Project "Development and Implementation of Aquatic Biodiversity Action Plan for Dariali HPP"

Blue Rivers ™

Environmental Consulting

Final Report

Adaptive Management Plan

Kyiv

March 2016

Document verification

Job title		Development and Implementation of Aquatic Biodiversity Action Plan for Dariali HPP
Document title		Adaptive Management Plan
Revision	**Date**	**Authors**
Draft 1	20.01.2016	Dr. Prof. Sergey Afanasyev, Dr. Valentin Dolynsky, Mr. Oleg Golub, Dr. Oleksii Iarochevitch, Dr. Olena Lietytska, Mr. Vasyl Manivchuk, Ms. Olena Marushevska. Ms. Kateryna Mudra
Draft 2	09.03.2016	Dr. Prof. Sergey Afanasyev, Dr. Valentin Dolynsky, Mr. Oleg Golub, Dr. Oleksii Iarochevitch, Dr. Olena Lietytska, Mr. Vasyl Manivchuk, Ms. Olena Marushevska. Ms. Kateryna Mudra
Final	16.03.2016	Dr. Prof. Sergey Afanasyev, Dr. Valentin Dolynsky, Mr. Oleg Golub, Dr. Oleksii Iarochevitch, Dr. Olena Lietytska, Mr. Vasyl Manivchuk, Ms. Olena Marushevska. Ms. Kateryna Mudra

Contains

Executive summary

This Report presents the draft Adaptive Management Plan, which is developed based on the results of the implementation of the Aquatic Biodiversity Action Plan in 2015. It includes the main impacts of the HPP (both at construction and operation stage) at flow and physical habitat as well as invertebrates and brown trout. A special chapter in this Report is devoted to monitoring programme for 2017.

The Report presents a number of measures, which should be implemented, their goal, location, frequency and season:

1. Fine sediments (sand, gravel and pebble) reset downstream the headworks;
2. Installation of automatic water level meters to measure the discharge in the fish pass and at all gates
3. Flushing of the sand traps during the night
4. Installation of the temporary fish trap framework and resistive counter to measure fish pass efficiency
5. Deepening of the underwater channel at the most high velocity (thalweg) part of the riverbed downstream the headworks
6. Adjustment of the designed water discharge in the fish pass
7. Ensuring conditions for effective fish pass operation
8. Conduction of the monitoring for the post-commission period
9. Conduction of trainings for local staff.

A number of measures are theoretically identified and should be specified based on the results of the post-commissioning monitoring. After the post-commissioning monitoring, the Adaptive Management Plan should be updated and finalized.

Introduction

In frame of the development, construction and operation of the 108 MW Dariali HPP (further the "Project"), the Aquatic Survey and Monitoring Program was developed and implemented by the Blue Rivers^{TM} Environmental Consulting experts. Its results create a background for Adaptive Management Plan. The main goal of the Plan is to ensure optimal operation of the Project considering the specific biodiversity and hydromorphological characteristics of the Tergi River. The Plan is based on a precautionary principle and includes adaptive management practices in the implementation of mitigation and management measures, responsive to changing conditions and the results of the Project monitoring through the Project lifecycle, as it is required by EBRD Environmental and Social Policy (2014).

According to the EBRD Performance Requirement 6 "Biodiversity Conservation and Sustainable Management of the Living Natural Resources", "where the assessment had identified that the project could have significant, adverse and irreversible impacts to priority biodiversity features (in our case, brown trout), the client should not implement any project related activities unless… appropriate mitigation measures are put in place in accordance with the mitigation hierarchy, to ensure no net loss and preferably a net gain of priority biodiversity features over the long period, to achieve measurable conservation outcomes"[1].

Below the relevant adaptation measures are listed. The need of each measure is defined by describing of possible negative impact of the HPP construction and operation on the relevant elements of environment with the focus on priority biodiversity feature. Each measure includes a series of actions, their objective, locations, frequency and season for their implementation.

1. Strategy for protection of the flow and physical habitat

1.1. Impact of the HPP on the flow and physical habitat

The following impacts on the flow and physical habitat at the possibly affected reach (Tergi from downstream the Dariali headworks till the outlet of diversion section):

- Reduction of water discharge;
- Reduction of flow velocity due to increase of the roughness of the riverbed;
- Reduction of depth;
- Channel simplification, especially in case of braided channel;
- Increase of the duration of ice phenomena.

[1] EBRD Environmental and Social Policy (2014) – p.46.

Reduction of water discharge

Reduction of water discharge is considered as the main impact of the HPP at flow and physical habitat at the possibly affected reach. The minimum environmental flow calculated is 2,54 m^3/s. The designed water discharge of the HPP is 33 m^3/s[2]. The rest will be released through sluices.

Taking into account the flow variability, the HPP operation will have the different impact on the discharge at the possibly affected reach, namely (Table 1, Figure 1):

- Q 90% (low run-off year) additional water release during two months (June- July);
- Q 50% (average run-off year) and Q 10% (high run-off year) additional water release during four months (May- August).

