

Report on

**4<sup>th</sup> Riparian Information-Sharing and Consultation  
Process on the Assessment Studies of a Proposed Rogun Hydropower Project**

September 30 – November 4, 2013



Prepared by  
Europe and Central Asia Region  
World Bank

In partnership with the Independent Engineering and Dam Safety and Environment/Social Panels of  
Experts for the Rogun Assessment Studies

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### Acronyms

EDS	Engineering and Dam Safety
EDS-PoE	Engineering and Dam Safety Panel of Experts
ES-PoE	Environmental and Social Panel of Experts
ESIA	Environmental and Social Impact Assessment
HPP	Hydro Power Plant
ICOLD	International Commission on Large Dams
MCE	Maximum Credible Earthquake
OBE	Operating Base Earthquake
TEAS	Techno-Economic Assessment Study
ToRs	Terms of Reference
PoE	Panel of Experts
PMF	Probable Maximum Flood



**4<sup>th</sup> Riparian Information-Sharing and Consultation  
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September 30 – November 4, 2013

**EXECUTIVE SUMMARY**

*This report provides the context, main findings, and topics covered during the fourth Riparian Information-Sharing and Consultation process for the Assessment Studies of a proposed Hydropower Project. The report also documents comments received from participants and responses provided by the technical experts.*

**Context:** Two studies are being conducted to assess the potential benefits and risks of a proposed Rogun Hydropower Project (HPP): a *Techno-Economic Assessment Study* (TEAS) and an *Environmental and Social Impact Assessment* (ESIA). The studies cover technical, economic, social, and environmental factors, within the context of a least cost (electricity) generation expansion plan to meet energy demand within Tajikistan.

The World Bank is funding the studies and providing support to ensure they are completed in accordance with the World Bank's policies and procedures, meet international standards, and are objective and transparent. As part of its engagement, the World Bank coordinates two independent Panels of Experts (PoEs) that scrutinize the technical quality of the Assessment Studies. In order to share intermediate findings and ensure that the diverse perspectives of the potentially affected stakeholders in the riparian countries are heard and understood, the Bank also supports a riparian consultation and information sharing process. The process also provides an opportunity for riparian stakeholders to interact with the consortium of consultants conducting the studies, and with members of the two independent Panels of Experts (PoEs): the Engineering and Dam Safety Panel of Experts and the Environmental and Social Panel of Experts. The PoEs consist of ten experts with internationally-recognized expertise in their respective fields. They are funded by and report to the World Bank, and thus enhance objectivity and technical oversight for the TEAS and ESIA. The riparian process began with consultations on the Assessment Studies' Terms of Reference (2008/2009) followed by information sharing and consultations sessions in May 2011, November 2012, and February 2013.

**Fourth Information Sharing and Consultation Process:** On September 30, 2013, the World Bank initiated the fourth information-sharing and consultation process which focused on two draft reports of the TEAS: *the Geological and Geotechnical Investigation of the Salt Wedge in the Dam Foundation and Reservoir Summary Report* (Phase 0 of the TEAS Terms of Reference) and *Assessment of the Existing Rogun HPP Works, including caverns and tunnels Summary Report* (Phase I of the TEAS Terms of Reference). These summary reports were disclosed on the websites of the World Bank and the Government of Tajikistan on September 30, 2013. The consultation process included a comment period to November 4, 2013 and a series of meetings on October 17, 18, and 20, 2013 with the governments and civil society of the riparian countries, as well as development and diplomatic communities.

Representatives of Kazakhstan, Kyrgyz Republic, Tajikistan and Afghanistan participated in the sessions for riparian governments; Civil Society Organizations (CSOs) from Kazakhstan, Kyrgyz Republic, Tajikistan, Uzbekistan and Afghanistan participated in the session for civil society; written comments were received from individuals from Afghanistan, Tajikistan, and Uzbekistan. The disclosed reports as well as the presentations made in the sessions are publicly available on the Bank’s website at [www.worldbank.org/eca/rogun](http://www.worldbank.org/eca/rogun).

**Consultant findings:** The first summary report -- *Geological and Geotechnical Investigation of the Salt Wedge in the Dam Foundation and Reservoir* (Phase 0 of the TEAS Terms of Reference) -- examines the potential risks to dam safety of the wedge of salt that exists along the Ionakhsh Fault. The Consultants’ findings indicate that mitigation measures are both necessary and feasible to prevent the dissolution of the salt wedge from affecting dam stability, thereby ensuring consistency with international dam safety standards. The second summary report -- *Assessment of the Existing Rogun HPP Works, including caverns and tunnels* (Phase I of the TEAS Terms of Reference) -- evaluates the conditions of the existing facilities at the Rogun site, including tunnels and powerhouse caverns. The Consultants have concluded that several of the underground structures, including the existing two diversion tunnels and the powerhouse cavern, would require strengthening and remedial measures to be operated safely. Measures for both the salt wedge and existing works require comprehensive monitoring throughout the life of a proposed project. Estimated costs of these measures and monitoring are being included in the economic and financial analysis of a proposed Rogun HPP.

**Riparian Feedback:** A comprehensive set of questions and comments was received from stakeholders both during the consultation sessions and through written submissions. The key areas of interest were:

Phase 0: Salt Wedge	Phase I: Existing Works
<ul style="list-style-type: none"> <li>• The potential impacts of dissolution of the salt wedge at both the local and downstream level</li> <li>• Planned mitigation measures</li> <li>• Adequacy of data and modeling</li> <li>• Monitoring</li> </ul>	<ul style="list-style-type: none"> <li>• Standards, technical requirements and design data</li> <li>• Concrete and construction standards</li> <li>• The suitability of existing electro-mechanical equipment present on site</li> </ul>

Other issues, outside the scope of the disclosed material but pertinent to on-going studies and analysis included:

- The Assessment Study and consultation process (e.g., timing of next study outputs; review period; role of the Panels of Experts)
- Downstream flows
- Dam safety criteria
- Alternative project designs.

Responses were provided by the Consultants, the Engineering and Dam Safety Panel of Experts or the World Bank at the consultations sessions, and are included in a comprehensive matrix attached to this report.

**Independent Engineering and Dam Safety Panel of Experts:** During their presentations, the Panel of Experts endorsed the conclusions of the Consultants based on independent analyses and site visits. The Panel inspections emphasized the need to implement safety-related mitigation measures and monitor their effectiveness over the life of any dam. The Panel also observed that the Government of Tajikistan was following guidance for ensuring transparency and demonstrating good practice in information-sharing throughout the Assessment Study process. Based on the Panel's expertise and the verbal and written feedback from participants in the Riparian Program, the PoEs made several recommendations to the Government of Tajikistan. Integration of these recommendations into the Assessment Studies will be monitored by the World Bank.

**Next Steps:** The TEAS and ESIA consultants are continuing analyses as inputs into the remaining reports. The economic and financial analysis is underway. In addition, the comparison of three dam heights (and reservoir size) and assessment of the least cost expansion plan for power in Tajikistan (also in progress) will provide insight into project relevance and benefits. The ongoing ESIA analysis will examine the potential ecological and social impacts. As such, no conclusions on a proposed project can be drawn at this time. The fifth riparian meetings will be scheduled at a later date to review drafts of the Phase II Techno-Economic Assessment Study Summary Report (TEAS) and the Environmental and Social Impact Assessment (ESIA). The World Bank welcomes the continued participation of riparian governments, civil society and other stakeholders in the Assessment Study process.

## **4<sup>th</sup> Riparian Information-Sharing and Consultation Process on the Assessment Studies of a Proposed Rogun Hydropower Project**

September 30 – November 4, 2013

### **I. Introduction**

The purpose of the *Techno-Economic Assessment Study* (TEAS) and *Environmental and Social Impact Assessment* (ESIA) Studies is to determine the environmental, economic, social and technical feasibility of a proposed Rogun HPP, including within the context of a least cost (electricity) generation expansion plan to meet domestic demand. These Assessment Studies will not decide whether a proposed Rogun HPP will be built, nor will they determine the final design, if a project proceeds. They will serve as an input to decision-making and support further dialogue among riparian countries, and with other stakeholders, development partners, and financiers.

On October 17, 18 and 20, 2013, the World Bank facilitated meetings with governments, civil society and diplomatic and development communities in Central Asia and Afghanistan on the first formal deliverables of the TEAS, namely the *Summary of the Phase 0 Report on the Geological and Geotechnical Investigation of the Salt Wedge in the Dam Foundation and Reservoir*, and the *Summary of the Phase 1 Report on Assessment of the Existing Rogun HPP Works*. These meetings, complemented by an open comment period (September 30 – November 4), constituted the 4<sup>th</sup> Rogun Information-Sharing and Consultation Process. The consultation meetings on October 17, 18 and 20 were conducted via video conference from the World Bank's Country Office in Dushanbe, Tajikistan.

This report summarizes consultant findings, the expert opinions of the Panels of Experts (PoEs), comments of riparian stakeholders from both the consultation meetings and written inputs as well as responses to these comments.

**Rogun Riparian Consultation and Information Sharing Program:** The Bank is committed to 1) ensuring the application of international standards for safety, quality, and transparency in the Assessment Studies; and 2) facilitating good practice in information-sharing and riparian dialogue. Support for the Assessment Studies does not imply a financial role for the World Bank in any potential project. The Assessment Studies are one factor informing the decision on a proposed project. The World Bank's role is to help establish objective, independent, and comprehensive facts for all stakeholders so that the studies usefully serve as an input to decision-making.

The Rogun Riparian Consultation and Information Sharing Program is an essential element in the World Bank's involvement in the Rogun Assessment Studies in recognition of the significance and sensitivity of a proposed Rogun project to all six riparian countries. Focusing on communication and openness, the specific objectives of the consultation process are:

- To ensure credible, transparent assessments that benefit from international scrutiny

- To encourage dialogue among riparians
- To respond to the request of riparian governments with the support of international financial and donor communities
- To ensure the highest quality of the Assessment Studies and a process that considers stakeholder concerns.

The consultation process provides information on key aspects of the Assessment Studies and enables riparian governments (Afghanistan, Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan) as well as Central Asian Civil Society Organizations (CSOs) to exchange knowledge, information and expertise. Interim reports and findings, and draft reports are shared to obtain early comments for influencing and improving the studies. Documents from the consultants, previously reviewed by the PoEs and World Bank technical team, are disclosed publicly for a period of 4-6 weeks. During that time, information sharing sessions are convened by the World Bank, complementing written feedback (via email at [rogunconsult@worldbank.org](mailto:rogunconsult@worldbank.org) or mail to World Bank offices). The consultation meetings provide an opportunity for riparian governments and civil society representatives to interact with two international firms conducting the TEAS and the ESIA, with members of two independent Bank-funded Panels of Experts (PoEs)<sup>1</sup> that are providing additional oversight to the studies, and with World Bank experts. The PoEs review stakeholder comments and then integrate them into the PoEs' independent recommendations to the Government of Tajikistan and Consultants.

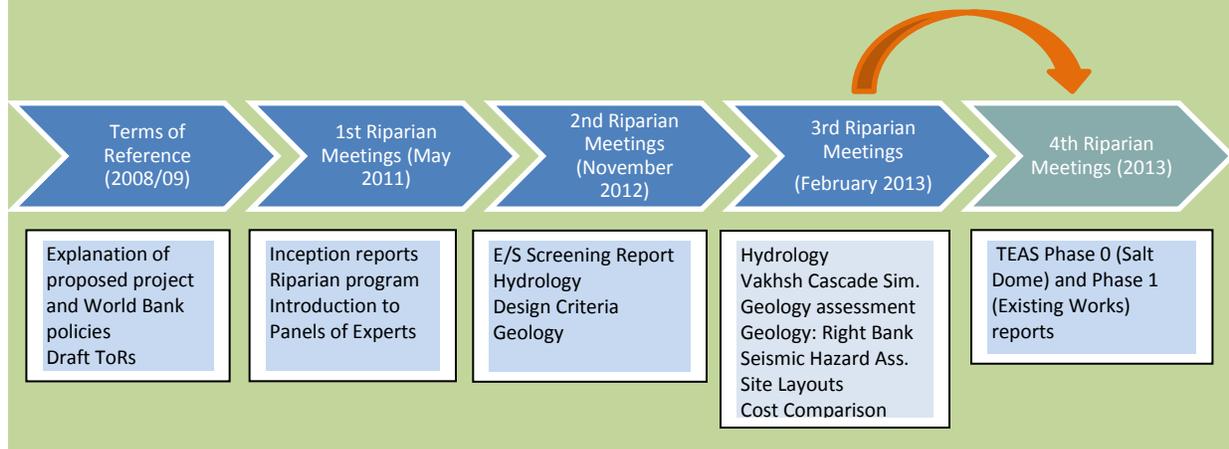
The Information Sharing and Consultation process is essential to ensure that the diverse perspectives and points of view of the affected stakeholders in the riparian countries are heard and understood. It is part of a broader World Bank effort in water and energy in Central Asia (see <http://worldbank.org/eca/caewdp>). Previous consultations were held at key milestones in the Assessment Study process, as illustrated in Figure 1. Reports on these meetings and more details about the World Bank's engagement in the Assessment Studies can be found at: <http://worldbank.org/eca/rogun>. The Report from the 2<sup>nd</sup> Riparian Information-Sharing and Consultation process includes an overview of the Riparian process since 2009 (see [http://siteresources.worldbank.org/ECAEXT/Resources/ENG\\_2nd-Rogun-Riparian-Consultation-Report\\_final.pdf](http://siteresources.worldbank.org/ECAEXT/Resources/ENG_2nd-Rogun-Riparian-Consultation-Report_final.pdf)). The consultation process will culminate in the review of the ESIA and Summary Report of the TEAS deliverable (Phase II).

