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THE PROBLEMS OF INCREASING THE EFFICIENCY OF OPERATION OF THE RIGHT CHANNEL OF THE AKHURYAN RIVER

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THE PROBLEMS OF INCREASING THE EFFICIENCY OF OPERATION OF THE RIGHT CHANNEL OF THE AKHURYAN RIVER

Abstract

A distinctive feature of mountain rivers are significant riverbed slopes, alluvial channels, sometimes composed of boulders and rock fragments, steep banks and the presence of rapids and rapids. In such conditions, it is sometimes impossible to build ladder fish passages, the average slope of which is very often less than the slope of the riverbed. Meanwhile, these rivers are currently the most attractive for the construction of small hydroelectric power plants of the derivational type. Studies of more than 120 designs of existing fish channels at the water intakes of small mountain rivers in different countries show that the design solutions and geometric dimensions of their execution, as a rule, do not ensure the free migration of fish upstream.

Keywords: river, shut-off system, hydroelectric power station, fish passage, hydroelectric plant, ecological outlet.

Introduction

The deep valve at the mouth of the right bank channel of the Akhuryan River (Fig. 1) is designed for hydrotreating the channels at the entrance to the valve system of the basin forming a retaining level.

Fig. 1. View of the right-bank channel of the Akhuryan River and the retaining level of the basin

Hydrotreating must be carried out to ensure that the cleanest possible water flows into the intake channel, which turns into a tunnel and then into dukes, and the presence of a significant

amount of silt there is undesirable. Hydrotreating has a local (local) territorial impact, since structures that create a retaining level do not solve the problem of water accumulation. At the same time, it should be noted that the depth canal cannot be used as a fishing channel for a number of reasons. In particular.

- the valve is brought to the open state infrequently and for short periods of time in order to flush the area from splashes.
- during intensive work, there is a hydraulic regime that is not favorable for the passage of fish

Hydrotreating must be carried out to ensure that the cleanest possible water flows into the intake channel, which turns into a tunnel and then into dukes, and the presence of a significant amount of silt there is undesirable. Hydrotreating has a local (local) territorial impact, since structures that create a retaining level do not solve the problem of water accumulation. At the same time, it should be noted that the depth canal cannot be used as a fishing channel for a number of reasons. In particular.

- the valve is brought to the open state infrequently and for short periods of time in order to flush the area from splashes.
- during intensive work, there is a hydraulic regime that is not favorable for the passage of fish.

From the point of view of dam safety, there is no urgent need to repair the deep valve. For the above reason, the need for a valve is essential for the operation of the entire structure: channel, tunnel, pipe canal. From the point of view of ensuring environmental requirements, the operation of a deep valve to ensure ecological flow in a river occurs when water does not move along a concrete dam into the lower reaches, because in this case the water in this area has no other way. The operation of the waterworks should be carried out in such a way that the ecological runoff into the lair passes through a concrete dam, which is technically possible to organize. The capacity of the right-bank channel of the Akhuryan River also depends on the hydraulic parameters of the tunnel and duker. Judging by the presented images, the hydraulic system is in a technically unsatisfactory condition (Fig. 2).

Here we mean an integrated, interconnected water system. The answer to this question can be provided by the study of these structures, which is a laborious and lengthy process. In order to determine water losses, it is necessary to develop and conduct a hydrological survey of the waterworks under conditions of maximum flow. It should be noted that the existing regulatory documentation on the design of fishing vessels is not acceptable for small mountain rivers. Thus, the proposed depth and width of the fish passage path are often commensurate or even exceed the size of small mountain rivers, which makes them unacceptable for designing water intakes on them.

Due to the smallness of the watercourses on such rivers, as a rule, there are no serious ichthyological studies, and there are discrepancies in the reference and regulatory documentation, and sometimes there is no necessary information at all about the characteristic speeds of movement of various fish species, which complicates the design of fishing vessels according to the classical scheme [1, 2].

Fig. 2. Structures of the retaining level
of the right-bank channel of the Akhuryan River

Conflict setting

If we take into account the presence of the Lake Arpi reservoir with a volume of 105 million cubic meters in the upper reaches of the Akhuryan River, the need for a fishing channel is very great here. To do this, it is necessary to develop and build a special facility on the left bank of the hydroelectric complex. The task is to determine the main approaches to the design of fish passage at the water intake of small mountain rivers in the absence of ichthyological studies. The problem at the hydroelectric complex in question is complicated by the fact that there are two obstacles to the passage of fish: the Akhuryan right-bank canal dam and a small hydroelectric power station.

