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Environmental Risk Assessment and Analysis for Nuntaşi Hydrographic Basin

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Abstract: *The way of approaching the flood hazard in the Dobrogea Hydrographic Area consists in a first phase in the grouping of registered water courses on three levels of detail according to the frequency of floods in recent years, their amplitude, the form of manifestation, the degree of equipping with works of defence against floods, social or economic objectives subject to flood hazard. The causes of these floods were the amounts of precipitation from torrential rains recorded in a certain period of time. Due to the flood waves, the danger levels were exceeded, some sectors of the permanently flowing watercourses were flooded. In Nuntași, between 02.09-04.09.1999, the flood produced on the Nuntaşi river destroyed houses, cultures, lives, etc. The assessment of the water resources in this basin consists in the assessment of the hydrographic and hydrogeological basins, which together form the reception basin. surface, shape, hypsometric curve and average altitude of the basin, average slope, vegetation cover, hydrogeological basin, hydrograph, rainfall hyetogram, etc.) The risk analysis of the NUNTAȘI hydrographic space consists in the measurement and quantification of 4 parameters using the RkFMEA method (RisK Failure Mode Evaluation Analysis): vulnerability (exposure) (R), probability (P), the effect of the existence of a control instrument/measure/control/action (N) and the efficiency indicator of a new measure (F). The simple risk level (RPN factor) and the efficiency factor F (complex risk level, RPNF) were automatically calculated. The conclusion of the risk analysis was: the NUNTAȘI bed falls under "low risk with serious prevention measure without any urgent implementation with RPNF values between (1...150)".*

Keywords: *Risk, environment, assessment, analysis, basin, vulnerability, probability, control, level, measure*

1. Introduction

The risk factors for the NUNTAȘI hydrological basin are floods and anthropogenic pollution.
One of the risk factors is *flooding.* The way of approaching the flood hazard in the Dobrogea Hydrographic Area consists in a first phase in the grouping of registered water courses on three levels of detail according to the frequency of floods in recent years, their amplitude, the form of manifestation, the degree of equipping with works of defence against floods, social or economic objectives subject to flood hazards, etc. (Fig. 1) [1]: level A – very detailed; level B – detailed; level C. The Nuntași Basin - Nuntași locality, the Nuntași Basin - Fântanele locality were analysed. From the point of view of the structural measures, costs are imposed regarding the regularization of the bed on the urban section Nuntași-Fântanele and costs for the regularization of the bed on the urban section Nuntași-Nuntaşi Basin, which have as their final goal the avoidance of loss of human life [2]. The causes of these floods were the amounts of precipitation from torrential rains recorded in a certain period of time. Due to the flood waves, the danger levels were exceeded, some sectors of the permanently flowing watercourses were flooded (Fig. 2) [3]. In Nuntași, between 02.09-04.09.1999, the flood produced on the Nuntaşi river destroyed houses, cultures, lives, etc.
Another risk factor is *anthropogenic pollution*. Human activities lead to alterations in the riverbed morphology and dynamics to change its hydraulics. Aspects should be considered amending the short term (dams, bridges, erosion, etc.) and long term (changes generated by the embodiment Management work) [3].

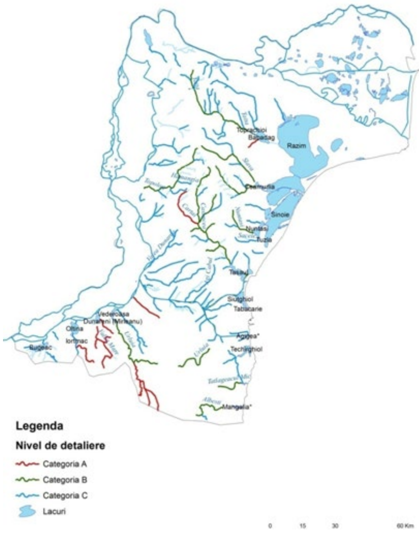


Fig. 1. Map of the hydrographic network Dobrogea Water Basin Administration [2]