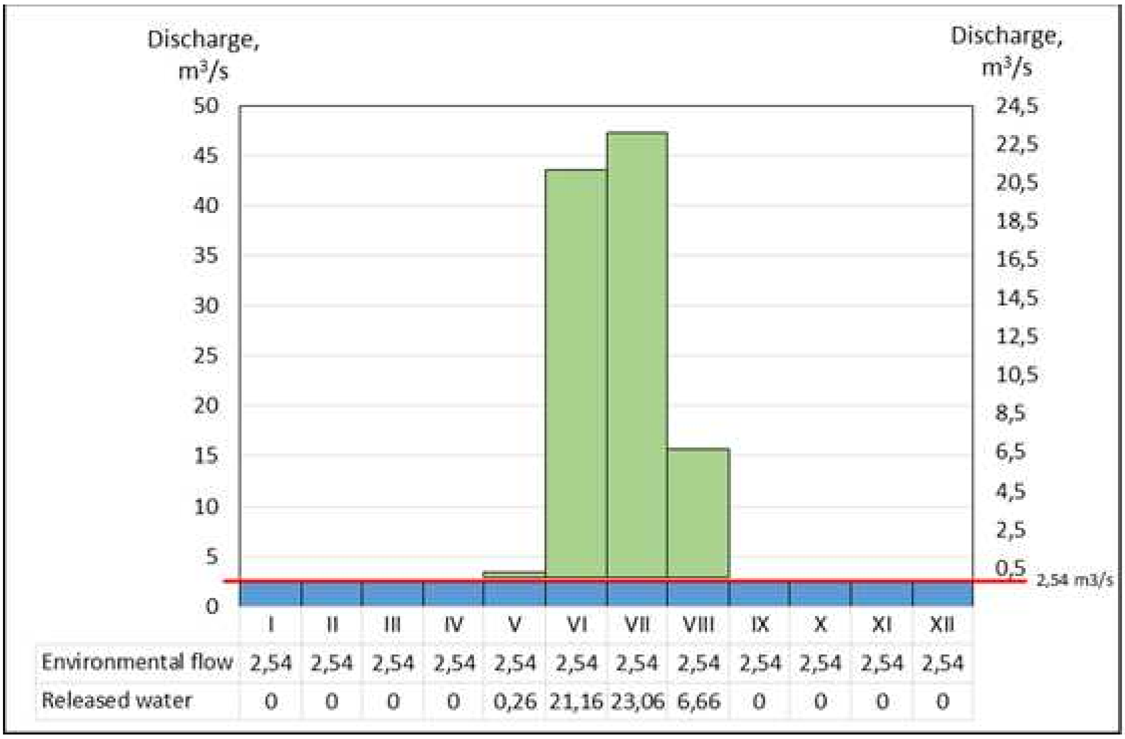

Figure 1. Average monthly hydrograph (Q 50%) at the affected reach of Tergi

[2] Instruction for maintenance of the Dariali HPP Hydrotechnical structures – p. 33.

Table 1. Dariali HPP hydraulic calculations for years with Q 90%, Q 50% and Q 10%

Parameter	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Ave.
Q 10 %													
Inflow	11,70	11,00	11,10	19,00	48,10	76,10	78,60	56,50	34,60	23,70	16,80	13,60	33,40
Minimum environmental flow	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54
HPP water flow rate	9,16	8,46	8,56	16,46	33,00	33,00	33,00	33,00	33,00	21,16	14,26	11,06	30,00
Released water	0	0	0	0	12,56	40,56	43,06	20,96	0,00	0	0	0	1
Q 50 %													
Inflow	8,74	8,20	8,36	14,20	35,80	56,70	58,60	42,20	25,80	17,70	12,40	10,10	24,90
Minimum environmental flow	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54
HPP water flow rate	6,20	5,66	5,82	11,66	33,00	33,00	33,00	33,00	23,26	15,16	9,86	7,56	22,36
Released water	0	0	0	0	0,26	21,16	23,06	6,66	0	0	0	0	0
Q 90 %													
Inflow	6,37	5,92	6,00	10,30	25,90	40,90	42,40	30,40	18,70	12,80	9,00	7,31	18,00
Minimum environmental flow	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54
HPP water flow rate	3,83	3,38	3,46	7,76	23,36	33,00	33,00	27,86	16,16	10,26	6,46	4,77	15,46
Released water	0	0	0	0	0	5,36	6,86	0	0	0	0	0	0

1.2. Riverbed maintenance and monitoring measures

The needed riverbed maintenance and monitoring measures include:

Measure 1	**Fine sediments (sand, gravel and pebble) reset downstream the headworks**
Objective:	To restore natural share of the fine sediments in the sediments composition
Background:	During the HPP operation, the fine sediments will be collected in the chambers of sand trap. In the same time, due to reduction of the flow velocity there will be increase of deposition of the fine sediments at the affected reach in the period from November to March. It mean that overall annual budget in the river will not be changed. Tergi river channel is used by brown trout mainly as a migration route, but not for spawning so possible changes in the annual distribution of the fine sediments should not create a problem for fishes. According to information provided by Dariali Energy during the clean water in the river October – March each chamber will be flushed out once per month (during flushing process of one chamber plant continues operation with second chamber. When one chamber is cleaned, it will be filled with water and then second chamber will be flushed out.) Flushing duration for each chamber in this period will be 5-8 hours. There is no need maintaining operational water level during flushing, it is enough 0.3-0.5 m^3/s discharge for each chamber. Twice a day staff should check consolidation of sediments in front of the threshold at the end of settling chamber. When sediment height will reach less than 40 cm before threshold 1730.40 - 0.40 m = 1730.00 m chamber will be immediately cleaned.
Location:	Dariali headworks
Period:	October – March each month, and in the rest period of the year will depend on turbidity of the river upstream headworks

Measure 2	**Installation of automatic water level meters to measure the discharge in the fish pass and at all gates**
Objective:	To monitor the released water into the affected reach, including control the minimum environmental flow release by the HPP
Background:	The Consultant proposes the instalment of automatic water level meters to measure the discharge in the fish pass and at all gates. The obtained values will be transformed into the values of the water discharge and flow velocity using curves Q=f(H) and V= f(H). This measure corresponds to the requirements of Environmental and Social Action Plan (Action 6.1)[3].
Location:	Dariali headworks
Frequency:	Permanently, in real time mode

[3] Environmental and Social Action Plan – p. 6.

Period:	It is important to install it prior Dariali HPP commencement to be ready for monitoring of the water discharge during the whole period of its operation.

In the period of the surveys in 2015, the water discharge of Tergi was not significant (30-40 % from average multiannual discharge), but in the same time it was in 3-4 times higher than minimum environmental flow. There were big variety of river channel types, in-stream features (substrates, bed elements and flow types) and sediments types at Tergi fixed. **Development of exact list of adaption measures on riverbed maintenance (with identification of location, length of the reach etc.) based on the monitoring results of 2015 is not feasible**, **because it was done prior to the Dariali HPP commencement.**

Other possible measures can include (subject to identification during post-commissioning monitoring):

- **Increase of minimum environmental flow:** possible increase of minimum environmental flow is a back-up measure if the others above are not sufficient. The Consultant assumes that 2.54 m^3/s in environmental flow is sufficient as a continuous discharge for most of the affected reach. There are two criteria for the checking of the environmental flow appropriateness:
    - Ecological: by composition of the bottom invertebrates and fish abundance (in comparison with reference 2015 data)
    - Hydrological: assuring critical ichthyologic depth (which is equal to 1.2 of the average height of the brown trout body = 7 cm) along the entire affected reach. Under environmental flow, the depths at the affected reach will be reduced. The Consultant assumes, that the depths there will be still higher than critical ichthyologic depth.The most critical depths drops will presumably be observed at the braided riverbed channel type.

