



## **IMPLEMENTING PASSAGES FOR LIVING ORGANISMS ON DAMS ON THE RIVER DRAVA**

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### **ABSTRACT**

In accordance with the requirements of the EU Habitats Directive (The habitat directive - FFH Directive 92/43/EEC) and Water Framework Directive (WATER Framework Directive - WFD, Directive 2000/60/EC) and a Slovene legislation, the Drava Power Plants Company began operations for implementation of passages for living organisms.

The area of the Drava power plants comprises 133 km of waterway, on which 10 large dams are situated. Facilities were built from 1913 (hydro-power plant Fala) to 1978 (hydro-power plant Formin). During construction there was no mandatory provision of passages for living organisms, hereinafter building of fish paths, so there were only three fish passages build on the dams: on the Vuzenica hydro-power plant, Fala hydro-power plant and Mariborski Otok hydro-power plant.

In accordance with the above legislation, we carried out an examination of current state. After analyzing the situation, we began to adapt existing fish path on hydro-power plant Mariborski Otok and to plan implementation of fish path on the Markovci dam, based on idea concepts.

## **1. Introduction**

There are eight production objects, i.e. hydroelectric powerplants (HPP), on the river Drava, which are maintained by the Dravske elektrarne Maribor (DEM). Six of the dams are accumulating with concrete-gravity dams (Dravograd HPP, Vuzenica HPP, Vuhred HPP, Ožbalt HPP, Fala HPP and Mariborski otok HPP) and further two are channel dams (Zlatoličje HPP and Formin HPP). Based on the construction height, the amount of water reservoir and maximum flow, they are all classified as large dams by the IOCOLD (International Commission on Large Dams) classification.

Due to the silting, six hydroelectric powerplants between the border with Austria and Maribor city are all located directly on the river, followed by two channel powerplants with Maribor and Ptuj lakes respectively serving as accumulation lakes. In the area of Melje and Markovci, two additional small hydroelectric powerplants are built that use the biological minimum water energy, which flows in the Drava riverbed. The Drava River can be classified as large river for Slovenian environment, due to its high water level and flow that averages at 400-500 m<sup>3</sup>/s.

Despite its energetic values, impoundment of the Drava River is consequently an obstacle for the passage of migratory species of aquatic organisms (fish, etc).

### **1.1 Fish passages**

Three fish passages were built on side of the HPP buildings on the Drava River, on the Vuzenica HPP, Fala HPP and Mariborski otok HPP. They were in use for a limited time and were later closed on the initiative of local communities and fishing families. During the construction of Zlatoličje HPP and Formin HPP, there was no demand for building of fish passages.

In year 2011, study of field placement of river passages in the area of Markovci dam was carried out in accordance with law regulations. Because there is a lack of space for placement of river passages besides some HPPs on the Drava River, we are constantly monitoring best practices for river passage implementation on similar object in Europe.

### **1.2 Study of fish population on the Drava River**

Prior to the year 2005, the assesment of population of species in the river Drava was based on the statistical analysis for the minimum of 20 years, which however was not a reliable and quality information.

Between years 2005 and 2013 a study of fish population in the Drava River was carried out on behalf of DEM. The study was carried out in similar way as this was done on behalf of Austrian hydro powerplants (Verbund) for the river Drava stream in Austria. The results of the study are the continuation of this study and assesment of current quantity and variety of species in the river Drava in the area covered by DEM. The assesment on each segment of the river takes two years and is based on the actual harvesting of fish. The assesment for the most of the area between Dravograd and Markovci dam is completed.

### **1.3 Problem solving**

In accordance with Bernsko (1979) and Bonsko (1979) conventions, EU directives on habitats and rivers (The Habitat directive –FFH, directive 32/43/EEC), water framework directive (WDF, Directive 2000/60/EC) and in accordance with Slovenian legislation, we approached to organisation of passages for living organisms on the Drava River with fish passages.

