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ОБЕКТ: Изграждане на рибни проходи на бент на р. Вит при с. Садовец

OBJECT: Construction of fish passes on the existing drop structures on Vit river near Sadovets

ВЪЗЛОЖИТЕЛ: WWF – Световен фонд за дивата природа, Дунавско-Карпатска програма България

CONTRACTOR: WWF – World Wide Fund for Nature, Danube-Carpathian Program Bulgaria

ФАЗА: Идеен проект

PHASE: Conceptual design

РЕЗЮМЕ

SUMMARY

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УДОСТОВЕРЕНИЕ

ЗА ПЪЛНА ПРОЕКТАНТСКА ПРАВОСПОСОБНОСТ

Регистрационен номер № 10268

Важи за 2017 година

ИНЖ. НИКОЛАЙ ПАВЛОВ ЛИСЕВ

ОБРАЗОВАТЕЛНО-КВАЛИФИКАЦИОННА СТЕПЕН

МАГИСТЪР

ПРОФЕСИОНАЛНА КВАЛИФИКАЦИЯ

СТРОИТЕЛЕН ИНЖЕНЕР ПО ХИДРОТЕХНИЧЕСКО СТРОИТЕЛСТВО

включен в регистъра на КИИП за лицата с пълна проектантска правоспособност
с протоколно решение на УС на КИИП 26/07.07.2006 г. по части:

ХИДРОТЕХНИЧЕСКИ СЪОРЪЖЕНИЯ
СТРОИТЕЛНО-КОНСТРУКТИВНА ЗА ХИДРОТЕХНИЧЕСКИ СЪОРЪЖЕНИЯ
ТЕХНОЛОГИЧНА ЗА ХИДРОТЕХНИЧЕСКИ СЪОРЪЖЕНИЯ

Председател на РК

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EXPLANATORY NOTE

I GENERAL

The present document is prepared based on a contract between the Contractor – WWF – World Wide Fund for Nature, Danube-Carpathian Program Bulgaria and the Contractee – “NINKA-HM” Ltd and includes the preparation of a Conceptual design project for Fish passes on the existing drop structures on Vit river near Sadovets and on Yantra river near village Dolna Studena, according to TOR. The explanatory note considers the proposed conceptual design for “Construction of fish pass on the existing drop structure on Vit river near Sadovets”.

The design procedures are based on data from a geodetic survey and site observation. The survey provides the required information regarding the geometrical parameters of the existing drop structure (weir), the adjacent outlet facilities, gates etc. and the topography of the main channel and both river banks downstream from the structure.

A hydrological analysis is prepared for the aims of the project, presented as a separate chapter in the present document. The conceptual design is planned by considering the characteristic statistical parameters for the discharges in Vit river near Sadovets.

The following guidelines, standards and other documents are used:

- Guidelines for building fish migration facilities, Fed. Ministry of Agriculture, Forestry, Environment and Water Management, Vienna, 12.2012
- Preparation of guidelines on fish pass requirements for several aquatic species, Ao. Univ.Prof. DI Dr. Stefan Schmutz, 10.12.2016
- Fischaufstiegsanlagen und fischpassierbare Bauwerke – Gestaltung, Bemessung, Qualitätssicherung, Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfälle, 2014
- Fish passes – Design, Dimensions and monitoring, FAO & DVWK, Rome, 2002
- Standards for Design of Irrigation Facilities, Ministry of Agriculture and Food, DF “Vodproekt” 1991/ Норми за проектиране на хидромелиоративни системи”, Министерство на земеделието и горите, ДФ „Водпроект”, София, 1991
- Standards for design of hydraulic structures. General considerations, BSA 11, Sofia, 1985/Норми за проектиране на хидротехнически съоръжения. Основни положения, БСА 11, София, 1985 г.
- Manual for design of hydraulic structures, Papazhev, Abadzhiev, Sheytanova, Toshev, Sofia, 1987/ Ръководство за проектиране на хидротехнически съоръжения, И. Папазчев, Хр. Абаджиев, Л. Шейтанова, Д. Тошев. София, 1987 г.

II GEODETIC SURVEY

The geodetic survey is carried out on 03.08.2017. A GNSS receivers Trimble R4 (horizontal accuracy 8 mm +1 pmm, vertical accuracy 15 mm + 1pm RSM) for real-time measurements is used. The equipment is certified by the State Geodetic, Cartographic and Cadastral Fund (Geocartfund) “GEO-NET”,

which meet the requirements of Instruction № ПД-02-20-25/2011 for definition of geodetic points by means of Global Navigation Satellite System (GNSS).