  The post-commissioning monitoring in 2016 will show whether it might be necessary to increase the environmental flow during migration time and / or to conduct riverbed maintenance.

- Riverbed maintenance measures**:** channel size and form can be re-configured to provide good hydraulic conditions for fish, including needed depths and velocities for the brown trout. The geomorphological system on and around Tergi is very dynamic, and prone to catastrophic debris flow events and extreme floods, which are capable of moving boulders and large volumes of sediment. By river maintenance measures the Consultant means small-scale short-term actions, like deepening the channel, rearrangement of the boulders etc, which should be done regularly. Such activities will not affect the natural state of the riverbed significantly in same time providing for reduced flow. Significant riverbed modification related to the construction are not recommended as they are unsustainable long-term, while putting additional pressure on the natural state of the riverbed.

After the post-commissioning monitoring in 2016, critical locations will be defined (if any). Detailed riverbed maintenance for each location will be developed including location and frequency of inspections, possible measures to be adopted, monitoring of their success, review of future options and reporting.

2. Strategy for protection of aquatic biodiversity

Different mountaineer landscapes of Caucasus create high diversity of microclimate conditions and flowing watercourses, creating a good basis for rich fauna of amphibians' insects. As far as glaciation was quite weak in Caucasus, part of tertiary fauna, died out in Southern Europe, is conserved here. Besides, the process of establishment of new species was very active here. All this explains abundance of endemic species in Caucasus. Mountaineer secondary water species' imago are reophilic and stenothermal, which does not allow them expanding to lower regions. Weak flyover of adults and their close connection to watercourses reduce their capacity to expand and support local species establishment.

Regarding macroinvertebrates, *Ephemeroptera* is represented in the Tergi basin by 15 species, out of which nine are endemics[4], *Plecoptera* is represented by 15 species, out of which 10 are endemics[5], *Trichoptera* is represented by 13 species, out of which eight are endemics[6].

Regarding the fish, the only found fish specie is brown trout, resident form of *Salmo trutta ciscaucasicus* (Dorofeeva, 1967). For it, the establishment of local species is quite typical. Comparison of the morphometric features of the brown trout, caught in Tergi between Kobi and Larsi, brown trout from Trusso gorge and brown trout from Sno river basin shows the difference not only in colour and size of the specimens, but in ratio between height and length of the body and main characteristics of the skulls. **One can say that there are quite stable, partly isolated sub-populations of the brown trout at the Project area.** Turbulent flow of Tergi during the summer flood limits and even interrupts fattening and prior spawning migrations of fish. Taking into account non-lethal catch, such conclusions cannot be confirmed statistically based on the monitoring and surveys, conducted in 2015. However, for the conservation of the gene pool of the trout and avoiding the fragmentation of its Georgian sub-population free migration of the trout along the whole Tergi basin should be assured.

2.1 Impact of the HPP on invertebrates

The most important environmental factors affecting the invasion of macroinvertebrates into mountaineer watercourses are temperature regime, flow velocity and mobility of sediments. High flow velocity (more than 2-3 m/s) leads to development of morphological (cupules and cupules - branchiate, attached shelters) and behavioural adaptations (development at water edge beyond boulder and avoiding drift during the increase of the water turbidity).

The collected material showed high diversity of macroinvertebrates in the Project area (in total 109 species were identified). The main groups include imagoes of amphibian insects: *Ephemeroptera*, *Plecoptera, Trihoptera* and *Diptera*. The most diverse are imagoes of *Diptera* (44 species).

[4] *Ametropus fragilis*, *Epeorus caucasicus*, *Rhithrogena caucasica, Baetis baksan*, *B. buceratus*, *B. gemelus*, *B. Ilex*, *Epeorus caucasicus*, *Rhithrogena caucasica*

[5] *Amphinemura trialetica*, *A. mirabihs*, *Bracbuptera transcaucasica*, *Perla caucasica*, *P. pallida*, *Isoperla caucasica*, *Taeniopteryx caucasica*, *Protonemura alticola*, *P. bacurianica, P. capitata*

[6] *Glossosoma capitatum*, *G. unguiculatum*, *Sericostoma grusiensis*, *Rhyacophila forcipulata*, *Rh. cupresorum*, *Diplecrona felex*, *Chaetopteryx abchasica*, *Halesus digitatus*

2.2.1. Impact of the HPP construction

In order to assess the impact of the HPP construction, one should assess the distribution of macroinvertebrates in Tergi at the affected reach, where the main impact on invertebrates is periodic turbulence due large volume of construction land works.

Structure of the bottom invertebrates of different habitats of the affected reach was quite diverse. There were more than 87 species out of 12 groups fixed with domination of *Insecta (*91,3 %). Insecta were presented by the following families: *Ephemeroptera* (14 species), *Plecoptera* (15 species), *Trichoptera* (9 species), *Coleoptera* (3 species), *Diptera* (35 species, out of which 23 species were *Chironomidae* and 12 imagoes of flies).

Based on the monitoring data and biological indication, the direct zone of the impact of construction works at Dariali HPP at Tergi riverbed was 2 – 2.5 km. Here the total number of invertebrates was reduced comparing to other similar reaches in 1.5 - 2 times. At boulders directly downstream Dariali HPP, invertebrates were presented by 14 species, at boulders outside of the Dariali HPP construction, invertebrates' abundance was 43 species. At braided riverbed within the zone of the impact of construction works at Dariali HPP at the distance of 1 km, there were 28 species identified, and outside of the direct zone of the impact of construction works upstream the confluence of Tibaistkali - 62 species.