**Overview of Fourth Riparian Information-sharing and Consultation Process:** The purpose of the 4<sup>th</sup> information sharing and consultation process for the Rogun Assessment Studies was to share and discuss the draft summaries of the *Geological and Geotechnical Investigation of the Salt Wedge in the Dam Foundation and Reservoir* (Phase 0 of the TEAS Terms of Reference) and *Assessment of the Existing Rogun HPP Works*, including caverns and tunnels (Phase I of the TEAS Terms of Reference). These reports are the first draft deliverables from the TEAS.

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<sup>1</sup>An Engineering and Dam Safety Panel (EDS-PoE) and an Environmental and Social Panel (ES-PoE) for the ESIA.

**Figure 1: Rogun Riparian Information-Sharing Program  
2008 to November 2013**



The information-sharing and consultation process followed the same structure as the three previous consultations. The Government of Tajikistan and the World Bank disclosed the reports in English and Russian on September 30, 2013. Comments were accepted until November 4, 2013, via email ([rogunconsult@worldbank.org](mailto:rogunconsult@worldbank.org)) and mail to the World Bank Country Offices in all riparian countries. Information-sharing and consultation meetings took place over three days as follows:

- Riparian governments:** On October 17, riparian government representatives from Kazakhstan, Kyrgyz Republic, and Tajikistan attended discussions. Due to a holiday conflict on October 17 in Afghanistan, an additional information-sharing session was held for Afghanistan government officials on October 20<sup>th</sup>. Similarly, Turkmenistan declared a national holiday for October 17 and 20<sup>th</sup>; all materials were provided to the Government of Turkmenistan. The Government of Turkmenistan indicated a separate full consultation was not needed. The total number of country delegates at these meetings totaled 31 individuals<sup>2</sup>, with an additional 17 from the World Bank, consultants and Panels of Experts.
- Civil society organizations:** On October 18<sup>th</sup>, 34 civil society organizations attended via video and audio conferencing among Almaty, Astana, Bishkek, Dushanbe, Kabul, and Tashkent.
- Diplomatic and development community:** The Bank also briefed representatives of development organizations and the diplomatic community in Astana, Dushanbe, and Tashkent on October 18.

The sessions were hosted from the World Bank office in Dushanbe, Tajikistan, with video links to all Central Asia and Afghanistan country offices (audio link to Turkmenistan on October 17 for official observers from the UN) as well as Bank offices in Paris and Washington. Additional audio connections

<sup>2</sup> Including fifteen from the Government of Tajikistan

were made available on an as-needed basis. The Bank extends its appreciation to the Government of Tajikistan for welcoming participants. The agenda for all three sessions was similar. Findings were presented by the consultants followed by presentations by the independent Engineering and Dam Safety (EDS) PoE and then open questions and discussion with stakeholders. Comments from riparians were reviewed by the PoE and recommendations provided to the Government of Tajikistan for integration into the Phase 0 and Phase 1 reports. The documents as well as presentations are publicly available on the Bank's website at [www.worldbank.org/eca/rogun](http://www.worldbank.org/eca/rogun).

This consultation report documents both the submitted comments and the information-sharing and consultation sessions. The report is structured as follows: Sections II and III focus on Phase 0 and Phase I, respectively, summarizing the findings, main issues discussed and questions raised by stakeholders; Section IV covers cross-cutting themes and issues raised by stakeholders that lie outside the specific scope of the two technical reports; Section V presents the PoEs' recommendations to the Government of Tajikistan related to the summary reports, integrating the opinions of, and discussions with, stakeholders. Section VI outlines next steps. Annex A provides the agenda of the meetings, and a more detailed matrix of questions and responses is provided in Annex B. This report is available on the Bank's website ([www.worldbank.org/eca/rogun](http://www.worldbank.org/eca/rogun)).

## **II. Phase 0: Geotechnical and Geological Investigation of the Salt Dome**

In line with the agreed Terms of Reference (ToR) for the Techno-Economic Assessment Study (TEAS), the Consultant is required to undertake a risk assessment pertaining to the potential influence of the salt dome on dam safety. This section of the ToR, referred to as “Phase 0”, covers the geotechnical and geological investigation of the salt dome or wedge in the dam foundation and reservoir. The Consultant presented both the assessment results and mitigation recommendations; specifically, potential salt dissolution scenarios, possible treatment options, residual risks during Rogun operation as well as how to mitigate these risks.

A body of salt referred to as the salt dome, is located within the 1 kilometer section of the Ionakhsh Fault,<sup>3</sup> increases in width by about 15 meters for every 100 meters in depth (hence a “wedge”). The unique geological feature has been extensively investigated and detailed information on its specific characteristics is available.

The salt wedge poses a potential issue with regard to dam safety, which is why the ToR for the Techno-Economic Assessment Study calls for a very thorough investigation. Under the effect of orogenic forces (i.e. the folding and faulting of the earth’s crust), the wedge of salt is being extruded along the Ionakhsh Fault at an estimated rate of 2.5 cm per year. In the vicinity of the Vakhsh River, it is being dissolved at a similar rate, resulting in a state of equilibrium. The impoundment of the Rogun reservoir would result in the creation of a hydraulic gradient across the salt wedge and, if not mitigated, would result in accelerated dissolution of the salt wedge and potential formation of a cavity in the dam foundation over time.

### **Consultant findings**

The Consultants conducted a review of previous assessments and available data on the salt wedge, including:

- Existing models and literature dating from the 1978 design;
- The original Hydro Project Institute (HPI) model on hydraulic conductivity; and
- An analysis of initially proposed mitigation measures that included a hydraulic curtain, a brine curtain and a grouting cap.

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<sup>3</sup> The Ionakhsh Fault crosses the dam site, running from the north-east to south-west.

Existing documentation was augmented by visual surveys and additional site investigations. This analysis enabled the Consultant to identify the key parameters impacting the behavior of the salt wedge. In addition to the review of existing models, the Consultants developed new models to independently assess the results of the previous studies.<sup>4</sup> Mitigation measures proposed in previous studies to control the dissolution process were assessed and new mitigation measures were proposed by the Consultants utilizing up-to-date technologies. The efficiency of the recommended mitigation measures (to reduce dissolution) was assessed in sensitivity analyses. The estimated costs of the proposed mitigation measures were derived to be included in the overall estimated cost of a proposed project.

The Consultants concluded that measures are needed to manage the potential dam safety risks associated with the salt wedge in the long term. The data analysis and modeling results indicate that measures should include both: (i) grouting of the top of the salt wedge; and (ii) the establishment of a hydraulic barrier, complemented by adequate monitoring to detect any loss of efficiency and ensure timely maintenance.<sup>5</sup> A brine curtain (brine injection into the cap aquifer) would theoretically further reduce the dissolution process but is less reliable due to a possible clogging of the injection holes, and appears to be superfluous when grouting and hydraulic barrier are used.

Even though the results of the analysis show that an efficient hydraulic barrier alone, or efficient grouting alone would be acceptable, both mitigation measures are required to cover the risk that one of the two mitigation measures might lose part of their effectiveness to prevent excessive salt dissolution. Both mitigation measures should remain operational throughout the lifetime of the dam. None of the mitigation scenarios reached a size of potential fissure (cavity) that would endanger dam stability and, under a range of scenarios, the combined measures meet international standards for dam safety, using a safety factor of three. (As confirmed by the PoE a “factor of 3” is the highest standard possible compared to international practice of 1.5 – 3.0.)

The proposed remedial measures of grouting and hydraulic barrier would require on-going monitoring to confirm efficiency measures, the dissolution rate and the models’ predictability. Monitoring should begin as soon as possible and be maintained throughout the lifetime of a proposed dam. The monitoring measures identified in the reports include measurement of the displacements within the salt wedge and the embedding rock as well as a follow-up of the deformations within the salt body by a series of clinometers. In addition, to effectively monitor potential salt leaching, the following systems are proposed:

- Groundwater head monitoring, in order to check the hydraulic barrier efficiency (boreholes and pressure cells);
- Water conductivity monitoring to check the model reliability and the on-going leaching process, if any (boreholes and conductivity cells);

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<sup>4</sup> The whole dissolution process is simulated by three separate sub-models which are used sequentially: a groundwater flow model, a dissolution process model and a transport model.

<sup>5</sup> The hydraulic barrier consists of a series of boreholes on the downstream side of the salt wedge to maintain reservoir pressure; this minimizes the water gradient between the two sides of the salt wedge.

- Microgravity in order to check the salt rising rate at Ionakhsh Fault and potential cavity generation (one campaign every six months during stage 1 phase); and
- Regular sonar inspection of the dam face once impounded, to detect any abnormal deformation of the upstream face.

This continual data feed combined with modelling would enable early detection of variances in the efficiency and performance of the mitigation measures that could lead to formation of cavities. If such variances were to be discovered, remedial measures could be initiated in a timely manner, both during construction and operations. The PoE indicated that the slow movement of the salt wedge (i.e., 2.5 cm/year) provides ample time for response and additional remediation without risk to dam stability.

### **Panel of Experts**

In their independent presentation at the consultation meetings, the Engineering and Dam Safety (EDS) PoE endorsed the conclusions of the Consultant regarding the potentially adverse conditions imposed by the salt wedge at the dam foundation. The Consultants concluded that feasibility within the context of the salt wedge is conditional on: the implementation of both grouting and hydraulic barrier; a comprehensive monitoring system that operates uninterruptedly; and readiness of remediation capability for any works exhibiting diminished effectiveness. The EDS PoE also confirmed the adequacy of the modelling and sensitivity analysis, and noted the significant historical and new site data that were used in the analysis. The EDS PoE's specific recommendations to the TEAS Consultant can be found in section V of this report.

### **Consultation and Information Sharing**

Riparian stakeholders, including both government representatives and representatives from civil society organizations, engaged in the meetings and through the online forum. Questions were primarily grouped into four main areas:

- The potential impacts of dissolution of the salt wedge at both the local and downstream level;
- Planned mitigation measures;
- Adequacy of data and modeling; and
- Monitoring.

In addition, written comments identified a number of translation issues that will be addressed in the revised reports. Questions regarding details of monitoring of remedial works are addressed in the previous technical section. The remaining groups of comments are summarized below. Annex B details comments as well as responses from the consultant's report, the PoE and the World Bank team.

**Potential downstream impact of salt dissolution:** Stakeholders asked about the extent of potential impact of the salt wedge on the environment downstream, the hydro-geochemistry of the site, the turbines and electro-mechanical equipment. The Consultants were able to confirm that the salt dissolution effect is a very local phenomenon (i.e. only at the dam site) with only a very small amount of salt being dissolved in a large volume of water of the Vakhsh River. The current situation represents a natural state of the salt dissolution process and there are no downstream impacts. Dissolved salt levels are only recordable at the dam foundation; salt has not been detected in water sampling measurements at the higher level of the embankments of the Vakhsh riverbed. In addition, the mechanical properties of the material used in the dam foundation would not be affected as the materials are from the same source as the riverbed. The Consultant also confirmed that the presence and treatment of the salt wedge would not affect electromechanical equipment.

**Planned mitigation measures:** As noted above, the Consultant, supported by the PoE, recommends a hydraulic barrier implemented concurrently with grouting. The combined approach was found to be feasible and meets international standards for safety. On-going monitoring, starting with a full baseline before any resumption of construction and impoundment, would be designed to continually update the information base and models. This approach would allow abnormalities, such as fissures, to be detected and addressed in a timely manner.

