CONTOURGLOBAL

VOROTAN CASCADE OF HYDROPOWER PLANTS

404MW Vorotan hydro cascade in Armenia

Dam and civil structures survey and monitoring plan

December 2015

Summary of revisions

No	Date	Description	Prepared by	Checked by	Approved/ Issued by
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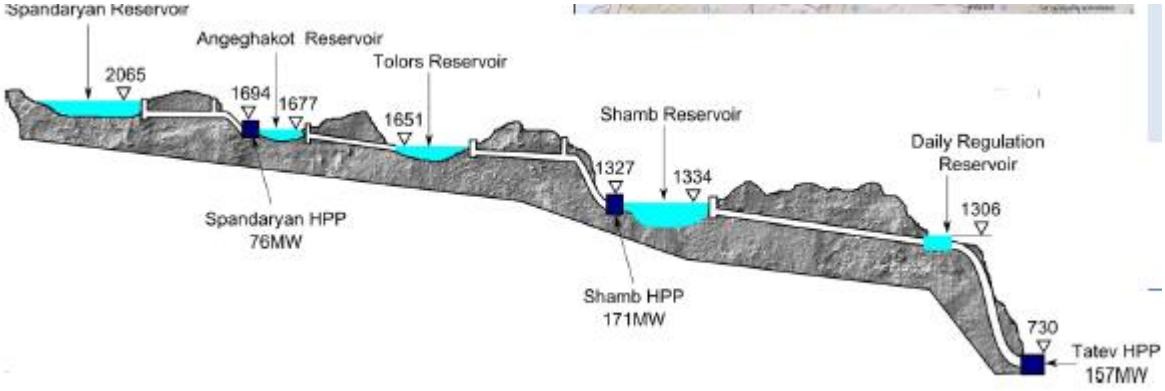
1 Site Overview

The Vorotan hydro cascade consists of three hydro power plants on the Vorotan River in the south east of Armenia with a total installed capacity of 404MW. The Vorotan Cascade produces approximately 20% of the electricity generation of the country from three hydro plants and five hydro structures built during the Soviet period:

- Spandaryan HPP - the 76MW Spandaryan hydro power plant consisting of two units built in 1989,
- Shamb HPP - the 171MW Shamb hydro power plant consisting of two units built in 1979, and
- Tatev HPP - the 157MW Tatev hydro power plant consisting of three units built in 1970;
- Spandaryan Reservoir – the main water storage for the hydro cascade;
- Angheghakot Reservoir;
- Tolors Reservoir;
- Tatev (Shamb) Reservoir;
- Tatev Daily Regulation Reservoir.

Figure 1: Vorotan Cascade



The plants are located over a stretch of 178 km and cover a total head of 1,223 meters. The plants have historically operated in a reliable way, averaging 1,133 GWh of generation annually over the past decade. The two upper plants are generally used for peak production, whereas Tatev is used for baseload energy and grid stabilization.

It is important to highlight that the Vorotan Cascade is of strategic importance to the Armenian grid as it is a key player in the provision of frequency and voltage regulation in the Southern Armenian region, providing the necessary structure for a best practice risk allocation.

Figure 2: Location of Vorotan Cascade

Due to the age of the equipment, the low monitoring level required by Armenian regulations and the total time of operation, dams and civil structures survey is required, as identified in the technical due diligence performed by ContourGlobal, Sargent&Lundy Consulting / Mead & Hunt and Norplan.

1.1 Purpose of this document

This document aims to prioritize the recommendations on dam safety made by Norplan and Sargent & Lundy / Mead & Hunt and prioritize areas of further study and investment to improve dam safety. A dedicated site visit by ContourGlobal engineers and discussions with the Goris based team was made in the beginning of December 2015, in order to ensure that all aspects are considered.

2 Documentary Framework

- Technical, environmental and hydrological due diligence, by Norplan, March 2013
- Technical Due Diligence Review Report, by Sargent & Lundy / Mead & Hunt, November 2013
- Armenian Power Sector: Dam Safety Conditions and Concerns, USAID, by Hagler Bailly, June 2000 (later on called "2000 Report")
- Geotechnical dam records (existing old records since 2001), Vorotan hydro cascade
- Monitoring dam records (monthly records), Vorotan hydro cascade
- Site visit reports, ContourGlobal, December 2015
- Dams and civil structures drawings

3 Project Management Approach

3.1 Definition of project scope and goals

- Project scope definition - Dam and civil structures survey and monitoring of the Vorotan hydro cascade facilities;
- Project goals – to evaluate current status and condition of the Vorotan hydro cascade dams and civil structures and to define and implement respective countermeasures for improvement.