The following conclusions can be made:

- The impact of the construction works at Dariali HPP (namely increase of turbulence and sedimentation) was confirmed for 32 species of invertebrates living in boulders riverbed section and 34 species of invertebrates living in braided riverbed section of the affected reach.
- This impact is visible at the site of 2-2,5 km length downstream of the Dariali headworks,
- This impact is temporary. Due to different adaptations of invertebrates, connected to environmental peculiarities of habitats in Tergi riverbed (high mobility of bottom sediments and natural turbidity during floods, mud flows), the construction works do not affect the specie composition and abundance of invertebrates downstream the Dariali headworks in the long run, as far as intensive drift of invertebrates (up to 90 kg per day) from upstream reaches will lead to quick restoration of the population.
- By level and time of the impact, absence of cumulative effects, the negative impact from the HPP construction is much less than pollution of Tergi by wastewaters coming from settlements (mainly from Stepantsminda), which causes reduction of composition and quantity of macroinvertebrates and deteriorates in general status of the river.

2.2.2 Impact of the HPP operation

The total number of species, which can be affected by the reduction of flow during the HPP operation is 87 species living at affected reach. The following impacts theoretically can be observed:

1.) Diversification of the discharge leading to reduction of flow velocities and as a result, deterioration of the conditions for reophilic animals

<u>Possible impact:</u> low. Minimum environmental flow will ensure needed depths and flow velocities for reophilic bottom invertebrates, namely preservation of needed turbulence.

2) Diversion of the part of the flow via turbines creating mechanic and hydraulic barriers will lead to mechanic damage of drifting animals.

Possible impact: low. The HPP is constructed in such a way that most of the bottom invertebrates will enter flushing orifice, as far as a water reservoir established directly upstream the headworks leads to reduction of the natural flow velocity of Tergi, and drifting organisms get additional opportunity to move to the near-bottom water layer.

3) Establishment of impoundment leads to increase of the concentration of invertebrates directly upstream the headworks and water in-take;

Possible impact: low due to small size of the water reservoir located directly upstream the headworks.

4) Flushing of the water from the sand trap and rapid increase of the sedimentation can lead to decrease of the number of the invertebrates.

Possible impact: low. As far as the flushing will be done more frequently in the period of high water, when there is high natural sedimentation, bottom invertebrates are adapted to such changes, so they will not be affected. During October till March, the impact will be low (visible at the site of the 2-2,5 km length downstream the Dariali headworks according to the results of the monitoring in 2015) and short-term (5-8 hours).

2.2 Mitigation measures

As far as all above-mentioned impacts during the HPP operation have low impact, no mitigation measures are proposed. They might be identified if post-commissioning monitoring will show the deterioration of the bottom invertebrates' communities.

2.3 Impact of the HPP on brown trout

2.3.1. Impact of the HPP construction

The main factor affecting the fish during the HPP construction is periodical turbulence caused by construction land works, not related to natural change of turbidity. No negative impact of the HPP construction was fixed. At the whole affected reach, trout of different age was fixed during summer and autumn. The brown trout prefers braided riverbed channel and to less extend single threat riverbed channel. These riverbed channel types were located outside of significant turbulence traces caused by construction works (2 – 2,5 km downstream the headworks, indicated by the state of invertebrates). There was no trout caught in boulder channel type. However, it does not mean that trout does not live there, but catching it using allowed catching devices (electrofishing is needed, which is prohibited in Georgia) is not feasible. In the same time, during autumn field survey, two trout specimen were caught in close vicinity of the headworks after technological diversion of the riverbed from the left flushing gates to the right ones. In summer during quick drying out of the riverbed in front of left flushing gates the group of fish (more than 20 specimens by visual assessment) was seen, which in conditions of the quick reduction of the water level partly went to the riverbed and partly stayed in deepenings in front of the headworks.

This fact confirms that construction process itself almost did not affect the trout, which is highly adaptable to conditions of periodical increase of river turbidity.

2.3.2 Impact of the HPP operation

The following impacts of the HPP operation are theoretically possible:

1) *Barriers to migration*

The only fish specie, fixed in Tergi is brown trout. This fish specie is migratory: adult specimens migrate upstream for spawning in autumn, in spring juvenile fish migrate downstream. Prior Tergi regulation, trout could theoretically migrate downstream for fattening to the sea and migrate upstream from it to upper reaches. After over-regulation of Tergi by dams, trout population got fragmented, establishing its local sub-populations. Construction of the dam with the pressure head 5,6 m (in case if fish pass will not operate) will break up upstream and downstream migration, which can lead to the deterioration of the gene pool of the trout because of the fragmentation of its population.

<u>Possible impact:</u> low due to establishment of the fish pass.

2) *Death at turbines*

Use of the high effective in hydropower context Pelton turbines can also lead to numerous deaths of the fish, entered the turbine in-take. On the contrary, with other types of turbines, Pelton turbine does not give any chance for survival to any fish, because of the high-pressure drops and high speed of its rotation.

Trout can enter the turbines during the downstream migration: juvenile fish in spring and autumn and adult fish in autumn after spawning. During the flow distribution, during the downstream migration, fish select the more powerful flow. While coming to the dam for further downstream migration fish have the following options:

- when the station does not operate – through open gates;
- when the station operates – through the spillway crest (during floods), as well as through fish pass, flushing orifice, and water in-take of the derivation channel.

Figure 2. Dariali headworks

Possible impact: low because of the establishment of the water reservoir (Figure 2) and water in-take from upper and middle water layers, which gives chances to the downgrading juvenile and adult fish to escape in lower water layer and further though flushing orifice.

3) Death because of the low water levels in the natural riverbed

Possible impact: low, as far as preliminary minimum environmental flow should be sufficient for the ensuring the needed for the trout depths and flow velocities. Moreover, there can be a positive impact observed: reduction of the depths and flow velocities can create additional shallow habitats in Tergi, close by their conditions to the ones in Trusso gorge, favourable for spawning. This is only a hypothesis, which will be confirmed or rejected after post-commissioning monitoring.

4) Negative impact of the sediment flushing on the trout life cycle

According to the information provided by the Dariali Energy, during October – March each chamber will be flushed out once per month only. At the borders of this period – in March and October, the main trout migrations take place: in March, it is downstream migration of juvenile fish, in October – upstream and downstream spawning migration of adult fish. During upstream spawning migration, water flow from flushing of the sand trap can theoretically distract fish from the entering the fish pass.

