ASPECTS OF OPTIMIZATION OF WATER MANAGEMENT SYSTEMS

***E. BEILICCI*[1], *R. BEILICCI*[1]**

ABSTRACT. - Aspects of optimization of water management systems. Water management system include all activities and works which providing the administration of public domain of water, with local / national interest, and qualitative, quantitative and sustainable management of water resources. Hydrotechnical arrangements, consisting of a set of hydraulic structures, produce both a favorable and unfavorable influences on environment. Their different constructive and exploitation solutions exercise a significantly impact on the environment. Therefore the advantages and disadvantages of each solution must be weighed and determined to materialize one or other of them seriously argued.
The optimization of water management systems is needed to meet current and future requirements in the field of rational water management in the context of integrated water resources management. Optimization process of complex water management systems includes several components related to environmental protection, technical side and the business side. This paper summarizes the main aspects and possibilities of optimization of existing water management systems and those that are to be achieved.

Keywords: system, water management, optimization.

1. INTRODUCTION

A water management system is the set of activities and works which ensure the management of public domain of waters with local / national interest and the qualitative, quantitative and sustainable management of water resources. Water management systems, in generally, consist of one or more of the following construction:
- barring hydrotechnical construction on the river in order to accumulate a volume of water required for different uses (electricity, water supply, irrigation, flood protection etc.);
- hydrotechnical construction for water captation;
- hydrotechnical construction for water transport from the captation point to site where water is use (channel, pipeline, gallery etc.);
- hydrotechnical construction for water use (hydroelectric power station, water treatment plant for population supply, pumping station to supply irrigation systems etc.);
- hydrotechnical construction used to restore water in natural courses, after it has

[1] „Politehnica" University of Timisoara, Faculty of Civil Engineering, Department of Hydrotechnical Engineering, 300022 Timisoara, Romania, e-mail: beilicci_erika@yahoo.com

been used (run gallery or channel, sewage system, treatment plant etc.).

In Romania, most water management systems were achieved before 1990, the main purpose was the electricity generation, and in a lesser extent to ensure water quantity necessary for irrigation systems, respectively for navigation (Danube - Black Sea Channel). In their implementation has not focused on their optimizing, in particular for environment protection. After 1990, due to the economic situation, most of the work specified in water management remained in early stages of implementation. Works were in progress continued with a slow rate or entered in the stage of conservation.

Currently the focus is on achieving flood protection systems, respectively restoration of abandoned irrigation systems after 1990. This work may be new arrangements or fit into existing water management systems.

Equally important is the development of new small hydropower facilities or modernizing / upgrading / optimizing existing facilities with hydro energy purposes. As a member state of the European Union, Romania has to comply with its obligations in provisions of Directive 2001/77/EU on the promotion of electricity produced from renewable energy sources (the most important renewable energy source is water, followed by wind, solar, or geothermal sources).

Hydrotechnical arrangements produce about environment both a beneficial and unfavorable influence. Different constructive and exploitation solutions of these arrangements exert significantly impact on the environment. Therefore the advantages and disadvantages of each solution must be analyzed and the determination to materialize one or other of them seriously argued. Water management system optimization is needed to answer current and future requirements in the field of rational water management, in the context of integrated management of water resources. (www.library.utt.ro)

2. OPTIMIZATION OF WATER MANAGEMENT SYSTEMS

Optimization is the activity of selecting, from the set of possible solutions to a problem, the solution that is best compared to a predefined criterion. This definition implies that the following components:

1. A technical problem consisting in a mathematical calculus of solutions;
2. Existence of multiple solutions to the same problem;
3. A criterion for selecting the optimal solution.

The objective function is the mathematical expression of optimization criterion. This should reflect the economic efficiency of the process and at the same time to answer any technical process operation objectives: operational safety and quality compliance.

Optimization problem is a mathematical application of selecting a solution from a lot possible, based on the objective function evaluation. Optimization can be seen as a ratio between the effects and efforts to achieve these effects. As this ratio have a higher value, the optimization process is more efficient.

Purpose for which is achieved mostly water management systems are mainly related to satisfy water needs for uses such as: electricity generation, flood protection, water supply of localities and industrial sites, irrigation, fisheries, navigation, recreation.

If a water management system is achieved for a limited number of types of uses, the optimization procedure is simple, if the system have a large number of types of uses, then talked about a complex system of water management, whose optimization is more difficult. (Nica, 2001)

2.1. The optimization of choice of water management system emplacement

To achievement of water management systems should be considered that they affect the territory in which they are located, and surrounding areas, this problem is more important for reservoirs.

