Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. IV, 2015
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

FLOODPLAIN DELINEATION FOR CALNAU RIVER USING HEC-RAS SOFTWARE

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Abstract

1-D mathematical hydraulic models are the most commonly used for floodplain mapping. Based on detailed topographic and structural surveys, they provide a description of the river channel, structures and floodplains. The paper aimed to present the development of flood boundary map for Calnau River section between Costomiru and Potarnichesti gauging stations by running the Hydrologic Engineering Centre's River Analysis System (HEC-RAS). It was created the 1-D hydrodynamic modeling of the river using different flow values for the probability of exceedance– 0,1%, 1%, 5% and 10%. The simulations were for both steady and unsteady flow.

Key words: *1-D modeling, boundary, flood, HEC-RAS.*

INTRODUCTION

A numerical model which is used to represent the hydraulic behaviour of a water body is called a hydraulic model. Hydraulic models may be broadly categorised into one-dimensional (1-D), two-dimensional (2-D) and three-dimensional (3-D) schemes.

1-D mathematical models are the most commonly used for floodplain mapping and use the Saint Venant equations, and therefore rely on many high resolution morphological parameters (cross sections) (Saleh al., 2013).

This study utilises 1-D numerical models to simulate the flow of water through a section of Calnau River based on detailed topographic survey and it provides a description of the river channel with its floodplains.

The development of effective floodplain management plans requires that engineers understand the hydraulics of open channel flow, which depend upon the flow classification, flow and conveyance, and the energy equation.

HEC-RAS is a hydraulic model developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers. The software is a one-dimensional steady flow model, intended for computation of water surface profile. Modules for unsteady flow simulation and movable-boundary sediment transport calculations are scheduled to be included (USACE, 2010).

Updates to HEC-RAS have been periodically released and the product is still being actively developed. Among the many improvements since the initial version of HEC-RAS have been geographic information system (GIS) integration capabilities (Yang al., 2006).

By using topographic datasets (LiDAR) and the 1-D model (HEC-RAS) on the case study, the sensitivity of hydraulic model and flood mapping to terrain data, geometric configuration and model type are analyzed (Merwade, 2012).

MATERIALS AND METHODS

The Calnau River is part of the Buzau Catchment with a length of 113 km. The analyzed sector crosses a relatively populated area, the most important villages being Posta Calnau and Fundeni (Figure 1).

The analysis started with the ESRI GRID digital terrain model – pixel size in plan of 5 m. This model resulted from the combination of LiDAR data performed on the bank lines of the stream and digitized maps 1:100000.

Hydrological data were considered the water level and average daily flow series (Correia al., 1999) from Costomiru and Potarnichesti gauging stations, considering four flood events measured in both gauging stations (1975, 1984,

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1991, 2005 events) and different probabilities of exceedance (0,1%, 1%, 5% and 10%).

Figure 1. Location of Calnau River in Buzau Catchment Area

First processing were performed in ArcHydro Tools, then in HEC-GeoRAS; it provides specific access to GIS procedures that assists the hydraulic engineer in the creation and evaluation of hydraulic models using digital terrain data (Ackerman C.T., 2001).
HEC-GeoRAS was used to create a geometric import file for HEC-RAS. The import file is containing head, stream network, and cross-sectional information (Williamson T., 2004).
Hydraulic models were developed for existing conditions and alternative condition scenarios, for both steady and unsteady flow.

RESULTS AND DISCUSSIONS

The simulation of flow direction turned into the raster below, with a legend of colours, each color corresponds to a number and each number indicates the flow direction between the gauging stations considered.

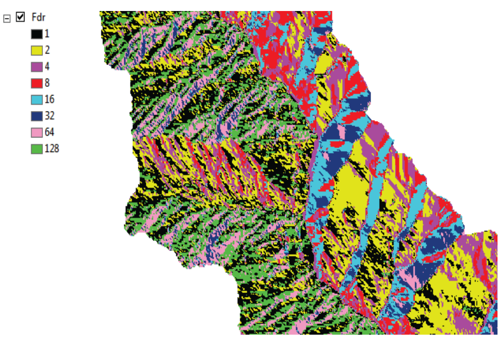

Figure 2. A closer view of flow direction raster with its legend

In HEC-GeoRAS each attribute is stored separately in a feature class. Using RAS Geometry was created a layer for stream centerline (Figure 3), banks, flow paths and cross sections (Abbas A., 2011).

For the simulations in HEC-RAS for steady flow were considered as upstream boundary conditions the maximum flows measured (Yuan Y., Qaiser K., 2011) at Potarnichesti gauging station (with the probability of exceedance 0,1%, 1%, 5%, 10%) and as downstream boundary condition the rating curve (Figure 8).

