Journal of Young Scientist, Volume I, 2013
ISSN 2344 - 1283; ISSN CD-ROM 2344 - 1291; ISSN Online 2344 - 1305; ISSN-L 2344 – 1283

THE IMPROVEMENT OF REDIU RIVERBED, UPSTREAM OF TARGU FRUMOS CITY, IASI COUNTY

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Abstract

The water scheme goal is to provide flood defence and to protect the objectives on the south side of Targu Frumos. In this paper I approach the issues of the optimal choice for an ideal design. This thing was possible by interpreting two solutions, using multi-criteria analysis. Also, I analyzed the aspect of the environmental impact during the execution of the work, as well as during the operation. After calculations, the second scenario is considered to be the optimal, thus solving the flooding problem on the south area of the city.

***Key words**: environment, flood defence, multi-criteria analysis, riverbed.*

INTRODUCTION

The water scheme goal is to provide flood defence and to protect the objectives on the south side of Targu Frumos city: houses, greenhouses, land, railway, by increasing the transport capacity of the river in order to transit Rediu flood flows.

MATERIALS AND METHODS

The river flows from the hill Breazu, flowing through the valley, along the road that connects Iasi city with the Rediu village. The river is an affluent of Bahluiet river and it is part of a complex scheme of Bahlui river basin (river basin Prut), whose main purpose is the protection against flood Iasi city. The river has a total length of 14 km and a river basin at the confluence zone of 42 km^2.
Current situation is as follows (figure 6):
The dam shows a gap of about 80 m, located between the bottom and left side drain.

Figure 1. Current situation

Also, there is settling of about 70 cm. The bottom outlet is destroyed in proportion of 90%. The surface spillway is about 50% destroyed. The reservoir is silted at a rate of 70%. On the left bank there is the railway Pascani - Podu Iloaiei. Currently, in the impoundment there is in progress a social project including a stadium and a natural park with playgrounds for children.
The non-permanent water storage is out of operation; as a result it has been made works for clogging and river cross section

recalibration obtaining a channel base width of aprox. 10 m, in order to assure the capacity needed to transit the $Q_{10\%}$. Works were carried out downstream the confluence with Bahlueţ river (figure 2) (Consitrans, 2009).

Figure 2. Current situation

Taking into account these considerations, it is considered that reservoir rehabilitation involves high costs and low efficiency. Therefore, the proposed solution for flood defence consists in cross section recalibration and dike construction to insure the city in flood periods. Considering the assets protected, constructions to be performed will be included in Class IV of importance, according to STAS 4273/83, the flow calculation is $Q_{5\%} = 49m^3/s$, according to STAS 4068/88.

Present situation of Rediu stream water scheme looks as follows:

-upstream of the earth-dam, for L = 3000ml, the riverbed is natural

- downstream the earth-dam up to the bridge over DN28, for L = 350ml: cross section was enlarged, the base width is about 10 m, and the resulting material was systematized on the left bank, in the form of dikes with slopes of 1: 1 ÷ 1: 1.5 and crest width of about 3 m, poorly compacted.

-downstream the bridge over DN28 up to the confluence with Bahlui river, for L = 200ml, the cross section has not sufficient transport capacity. On the left side there is a defence dyke of reduced height, its crest being under the water level. This area is frequently flooded.

Proposed solution consists in all the works described in the following:

A.Cross section recalibration

The technical solution adopted takes into account the morphological characteristics of Rediu riverbed and geotechnical characteristics of the materials from the riverbed and banks. It is proposed cross section recalibration, ensuring a base width of 10 m and 1:2 slopes (figure 3). Material extracted will be used for filling in the defence dike body.

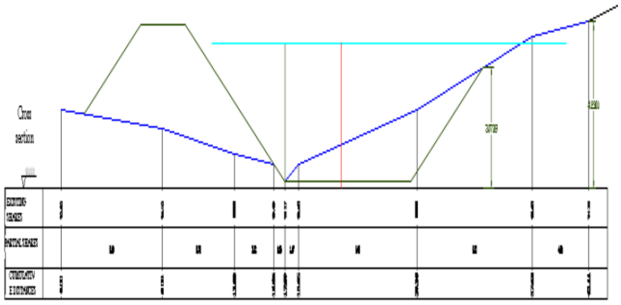

Figure 3. Recalibrated cross section

B.Defence dike. There is proposed a defence dyke and additional works for raising the existing dike and bringing it to the corresponding level for the Class IV of importance, plus a safety guard of 0.3-0.5 m.

Considering that:

-the right slope is steep and therefore the city extends and expands the itself on the left bank;

-there is an ongoing project for a beltway, developed on the stream right bank;

-during flood periods, by overcoming the right bank, floods cause not damages, because there is an unproductive area;

Those are the reasons to sustain the solution of a defence dike construction on the left bank (figure 4).

