

Contributions to the determination of flooding levels using HEC-RAS program for the Mures River in Arad

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Abstract: The study area falls within the Tisa Plain, which the Mures River crosses in its eastern sector, forming a corridor of 140 km. This sector is composed of loamy silt and loess deposits that create rain water stagnation. Morphologically, the sector consists of the heights that get lower from 150 m in the east to less than 100 m in the west, given these data; the slope of the basin area has very low values. In lowland areas, groundwater is formed at great depths and it slightly fills the river.

The length of the Mures River in the studied sector is 53.4 km. The Mures Floodplain National Park is located here and includes the embankment part of the Mures River. This is the area located on both sides of the river, between high terraces, with great tourist attractions: the specific landscape of meadow, the 200 species existing bird, remarkable biodiversity, water lily pond from the Prundul Mare reservation.

Keywords: Mures River, HEC-RAS Model

1. HEC-RAS PROGRAM

HEC-RAS program was used to determine the floods level in that area. HEC - RAS (4.0) is a program developed by the US Department of Defense, Army Corps of Engineers in order to manage the rivers, harbors, and other public works under their jurisdiction.

Hydrologic Engineering Center for the U.S. Army Corps of Engineers aims to one-dimensional hydrological analysis of rivers and includes four types of analysis: the calculation of water surface for steady flow, flow simulation variables, the study of solid flow and water quality analysis. Common to these types of analysis are cross sections of the river and the geometric and hydraulic calculation principles. The application is an interactive multi-tasking software system that includes a usual graphical user interface, an analysis of the components, data storage, graphics and easy reports. The main objective of the program is to calculate the water surface at all points of interest.

The interface provides for the following functions:

- file management
- data entry and editing
- river analyses
- tabulation and graphical displays of input and output data
- reporting facilities
- on-line help

2. MODELING PRINCIPLES

a. The modeling of the dynamic behavior of the river is based on the momentum and energy conservation equations that are solved by finite difference method.

$$Y_2 Z_2 + \frac{\alpha_2 \times V_2^2}{2g} = Y_1 + Z_1 + \frac{\alpha_1 \times V_1^2}{2g} + h_e \text{ where:}$$

Y_1, Y_2 are the levels in cross sections;

Z_1, Z_2 represents the riverbed elevation

V_1, V_2 average speed of the water;

α_1, α_2 speed weighting coefficients;

h_e energy loss

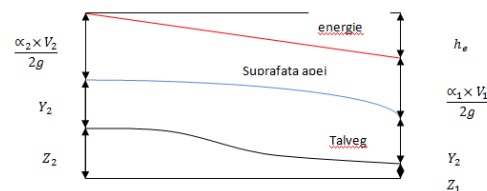


Fig. 1. Representation in terms of energy equation

b. The program can analyze the riverbed segments whose roughness coefficient is different.

c. Contraction and expansion coefficient:

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$$h_c = L S_f + C \left| \frac{v_1^2}{2g} - \frac{v_2^2}{2g} \right| \quad (2)$$

Where:

L is the distance between two sections;

(S_f) represents the friction due to the slope between the two sections;

C is the loss shrinkage / expansion coefficient

-for flow rates below the critical

flow rate, C = 0.1, 0.3-

for higher flow rates than the critical flow rate, C = 0.01, 0.03-

for very steep flow channels larger than the critical flow rate, C = 0.05; 0

3.CALCULATION PROCEDURE

Water surface level in a section is determined by iterations of equations (1) and (2).

a. the water level in an upstream section is implied;

b. the correspondence between the flow rate and the highest speed is determined;

c. the equation (2) for h_c is solved by using the values obtained in(b);

d the equation (1) for water level in section 2 is solved by using the values of (b) and (c);

e the solved water level value is compared with the amount assumed in (a). These steps are repeated until an acceptable tolerance is obtained.

Upon request, we can calculate the critical level

4.LIMITS OF THE PROGRAM:

The debit is constant because the time dependent term is not included in the energy equation.

