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SYSTEM FOR FACILITATE FISH MIGRATION UPSTREAM/DOWNSTREAM OF THE BULZ DAM

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Abstract

The study area is part of the Iad River basin, one of the largest basins, a right tributary of the Crişul Repede River. The Iad River, a tributary of the Crişul Repede River is located in the north-western România, and is intensively arranged in the matter of engineering. Throughout its length the Iad River is provided with three dams and reservoirs (Bulz, Munteni and Leşu), which are part of the hydropower developing system on the Crisul Repede River. Bulz Dam (17 m height), which is subject to this paper, is located near the confluence between the Iad River and Crişul Repede River and is part of the grayling fish zone, where there are three protected migratory fish species: Danube gudgeon (*Gobio uranoscopus*), barbel (*Barbus barbus*) and the common nase (*Chondrostoma nasus*). In order to facilitate the possibility of migration of the above mentioned migratory fish species upstream of Bulz dam, we recommend performing the execution of a canal for migrating fish, which is fastened to the right abutment of the dam. The achievement of such migration system suggested in this paper will help restore the longitudinal connectivity of the Iad River on a length of about 5 km, creating optimal conditions for the development of aquatic fauna.

Keywords: longitudinal connectivity, dam, fish migration

1.INTRODUCTION

The watercourses connectivity is currently recognized as a fundamental property of water ecosystems worldwide, while the emphasis is on the hydrologic connectivity as it is incontestably a defining feature of all riparian ecosystems (Pringle C., 2003).

In România the need to ensure the lateral and longitudinal connectivity of watercourses and fish migration implicitly has been imposed by implementation of the Water Framework Directive 60/2000, transposed as a national law, and it represents an important hydromorphological quality element of the River Basin Management Plans.

This paper represents a continuation of the authors' concern regarding the issue of longitudinal connectivity restoration of the Iad River, a left tributary of the Crişul Repede River, in order to enable the fish fauna migration upstream of dam Bulz. Dam Bulz is part of the hydropower development on the Crişul Repede River, being the first at the confluence of two rivers – Iad and Crisul Repede.

In order to facilitate upstream and downstream the dam we propose an engineering solution which aims to develope a fish migration canal fastened to the right abutment of the dam. The proposed solution provides for creation of a pool of fish transport (vertically), which operates on a "platform rack" and some metal sheet piling, in order to increase the water and redirect it to the inlet of the migration. The proposed solution also provides the execution of a basin for fish transportation (vertically), which operates as a „platform rack" and uses some metal sheet piling, in order to increase the water level and redirect it towards the migration system inlet.

2. THE STUDY AREA

The study area is part of the Iad River basin (Iada Valley), a right tributary of the Crişul Repede River. The Iad River (basin 223 km^2, length 44 $km^{2)}$ (*Atlas Water Cadaster of Romania*) is intensively arranged in the matter of engineering. Its hydropower potential is exploited by the means of a complex of reservoirs and underground hydropower plants (Bulz, Muntenia and Leşu).

Bulz Dam (17 m height), which is subject to this paper, is located near the confluence of Iad River with Crişul Repede River (figure 1). Bulz accumulation is 1 km length, covers an area of 12.58 hectares and has a total volume of 0.54 million m^3 (of which 0,518mil.m^3 = working volume); it acts as a compensator lake and allows the partial adjustment of the discharge

flow being characterized by a satisfactory uniformity with average daily flow of about 10 to 12 m^3/s (Csaba, 2008; Dume, 2009).

Figure 1. Bulz dam location (Image source: Google Earth, 2012)

According to fish zoning of the Romanian rivers (Banarescu, 1964), the study area is part of the *grayling fish zone*, including the lower part of the Iad River. There are four species of protected migratory fish in this area: Mediterranean Barbel (*Barbus meridionalis petenyi)*, Danube gudgeon (*Gobio uranoscopus*), barbel (*Barbus barbus*) and common nase (*Chondrostoma nasus*).