Research Results

It is very important to collect the initial data for designing a fish tank. The main initial data are determined on the basis of hydrological and topographic surveys, as well as by means of expeditionary surveys of the riverbed from the mouth of the proposed intake to the mouth of the river, or at least to the outlet of the return of waste water at the station.

The first section: the small hydroelectric power station (SHEPS) – the dam of the right-bank canal.

The initial parameters for the design of fishways, in the absence of special ichthyological observations, are:

1. The average slope of the river at the SHEPS construction site (i_{ev}).

The purpose of measurements is the determination of the permissible slopes of the fish passage path with a uniform slope along its entire length. It is determined by dependence:

$$i_{av} = \frac{(H_1 - H_2)}{L_r}, \quad (1)$$

where: H_1– river mark in the alignment of the right bank canal, H_2 - the mark of the river at the point of return of the waste water at the SHEPS, L_r - is the length of the riverbed in the section from the intake to the point of return of the water, taking into account the turns.

2. The maximum slope of the river at the SHEPS construction site (i_{max}). The purpose of measurements is the determination of the permissible slopes of individual short sections of the fish passage path when executed in the form of alternating inclined sections with ponds between them. The section of the river with the maximum slope should be selected on the section of the river from the intake to the mouth of the river. In this case, the following rules should be followed:

- The length of the section must be at least 20 m;
- The site should not have pronounced thresholds with a vertical drop;
- In the selected section, the riverbed should not have separate branches and island formations.

The maximum slope of a river section is determined by the dependence:

$$i_{max} = \frac{(H_1 - H_2)}{L_{1-2}} \quad (2)$$

where: H_1– the river marker at the beginning of the selected section with the maximum slope, H_2 - the river marker at the end of the section with the maximum slope, L_{1-2} – the length of the riverbed in the area with the maximum slope, taking into account the turns of the riverbed.

3. The maximum height of the rapids in the studied section of the river (h_t).

The purpose of measurements is to determine of the permissible magnitude of the fluctuations in the execution of the fish passage path in the form of multi-stage fluctuations. The site for the study of rapids should be selected on the section of the river from the intake to the mouth of the river. In this case, the following rules should be followed:

- The planned threshold setting should not exceed the vertical threshold drop;
- There should be no separate sections of the riverbed in the formation of the threshold with a lower slope than the slope of the threshold itself.

Determination of the permissible magnitude of the fluctuations in the execution of the fish passage path in the form of multi–stage fluctuations (SHEPS – dam of the right-bank canal – "Arpi Lich" reservoir). The site for the study of rapids should be selected on the section of the river from the range of water scoop to the mouth of the river. In this case, the following rules should be followed:

- The planned threshold setting should not exceed the vertical threshold drop;
- There should be no separate sections of the riverbed in the formation of the threshold with a lower slope than the slope of the threshold itself.

The height of the threshold is determined by dependence:

$$h_t = h_r - h_{\text{н}} \quad (3)$$

where: h_r and $h_{\text{н}}$ is the water level in the river directly above and below the threshold.

4. Minimum water depths in the river at the construction site of the SHEPS (h_{min}).

The purpose of measurements - to determine the minimum allowable depths in the fish passage.

River depth measurements are carried out at water flow rates close to the value of regulatory environmental passes. In particular, in many countries it is accepted that the environmental expenditure should correspond to the expenditure of the river 95% of the provision in the middle row. When measuring the minimum depths of a river, the following rules should be followed:

- Depth measurements should be carried out in areas of the studied target with maximum depths,
- The selected water depth should be observed in an area of at least 1-2 m of the measuring runway,
- The dam location should be selected perpendicular to the flow direction as much as possible.

5. Average water velocities in the river at the construction site of the SHEPS (V_{av}).

The purpose of measurements. To determine the speeds traveled by fish over long distances. Average speeds are measured when river flow rates are close to the estimated environmental flow rate. Measurements are performed using instrumental methods. The site for measuring average speeds is selected using the following method:

- A section of the river is selected with a length of at least five times the width of the river, with a uniform slope equal to the average slope of the river i_{av};
- The measuring runway is selected at a distance of $3l_s$ from the upper segment of the selected river section (l_s is the width of the river in the measuring channel);
- The velocity measurement is carried out on the section of the runway, remote from the coast at a distance of $0.2\ l_s$.
- Measurements are performed according to the procedure given in [3]. With a significant width of the river, measurements are made on several runways, followed by averaging the velocities over the section.