3.2 Roles and responsibilities description

<u>Project Steering Committee (PSC)</u>

- Consists of senior managers of ContourGlobal;
- Led by Executive Sponsor, responsible for the entire project;
- Provides overall executive guidance, oversight and leadership;
- Makes key/strategic decisions;
- Monitors budget;
- Holds regular meetings/calls as needed.

<u>Internationally Recognized Expert (IRE)</u>

- Well known and experienced internationally recognized expert in dam and civil structures;
- Consists of senior experts;
- Provides overall dam and structure expertise;
- Coordinates survey and monitoring scope and studies;
- Creates and coordinates monitoring and survey plans and studies;
- Identifies and raises critical issues by task priority;
- Communicates and coordinates with the ContourGlobal teams;

- Participatec in regular meetings /calls as needed.

Local Support and Execution Team (LSET)

- Consists of ContourGlobal and Vorotan local subject matter experts on the subject of dam and civil structure facilities: Plant management, Procurement, IT, Operations and Maintenance, Health & Safety & Environment;
- Manages the local work streams, activities and tasks;
- Prepares work plans;
- Executes survey and monitoring activities on sites through appropriate Contractors;
- Regularly reports progress and raises issues to the responsible Project manager.

Offshore Support Team (OST)

- Consists of ContourGlobal experts on the subject of dam and civil structure facilities: Project Management, Procurement, IT, Civil engineers;
- Supports of the local execution team;
- Participates in regular meetings /calls as needed;
- Raises issues to the responsible Project manager.

3.3 Project Time Management

Overall Master Project Gantt chart with important milestones definitions and constraint dates will be developed jointly with the IRE as a tool for project progress and time management. It will be based on the prioritized recommendations made by Norplan and Sargent & Lundy / Mead & Hunt developed in this plan and attached as Appendix 1.

3.4 Project Procurement Management

The costs incurred for survey, study and improvements are expected to be capitalized and included in the tariff. Thus, the Public Procurement Law needs to be followed in parallel with the ContourGlobal Procurement guidelines.

A single Internationally Recognized Expert (IRE) will be selected for the performance of overall survey and program for the dams and civil structures improvement. A firm fixed price contract will be concluded with an extensive milestone schedule and possibility to entrust portions of the scope only after the successful completion of certain milestones. Relevant survey reports with conclusions and action plan will be prepared and presented. During the execution period, an IRE supervision should apply.

The tender process should ensure the selection of a contractor with the right technical capability (experienced internationally recognized expert with respective references from previous similar projects), financial capacity, management approach (project management certification) and warranties.

The Internationally Recognized Expert should be adequately qualified to participate in the dams and civil structures survey and improvement and shall be selected among the leading companies in the sector.

All civil works needed for the testing, implementation of additional measurement facilities, as well as the periodical monitoring as recommended by the IRE (geodetical, piezometer levels etc.) will be conducted by ContourGlobal using appropriate and qualified contractors, and under IRE supervision where deemed necessary.

4 Dam and civil structures survey and monitoring plan

4.1 Introduction

The information for assessment of the condition of the dams and civil structures on the Vorotan Cascade has come from a site visit carried out in December 2015 as well as form the previous survey

reports and the available technical documentation. In the next step, jointly with the IRE it will be necessary to get more information in form of detailed drawings, As-built drawings and specification of the dam fill material and the foundation conditions. Further studies, especially regarding the stability of the dams should apply. All dams are classed as High Hazard Dams, which means a failure would result in substantial downstream property damage and possible loss of life.

4.2 Spandaryan Reservoir

4.2.1 Overview

The dam is a zoned rockfill structure with a maximum section of about 83 meters high and is designed to include instrumentation including piezometers, seismic monitors, inclinometers and a settlement monitoring points. For a high hazard dam of this size, the availability of such monitoring instrumentation is to be expected. Because of the severe weather conditions (heavy snow), it was not possible to inspect the dam during the visit in December 2015. During the meetings with the local Vorotan cascade team it was observed that the equipment had fallen into disrepair and that no monitoring was being carried out.

