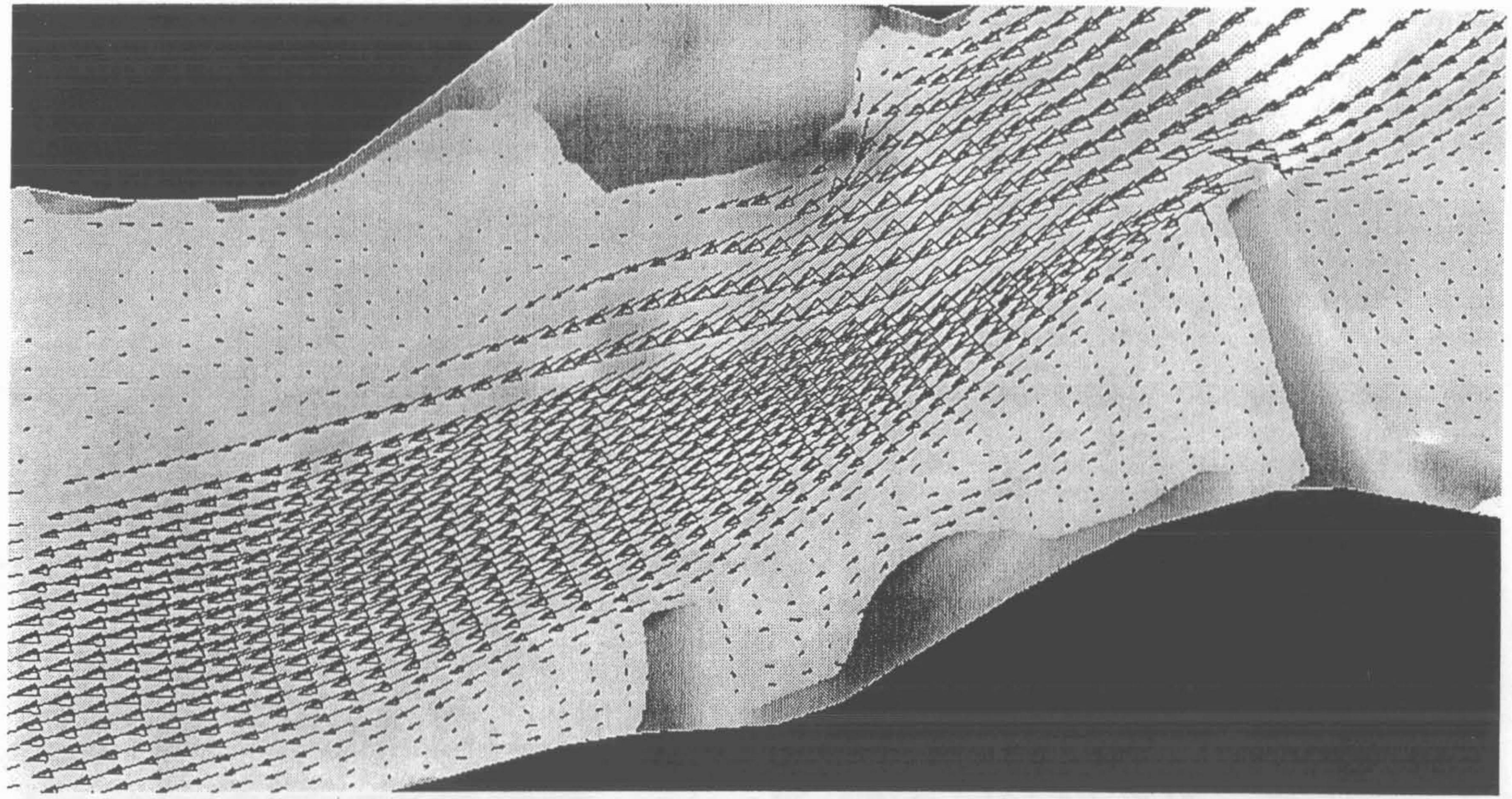

Figure 4   Flow Around Hypothetical Spur Dikes in a Natural Channel

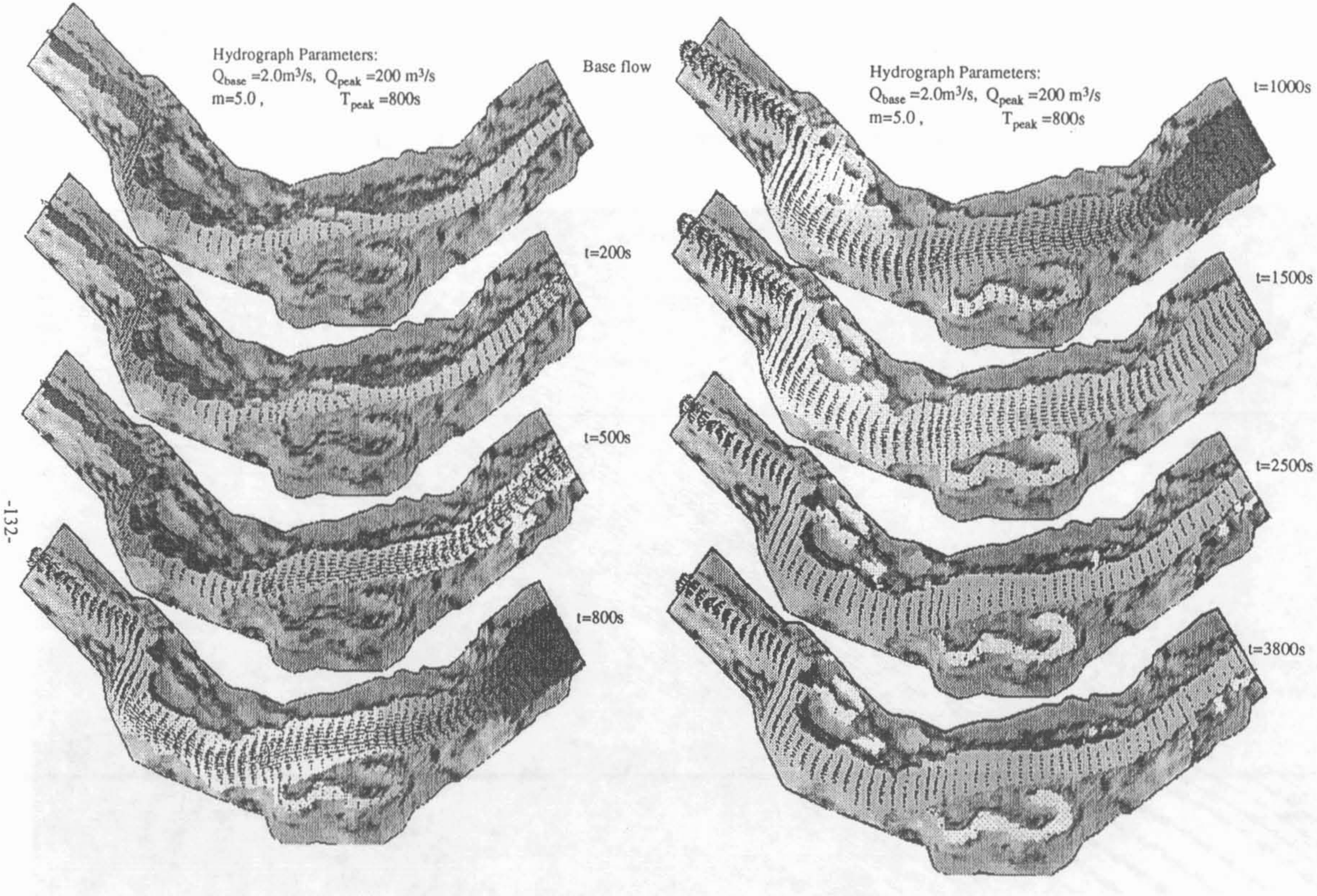