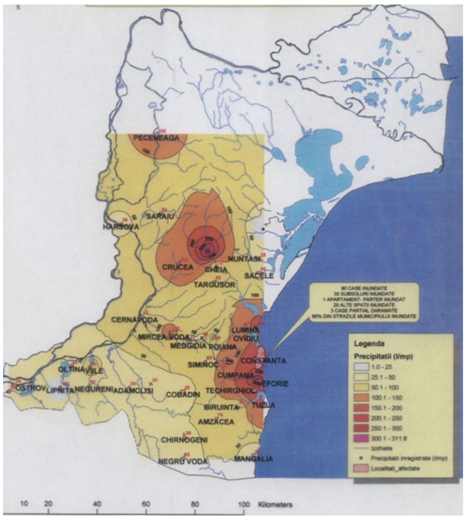


Fig. 2. Map with isohyets resulting from the hydro meteorological phenomena of August 2004 [3]

Due to the flood waves, the danger levels were exceeded, some sectors of the permanently flowing watercourses were flooded.

2. Material and methods

In this work we propose to present the flood produced on the Nuntași river and risk analysis for this case study (Fig. 3) [2].

Fig. 3. Flood bed Nuntași [2]

Considering the flood risk situation, in order to overcome the damage caused by the overflowing of the river, it was considered that the most suitable option, for the Nuntași Basin area - Fântanele locality (Fig. 4) [2] is the execution of a covered trapezoidal section, because this option offers a high degree of naturalness and integration of the works in the environment compared to the possibility of channelling the water course on urban land.

Fig. 4. Nuntași Basin - Fântanele locality [2]

This option implies a slight increase in the occupied area, in an area subject to intense human pressure, and a dramatic process of regression of natural values.
For the Nuntași Basin area - Nuntași locality (Fig. 5) [2], the flow of the river increases dramatically as a consequence of torrential rains. As a result of this circumstance, floods occur that cover large areas on both banks, because the size of the current water course does not have enough capacity to evacuate the maximum flow that comes along the course. This fact causes the water to flow to the areas adjacent to the channel, leading to overflow and flooding (flood), causing damage to agriculture, urban and industrial areas and people's lives. To overcome the damage caused by the overflowing of the river, the execution of a covered trapezoidal section was considered as the most suitable option [4], [1].

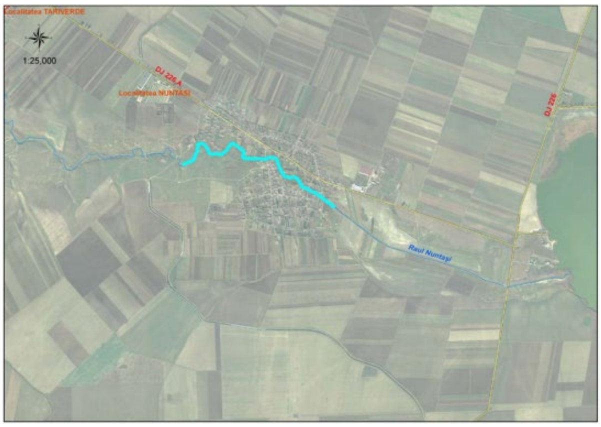


Fig. 5. Nuntaşi Basin - Nuntași locality [2]

From the point of view of the structural measures, costs are imposed regarding the regularization of the bed on the urban section Nuntași-Fântanele and costs for the regularization of the bed on the urban section Nuntași-Nuntaşi Basin, which have as their final goal the avoidance of loss of human life [3].
Human activities lead to the alteration of the morphology of the bed, as well as to the modification of its hydraulic dynamics. Both short-term and long-term change aspects must be considered. Among the short-term aspects, we mention: changes in local sections as a result of constructions in the riverbed (dykes, bridges, etc.), or major changes generated by materials resulting from erosion, transported by currents and randomly deposited. Among the long-term aspects, we

mention the changes generated by the way the landscaping works are carried out. The flood on the Nuntași river either destroyed human settlements, cultures, or bypassed the damming works upstream and spilled over the road, the situations being repeatable (in 2004 and 2007).