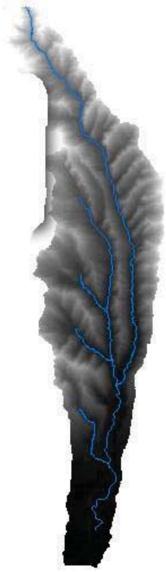

Figure 3. Stream centerline for Calnau River between Costomiru and Potarnichesti gauging stations

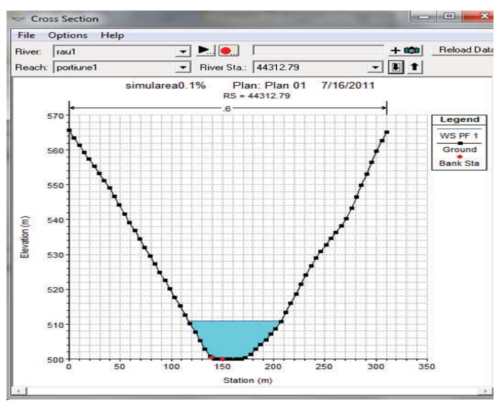

Figure 4. Graphical result of cross-section in HEC-RAS

Finally, the simulation results were exported to ArcGIS, where the flood maps were generated (Figures 5 and 6) (Tate E.C., 1999).

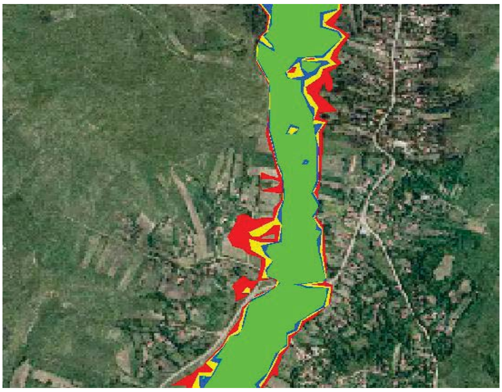

Figure 5. Detail of floodplain delineation where Q 10% - green, Q 5% - blue, Q 1% - yellow, Q 0,1% - red

Figure 6. Another close view of floodplain delineation where Q 10% - green, Q 5% - blue, Q 1% - yellow, Q 0,1% - red

Simulations on unsteady flow were used on the same geometric model and required as upstream boundary the flood hydrographs recorded at Costomiru gauging station from flood events in 1975, 1984, 1991 and 2005 (Figures 7 and 9). For downstream boundary condition was kept the rating curve from steady flow simulations (Figure 8). Ultimately the simulation results were exported again to ArcGIS for generating the floodplain maps (Ionita F., 2011).

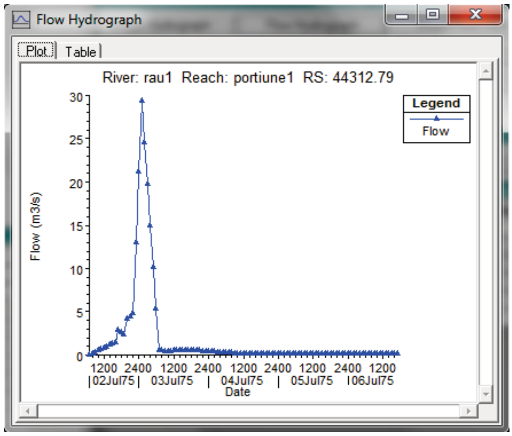

Figure 7. Flow hydrograph for flood event 1975

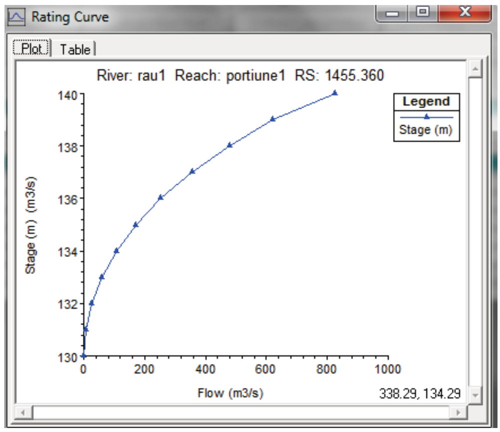

Figure 8. Rating curve used as downstream boundary condition

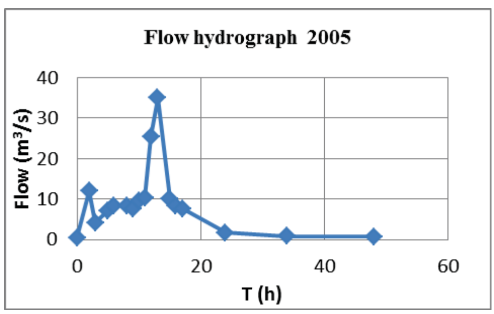

Figure 9. Flow hydrograph for flood event in 2005

Figure 10. Floodplain delineation for the flood event in 2005

CONCLUSIONS

A study for automated floodplain mapping and terrain modeling was presented. The paper provides a link between hydraulic modeling using HEC-RAS, and spatial display and analysis of floodplain data in ArcGIS.

As inputs, the study requires a completed HEC-RAS model simulation and a GIS stream centerline representation.

The procedure consists of several steps: data import from HEC-RAS, stream centerline representation (Figure 3), cross-section georeferencing, terrain modeling, and floodplain mapping. The outputs are a digital floodplain map that shows extent of flood. (Figure 10).

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