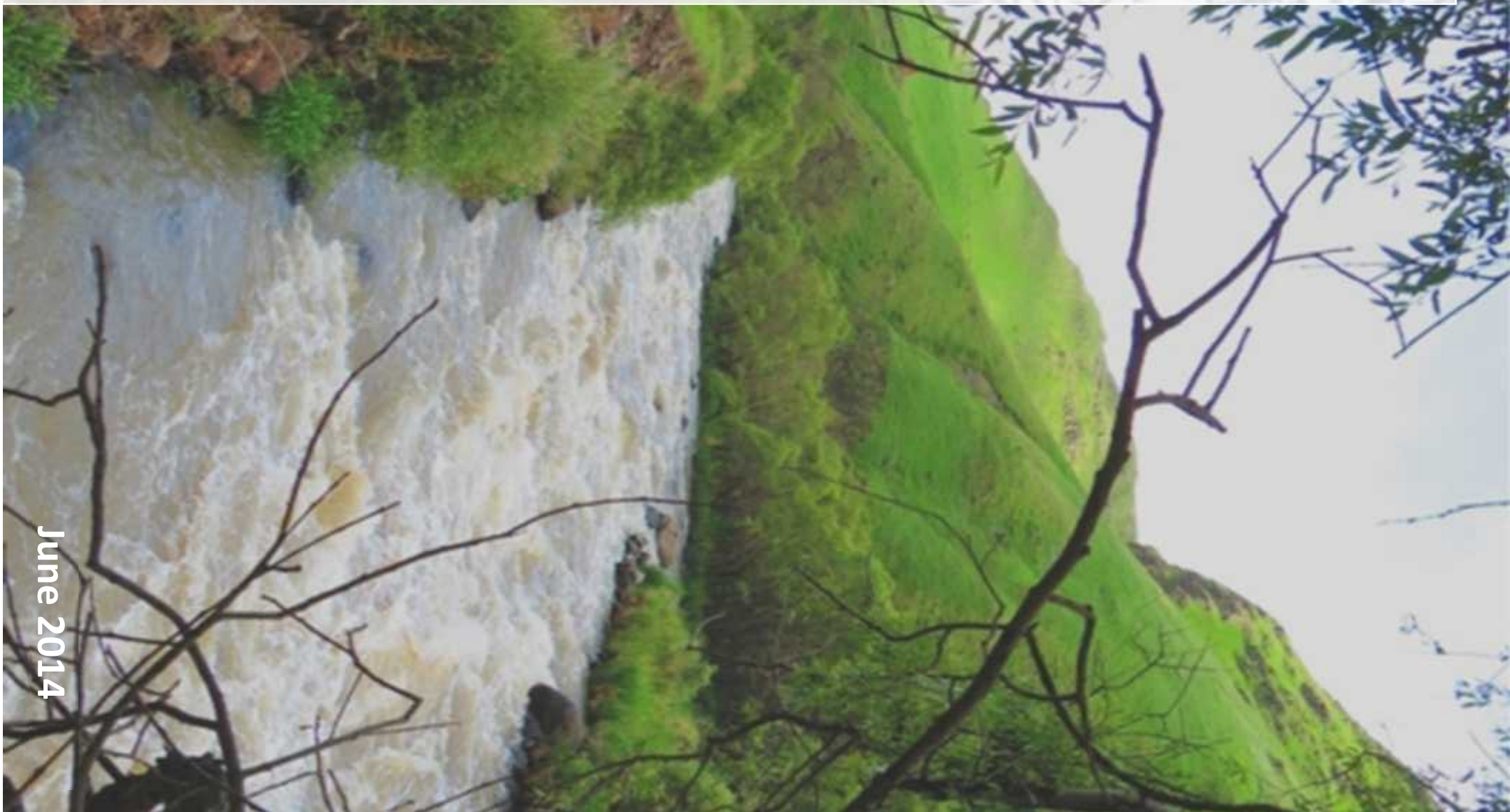
Aquatic monitoring plan

Paravani HPP Project



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1 BACKGROUND

According to the Environmental and Social Action plan developed for the Paravani project implementation of robust multi-taxa aquatic monitoring programme to measure changes attributable to the project in fish and other aquatic life and water quality in the Paravani, from at the upstream area to the point of convergence with Mtkvari River is planned.