2.1 The assessment of the water resources in Nuntași basin

2.1.1. Catchment

In the case of Nuntași Basin, it includes the Nuntaşi River and Nuntași Lake (Fig. 6) [5,6].

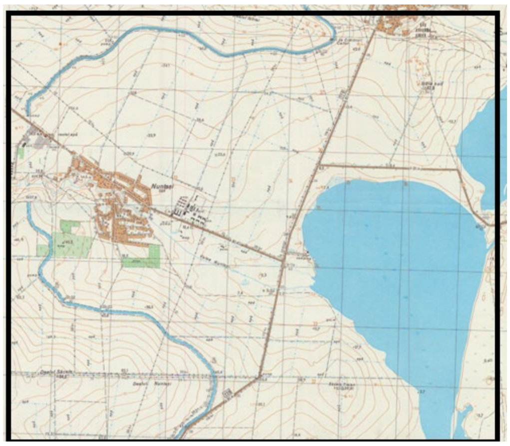


Fig. 6. The hydrographic basin-delimitation on the map

- *Catchment area*

Catchment area is expressed in km^2 or ha. Nuntaşi Basin has an area F = 145 km^2.

- *Form of the basin*

It can be stated with some approximations in a regular geometric shape and quantified by (Fig. 7) [5]:

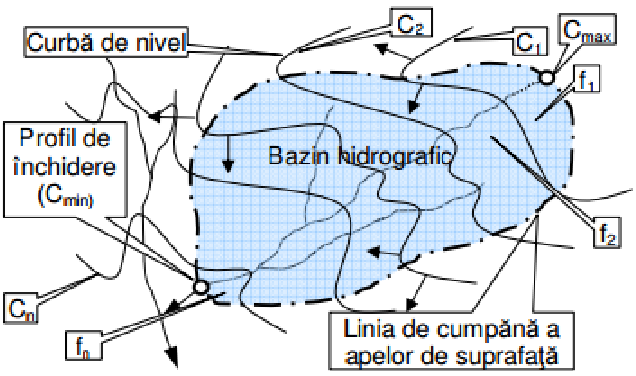


Fig. 7. The hydrographic basin-delimitation on the map

- average width of the river basin B (eq. 1) is B = 10,357 km;

$$B = F / \lambda \tag{1}$$

- basin shape coefficient (β) (deviation from circular shape) (eq. 2) is β = 0.364,

$$2\ \beta = 4\pi F / L^2 \tag{2}$$

Where L- the total length of the surface water balance line that delimits the watershed.

- hypsometric curve and average altitude basin (Fig. 8) [6].

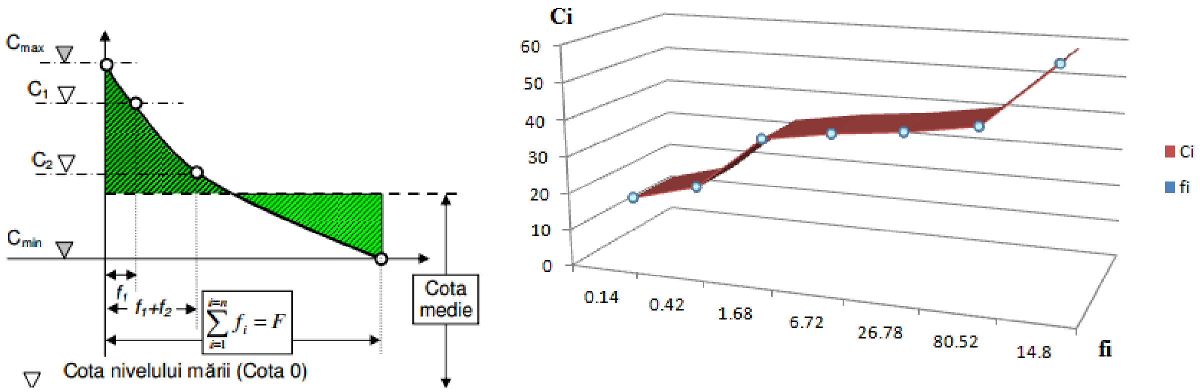


Fig. 8. Hypsometric curve of Nuntaşi basin

Hypsometric curve allows rapid assessment of the average river basin and areas that are above or below certain levels.