The slope limit must be smaller than 1:10 and it is based on the fact that the equation of the energy:

$$H_p = d \cos \theta \quad (3)$$

Where:

H_p este presiunea pe vertical

d is the depth of the water analyzed perpendicular on the thalweg/ contour line

θ is the riverbed slope expressed in degrees

For 1:10 or less, cos θ= 0,995. This way, the vertical pressure is approximately d and the estimation of the depth is low, the error being of 5%.

The loss of energy is evaluated through friction and through coefficients of contraction/expansion.

In calculations, changes made by bridge, culvert, barrage and dam blockings, as well as river junctions, etc, may also be considered.

The special characteristics of this program include: multiple analyze plans, multiple profiles of calculation, bridges and dams, etc.

When the transversal sections are located at a big distance, the program may not be accurate in calculating the critical level. HEC-RAS has the ability to generate transversal sections through geometrical interpolates between two different sections. The interpolation is based on the modeling of a row like so:

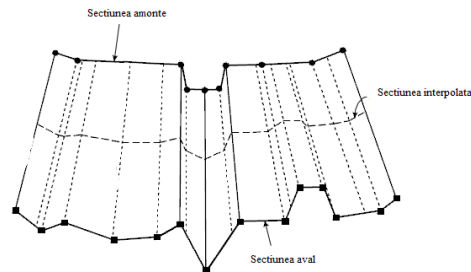


Fig.2 Obtaining sections by interpolation

5. DATA NEEDED

Geometric data are necessary in the first place. The model defines geometric data, drawing the river scheme firstly. The cross sections upstream and downstream and the possible dams, bridges and drains are defined, and they may change the hydraulic data. It can then be proceeded with entering the constant flow rate data. These data will contain the number of profiles to be calculated, the flow and edge conditions. If a constant flow below the critical flow is analyzed, conditions are necessary only in the downstream edge. For a rate above the critical flow, it is necessary to specify the upstream edge conditions.

The hydraulic calculation goes next.

6. THE MURES RIVER LEVEL STUDY

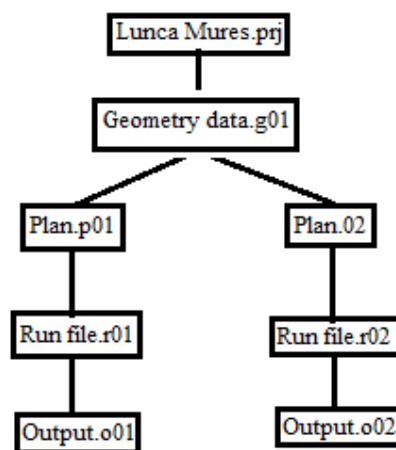


Fig.3 Scheme Project

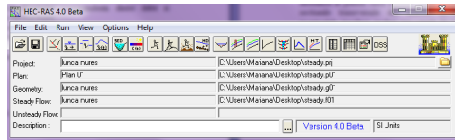


Fig.4 Project Start

For the Mures River, Arad area, HEC RAS software was used, having as a starting point Arad hydrometric station and as a terminus, Nadlac hydrometric station, located on the border with Hungary. The coordinates of hydrometric stations in the profile, where the main sections can also be found, are:

Arad 21019 'eastern longitude
 46 010 'north latitude
 Nadlac 20040 'eastern longitude
 46 008 'north latitude

i.e.:

Arad x = y = 525 107 215 655
 Nadlac x = y = 523 936 165 299

Geometric data is entered by pressing Reaver Reach, after establishing the measuring units and the proper framing of the coordinates in the drawing. The form of the river can be drawn by clicking the mouse on the main points that are determined by the coordinates of stations considered.

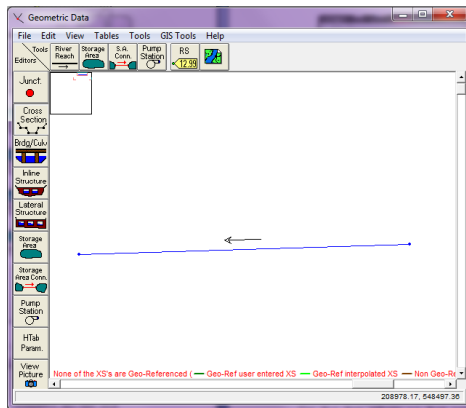


Fig.5 Geometric Data Editor

Known cross section data is then inserted by means of the cross section button.