2 MONITORING OBJECTIVES

The monitoring is to enable timely response to any changes in the status of fish population and ecosystem heath downstream the diversion point, due to the reasons attributable to the project, up to the review of management approach.

The goal of the monitoring is to evaluate the status of fish populations in selected reaches under the 'reduced flow regime. The specific objectives of the monitoring include the following items.

- Monitor fish species composition and relative abundance in the reaches upstream and downstream the weir (in the Paravani River), upstream and downstream (in the Mtkvari River);
- Monitor size/age distribution of fish species;
- Monitor condition factor of sampled fish species.

Information provided by fish monitoring will be interpreted together with water quality, macro-invertebrates control and visual observation of the status of riparian vegetation along the section of interest.

3 SUMMARY

3.1 Aquatic Impact Monitoring Plan (AIMP) Components

Water quality

During operation water quality in the Paravani River will be monitored upstream and downstream of the intake . Sampling will be done seasonally.

Aquatic Habitat

During operation, monitoring includes two primary components:

- monitoring to describe the status of near-shore habitat; and
- monitoring to document substrate composition upstream and downstream of the weir over time.

Annual monitoring will be conducted for the first 2 years following the start up.

Aquatic Macroinvertebrates

Benthic macroinvertebrate sampling will be conducted in autumn of each year, the drifting ones - four times a year during the first 2 years of operation.

Fish Community

Fish community monitoring during the operation phase will consist of core monitoring of the fish community upstream and downstream of the weir in the section from the weir to the Paravani-Mtkvari confluence, upstream and downstream the Mtkvari confluence. Monitoring will be done annually for the first 2 years of operation. To monitor movements of the fish community species upstream and downstream of the weir for the first 2 years of operation (efficiency of the fish passage) traps at the upper and lower end of the fish ladder were used.

3.2 Physical Environment Monitoring (PEM)

The PEM will provide a complete description of the monitoring of the physical environment. Several topics addressed in the PEMP will be required as inputs to the AIMP, as described below:

- Measurement of water depth and velocity upstream and downstream of the weir;
- Monitoring of water quality parameters (e.g., total suspended solids (TSS), turbidity) upstream and downstream of the weir - to provide input into the water quality program;
- Monitoring of shoreline erosion - to provide a link between mineral and organic inputs and effects to water quality;
- Measurement of sediment deposition upstream and downstream of the weir – to provide input to the aquatic habitat (substrate) and benthic invertebrate monitoring programs;
- Monitoring of dissolved oxygen (DO) and water temperature downstream of the weir – to provide information important for the water quality, benthic invertebrate, and fish community.

Monitoring of water quality, benthic invertebrates and fish will be conducted by GUEN.

4 BASELINE DATA

Baseline data were collected as part of the environmental studies. Water quality has been controlled quarterly, hydrological flow monitoring – done in high and low water periods, fish survey carried out in winter (December 2011 - January 2012) and late spring-summer (May -June 2012). Results are presented in relevant reports.

5 MONITORING SCHEDULE

The frequency of monitoring activities will vary, depending on the parameter being controlled. Intensive monitoring will be conducted annually during the first 2 years post-commissioning.

As the components of aquatic environment use to experience wide range of seasonal and year-to-year variation, some effects of the project may only be detectable after a period of several years. With consideration of that, the subsequent periodic control is recommended. The frequency of subsequent monitoring may be adjusted depending on initial results.

Parameter	Location	Year of operation								
		1	2	3	4	5	6	7	8	…
Water quality	Upstream and downstream the weir									
Water level/flow	Upstream and downstream the weir									
Aquatic habitat	Upstream and downstream the weir, downstream the confluence									
Nearshore habitat	Downstream the weir									
Macroinvertebrates	Upstream and downstream the weir, downstream the confluence									
Fish - composition	Upstream and downstream the weir, downstream the confluence									
Fish- movement	Upstream and downstream the weir, downstream the confluence									
Riparian vegetation	Upstream and downstream the weir									

Annual sampling, frequency per component is given in the text (see relevant sections of the plan)

Periodic control, at least once every three years

Monitoring results will be reported annually. Evaluation of monitoring results will help to determine whether:

- unexpected effects are occurring;
- mitigation measures need to be modified; and
- refinements to the monitoring approach are necessary.

In case the monitoring session reveals any significant change – the monitoring plan will be adjusted (if advisable) and/or additional mitigation measures will be developed and introduced.