The construction of fish passages involves high costs, which are not known to date and will vary between locations. Based on the possibilities, we started building fish passages on

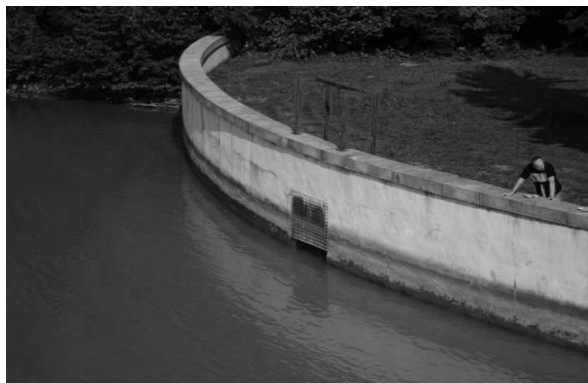
Mariborski otok HPP and Formin HPP, on Markovci dam. On the other objects, HPPs on the upstream from Mariborski otok HPP, former fish passages are now used for other purposes, like instalation of new aggregates or used as assembly hall.

*Picture 1 Drava river HPPs in Slovenia*

## **2. Revitalisation of fish passage at Mariborski otok HPP**

In 2011, Slovenian Institute for fishing performed a study on existing fish passage on the Mariborski otok HPP, which was in use only for a short period of time in 1952. Later, the fist passage was closed on the request of local community and fishing families. The study was completed in 2012. Thorough analysis of the state of the fish passage in realtion to fish population was carried out and served as a base for the evaluation of suitability with new criteria for such objects.

Based on historical data and analysis as well as fishers' catch, we know that there are five different species of migrating fish present, while one specimen was present in the past but has not been spotted in past years. It is expected that improvements in the water structure would most probably cause for this specimen to appear again in the waters.

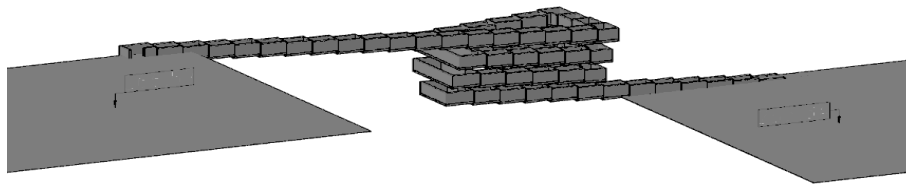


*Picture 2 Inflow of fish passage on the left side of Mariborski otok HPP*

Monitoring of the fish passages for several months has lead to conclusion, that the inflow of fish passage is too high for current operation of hydroelectric powerplants and this consequently prevents constant flow of water in fish passage.

Following parameters were observed in the study: hydrological demands, nutritional demands, reproduction demands and migrating characteristics of present fish. In the segment observed, the quality of water is classified into 2<sup>nd</sup> quality class as quality water based on detailed physical-biological-chemical analysis.

Basic demands for form and dimensions of existing fish passage were based on the evaluation of AG-FAH (2011) and FAO & DVWK (2002). The results show, that the geometry of fish passage does not match modern requirements in at least four parameters. The conclusion of the study recommends reestablishment of current object with recommendations that are to be implemented in steps and evaluated with monitoring. Additionally, hydraulic test was performed as part of the study.



Picture 3 Fish passage geometry at Mariborski otok HPP

Splošno:	Ribja steza Mariborski otok	AG-FAH, 2011	FAO & DVWK, 2002
disipacija enetgije (W/m <sup>3</sup> )		100,0	150,0
max. višina stopnje (cm)	25,0	10 do 13	20,0
max. naklon (%)	8,0	4,2	
volumen kotanje (m <sup>3</sup> )	5,5	7,0	3,2-6,0
<b>Režasti prehod:</b>			
min. širina reže (cm)		35,0	30,0
min. dolžina kotanje (cm)		310,0	275-300
min. širina kotanje (cm)		210,0	180,0
min. globina vode - tolmun (cm)		105,0	75,0
min. globina vode - reža (cm)		111,5	
pretok (l/s)		550,0	410,0
dolžina roba-c (cm)			18,0
zamik-a (cm)			14,0
širina usmerenika-f (cm)			40,0
<b>Stopničaste kotanje:</b>			
min. širina odprtine (cm)	40,0		40-50
min. višina odprtine (cm)	40,0		30-40
max. hitrost v odprtini (m/s)	> 2,0		2,0
min. dolžina kotanje (cm)	260,0		250-300
min. širina kotanje (cm)	145,0		160-200
globina vode (cm)			80-100
pretok (l/s)			200-500