**Adequacy of data and modeling:** A number of general and specific questions were raised related to the accuracy of data and appropriateness of models employed to identify and assess the treatment options. The mathematical modeling is supported by a base of information, in part developed from the late 1960's design and augmented by subsequent studies and new site investigations performed for the current studies. The adequacy of the measures was examined through a series of sensitivity tests that explored such factors as grouting efficiency losses, mineral composition of the salt wedge, dispersion and porosity degree, rock solubility and overall hydro-geological conditions of the site. The PoE noted that the database, choice of parameters for the modeling and in case of uncertainties, a parametric consideration with sensitivity tests, combined with the use of a high safety factor, are appropriate for this feasibility stage of the studies (more analysis would be needed for detailed design). The monitoring program would add to the database and continuously refine the model for more precise management of the salt wedge.

More details on the data and modeling assumptions, key parameters and recommendations (including remedial measures) can be found in the presentation prepared by the Consultants as well as a presentation of the independent EDS PoE assessment and review of the Consultants' analysis (see [www.worldbank.org/eca/rogun](http://www.worldbank.org/eca/rogun))

### III. Phase I: Existing Works of the Proposed Rogun HPP

As stipulated by the TEAS ToR under the section delineated as “Phase I,” the Consultant carried out an assessment of the existing works at Rogun site. The purpose of the assessment was to establish the adequacy of the existing works as a basis for the development of a proposed project. This assessment is necessary in consideration of the fact that most of the works were carried out 30 years ago, construction activities were then stopped, and the works were exposed to damage in the intervening period. The adequacy of existing works can affect the following factors, should a project be assessed as viable: costs, site safety, dam safety and scheduling. Relevant structures that were included in the assessment included: 1) open air works (e.g. roads and transportation facilities, quarries, Conventional Vibrated Concrete (CVC), conveyor belts, etc.), the construction site, equipment on site and general site conditions; and 2) underground works (i.e. transportation tunnels, drainage tunnels, cable tunnels, diversion tunnels) and specifically the powerhouse cavern, transformer hall and electromechanical items currently on site. The costs of upgrades and remedial works were estimated and will be included in the economic analysis (Phase 2 of the TEAS).

#### Consultant Findings

The Consultant concluded that existing works range in quality from adequate, to requiring minor remedial works, to requiring sophisticated remedial actions, should a potential project be assessed as viable and later developed. The Consultant stated that major remedial works are mandatory for Diversion Tunnels 1 and 2, the Powerhouse and Transformer Hall Caverns, the Powerhouse Access Tunnel (T-4) and the Permanent Access Tunnel (T-3). The identified remedial actions are technically feasible and, after a subsequent phase to detail design, would bring the structures into compliance with internationally recognized dam safety standards that have been adopted in a proposed project’s design criteria. Detailed findings of site investigations and subsequent analysis were presented in the presentation made by the Consultant at the consultation sessions and in the disclosed Summary Report (see [www.worldbank.org/eca/rogun](http://www.worldbank.org/eca/rogun)).

**Tunnels:** With regard to the tunnels, the Consultant concluded that “the structures analyzed are not adequate in the present conditions for the purpose they have been designed for, since they do not fulfill the technical requirements in respect to safety and serviceability required by the presently internationally recognized design criteria and Standards, and the tunnels’ permanent supporting systems need to be strengthened” (Phase 1 Summary report page 14). These conclusions followed testing of the actual strength of the existing concrete lining and subsequent detailed modeling of the structures.

Possible remedial measures include a drainage system to control loads on the structures, or additional supports (bolts or anchors), with special measures identified for tunnels crossing fault 35. However, it was stressed that detailed analysis of individual sections will need to be carried out in a subsequent detailed design phase to specify appropriate strengthening measures for different tunnel structures. The Consultant did undertake a more detailed analysis of the most critical section of the diversion tunnels to verify possible remedial measures. The analyses confirmed that the measures can increase

the bearing capability of the supporting system complex, so that the tunnel structure would meet the required criteria of safety and serviceability.

**Powerhouse and Transformer Hall Complex:** Examination of the powerhouse and transformer hall complex revealed significant deformations (738 mm up to August 2012) in the powerhouse cavern walls. The observed strains and deformations do not meet required stability conditions for the cavern complex as a whole, and the Consultant concluded that additional reinforcement and stabilization measures are required before any further excavation in the powerhouse cavern can be undertaken safely. These measures could include rock anchors on both sidewalls. The analyses confirmed that, through the proposed set of stabilization measures, it is possible to improve the stability conditions in the caverns with the aim to achieve compliance with the required criteria of safety and serviceability. The proposed stabilization measures would need to be optimized by more detailed studies in any subsequent phase of the project. A suitable monitoring system to track performance of the remedial measures is a mandatory condition. Proposed remedial measures for all underground works would take a minimum of 18 months.

### **Panel of Experts**

After extensive review and independent site inspections, the EDS PoE concluded that the stability of the powerhouse cavern can be feasibly secured with the implementation of proposed (and mandatory) stabilization works. They also agreed that the remedial works proposed by the Consultant for Diversion Tunnels DT1 & DT2 are necessary and appropriate. The Panel noted that some defects in other underground structures will need to be addressed, but in general they do not impair the safety condition of the works. It was also reconfirmed by the PoE that there would be no underground expansion of the Powerhouse and Transformer Hall cavern complex beyond current design. More detail on the EDS PoE's specific recommendations to the Government of Tajikistan and the TEAS Consultant on existing works can be found in section V of this report, with background provided in the Panel's presentation.

### **Consultations and Information Sharing**

As with Phase 0, Annex B includes a matrix of comments on Phase 1 Summary Report as well as responses from the technical experts of the PoE, the TEAS Consultants and the World Bank team. In addition to translation, comments focused on three main areas:

- Standards, technical requirements and design data;
- Concrete and construction standards; and,
- The suitability of existing electro-mechanical equipment present on site.

***Standards, technical requirements and design data:*** The current feasibility assessment studies have reviewed design issues for a proposed Rogun Hydropower Project, including the critical aspects of dam safety. A Design Criteria Document was produced by the TEAS Consultant, at the PoE's request, to incorporate the latest international standards for dam design, construction and safety in the TEAS

studies. This document was disclosed and discussed during the 2<sup>nd</sup> Information Sharing Meetings in Almaty on November 6-7, 2012. The Design Criteria are a significant update from past standards and ensure that current international safety standards are applied. These design parameters consider population at risk as well as dam safety hazards, most importantly the design floods (PMF) and the design earthquakes (MCE)<sup>6</sup>.

The establishment of such a new set of fundamental Design Criteria appropriately reflects the scale and risks associated with the Rogun site. The Design Criteria Document is applicable to all segments and components of a proposed project, including existing works. Existing works would need to be upgraded where they do not meet the Design Criteria.

Specific questions were raised with respect to the consideration of seismicity in the assessment of existing works. Using MCE as a Design Criteria, the seismic load methodology in the Phase I Report was developed using Eurocode recommendations. Eurocode recommendations cover important aspects of dam design such as the structural and geotechnical design of dams, including foundations, tunnels, slope stabilization, etc., in seismic regions.

***Dam construction materials:*** Following the analysis of the Consultant and verified by independent site visits, the PoE confirmed that the volumes of material needed for the dam construction are available on site, but that core material will need to be improved by adding fine material from a different source to improve water tightness.

***Electro-mechanical equipment:*** The Consultant as well as the PoE carried out a complete assessment, including extensive site visits,<sup>7</sup> of the existing electromechanical equipment. This includes power generating equipment, turbine components and hydraulic steel structures. For each stored component, the conditions were assessed and the necessary maintenance and refurbishment works required to restore the equipment to suitable working conditions were recorded. The Consultants found that limited remedial measures are necessary to bring some of the electro-mechanical equipment up to modern standards. Findings were verified by the Electromechanical Expert from the PoE. In addition, the EDS PoE found that units 5 & 6 do not require major modification. All cost implications will be taken into account in the Economic Analysis in Phase II of the TEAS.

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<sup>6</sup> Probable Maximum Flood (PMF) is adopted in design structures for hydrological safety and the Maximum Credible Earthquake (MCE) is taken into account for the seismic safety of the structural design of the dam and appurtenant works.

<sup>7</sup> The international electromechanical expert on the Dam Safety and Engineering PoE conducted extensive investigations on site.

#### IV. Cross-cutting Themes

Riparian stakeholders inquired about aspects of the Assessment Studies that were outside of the scope of the material disclosed and presented for the 4th consultation meetings. Such comments are nevertheless important to the transparent and inclusive riparian engagement process.

Several questions were raised regarding the Assessment Study process. These were addressed in the consultations sessions and are noted in Annex B, as follows:

- **Timing:** The specific dates of the next study outputs and consultation sessions are not yet determined. They will depend on the progress of the studies to ensure high quality, international standards and adequate independent technical review prior to disclosure.
- **Disclosure of documents:** The next set of documents, in draft, will cover: (i) the *Environmental and Social Impact Assessment (ESIA)*; and *Phase II of the Techno-Economic Assessment Study*. Disclosure of full documents was requested. The ESIA will be disclosed in full; a Summary Report from the Phase II TEAS will be publicly available. The full report will not be public to protect confidentiality related to public safety and commercial interests. This is consistent with World Bank practice.
- **Review period:** Recognizing the complexity and scope of the Assessment Studies, stakeholders requested adequate time for review. A six week review period is scheduled. Within that period, consultation meetings will be convened. The specific design of the meetings is underway, but the breadth and complexity of the documents will be taken into consideration. In addition to the World Bank's consultations across all riparian countries, the ESIA consultant will, as a requirement of its Terms of Reference, hold consultations with local communities in Tajikistan.
- **Panels of Experts:** One stakeholder suggested that the Panels of Experts should make a definitive statement regarding the construction of a proposed Rogun HPP. The PoEs provide expert advice throughout the study process, ensuring quality of analysis and consistency with international standards. The PoEs have not expressed an opinion on the techno-economic and socio-environmental viability of a proposed project, and such expert opinions as have been expressed relate solely to the technical aspects of the ongoing studies. The Panels will provide a summary assessment at the conclusion of the studies, as many aspects are still being reviewed.

Important themes such as downstream flows, dam criteria and alternative project designs were raised. These have been discussed in previous consultation meetings, and are part of on-going studies and analysis. They will be addressed in depth at future information-sharing and consultation meetings, as part of the ESIA report and TEAS Phase II Summary Report.

## V. Panel of Experts' Recommendations to Government of Tajikistan

Representatives of the Environmental and Social Impact Assessment and the Engineering and Dam Safety Panels of Experts participated in the three days of consultation and information sharing (October 17, 18 and 20, 2013)<sup>8</sup>. The following recommendations from Engineering and Dam Safety Panel of Experts based on the opinion of the experts, site observations, and comments from the 4<sup>th</sup> riparian information-sharing and consultation process, were presented to the Government of Tajikistan.

During the consultation process, the EDS PoE delivered two presentations, on the Phase 0 and Phase 1 studies. Below is a summary of the salient points of the PoE's presentations, preceded by an overview of riparian discussions as they relate to the studies' findings.

### Riparian comments

Questions from stakeholders largely focused on understanding remedial measures for both Phase 0 and Phase 1, which were answered by either the TEAS Consultant or the PoE. Some questions addressed aspects of the TEAS and ESIA studies that were outside the scope of Phase 0 and Phase 1 and were answered by the World Bank team.

On the basis of stakeholder feedback, the EDS PoE suggests the Consultants clarifying the following matters when finalizing the two reports:

#### ***Phase 0: Salt wedge:***

- Clarify that the formation of any cavity would not occur suddenly and therefore the planned monitoring will enable timely rectification of the mitigation measures if needed.
- Clarify the term "safety factor of 3" that was applied in the analyses of remedial measures and relate it to standard engineering practice.
- Clarify that the mitigation measures can be repeated over time and so can ensure sustainability of the dissolution prevention process.

#### ***Phase 1: Existing works***

- Further clarify that a staged process is proposed for the construction and operation of the existing electro-mechanical equipment, whereby some already manufactured electromechanical equipment will be used initially, while the reservoir fills, and will subsequently be replaced to enable efficient operation at high reservoir levels.

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<sup>8</sup> The following PoE members attended the October 17, 18 and 20 riparian meetings: Roger Gill (Chair) attended in person in Dushanbe on October 17 and 18 and by telephone on October 20; Ljiljana Spasic-Gril attended in person all 3 days; Prof. Paul Marinos attended on 17th and 18th October from Paris. Eric Helland-Hansen represented the Environmental Panel of Experts from Paris. The comments and recommendations reflect the opinion of the Panel as a whole:

## PoE Comments on Consultant studies

The PoE's direct comments on the studies follow.