6 STUDY AREA

The study area includes the area upstream the weir to the confluence with the Mtkvari River, as well as 200m long section upstream the Paravani-Khandostskali confluence (Figure 1).

The section under control starts from about 50 m upstream the impoundment area (reference sampling site), in 150m before and after the confluence with Mtkvari .

Fish monitoring may also include the Khandostskali section in about 200m upstream from the confluence with Paravani (this control point has been selected with consideration of the fact that the confluence areas use to be considered as sensitive locations worth to be controlled during aquatic monitoring exercise – optional observation point).

Sampling to collect macroinvertebrates will be conducted upstream and downstream of the weir in the Paravani River and upstream and downstream the confluence in the Mtkvari River. Upstream data will be used as reference.

Monitoring for the water quality will be done upstream (50 m upstream the impoundment area) and downstream the weir in two locations – one in the closest accessible location after the diversion point; another – farther downstream in the section up to the Mtkvari confluence site. Control will be done quarterly.

In addition, visual control of riparian vegetation downstream the intake (up to the Mtkvari confluence) will be carried out.

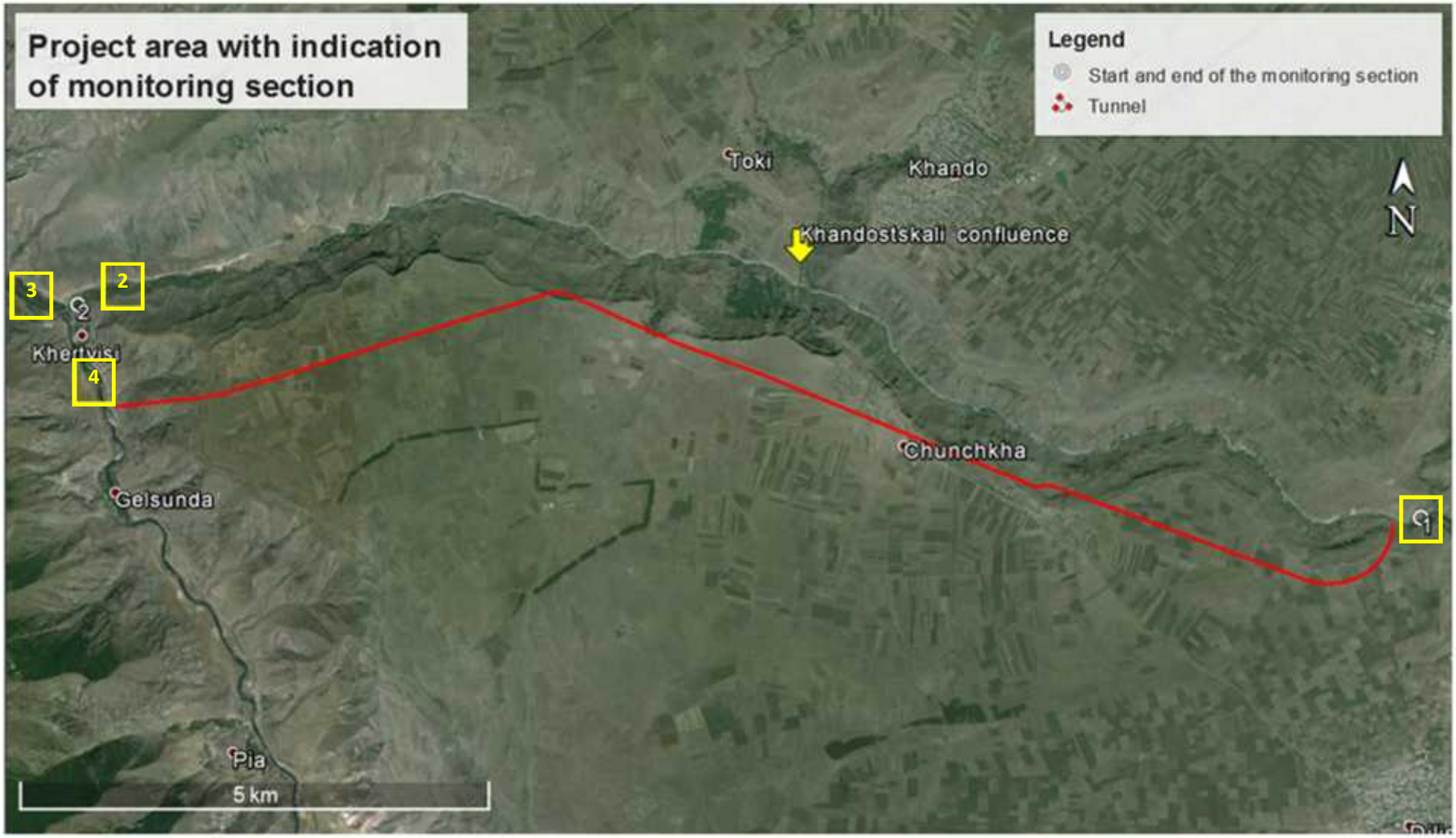

Figure 1. Project area with indication of the boundaries of the monitoring area and Khandostskali confluence area

(Coordinates of the monitoring section start and end points are as follows: point 1: 37162985E – 4590715.50N; point 2: 356885.26E – 4593539.50N; Khandostskali – 36507505E – 4593648.04N (optional), point 3: 356383.05E – 4593599.96N, point 4: 356970.26E – 4592716.67N)

7 WATER QUALITY

Monitoring data collected during operation will be compared to upstream reference sampling site and technical guidelines for surface water quality. Monitoring will be conducted upstream and downstream the weir. As mentioned above monitoring will be done upstream (50 m upstream the impoundment area) and downstream the weir in two locations – one in the closest accessible location after the diversion point; another – farther downstream in the section up to the Mtkvari confluence site. Control will be done quarterly.

The monitoring program will include collection of samples for laboratory analysis (pH, TSS/turbidity, colour, total nitrogen, total phosphorus, chemical and biological oxygen demand and conductivity/TDS). Analysis will be done in an authorized laboratory. Dissolved oxygen and temperature will be measured in situ.

Water quality will be monitored quarterly (second week of every first month of the quarter) during operation. Samples of water will be collected by directly filling sample bottles (provided by the analytical laboratory) at approximately 30 cm below the surface at all sampling sites.

8 AQUATIC HABITAT

Aquatic habitat provides environment in which aquatic biota live, as defined by water depth, velocity and substratum, as well as structure, including non-living and living (rooted plants) components.