The survey includes the existing drop structure (weir) on Vit river near Sadovets, located in the immediate vicinity of the regulation of the urban area, in northern direction. The coordinates of characteristic points of the weir, the main river channel and banks, the adjacent terrain and the visible portions of the existing irrigation facilities, geomorphological forms etc.

The collected data is processed by application of the software product BGSTrans. The horizontal coordinates are presented in coordinate system 1970 and the vertical in Baltic height system.

A digital and graphical terrain models are constructed.

II. HYDROLOGICAL ANALYSIS

II.1 GENERAL

For the aims of the project a hydrological analysis and evaluation of the design and control maximum discharges for the stations of interest are performed. The corresponding water levels are established based on detailed hydraulic calculations.

According to the acting standards for design of river training works ("Standards for Design of Irrigation Facilities", Ministry of Agriculture and Food, DF "Vodproekt" 1991) the river bed should provide safe evacuation of maximum water discharges with probability of exceedance $p=0.01$ (1%) by standard freeboard of 0.5 to 1 m. A total depletion of the freeboard is acceptable for maximum check discharge with probability of exceedance $p=0.001$ (0.1%).

II.2 OROHYDROGRAPHICAL CHARACTERISTICS

Vit River leads its way from the northern slopes of the Balkan Mountain. Its length is 189 km and it has a long and narrow catchment area of about 3 220 km², and a small number of tributaries (about 10 Rivers exceeding 10 km in length).

The shape of the catchment area is highly elongated (average width of 25 km). The density of river network is too small - 0,5 km/km², mainly due to the shape of the catchment area and its small altitude.

Vit River high water occurs during March - May when the spring is coupled with snow melt and rainfall over the catchment. In the high mountain part of the catchment at an altitude of 1500 m above permanent snow cover is maintained until the end of March. High water of the river terminates at the end of June, then begins summer - autumn low water.

Within the catchment there are two administrative districts - Pleven and Lovech, including in total 11 Municipalities, 7 towns and 74 villages. The biggest town is Pleven - a district centre with a population of over 100,000; the population of other towns vary between 2,800 and 10,600; the population of the villages varies between 50 and 3,800 residents. The water supply system is operated by two companies and it is characterized by quite a high share of non-revenue water (50%), mostly due to significant physical leakages resulting from the outdated pipe network. There is a number of industrial water consumers concentrated mainly in two towns: Pleven and Dolna Mitropolia. The total water use within the Vit River Basin in 2009 was 134 million m³. The electricity and steam producing industries have the biggest share (63%), followed by agriculture (16%) and urban (10%). It should be noted however that the hydro power plants that belong to the former group are situated in a cascade thus the same amount of water is recorded several times.

Average discharges

The hydrological stations network of Vit River's catchment consists of 6 hydrological stations. Three of which are situated on the main river and the rest on the tributaries. On figure 1 is shown stations position. Station Sadovec 21750 (old number 54) is about 1.6 km upstream of the project site location.