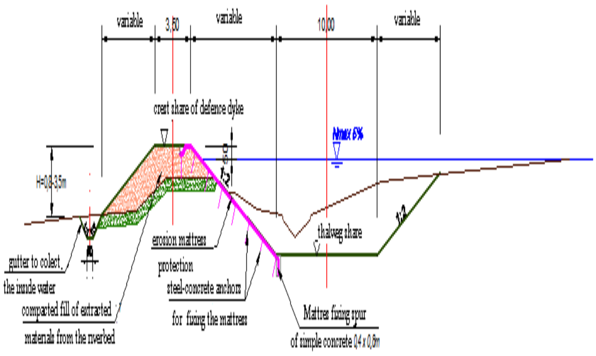

Figure 4. Dyke section

The dike will be done in extending bank, will have the crest width of 3.5 m and slopes of 1:2.

To protect the dyke downstream it will be protected with an erosion mat, set at the slope foot in a spur plain concrete of 0.4x0.8m.

The dike upstream slope will be covered with a 20 cm topsoil, to be grassed.
For the dike body filling it will be used material from the riverbed and from the existing earth-dam.
C.Undercrossing
For rainwater discharges the project includes 3 undercrossing works underneath the dyke body. They will take over the collected water at the upstream slope foot channel and will discharge it into Rediu river. Undercrossings will be placed into lowest levels to ensure gravity flow. They will be equipped with planar gates upstream and downstream with inverted flaps which closing under water pressure when the water level increase.
Proposed solutions are:
Variant 1
Dyke length is of 1040 ml. The defence dyke is intersecting downstream (near confluence) the railway embankment and upstream the higher terrace on left bank, defending only the stadium and the park area (project in execution) Recalibration work will be done on 850 ml. The effect is to protect an area of 9 ha from the flooding.
VARIANT 2
Dyke length is of 1650 ml. The defence dyke is intersecting downstream (near confluence) the railway embankment and upstream the existing discharge channel, defending the stadium and the park area (project in execution) and an additional area of 11ha.
In this area it is possible to develop the city in complete flood protection on account of cross section recalibration on 1600ml. Effect is to protect an area of 20ha. (Consitrans, 2009)

RESULTS AND DISCUSSIONS

A.Hydraulic calculation
For the sector of Rediu stream analysed we propose cross section recalibration after calculation being obtain water level using 20 cross section (P1 - P17 and intersections with DN 280 A and DN 28) for 5%, 2% and 1% flows in two variants: current situation and the situation occurring after work execution.
It has been developed calculation to determine appropriate water levels and velocity spectrum. Surveying results are used for this kind of calculation.

Hydraulic calculations were performed with HEC-RAS computer soft-wear: it determines the water level applying energy equation under uniform motion and solving it by iterative procedure called standard step method applied from a cross section to another.
Hydraulic calculation was performed assuming both natural regime establishing water level for $Q_{5\%}$ as well as for designed solution (cross section recalibration and dike construction). Given the current configuration of the riverbed and valley and required earthworks compensation between different cross sections it was accepted the assumption that, in some sections, the right bank could be flooded without reaching the road and houses. (Rotaru E.D., 2011)
B.Slope stability computation
For defence dike cross section I realized slope stability computation with GeoSlope Studio soft-wear using analysing methods Spencer, Fellenius, Janbu, Morgenstern-Price (figure 5).

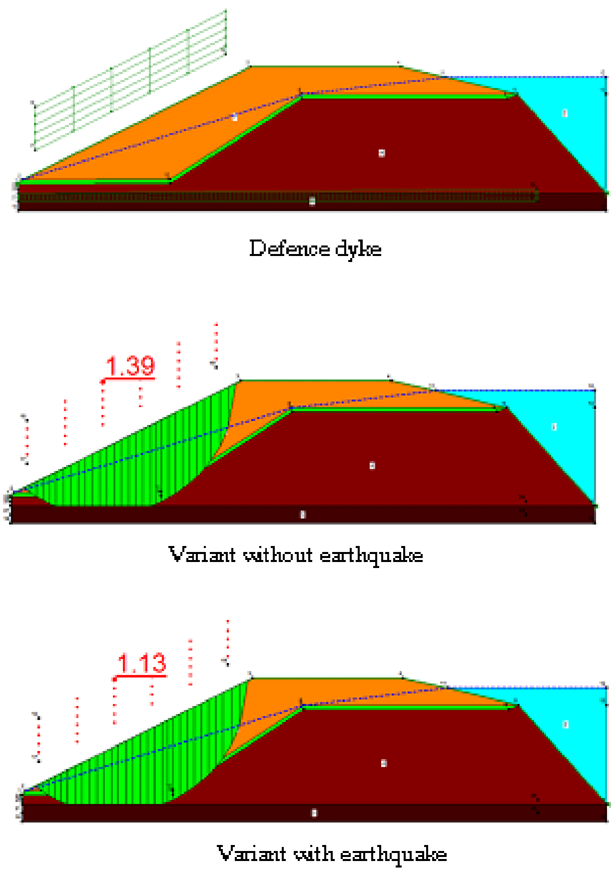

Figure 5. Stability calculations

I choose values resulting form Morgenstern-Price method because they are the lowest. (GeoStudio, 2007).
C. Environmental impact

Environmental impact has three aspects: water, soil and air.