Monitoring will record status of existing aquatic habitat affected by the Project both upstream and downstream of the weir and confluence. Information related to aquatic habitat (including water depth, water velocity) will also be collected as part of the Physical Environment Monitoring Program (PEMP). Other activities in the PEMP, such as monitoring erosion shorelines and status of riparian vegetation, will be used to complement the aquatic habitat monitoring program.

The core aquatic habitat monitoring program will provide information on development/changes of nearshore habitats. Potential effects on aquatic habitat downstream of the weir will be related to changes in water level, erosion processes, transport, and deposition of fine sediments over existing cobble and gravel substrate, water quality; impact of the change in hydrological regime in upstream and downstream sections of the Mtkvari River.

The monitoring area will include the area from the upstream of the impoundment site to the confluence and upstream and downstream of the Mtkvari River. Changes in the characteristics of nearshore areas will be assessed using reconnaissance of randomly selected spots (at initial stage) and representative set (on subsequent stages of monitoring) of spots selected within the section under consideration. (Photographic evidence of situation will be collected). Transects perpendicular to the shoreline in the sections where water level gauges are installed (2 locations – one upstream and another downstream the weir) and Khertvisi hydrological observation station (near the confluence with the Mtkvari River) will be used to control water velocity and changes in topography of the riverbed.

Nearshore habitat monitoring will be conducted in each of the first 2 years. Monitoring may continue at reduced frequency depending on results.

9 AQUATIC MACROINVERTEBRATES

Aquatic macroinvertebrates are standard indicators of ecological integrity used in bio-monitoring programs worldwide. Similar to most biological indicators, they are sensitive to the status of environment. At the same time aquatic macroinvertebrates represent an important food source for fish.

As species composition of drifting macroinvertebrates is often different from that of the benthos on operation stage of the project macroinvertebrates (both benthic and drifting) will be monitored.

Operation-related pathways that may affect macroinvertebrates downstream of the weir because of alteration of flow patterns, water velocities, and depths.

Benthic sampling will be designed to assess the biological effects of predicted alteration of flow, as well as water velocities and depths (where sampling is feasible). Drift net sampling is intended to assess the effects of the predicted alteration of flow, and water velocities and depths (where sampling is feasible). Checked will be whether the macroinvertebrate taxa richness is affected, has downstream invertebrate drift density and community composition changed during operation in comparison to the upstream area, is any unexpected effect on benthic or drifting macroinvertebrates is observed because of the project.