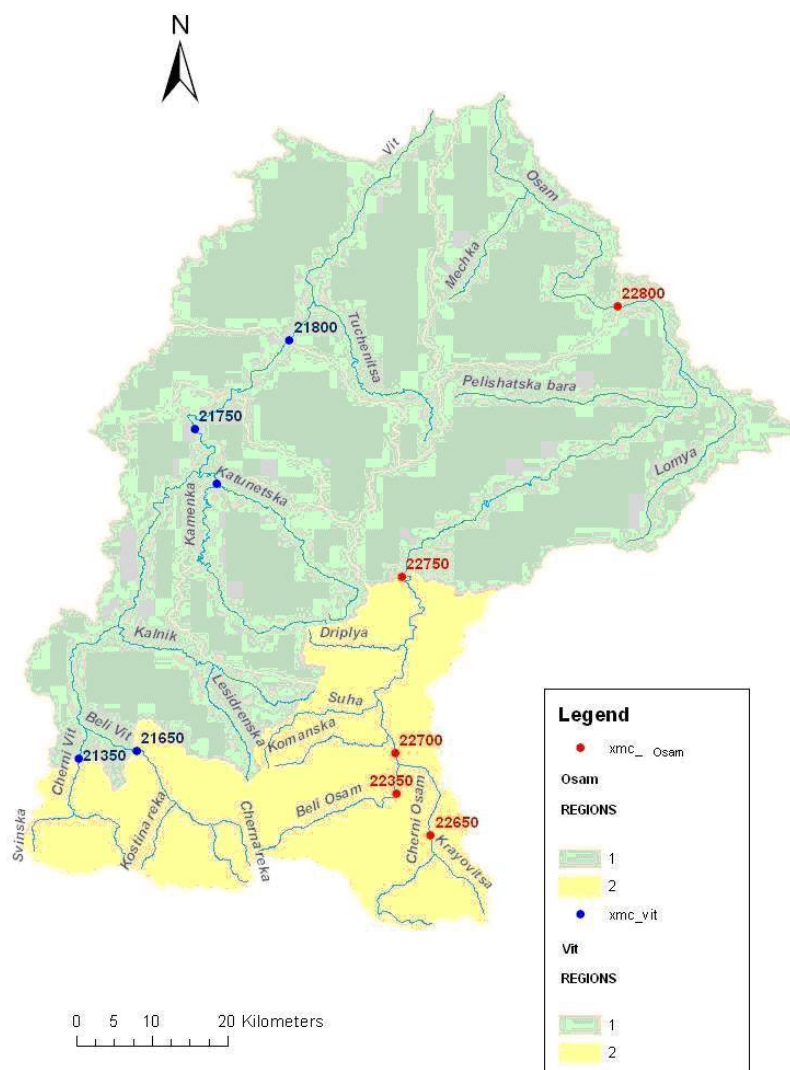


Figure 1. Separate regions of the Watershed Vit and Osam (Source Ninov et al, 2016)

