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SOME ENGINEERING ASPECTS OF NATURE CONSERVATION MEASURES TO ENHANCE SMALL HYDROPOWER

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The last decade can be considered as the decade of small power engineering development. High activity in this business has affected practically all large and small rivers of Armenia. In this situation, the investors face various well-grounded, and often groundless environmental problems. Some of these problems are considered on the basis of summarizing the experience of construction and operation of some small scale hydropower plants of the country, gained by carrying out studies on more than 60 power stations.

Key words: *ecology, transformer station, fishway, water intake, river.*

A small hydropower plant consists of four main components diversion unit, derivation, power dam and discharge channel, transformer stations and power lines. Let us estimate the potential environmental impact of each element on the power station environment.

1. Water intake facilities. Regarding ecology the component drawing the most attention is the headworks. The key part of the problem lies in damming the riverbed with all ensuing consequences. The main environmental problem under consideration in this context is to provide free passage of fish through the structures erected on the river. At that fishway at the diversion works is brought to an unavoidable component of the scheme without proper justification of its necessity. There are many aspects that need to be considered within the design of a fishway, In the design stage fishway constructions are foreseen on all water intakes, without any exception. According to the design organizations, often make a statement that they just want to avoid having trouble getting positive environmental review of fishway facilities schemes. The Karagluh small scale power station can serve as an illustrative example below the water intake of which there is a waterfall with a drop of over 20 m, through which upstream fish migration practically is impossibl (Fig. 1). Meanwhile, design solutions of fishway structures and what is more important their physical implementation during construction should be analyzed principally and in details. Today, on all water intakes standard reinforced concrete fish ladders or their simplified modifications are designed.

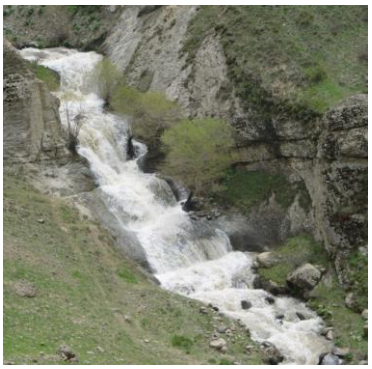


Figure 1 Waterfall on the Karagluh river below the water intake of the alignment

Unfortunately, during the construction in order to simplify building work fishways are made of metal (Fig.2) or completely change their original draft which further reduces the effectiveness of their operation.

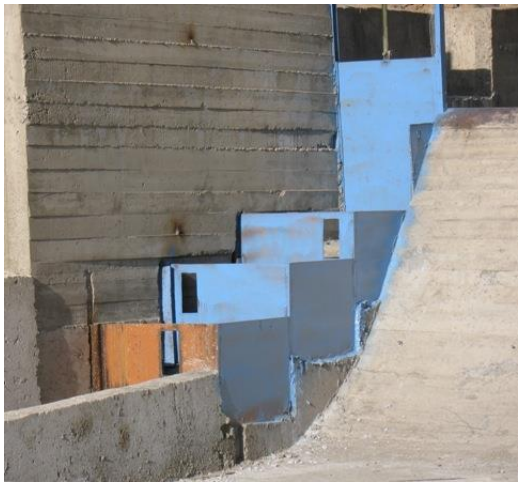
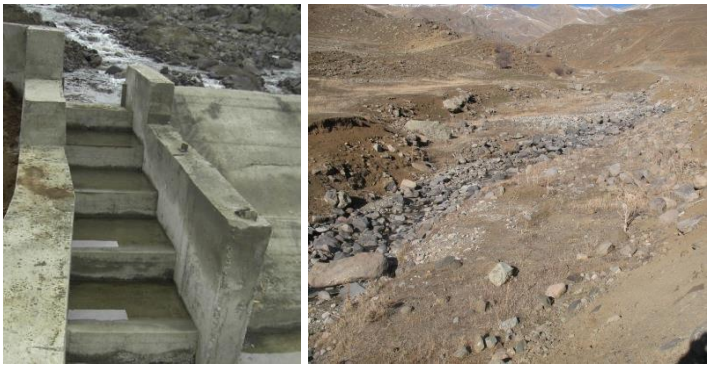


Figure 2. Standard typically pre-fabricated out of metal sections cellular fish ladder