4.2.2 Present State

The 2000 report raises concerns regarding the seismic criteria that the dam was designed to withstand. It states that it should have been designed according to a Force 9 criteria and not a force 8 criteria. However in the documentation provided to NORPLAN states that it was originally designed for a force 9 criteria. There is therefore some confusion on this matter and this should be investigated further.

4.2.3 Planned Actions

Spandaryan dam appears to be in relatively good condition and there are no obvious issues which raise concern. However there is a need for further investigation and works as follows:

- - The instrumentation for monitoring needs to be rehabilitated or replaced, and a regime for recording data needs to be implemented. This data needs to be reviewed and analysis in conjunction with visual inspections of the dam in order that any dam safety issues with the dam can be spotted early. Until the instrumentation described above is installed, a twice yearly level survey of the dam and weekly monitoring of seepage with the corresponding reservoir water level should be implemented immediately.
- - A better understanding of the dam materials and foundation conditions needs to be obtained in order that a stability analysis, which includes seismic loads, can be carried out for the dam.

4.3 Angeghakot Reservoir

4.3.1 Overview

Angeghakot dam is a concrete gravity dam about 30m high on the Vorotan cascade and is in-between Spandaryan and Tolors Dam. The volume of the reservoir is 3.4 million m^3/ 0.5 million m^3. The dam has an overtopable section and a non-overtopable section. The overtopable acts as a free overflow spillway and the sill defines the full supply level of the reservoir. The spillway flows in to what appears to be a USBR type III stilling basin. There is also a lower level outlet which also flows into the stilling basin. There is a road along the crest of the dam with a bridge over the spillway.

There is only very little information on the dam which consists of a few sections and a plan. There is no specification of the dam or foundation material. Regarding the condition of the concrete dam it was noticed that some of the baffle blocks in the stilling basin where missing. These should be replaced and the other blocks rehabilitated as these baffle block reduce the length of the hydraulic jump and are therefore required for effective energy dissipation.

There is a gallery through the dam and there appears to have been grouting below the dam in the rock foundation. It was not possible to see the dam condition due to missing lighting system inside the gallery.

The water of Angheghakot Reservoir is diverted from, to the Tolors reservoir by 10.5 km long free-flow tunnel with 3.0m x 3.0m section and with 18 m^3/sec throughput capacity.

4.3.2 Present State

A concrete gravity dam is more tolerable to overtopping than an embankment dam from a flood. Stability of the dam in flood and normal operation needs also to be assessed. The 2000 report states that there has been concern that the dam does not meet the stability criteria under an earthquake load.

The dam visually is stable and the condition of the structure seems acceptable. There is not piezometers measurement system on the dam, but geodetic net (bench marks) exists on the site. Monitoring of geodetic system has not been done since 2001 because the last measurements shows that there are not deformations and displacements of the dam, as well as there are not mandatory rules in the regulations for periodic measuring if there are not deformations.

4.3.3 Planned Actions

The dam appears to be stable and there is no immediate concern. However the following recommendations are listed below:

- A twice yearly level survey of the dam should be started immediately and monthly monitoring of seepage with the corresponding reservoir water level should also be started. This should include monitoring seepage into the drainage gallery. The data needs to be reviewed and analysis in conjunction with visual inspections of the dam in order that any dam safety issues with can be spotted early.
- A better understanding of the dam materials and foundation conditions needs to be obtained in order that a stability analysis, which includes seismic loads, can be carried out for the dam for both the normal and flood level. As for the other dams, we have included the costs for a study to determine if it meets the stability and seismic criteria.
- The baffle blocks in the stilling basin need to be repaired and reinstated where they are missing.
- Study of condition of geodetic measurements points and prescription of improvements or preparing of design and methods for periodic measurements, tracking the stability of the Dam.
- Restarting of periodic geodetic measurements.

4.4 Tolors Reservoir

4.4.1 Overview

The dam is earth/rockfill embankment dam about 70m high and the reservoir receives water flow via a tunnel from the Angeghakot dam and impounds waters of the Sisian River and another tributary. The core in the dam slopes upstream at almost the same slope as the dam itself, and almost forms a clay blanket on the upstream face. The upstream protection is made not from rip rap but from concrete slabs, which appear to cover the entire downstream slope of the dam. Also during the construction of the dam there was a landslide in the reservoir area and to dispose of the fill the berm on the upstream side was considerably increased.

The Tolors reservoir has total capacity of 96 million m^3 and actual capacity 80 million m^3.