Possible impact: low during the spawning period, as far as water discharge needed for the sand trap chamber flushing (0,3 – 0,5 m^3/s) is smaller than the one coming from the fish pass (0,7 m^3/s), the relevant velocity in the sand trap will be smaller due to larger sectional area of the pipe of the sand trap. Together with significant turbidity of the water, the sand trap flow will create less attractive conditions for the fish. In addition, flushing is short-term (0,8% of month duration).

In conditions of increased turbidity as well as during flood, the trout searches for the less turbid water and hides in the deepenings beyond stones. So the spawning migration temporary stops during this period. However, taking into account the short duration of the flushing (5-8 hours) this impact is the same as the natural impact of heavy long rain.

In period from April to September during the increase of water levels, there are no spawning migrations of the fish, but just fattening ones. Short-term increase of the turbidity because of sediments flushing can distract the trout from eating and cause its leaving the site. The impact can be avoided if sediment flushing will be done during the nighttime (see Measure 3).

2.4 Mitigation measures

Measure 3	**Flushing of the sand traps during the night**
Objective:	To avoid distracting trout from fattening migrations
Background:	Short-term increase of the turbidity because of sediments flushing can distract the trout from eating and cause its leaving the site. The impact can be avoided if sediment flushing will be done during the nighttime.
Location:	Dariali headworks
Period:	During sand traps flushing

Fish passes are of increasing importance for the restoration of free passage for fish and other aquatic species in rivers as such devices are often the only way to make it possible for aquatic fauna to pass obstacles that block their up-river journey. The fish passes thus become key elements for the ecological improvement of running waters. Their efficient functioning is a prerequisite for the restoration of free passage in rivers.

Dariali HPP is equipped with a fish ladder. Fish migration is theoretically possible if fish pass will be effective and it will be proven by monitoring.

At the fish pass inlet, 1.5 m wide orifice with depth gate is arranged that controls water stream flow in the fish pass. Its canal is 4.0 m wide at the beginning and the ladder steps are placed in longitudinal and transversal directions. Further, the fish pass canal is narrowed to 2.8 m. Its length is 48.8 m where bottom elevation is dropped from 1733.80 m (the entry orifice threshold elevation from the upstream side) to 1728.20 m (the exit threshold elevation from the downstream side). Therefore, the total drop within the fish pass limits is 5.6 m and the height of each step is 20 cm[7]. The flow velocities in the fish pass can vary from 0,1 to 2 m/s, depending of the position of a special gate installed at the entrance of the fish pass for regulating the water discharge and velocity in the fish pass.

[7] Instruction for maintenance of the Dariali HPP Hydrotechnical structures – p. 33.

Measure 4	**Installation of the temporary fish trap framework and resistive counter**
Objective:	To measure fish pass efficiency
Background:	The following equipment is proposed to be installed: o Fish trap to be temporary installed for monitoring of the fish migration and ichthyologic site The Figure 3 presents the framework of the temporary fish trap. It is proposed to be made of aluminium pipe 30 mm in diameter x 2 mm thick. The baseline of the fish trap (highlighted in the Figure 1 by colour) has extended ends of 100 mm long, by which the trap is fixed at hooks. The hooks should be made of still rod Ǿ 16 (or squire rod) with the length of 200 mm and installed under the inclination of 30-35^{o} to vertical. The Figure 3 presents an option of the hook, which can be welded to the steel parts of the fish pass. If the fish trap should be fixed at concrete, the anchor bolts should be installed in the concrete prior the installation of the fish trap. The framework will be covered with net with the mesh size 10-12 mm from all sides except the basement.

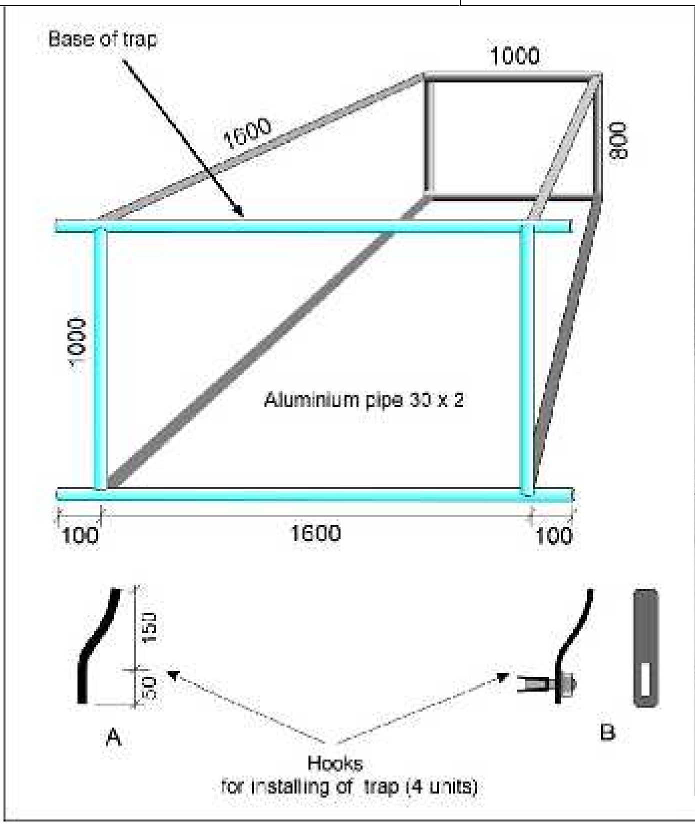

Figure 3. Framework for temporary fish trap

Figure 4. Place of the fixing of the trap

The Figure 4 shows how to fix the trap at the fish pass outlet by hooks. The trap should be put vertically down and hanged up at four hooks (highlighted in yellow). By colour, the forepart of the fish trap is selected. The hooks should be welded or fastened by anchors the fish pass outlet in such manner so that basement of the trap fully blocks the outlet. In order to pull up or pull down the trap, it is better to use the block installed above ichthyologic site (Figure 5) or it can be done manually.