A common mistake in the design of such fishways is a failure of the partition wall between the fish ladder and spillway wall (Fig. 2). This leads to fishway path to be filled up by waste water which will cause disturbance hydraulic regime of the facility.



a) b)

Figure 3. Lack of sanitary outflow
a) in the fish ladder, b) intake of NB

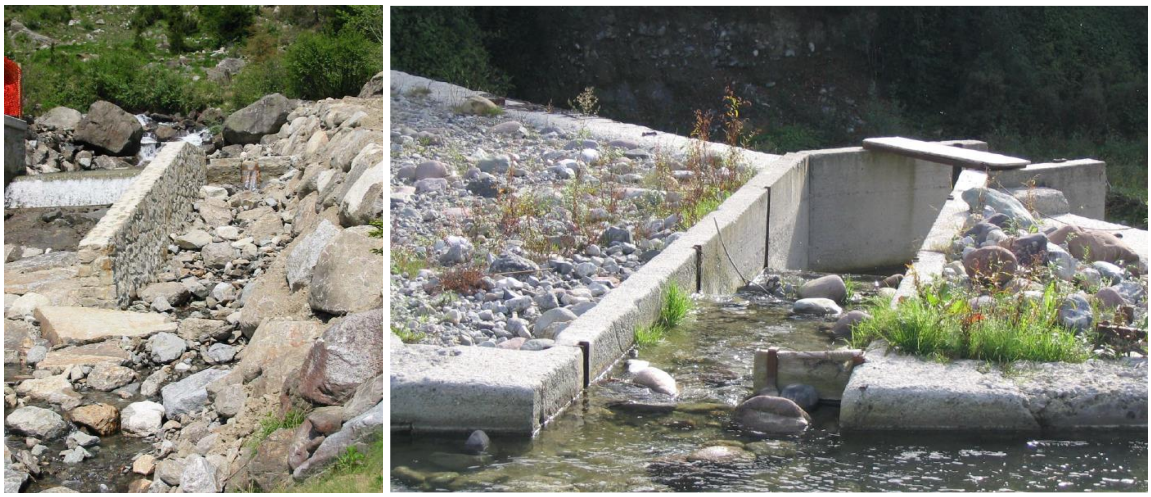
Another problem is a clear observance of sanitary outflows according to the design size. An inspection of structures we have more than once observed cases where sanitary outflows were lowered up to zero value (Fig.3). You cannot always prescribe this phenomenon on the intentional water use violation rules, although such cases are not rare. Often the cause of violations of the sanitary outlet regime is objective and is in hiding from being absent of the regulatory system of the set operation. At that, such regulatory system is not available on all operating small scale hydropower plants of the country.

Most of the rivers in Armenia have quite large daily flow fluctuations. It is reasonable that even under constant duty of personnel at the water intake (and it is not so at 90% of SHP), it is impossible to provide a precise regulation of units and, therefore, to maintain the water level at the

water intake. As a consequence, in addition to the loss of energy generation at the plant (20%), are violated sanitary water releases. At that violations are equally harmful both in underestimation and overstating of the design flow. If in the first case the size of sanitary flow of a river, then, in the second one, velocities on the fishway can reach values that do not provide fish freely passage through them. Consequently, the absence of the unit regulatory system level-sensitive regime is not only technical, but also a very important environmental problem. However, stations projects with the regulatory system absence are free to both technical and environmental expertise

Often the fishway design is simplified and reduced to a step drop. A similar design can normally operate at a single certain level in the upstream. However, even with a slight overflow over the dam on the fishway is formed a raging torrent that does not meet the conditions of spawning migration.

This problem was worked out by many researchers. They have proved that even with the best performance of such fishways, as a rule, are unattractive for spawning fish, because building materials used in fishway structures are foreign material [1]. Therefore, such fishway operates inefficiently. Operation experience has shown [2,3] that it is more expedient to install not large semi-natural channels faced by local materials (stones, pebbles) shown in Fig.4. Such design of fishways are not expensive, simple in implementation and more effective in operation. Rough stone facing of fish migration path decreases velocities in facilities, improving spawning conditions.



a) **b)**

Figure 4. The design of the fishway of semi-natural path
a) the view from the NB, b) view from WB

The very construction of a SHP headwork on mountain rivers of Armenia can not cause serious environmental problems at the height of water retaining works up to 3-4 meters.

Environmental issues may rise in the course of headwork construction. Such issues are standard for any construction in riverside zones and are principally overcomable for such volumes of work.