Picture 4 Results of the existing fish passage analysis

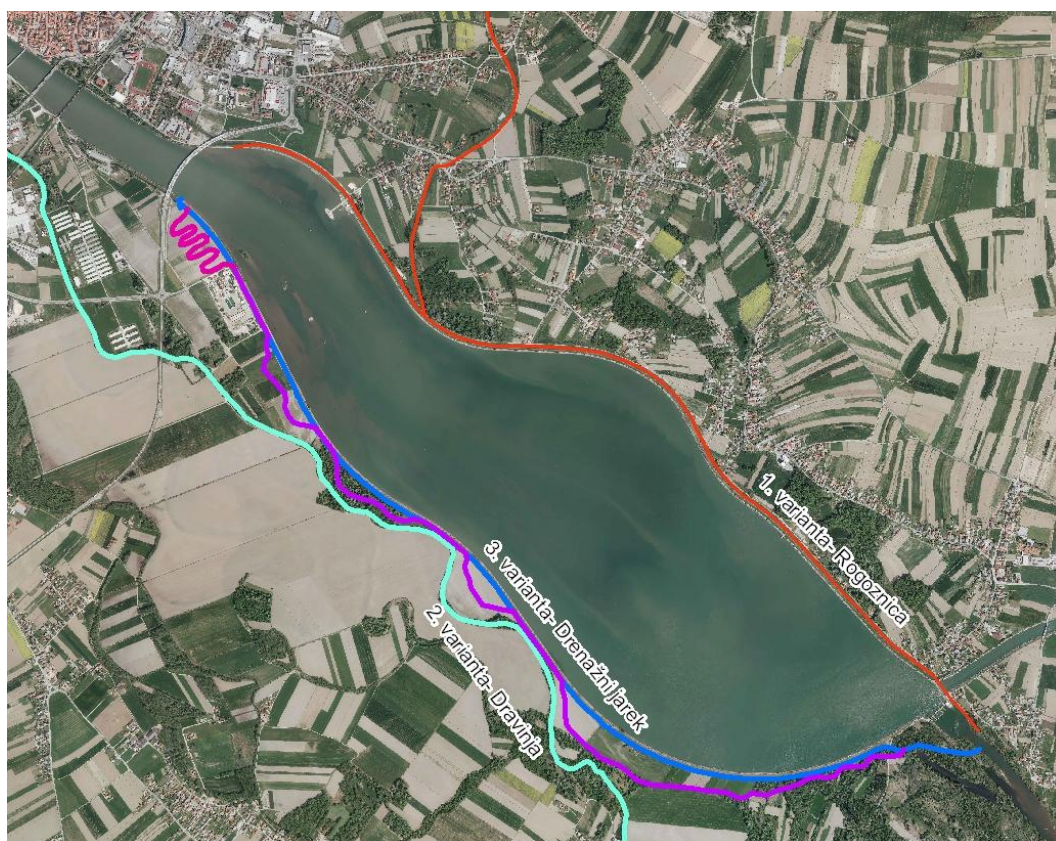
Based on the results, following recommendations were given for the reconstruction of existing fish passage:

- Construction of new inflow, which is approximately 0,75 m lower to ensure constant flow of water and in this way, wettability of fish passage.
- Arrangement of fish passage outflow by elevation of walls at the outflow area of fish passage. The height of the walls must be approximately 20 cm higher than the maximum operational level of lower waters. To ensure appropriate water depth in outflow area, vertical walls should be inserted
- The floor of fish passage should be adapted for aquatic invertebrates. The design should increase the roughness of the floor and in this way partially improve hydraulic conditions at lower flow rates.
- Hydraulic conditions in the fish passage should be improved
- reduce the speed of water flow by placing barriers.



- Redesign fish passage into a gap passage – the water flows from basin in the basin through the slots, which are open on the entire height of barrier wall. This allows the passage for species that are weak swimmers and those living on the floor, it is less sensitive to fluctuations in the depth of water in the fish way and has less chance of clogging.

The results of the study suggest the complete reconstruction of fish passage. Currently, the project for reconstruction resp. improvement of fish passage on the Mariborski otok HPP is in process.