In addition to satisfy the uses for which they were designed, site selection for hydrotechnical arrangements must follow two important criteria: investment cost as low as (hydrological, geological, hydrogeological favorable conditions), respectively as small negative effects on the population (displacement of communities, jobs, moving of social - economic objectives) environment, land use (land taken out of agricultural circuit, flooded forests and pastures etc.).

When analyzing all existing variants of arrangements, should be imposed the condition that the effects of water management system implementation can compensate losses due its negative effects on the environmental factors (human settlements, water, air, soil, subsoil, flora and fauna). (Chiriac et al., 1976)

2.2. The quantitative optimization of water management system

As optimization criteria can be used to allocate expenses necessary for surface and / or groundwater discharges allocation, or costs for development and / or operation of one or more watersheds.

The objective function is:

$$z = min \sum_{i=1}^{n} (C_i + P_i) \qquad (1)$$

where: n - time period (month, year), C_i - expenditures of different water management measures during the period i (costs of maintenance, operation and investment), Pi - losses.

Decision variables x_i can be reported flows at a certain level or volume of water stored in reservoirs. Restrictions result from hydrological and hydrogeological conditions of the studied watershed. (Crețu, 1980)

2.3. The qualitative optimization of water management system

Water quality management models include sources of pollution (especially point sources, but and diffuse sources) - restitution of wastewater, totally or partially treated - and their effects on surface water and uses, respectively the measures taken to reduce negative effects.

As optimization criteria can be used the necessary expenses for wastewater treatment in a river basin and the cost of water treatment for drinking, from the same river basin.

Decision variables x_i are levels of treatment in i points (Fig. 1), located along a stream, where are located restitutions of wastewater.

The objective function is:

$$z = min(\sum_{i=1}^{m} B_i + \sum_{j=1}^{n} A_j) \tag{2}$$

where: B_i - the cost of wastewater treatment in the point i, A_j - the cost of water treatment for drinking in the point j. (Crețu, 1980)

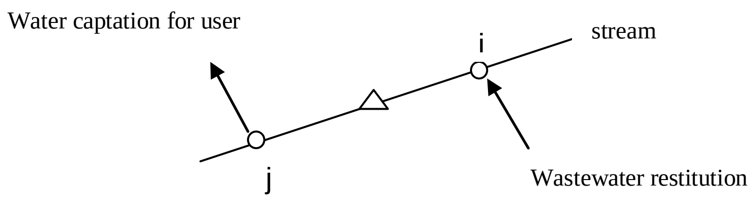

Fig. 1. *Optimization scheme*

2.4. Optimization of complex water management systems

2.4.1. Optimization of complex water management systems from point to view of environmental protection

In accordance with the statement of the United Nations Conference in June 1972 in Stockholm, the "environmental impact (IMI)" means any effect of a activities product on environment, such as: fauna and flora health and safety, soil, air, water, climate, landscape and historical monuments or other structures, on the interaction between these factors, effects on cultural heritage or socio-economic conditions resulting from alterations to those factors.

Hydrotechnical arrangements in generally, and hydrotechnical structures in particularly, produce on the environment both a positive and a negative impacts. Regardless of the implemented measures, their negative impact on the environment cannot be removed completely. Therefore it was concluded that this quantitatively and qualitatively decrease may only issue, finally reaching a convenient impacts, widely accepted, by potentiating the beneficial effects and reducing harmful effects, thus protecting the important elements of the environment.

Effects of hydrotechnical arrangements achieving on environment are: clearing vegetation on the site of constructions for barring, transport and water valorification; partial or total destruction of aquatic flora and fauna of the river bed because during construction the water discharge of river will be diverted, and then it will be reduced, and will ensure normally just a discharge of servitude and exceptionally, a overflow discharge depend of the needs of barring structure operation; out of use of land areas, destruction of flora (forests, shrubs, vegetation) and fauna on them due to their flooding to ensure the retention of a volume of water, necessary to satisfy uses for which it was designed barring construction; flooding some areas due to losses from the partial or total water transport construction damage; producing residual materials from water and wastewater treatment procedures.