During the execution of the objective the possible sources of water pollution are: traffic, excavation, earth and other construction materials handling and placing, grading and ditch cleaning, other specific construction. The pollution could be made with oil and fuels that may leak from vehicles or machinery involved in the construction.

After execution, the problem of water pollution is minor because there are no processes which can be occurred.

Work carried out in the period of execution of the objective may have a notable impact on air quality, in construction site and adjacent areas.

The execution woks are a source of dust emissions and a source of pollutant emissions, specific combustion of fossil fuels (petroleum distillates) both in engines of the equipment needed to perform the work and the transportation equipment.

Dust emissions that occur during the execution of the construction are associated with the excavation, earth and other construction materials handling and placing for grading and ditch cleaning and other specific construction.

Release of dust into the atmosphere may vary substantially from day to day, depending of the activity, the specific of operations and weather conditions.

The work involves a number of different tasks, each one with its own duration and potential dust generation. In other words, for creating a construction the emissions are associated with well defined period of existence (period of execution), but can differ substantially in intensity, nature and location from a phase to another of the building process.

The proposed objective shows no air impact. There is a minor potential for soil pollution by performing proposed objectives.

The impact on soil is produced by excavation, earth and construction materials handling and placing the soil for grading and ditch cleaning and other specific construction. Another way of soil pollution would be fuel or oil leaks from equipment used during construction. There is no risk for soil pollution.

Accidental pollution during execution can occurs during accidents, oil leaks (fuel, oil) that can cause degradation of the soil, the watercourses, groundwater and vegetation.

The risk of accidental pollution during execution is higher than during operation because site specific traffic (big cars, loaded with construction materials or fuel). To decrease this risk, the site will be suitably marked and will be established routes for construction and transportation equipment. In conclusion, the designed solution does not have adverse effects on soil, air, surface water, climate, vegetation, wildlife, and landscape.

In principle, the water scheme works and flood defence effect have a positive impact on the environment.

Regarding the negative impact, the influence occurs during execution period. During operation the negative impact decreases and tends to a normal situation, increasing positive weight to negative influences.

The proposed works do not generate waste and require no materials leading to environmental pollution.

The project analyzes constructive solutions which harmoniously frame with the landscape, being used mostly natural materials. Defence embankments slopes unprotected will be filled with grass. After work completion, the contractor will dismantle buildings and facilities concerning site organization. On this occasion the arrangements will be made to regain the previous land destination. It will be removed all potential sources of pollution (production zones, equipment repair and maintenance sites, fuel depots). On the occasion of the site organization dissolution, the Contractor shall also ensure site cleaning. (Consitrans, 2009)

D.Multi-criteria analysis

Multi-criteria analysis method allows comparing multiple versions of a project design, based on relevant and representative criteria.

The purpose of the method consists in selecting and recommending the alternative which complies as rigorously and completely to the specific requirements.

For multi-criteria analysis looking the optimal choice it can be consider the following criteria and sub-criteria:

a) C1 - economic criteria:

- C1.1 - cost of investment, operation and

maintenance costs updated for a period of 20 years;
- C1.2 - the cost of damages caused by erosion, collapse of banks, flooding .
- C1.3 - related costs: lower revenues from tourism, sport, recreation
b) C2 - Social criteria:
- C2.1 - aesthetic landscape;
- C2.2 - protection of riparians;
- C2.3 - recreation, tourism, sport,
- C2.4- affecting effect on the population in the area (restrictions, circulation, stress, including the works execution);
- C2.4 - quality of water used by riparians
c) C3 - ecological criteria:
- C3.1 - overall impact index due to spatial solutions, IGSA;
- C3.2 – index of the overall impact due to constructive solutions, IGSC;
- C3.3 - degree of impairment of ecosystems, preservation, conservation, transformation, destruction;
d) C4 - compliance criteria restrictions:
- C4.1 - compliance with urban river basin and river basin management plan;
- C4.2 - approved areas "accepted" as flooded;
- C4.3 - affecting protected areas
- C4.4 - public services affecting water supply, sewage, landfills.
Criteria and sub-criteria chosen are those for which the expected spatial differences between variants are considerable.
For multi-criteria analysis of the optimal choice for the Rediu stream project it is considered the following criteria and sub-criteria:
a) C1 - economic criteria:
- C1.1 - cost of investment and operation and maintenance costs updated for a period of 20 years;
- C1.2 - the cost of damages caused by erosion, collapse of banks, flooding (affecting households, land, crops etc.) for a period of 20 years;
b) C2 - Social criteria:
- C2.1 - aesthetic landscape;
- C2.2 - areas removed from the effect of flooding;
c) C3 - ecological criteria:
- C3.3 - degree of impairment of ecosystems, preservation, conservation, transformation, destruction;
d) C4 - compliance criteria restrictions:
- C4.1 - compliance with urban river basin and river basin management plan.
They were take into account three situation:
VARIANT 1
Defence dike length = 1040ml.
Cross section recalibration L = 850 ml. Effect is removing an area of about 9 ha from the flooding.
VARIANT 2
Defence dike length = 1650ml.
Cross section recalibration L = 1600ml. Effect is removing an area of about 20 ha from the flooding.
VARIANT 3 - no work (option 0).
The results of the 3 different scores obtained are presented in the following (table 1):

Table 1. The results of 3 different scores

Criteria	Share of	Sub-criteria	Share of Total -p	Variant 1		Variant 2		Variant 3	
				Normalized grade p	Weighted grade	Normalized grade Np1	Weighted grade Np2	Normalized grade	Weighted grade Np3
Economical C1	0.25	C 1.1 Investment	0.17	0.09	0.01	0.06	0.01	0.852	0.142
		C 1.2 Damage cost	0.08	0.31	0.03	0.63	0.05	0.06	0.005
Social C2	0.4	C 2.1 Esthetic	0.13	0.35	0.05	0.5	0.07	0.15	0.02
		C 2.2 Defence surfaces	0.27	0.37	0.1	0.53	0.14	0.11	0.028
Ecological C3	0.25	C 3.1 Degree of damage	0.25	0.17	0.04	0.39	0.1	0.43	0.109
Respecting restrictions C4	0.1	C 4.1 Plan and river basin management	0.1	0.41	0.04	0.59	0.06	0	0
Total			**1.00**		**0.27**		**0.43**		**0.30**

According to the table bellow (table 2), suitable for multi-criteria analysis (by weight criteria) the variant 2 has obtained the highest weighted score.

Table 2. Comparison of a 2 solutions

Criteria	Np1	Np2	Np1/Np1	Np2/Np1
C 1.1 Investment	0.01	0.01	1	0.73
C 1.2 Damage cost	0.03	0.05	1	2.00
C 2.1 Esthetic	0.05	0.07	1	1.43
C 2.2 Defence surfaces	0.1	0.14	1	1.43
C 3.1 Degree of damage	0.04	0.1	1	2.25
C 4.1 Plan and river basin management	0.04	0.06	1	1.43
TOTAL	**0.27**	**0.43**	**1**	**1.58**

Variant 3 (variant "zero" – no work, no investment) can not be taken into account because, although ecologically is the most advantageous, economic and social factors are severely affected. So, by floods that occur, if they do not perform any modification on the stream Rediu, a number of households are directly affected.

The damages avoided justify realization of proposed works for flood protection.

Option 2 is the most advantageous social and environmental solution.

From the economic perspective, the investment needed to carry out the works in version 2 is higher than for variant 1, but the increase is not directly proportional to the surface removed from the flood effect. (at 30% increase of the investment, the protected area is increasing 100%), meaning that from a social perspective, the village will have secured an area (owned by municipality) where can be built public interest objectives.

Variant 2 has some ecological disadvantages (especially in the execution of works, thus directly affecting the existing ecosystem) but is recommended to be implemented.

Multi-criteria analysis method clearly shows that exclusive consideration of the investment cost criterion is disadvanta to all general and local requirements and interests.

It follows from the above that the project in Variant 2 is the most responsive to the requirements imposed by multi-criteria analysis and has the least impact on the environment. (Rotaru E.D., 2011)

CONCLUSIONS

Rediu stream water scheme upstream Targu Frumos city, Iasi county for defence against floods by increasing the transport capacity of the river, after studying design alternatives, involves the design objectives described in variant 2 and is applied on 1650 ml. The defence dike is intersecting downstream the railway embankment and upstream the existing discharge channel, defending the park and stadium but also an additional area with a surface of approx. 11 hectares.

In this area it is possible to develop the city in complete safety from the point of view of the defence against flooding. Works consist on cross section recalibration of 1600ml length Effect is to remove a 20 ha area from the flood risk zone.

The proposed works will be carried on public property. Riparian residents on whose property is to run defence works are directly interested in their achievement, being the first to suffer when floods.

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