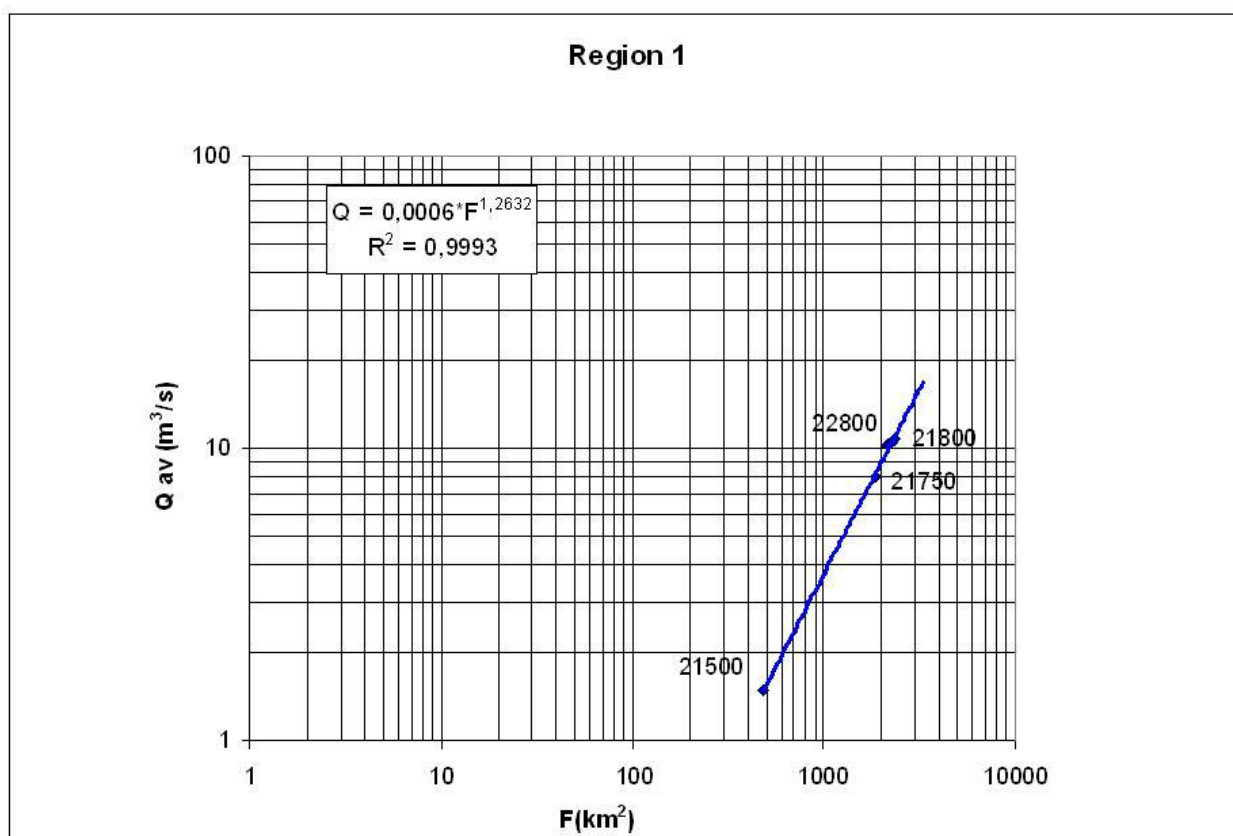


Figure 2. Regional relationships of the Watershed Vit and Osam. (Source Ninov et al, 2016).

The orohydrographical characteristics of the watershed at the hydrological station Sadovetz 21750 are shown in Table 1.

Table 1. Orohydrographical characteristics of the watershed at the hydrological station in the village Sadovetz

HMS №	River	Watershed area	Av. watershed altitude	Length from source	Av. river slope	Av. watershed slope	Drainage density	Afore station	Period of observations from... – to...
-	-	km2	m	km	-	-	km-1	%	-
35	HMS № 21750/54 v. Sadovetz	1750,0	595	94,5	18,1‰	0,253			1952 -

Region 1 covers the lower part of the watershed, located in the Danube Valley with $Q = 0.0006 * F^{1.2632}$ and $R^2 = 0.9993$. **Region 2** covers parts of the watershed, including fore and northern slopes of the Balkan Mountains with regional relationship $Q = 0.0931 * F^{0.6714}$ and $R^2 = 0.9729$.

The average water discharge for the site of fish pass is about 8.1 m³/s. In table 2 are shown monthly average discharges.

Table 2. Average water discharge per month at Sadovetz 1950-1990 m³/s

XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	
Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Average
6.69	10.20	10.30	13.40	18.90	23.50	27.00	21.40	13.80	8.04	7.08	6.06	8.10

Maximum discharges

Regional relationship of maximum flow is developed (figure 3) based on the data of the following stations (table 2).

Table 2. Statistical parameters

HMS	HMS № 51	HMS № 52	HMS № 54
Qmax. Avr. m³/s	140.17	50.29	226.54
Standart deviation σ m³/s	89.91	34.61	122.72
Coef. Of variation Cv	0.642	0.688	0.542
Skewness coefficient Cs	1.284	1.371	1.083
Modul of maximum flow Qmax.av (l/s.km²)	448.000	324.000	129.000

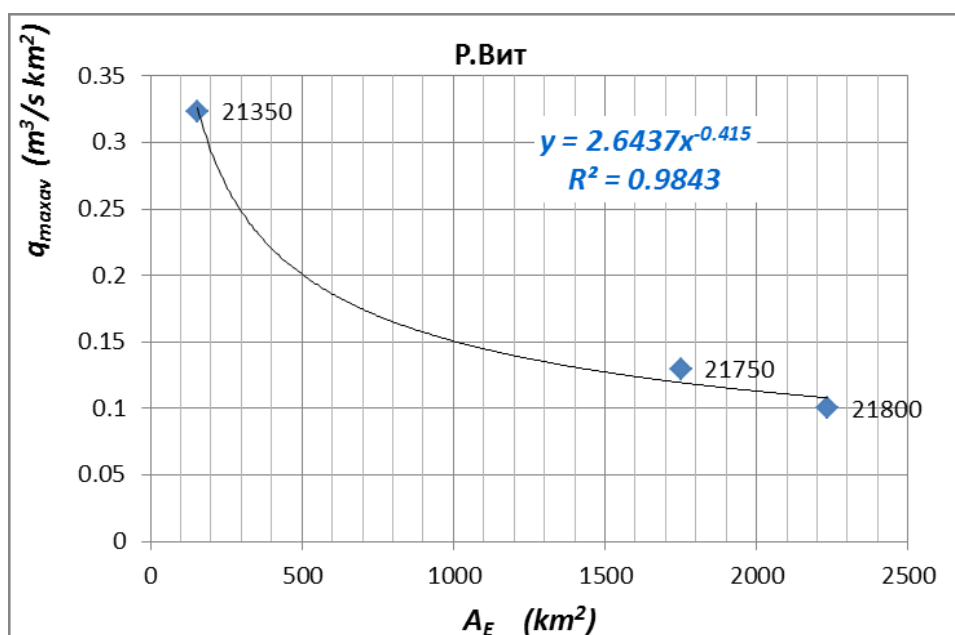


Figure 3. Regional relationships of the maximum flow for main stream of river Vit.