The water from Tolors Reservoir reaches Shamb HPP by 6.9 km long and 75 m^3/sec throughput capacity tunnel.

4.4.2 Present State

The actual condition of Tolors dam seems stable, but there are some concerns whether the dam meets revised stability criteria. The 2000 report quotes an excerpt from a report by the Hydro design Institute completed in 1998. The report concluded that the slopes of the dam do not meet earthquake criteria and that this could be achieved by flattening the slopes both on the upstream and downstream side, by the addition of 345,000 cubic meters of fill. The effect of this additional fill on the side slopes has been considered but its effect on the stability of the dam cannot be conclusively established.

There is a piezometers system and geodetic net with bench marks and measure points on the site. The level of filtration waters is measured by using of piezometers system and respective records are carried out. The piezometers are in good condition except two-three of them, which are blocked with stones and need to be repaired.

There is a good geodetic bench marks system, but records from measurements are not available. Monitoring of geodetic system has not been performed since 2001 because the last measurements taken show that there are not deformations and displacements of the dam and there are not mandatory rules in the regulations for periodic measure if there are not deformations. According the Armenian legislation and ordinance, geodetic system measuring has to be performed in the first two years after construction of the dam. After that measurement has to be done in the fifth year and if there are no deformations found, further measurements should be done at owner's discretion.

4.4.3 Planned Actions

The dam appears to be in relatively good condition and no significant issues appear to have occurred at the dam. The recommendations witch need to be considered are:

- The instrumentation for monitoring may need improvements, and a regime for recording data needs to be implemented. This data needs to be reviewed and analyzed in conjunction with visual inspections of the dam in order to ensure that any dam safety issues can be identified early.
- The side slopes of the dam appear to be quite shallow; however this may be due to the quality of material used to construct the dam. A better understanding of the dam materials and foundation conditions needs to be achieved in order to perform a stability analysis of the dam including seismic loads. This will help confirm the additional 345,000 cubic meters of material calculated by previous studies.
- Construction activities for implementation of new piezometers to be considered.
- Expert investigation of the design and actual condition of Tolors Dam concerning seismic stability. Preparing of report with conclusion for the Dam condition and solution for improvement.
- Construction of inclinometers for monitoring of the displacements.
- Study of condition of geodetic measurements points and prescription of improvements or preparing of design and methods for periodic measurements, tracking the stability of the Dam.
- Starting the periodic geodetic measurements.

4.5 Tatev (Shamb) Reservoir

4.5.1 Overview

The Tatev (Shamb) Reservoir is a rockfill embankment dam. The reservoir has total capacity of 13.6 million m³ and actual capacity 1.80 million m³. The water from Tatev (Shamb) Reservoir reaches Daily Regulation Tank by 18.4 km long throughput capacity tunnels.

4.5.2 Present State

As with Spandaryan and Tolors no monitoring is being carried out and most of the instrumentation has fallen into disrepair. Settlement has been monitored annually from 1972 to 1998 and the monuments have not moved more than the allowable criteria. However this appears to have stopped

in recent years and it is important that the recording is restarted. There is some vegetation, which needs to be removed and the stone protection re-graded.

The actual condition of Shamb Dam seems stable. There is no information for the seismic stability.

There are piezometers system and geodetic net with bench marks and measure points on the site. The underground level of filtration waters is measured by piezometers system and the data is recorded in a Record book. As per the Operation staff, the piezometers system is in a good condition.

4.5.3 Planned Actions

The dam appears to be in the least good condition of the dams but without immediate signs of concern. Recommendations are listed as follows:

- The instrumentation for monitoring needs to be rehabilitated or replaced, and a regime for recording data needs to be implemented. This data needs to be reviewed and analyzed as well as visual inspections of the dam to be performed in order to ensure that any dam safety issues can be spotted early. Until the instrumentation described above is installed, a twice yearly level survey of the dam should be carried out effective immediately.
- A better understanding of the dam materials and foundation conditionsneeds to be obtained in order that a stability analysis, which includes seismic loads, can be carried out for the dam.
- Vegetation downstream of the dam should be removed. Covering the external slope with geotextile or geomesh could prevent future vegetation grow.
- Detailed study of the condition of piezometers and prescription for replacement of the inactive once. Installation of new (additional) piezometers.
- Study and investigation of the design and actual condition of Shamb Dam concerning seismic stability. Preparing of report with conclusion for the Dam condition and solution for improvement.
- Construction of inclinometers for monitoring the displacements.
- Study of condition of geodetic measurements points and prescription of improvements or preparing of design and methods for periodic measurements, tracking the stability of the Dam.
- Starting the periodic geodetic measurements.
- Study of structure condition of concrete spillway and prescription for improvement of it.

