# D-8

# GORDON

## DRAFT 2

inserted modified ver. 8/30

Dave 8/23 See revised ver.

## Operational Variance and Repeatability

added to Comparison Report

The ability of the micro model to repeatedly produce similar resultant bed configurations between identical experimental runs was analyzed using statistical variance. The study was conducted as a means to verify operational repeatability of the micro model. A similar study was conducted by Davinroy (1994) to compare the repeatability of a micro model with a WES model (Dogtooth Bend Model, Mississippi River, Miles 38 to 20). In this study, the operation of the micro model was substantially different than the model operation currently used today. Flow was controlled manually and sediment was introduced at the upper end of the model by hand. Today, flow is controlled by a computerized control system and sediment is automatically re-circulated through the model.

The Jefferson Barracks Micro Model (Mississippi River Miles 176 to 166) was used to study the change or variance in relative elevations of the bed configuration of the base test condition after numerous identical flows were run in the model. The scales of this model were 1:9600 horizontal and 1:1200 vertical, for a distortion of 8. For each run, a constant flow of 0.9 gallons per minute was subjected to the model bed for a variable period of time (1/2 hour average). A total of eighteen experimental runs were conducted. At the end of each run the flow was shut off, the water was allowed to drain, and the resultant bed configuration was surveyed with a three-dimensional laser scanner. The survey data was then processed and converted to real world coordinates with all elevations being referenced to the Low Water Reference Plane (LWRP). Cross sectional plots were then generated at 7 locations over a representative four-mile reach of the model. The variances in elevations produced by the 18 runs were analyzed using statistical variance at each of the sections. Cross sectional plots of the data are shown in Figures 1 through 7.