Following the relationship on figure 3 maximum water discharges for the site of the project are calculated (table 3).

Table 3. Maximum water discharges for the project section on the river Vit.

Probability of exceedence %	Q_{max,p} m³/s
1	835
3	682
5	584

According to the order issued by MOEW the minimum runoff has to be equal to 10% of average annual flow based on information of some representative period and cannot be less than the minimum monthly discharge with exceedence probability of 95% for the corresponding site in undisturbed conditions [Law for Env.Prot.,2004]. This regulation was followed in this investigation at the determination the minimum admissible runoff. For the project section it gives $Q = 0,81 \text{ m}^3/\text{s}$.

Average minimum discharge is $0,428 \text{ m}^3/\text{s}$ which is less than $0,81 \text{ m}^3/\text{s}$, therefore the last one is accepted as more conservative.

III TECHNICAL PROPOSAL

The technical proposal considers the specific site characteristics and the comparison of possible design variants.

III.1 GENERAL

The weir has a total length of approximately 180 m (bank to bank). Its axis is oblique with respect to the main flow direction.

The hight of the weir corresponding to the upstream river bed is approximately 0.7 to 1.0 m. Its construction consists of mass concrete and a revetted sloping section (total 6.6 m). The crest elevation vary between 108.70 - left and 108.55 – right. This provides concentration of the flow near the right end and in several stripes along the strucuture, where irregular lower sections are available.

A total displacement between the weir crest and the downstream end of its sloping section is approximately 0.4 m is measured.

The natural river bed immediately downstream of the structure has suffered a severe erosion, due to local scour and probably general river degradation. This gives an average head of the structure – 1.35-1.45 m (from crest to tailwater bed). The total scour depth reaches 1.7 m. Almost the entire amount of the eroded material, originating from the riprap armour, which was probably installed for scour protection, is transported downstream, forming mounds of boulders.

Despite the scour formation there are no signs of undermining of the footing. It can be assumed that the structure is grounded in a rock base.



Figure 3. Drop structure (the picture is taken from the left bank, looking towards the right bank)

The weir is part of an irrigation system, which is currently out of operation. The intake consists of two bays equipped with sluice gates. It is located at the left end of the weir (Figure 4). An irrigation channel with trapezoidal cross section follows the intake. Immediately in front of the intake a flushing bay is constructed towards the river i.e. perpendicular to the irrigation channel. It consists of a rectangular channel of reinforced concrete (Figure 5). The clear width of the opening amounts to 1.45 m and its approximate length is 8.5 m.



Figure 4. Intake structure and irrigation channel



Figure 5. Flushing outlet

The existing drop structure (weir) generates a backwater which leads to widening of the impounded areas from approximately 35 m to ca.180 m. Moreover the route of the weir axis is oblique with regard to the main direction of flow, which contributes to the additional widening immediately upstream from the structure. Due to this change in the flow direction the right river bank immediately downstream of the structure is heavily eroded.

After the weir the river is braded and forms three branches, two of which conduct the major part of the total discharge. They are located near the right river bank and slightly right from the center of the weir. These two branches are connected approximately 100 m downstream. The third branch originates from the flushing outlet and conducts minor discharges in comparison with the others.

III.2 DESIGN VARIANTS AND SELECTION

Considering the site characteristics, the hydrological and hydraulic conditions, the requirements and recommendations in the literature and other guidelines three major conceptual variants for fish pass design can be proposed.

III.2.1 TECHNICAL FISH PASS – VERTICAL SLOT PASS

A possibility for reconstruction of the flushing outlet at the intake is analysed as a first scenario. The construction requires deinstallation of the clogged gate, rehabilitation and extension of the existing walls as well as installation of slots.

The proposed design has the following drawbacks:

- a major extension of the structure is required in order to reach the main channel of the river. If the route of the fish pass follows the left bank (currently the discharges from the flushing outlet are flowing in a branch close to the left bank) it should be constructed in a section with total length of 150 m.
- a shorter structure (directed towards the main river channel) would be subject of extensive hydrodynamic loads during high water.
- the capacity of the opening is limited and the discharges that can be conducted through the structure are less than the other possible scenarios.
- as stated before, the crest of the weir is lower near the right bank which leads to concentration of the flow in this area and hence depending on the discharge there will be some overflowing which could lead to reduction of the attraction.
- The performance of construction works in the left bank will be difficult due to the presence of channel inlet, levee and narrow approach.