**Phase 0 - Salt Wedge:** A salt wedge exists under the upstream part of the dam axis along the creeping Ionakhsh fault which, if not addressed effectively to prevent dissolution by the potential hydraulic gradient, could impact the feasibility of the project.

Mitigation measures comprising an installation of a hydraulic barrier and grouting of the upper part of the salt wedge have been proposed by the TEAS Consultant.

The PoE commented that they endorsed the recommendations of the TEAS Consultant on the feasibility of the project vis-a-vis the extremely adverse condition imposed by the evaporitic intrusion at the dam foundation. This conclusion goes with the condition that a sophisticated monitoring system is installed, operating uninterruptedly, and new remedial work is to be ready to replace any failed works. The PoE also agrees that a 3rd level of protection, proposed by the original HPI design, comprising a brine curtain, should not be deployed due to a possible clogging of the injection holes and the enormous quantities of salt required.

As a conclusion, the PoE also pointed out that the dissolution of the salt in the dam foundation was a very slow process and that it would take a long time before significant impacts would begin to be felt. Therefore, implementation of remedial measures even after a few years would address the problem. Thus, this is not an issue with the same risk level as large earthquakes or extreme floods where adverse impacts can be immediate.

**Phase 1 – Assessment of the existing Rogun HPP works:** The disclosed report covers existing surface and underground works which comprise the following:

- Existing accommodation;
- Access roads;
- Borrow areas for the construction materials and their transportation to the construction site;
- Underground powerhouse and transformers hall cavern;
- Existing diversion tunnels DT1 and DT2;
- Other transportation tunnels;
- Early generation equipment.

The objective of this phase of work is to evaluate if the existing surface and underground structures are fit to use for river diversion, construction and operation of a potential dam.

The main focus of the PoE's presentation was on the powerhouse cavern, diversion tunnels DT1 & DT2, availability of the appropriate construction materials, and the status of the equipment for early generation, all of which could have a significant impact on the schedule and cost of the project.

**Powerhouse Cavern:** The powerhouse cavern is approximately 21m wide, 69m high and 220m long. The cavern is located within sandstone and siltstone, the latter mainly occurring in the area of Units 5 and 6.

A significant amount of excavation has been already conducted (more than 30m in height). The excavation started in the late 1980s and was stopped in the 1990s. It resumed in 2011 and was stopped again in June 2012. Time-dependent deformations have been exhibited since the late 1980s and questions were raised about an increasing creep behavior and the possibility of compromised stability mainly in the siltstone section.

An independent site inspection and evaluation of conditions and convergence measurements were undertaken by the PoE in April 2013, in conjunction with a sampling campaign by the TEAS Consultant. The PoE suggested that possible progressive distress of the rock mass in association with the ageing of the strengthening measures applied since the late 1980s could be the reason of the time-dependent deformation, and not a gradual deterioration of the petrographic quality due to softening of the siltstone. Such a state could be addressed efficiently by additional support in the sidewalls.

The PoE concurred with undertaking numerical modelling with all new data from measurements and laboratory test results by both HPI (3D model) and the TEAS Consultant (2D model) to resolve the feasibility of implementation of Units 5 & 6 in the siltstone zone.

The TEAS Consultant recommends that cavern stabilisation measures for Units 5 & 6 be implemented prior to any further excavation in the caverns. The stabilisation measures would include:

- a) Installation of 35m long rock anchors on both sidewalls and in both caverns, above the current excavation level, starting from the crown downwards to reduce/limit the rate of movement, and
- b) Reinforcement and stabilisation of the highly de-stressed rock mass in the “pillar area” between the two caverns. This will be achieved by installation of the Multiple Packer Sleeved Pipe (MPSP) that will reinforce the rock mass, as well as be used for consolidation grouting.

The PoE believes that with the implementation of the proposed stabilization works the stability of the caverns can feasibly be secured. However, the PoE has made additional recommendations to:

- Continue with the monitoring of the caverns’ displacements;
- Update the numerical model to take into account the new displacement measures and the additional results of the laboratory testing;
- Define the extent of the proposed stabilization works in the “pillar area”;
- Identify other feasible strengthening measures to the “pillar area” and allow adequate contingency funds in the cost estimate;
- Consider strutting of the caverns, as excavation goes, as another solution that may also be implemented along with the new anchors;
- Prior to detailed design, undertake the in-situ testing of rock anchors, including creep pull-out tests on anchors and anchor heads and in-situ trial testing of the rock mass grouting. These activities should be included in the cost estimate of the stabilization works.

*Diversion Tunnels 1 and 2 (DT1 & DT2):* These two diversion tunnels have been excavated in the 1980s. The tunnels pass through a complex geological setting and the alignments cross active faults F35 and

F70. In the 1990s, while the construction works were put on hold, both tunnels experienced partial collapse in the area where the alignments cross the fault F35.

The TEAS Consultant's findings of the Phase 1 work are as follows:

- DT1 & DT2 do not fulfill the technical requirements with respect to safety and serviceability required by the presently internationally recognized design criteria and standards.
- The tunnels need substantial remedial works (drain holes, additional concrete strengthening supported by additional rock dowels, stabilization of the tunnel invert in some sections, additional grouting in more permeable sections, and additional structural measures where the tunnels cross faults F35 and F70) before they can be used for river diversion.

The PoE has done an independent inspection of the tunnels and review of appropriate documents. The PoE agrees with the assessments undertaken, methodology applied and the remedial works proposed, which have to be implemented before the tunnels could be used for river diversion.

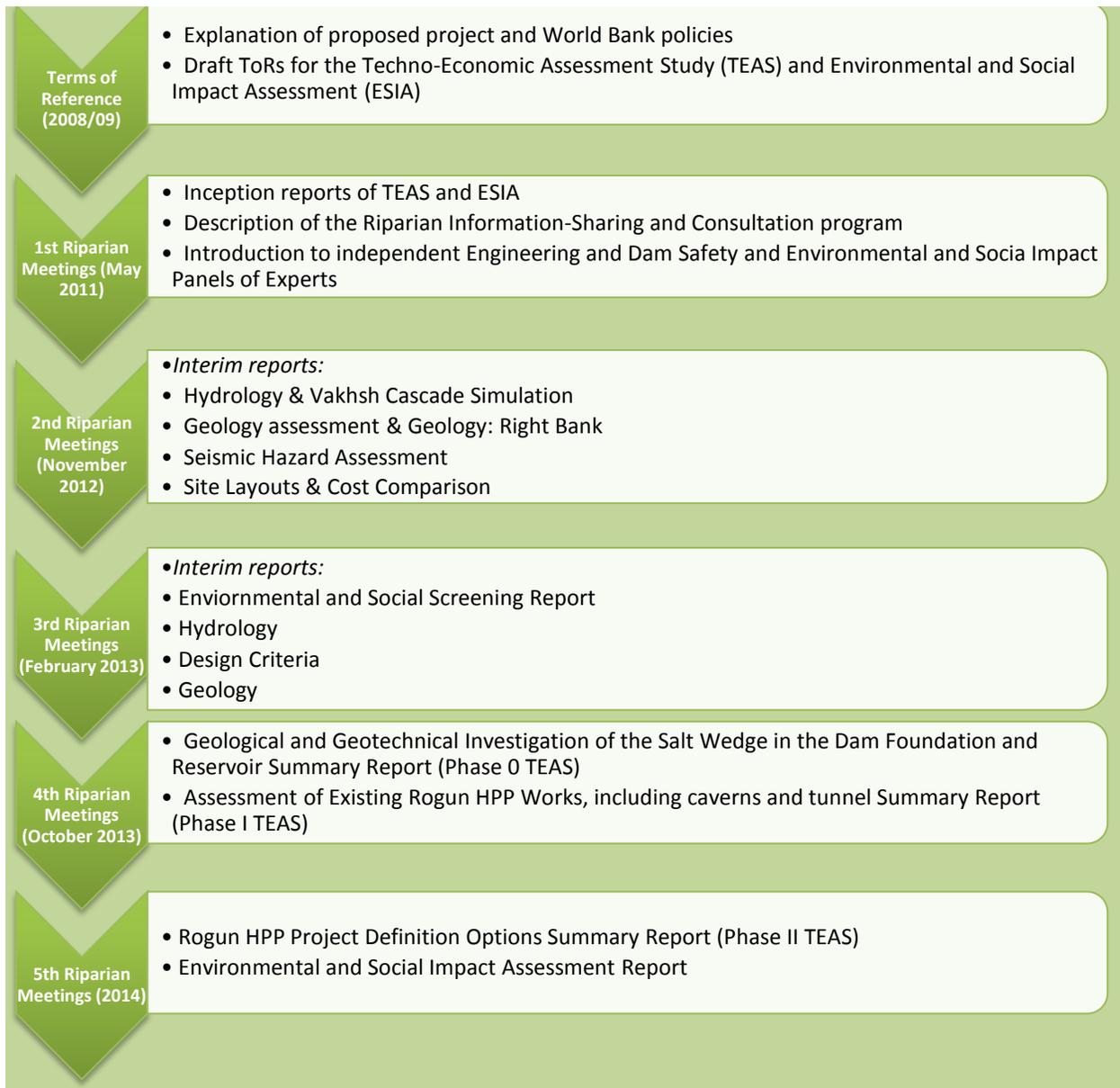
*Construction materials and their transportation:* It has been shown by the TEAS consultant that the volumes of material needed for dam construction are available in quarries / borrow areas and associated storages. However, some improvement in grading and moisture content of the core material from Borrow Area 17 will be necessary. Also, care would need to be given to timely extraction of the alluvium from Borrow Area 15 as this borrow area will be flooded at the early stages of the construction.

*Early generation equipment:* The PoE agrees that the staged development as foreseen in the original scheme is both safe and expedient. The existing equipment for Units 5 & 6 does not require major modification.

## **VI. Next Steps**

Significant work to complete the Assessment Studies is still underway. Building on the Screening Report and TEAS analysis, the ESIA is completing the assessment of potential ecological impacts, resettlement, and implications for riparian countries (including for downstream flows). The TEAS, similarly, is completing analysis on flood management, seismicity and economic and financial analysis, including a least cost expansion plan for meeting energy needs of Tajikistan. These two reports will require additional consultation and dialogue with riparian stakeholders. As shown in Figure 2, a fifth information-sharing and consultation process is planned to discuss the draft Summary of the Phase II TEAS report and the draft ESIA report, scheduled for later in 2014. The fifth consultation will conclude the information exchange and consultation on the studies to serve as a basis for decision-making by the Government of Tajikistan.

## Figure 2: Rogun Riparian Information-Sharing Program



Report on  
**4<sup>th</sup> Riparian Information-Sharing and Consultation  
Process on the Assessment Studies of a Proposed Rogun Hydropower Project**

**ANNEXES**

**Annex A: Agenda of October 17 Meeting**  
**ASSESSMENT STUDIES FOR PROPOSED ROGUN HYDROPOWER PROJECT**  
**FOURTH RIPARIAN INFORMATION-SHARING AND CONSULTATION MEETING**  
**MEETING OF RIPARIAN GOVERNMENTS**

**OCTOBER 17, 2013**

**Video and Audio Conference from Central Asia World Bank Country Offices**

Chair: Dushanbe Country Office, Tajikistan Tel. (+992-48) 701 5810

48 Ayni Street, Business Center "Sozidanie", 3rd Floor

**AGENDA**

*Note: Session held at local Dushanbe time; the time difference with other participating sites needs to be taken into account*