4.6 Tatev Daily Regulation Pond

4.6.1 Overview

The daily regulation pond at Tatev (DRP) presents many leaks and had at first been seen as a potential problem but it seems that there is no structural problem and that the leakages can be contributed to minor defects or lack of periodic maintenance activities. The DRP is a concrete tank and has a total capacity of 85 000 m³.

4.6.2 Present State

The DRP appears to be in good condition but there are many defects on the external plaster – torkret that should provide protection of the main concrete structure. There are many structure damages and defects on the concrete staircases and towers for the gates and walkways.

Some leaks from the temperature joint are visible and need to be repaired. Detail study of the leaks source should be carried out.

There are geodetic bench marks, but records from measurement and monitoring are not available.

4.6.3 Planned Actions

Recommendation for further actions for improvement of the DRP structure are:

- Expert investigation of the actual condition of Tatev Daily Regulation Pond concerning residual strength of the construction and seismic stability and comparing with the design of the facility. Preparing of report with conclusion for the Dam condition and solution for improvement.
- Study of condition of geodetic measurements points and prescription of improvements or preparing of design and methods for periodic measurements, tracking the stability of the Tank.
- Starting the periodic geodetic measurements.
- Rehabilitation and maintenance of the external plaster – torkret as well as to the building structures, stairs and walkways. This will include dewatering of the pond and must be planned well in advance.
- Detail study of the leaks source to be arranged and leaks to be fixed.

4.7 Powerhouse civil structures

4.7.1 Overview

4.7.1.1 Spandaryan HPP

Spandaryan HPP is the first stage of the Vorotan Cascade and is currently used for peak-load generation. The Spandaryan HPP has been in service since 1989, and consists of two vertical Francis turbines with a combined rated capacity of 76 MW and design head of approximately 300 m. The HPP is fed through 8.1 km of pressure tunnels from the Spandaryan Water Reservoir. The Spandaryan Water Reservoir has an embankment dam and is designed for a total capacity of approximately 257 million m3 and an active capacity of 218 million m3. The Spandaryan Reservoir has three inlets. The first inlet is submerged in the reservoir and directs flow to the Spandaryan HPP and the spillway tunnel. The second inlet conveys flow to the surface spillways. The third inlet is on the north side of the Spandaryan Reservoir and feeds water into Lake Sevan. The third inlet and tunnel is the newest inlet of the three and was completed this decade. The third inlet tunnel has a reported capacity of 15m3/s, but has never been in use. Water that flows through the Spandaryan HPP discharges into the Angeghakot Water Reservoir. The Angeghakot Water Reservoir is connected to the Tolors Reservoir through approximately 10.5 km of tunnel.

4.7.1.2 Shamb HPP

Shamb HPP is the second stage of the Vorotan Cascade and is currently used for peak-load generation. The Shamb HPP has been in service since 1978, and consists of two Francis turbines with a combined rated capacity of 171 MW and a design head of approximately 267 m. The concrete Angeghakot Dam diverts water to the Tolors Reservoir, which then feeds the Shamb HPP through 6.9 km of pressure tunnels. The Tolors Reservoir has an embankment dam. The combined storage capacity of both reservoirs is approximately 96 million m3 and active capacity is 80 million m3. Water that flows through the Shamb HPP discharges into the Tatev Water Reservoir.

4.7.1.3 Tatev HPP

Tatev HPP is the third and final stage of the Vorotan Cascade and is currently used consistently for active grid regulation. The Tatev HPP has been in service since 1970, and consists of three Pelton-type turbines for a combined rated capacity of 157.2 MW and a design head of approximately 552 m. Tatev HPP is fed from the Tatev Water Reservoir through 19.9 km of pressure tunnels to the Daily Regulating Pond (DRP), which acts as a regulating forebay for the HPP. Discharge from the DRP is then delivered through a steel surface penstock into a short section of tunnel which enters the Tatev HPP. Water that flows through the Tatev HPP discharges into the Vorotan River.

Tatev HPP is the pilot hydro power station in the complex and highest-head HPP in the territory. The structure of the facility is in best condition comparable with the other two plants.