Due to the above mentioned drawbacks the described scenario is considered as ineffective.

III.2.2 FISH RAMP ALONG THE ENTIRE WEIR

A construction of natural type fish pass such as fish ramp is analysed. Several major drawbacks are assessed:

- A structure that spreads over the entire length of the weir presumes insufficient flow depths in case of mean and low water. If the construction consists of permeable dumped rock material a leakage between the stones could be expected and hence no actual depths for fish migration will be available.
- The recommended longitudinal slopes of 1:20 to 1:40 would require large amounts of fill material. This would increase both the construction time and cost.

III.2.3 FISH RAMP NEAR THE RIGHT BANK

The site characteristics in the area of the right river bank provide very good conditions for construction of a fish ramp. Apart from its major function the ramp will contribute also for the stabilization of the right bank.

The following major advantages can be pointed:

- Currently the main flow is discharged through this area and a stripe near the central part of the weir, which explains the formation of two major channels (branches) collecting approximately 80 m downstream. It can be expected that this area provides the best conditions for fish attraction during low and mean discharges and moderate attraction during high waters, which is a major concern.
- The cross section can be freely chosen and can provide sufficient hydraulic conditions for a range of low and mean discharges. During mean and high water in the river an overflowing through the entire length of the weir will be present, but the major portion of it will be concentrated near the right bank due to the lowering of the crest at the upper end of the fish ramp.
- The length of the ramp will be less than 80 m and hence it will provide the cheapest solution.
- Various constructions can be applied.
- This part of the site provides good access conditions and areas for mechanization and material storage during construction.

III.2.4 DESIGN SELECTION

Considering the advantages and disadvantages of the described design variants the third one is selected as the most favorable one. It provides the best attraction conditions, flexibility and ease in construction, short terms and most cost effective solution.

III.3 CONSTRUCTION

The parameters of the fish pass are based on the concept for fish ramp with trapezoidal (nearly v-shaped) cross section. This profile is selected by considering the water depths along the structure for different discharges as a result of the preliminary hydraulic calculations.

III.3.1 HYDRULIC AND HYDROLOGICAL CONSIDERATIONS

The major consideration for the selection of fish pass cross section and elevation of the crest is namely the minimum depth along the structure during low water. By considering the statistical data from the hydrological analysis the minimum ecological discharges can be assumed as 10% of Q_{av} . This gives a minimum discharge of 0.81 m³/s. According to literature data the recommended minimum flow depths should be not less than 0.30 m (Fischaufstiegsanlagen und fischpassierbare Bauwerke – Gestaltung, Bemessung, Qualitätssicherung, Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfälle 2014).

The recommended slopes for a standard trapezoidal section are of the order 1:2 and 1:10, which is adopted in the present design. Considering this recommendation one can fix the width of the horizontal portion of the profile in order to provide a minimum depth at the crest of the ramp of 0.3 m. In this case the hydraulic calculations give a width of 0.5 m.

A schema of the selected profile is presented on Figure 6.