All mentioned species are sensitive to pollution and prefer clear, flowing and well oxygenated waters. Habitat alteration and modification, dams, water extraction and pollution are the main factors threatening these species, why they are protected at the international level by Bern convention, Habitats Directive, Natura 2000 Species status and Red List of RBDD.

3. Description of the proposed solution
System to facilitate downstream fish migration

To facilitate the migration of fish fauna upstream and downstream of Bulz dam, this paper proposes the execution of an oval or trapezoidal canal for fish migration and fixed by the dam abutments. The proposed solution also provides the execution of a basin for fish transportation, which operates as a „platform rack" and uses some metal sheet piling, in order to increase the water level and redirect it towards the migration system inlet. This system of migration can be made of various lightweight materials (metal, wood, carbon fiber), and it can be easily disassembled, if necessary.

Thus, near the right bank sluice of the of Bulz dam a M1 sheet pile made of metal, plastic or wood will be fixed on the dam pile and on a metal or concrete pillar, located upstream of the spillway crestl (figure 2).

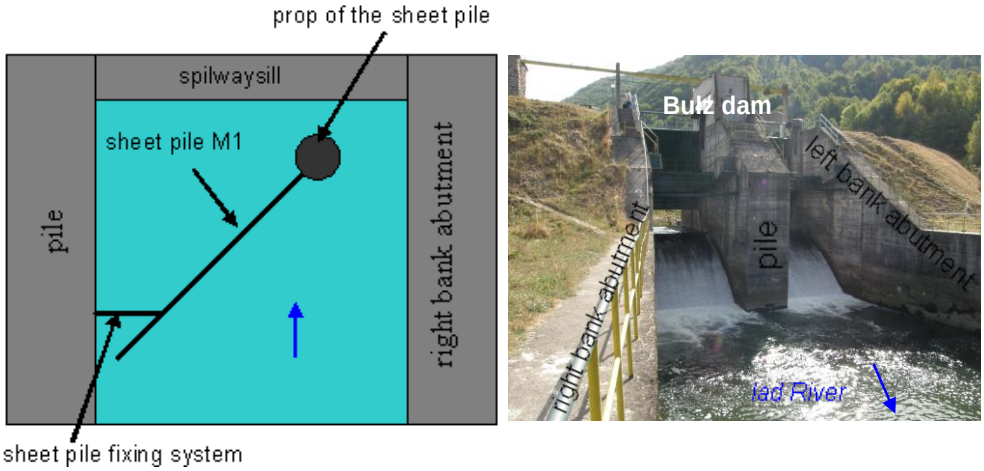

Figure 2. Indicative scheme for positioning of M1 metal sheet pile (Photos by E.Luca, July and September 2011)

Further, the mobile M2 sheet pile, fastened by the means of some stainless steel hinge, is attached to the pillar of the M1 sheet pile. M1 sheet pile will be able to redirect much of the transit flow by the means of the first sluice (placed nesr the left bank) towards a canal formed between the right bank abutment of the Iad River and the M2 sheet pile (figure 3).

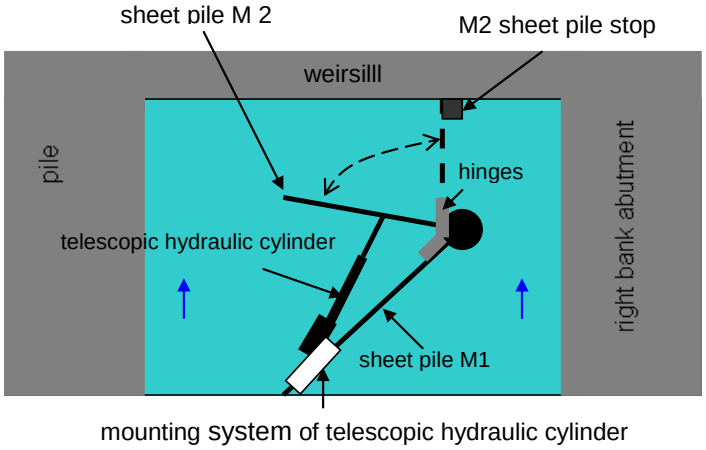

Figure 3. Scheme for M2 sheet pile positioning (*plan section*)