<b>Purpose:</b> To share new information from the assessment studies on a proposed Rogun Hydropower project		
<b>Chair:</b> Marsha Olive, Country Manager, Tajikistan, World Bank		
<b>Co-Chair:</b> Daryl Fields, Senior Water-Energy Specialist, Sustainable Development Network, Europe and Central Asia, World Bank		
<b>Time (Dushanbe)</b>	<b>Topic</b>	<b>Moderator/Speakers</b>
13:00 – 13:30	<i>Registration</i>	
13:30 – 14:00	<b>Welcome</b> <ul style="list-style-type: none"> <li>• Opening comments</li> <li>• Welcome message from Tajikistan</li> <li>• Comments from Heads of Delegations</li> <li>• Update on Assessment Studies and consultations</li> <li>• Review of Agenda</li> </ul>	<b>Chair:</b> Marsha Olive/Daryl Fields, World Bank  <b>Speakers:</b> <ul style="list-style-type: none"> <li>• Mr. Farrukh Khamraliev, State Advisor to the President on Economic Policy, Government of Tajikistan</li> <li>• Imtiaz Hizkil, Senior Power Engineer, World Bank</li> </ul>
14:00 – 15:00	<b>Geological and Geotechnical Investigation of the Salt Wedge in the Dam Foundation and Reservoir (Phase 0 Summary)</b> <ul style="list-style-type: none"> <li>• Consultant presentation</li> <li>• Feedback from Panel of Experts</li> <li>• Open discussion and participant roundtable</li> </ul>	<b>Moderator:</b> Laurent Debroux, Sector Leader, Sustainable Development Network, Central Asia, World Bank  <b>Speakers:</b> <ul style="list-style-type: none"> <li>• Coyne &amp; Bellier and consulting consortium</li> <li>• Paul Marinos, Independent Panel of Experts, Engineering and Dam Safety</li> </ul>
15:00 – 15:30	<i>Tea/Coffee/Snacks</i>	
15:30 – 17:00	<b>Assessment of Existing Rogun HPP Work (Phase 1 Summary)</b> <ul style="list-style-type: none"> <li>• Consultant presentation</li> <li>• Feedback from Panel of Experts</li> <li>• Open discussion and participant roundtable</li> </ul>	<b>Moderator:</b> Daryl Fields, World Bank  <b>Speakers:</b> <ul style="list-style-type: none"> <li>• Coyne &amp; Bellier and consulting consortium</li> <li>• Roger Gill, Ljiljana Spasic-Gril, and Paul Marinos, Independent Panel of Experts, Engineering and Dam Safety</li> </ul>
17:00 – 17:30	<b>Summary</b> <ul style="list-style-type: none"> <li>• Recap of findings and comments</li> <li>• Next steps</li> <li>• Closing comments</li> </ul>	<b>Chair:</b> Marsha Olive/Daryl Fields, World Bank  <b>Speakers:</b> <ul style="list-style-type: none"> <li>• Daryl Fields, World Bank</li> <li>• Heads of Delegations</li> </ul>

## Annex B: Matrix of Comments Received and Responses

### 4<sup>th</sup> Information-Sharing and Consultation Meetings on the Assessment Studies of a proposed Rogun HPP Comments received during comment period (September 30 - November 4, 2013) at [rogunconsult@worldbank.org](mailto:rogunconsult@worldbank.org) and information sharing sessions

The purpose of the *Techno-Economic Assessment Study* (TEAS) and *Environmental and Social Impact Assessment* (ESIA) is to determine the environmental, economic, social and technical feasibility of a proposed Rogun HPP through comprehensive evaluation within the context of a least cost (electricity) generation expansion plan to meet energy demand in Tajikistan. These Assessment Studies will decide neither whether a proposed Rogun HPP will be built, nor the final design, should a project proceed. They will serve as an input to decision-making and support further dialogue among riparian countries, and with other stakeholders, development partners, and financiers.

Topic	Comment/Question	Response
<b>Investigation of the Salt Wedge (TEAS Phase 0 Summary Report)</b>		
<b>Potential impact of salt wedge (local or downstream)</b>		
<b>Hydro-geochemistry</b>	<p><b>Is there water under the [salt dome]?</b></p> <p>The Consultant notes that “various aquifers were defined and their natural conditions and features were described.” Because the details are not given in the summary report, the questions arise: is there water under the salt layer? (Under certain geological conditions subsalt water may be formed out of oversalt and lateral water. It may be in no way connected with salt dome or salt layers, and its collecting area may be located outside of salt. Sometimes subsalt water wells up the fissures in the salina or along its flanks). [Is there] intersalt water?</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>The overall hydrogeological conditions of the site have been assessed and the water levels are clearly identified. The hydrogeological model is well defined as are the relations of aquifers. Thus the analysis made on the dissolution process has considered the recognized conditions.</p>
	<p><b>No information on “oversalt” water and resulting phenomenon.</b></p> <p>Only a brief description is given of oversalt water: water and brines that move in the cover rocks over the salt. Oversalt water may induce the most intensive karst processes and is the</p>	<p>The dissolution phenomenon of the uppermost layer of the salt dome as it comes into contact with water, is the focus of the Phase 0 Summary Report. Different scenarios considered a range of parameters at</p>

	<p>greatest hazard. The report contains no data on the study of this eventual phenomenon/process.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>difference values and so capture karst processes. The mitigation measures proposed consider this possibility. Mitigation measures, monitoring arrangements and potential future remediation approaches have been proposed to deal with the situation – see below.</p>
	<p><b>Has the downstream impact of the salt dissolution phenomenon been assessed?</b></p> <p><b>Information on the hydro-geochemistry of the power site is missing.</b></p> <p><b>Is there an effect [of the salt in the water] on the turbines or other electromechanical equipment?</b></p> <p>Expressed by stakeholders from Tajikistan, Afghanistan, Kyrgyz Republic and Kazakhstan.</p>	<p>The hydro-geochemistry covered in Phase 0 addresses the salt dome as the dissolution effect is a very local phenomenon with only a very small amount of salt being dissolved in a large volume of water. The current situation represents the natural state of the salt dissolution process and there are no downstream impacts. Salt has not been detected in water sampling measurements at the embankments of the Vakhsh riverbed. In addition, the mechanical properties of the material used in the dam foundation will not be affected as the materials are from the same source as the riverbed.</p> <p>Given the local nature of the salt dissolution, the salt wedge issue is not applicable for the zone of the power house.</p> <p>The minimal trace presence of salt in the Vakhsh river will not have an effect on the electromechanical equipment.</p>
<p><b>Planned measures for managing the salt wedge</b></p>		
<p><b>and Groutin</b></p>	<p><b>The Summary Report does not provide enough information on the implementation or precise monitoring measures pertaining to the hydraulic curtain and grouting efficiency.</b></p> <p>Since there are rock salt and gypsum in the foundation of the Rogun HPP dam, therefore,</p>	<p>As stated in the Summary Report, implementing grouting as the only mitigation measure is not acceptable. A hydraulic barrier will need to be</p>

	<p>reliable methods are required that would allow timely evaluation of the efficiency of antifiltration measures and integrity of salt and gypsum. The coefficient of the dam stability against sliding and per cent of pressure reduction at the curtain are the main parameters used for evaluation of the efficiency of antifiltration facilities. This question is not considered in the Summary Report.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>concurrently implemented along with the grouting works.</p> <p>The Phase 0 Summary Report demonstrates that the combined approach is feasible and meets international standards of safety as represented by ICOLD. The sensitivity analyses undertaken cover the potential grouting efficiency losses. More detailed information would be developed during the detailed design stage.<sup>9</sup></p> <p>The remedial measures will require ongoing maintenance and monitoring which are feasible during construction and operations. Both the consultants and the Panel of Experts emphasize that a comprehensive monitoring system is a mandatory part of the proposed project. (See below) The efficacy of the measures was evaluated by modelling and sensitivity analysis, supported by significant historical and new site data that are deemed to be fully adequate by the Panel of Experts.</p> <p>The maximum allowable size of potential fissures that would not endanger dam stability has been calculated. None of the scenarios with mitigation arrangements in place reached this maximum size. In other words, the modelling takes into account the salt and gypsum integrity with regards to dam safety parameters.</p>
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<sup>9</sup> The Terms of Reference for the TEAS include a third Phase of study, namely detailed design. The decision to proceed with Phase III, and under what contract, will be taken by the Government of Tajikistan.

<p style="writing-mode: vertical-rl; transform: rotate(180deg);"><b>Use of Brine Curtain</b></p>	<p><b>Recommendation to use chemical gel-forming solution instead of brine curtain.</b></p> <p>I recommend (instead of brine curtain) considering use of chemical gel-forming solutions with the penetration ability being close to water in order to increase the density of the antifiltration grouting curtain. The use of chemical solutions of high value is a forced measure when we have to deal with micro-fractured rocks where grouting will not give the required effect. The international practice shows that the use of the solution results in specific water absorption at the curtain not exceeding 0.005 L/min.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>It has been confirmed by both the Consultants and the Panel of Experts that a brine curtain will not be included as part of the remedial measures. The brine curtain, which was part of the original HPI design, should not be deployed due to a possible clogging of the injection holes. Furthermore, the Panel of Experts considers that the grouting results are acceptable so that a chemical solution is not warranted. However monitoring of the efficiency of the grout curtain in operation will be required and remedial action implemented as necessary – see below.</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);"><b>Overall adequacy of measures</b></p>	<p><b>What is the overall adequacy of the measures in managing the potential risks of the salt wedge?</b></p> <p>Do the two measures, together, eliminate risk? What is the relevance of a safety factor of “3”? Are the measures sustainable over time or will they deteriorate, thereby increasing risk in the future? Are there additional measures to address an unfavourable scenario?</p> <p>What measures can be taken if leakage is discovered after construction?</p> <p>If the measures are not successful, what will be the impact downstream of the dam?</p> <p>Expressed by stakeholders from Afghanistan, the Kyrgyz Republic, the World Bank.</p>	<p>The analysis confirms that, under a range of scenarios, the combined measures meet international standards for dam safety, using a safety factor of 3 (with 3.0 being the most rigorous). The PoE agrees that a “factor of 3” is the highest standard possible compared to international practise of 1.5 – 3.0.</p> <p>Both the Consultants and the Panel of Experts have reiterated the necessity of immediate, comprehensive and sustained monitoring to detect variances from expected performance of the remedial measures and protection of the dam (see below). If such variances (i.e. fissure) were discovered, remedial measures could be initiated (both during construction and operations). These measures include the restoration of the hydraulic barrier and / or grouting using directional drilling which has been developed and commonly used in the industry during the last decades.</p>

<b>Future Monitoring</b>	<p><b>Accurate monitoring of the salt formation has to begin immediately.</b></p> <p>This is undoubtedly the most important recommendation of the Consultant. It is not subject to disputing and must be accepted. A tight monitoring must be established.</p> <p>Please, take note, that neither monitoring of subsurface water pressure, nor monitoring of permeability, nor microgravimetry allow registering or determining possibly beginning suffusion processes after the dam construction have been completed and the reservoir has been filled with water. Timely control of this process requires for another monitoring and other engineering protection measures.</p> <p>Obviously, all the recommended monitoring systems along with the observation, evaluation, control and management of the dam state, hydrodynamic and hydrochemical conditions, and other parameters should also include fundamental studies.</p> <p>It is also apparent that the natural hydrogeological situation will considerably change after the construction and during the operation of the HPP.</p> <p>Given the specific features of the site hydrogeological conditions it would be reasonable to accept the activities that would allow for maximum saving the natural hydrochemical conditions after the reservoir has been filled.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>Consultants and the Panel of Experts have reiterated the necessity of immediate, comprehensive and sustained monitoring. The monitoring measures identified in the reports include measurement of the displacements within the salt wedge and the embedding rock as well as a follow-up of the deformations within the salt body by series of clinometers. In addition, to effectively monitor potential salt leaching, the following systems are proposed:</p> <ul style="list-style-type: none"> <li>• groundwater head monitoring, in order to check the hydraulic barrier efficiency (boreholes and pressure cells),</li> <li>• water conductivity monitoring to check the model reliability and the on-going leaching process if any (boreholes and conductivity cells),</li> <li>• microgravity in order to check the salt rising rate at Ionakhsh Fault, potential cavity generation and even salt leaching when exceeding the wedge rise (one campaign every six months during stage 1 phase),</li> <li>• regular sonar inspection of the dam face once impounded, to detect any abnormal deformation of the upstream face.</li> </ul> <p>This continual data feed combined with modelling would enable early detection of variances in performance or formation of cavities.</p> <p>The Panel of Experts indicated that the slow rise of the salt wedge provides ample time for response and additional remediation (i.e., at a pace of 2.5 cm/year. it is estimated that it would take 40 years for a critical size fissure to form in the absence of any remedial measures).</p>
	<p><b>With particular regard to the reaction of salt on grouting material, what monitoring is needed to ensure the measures are sustainable?</b></p> <p>Expressed by stakeholders from Afghanistan.</p>	

**Technical efficiency and reliability of protection measures should be confirmed by facts.**

*The technical efficiency and reliability of the protection measures proposed by the Consultant are now confirmed only by mathematical modelling. It is not clear, whether the effect of the HPP dam and of the measures on the salt and gypsum dissolution process has been taken into account.*

**Were the calculations and parameters used in the modelling certified appropriate? Is the data base adequate (sufficient and up to date)?**

Expressed by stakeholders from Tajikistan and Kazakhstan.