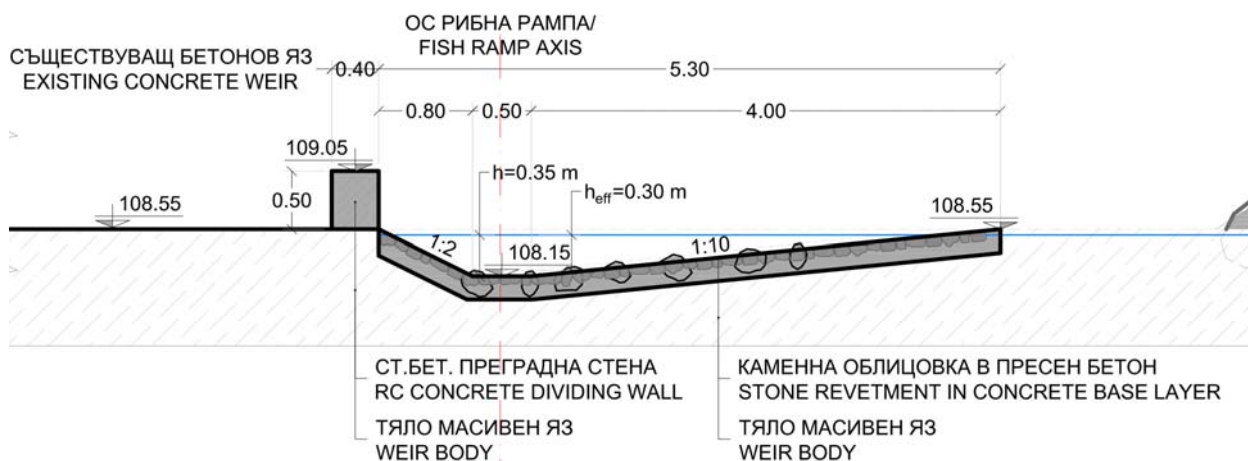


Figure 6. Fish ramp cross section

The effective capacity of the ramp is in the range 0.8 and 2.5 m³/s, considering the maximum flow velocities. The maximum discharges that can be conveyed through the structure reach approximately 35 m³/s.

The weir crest elevation is chosen so that in case of minimum discharge (0.8 m³/s) the entire flow to be conducted through the fish ramp. This gives an elevation 108.15 m, i.e. 0.4 m below weir crest.

Layout and longitudinal profile

The layout of the fish ramp follows the route of the existing branch of the river. It consists of two straight sections, connected with a horizontal curve.

The longitudinal profile of the structure is planned according to the general recommendations (DVWK 2002 etc.) in the range 1:20 to 1:40. A median slope of 1:30 is adopted. Considering the selected slope and fixed elevation at the crest the required length of approximately 50 m. Since the total displacement of 2.5 m is more than 2 m a resting section should be provided. A 10 m long section with horizontal bed is planned in order to provide more tranquil conditions along the structure.

The downstream end of the ramp is planned at elevation 0.2 m below the natural river. A 5 m long shallow pool contributing for the energy dissipation should be excavated at this point.

An approach ramp should be constructed upstream from the weir in order to provide a gradual transition between the ramp crest and the natural river bed. The slope of the transition is 1:3.

Construction and materials

The upstream portion of the ramp, located in the body of the weir, requires removal some parts of the concrete. The deepest cut will be approximately 0.6 m.

In order to avoid overflowing from the left, where the main flow can enter and create unfavorable hydraulic conditions in case of mean and high water, a dividing reinforced concrete wall will be constructed. The height of the wall is the crest of the wall is fixed 0.5 m above the weir crest. It should be anchored in the body of the weir.

The bed of the ramp should be roughened by means of natural stones, placed in a concrete layer. Several larger stones should be placed along the horizontal portion of the cross section and both banks.

The relatively mild slope of the ramp and the eroded downstream section require the filling of material under the construction in order to achieve the design elevations. A local material should be used (gravel, alluvial or other suitable material).

The left side of the ramp should be enclosed by a reinforced concrete wall. This wall will reduce the required fill volumes and hence the clear width of the river downstream from the weir. A riprap protection should be provided at the footing of the wall in order to avoid scour.

The right bank of the ramp should be extended with same slope 1:10 in direction of the bank. The revetment should consist of large boulders 0.6 – 1 m in diameter. This riprap protect the bank from erosion.

Literature

Guidlines for building fish migration facilities, Fed. Ministry of Agriculture, Forestry, Environment and Water Management, Vienna, 12.2012

Preparation of guidelines on fish pass requirements for several aquatic species, Ao. Univ.Prof. DI Dr. Stefan Schmutz, 10.12.2016

Fischaufstiegsanlagen und fischpassierbare Bauwerke – Gestaltung, Bemessung, Qualitätssicherung, Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfalle, 2014

Fish passes – Design, Dimensions and monitoring, FAO & DVWK, Rome, 2002

Standards for Design of Irrigation Facilities, Ministry of Agriculture and Food, DF “Vodproekt” 1991/ Норми за проектиране на хидромелиоративни системи”, Министерство на земеделието и горите, ДФ „Водпроект”, София, 1991

Standards for design of hydraulic structures. General conciderations, BSA 11, Sofia, 1985/Норми за проектиране на хидротехнически съоръжения. Основни положения, БСА 11, София, 1985 г.

Manual for design of hydraulic structures, Papazchev, Abadzhiev, Sheytanova, Toshev, Sofia, 1987/ Ръководство за проектиране на хидротехнически съоръжения, И. Папазчев, Хр. Абаджиев, Л. Шейтанова, Д. Тошев. София, 1987 г.

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