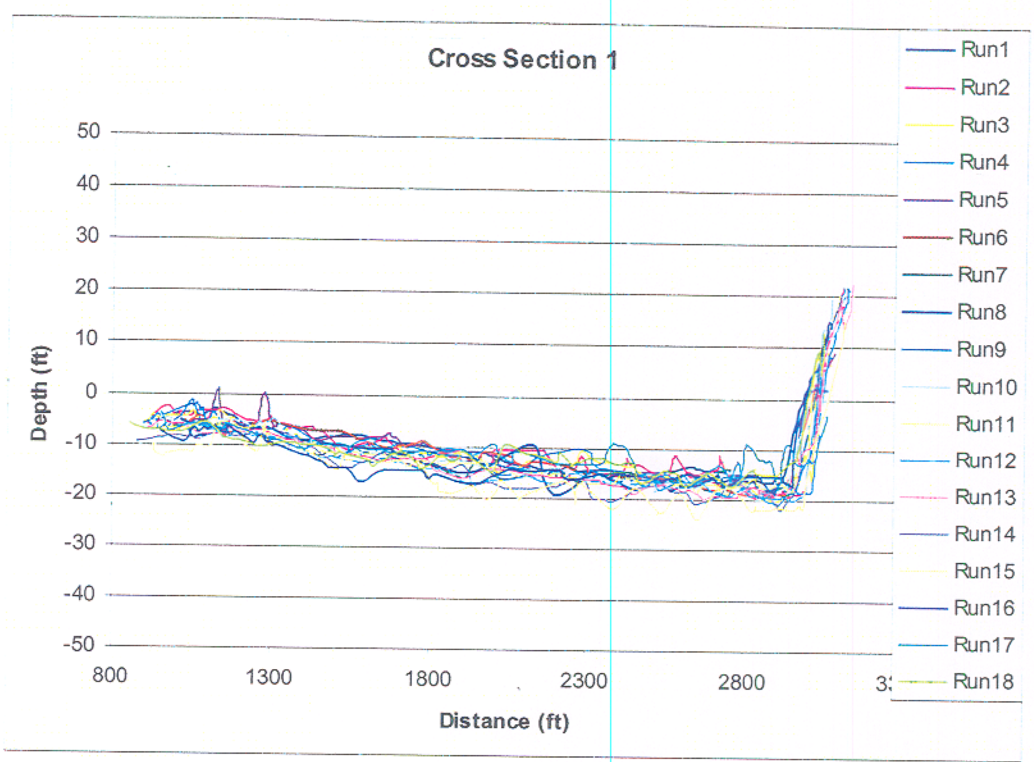


**Figure 1: Cross Section #1**

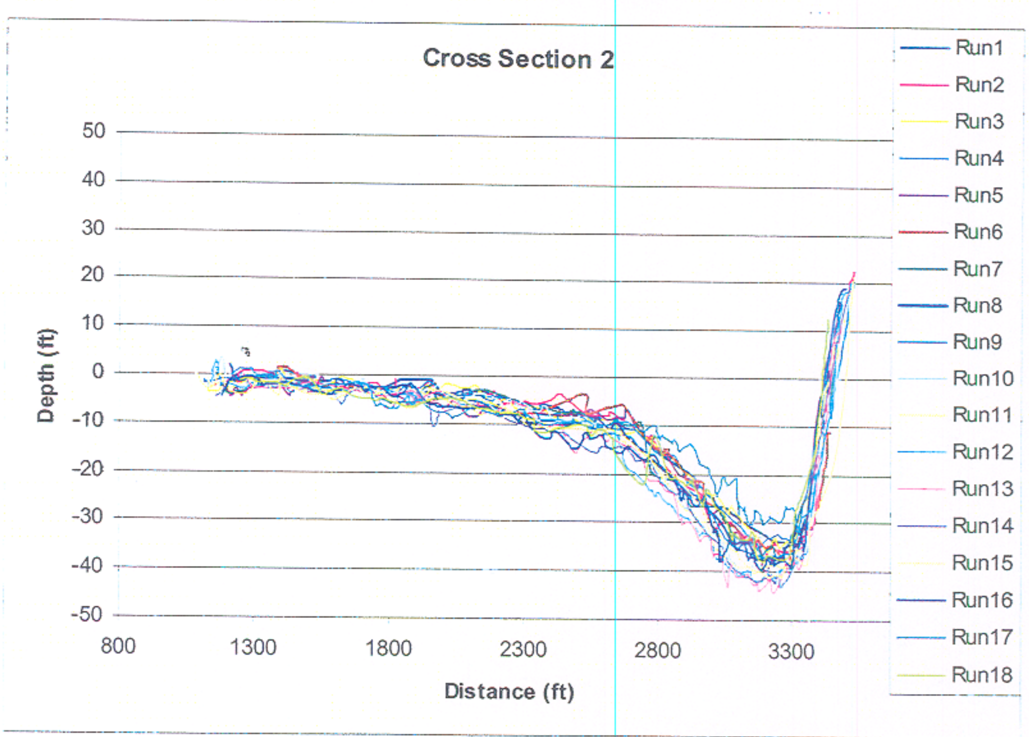


**Figure 2: Cross Section #2**

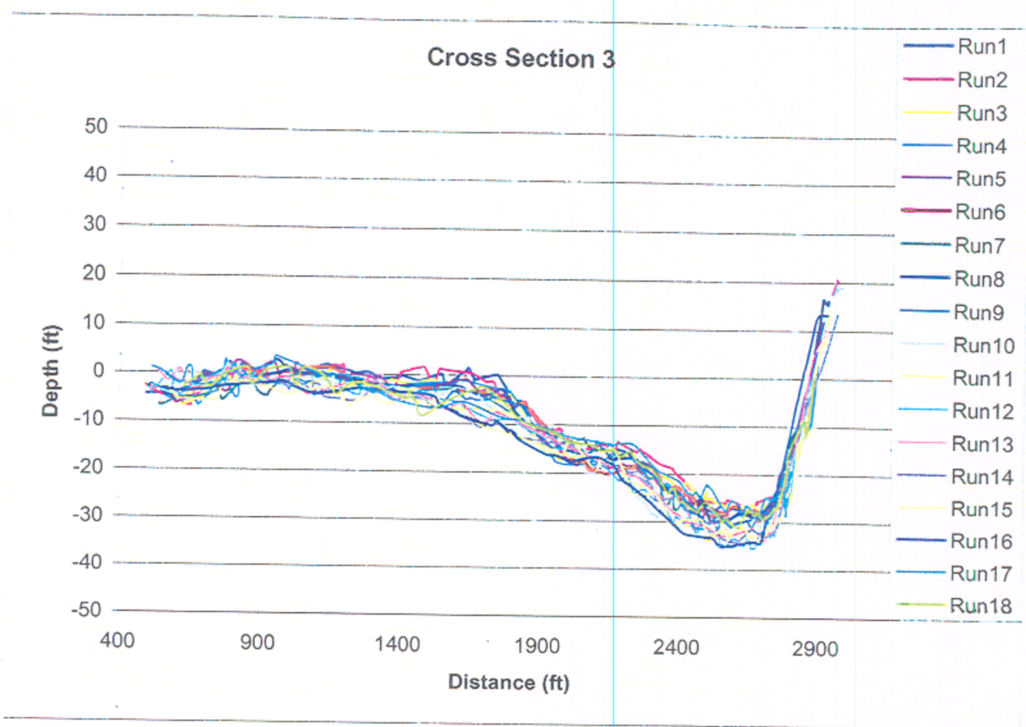


**Figure 3: Cross Section #3**

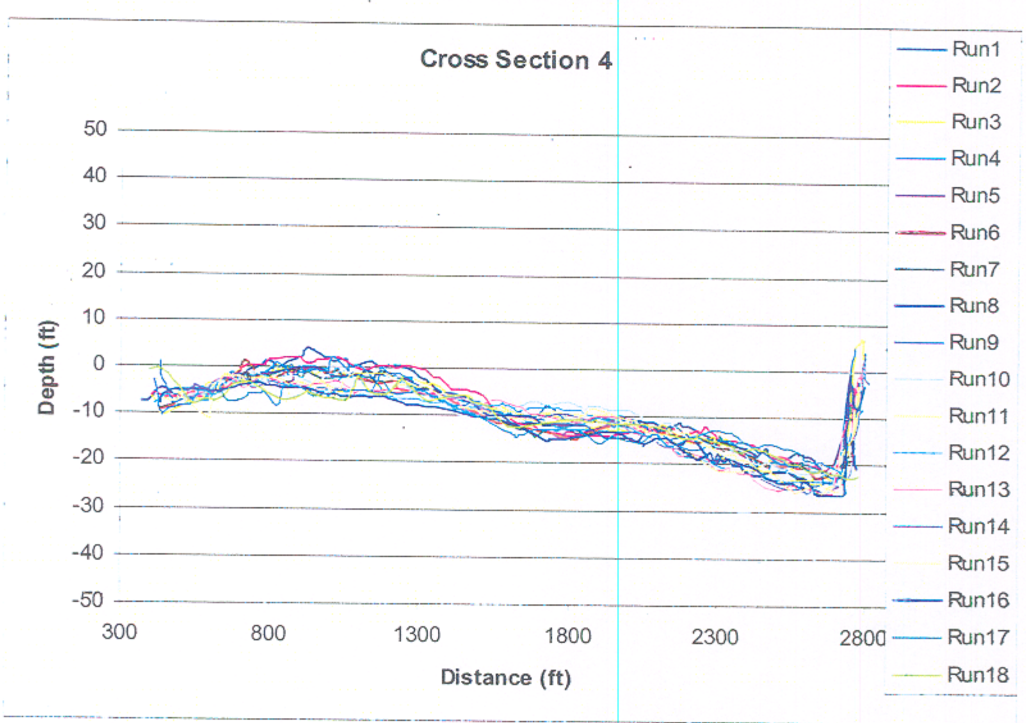


**Figure 4: Cross Section #4**

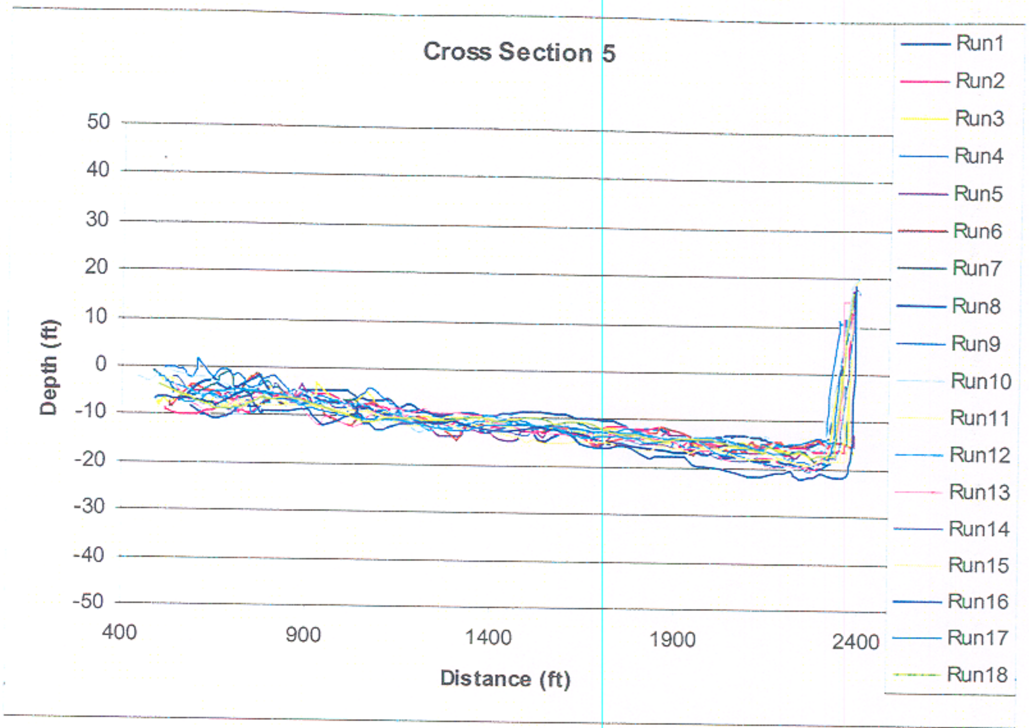


**Figure 5: Cross Section #5**

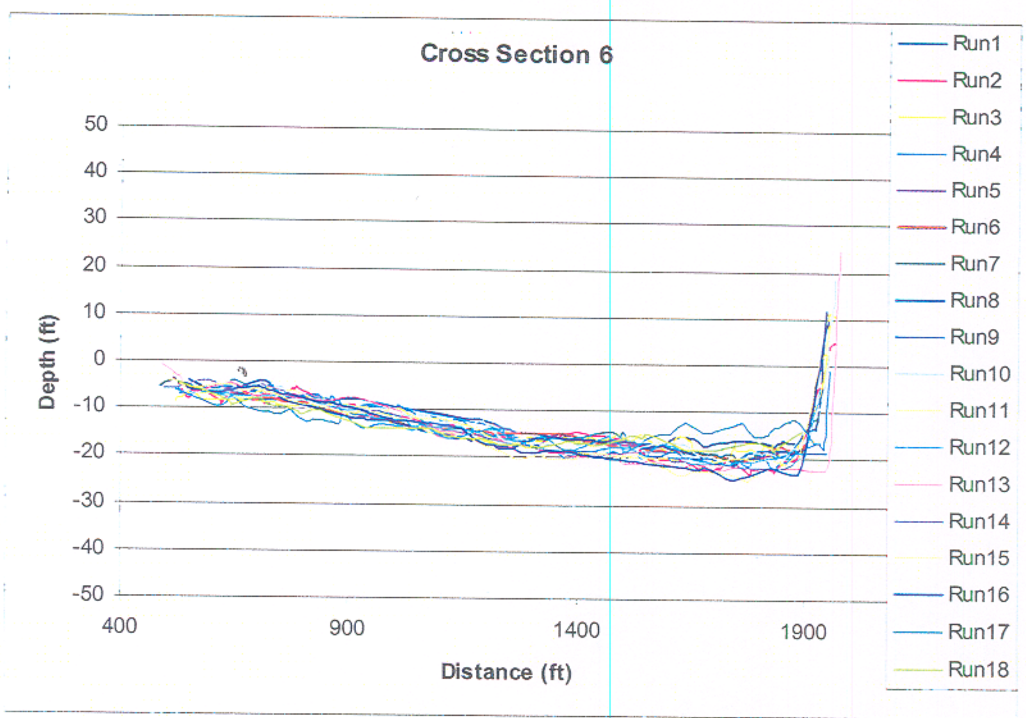


**Figure 6: Cross Section #6**

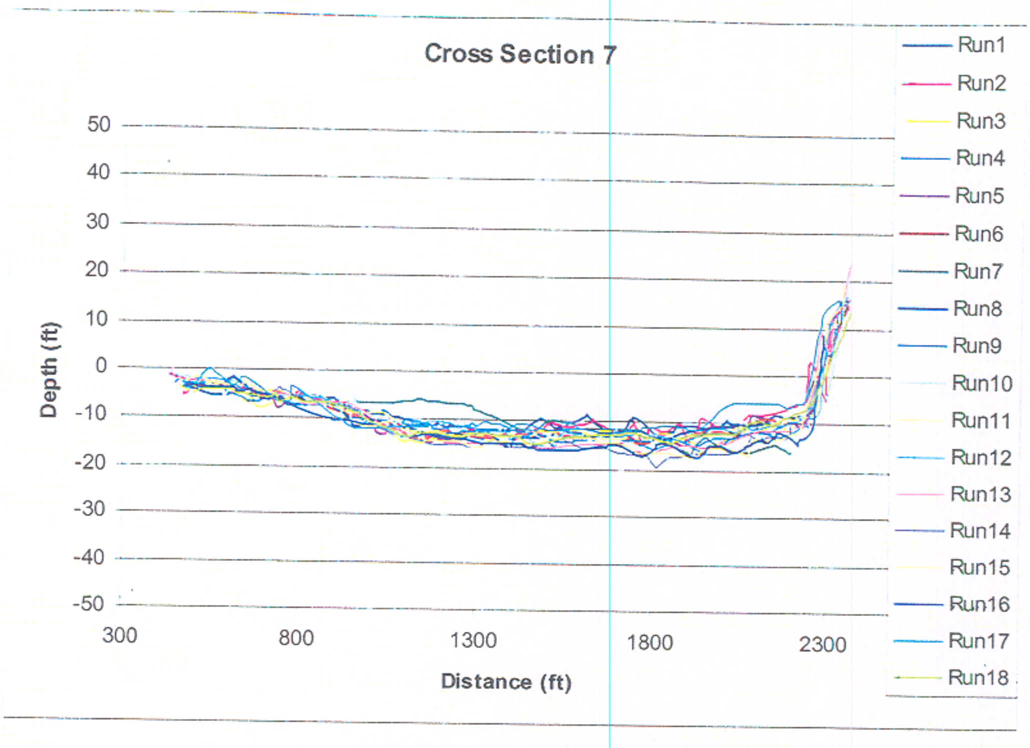


**Figure 7: Cross Section #7**

Average variance computed at each of the cross sections were as follows:

Cross section 1: Average Variance = 3.69
Cross section 2: Average Variance = 5.78
Cross section 3: Average Variance = 5.76
Cross section 4: Average Variance = 3.91
Cross section 5: Average Variance = 2.71
Cross section 6: Average Variance = 2.69
Cross section 7: Average Variance = 2.71
Overall Average Variance = 3.89

