Two-dimensional hydrodynamic modeling of the Middle Rio Grande

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Introduction. Although river engineering practices can provide benefits such as flood protection and floodplain accessibility, engineered structures have greatly impacted the geomorphology and flow characteristics of rivers throughout the world. Changes to the natural flow regime and geomorphology can reduce main channel-floodplain connectivity, thus leading to changes in the ecosystem services provided by a river system. Flood wave attenuation, one ecosystem service related to floodplain connectivity, involves the dampening and elongating of a flood wave as it moves downstream through momentum transfer at the channel floodplain interface, loss of momentum due to roughness effects of vegetation, and water storage within the floodplain. The Middle Rio Grande of New Mexico, historically, is susceptible to flood events due to both spring snowmelt and late summer monsoonal precipitation. The river, once classified as shallow, sandy, and bar-braided with a wide floodplain is, at present, generally deeper and meandering due to channel training with jetty jacks and the historic floodplain is inaccessible because of constraining levees. In addition, the flow regime has been altered as a consequence of upstream flood control and diversion dams. In recent years, projects have been implemented in the name of river restoration and rehabilitation to promote increased floodplain connectivity. These projects can include excavation and reconnection of floodplain surfaces to promote enhanced hydrologic connectivity, revegetation of native floodplain species, removal of channel training devices, levee setback strategies, and flow manipulation. This research strives to understand the impacts of both historic river engineering and various river rehabilitation strategies on the ecosystem service known as flood wave attenuation along the Middle Rio Grande.

Modeling Approach. Physically, the process of flood wave attenuation entails mass and momentum transfer through eddies at the main channel and floodplain interface, flow interaction with channel and floodplain roughness, and floodplain storage.1-3 Because flood wave attenuation is dependent on lateral mass and momentum transfer, two-dimensional hydrodynamic modeling is more appropriate than one-dimensional modeling as two-dimensional modeling has the ability to quantify lateral flow characteristics important to the physical processes occurring as a wave moves downstream. Two-dimensional modeling for this study was conducted with Deltares’ D-Flow Flexible Mesh, a new unstructured, hydrodynamic model that solves the depth averaged mass and momentum equations.4

The D-Flow Flexible Mesh model provides an environment in which a two-dimensional mesh can be created. The term flexible mesh, otherwise known as an unstructured mesh, refers to the ability to represent the land surface as any number of shapes including triangles, quadrilaterals, and pentagons. As is typical for two-dimensional mesh development, the main
channel of river models are typically made up of curvilinear (i.e. quadrilateral) cells, while the floodplain and other complex features are represented by triangles as well as other shapes. After the mesh has been developed to the desired resolution, elevation and vegetation roughness data are then interpolated to the mesh. Currently this study focuses on a 42 km stretch of the Rio Grande (Fig. 1). At 3-meter resolution, the river and accessible floodplain are represented by approximately 8.7 million elements. The mesh is then partitioned to allow for tightly coupled parallel computations of the given flow conditions. Gauge data from the United States Geologic Survey provide the flow conditions at the upstream and downstream boundaries of the mesh.

**Results.** Results of this research are presented as a Relative Attenuation Ratio (RAR) for both peak discharge and peak flood stage. These ratios normalize peak discharge and stage occurring during an unsteady flow event with those values that would occur under steady upstream peak discharge conditions. Therefore, the values are normalized to specific flood events for a specific length of river. This allows for multiple flood events to be compared to one another for the same stretch of river. Preliminary results show that increased floodplain roughness on a large scale can reduce peak discharge of a flood event by as much as 7% (Fig. 2). In comparison, small-scale lateral connection of the floodplain created almost no change in peak discharge, however flood stage was locally attenuated by 14% within an area of laterally-connected floodplain (Fig. 3).

**References**


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