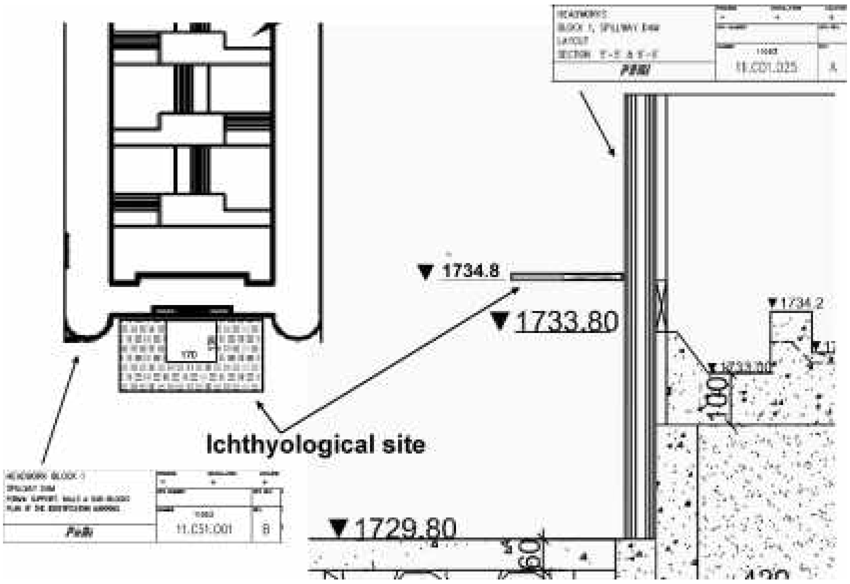

Figure 5. Scheme of the ichthyologic site

Once the trout is captured, it will be measured in terms of body length, weight; few scales will be taken to identify the age of the fish; the fish will be tagged with unique number (to see its growth) and released.

- A resistive counter. It is used in conjunction with an electrode set to detect continuously the upstream and downstream passage of fish in the fish pass. It detects untagged fish and what is very important it operates in high turbid water and at night.

Period:	Installation – once prior the trout upstream spawning migration (September – October); fish pass efficiency testing – 1 week during the spawning period

Measure 5	**Deepening of the underwater channel at the most high velocity (thalweg) part of the riverbed downstream the headworks**
Objective:	To make fish pass entrance for upstream migration trout more attractive
Background:	To assure that the trout reaches the fish pass it is necessary downstream the headworks to make deepening underwater channel at the most speedy (thalweg) part of the riverbed. This channel should lead to the fish pass. The depth of the underwater channel in the place of the conjunction with fish pass can be deeper than the fish pass but not more than 20 cm. It is important to prevent underwater channel erosion, for this the stone wall should be put at the length of minimum 2-3 m.
Location:	30 m downstream the fish pass outlet
Period:	Once prior the HPP commencement

2.5 Fish pass operation

Measure 6	**Adjustment of the designed water discharge in the fish pass**
Objective:	To make flow in the fish pass more attractive
Background:	According to the Instruction, minimal environmental flow (2,54 m^3/s) will be provided by the two sources: fish pass (1,0 m^3/s) and 2 m wide flushing orifice of sediments trapping chamber arranged before the intake, or between the double gates, or water flowing under the main gates (1,54 m^3/s). The Consultant's calculations show that in order the provide attractive flow velocity for the trout living in Tergi downstream the Dariali headworks, the best discharge for the fish pass will be not 1,0 m^3/s, as Instruction mentions, but 0,7 m^3/s. The fish pass will provide the necessary hydraulic conditions required by the migrating fish at a river discharge between Q30 = 60 m^3/s and Q330 = 9m^3/s with and without the plant being operational if the depth of the water at the first step of the fish pass will be in the range 0,1- 0,4 m, flow velocity not more than 1,2 m/s. It means the water discharge in the FP maximum 0,7 m^3/s. It can this be achieved at the fish path intake by operating the relevant gate. The water discharge does not affect the fish movement directly. The limiting factor for the fish is flow velocity (attractive flow), so the fish pass will be swimmable under these conditions. In times of the water discharge up to 35 m^3/s, a part of environmental flow (1,84 m^3/s) will be discharged via 2 m wide flushing orifice of sediments trapping chamber arranged before the intake, or between the double gates, or water flowing under the main gates. This discharge will be distributed over the concrete surface of the apron with the depth less than minimal ichthyologic depth, which will not allow fish selecting this route. The flow in the fish pass with the discharge (0,7 m^3/s) at the outlet will have the depth up to 0,6 m and flow velocity 1 m/s, which is more attractive for the trout. In times of the water discharge more than 35 m^3/s, fish pass can be less attractive for the trout because of the low flow, but such conditions in the period of the trout spawning can be only in the years with Q10.
Frequency:	Once during the HPP commencement
Period:	Prior to the trout upstream spawning migration (September – October)

Measure 7	**Ensuring conditions for effective fish pass operation**
Objective:	To make the fish pass more attractive
Background:	The following statements are important for the effective fish pass operation: • Fish pass should operate during the whole year as minimum 300 days and obligatory during autumn upstream spawning migration. Obligatory fish pass operation in autumn is stated because the only fish specie living in Tergi (brown trout) has upstream spawning migrations in autumn. This recommendation does not mean that fish pass should not be operational in spring. In spring, the juvenile fish can migrate downstream using fish pass, as well as through fixed orifice.

	• Prior the fish pass commencement, the following elements, which can injure the fish should be taken away from the fish pass: steel framework and sharp concrete residues. • The fish pass should be regularly checked to take away the garbage, which can lead to change of its hydraulic characteristics leading to rejection of the fish to enter the fish pass. Optimal frequency of fish pass checks should be defined during the fish pass operation, but not less than once per week and obligatory once per week and prior spawning migration (September). In case of the need to clean the fish pass, its intake in upper part should be closed by lock. During fish pass closure, the minimum environmental flow should be compensated by increase of the flow through flushing orifice.
Period:	prior to the HPP commencement during the whole period of the fish pass operation

3. Monitoring programme and training for post-commission period

Measure 8	**Conduction of the monitoring for the post-commission period**
Objective:	To monitor the impact of the HPP operation at flow and physical habitat and aquatic biodiversity

Background:

It is continuation of the monitoring programme developed for 2015 with special attention paid to ensuring fish pass efficiency (fish pass calibration and its efficiency monitoring) and sediments dynamics monitoring.