The range of low variance values indicates that this model demonstrated exceptional bed configuration repeatability between eighteen experimental runs. The average variance computed by Davinroy (1994) for the Dogtooth Bend reach was 8.34 for the micro model and 10.46 for the WES model. The lower values achieved with the Jefferson Barracks Micro Model could be due to a variety of factors, including improved automation of the model flow and sediment as compared to manual control, improvements in model data collection, or a combination of reach specific factors such as the alignment, geometry, and depth.

provided by Dave 8/23/02

added to Eval. Report

**Simulation of River Training Structures in the Model**

The generalized impact on the riverbed imposed by dikes, weirs, closure structures, and other channel regulating structures in the prototype are highly desirable to the river engineering community. These type structures have been used extensively in both micromodels and large-scale models to mimic current conditions or to test new design alternatives.

One of the most important functions of movable bed models is the ability to make qualitative assessments on the three-dimensional effect of dike structures on the bathymetry of a river. An area of concern in the model's bathymetric response to these structures involves a realistic reproduction of scour patterns. The reproduction of scour in vertically distorted models requires special attention.

Because the model is geometrically smaller than the prototype, the turbulence associated with a solid boundary structure in the model is relatively greater than the turbulence associated with the same boundary structure in the prototype. This increased turbulence, which exaggerates scour patterns, was evident on many past models studies at WES as well as on the early micromodel studies where solid boundary structures were used.

The exaggerated response typically observed around many of the dikes in the models was a large scour hole off the end of the dike which wrapped around the upstream side of the structure. This formation is the opposite of conditions observed in the river. Typically, a depositional pattern is located upstream of the dike while an area of scour or plunge pool is formed downstream when the dike is overtopped.

Two types of material, sheet metal and a cement-pebble conglomerate, were predominantly used in the WES models to represent dikes. In many cases, the response of the bed observed around these structures was not representative of what was actually occurring in the river. Figures 1 and 2 shows excessive scour around sheet metal structures and rock structures tested in the St. Louis Harbor model. Other structures, including the bendway weirs in the large-scale Dogtooth Bend Model, also exhibited increased scour. The scour that occurred off the ends of many of the structures was so great that the bottom of the concrete flume was exposed. Once the flume bottom was exposed, the bed was essentially armored, which then caused the scour to exaggerate laterally. This created a wider scour pattern that unrealistically represented the bed response of the prototype. Case studies of both models are presented later in this report and provides more description on the model studies.