6. Maximum water velocities in the river at the SHEPS site.

The purpose of the measurements is to determine the maximum speeds on individual elements of a short-length runway. The maximum flow rates are measured by instrumental methods in the rapids of the river at costs close to the value of the regulatory environmental passes. In this case, the narrowest sections of the river are selected without the presence of lateral sections of the channel with lower speeds. The length of the measuring section should be equal to $2\ l_s$, but not less than 10 m. The areas where the river passes between two rocky shores in cramped conditions are the most suitable for such measurements.

7. Description of the fractional structure of the riverbed with photographing.

The purpose of the measurements is to design the bed of a fish passage of the "natural channel" type. When performing these works, it is necessary to choose bare sections of the riverbed, without inclusions of large-block rocks and channel stones of large sizes. When photographing, you should capture the zoom element in the frame in the form of a small metal ruler.

The design of the fish passage path in the greatest similarity with the natural riverbed involves ensuring the roughness of the channel of the fish passage path in accordance with the roughness of the riverbed itself. The correct choice of the channel roughness coefficient is very important for designing a fish passage. The roughness of mountain riverbeds is most fully covered in [4]. Based on tabular data on the roughness of mountain rivers, we have obtained the dependence of the roughness coefficient *n* on the slope of the i_{cp} river, which is acceptable for hydraulic calculations of the fish passage path.

$$n = 0.1526 {i_{av}}^{0.2418} \tag{4}$$

To obtain the specified roughness, the channel of the fish passage path must be laid out of channel alluvium with chaotic filling.

In addition to these parameters, it is necessary to collect possible information about the species of fish living in this section of the river. At a minimum, it is advisable to collect information about the length and height of adult fish carcasses, which can be obtained from various printed and electronic sources, as well as by interviewing the local population.

The design of the fish passage should begin with the enclosing wall in the upper reaches. The height of the hole in the wall is determined from the height of the carcass of the largest of the spawning fish. In the absence of data, the height of the hole should be assumed to be at least 0.2 m. The calculation begins at the water level of the upper stream at the level of the normal supported level. Assuming that the water velocity in the hole corresponds to the maximum velocity measured on a 10 m long river segment, we determine the width of the hole based on:

$$b=Q_f/aV_{max,} \tag{5}$$

where: Q_f is the estimated flow rate of the fish-pass (usually ecological passes), *a* is the height of the hole, V_{max} is the maximum speed measured in the river.

Substituting the value V =Q/A into the well-known formula for the outflow of water from a single rectangular hole in the conditions of the two-dimensional problem [5], and taking the velocity of water in the passage equal to $V_{max,}$ we determine the water level drop on the enclosing wall according to the dependence:

$$z = \frac{v_{max}^2}{2g\mu^2} \tag{6}$$

where μ is jet compression ratio.

In case of imperfect compression, the coefficient is determined by the dependence [5]:

$$\varepsilon = 0.57 + \frac{0.043}{1-n} \tag{7}$$

where *n* is the ratio of the passage area in the enclosing wall to the cross-sectional area of the flow in front of the passage opening in the upper stream.

As noted above, environmental releases from the intake are usually carried out through the fish passage. Therefore, it is proposed to install a small pool with a measuring spillway at the end directly after the enclosing wall of the fish passage, which, in addition to ensuring normal hydraulic working conditions of the fish passage, will allow for operational monitoring of ongoing environmental releases.

Hydraulic studies of measuring spillways of various designs have shown that triangular-shaped spillways are most suitable for installation in fish passage paths (Fig.3). Numerous calculations show that the threshold of the spillway when used at the water intakes of small rivers usually has a low height (within 0.5 m), and the slope of the lower edge of the spillway (5P) makes them easily surmountable for fish.