Picture 5 Variant solutions of passages for living organisms for the Ptuj Lake (Markovci dam)

Text legend:

1. varianta – Rogoznica (red line) = Variant 1, drainage channel Rogoznica
  2. varianta – Dravinja (cyan line) = Variant 2, Dravinja River
  3. varianta – drenažni jarek (magenta line) = adopted Variant 3
- Blue line represents an existing right-bank drainage channel

### 3. Placement and installation of a new fish passage on Ptuj lake, Markovci dam

During the construction of the last in a chain of hydroelectric object on the Drava river in 1968, there were no environmental requirements to build a passage for aquatic organism between the border with Austria and border with the Republic of Croatia. Newly constructed Markovci dam has closed migratory route from Lake Ptuj in the river Drava to all aquatic organisms in the area. We have therefore approached to the rescue and ordered a concept plan for implementation of fish passes on the lake Ptuj.

Water Management Offices Maribor, has analyzed all the conditions and the influencing factors and created several variants of solving the problem in the project nr. 3336/12, Maribor, February 2012, on the basis of the above applicable legislation. Proposed concepts were audited in a professional institution (ZZRS Slovenia). The result of the review is the choice and the proposal of implementation variant in the drainage channel at the reservoir - Lake Ptuj. The report defines in details the methods to analyze all variants and provides justification for the chosen variant. The facility, which enables and meets all the necessary conditions for the migration of most sensitive species requires certain spatial features, such as first and foremost general decline in the flow of water through the surface of gateway for aquatic organisms, which defines the flow velocities in the passage. The gateway for aquatic organisms can be traced in several options. In the case study, we examined three trace variants with some subvariants.

### **3.1 Study conclusions**

- 1) Optimization of three basic variants, evaluated variant 3 as the most appropriate, i.e. right bank with drainage ditch and third subvariant of exit gateway under Puh's bridge
- 2) Entrance to gateway for aquatic organisms and attraction remain open.
- 3) For the proposed variant 3, it is necessary to solve the problem of water release from Č.N. in the drainage ditch and properly clean contaminated sediments from the drainage ditch.
- 4) Drainage ditch must be edited in the length of approximately 5.1 km.
- 5) In order to equalize the water temperature in the gateway for aquatic organisms and the Drava River, part of the pouring section of gateway for aquatic organisms must be built waterproof (separation from the cold ground).
- 6) The proposed solutions meet all the criteria for maximum water flow rate and energy dissipation in the gateway for aquatic organisms.
- 7) It is proposed that the minimum withdrawal from the pool is approximately 500 l/s and a maximum around 700 l/s (as addressed in calculations).
- 8) Rebuilt drainage ditch flow is added to the withdrawal from the lake. Estimated flow in the nature-friendly section is about 1100 l/s.
- 9) By building gateway for aquatic organisms after the drainage ditch, the degraded area is rebuilt and new water habitat will be established.
- 10) It would be a good idea to extend the project onto following problems :
  - 11) – returning of the fish in the downstream,
  - 12) – prevention of migration in the wrong direction and
  - 13) – in the case of the confluence of Formin HPP channel and Drava river, in directing migration upstream along the Drava river towards the dam in Melje (Maribor), the flow across the channel sink of Formin HPP is 40 times the flow of the river Drava.
- 14) For management, monitoring and control, administrative facility is planned at the exit of gateway for aquatic organisms.

This variations study was reviewed and evaluated in the audit report by the Institute of fishing, Slovenia (ZZRS). The detailed results are available in the report by ZZRS : Review of concepts of 26/10/2012 .

The report carefully examined and analyzed variants, added some more technical aspects of choice and suggested the selected variant. After thorough analysis, the proposed project of a designer to choose variant 3 as optimal solution, is accepted.

In 2013, it is planned to run the project on fish passes based on the design concepts of selected variant 3.

#### **4. References**

- [1] JUVAN, S. AND KOVAČIČ, A., 2012. Idejna zasnova - Umestitev ribje steze na območju jezua Markovci, 3336/12. Vodnogospodarski biro, Maribor.
- [2] ZABRIC, D., 2012. Poročilo: revizija idejnih zasnov. Zavod za ribištvo Slovenije.
- [3] ZABRIC, D. ET AL., 2012. Študija: Prehod rib skozi ribjo stezo na HE Mariborski otok. Zavod za ribištvo Slovenije.