Benthic monitoring will be conducted annually in autumn, drifting macroinvertebrate monitoring will be conducted in summer- autumn each year for the first 2 years following commissioning, and may continue at a reduced frequency until thirty years post-impoundment, depending on results. Sampling will be carried out during the high water period. Two methods will be used:

1) kick sampling - which is considered to be effective in the rocky bottoms. The sediments and stones are disturbed immediately upstream of the net by stirring it up. The sample is collected using a net (pore size 0.5mm) downstream the agitated site;
2) sweep sampling – for sampling along banks and amongst vegetation. For sampling a net is bounced backward over the bottom to stir up the sediments, then scooped forward to sample. In both cases, excessive sediments will be removed, the sample placed into a bucket half filled with water.

10 FISH COMMUNITY

Monitoring activities include: desk research; anamnesis (interview method); field survey - field survey includes habitat visual identification method. Monitoring during operation will include fish community composition and abundance, size/age distribution of fish species, condition of sampled fish species. Specific effects monitoring programs will be conducted to examine fish pass efficiency.

Fish monitoring process will be carried out in compliance with the order N07 approved by the Minister of Energy and Natural Resources on 6 April, 2011, setting the " list of wildlife species, rules, terms and weapons/equipment allowed for their catching"; the order of the Minister of Environment of Georgia (21, 17.10.2011) on approval of the rules regulating fishing for scientific purposes" and the order of the Minister of Environment (126, 05.09.1996) on prohibition of electro-fishing in Georgia.

Monitoring will be carried out seasonally. The duration of each stage will be 7 days. The dates will be set with consideration of hydrometeorological conditions. This will enable to cover all hydrological stages typical for the river, as well as the cycles of spawning, fattening and wintering of ichthyofauna. The following periods are determined for monitoring of ichthyofauna:

1. January-February (low waters in winter);
2. April-May (spring floods);
3. July-August (low waters in summer);
4. October-November (autumn floods).

Monitoring will occur upstream and downstream the weir site and upstream and downstream the confluence with the Mtkvari and in case deemed advisable, based on initial observation, in 200m long section upstream the Khanistskali –Paravani confluence (optional observation point). (see Figure 1). Sampling will be done annually during the first 2 years of operation. Monitoring may continue at a reduced frequency depending on results.

FISH COLLECTION METHODS

Since electrofishing is forbidden in Georgia angling and active gear and/or combination of angling and cast net will be used.

Fish catching will be performed using a cast net (weighing 7 Kg. Net spacing 20 mm.), with a so-called parachute (dual walled, excluding the size of the net spacing, 60 mm. with the internal walls' having

spacing of 20 mm) and different forms of hand angled and spinning fishing rods (and/or using natural, man-made appellants). Several sections for fish capture will be selected. The section lengths varying from 100 to 500 meters.

In each cast number, size of species will be recorded. Concentration of the target fish within a specified area will be calculated, and the number of fish existing within an entire target habitat - estimated by extrapolating this number throughout the total habitat.

The target habitat will be divided by distinct topography types and the capture efficiency for each type of habitat calculated in order to minimize the variability of capture efficiency. The capture efficiency of one cast of the net prior to sampling will be measured. This capture efficiency - maintained throughout the sampling.

FISH SAMPLING PROCEDURES

Once fish have been captured they are measured for length, their stage of maturity assessed and scales or some other structure is removed for aging.

Length - is the most important measurement when collecting information on the size of fish in a population. Grouping fish by length categories is also used to determine age classes and growth rates. Whole body measurements will be done. Length measurements will be reported in millimeters (mm). The units and type of length measurement will be recorded on the data sheets and be consistent for all the data collected during a sampling program to avoid confusion when the data is analyzed[1].

Weight - measurements will be made in grams (g). Before measurement excess water will be drained or blotted from the animal with paper towel. As with the length measurements, units and methods will be recorded in the field notes and remain consistent in the techniques used. Electronic balances will be used for weight assessment.