- *The average slope of the basin*

Average slope of the basin (i) is estimated based on the slope between each two consecutive contours (eq. 3) and is:

$$\bar{i} = \frac{\sum_{k=1}^{k=n} i_k \cdot f_k}{F} = \frac{\sum_{k=1}^{k=n} \frac{C_k - C_{k-1}}{b_k} \cdot f_k}{F} \tag{3}$$

where C_k - elevation of the k level curve; b_k - the average width between the level curves C_k and C_{k-1}; f_k - the surface of the hydrographic basin between the level curves C_k and C_{k-1}; F - total area of the hydrographic basin. So,

i_{med} = (0.028+0.100+0.080+0.214+0.966+1.00)/145=0.0165.

- *The coating plant of the river basin*

Is expressed through afforestation (α_p) of the river basin (eq. 4)

$$\alpha_p = \frac{F_p}{F} \tag{4}$$

and equals α_p = 0.1.

2.1.2. Hydrogeological basin

The hydrogeological basin represents the aquifer domain (underground), simple or complex, in which groundwater flows to the same surface drainage element, which can be a water course or a line of springs. The correct assessment of the flow regime of water courses is mainly determined by the knowledge of two categories of information:

- morphometry of the hydrographic network;
- hydrometry of the hydrographic network.

The morphometric characteristics of the hydrographic network are expressed by:

- the transverse profile of the bed (Fig. 9) [3, 6];
- the longitudinal profile of the bed (Fig. 10) [3, 6];
- the density of the hydrographic network (Table 1).

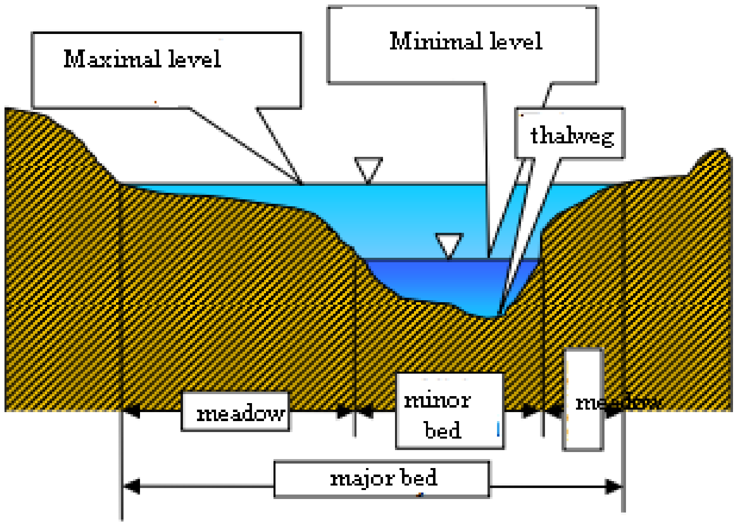


Fig. 9. Transverse profile through the bed of a river

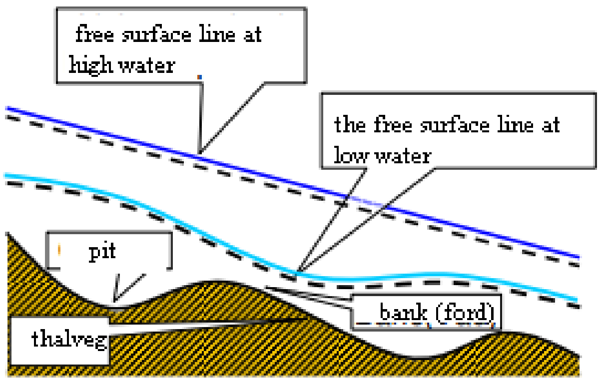


Fig. 10. Longitudinal profile through the bed of a river

Table 1: The characteristics of the Nuntași basin [7]