In order not to affect the operating system of the sluiceway, is recommended to choose a mobile M2 sheet pile with variable geometry in

the vertical plane that can be operated (opened and closed) using a telescopic hydraulic cylinder mounted on a metal plate fixed, in its turn, on the M1 metal pile using some bolts (figure 4). A resistant metal spring will be welded to the end of telescopic hydraulic cylinder to ensure greater mobility of it; it will be welded to the M2 metal sheet pile shown in Figure 3.

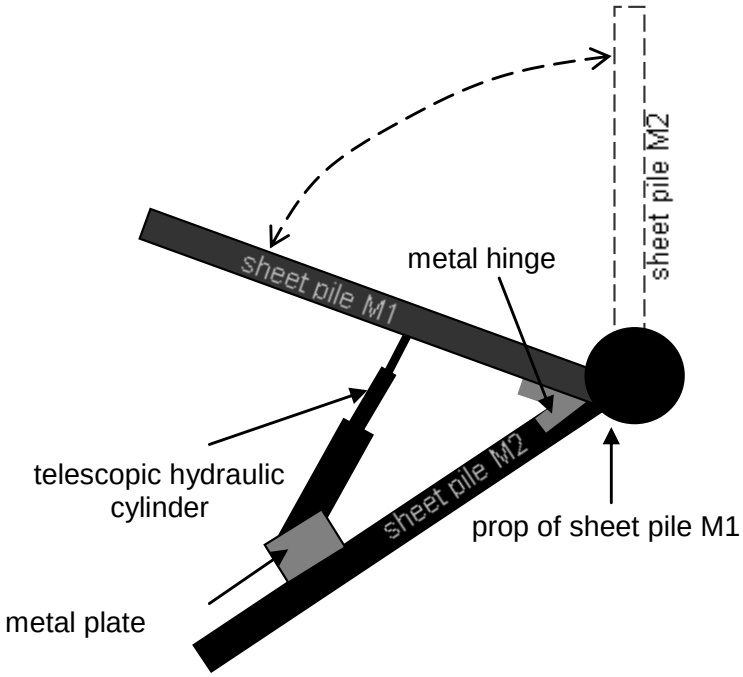

Figure 4. Scheme for opening and closing of the M2 sheet pile

In case of necessity (emergency situations, floods, small quantity of water, repairs and maintenance) and to protect the system during the winter migration, the telescopic hydraulic cylinder disconnects the M2 sheet pile, bringing it to its original position which does not block river flow.

There is a space between central pile and the M1 sheet pile (figure 5) through which the water can flow downstream of the spillway.

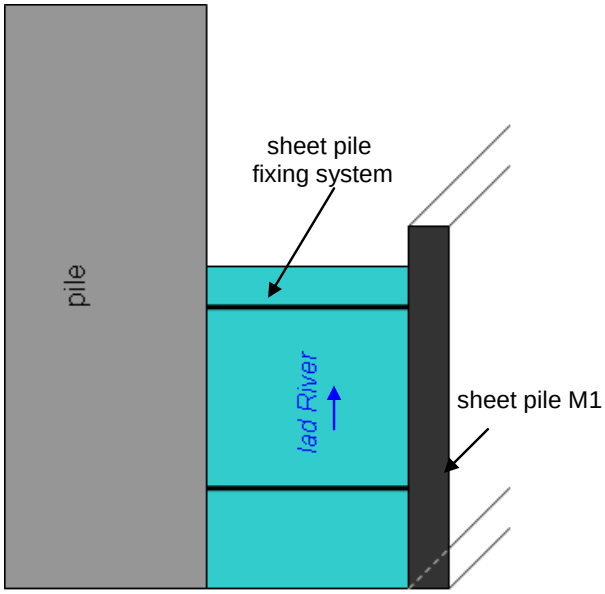

Figure 5. Indicative scheme for M1 sheet pile mounting system (*longitudinal section)*