Headworks of SHP if are properly in operation can contribute to a large positive impact on the sanitary condition of the river. Tthe fact of the matter is that man-made pollution of rivers by plastic bags, etc. above the water intake site. All synthetic items and debris are accumulated at trash rack of a water intake becoming obstacles in the path of water resulting in poor operation of the powerhouse. Consequently, there is a constant need of cleaning receiving chambers from thrash. Collection,

disposal and utilization of trash accumulated on lattices essentially cleans the river below the diversion unit.

Unfortunately, often the trash is left on the banks of the river and washed away back into the river by rain. The situation is worsened in cases when the trash gathered in the riverside is purposely disposed back into the river. This matter will require an undivided attention up to refusal of submitted projects where there is no address to trash utilization amassed before trash rack of a water intake

2. Derivation. A distinctive feature of the derivation of newly built small HPPs in Armenia is that practically almost their majority are installed in the form of pipelines all of them in the form of a pressure line starting from the abstraction and ends in powerhouse building. As the development of new projects laying of derivation pipelines tracks becomes more and more complicated. This may necessitate cutting down a large number of trees and pushing large quantities of soil, sand, rubble, or other such material (Figure 5), which can cause environmental problems, which are soluble in certain reasonable limits.

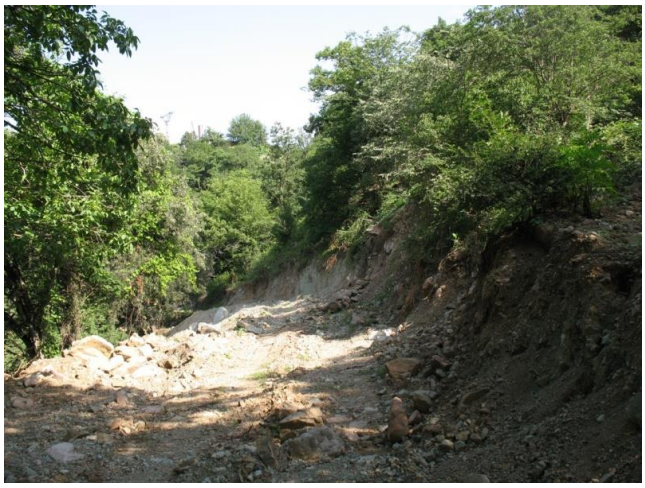


Figure 5. Cutting of the shelf under the pipeline is accompanied by felling of a large number of trees

However, a more serious problem is evaluation of technical and ecological safety when occurs breach of the pipeline derivation. It is obvious that throughout the country when building of small scale power plant as a derivation old pipes are installed which at times having corroded surface of the metal.

Pressures in a number of stations reach values over 300m.

There are cases where a pipeline route passes through areas of potential landslide or secondary landslide without any engineering measures. The probability of a water line breakthrough on such a high section and can cause catastrophic consequences both technical and environmental point of view. Meanwhile, none of SHP projects is evaluated in terms of environmental safety.

3. Power house. For its size and area of a powerhouse small scale hydropower ranks among small structures and practically do not influence on environment. Under observance of ecostandards for construction within water protection zone of rivers, they cannot cause any serious environmental problems.

However, environmental problems can cause different storage facilities for combustive-lubricating products, arranged on the territory of the station unit. In practice, very often during the

design of these units altogether are absent in the Master Plan of the station unit. However, as the SHP is put in commission, they will undoubtedly appear very often with violations of environmental regulations. In making an environmental examination it should be required design solutions on organization of combustive-lubricating products' stores providing their environmental safety.

Yet, there is one more important issue which also can influence on the level of environment wellbeing. It is connected with architectural and aesthetic solutions of station units design. Most of stations are built in tourist attracting beautiful riverside landscapes making them wonderful places to visit. In many European countries small scale hydropower plants are shaped and arranged like hunting lodges and other facilities harmoniously blending in the landscape. Such architectural implementation not only doesn't spoil aesthetic balance of a landscape but, conversely, attracts tourists and hikers. As for architectural solutions of many our small hydro powerhouses are meaningless, do not meet today's requirements and simply provoke serious concern. The same applies to headworks, where harmony with the environment can be achieved by using small elements of landscape design.