Figure 5 Simulation of Flow in Natural Channels

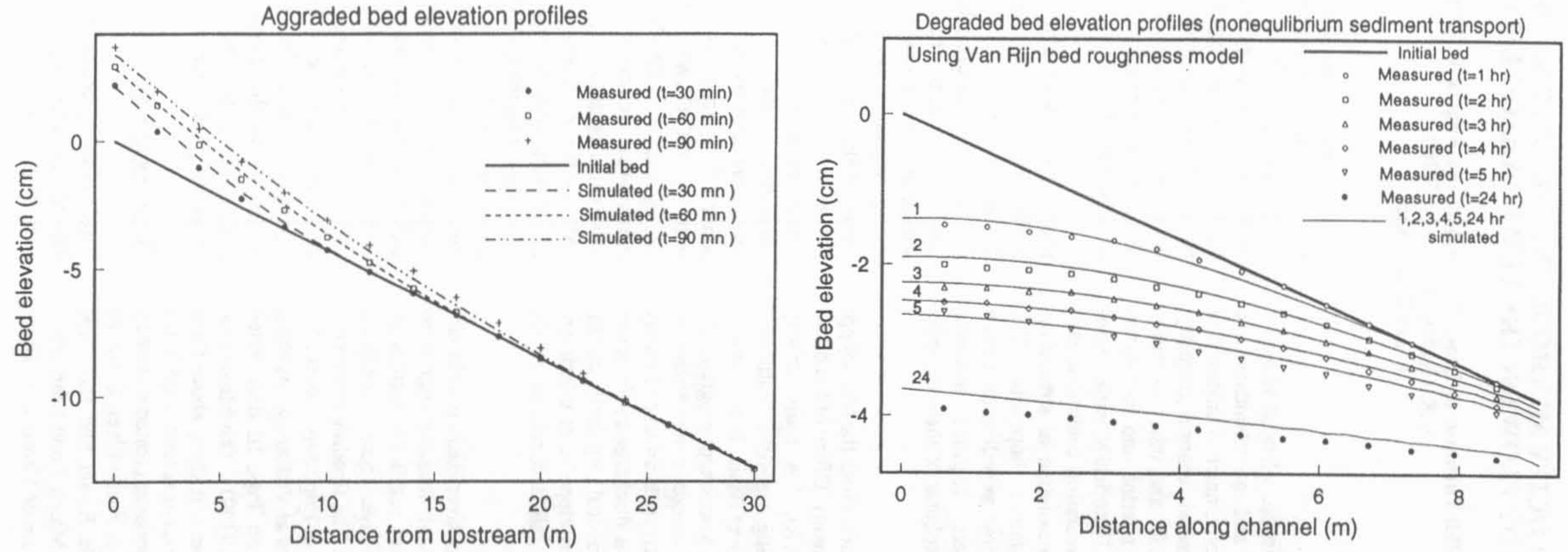

Figure 6 Comparison of CCHE2D with Aggradation and Degradation Experiments