The two sheet piles installed upstream of the 1st sluice will be raised about 1 m above the water level, aiming to raise the water level by about 40 cm and ensuring the necessary flow for the migration system, and facilitating fish migration upstream the spillway sill of the 1st sluice. A rectangular canal for fish migration that fully takes the flow created by the two sheet piles M1 and M2 shall be fixed on the end of the spillway crest (figure 6).

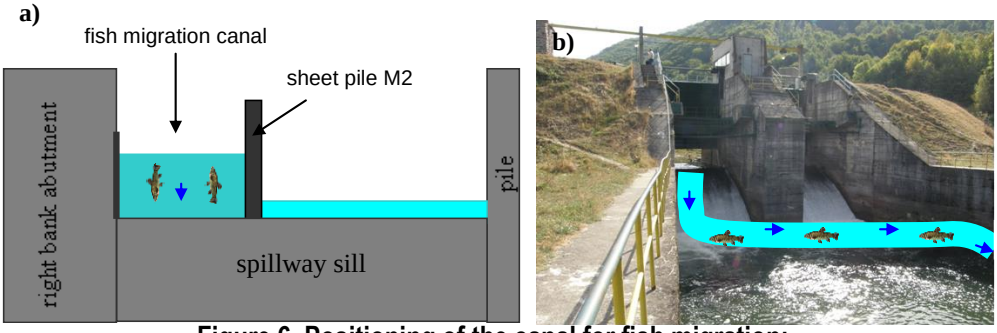

Figure 6. Positioning of the canal for fish migration:
a) cross section; b) indicative scheme on location
(Photos by E.Luca, July and September 2011)

The rectangular canal for fish migration, made of light materials (carbon fiber or waterproof metal) will be fastened by the means of some dowels and metal bars on the right bank abutment (figure 7).

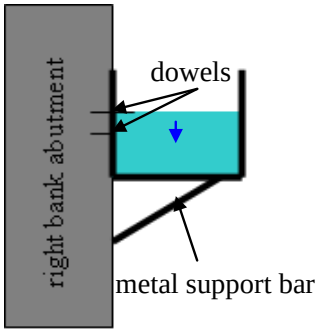

Figure 7. Sheme of fixing system for fish migration canal

The first 10 m of the canal for fish migration will be fixed to the right bank abutment of the dam; then the canal will turn left, crossing the Iad riverbed above the stilling basin area and it will be fixed to the left bank abutment of the dam (figure 8).

he canal will also be equipped with two resting pools where fish can rest in their way to breeding habitats.