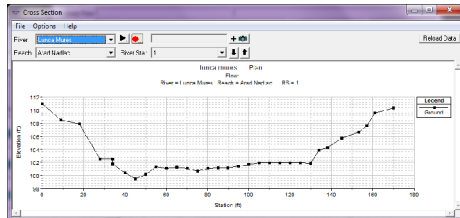


Fig.6 Cross section through the Mures riverbed, Arad

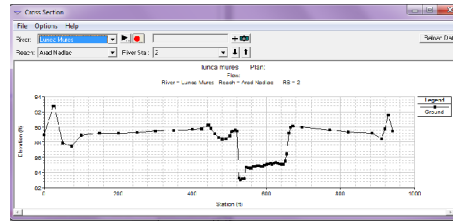


Fig. 7 Cross section through the Mures riverbed, Nadlac

The next step was the introduction of hydraulic data. We chose the constant flow calculation level. For a more accurate calculation we applied a thickening of the points in which there were cross-sections, so they could stand at about 1,000 m, while the shapes of respective profiles were determined.

Results after running the program can be obtained in several forms.

- Cross section plots
- Profile plots
- General Profile Plot
- Rating curves
- X-Y-Z Perspective Plots
- Detailed tabular output
- limited tabular output at many cross sections

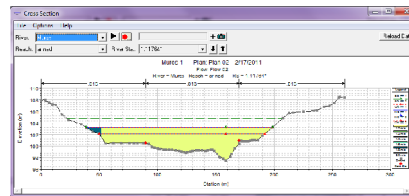


Fig. 8 Determining the level at Arad hydrometric station



Fig. 9 Determining the level at Nadlac hydrometric station

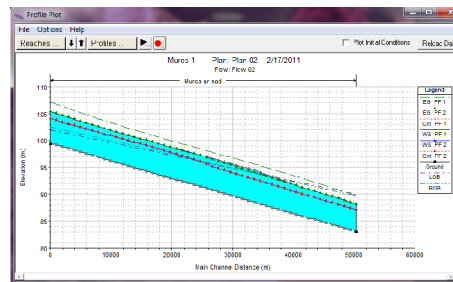


Fig. 10 Longitudinal profile of the study area

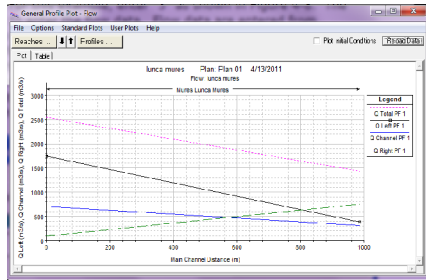


Fig. 11 The distribution of flow along the section

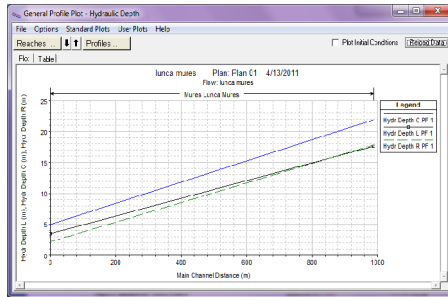


Fig. 12 Hydraulic Depth

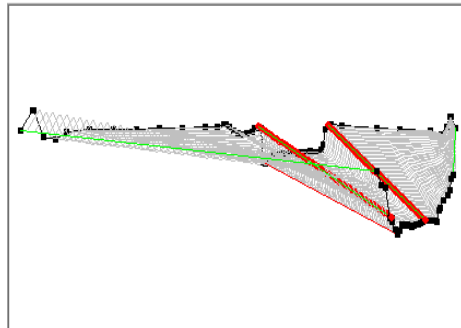
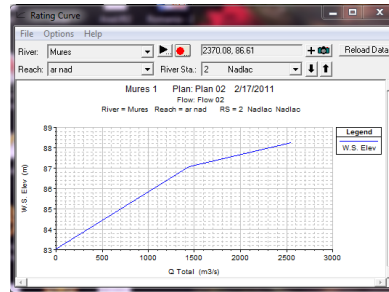