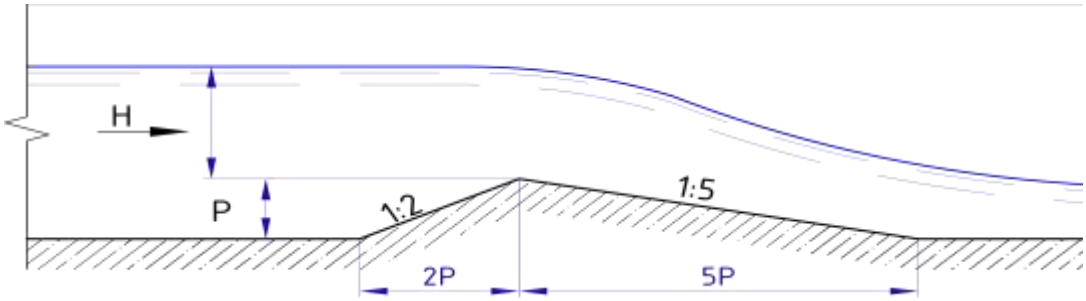

Fig.3 Schematic section of a dimensional spillway wall with a triangular profile

The height of the overflow layer above the spillway should be chosen, just as the height of the hole in the enclosing wall. In the absence of information about the geometric dimensions of spawning fish, the height of the overflow layer should be set at least 0.2 m.

$$H \geq 0{,}2 \text{ м} \tag{8}$$

The height of the spillway threshold is set depending on:

$$\text{P} \geq \text{a} \tag{9}$$

where *a* is the height of the hole in the enclosing wall.

This approach to setting the threshold height is based on ensuring that the water inlet is flooded through the enclosing wall.

According to the values obtained from dependencies (6), (8) and (9), it is possible to determine the threshold marks of the measuring spillway and the bottom of the basin.

The width of the measuring spillway is determined from the condition of passing through it the environmental flow rate according to the dependence [6]:

$$B = \frac{Q_f}{1.96 C_v H^{\frac{3}{2}}} \tag{10}$$

where C_v is the coefficient that takes into account the speed of water approach to the spillway, and depends on the ratio H/(H+P).

The values of the C_v coefficient are determined from [6], or calculated by a polynomial of the 5th degree, the coefficients of which are given in tab. 1.

Table 1

Coefficients of a 5th degree polynomial for calculating C_v

K^5	K^4	K^3	K^2	κ	Free member
3.2239	-4.3542	2.3318	-0.1941	0.0336	1

Next, the operation of the inlet is checked at the forced retaining level (FRL) by equating the water flow through the hole in the enclosing wall with the water flow through the triangular profile spillway.

Next, the operation of the inlet is checked at the FRL level by equating the water flow through the hole in the enclosing wall with the water flow through the triangular profile spillway.:

$$\mu ba(2gZ_F)^{0.5} = 1.96C_vB(Z_F - H_p)^{3/2} \quad (11)$$

where Z_F is the drop in the water level on the enclosing wall at a forced retaining level. Equation (11) is solved graphically, or by the approximation method, given by the value of Z_F.

After determining Z_F, we determine the water velocity in the hole of the enclosing wall according to the dependence:

$$V_{\text{FRL}} = \mu\sqrt{(2gZ_F)} \quad (12)$$

After the calculations, the working conditions of the fish way head are checked as a measuring spillway according to the dependencies:

$$B_{min}=0.3 \text{ m; } H/P<=3; B/H>=2; \text{ NRL } >=H+a. \quad (13)$$

where NRL - normal retaining level

In addition to conditions (13), it is necessary to ensure that the triangular-shaped spillway does not flood. To do this, follow the condition:

$$\eta = h_D/H \leq 0.75 \quad (14)$$

where h_D is the water level in the lower reaches of the triangular threshold.

Studies by a number of experts in the field of ichthyology have shown that the throwing speeds of fish movement largely depend on the swimming time. So, for a swimming time of 1 sec, Bainbridge indicates a speed of about 10-12 *L/sec* for trout, crucian carp and spruce, and for a time of 10 sec. - only 3.7 *L/sec* (*L* is the length of mature fish) [7].

Other experts have come to similar results by studying different types of fish, the speed of movement of the fish for 1 sec. They are often referred to as "speed limits". Based on this, it can be assumed that fish that have overcome the maximum current speeds measured in the rapids of a 10 m long section, when overcoming the hole in the enclosing wall (travel time less than 1 second), will be able to overcome the current 2.7-3.2 times higher than the maximum speeds measured in the rapids of the river (V_{max}).

It follows from this that the maximum allowable water velocity through the enclosure wall can be determined from:

$$V_{\text{FRL}} \leq 2.7V_{max} \tag{15}$$

If condition (15) is met, it can be argued that the passage of fish to spawn through the hole in the barrier wall of the fish passage is ensured under all leveled conditions in the spill way basin of the intake.

The length of the basin in front of the spillway of the triangular profile L_b is determined according to the recommendation [6] by the dependence:

$$L\text{б} \geq 2\text{H}_{\text{FRL}} \tag{16}$$

The fish passage path should be designed as a pressure-free channel of rectangular, trapezoidal, or trough-shaped section.