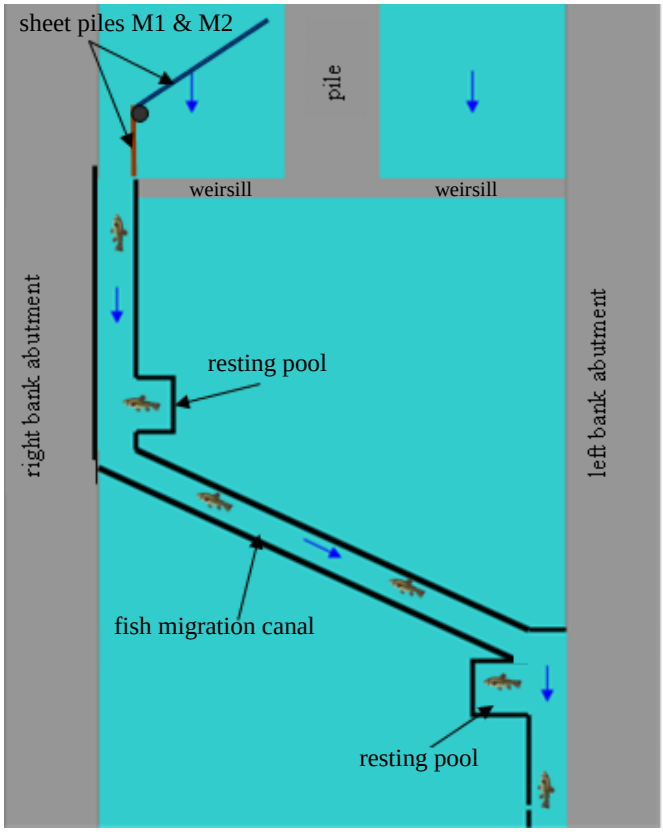

Figure 8. General scheme of fish migration system (*plan section*))

After passing stilling basin and fixed risberma, the fish migration canal crosses the river bed (figure 8) and reaches the river on inclined plane, into a specially natural basin designed in the river bed (figure 9).

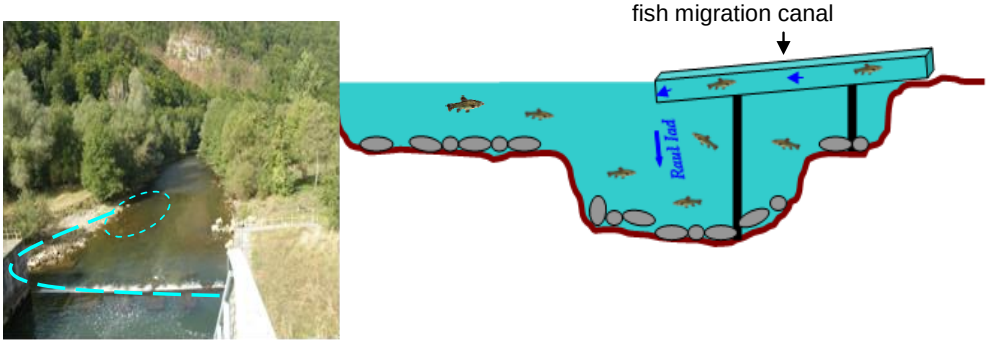

Figure 9. Indicative scheme of the fish migration canal entrance
(Photos by E.Luca, July and September 2011)

System to facilitate downstream fish migration

To facilitate the downstream fish migration a fish transporting system provided with a tank (basket type) with pinion-rack system can be developed. The rack is fastened to the dam abutment on the right bank of the Iad River and the lifting basin will be situated between the abutment and the M2 sheet pile, upstream of the spillway crest (figure10).

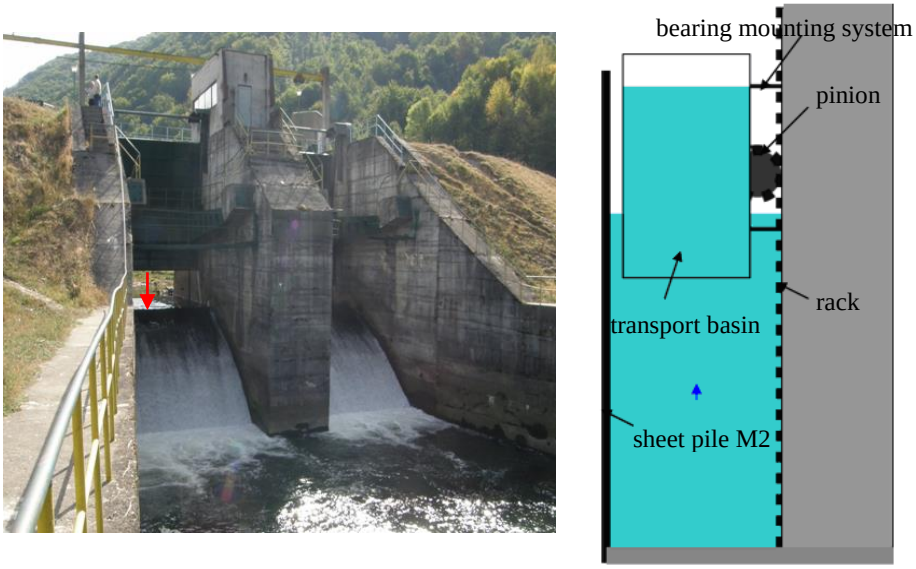

Figure 10. The location of the fish lifting basin and of fixing system (*cross section*)
(Photos by E.Luca, July and September 2011)