Another equally important problem is noise made in operating small hydro power plants. Typically, equipment of the pants manufactured by leading companies meet certain standards in terms of noise. However, remember that over 90% of small scale hydro in Armenia are equipped with components, subassemblies and assemblies produced in Armenia have not undergone any standards in terms of noise. As a consequence, in Armenia there are stations at which the noise level exceeds all possible limits.

Transformer substation and power line. The transformer substation is installed at a short distance from the powerhouse of hydropower plant in the facility site. This is dictated by the technical conditions designed for construction of such structures. Therefore, as a rule, transformer substations are built within the water protection zones of rivers. In such a situation, it becomes very important issue of protection of rivers from ingress of the transformer oil at their failure or replacement. We have examined over 50 plants and, unfortunately, none of them has solved this problem. Meanwhile, the problem is solved by the foundations built in the reinforced concrete impenetrable box filled with gravel and an outlet basin for the collection of waste oil have fallen on the ground surface.

Power lines usually do not cause serious environmental problems and should be carried out taking into account the general and environmental requirements during construction.

All the above arguments are based on the current level of environmental problems related to the design, construction and operation of small scale hydro power plants in Armenia. However, the environmental impact assessment procedures in the field of renewable energy projects should always be borne in mind that the main environmental impact of such stations is the station itself, providing the production of ecologically clean energy. The problem which such plants solve is number one environmental problem for the entire planet. Therefore, environmental impact assessment of such facilities should be held under the leitmotif of maximum assistance to the investor to ensure the project feasibility.

Conclusion

1. In projects more clearly should be grounded necessity of fish passage facilities construction.

2. Projects of fish passage structures should be developed in more detail, based on current research achievements in this area. It is impermissible to make unjustified changes in fishway designs during construction.

3. Lack of the unit control system according to the level-sensitive regime is not only engineering, but also a very important environmental problem. When the environmental assessment of projects is performed it should be required a clear solution of the issue of regulation of water regime in water intake site.

4. Problems of trash collection and disposal accumulated on trashrack structures should be clearly solved in the design stage.

5. Projects of pressure derivation of small scale hydropower plant should be assessed from the point of view of environmental safety when pressure pipeline broke.

6. When carrying out environmental impact assessment it should be required to design solutions for combustive-lubricating products storing to ensure their environmental safety.

7. Architectural solutions of small scale hydropower plants' basic units must comply with the landscape and harmoniously blended into the environment.

8. It should pay attention to the noise generated by operation of the unit.

9. Transformers and oil circuit breakers of substations should be installed so as to ensure the safe collection and disposal of oil leaks, excluding them from getting into the soil and the river.

10. In a routine inspection of environmental compliance with renewable energy projects should not be forgotten that such projects are designed to address the most important environmental problem of global environmental pollution. According to this, such projects require a special approach from environmentalists, excluding deviation projects without good justification.

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Շուշիի տեխնոլոգիական համալսարան

Վերջին տասնամյակը կարելի է համարել փոքր հիդրոէներգետիկայի զարգացման տասնամյակ: Նշված բիզնեսում բարձր ակտիվությունն անմասն չթողեց Հայաստանի մեծ և փոքր գետերը: Տվյալ դեպքում ներդրողների առջև ծառանում են հիմնավորված, հաճախ նաև

չհիմնավորված, բազմաբնույթ բնապահպանական խնդիրներ: Դիտարկվում են դրանցից մի քանիսը, որոնք առաջացել են ավելի քան 60 կայանների շինարարության և շահագործման ուսումնասիրությունների փորձի հիման վրա:

Բանալի բառեր. բնապահպանություն, տրանսֆորմատորային կայան, ձկնանցարան, ջրընդունիչ, գետ:

НЕКОТОРЫЕ ИНЖЕНЕРНЫЕ АСПЕКТЫ ПРИРОДООХРАННЫХ МЕРОПРИЯТИЙ МАЛОЙ ГИДРОЭНЕРГЕТИКИ

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Последнее десятилетие можно считать десятилетием развития малой энергетики. Высокая активность в этом бизнесе затронула практически все большие и малые реки Армении. В этой ситуации перед инвесторами возникают различные обоснованные, а часто необоснованные экологические проблемы. Рассматриваются некоторые из них на основании обобщения опыта строительства и эксплуатации некоторых малых ГЭС республики, изученного на более чем 60 станциях.

Ключевые слова: экология, трансформаторная станция, рыбоход, водозабор, река.