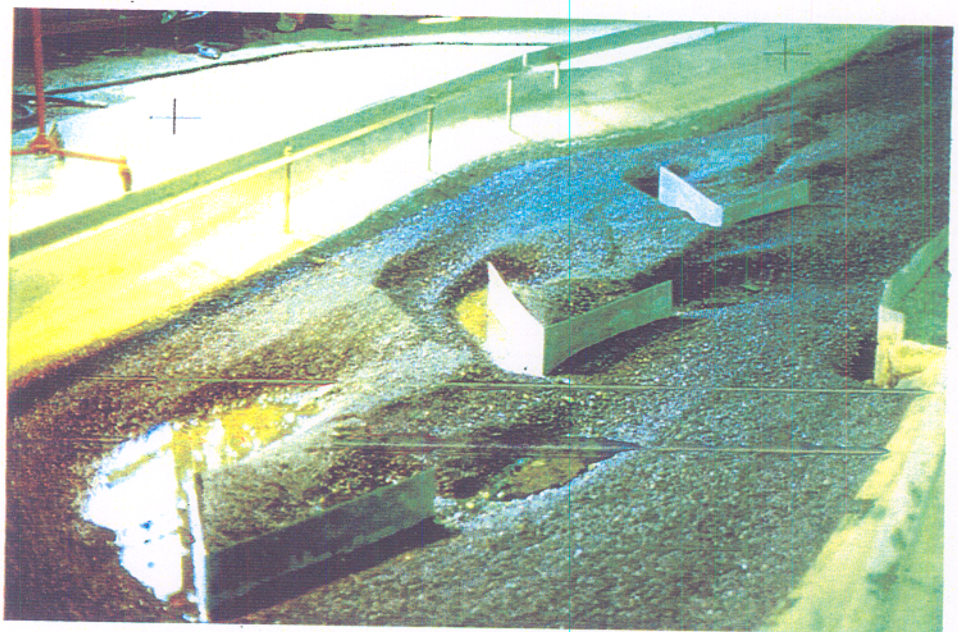

**Figure 1: Sheet Metal River Chevrons in the St. Louis Harbor Model.**

**Figure 2: Cement/Pebble Conglomerate Dike in the St. Louis Harbor Model Formed an Exaggerated Scour Hole to the Floor of the Flume**

The same types of problems were noted early on with the development of the micromodels, including the original work done at the University of Missouri-Rolla (UMR) (Davinroy, 1994). Impervious sheet metal (.01 inch) was first used to represent prototype rock dikes. As was the case of the WES models, the exaggerated scour of the models was accepted as a limitation of the model, with the underlying philosophy that as long as changes in the thalweg could be observed, one could still make general conclusions about the effectiveness of dikes in the model. However, this limitation would result in extreme difficulty during model calibration due to the inability to control the exaggeration of scour depths and the lateral extent of the scour created by the dikes.

Later, however, through flume experimentation, porous structures proved to be much more realistic and effective in mimicking the bed response of solid dike structures observed in the river. The micromodel approach now utilizes pervious steel mesh to represent prototype training structures that simulate similar scour patterns and the depositional response observed in the prototype. The use of porosity in the micromodel was reinforced by the effects generated by both impervious and porous structures observed in flume studies at IIHR. The experiments in a fixed bed showed that impervious structures radically distort the near flow field. However, this negative effect was severely dampened by the use of porous structures combined with a movable bed. The porosity proportionally scales the magnitude of roughness created by dikes in the actual river. The porous structures enable a relative lowering of the hydraulic roughness and conversely a reduction in force and shear stress traditionally applied to the model bed with solid structures. The end result is a three dimensional response around and over these structures that is comparable to the response created by solid rock structures in the prototype.

During the calibration phase of either large-scale or micromodels, the existing dikes in the study reach are set in the model according to their actual elevations~~, using the selected vertical scale and shift~~. If these dikes are not set to ~~their proper~~ elevations, then the model will not respond correctly and will not calibrate. Using either modeling technique, dikes can then designed to an approximate elevation by setting their elevation relative to the existing structures in the model. Therefore, an approximate final design elevation is attained for construction in the river.