The basin for ichthyofauna transportation is rectangular parallelepipedic, has two access windows automatically operated and located on the lower surfaces of the basin (figure 11). The fish access window to the migration canal is oriented upstream and closes automatically when the sensor detects a limited number of fish within the basin. When the basin for fish transportation reaches the spillway crest, at the entrance of the migration canal, the window oriented downstream opens automatically.

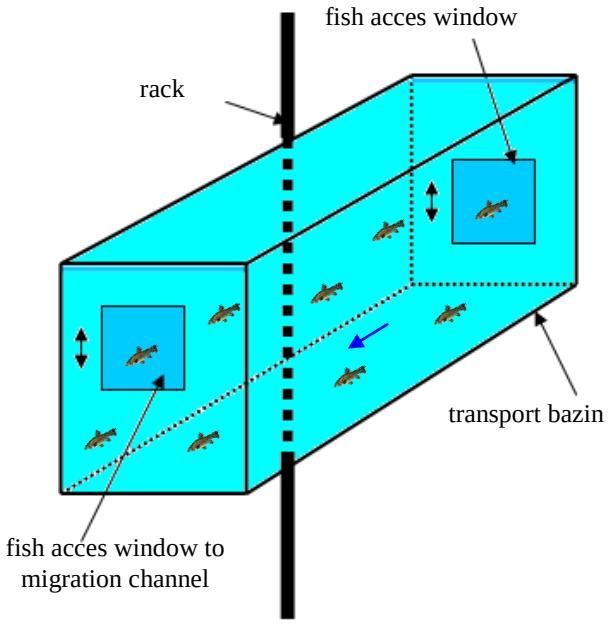

Figure 11. Indicative scheme of positioning of the access window

The main function of the transportation basin, by the means of which fish can be raised and guided to the entrance of the migration canal, is increasing the system efficiency when a large population of fish (especially a large number of spawn) is present. This additional system can be built, if necessary, after the execution of the other components of the fish fauna migration system.

During the winter, when the migration process is reduced and the system for ensuring fish migration upstream / downstream of Bulz dam is less functional, its components can be preserved and can be reassembled before the spring migration period of fish fauna. The proposed migration system is viable and the implementation costs are lower than the usual cases due to materials used (carbon fiber and metal).

4. CONCLUSIONS

The technical solution proposed in this paper has a *high practical value*, considering the measures to restore the longitudinal connectivity of rivers, set in River Basin Management Plan in Romania, as the main instrument for implementation of the provisions in the Water Framework Directive which must be achieved by 2015, or by 2015 through some derogation. This is not a radical and invasive solution and it preserves the property of Hidroelectrica, being feasible by any technical and engineering point of view.

The proposed migration system can be easily achieved, its components can be made of light materials (metal, wood, carbon fiber) which does not require special manufacturing technology and gives it some advantages (a wide range of use, lower costs, fast assembly durability and a more efficient maintenance). The paper does not aim to estimate a final cost of execution, but a simple comparison shows that the price of materials and the labor costs used are cheaper than achieving the conventional concrete.

Developing the migration system proposed in this paper will help to restore the longitudinal connectivity of the Iad River on the river sector between its confluence with the Crişul Repede River and Munteni dam, creating optimum conditions for aquatic habitat restoration and recovery of natural ecosystems and water quality. If it is necessary, the system can be easily disassembled if it is be no longer useful over time, it can also be easily removed, returning to the initial state of the dam.

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