The mathematical modelling is supported by a rich base of information, in part developed from the Soviet design years and augmented by subsequent studies and new site investigations performed for the current studies. There are some inevitable uncertainties in the values of a number of parameters. Reasonable estimates were chosen but uncertainties were addressed parametrically and by the adoption of a high safety factor. When there was some uncertainty on one parameter, the most unfavourable value was considered. Hydraulic conductivity and effective porosity are one of the most crucial parameters; they were determined by the mean of a long duration pumping test. The residual clay thickness above the salt wedge gives an idea of past leaching rate and fits with the model results in a reasonable range of uncertainty. The choice of parameters for the modelling combined with the use of a high factor of safety are considered to be appropriate by the PoE.

Ongoing monitoring, starting with a full baseline before any resumption of construction and impoundment, would be designed to continually update the information base and models. As noted above, this approach would allow abnormalities to be detected and addressed in a timely manner.

**Appropriateness of models, standards and data used**

<b>Rock Characteristics</b>	<p><b>The reduced level of lithological conditions for the salt cap with respect to the bottom of the reservoir and thickness of rock materials are not presented.</b></p> <p>Lithological conditions around the salt cap are presented without reduced levels with respect to the dam foundation and to the reservoir bottom and thickness of rock materials. This is necessary for the analysis and comments.</p> <p>Expressed by stakeholders from Uzbekistan.</p>	<p>The Summary Phase 0 Report does cover the lithological conditions for the salt cap.</p> <p>More detail on the entire site is covered by the more comprehensive geological assessment. A presentation on geological conditions was given in October 2012 for the 2<sup>nd</sup> Riparian Information-Sharing and Consultation Meetings. It reported on site investigations such as drilling, geophysics, rehabilitation of exploratory adits and hydrogeology. Based on preliminary results and numerous site visits, the Panel of Experts is of the opinion that the stability of the dam site and type of dam can be confirmed; the salt structure below the dam site can be appropriately managed to ensure operational safety, as covered in the Phase 0 Summary Report.</p>
	<p><b>More information on geotechnical and other rock parameters needed.</b></p> <p>Undoubtedly, the Consultant has studied the (heterogeneous) rocks, but the report bears scant results of rock study. Geotechnical parameters are not present in the report.</p> <p>One of the unfavourable geotechnical conditions for Rogun HPP construction is known to be common salt and gypsum in the dam base. The results of thorough evaluation of all would-be rock types for Rogun HPP dam are missing.</p> <p>On the basis of exclusively thorough studies of heterogeneous rock the following detailed rock characteristics shall be given: fissuring, gypsiferousness, mineral composition of salt wedge (common salt), mineral composition and structure of aquiclude-clay-3-m thick, degree of dispersivity and porosity, water permeability, rock condition etc.</p> <p>It is possible that such details are not required for the TEAS stage, yet these questions were included into the scope of the Terms of Reference for the Consultant.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>The noted rock characteristics are appropriately addressed for this (feasibility) phase of the proposed project development.</p> <p>The TEAS Phase II report will further assess the geotechnical characteristics of the site consolidating all geological investigations will be reported in the TEAS Phase II Summary report.</p>
	<p><b>The behaviour of rocks in interaction with the future dam was not studied.</b></p> <p>The presence of soluble rocks in the dam foundation creates conditions conducive to development of karst (cavern, cavity) and suffusion. Therefore, the Report should contain a description of possible karst and suffusion manifestations and the nature of the threatening risk, and the dynamics of their development. It is possible that the cavities (karst caverns) are observed in both soluble rocks (salt, gypsum) and above insoluble rocks.</p> <p>Expressed by stakeholders from Tajikistan.</p>	

<p style="text-align: center;"><b>Risk Assessment</b></p>	<p><b>Risk assessment and risk register missing.</b></p> <p>No risk assessment was performed (risks connected with simple dissolution of salt in combination with lixiviation of gypsum contained in other rocks surrounding the salt wedge, the risk of effect of the load of the dam and other facilities on easily soluble rocks). A risk assessment should be performed before and after mitigation measures. No risk register is prepared (probability, degree of risk, consequences). The measures recommended by the Consultant for prevention of dissolution of salt and consolidation of the rocks must minimize the risks to the level accepted internationally. The Report contains no data about it.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>A Risk Assessment is being prepared as part of TEAS Phase II Summary Report. It will include, but is not limited to, residual risks and mitigation measures.</p>
<p style="text-align: center;"><b>Cap Rock</b></p>	<p><b>Layer above salt cap not thick enough.</b></p> <p>According to Figure 4-1 Lithological conditions above the salt cap, the clay (formation) thickness is 3 m, what is less than 5 meters and cannot be considered as a reliable confining layer.</p> <p>The stated condition of the formation should be complemented with the following: the salt formation is in a stress state at depth.</p> <p>Expressed by stakeholders from Uzbekistan.</p>	<p>The long duration test evidenced that the cap aquifer behaves as a confined aquifer. The importance of the clay cover is crucial as it limits the leaching process. However its influence is related to the surface covering the wedge, not the thickness. To address potential uncertainty on the clay thickness, one scenario envisages that the clay cover is completely lost. The result of this modelling shows that one mitigation measure alone would not be enough to counter the dissolution effect and that in case of no clay cover, both grouting and hydraulic barrier have to be installed as recommended in the conclusions of the report.</p>

	<p><b>First layer above salt wedge (breccia) is not impermeable as stated in the report.</b></p> <p>In Figure 4-1, the first layer above the top of the salt wedge that consists of breccia, anhydrite and clay is specified as impermeable dense. Scientists from the Tajik Technical University (TTU) give a different definition:</p> <p>“Over the top of the salt formation, there is a cavity formed as a result of salt lixiviation, was filled with breccia represented as a reddish-brown argillo-arenaceous dense gypsified mass with argillite fragments. 25-30 m above the salt cap breccia is loose and insufficiently consolidated; argillite is heavily loosened and adjacent to breccia were identified there. (Source: TTU bulletin No.3, 2008).”</p> <p>In that case the filtration flow will move from the reservoir through decompressed oversalt cavity and unload to the downstream pond by contacting with the wedge.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>The TEAS consultants consider that a significant part of the wedge is covered by an impermeable body and that another part is covered by a more permeable one, containing the confined aquifer and being the vector of leaching. One of the scenario considered in the study corresponds to a complete loss of the partial impermeable clay cover: this requires implementation of the two mitigation measures concurrently as expressed in the final solution recommended to be implemented;</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);"><b>Rock solubility (modelling)</b></p>	<p><b>It is not clear how the filtration process will be controlled on the banks of the riverbed the dam is adjacent to.</b></p> <p>The Report also states that “all results are dependent heavily on the part of the salt formation surface covered with clay.” As it was stated above, the clay layer thickness (according to the more précised lithology) is merely 3 meters, and it should not be considered a reliable confining layer.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>Dissolved salt levels are only recordable at the dam foundation, meaning that salt is not found at the higher level of the riverbed embankments. This issue is covered in the sensitivity analysis section of the Phase 0 summary report.</p>

	<p><b>Was the potential increase in the solubility of rocks subjected to the effect of dam load taken into account during the modelling process?</b></p> <p>The main purpose of point 5 «Mathematical modelling of the dissolution process» is to substantiate the measures (grouting, hydraulic barrier) aimed to prevent dissolution of salt and, consequently, to control suffosion. These measures are specifically aimed to reduce the loss of water from the reservoir, to reduce water pressure and to reduce the filtration flow rates. The measures recommended by the Consultant for mitigation of consequences of dissolution of salt and probably of gypsum, extend the route of water filtration, i.e., the length of the shortest path of percolation.</p> <p>Were any studies undertaken of the influence of salt on the physical and mechanical properties of the embedding rock?</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>The wedge embedding rock has been subject to groundwater flow enriched with salt for more than several thousands of years (since the last ice age). The material has been tested and there is no evidence of reduced geo-mechanical properties.</p>
	<p><b>Log measurements would be a more effective means of determining the physical and mechanical rock properties (instead of only using data for core samples).</b></p> <p>Reliability of the mathematical model, according to the forecast of potential scenarios for dissolution process, is based on the data of physical and mechanical properties of the rocks obtained from core samples. However, core samples give restricted information about the fault due to a small radius of core sampling and loss of original physical and mechanical properties of the samples from the time of sampling to the analysis in the laboratory. It is also difficult to determine the bedding angles and existence of fracturing on the basis of the results of the core sample analysis.</p> <p>Therefore, to address the task of determination of physical and mechanical properties of the rocks, log measurements would be more effective (gamma-ray spectral logging, acoustic logging measurements, scanning lateral logging, and neutron-lifetime GR log). In that case according to the results of interpretation of the above mentioned complex, a three-dimensional lithological model can be calculated, on the basis of the data on the composition of clays, physical and mechanical properties of rocks, attitude of the layers and identified fracturing of materials.</p> <p>Expressed by stakeholders from Uzbekistan.</p>	<p>Using rock core samples as a means of determining physical and mechanical properties is the conventional approach taken at this stage of feasibility assessment and meets international standards. The parametric analysis that has been used appropriately accommodates the uncertainties of some properties at this stage. However, additional data collection and sampling such as log measurements can be considered at the detailed design stage.</p>

	<p><b>Input data needs to be included in the final report for the mathematical model related to the identification of risks associated with excessive dissolution.</b></p> <p>A standard deviation of the mathematical model for identification of risks of excessive lixiviation of salt depends on the database components, therefore it is necessary to include data of design parameters included in the blocks of input data of sub-models into the final report.</p> <p>Expressed by stakeholders from Uzbekistan.</p>	<p>A sensitivity analysis on the input data was performed for the analysis underlying the Phase 0 summary report.</p>
<p style="text-align: center;"><b>Seismicity</b></p>	<p><b>There is no data on the tectonic structure of the HPP construction site.</b></p> <p>Expressed by stakeholders from Afghanistan and Uzbekistan.</p>	<p>Following discussions on seismicity in previous riparian sessions, a deterministic seismic hazard assessment was undertaken, which addressed the tectonic structure on the site. This work will be reported as part of the TEAS Phase II report.</p>