4.7.2 Present State

4.7.2.1 Spandaryan HPP

The design of the civil works seems generally to be robust and to follow good engineering practice. Normal maintenance works will be sufficient to keep the civil structures in an acceptable condition.

HPP building is in a good condition but there are many improvements that should be foreseen related to HVAC system, fire protection measures.. The existing wooden doors and floors in all electrical rooms need to be changed with fire resistant doors and covers.

220 kV Outdoor switchyard needs to be rehabilitated and modernized in both Civil and Electrical part. The cable tunnels in the outdoor switchyard need to be repaired and new covers are required.

A fire protection concrete wall at the power transformers is in a poor condition and needs to be reinforced and repaired in short term.

Oil collecting pits walls are partially destroyed and in bad condition and need to be reinforced.

Some leakages thought the walls in the underground floors of the building are visible and need to be fixed.

4.7.2.2 Shamb HPP

There are many leakages inside Shamb power station, including leakages from the walls at the lower floors of the station, leakages close to the penstock inlet, etc. plastic cover panels on the walls are to a certain degree concealing these leakages. It seems that the leakages are not critical but should be followed up as part of the normal maintenance works in the station and to protect the equipment inside from corrosion. As part of the upgrading works in the station the plastic covers should be removed to give a clear overview of the situation.

The turbines at Shamb power station present a number of serious problems, including heavy vibrations which reflects also on the building structures.

220 kV Outdoor switchyard need to be rehabilitated and modernized in both disciplines - Civil and Electrical part. The cable tunnels in the outdoor switchyard need to be repaired and new covers are required. Steel supporting structures and their anchors need to be observed and repaired.

A fire protection concrete wall at the power transformers is in a poor condition and needs to be reinforced and repaired in short term.

The existing wooden doors and floors in all electrical rooms need to be changed with fire resistant doors and covers.

4.7.2.3 Tatev HPP

The design of the civil works seems generally to be robust and to follow good engineering practice. Normal maintenance works will be sufficient to keep the civil structures in an acceptable condition. Tatev HPP building is in the best condition compared to the other two Vorotan cascade plants.

HPP building is in a very good condition but there are some improvements that should be foreseen related to HVAC system, fire protection measures and interior. The existing wooden doors and floors in all electrical rooms need to be changed with fire resistant doors and covers.

4.7.3 Planned Actions

4.7.3.1 Spandaryan HPP

Recommendation for planned actions for improvement of the structure are:

- Detailed study and analysis of concrete and steel structures in the 220 kV outdoor switchyard with follow up civil works for improvement as part of the Electro-Mechanical Refurbishment.
- Exchange of the existing wooden doors and floors in the electrical rooms with fire resistant. All floors in electrical rooms should be improved in accordance with international standards requirements as part of the Electro-Mechanical Refurbishment.

4.7.3.2 Shamb HPP

Recommendation for planned actions for improvement of the structure are:

- Detailed study and analysis of concrete and steel structures in the 220 kV outdoor switchyard with follow up civil works for improvement as part of the Electro-Mechanical Refurbishment.
- Exchange of the existing wooden doors and floors in the electrical rooms with fire resistant. All floors in electrical rooms should be improved in accordance with international standards requirements as part of the Electro-Mechanical Refurbishment.
- Leakages inside the power plant building need to be observed and repaired as part of the Electro-Mechanical Refurbishment and planned maintenance activities.

4.7.3.3 Tatev HPP

Recommendation for planned actions for improvement of the structure are:

- Exchange of the existing wooden doors and floors in the electrical rooms with fire resistant. All floors in electrical rooms should be improved in accordance with international standards requirements as part of the Electro-Mechanical Refurbishment.