River	**L** (km)	**Total Volume** (mil.m3)	**S** (km2)	**Alt** (mdM)	Q_{medma} (m3/s)	$Q_{minlmedma\ asig}$ 80% (m3/s)	$Q_{minlmedma}$ asig 90% (m3/s)	$Q_{minlmedma}$ asig 95% (m3/s)	Q^{min}/Q_{max*}
Nuntași	14	9.3	145	10	0.473	0.280	0.200	0.140	1/2250

2.2 The Nuntași Hydrography Basin

- *Unitary hydrograph*

The unit hydrograph can be defined as the flood hydrograph produced by an excess of precipitation equal to 1 mm, precipitation reaching the drain, or more briefly is the direct runoff hydrograph resulting from an effective (net) rainfall of a unit layer produced on a basin homogeneously in a given time. In order to determine the characteristic elements of a unitary hydrograph, several methods have been developed: the Snyder method, the US Soil Protection Service method, the Gray method [8].

For the construction of the hydrograph, a 14-hour rainfall forecast was received from 28.06.2007 on the Nuntași hydrographic basin (Fig. 11, Table 2) [3, 9, 10].

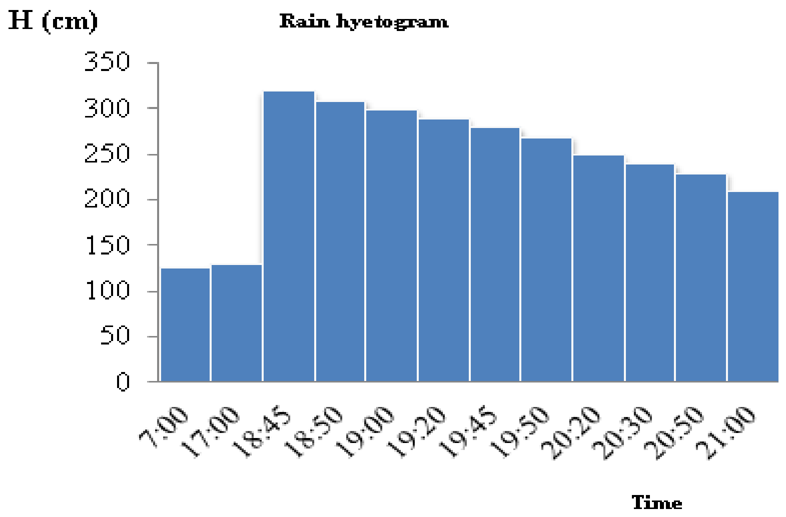


Fig. 11. Hyetogram of precipitation from the Nuntași basin

Table 2: Rainfall intensity in the Nuntași basin [2]

Date	Time	H (m)
27/ 06/ 2007	17:00	1.26
28/ 06/ 2007	7:00	1.26
28/ 06/ 2007	17:00	1.30
28/ 06/ 2007	18:45	3.20
28/ 06/ 2007	18:50	3.10
28/ 06/ 2007	19:00	3.00
28/ 06/ 2007	19:20	2.90
28/ 06/ 2007	19:45	2.80
28.06.2007	19:50	2.70
28/ 06/ 2007	20:20	2.50
28/ 06/ 2007	20:30	2.40
28/ 06/ 2007	20:50	2.30
28/ 06/ 2007	21:00	2.10

To analyze the hydrograph of the flow, the surface of the Nuntași hydrographic basin, F=148 km^2, and the maximum flows shown in the following table are taken into account (Table 3).

Table 3: Flood wave for the NUNTAȘI basin

Date	Time	Q (m3/s)
27/ 06/ 2007	17:00	0.05
28/ 06/ 2007	7:00	0.05
28/ 06/ 2007	17:00	0.08
28/ 06/ 2007	18:45	17

Date	Time	Q (m3/s)
28/ 06/ 2007	18:50	15
28/ 06/ 2007	19:00	14

The flood wave hydrograph, as well as its separation into its basic components (quick runoff, hypodermic runoff, and base runoff) are plotted in Figures 12 and 13 [10].