	<p><b>What impact does the site's seismicity have on for the salt wedge? Might It create rifts that increase the risks?</b></p> <p><b>Will impoundment increase the seismic risk?</b></p> <p>Expressed by stakeholders from Tajikistan and Afghanistan.</p>	<p>All of the seismic data collected in Tajikistan will be assessed and used in Phase II of the TEAS. The ongoing geological assessment will further establish the status of the faults and risks. A risk assessment analysis to reflect such risks is currently being finalized.</p> <p>Preliminary results from the Deterministic Seismic Hazard Assessment presented at the 3<sup>rd</sup> Riparian information-sharing and consultation meetings in February 2013, indicated that the proposed project's design could appropriately account for the seismic conditions and potential challenges (including impoundment and reservoir triggered seismicity) and meet the design criteria of Maximum Credible Earthquake (MCE).</p> <p>The existing data is fully adequate to assess reservoir triggered seismicity given the availability of data collected from Nurek.</p>
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<b>Salt Structure</b>	<p><b>The approximate total depth and potential volume of salt is not given in the report.</b></p> <p>According to other sources it appears that the main body of rock salt in nature is most often located at a depth of 5 km under the ground surface. Consequently, it is arguable that tens of thousands tons of salt are located under the dam foundation (halite/rock salt/cooking salt). The salt body is in tension at depth. It is disturbing that the reservoir and the dam may be a kind of trigger for this stressed environment.</p> <p>According to some sources, the salt surface cap is traced 20-25 m below the water edge in the river and at the level of ground waters in the walls of the gorge.</p> <p>Further, the Consultant concludes that under the compressive horizontal tectonic forces the salt layer moves, resulting in a salt cap rising by 2.5 cm a year. It is not clear here, whether the salt rises continuously and salt rises every year or periodically, intermittently or gradually? The Report gives no answer to the question.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>The salt structure (including total depth and potential volume) is described in the Phase 0 Summary Report. This information is based on extensive investigations that have been carried out since 1978.</p> <p>Under the effect of orogenic forces the salt is being extruded continuously at an estimated maximum rate of 2.5 cm per year and this was considered parametrically in the analysis.</p>
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<b>Translation and Clarifications</b>	<ul style="list-style-type: none"> <li>– Figures 1-1 and 4-1 are not translated into Russian.</li> <li>– The phrase kinematic porosity in point 7.2 of the Report (second line) is again translated as kinematic permeability (кинематическая проницаемость) instead of kinematic porosity (кинематическая пористость). <ul style="list-style-type: none"> <li>○ In the text of paragraph Sub-model 3, the phrase <i>kinematic porosity</i> is again translated incorrectly as <i>kinematic permeability</i> (кинематическая проницаемость). It should be <i>kinematic porosity</i> (кинематическая пористость).</li> </ul> </li> <li>– 4.1. There is a definition for the term <i>lixiviation</i>, but this definition is more appropriate for the term <i>dissolution</i>.</li> <li>– 4.2 In brackets the mineral <i>anhydrite</i> is incorrectly translated into Russian as anhydride. As it is known, anhydride is a substance related to chemistry, rather than to a geological mineral (geology).</li> <li>– In the second paragraph the phrase <i>deriving transmissivity</i> was transferred into Russian as <i>permeability coefficient</i>, what is an incorrect translation.</li> <li>– It should be translated as: <i>water transparency</i></li> <li>– 4.3. In the first paragraph (the fourth line) the term <i>discharge</i> must be replaced by the term <i>debit</i>. A dissolved substance always tends to move from the places with a larger concentration to the places with lower concentration – this phenomenon is typical for diffusion.</li> <li>– The phrase <i>transport process</i> should be replaced with the phrase <i>displacement process</i></li> <li>– 5.1. In the third paragraph the phrase <i>transport laws</i> should be replaced with the phrase <i>fluid motion laws</i>.</li> <li>– 5.2 Subtitle: <i>Sub-model 1 – Underground water flow model: (подземных вод)</i> would be reasonable to state as: <i>Sub-model 1 –Groundwater flow model (грунтовых вод)</i>.</li> <li>– The phrase: <i>would not damage the crust and filters of the dam (кору и фильтры плотины)</i> should be stated as <i>would not damage the core and filters of the dam (ядро и фильтры плотины)</i>. This will make it easier for readers to understand.</li> <li>– Further, it is stated in the Report: <i>A conservative assessment shows that cavity generated by salt lixiviation might be critical only if the area is larger than 25 m (оценка показывает, что образование полости в результате выщелачивания соли может иметь критический исход только когда это происходит на площади 25 м).</i> First, the English version does not contain the word area. Second, the cavity has a diameter and not an area. What is probably meant here is a critical diameter, i.e. the maximum size of the cavity in the plan for collapse of the cavity roof.</li> <li>– The phrase <i>to maintain the reservoir pressure</i> was not translated into Russian.</li> </ul>	<p>These translation issues are noted and will be taken into account in the revised reports</p>
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Assessment of Existing Works (TEAS Phase I Summary Report)		
<b>Observations</b>	<p><b>Structural Assessment of Underground Structures carried out well.</b></p> <p>Paragraph 4 in the Summary Report <b>Structural Assessment of the Underground Structures</b> containing systematized and critical description of the state of the issue is of critical importance. The data is presented accurately and fairly. The subject of the analysis is just new structural problems and possible approaches to the solution of these problems. This issue clearly outlines the ways for further work.</p> <p>Expressed by stakeholders from Tajikistan.</p>	
<b>Bridge Status</b>	<p><b>The Construction Site Inspection section of the ToR (5.2) is well addressed, with the exception of a lack of information on the state of the bridge at the construction site.</b></p> <p>Brief but important objective evidence of the construction site inspection (point 5.2 of the Terms of Reference is performed with excellence, except for missing data or assessment of the actual state of the single bridge at the construction site that connect the banks of the Vakhsh river) are presented at a high professional level.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>Both the TEAS and ESIA Consultants each hired an infrastructure expert to assess the site and existing structures. The status of existing structures and cost of bringing the bridge up to necessary international standards was discussed at the 3<sup>rd</sup> Riparian session. These costs are being finalized and will be included in the economic analysis and reported in the TEAS Phase II summary report.</p>

<b>State of Existing Works – Tunnels and Excavations</b>	<p><b>The Summary Report does not indicate if the works performed (e.g. tunnelling, installations) and constructed facilities deviate from the design data and/or technical requirements.</b></p> <p>The results of the assessment on point 5.3 of the ToR are well presented except for the assessment of the compliance of the performed construction and installations, tunnelling and other operations with the requirements of the effective technical project (specifications of the project of the Hydroproject Moscow Institute for the Rogun HPP). In brief, it is not stated in the Report if there are any deviations of the parameters of the works performed and constructed facilities from the design data (no assessment of the compliance of the works with the technical project).</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>A Design Criteria Document that was produced by the TEAS Consultant, at the Panel of Experts' request, to set out design data and technical requirements. It was developed in accordance to the latest international standards for Dam design, construction and safety. This document was released and presented during the 2<sup>nd</sup> Information Sharing Meetings in Almaty from 6-7 November 2012. The design criteria are a significant update from past standards and include population at risk and dam safety hazards when selecting various design parameters, most importantly the design floods and the design earthquakes.</p> <p>The Design Criteria Document is applicable to all segments and components of the proposed project, including existing works. Existing works would need to be upgraded where they do not meet the Design Criteria. For a more comprehensive summary of necessary remedial measures for existing works, please refer to the comment regarding the current status of underground works and the Phase I Summary report.</p>
	<p><b>What will be further functional purpose of the passed left bank tunnel No.T2 (access to the gate chamber, to the saline gallery and to the dam body) 690 m long and constructed brine production plant if the Consultant makes a recommendation about inexpediency of using brine curtain?</b></p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>The left bank tunnel No. T2 is not currently used for brine injection. In any case the tunnel is needed to reach tunnel T-8 which is the access to the diversion tunnels gates chambers; recommendations for its completion have been made in the Phase I report.</p>
	<p><b>Current situation of construction of mud flow dam (Obishur).</b></p> <p>For protection of the downstream area of the Rogun HPP from mud flows in Obishur river, construction of a mud flow dam 100 m long was provided for. What is the current situation?</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>Activity on the Obishur mudflow dam is allowed under current WB agreements with the Government of Tajikistan. If the Assessment Studies determine that a project is feasible and if the Government proceeds, the Obishur mudflow dam will need to be completed before the main construction works start as it is related to safety of the works</p>
	<p><b>Has the study considered a potential increase in the volume of underground excavation (e.g., to 1.5 to 2 times the current size of the underground caverns) for the purposes of</b></p>	<p>There would be no underground expansion of the Powerhouse and Transformer Hall cavern complex</p>

	<p><b>power generation?</b></p> <p>Expressed by stakeholders from Uzbekistan.</p>	beyond current design.
<b>Hydrological Data</b>	<p><b>The hydrological data is not sufficient.</b></p> <p>The design of the surface and underground structures of the Rogun HPP is carried out in accordance with the scenarios of the previous project from the Soviet times and ignoring modern safety regulations. For substantiation of main parameters of the hydrosystems, data of hydrological observations for at least 3-4 years is required.</p> <p>Expressed by stakeholders from Uzbekistan.</p>	<p>International standards and an up-to-date database have been used to carry out the hydrological analysis. At the 2<sup>nd</sup> Riparian Information-sharing and Consultation Meetings in November 2012, interim findings on the Hydrology Report were discussed. These findings included the characteristics of the Vakhsh river basin, inflows at the site of the proposed project, floods and potential climate change impacts. It was determined that sufficient hydrological and seismic data exist with which to continue the studies at this stage. The dam has now been reassessed for the Maximum Probable Flood, in accordance with the current international standards for large dams. This point was reiterated at the 3<sup>rd</sup> Riparian Information-sharing and Consultation Meetings in February 2013. Also see above on the Design Criteria Document.</p>
<b>Construction Standards</b>	<p><b>Adherence to construction rules and regulations.</b></p> <p>It is seen from section 2.3 that the concrete works are performed with violation of the requirements to organization and performance of works during construction of hydraulic structures. The quality of concrete is a basis for safety of the hydraulic structure and must meet the requirements to the concrete compressive and tensile strength, impermeability, frost resistance, resistance against aggressive effect of water, deformation and shearing parameters. According to the current rules, concrete mix should be prepared at a central computerized concrete plant or at an unattended automated plant with software with a mixer of at least 1000 l capacity. Preparation of concrete mix at several plants is permitted only subject to substantiation by the results of a technical and economic assessment.[Construction rules and regulations III-16-80].</p> <p>Expressed by stakeholders from Uzbekistan.</p>	<p>Tests on specimens drilled from the existing structures have been performed to determine the concrete compressive strength. This information was taken into account for the structural verifications of tunnels and caverns. These tests were conducted on the lining of the existing Caverns (powerhouse and gate chambers), Diversion Tunnels, Stage 1 Headrace Tunnel and transportation tunnels T-4 and T-3.</p> <p>The results of the tests show concrete compression strength figures usually in excess of 25 MPa: this value was assumed as reference for the structural verifications. Strengthening measures to the existing concrete works were proposed where the technical assessment gave negative results.</p> <p>The standards for concreting will be required to be followed when and if construction resumes.</p>

**What is the current status of Diversion Tunnels 1 and 2 as well as the Powerhouse? How much time would be required to complete the remedial measures?**

**Lining of the tunnels is currently 60 cm thick. Is additional treatment needed to mitigate the impact on the lining due to additional stress?**

Expressed by stakeholders from Tajikistan, Kyrgyz Republic and Uzbekistan.

Major remedial works are required for both the Diversion Tunnels 1 and 2, the Powerhouse and Transformer Hall Caverns, the Powerhouse Access Tunnel (T-4) and the Permanent Access Tunnel (T-3).

With regard to the **tunnels**, current as built conditions do not fulfil the technical requirements with respect to safety and serviceability under current internationally recognized design criteria and standards. The tunnels' permanent supporting systems need to be strengthened. Further analyses needs to be carried out in a subsequent detailed design phase to identify appropriate strengthening measures for different tunnel structures. For the purpose of this study, plausible estimates, appropriate to this stage of feasibility analysis, have been made of the extent of rehabilitation measures required for the various tunnels and of the related costs.

The impact and the additional pressure placed on the lining would be further assessed and measured during the detailed design stage through the creation of a complementary system that will reduce the level of stress on the concrete. Results from the measurements would be used to monitor adherence to international standards at individual points within the system.

Concerning the **Powerhouse and Transformer Hall Complex**, the stress and deformations distribution do not meet required stability conditions for the cavern complex as a whole. The current situation requires additional reinforcement and stabilization measures before any further deepening of the excavation in the powerhouse cavern can be undertaken safely. Strengthening measures are needed and the implementation of a monitoring system is required. The analyses confirmed that, through the proposed set of stabilization measures, it is possible to improve the stability conditions in the caverns with the aim to

		<p>achieve, once the detailed intervention design will be completed, full compliance of the work with the required criteria of safety and serviceability.</p> <p>Proposed remedial measures for all underground works will take a minimum of 18 months.</p>
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**What are the cement standards and do they comply with the requirements of international codes and regulation on construction and safety standards?**

It was very useful to find answers to the questions such as: number of cement grades and brands used, cement supply organization system, state of the premises of concrete production facilities and concrete aggregates supply communications, the degree of their isolation from the effect of low and high air temperature, insolation and availability of necessary heating, cooling, and dust collecting installations.

Undoubtedly, use of obsolete and physically worn-out equipment in production of concrete affects its quality. Therefore, we cannot but agree with the Consultants' opinion that the facilities need to be upgraded. Therefore, a question arose concerning the quality of already performed concrete works.

Subject to high risks and threats imposed by potential abnormal situations, I recommend to extend this section in the final report with provision of more detailed information **about actual performance of** formworks, reinforcement and concrete works, methods of preparation and transport of concrete mix, how precast reinforced constructions are mounted and their compliance with the requirements of the Construction Rules and Regulations and international safety standards.

Expressed by stakeholders from Uzbekistan.

The existing structures were performed with techniques and methodologies in accordance with Russian Standards valid at the construction time.

The TEAS assessment process included the execution of tests on concrete samples cored by existing structures, with the purpose to determine the concrete compressive strength. This information was taken into account for the structural verifications of tunnels and caverns. These tests were conducted on the lining of the existing Caverns (powerhouse and gate chambers), Diversion Tunnels, Stage 1 Headrace Tunnel and transportation tunnels T-4 and T-3.

The results of the tests show concrete compression strength figures usually in excess of 25 MPa: this value was assumed as reference for the structural verifications. Remedial measures in terms of structural strengthening were proposed for those structures where detailed structural calculations for Diversion Tunnel sections in the worst conditions, performed according to Eurocodes, and technical assessment for other structures, gave negative results.

New works will be performed according to codes and methods internationally adopted at present as the state of the art.