5 Appendix 1 – PRIORITIES LIST

Priority	Task Description	Detailed Description	Planned Start	Comment/Notes	Responsible
1	Restart periodic measurements and monitoring on all five hydro structures	• Small repairs and implementation of semi-annual geodetical bench marks measurements, as well as weekly seepage monitoring and registration, based on the currently available monitoring equipment. The data needs to be reviewed and analyzed and visual inspections of the dam to be carried out in order to ensure that any dam safety issues can be spotted early.	Q1/2016	Depending on weather conditions	ContourGlobal
1	Tatev Daily Regulation pond	• Site investigations, study and preparation of rehabilitation plan including the minimization of the time in which waterways to Tatev would be interrupted and undertake civil and hydro-mechanical rehabilitation of the daily regulation pond	Q2/2016		Internationally recognized expert
1	Tolors Dam	• Inspection of geodetic control network and review the results of periodic measurements. Preparing of design and instruction for monitoring. • Inspection of the condition of piezometers and inclinometers. • Ascertaining the current seismic stability of the dam dike. • Dam Break Analysis for the dam of Tolors. • Preparation of expert report with defined measures for improvement of condition geodetic control network, piezometers, inclinometers and measures for improvement the stability of the dam regarding earthquake	Q2/2016		Internationally recognized expert
1	Tatev Dam	• Inspection of geodetic control network and review of results from periodic measurements. • Inspection of the condition of piezometers and inclinometers. • Ascertaining the current seismic stability of the dam dike. • Dam Break Analysis for the dam of Tatev. • Calculation of the required spillway capacity at the Tatev Dam to evaluate the need for additional measures, including the potential need for additional spillway capacity, and if needed implement such remedial measures • Preparation of expert report with defined measures for improvement of condition geodetic control network, piezometers, inclinometers and measures for improvement the seismic stability of the dam	Q2/2016		Internationally recognized expert
2	Spandaryan Dam	• Inspection of geodetic control network and review of results from periodic measurements.	Q3/2016		Internationally recognized expert

Priority	Task Description	Detailed Description	Planned Start	Comment/Notes	Responsible
		• Inspection of the condition of piezometers and inclinometers. • Ascertaining the current seismic stability of the dam dike. • Preparation of expert report with defined measures for improvement of condition geodetic control network, piezometers, inclinometers and measures for improvement the seismic stability of the dam • Dam Break Analysis for the dam of SPANDARYAN			
2	Angeghakot Dam	• Inspection of geodetic control network and review of results from periodic measurements. • Ascertaining the current seismic stability of the dam. • A twice yearly level survey of the dam should be started immediately. • Preparation of expert report with defined measures for improvement of condition geodetic control network, piezometers, inclinometers and measures for improvement the stability of the dam regarding earthquake. • Dam Break Analysis for the dam of Angeghakot	Q3/2016		Internationally recognized expert
3	Improvement of monitoring of Tolors Dam	• Rehabilitation of the benchmarks and geodetic marks and construction of new if necessary. • Rehabilitation of the instrumentation (piezometers, inclinometers) for monitoring. Implementation a regime for records.	Q1/2017	After IRE recommendation and if deemed necessary	ContourGlobal
3	Improvement of monitoring of Tatev Dam	• Rehabilitation of the benchmarks and geodetic marks and construction of new if necessary. Starting the cycle measurement of geodetic control network. • Rehabilitation of the instrumentation (piezometers, inclinometers) for monitoring. Implementation a regime for records. The data needs to be reviewed and analyzed in conjunction with visual inspections of the dam in order to ensure that any dam safety issues can be spotted early	Q1/2017	After IRE recommendation and if deemed necessary	ContourGlobal
3	Improvement of monitoring of Angeghakot Dam	• Rehabilitation of the benchmarks and geodetic marks and construction of new ones if necessity. Starting the cycle measurement of geodetic control network. • Rehabilitation of the instrumentation (piezometers, inclinometers) for monitoring. Implementation of a regime for records. The data needs to be reviewed and analyzed in conjunction with visual inspections of the dam in order to ensure that any dam safety issues can be spotted early	Q3/2017	After IRE recommendation and if deemed necessary	ContourGlobal
4	Improvement of Spandaryan Dam monitoring	• Rehabilitation of the benchmarks and geodetic marks and construction of new if necessary. Starting the cycle measurement of geodetic control network. • Rehabilitation of the instrumentation (piezometers, inclinometers) for monitoring. Implementation a regime for	Q2/2017	After IRE recommendation and if deemed necessary	ContourGlobal

Priority	Task Description	Detailed Description	Planned Start	Comment/Notes	Responsible
		records. The data needs to be reviewed and analyzed in conjunction with visual inspections of the dam in order to ensure taht any dam safety issues can be spotted early			
4	Angeghakot Dam – structure repair	• The baffle blocks in the stilling basin need to be repaired and reinstated where they are missing	Q2/2017	After review from IRE	ContourGlobal
5	Study of the buildings of HPP's	• Inspection study of the buildings structure and preparation of reports with defined measures for improvements	Q1/2018		Internationally recognized expert