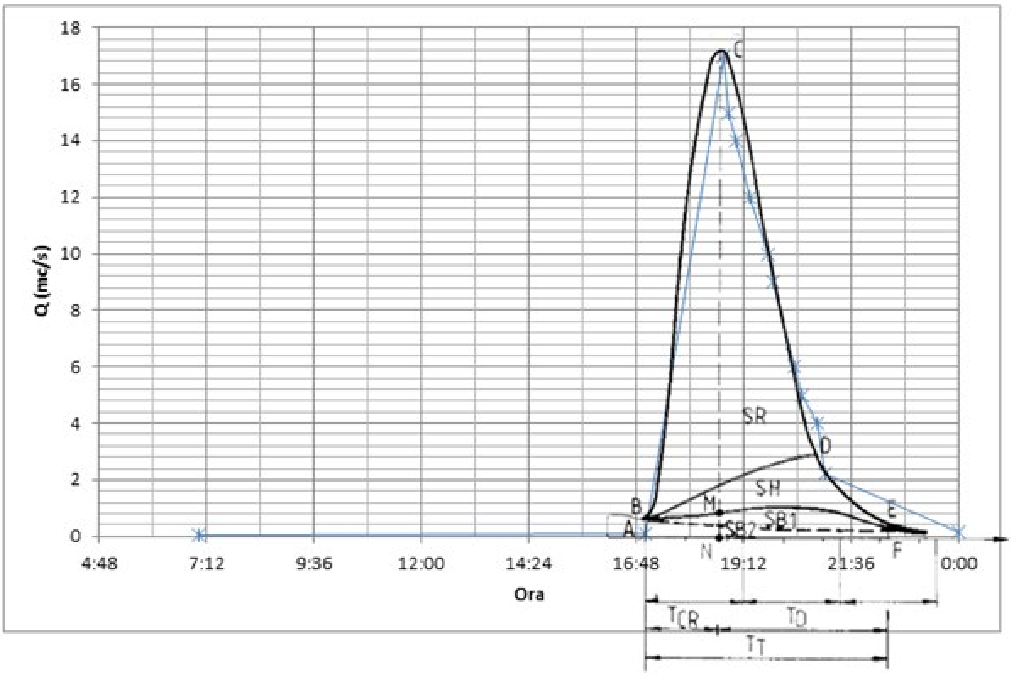


Fig. 12. The flood hydrograph for the NUNTAȘI basin

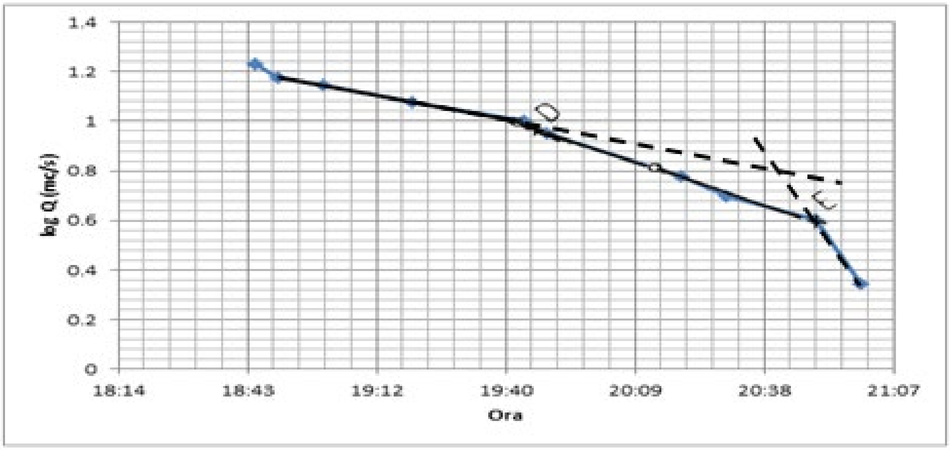
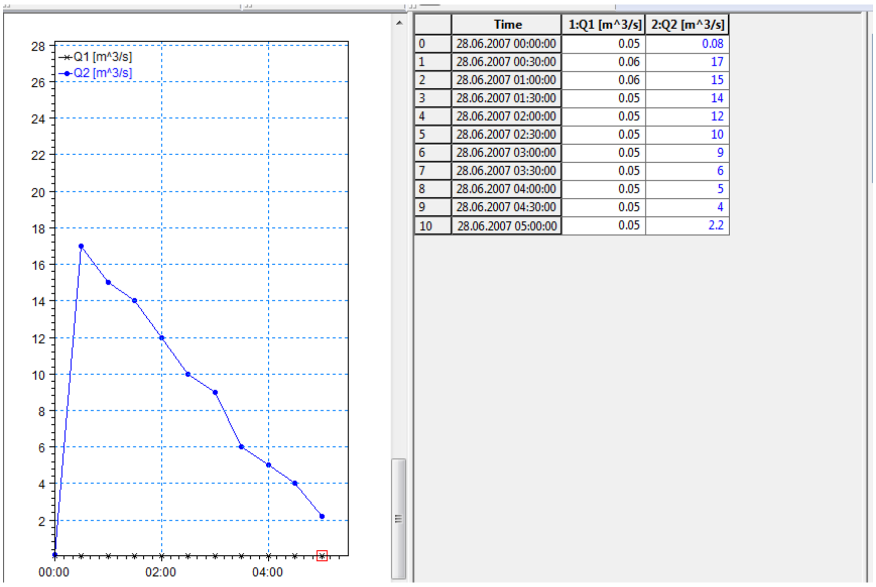


Fig. 13. Descending branch of the runoff hydrograph

The same hydrograph can be constructed with the MIKE 11 program (Figure 14) [3].



	Time	1:Q1 [m^3/s]	2:Q2 [m^3/s]
0	28.06.2007 00:00:00	0.05	0.08
1	28.06.2007 00:30:00	0.06	17
2	28.06.2007 01:00:00	0.06	15
3	28.06.2007 01:30:00	0.05	14
4	28.06.2007 02:00:00	0.05	12
5	28.06.2007 02:30:00	0.05	10
6	28.06.2007 03:00:00	0.05	9
7	28.06.2007 03:30:00	0.05	6
8	28.06.2007 04:00:00	0.05	5
9	28.06.2007 04:30:00	0.05	4
10	28.06.2007 05:00:00	0.05	2.2

Fig. 14. Flow simulation for two discharge flows at the 2007 level

3. Risk analysis of hydrographic area NUNTAȘI

With the method of analysis of the possibilities of risk RFMEA (failure mode risk evaluation analysis) are measured and quantified four parameters [11], [12], [13], [14]:

- •vulnerability (exposure) (R)
- • the probability (P),
- • the effect of being an instrument of control / measurement / control / share (N)
- • efficiency indicator of a new measure (F).

Vulnerability characterize exposure to risk factors analyzed location. For probability, an event in a year can be classified with another likely in the coming year, when more accurate data are available. The same is true with other factors in the selection process. Next, will be described the means of prevention and protection present actions and active policies. These are defined mainly by preventing complex parameter-control measure (N). The level of risk can be simply determined (RPN), or determined by the efficiency factor F (complex level of risk, RPNF).
Automatic calculation of the level of risk (value RPN) is done by multiplying the three values.

The risk levels based on RPN values are chosen so:

- • High (marked in red) for RPN values> 250;
- • Intermediate (marked in yellow) є RPN values (41 .... 250);
- • Low (marked in green) for RPN values є (1 .... 40).