Measures that can be taken to reduce harmful effects on the environment are: restoring flora (forests, shrubs, vegetation) in other locations on equal surface with to flooded areas and from construction sites, if possible; to ensure all possible conditions for the survival of aquatic fauna and flora by taking these considerations into account when determining the discharge of servitude, and provision of fish ladder for perpetuating the species of fish that goes upstream for spawning; replacement of water transport construction (more or less damaged), which have negative effect on environment, with some with produce a smaller or zero negative effect on environment; upgrading water and wastewater treatment plants or build new ones in order to reduce waste material and increase treatment level.

These measures are actually the optimization of existing works included in complex water management systems, in terms of environmental protection.

In case of new arrangements, all environmental factors should be included in their design phase. Different constructive solutions have a significantly different impact on the environment. Therefore the advantages and disadvantages of each solution must be weighed and decision to materialize one or other of them seriously argued.

General concept of water management systems design must respect criteria that minimize the ecological balance damage, which include:

a) the priority objective must be the environment protection and biodiversity conservation, taking into account the conservation and protection of habitats and species of community interest;

b) the constructions must be "elastic" type, capable to support large, differentiated deformations;

c) allow free and natural water flow, especially during floods, and in case of ice, float or solids existence in water table;

d) the constructions must to be properly founded on natural ground to avoid damage caused by advancing erosion under construction body, including in water withdrawal period;

e) avoid increased rate of water course modification through sewers and changes in water bed geometry;

f) allow, for large sectors of watercourses arrangement, phased implementation of waterworks, ensuring time tracking of morphological processes and performance parameters of the project;

g) design of hydrotechnical arrangements will be considered the limits allowed for hydromorphological, physico-chemical and biological indicators of ecosystems, to achieve the main goal of environmental targets on all arranged watercourses;

h) deviations from these criteria can be justified only to defend the population and / or economic objectives with social value.

To reduce the impact on environment exist the following solutions:

- use of local materials for proper integration of construction works in landscape;
- buildings that are to be put into practice must have the characteristics of local architecture;
- ecological rehabilitation / reconstruction measures, that will override on integration measures in environment, will result in a decrease of impact supposed by project implementation. (www.library.utt.ro) (www.studiidemediu.ro) (Normativ tehnic, 2008)

2.4.2. Technical optimization of complex water management systems

To achieve a real optimization of complex water management systems is necessary to analyze all the components of systems in order to bring them operating at maximum performance.

Once this analysis is done and identifying the causes that restrain functionality at maximum capacity, is possible to determine the measures to be taken to ensure the functioning of these components to maximum efficiency or replace them if necessary.

It examines the behavior in time of construction, the state of degradation of them, if the equipment operates on designed characteristics and yields, if not affected by time (obsolescence of equipment), if not appeared in the meantime new technologies with a higher projected yield for existing conditions. (Cogălniceanu, 1987)

2.4.3. Economical optimization of complex water management systems

The fourth principle of the International Conference on Water and Environment (Dublin 1992) states that water has an economic value in all use in which is involved and this should be recognized as an economic good. This principle recommends to obtaining maximum benefit from limited resource of water for generating funds to recover investment costs and operating and maintenance costs of the system.

Operating and maintenance cost recovery is a minimum support condition for hydrotechnical arrangements.

In taking of investment decision, it is important to evaluate the economic impact of various hydrotechnical arrangements, in other words it is necessary to perform a cost-benefit analysis between different solutions.

The evaluation of these investments can be described as having four basic steps:

• arrangement quality performance evaluation;
• estimating the associated costs;
• characterization of different solutions in terms of cost and efficiency;

• achieving comparative economic analysis of different arrangement solutions.

A specific problem occurs to investments for hydrotechnical arrangements, they being forced to compete with other investment opportunities because the capital resources are limited, being typical for any investment aimed to reducing costs. In the allocation of capital resources, some investments are considered as "strategic investment", ie they are necessary for the national economy or to protect the public and social-economic facilities against effects of floods, environmental pollution or drought. Another group of investment is required by law, they have little or no recovery rate of capital and they are not selected based on economic criteria. (Metodologia B.I.R.D., 2009)

3. CONCLUSIONS

Climate change, dangerous hydrological phenomena's, which occur more frequently in last year's, respectively the current economic context impose a necessity of optimizing water management systems, because the water resources are limited and water demand are increasing.

Optimizing of water management systems is a very important process, both at the design stage (new arrangements) and in the operational phase of this work (new and existing arrangements).

Optimization process of complex water management systems includes several components related to environmental protection, technical side and the business side. The first two components can be implemented separately, but cannot be separated in any form of economic component.

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