The following monitoring stations are selected for the post-commissioning monitoring (Table 2, Figure 6).

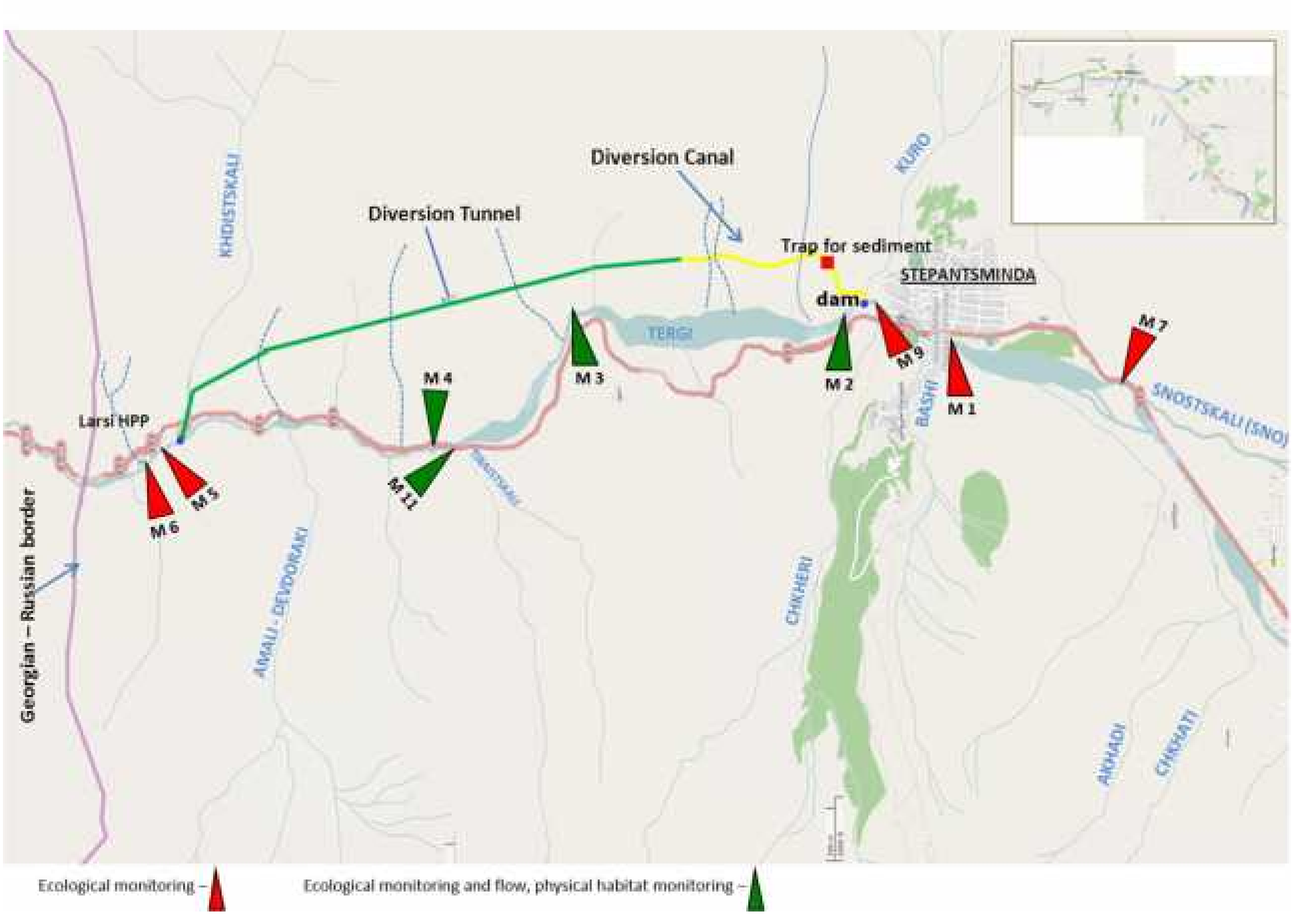

Figure 6. Location of the proposed monitoring stations for post-commissioning monitoring

Table 2. Proposed monitoring stations for the post-commissioning monitoring

Number	Location	Ecological monitoring	Flow and physical habitat
M 1	Tergi upstream the Dariali headworks	+	
M 2	Tergi downstream the Dariali headworks (boulder section)	+	+
M 3	Tergi downstream the Dariali headworks (braided section)	+	+
M 4	Tergi downstream the Dariali headwork (single thread section)	+	+
M 5	Tergi upstream the Larsi headworks	+	
M 6	Tergi downstream the Larsi headworks	+	
M 7	Sno mouth	+	
M 9	Chkheri mouth	+	
M 11	Tibaitskali mouth	+	+
	TOTAL	9	4

The monitoring will include the following components:

1. **Ecological monitoring**

1.1 Brown trout monitoring	
A Needed external conditions:	The dam fully blocks the river. There is a water reservoir. The sand trap is covered by the water. The water level at the affected reach is dropped. The fish pass is operational.
Objective:	Assessment of the changes in the trout distribution in Tergi at the affected reach and in the water reservoir; assessment of the change in the fattening area; assessment of the possibilities of the fish entering the turbines
Parameters:	Trout presence, distribution, abundance, age composition, length and weight
Monitoring stations:	• Catches by fishing rod and flying net in the river in the water reservoir (M9). • Distribution of the fish in the water reservoir (M9): day and night catches by installed nets, flying nets and rods at left, right banks of water reservoir and in the centre (both at the surface and the bottom) and near the water in-take. Echolocation. Duration: 4 days. • Control of possible entrance of the trout into the sand trap by flying net and installed nets, echolocation. Duration: during the whole field survey. • Periodical day and night catches using cone net at the water outlet from the fish pass. • Trout catches at all the stations. Tagging of the caught trout. • Observation over the sand trap flushing: installation of the nets in the outlet of sand trap.

Period:	May - June 2016, 2 weeks after the HPP commencement. Duration: 10-14 days.