F factor is automatically calculated by simply comparing the estimate danger in Euro (years for recovery), with estimated budget (years to recover) the measure of prevention (Table 4).
For urban river engineering on the section Nuntași- Basin Fantanele we fit the "prevention budget is higher than the estimated expense" (€ 5,797,003.10 - budget considered and the benefit obtained, € 760.763) [15], so the rate damages / costs is prevention 1.01 (falling between 1 ... 5) and F = 4.
For urban river engineering on the section Nuntași Basin Nuntași- we fit the "prevention budget is higher than the estimated damage" (4.404.135.83 € - budget considered and the benefit obtained, € 698.420), so the rate damages / costs is prevention 1.03 (fall between 1 ... 5) and F = 4.
Complex risk factor values RPNF is set as follows: high risk with prevention measure values greater priority for 1500 (red) (Table 4); environmental risk prevention measure acceptable values between (151 .... 1500) (yellow); low risk prevention measure without any serious urgent deployment of between (1 ... 150) (green).
So we fit at low risk of serious preventive measure without any urgent deployment of between (1 ... 150) (green).

Table 4: Complex risk factor values RPNF

The economic efficiency factor F – costs for damage and prevention	Damage rate/prevention costs	F value
Very high – the estimated damage is considered higher than the prevention budget	>50 1	10
	>20 to 1	9
High – the estimated damage is considered much higher than the prevention budget	10 1	8
	5 to 1	7
Almost equal – the estimated damage is slightly above the prevention budget	2 to 1	6
Equal	1	5
The prevention budget is greater than the estimated damage	1 to 5	4
The prevention budget is considerably high compared to the estimated damage	1 to 20	3
	1 to 100	2
Extraordinarily high prevention costs compared to estimated damages	>1 to 1000	1
Extraordinarily high prevention costs compared to estimated damages	>1 to 1000	1

The analysis offers the possibility of proposing new preventive measures. For each of these, an RPNF is calculated. The highest calculated RPNF value related to a new prevention measure implies the urgent implementation of this proposed new measure.

3. Conclusions

For studying the flow in the Nuntași riverbed eroded with environmental risk were analyzed elements: location and description of the hydrographic area, data sources feeding the aquifer basin data sources feeding the aquifer basin balance flows to the hydrographic area Dobrogea for 1999, 2004, 2007 and 2010, reporting to the climatological normal catchment area Dobrogea; hydro meteorological regime for the guests catchment area reported at Constanta County; morphological and morphometric elements of the bed of the guests; Nuntași riverbed proper flow modeling; risk analysis in the event of floods.

Building the model accordingly to Nuntași basin riverbed assumed the existence of a stage modeling that was done with the program MIKE 11 situation of 2007, to a forecast of rainfall for a period of 14 hours, the hydrograph basin Nuntași, based on the rainfall hyetogram; then simulated the flow along the river, indicating the distribution of speeds of flood related natural hydrograph.

Environmental risk analysis appropriate basin bed Nuntași imposed through some stages of analytical calculation and construction of flood wave hydrograph and its separation into its basic components, and use the same program to raise MIKE 11 hydrographer. It was also required volume calculation flood through plane measuring the S surface hydrograph and surface its basic components and the use method RFMEA (risk failure mode evaluation analysis) to calculate vulnerability, probability, the effect of being an instrument of control / measurement / control / share and efficiency indicator of new measures, the level of risk simple (RPN) and the risk level complex (RPNF), according to F-efficiency factor.

The conclusion of the risk analysis was: Nuntași riverbed fits at "*low risk prevention measure without any serious urgent implementation RPNF with values between (1 ... 150)*".

Following theoretical and experimental findings about river conditions change in response to the liquid phase flows and sediments are:

- Current depth is directly proportional to fluid flow and inversely proportional to the flow of solid material dragged;
- limits the embankments of river bed varies in direct proportion to the flow of liquid and solid material;
- varying flow is directly proportional to the variation solid ratio width / depth;
- slope of the river bed varies in direct proportion to solid and grain alluvial flow and inversely proportional to fluid flow;
- river meanders rate is directly proportional to the variation in relief and inversely proportional to the solid flow.

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