The normal depth of water in the channel (h_0) is determined from the equation [5]:

$$Q = A_0 C_0 \sqrt{R_0 i_0} \tag{17}$$

where A_0 is the area of the living section, C_0 is the Shezi coefficient, R_0 is the hydraulic radius. The Shezi coefficient is determined by the formula of G.V. Zheleznyakov:

$$C = \frac{1}{2}\left[\frac{1}{n} - \frac{\sqrt{g}}{0.13}(1 - 1gR)\right] + \sqrt{\frac{1}{4}\left[\frac{1}{n} - \frac{\sqrt{g}}{0.13}(1 - 1gR)\right]^2 + \frac{\sqrt{g}}{0.13}\left(\frac{1}{n} + \sqrt{g}1gR\right)}, \tag{18}$$

where the channel roughness coefficient is determined from the equation (4).

When designing a tract in the form of a channel with a constant slope along its entire length, the slope of the riverbed is assumed to be equal to the average slope of the river (i_{av}) along the entire length of the HPP construction site, determined by (1).

Equation (20) is solved by iteration. For the trapezoidal channel, equation (20) is reduced to the form:

$$h_{j+1} = \frac{1}{m}\left[\sqrt{\frac{Qm}{C_{0,j}R_{0,j}i} + \frac{b^2}{4}} - \frac{b}{2}\right] \tag{19}$$

To a first approximation, we set the value of the water depth in the channel equal to the height of the hole in the enclosing wall, and use the method of iterations to determine the final value of the normal depth. If the value obtained is less than the measured minimum depth of the river, then the channel should be recalculated, reducing its cross-sectional area. In the absence of measurements of the minimum depth of the river for small mountain rivers, its value should be set at least 0.2 m. These calculations are performed for the case of the water level in the upper reaches equal to the normal retaining level (NRL), i.e. for the calculated flow rate of the channel equal to Q_f.

Next, the hydraulic calculation of the fish passage channel is repeated at the flow rate of the fish passage at the water level in the upper reaches equal to the forced retaining level (Q_{FRL}).

The design of the fish passage channel begins with determining the making of the channel bottom (Hc) in its initial section.

In most cases, the sides of small mountain rivers are composed of alluvial-deluvial deposits with high water permeability.

Conclusion

The developed concept of designing a fish passage is based on ensuring the maximum similarity of the projected fish passage path to the natural conditions of the river, in the area below the intake. The slope of the river in the intake construction area often exceeds the average slope of the river. In such cases, the fish passage has to be designed with a greater bias than the i_{ev}. In such cases, the tract should be designed in the form of alternating sections with a constant slope not exceeding the slope measured on the rapids (i_{max}), separated by ponds for fish recreation. The lengths of the sections with a high slope are selected no more than the length of the section of the rapid where the maximum slopes of the riverbed were measured. The dimensions of the soothing pools should be at least two widths of the fish passage channel at the top.

When designing a fish tank, it should be ensured that it is waterproof. The waterproofness of the channel can be ensured by installing a concrete channel, or, shielding the channel, soil with polymer-mineral material (PMM), loam or geomembrane. In all cases, the channel must be lined from the inside with stones selected directly from the riverbed.

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ԱԽՈՒՐՅԱՆ ԳԵՏԻ ԱՋԱՓՆՅԱ ՋՐԱՆՑՔԻ ՕԳՏԱԳՈՐԾՄԱՆ ԱՐԴՅՈՒՆԱՎԵՏՈՒԹՅԱՆ ԲԱՐՁՐԱՑՄԱՆ ԽՆԴԻՐՆԵՐԸ

Գ.Ս. Գաբայան[1], **Է.Վ. Ավանեսյան**[2], **Լ.Վ. Թոքմաջյան**[3], **Գ.Հ. Մարտիրոսյան**[1], **Դ.Վ. Մադոյան**[1]
[1]Ակադեմիկոս Ի.Վ. Եղիազարովի անվան ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտ
[2]Ճարտարապետության և շինարարության Հայաստանի ազգային համալսարան
[3]Հայաստանի ազգային պոլիտեխնիկական համալսարան

Ձկնանցարանների նախագծման վերաբերյալ առկա նորմատիվ փաստաթղթերն ընդունելի չեն լեռնային փոքր գետերի համար: Առաջարկվող ձկնանցարանի խորությունն ու լայնությունը հաճախ համաչափ են կամ նույնիսկ գերազանցում են փոքր լեռնային գետերի չափերը, ինչը նրանց անընդունելի է դարձնում դրանց վրա ջրառի նախագծման համար: Նման գետերի վերաբերյալ ջրային հոսքերի փոքրության պատճառով, որպես կանոն, չկան լուրջ ձկնաբանական ուսումնասիրություններ:

Լեռնային գետերի ջրահավաքներում, ձկների անցման երկու խոչընդոտի պայմաններում և ձկնաբուծական հետազոտությունների բացակայության դեպքում,

G.S. Gabayan, E.V. Avanesyan, L.V. Tokmajyan, G.H. Martirosyan, D.V. Madoyan,
THE PROBLEMS OF INCREASING THE EFFICIENCY OF OPERATION
OF THE RIGHT CHANNEL OF THE AKHURYAN RIVER

ձկնանցարանների տրակտի հաշվարկը անհրաժեշտ է կատարել ջրառի հատածքից վար գետի բնական պայմանների առավելագույն նմանության պահպանմամբ:

Ձկնանցարանի նախագծման համար կարևոր է ելակետային տվյալների հավաքագրումը: Հիմնական աղբյուրի տվյալները որոշվում են հիդրոլոգիական և տեղագրական հետազոտությունների հիման վրա, ինչպես նաև գետի հունի հետազոտությունների միջոցով՝ ջրառի կետից, մինչև գետաբերան, կամ մինչև հիդրոկայանում օգտագործված ջրի վերադարձի տեղամաս: Ձկնանցարանի տրակտում պետք է լինի ջրանթափանցելի: Դա կարելի է ապահովել բետոնե ջրանցքի կառուցման կամ ջրանցքի պատերն ու հատակը պոլիմերահանքային նյութերով (ՊՄՄ), կավով կամ գեոմեմբրանով պատելու միջոցով: Բոլոր դեպքերում ջրանցքը ներսից պետք է շարված լինի անմիջապես գետի հունից ընտրված քարերով:

Ձկնարդյունաբերության նպատակով ստորերկրյա ջրառի վրա անհարժեշտ է կիրառել բազմակի ջրօգտագործման մեխանիզմներ, որից հետո պոմպակայանների միջոցով դրանք ուղղել մոտակա ջրամբարները՝ ոռոգման համար օգտագործելու համար:

Բանալի բառեր՝ գետ, փականային համակարգ, հիդրոէլեկտրակայան, ձկնուղի, հիդրոհանգույց, էկոլոգիական ելք:

ПРОБЛЕМЫ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ЭКСПЛУАТАЦИИ ПРАВОБЕРЕЖНОГО КАНАЛА РЕКИ АХУРЯН

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Отличительной особенностью горных рек являются значительные уклоны русла, аллювиальные русла, сложенные порой из глыбовых камней и скальных обломков, крутые берега и наличие порогов и быстрин. В подобных условиях порой невозможно строительство лестничных рыбоходов, средний уклон которых, очень часто, меньше уклона русла реки. Между тем эти реки сегодня являются наиболее привлекательными для строительства малых ГЭС деривационного типа. Исследования более чем 120 конструкций существующих рыбоходов на водозаборах малых горных рек в разных странах показывают, что конструктивные решения и геометрические размеры их исполнения как правило не обеспечивают свободной миграции рыб вверх по течению.

Разработанная концепция проектирования рыбохода основана на обеспечении максимального подобия проектируемого тракта рыбохода к естественным условиям реки, на участке ниже створа водозабора. Часто уклон реки в зоне строительства водозабора превышает ее средний уклон. В таких случаях тракт рыбохода приходится проектировать с большим уклоном, чем $i_{ср.}$, проектировать в виде чередующихся участков с постоянным уклоном, не превышающим уклон, измеренный на быстринах

($i_{макс}$), разделенных прудками для отдыха рыб. Длины участков с высоким уклоном выбираются не более длины участка быстрины, где производились измерения максимальных уклонов русла. Размеры успокоительных бассейнов должны быть не менее чем в два раза шире канала рыбохода поверху.

При проектировании рыбохода следует обеспечить его водонепроницаемость, что можно обеспечить путем устройства бетонного канала, либо, экранирование канала, грунта с полимерно-минерального материала (ПММ), суглинком или геомембраной. Во всех случаях канал изнутри должен быть выложен камнями, выбранными непосредственно из русла реки.

Ключевые слова: река, запорная система, гидроэлектростанция, рыбоход, гидроузел, экологический выход.

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