B Needed external conditions:	Start of the upstream spawning trout migration
Objective:	Assessment of the fish pass efficiency
Parameters:	Trout presence, distribution, abundance, age composition, length and weight
Monitoring stations:	• Day and night catches by flying net directly downstream the headworks. Each caught trout will be tagged. • The temporary fish trap will be installed at the fish pass. The observations will be conducted both during the day and at night. Each caught trout will be tagged. Comparative assessment of the fish in the fish pass during the different discharges in the fish pass (0,3; 0,5; 0,7; 0,9 m^3/s). • Temporary fish pass drying and monitoring of the fish at the whole fish pass
Period:	1- 15 October 2016

In relation with the postponing of the Dariali HPP commencement, monitoring of the juvenile trout distribution in the water reservoir can be implemented in spring 2017 only.

1.2 Invertebrates monitoring	
A Needed external conditions:	The dam fully blocks the river. There is a water reservoir. The sand trap is covered by the water. The water level at the affected reach is dropped. The fish pass is operational.
Objective:	Assessment of the changes in the structure of the bottom invertebrates at the affected reach, assessment of the possibility for invertebrates to enter turbines; assessment of the impact of the sand trap flushing.
Parameters:	Diversity and abundance
Monitoring stations:	• Invertebrates sampling in the water reservoir (M9) in order to monitor their distribution • Control of the possibility for the bottom invertebrates to enter the sand trap (daily draft catches directly upstream the sand trap) • Invertebrates sampling at the rest of the stations • Observation over the sand trap flushing and its effect on the invertebrates
Period:	May - June 2016, 2 weeks after the HPP commencement. Duration: 10-14 days.

B Needed external conditions:	Start of the upstream spawning trout migration
Objective:	Assessment of the changes in the structure of the bottom invertebrates at the affected reach; assessment of the impact of the Dariali HPP at invertebrates comparing to the reference data of 2015; seasonal assessment of entering of

	the invertebrates in the HPP turbines
Parameters:	Diversity and abundance
Monitoring stations:	• Invertebrates sampling in the water reservoir (M9) in order to monitor their distribution • Control of the possibility for the bottom invertebrates to enter the sand trap (daily draft catches directly upstream the sand trap) • Invertebrates sampling at the rest of the stations • Observation over the sand trap flushing and its effect on the invertebrates
Period:	1- 15 October 2016

2. Flow and physical habitat monitoring

2.1 Flow monitoring at the affected reach	
A Parameters:	Water level / depth, discharge
Monitoring stations:	M2, M3, M4, M11
Period:	October – December 2016 (months with only minimum environmental flow at the affected reach) minimum 3 days after of minimal environmental flow
B Parameters:	Water level / depth, continuity of the flow
Monitoring stations:	The entire affected reach
Period:	October – December 2016 (months with only minimum environmental flow at the affected reach) minimum 3 days after of minimal environmental flow. The monitoring will be done by walking along the entire affected reach. Based on this monitoring cricitical locations for the further monitoring programme will be identified as well as the specific programme of measures.

2.2 Physical habitat monitoring at the affected reach	
Parameters:	Channel sinuosity; channel type (boulders, single threat or braided); in-stream features (bed elements, bed substrates); variation in width; depth; ratio of average width/average depth; flow types;; bank/riparian zone parameters; coefficient of roughness of the riverbed, riparian line and floodplain
Monitoring stations:	M2, M3, M4, M11
Period:	October – December 2016 (months with only minimum environmental flow at the affected reach) minimum 3 days after of minimal environmental flow

2.3 Monitoring of dynamics of fine and coarse sediments distribution downstream the Dariali headworks	
Parameters:	composition of the sediments
Monitoring stations:	M2, M3, M4
Period:	October – December 2016 (months with only minimum environmental flow at

	the affected reach) minimum 3 days after of minimal environmental flow. Exact dates will be fixed taking into account dates of sediment chamber flushing (need to be coordinated with Dariali Energy)

2.4 Fish pass calibration (establishment of the correlations between the water level and water discharge; water level and flow velocity in the fish pass arranged by the different positions of its gates)	
Needed external conditions:	• Stable (normal) water level in the upper reach of the Dariali HPP • Installed (manual or automatic) equipment for the water level measurements in the fish pass and other outlets, which assure minimal environmental flow release • Provision for the ensuring stable water levels out fish pass outlet during 1-2 hours with the depths 0,1 m, 0,2 m, 0,3 m, 0,4 m, 0,5 m.
Objective:	• Assessment of the correspondence of the flow velocity dynamics along the length of the fish pass to the thresholds, attractive to the trout • Identification of optimal range of water level in the fish pass for the trout • Identification of the factual part of minimal ecological flow (2,54 m^3/s), which goes through the fish pass under different water levels • Building of correlation curves (water discharge and flow velocity curves Q=f(H) and V= f(H)) in order to organize the control over the needed ichthyologic conditions • Measurement of the total water discharge in the lower reach of the Dariali headworks
Monitoring stations:	• Measurements of the depths and flow velocities along the whole length of the fish pass; • Measurements of the flow velocities, widths and depths of the flow at other outlets; • Measurement of the minimal ecological flow in the lower reach of the Dariali headworks (30 – 100 m downstream the headworks)
Period:	October – December 2016, duration: 1-3 days

The costs of the monitoring programme in 2016 are covered in frame of the present contract with the Consultant. The calculation of the further monitoring program (starting from 2017) will be done based on the findings of post-commissioning monitoring in 2016.

Measure 9	**Conduction of trainings for local staff**
Objective:	To assure proper further post-commissioning monitoring
Background:	According to ToR, trainings and skills transfer for local staff should be conducted to ensure further post-commissioning monitoring (from 2017). The Dariali HPP should identify the staff to be trained prior the monitoring missions, so that monitoring during 2016 will be conducted jointly with Georgian specialists to ensure on-job trainings. The following specialists need to be trained:

	1. Ichthyologist (3 people), 2. Zoologist (3 people), 3. Hydrologist and hydromorphologyst (2 people).
Frequency:	2-3 days during the autumn field surveys (both flow and physical habitat monitoring and aquatic diversity)
Period:	October

Based on the results of the monitoring for 2016, the current Adaptive Management Plan should be updated and more specified.