Fig. 13 Spatial representation of sections

Cross Section Output			
File Type Options Help			
River:	Mures	Profile:	PF 1
Reach:	ar nad	RS:	2
Plan: Plan 02		Mures	ar nad
Profile: PF 1			
E.G. Elev (m)	89.73	Element	Left OB
Vol Head (m)	1.49	Wt. nVal	Channel
W.S. Elev (m)	88.24	Reach Len. (m)	Right OB
Ch W.S. (m)	88.24	Flow Area (m²)	987.64
E.G. Slope (m/m)	0.001017	Area (m²)	463.54
Q Total (m³/s)	2550.00	Flow (m³/s)	2521.42
Top Width (m)	177.29	Top Width (m)	137.23
Vel Total (m/s)	5.28	Avg. Vel. (m/s)	5.44
Max Ch Dpth (m)	5.20	Hydr. Depth (m)	3.39
Conv. Total (m³/s)	79956.4	Conv. (m³/s)	79060.2
Length W/d. (m)	987.64	Wetted Per. (m)	140.40
Min Ch El (m)	83.04	Shear (N/m²)	32.93
Alpha	1.05	Stream Power (N/m s)	179.13
FriCh Loss (m)		Cum Volume (1000 m³)	3488.71
C.R.E Loss (m)		Cum SA (10000 m²)	2856.68
			5436.70
			2615.49

Fig.14 Results obtained in tabular form

Graphical representation of flow growth in the studied sections is also obtained.



The results are shown by a table synthesizer.

Profile Output Table - Standard Table 2												
HEC-RAS Plan: Plan 02 River: Mures Reach: ar nad												
Reach	River Sta	Profile	E.G. Elev (m)	W.S. Elev (m)	Vol Head (m)	FriCh Loss (m)	C.R.E Loss (m)	Q Left (m³/s)	Q Channel (m³/s)	Q Right (m³/s)	Top Width (m)	Reload Date
ar nad	2	Nadlac	PF 1	88.21	88.24	1.49			2521.42	28.58	177.23	
ar nad	2	Nadlac	PF 2	88.21	87.06	1.14			1440.00		134.14	
ar nad	1	Arad	PF 1	105.42	88.36	1.54	1.62	1.00	2930.89	19.11	176.08	
ar nad	1	Arad	PF 2	105.42	87.39	1.15	1.30	0.00	1440.00		132.84	
ar nad	1	Arad	PF 1	90.46	88.90	1.65	1.94	0.00	2837.98	12.61	168.28	
ar nad	1	Arad	PF 2	90.46	87.72	1.17	1.30	0.00	1440.00		131.96	

Fig.15 Longitudinal profile

7. CONCLUSIONS

The role of the application is to analyze the role of riverbed rising water levels to determine the effects of flood waves.

As a first application, we introduced the constant flow of 1440 m³ / s, which represents the flow rate at 5% probability for that area. As a result, the river level reached 88.21 meters at Nadlac, a level that is below the rate of flooding, while the critical level is 86.07m.

For Arad, the level reached 105.42 m which is also situated below the flood rate. The second application has been made for constant flow rate of 1% probability that is 2550m³ / s.

Surface water level registered at Arad hydrometric station was 107.20 m and 89.73 m at Nadlac. Water levels also ranked below the rates of flooding, even in intermediate sections, which means that the area will be flooded even in terms of a flow rate of 1% probability.

References

1. U S Army Corps of Engineers, Hydrologic Engineering Center, HEC-RAS River Analysis System – Users Manual Version 4.0 Beta, nov. 2006
2. U S Army Corps of Engineers, Hydrologic Engineering Center, HEC-RAS River Analysis System –Hydraulic Reference Manual, Version 4.1, Jan.2010
3. U S Army Corps of Engineers, Hydrologic Engineering Center, HEC-RAS River Analysis System –Application Guide, Version 4.0 March 2008