Fish Age

Relationship between the size and age of fish provides insights to monitor the health of a population that may be affected by developments that affect fish habitat. Direct measure of age is made by analyzing hard body structures collected in the field. As fish grow, they deposit minerals in their skeletal tissues, producing characteristic growth patterns. Different periods of growth can be determined by counting the light and dark bands typical of annuli or by observing the differences in spacing of the circuli. By assessing these patterns the age of the fish can be determined.

Scales, fin rays are some of the typical structures collected for age information (e.g. scales cannot be used to age fish that are very long lived, because the circuli near the center of the scale become very compressed and difficult to read accurately). Ageing method that requires sacrificing the animal is not desirable in particular when studying sensitive populations.

Scales	Advantage	Disadvantage
	Relatively quick and easy method for determining the age of a fish. Removal of scales requires only simple dissecting tools, and has minimal impact on live fish when properly done.	Many fish have the ability to re-absorb scales or produce new scales to replace lost ones resulting in growth patterns that do not accurately reflect the age of the fish. Scales from older fish are very difficult to read and interpret.

[1] The most common whole body measurements are fork length, total length, and standard length: **Fork length** is measured from the most anterior part of the head to the median caudal fin rays. This method is only appropriate for fork tailed fish such as trout; **Total length** is the distance from the most anterior part of the head to the tip of the longest caudal fin ray when the fin lobes of the tail are pressed together; **Standard length** is the distance from the most anterior part of the upper jaw to the posterior end of the hypural bone. In applying this measurement, some other external landmark is often used instead of the hypural bone. This is normally the end of the caudal peduncle or the last scale of the lateral line. As well, measurements will often be made from the most anterior tip of the head as opposed to the upper jaw.

	Depending on the species, scale samples are taken from different locations on the body. Before sampling dirt and excess mucilage must be clear away from the area to be sampled. Scales are removed by gently scraping against the grain of the scales with the blade of a clean scalpel or knife. Large scales may also be removed with small forceps. To provide accuracy several scales (~5) must be collected from the fish. Removed scales are deposited onto a glass microscope slide, into a scale book, or envelope and clearly labelled. No special solutions is required to preserve the scales - air drying is sufficient, however in case long preservation is required, to avoid turning cloudy or obscuring circuli the scales can be frozen.
Fin Rays	Different fin rays or spines may be taken depending on the species. Generally fin rays are taken from the left pelvic fin. Fin rays sampling is easily performed with basic dissecting tools and does not involve sacrificing the fish. Fin rays can be removed using scissors. The fin ray must be cut perpendicular to the length of the ray or spine. Cut is to be done close to the body to ensure that all annuli will be present in the removed fin ray. For some species, several spines/rays may be taken or only small sections of rays may be taken, to allow the cut to heal over and reduce any disability the clipping may cause. Fin rays and spines are cleaned in distilled water and allowed to air dry. They are stored in small, clearly labeled envelopes. They may be frozen for long term storage.

Determination of Sex

Recording the maturity of specimens is important information as the onset of sexual maturity has an effect on weight-length relationships and condition factors. Accurate determination of maturity is best accomplished through direct observation of the gonads. However, classification can also be done based on external observations. The following provides basic descriptions for 6 stages of sexual maturity (brackets include abbreviations for coding).

Immature (IM):	Young individuals that have not yet reproduced; fish with underdeveloped gonads.
Maturing (MT):	Ovaries and testes begin to fill out and take up a large part of the body cavity; eggs distinguishable to the naked eye.
Mature (M):	Fish in full spawning colours; gonads at maximum size; body cavity feels full, especially females; roe or milt is not produced if the body cavity is lightly squeezed.
Spawning (SP):	Fish in full spawning colours; eggs and milt are expelled when body cavity is lightly squeezed (also referred to as gravid).
Spent (ST):	Still have spawning colours; eggs and sperm totally discharged; body cavity feels empty and genital opening is inflamed; gonads empty except for a few remaining eggs or residual sperm.
Resting (R):	Adult sized fish; spawning colours not as apparent; gonads are very small and eggs may not be visible to the naked eye.

Interviews

In addition to control catches, local fishermen will be interviewed to obtain additional information on the fish species met in the area of interest. For the interviews maps with indication of the layout of the main project facilities will be provided, so that the interviewees could mark preferred areas for certain species (including upper and lower territorial limits) and sensitive areas. The questionnaire used on the baseline study stage will be used (see Annex 1). To avoid he fishermen were interviewed individually to avoid “embellishment” and “bragging”. Information was assumed as reliable when confirmed by more than 3 interviewees.

11 FISH PASSAGE EFFICIENCY

To identify timing, species, condition and size of fish exhibiting intent to move upstream of the weir, efficiency of the passage will be checked. Traps at the upper and lower end of the fish ladder were used to assess passage efficiency. They were emptied daily. The control will be done during autumn and spring

summer fish monitoring sessions. Catches will be registered and recalculated for specific species migration period. Information will provide data on quantity of fish passing the passage throughout a year.

12 OUTPUT OF THE FIELD STUDIES:

The main impact the project will have on aquatic life is related to reduced water flow in the section downstream the weir, changes in water temperature and dissolved oxygen content, altered sediment flow, changes in riparian vegetation structure, altered hydrological regime - which may have indirect impact on aquatic life and macroinvertebrate fauna.

Objective of the monitoring is to assess efficiency of mitigation measures implemented as a part of the project, keep situation in the downstream area under control, timely register impact on aquatic life and suggest additional mitigation measures if/when advisable.

Data from the section upstream the weir will be used as a reference for the survey. In addition to that baseline information collected on previous stages of the survey will be used. Reports developed based on the analysis of implemented study (with photolog) will describe the status of aquatic environment; efficiency of fish and riparian vegetation preservation measures; describe any changes in river water quality, riparian vegetation status, macroinvertebrate and fish fauna composition/health; provide information on any problems revealed and measures required to resolve the issues.

Results of seasonal monitoring will be summarized n annual report. (The Table of Contents is given in Annex 2). Annual report will be disclosed to the public via the project website.

13 HEALTH AND FIELD SAFETY - FIRST PRIORITY

A risk assessment will be carried out before doing survey. Field safety equipment will be available, field personnel will be adequately trained and follow health and safety procedures.

The following rules and procedures will be ensured:

1. Do not sample if conditions are unsafe.
2. Never sample alone (A field crew will consist of at least two people.)
3. Always inform someone of the sampling route and sampling location along with the expected return time.
4. Establish a call-in procedure with colleagues.
5. Make sure you have an "in case of emergency" phone number with you before leaving for the field.
6. Equip the team with adequate personal protective equipment (PPE) i.e. appropriate footwear and waterproof jacket
7. Wear life jacket when working in river.
8. Consider using helmet while working on slippery surfaces.
9. Do not walk on unstable banks.
10. When in the channel, use a ranging pole or wading stick to check depth and substrate.
11. Carry a basic first aid kits and hand wipes
12. Take care to avoid contact with the water, soil or vegetation before eating or drinking during survey work

Annex 1. Questionnaire format for fishermen interviews

1	Date of survey		
2	Location	District:	Place:
3	Name of fisherman		
4	Location of the fishing site/sites (The interviewer should present a map to the fisher and subsequently clearly mark the locations on the map)		
5	The main rivers or tributaries?		
6	Does he fishes daily or seasonal?		
7	How many fishermen catch fish in this section?		
8	What fishing techniques are used? (e.g. rod and line)		
9	Is the fishing recreational and/or commercial?		
10	Which species are targeted by the fishers? (The interviewer does not enumerate the fish species. The fisherman should name the fish species himself. The interviewer should convert common name to full species name)		
11	Which other fish species are present? (The interviewer does not enumerate the fish species. The fisherman should name the fish species himself. The interviewer should convert common name to full species name)		
12	Is the fisherman aware of any protected or rare fish species in the river of interest? (The interviewer does not enumerate the fish species. The interviewer can supply photographs of rare or protected species potentially present. The fisherman should name the fish species himself. The interviewer should convert common name to full species name.)		
13	Are there any migratory species in the river and if so, when does he observed migration of the species upstream/downstream? (The interviewer does not enumerate the fish species. The fisherman should name the fish species himself. The interviewer should convert common name to full species name)		

14	Is he aware of any sensitive sites (e.g. spawning and nursery grounds) in the area and if so where are they located? (The interviewer should present a map to the fisherman and subsequently clearly mark the locations on the map)	

Annex 2 – Format of the monitoring report

1. Introduction
2. Study area
3. Baseline overview
4. Monitoring program components
5. Methods
6. Sampling locations
7. Physical environment monitoring
8. Macro invertebrate monitoring
9. Fish monitoring
10. Results and discussion
11. Recommendations

Annexes:
Maps,
Photographs,
Survey team