<b>Seismic Load</b>	<p><b>The seismic load methodology does not meet international standards.</b></p> <p>I would like to point to Chapter 4. Technical Assessment Of Underground Structures, containing a methodology for assessment of seismic load as not acceptable. In fact, given the accidental nature of seismic loads depending on many factors including amplitudes, spectral content, direction and duration of the effect, the estimates of the structures for seismic loads are connected with uncertainty of high degree. Therefore, in order to ensure safety of the structures designed in seismically active areas, it is logical to change from the limit state method to the maximum acceptable risk method of calculation. In this connection it is necessary to develop a monitoring programme in compliance with Eurocode recommendations.</p> <p>Expressed by stakeholders from Uzbekistan.</p>	<p>Maximum credible earthquake (MCE) was proposed and accepted as one of the design criteria for the proposed project. The seismic load methodology in the Phase I Report was developed using Eurocode recommendations reflecting international standards. Eurocode recommendations cover important aspects of dam design such as the structural and geotechnical design of dams, including foundations, tunnels, slope stabilization, etc., in seismic regions.</p> <p>Detailed Structural calculations performed on the Diversion Tunnels section in worst conditions (combination of loads and lining thickness) were carried out simulating the seismic effect in terms of shear stress calculated on the base of the maximum shear strain, estimated in free field condition, induced during the seismic event. The maximum shear strain was calculated with reference to the surface peak ground acceleration related to the MCE rectified considering the soil factor and the actual depth of the analyzed structure. (Appendix 2 of Phase I Report).</p> <p>The necessity of a monitoring program was confirmed by both the consultants and Panel of Experts (see above).</p>
<b>Electro-mechanical equipment</b>	<p><b>What is the condition of the existing electromechanical equipment?</b></p> <p>Expressed by stakeholders from Tajikistan and the Kyrgyz Republic.</p>	<p>A complete assessment, including extensive site visits, was carried out by the Consultant. The assessment found that some remedial measures are both necessary and feasible with regard to existing electromechanical equipment on site, but that such remediation is not extensive. The Consultants findings were verified by the Electromechanical Expert from the Panel of Experts who stated that the units are well designed for the era in which they were manufactured and do not require major modification.</p> <p>All cost implications will be taken into account in the Economic Analysis that is part of Phase II.</p>

<b>Translation</b>	<p>It is stated in the English version in point 2.2 “Quarries”: <i>The following tables summarize the available amounts of material to be placed in the highest dam alternative.</i> This sentence is translated as: <i>Следующие таблицы суммируют доступный объем материала, укладываемого в альтернативную самую высокую плотину</i> (in the Russian version the word <i>alternative</i> was excluded from the text for unknown reasons). Does it mean that the <i>highest dam alternative</i> means the dam height of 300 m (the design height is 335 m, alternative heights are 265 and 300 m).</p> <p>In paragraph 3.1 <b>Present Status of the Underground Works</b>, it is stated: <i>Extensive underground works have been performed at the Rogun project site during the period 1982-1990 with the total length of 27 km.</i> The English version of the same paragraph <b>does not contain the phrase with the total length of 27 km.</b> It states: <i>Extensive underground works have been performed at the Rogun project site during the period 1982-1990.</i> The total length about 27 km relates to 2012, and not to 1990 (see paragraph 2.1.2 of the Summary Report</p>	<p>These translation issues are noted and will be taken into account in the revised reports.</p>
<b>Consultation and Study Process</b>		
<b>Disclosure</b>	<p><b>The ESIA report and Phase II Report should be disclosed in full.</b></p> <p>I earnestly ask you and strongly recommend to publish the full (not summary) draft ESIA report with all appendixes. Also, I kindly request you to find an opportunity for publication of the full draft Phase II report.</p> <p><b>The [Phase I] Summary Report does not compensate for the analysis in the full report.</b></p> <p>The Summary Report does not contain sufficient data about the analysis and generalization of the results of examined documents (point 5.1 of the Terms of Reference was performed partially). Conflicting data contained in different documents/data must be analysed and assessed with particular care.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>The ESIA will be disclosed in full. A comprehensive Phase II Report Summary will be publicly available. This document will have been reviewed by the Panels of Experts and World Bank as a full and complete response to the Terms of Reference. The full Phase II report, consisting of some 20 sub-reports, will not be public to protect confidentiality related to security and commercial interests. This is consistent with World Bank practice globally.</p>

<b>Consultation Meetings</b>	<p><b>Ample time should be allowed for discussion of ESIA and Phase II reports in upcoming Consultations.</b></p> <p>I recommend that during the fifth final meeting draft Phase II and ESIA reports should be discussed not in one day, but separately in different days. The Phase II report should be discussed prior to the discussion of the ESIA report. Given the large volume of the ESIA report it would be advisable to discuss it for at least 1.5 - 2.0 working days, and civil society representatives should be allowed not only asking their questions but also entitle them for final speech/comments with respect to the ESIA with the speech time about 3 minutes.</p> <p>One and a half top two months should be allowed for review and comment on the final reports.</p> <p>Expressed by stakeholders from Tajikistan.</p>	<p>The World Bank appreciates these suggestions. The next round of Riparian Information-Sharing and Consultations Meetings will take into account the volume of information being disclosed. The World Bank remains committed to a transparent and inclusive consultation process.</p>
<b>Panel of Experts</b>	<p><b>The PoE should make a definitive statement regarding the construction of Rogun HPP before, or at least in parallel with the development of technical detailed designs.</b></p> <p>The international independent panels of experts confirmed the correct choice of the construction site subject to the current knowledge of the specialists and the high level of machinery and technologies. As one Chief Project Engineer says: "If we are entrusted with designing a plane without concrete, we will design it". The expert panel has not yet made its positive or negative decision, yet it tends to a positive decision concerning construction of the Rogun HPP.</p> <p>However, in the process of design of any large facility, the first step is TEAS, then an "outline", etc. In our case it is necessary to obtain the opinion of expert examination whether the reservoir construction is necessary and expedient or not. Otherwise, this question will not be solved unambiguously. This issue was also raised by Uzbekistan in the beginning of the year. The World Bank promised to provide answers to this question, after the opinion of expert examination, yet no answer to this question has been received so far.</p> <p>I think that the question of relevance and expedience of the Rogun HPP construction should be decided upon before the technical expert examination or at least in parallel with it. Technical expert examination is easier to conduct, as it is made for the ready project, whereas preparation of an opinion on the project relevance and expediency is very difficult and labour-intensive work, as the expert examination is carried out by unknown ways.</p> <p>If we are entrusted with this issue, we can take this job.</p> <p>Expressed by stakeholders from Uzbekistan.</p>	<p>The Panels of Experts (PoEs) provide advice throughout the study process, sharing their opinions – and receiving feedback – during consultation periods. The Panels' statement on the feasibility of the proposed project will take into account all aspects of the studies; as such, their opinion will be consolidated in a Final Report by the PoE at the conclusion of all supporting analysis (i.e., into the ESIA and Phase II TEAS reports).</p> <p>Some sections of both reports are still under review. For example, the economic and financial analysis is underway as are the comparison of three dam heights (and so reservoir size), assessment of the least cost expansion plan for power in Tajikistan, and flood management. These outstanding analyses will provide insight into project relevance and benefits.</p>
<b>Other Issues (outside the scope of the salt wedge and existing works)</b>		

<b>Downstream flow impacts</b>	<p><b>What will be the effect of Rogun Dam on [the] Amu River (River Between Afghanistan and Tajikistan) Discharge?</b></p> <p>Expressed by stakeholders from Afghanistan.</p>	<p>An understanding of the potential impacts downstream from the proposed Rogun HPP is a required component of the ESIA. This assessment is underway. It will be based on the Government of Tajikistan's commitment to the Nukus Declaration and obligations and rights under Protocol 566 that allocates flows across countries.</p> <p>With regards to the possible effects of Rogun on water tables in Afghanistan, there is no current treatment of this issue in the ESIA or in the ESIA TOR. The ESIA will consider only the potential impact of the proposed Rogun HPP.</p> <p>Afghanistan is not a signatory to Nukus Declaration or Protocol 566 but, Protocol 566 does assume Afghan water usage.</p>
	<p><b>What will be the effect of Rogun Dam on Water Table at Northern Afghanistan (Mazar, Kunduz Takhar and Badakhshan provinces)?</b></p> <p>Expressed by stakeholders from Afghanistan.</p>	
	<p><b>Has the flow analysis of the Amu Darya River taken into account dams that will be built in both Tajikistan and Afghanistan?</b></p> <p>As this Dam is going to be constructed on a river which flows toward Amu River, and Government of Afghanistan is also planning dams on different rivers in Northern Afghanistan (Kunduz, Takhar and Badakhshan etc) which all flows into Amu River. Have considered effects of all these Future Dams in Afghanistan and Tajikistan on Amur River?</p> <p>Expressed by stakeholders from Afghanistan.</p>	
	<p><b>Amu-Darya flow analyses should be sure to take potential Afghanistan intakes into account.</b></p> <p>The World Bank an active participant in addressing the issue of rational use of limited water resources in the Amu-Darya basin, should pay its attention to the reclamation works in Afghanistan in order to exclude unnecessary works and for saving financial means and for prevention of future misunderstanding on the question of water intake by Afghanistan.</p> <p>Downstream flow analysis should address water supply issues, including issues with Uzbekistan.</p> <p>Expressed by stakeholders from Afghanistan and Kyrgyz Republic.</p>	

	<p><b>All Riparians, including Afghanistan, need to adhere to the Nukus Declaration and Protocol 566.</b></p> <p>Afghanistan begins gradually take an active part in the use of water resources in the Amu-Darya River basin. In this connection Afghanistan must sign the Nukus Declaration and Protocol 566, as a full-fledged member in using water resources of Amu-Darya river basin, before preparation and signing future agreements.</p> <p>Expressed by stakeholders from Uzbekistan.</p>	
Alternatives	<p><b>What if the size of Dam is decreased instead of constructing a large dam?</b></p> <p>Expressed by stakeholders from Afghanistan.</p>	<p>The TEAS Phase II study is comparing three dam heights and three generating capacities for each height as well as a no-Rogun option for a total of ten separate scenarios.</p>
	<p><b>Has the need or rationale for this dam been established taking into consideration economic and ecological considerations?</b></p> <p>Expressed by stakeholders from Afghanistan.</p>	<p>The ToR of the ongoing TEAS and ESIA Studies provides for consideration of economic and ecological factors.</p>
Dam Type	<p><b>Is this Dam only for Hydro Power or Multi-Purpose Dam?</b></p> <p>Expressed by stakeholders from Afghanistan.</p>	<p>The ToR for the Assessment Studies treats a proposed Rogun HPP as a hydropower project. It may also provide protection for the Vakhsh cascade against extreme floods. The storage capacity could be used to provide additional summer releases in dry years if such operation can be agreed upon between riparian countries.</p>

<b>Dam Safety</b>	<p><b>What are the dam safety related measures in the event of dam failure?</b></p> <p>As the planned reservoir is very big, and there are also problems at the foundation (Salt Zone), in case of dam failure what will be the effects on Tajikistan and neighbouring countries?</p> <p>Expressed by stakeholders from Afghanistan.</p>	<p>The design criteria for dam safety were revised for modern international standards. Dam safety (design) criteria were discussed at the 2<sup>nd</sup> Riparian Information-Sharing and Consultation Meetings in November 2012. The dam safety criteria is based on international guidelines including the ICOLD (International Commission on Large Dams), specifically that Probable Maximum Flood (PMF) be adopted in design structures for hydrological safety and that the Maximum Credible Earthquake (MCE) be taken into account for the seismic safety of the structural design of the dam and appurtenant works. Design criteria apply to all aspects of any proposed project, including existing and potential works.</p> <p>As a part of the international standards, every dam, especially a large one, will need to have the Operation Manual and Emergency preparedness Plan produced before the impoundment starts.</p>
	<p><b>The Rogun dam was designed 50 years ago based on Soviet technology. These standards are out of date and the experts responsible for this study need to approach the issue of dam safety with great responsibility.</b></p> <p>Expressed by stakeholders from Uzbekistan</p>	<p>The current feasibility assessment studies have reviewed all the design issues for the Rogun power project, including the critical aspects of dam safety, on the basis of design criteria that was developed in line with modern design practices. In addition, the work of the Consultants has been subjected to intense scrutiny by both the Panel of Experts and the World Bank and improvements in the proposed design have occurred as a result.</p>

### **Annex C:**

#### **List of October 2013 Information Sharing and Consultation materials available on [www.worldbank.org/eca/rogun](http://www.worldbank.org/eca/rogun)**

- Meeting Agenda
- List of Participants (for October 18, 2013)
- Phase 0 -- Geological and Geotechnical Investigation of the Salt Wedge in the Dam Foundation and Reservoir: Summary
- Phase I -- Assessment of Existing Rogun HPP Works: Summary
- Presentations
  - [Key Issues of Participants](#) (by World Bank)
  - [An Update on Studies](#) (by World Bank)
  - [Geological and Geotechnical Investigation of the Salt Dome in the Dam Foundation and Reservoir \(Summary\) Phase 0 Report](#) (by Coyne Et Bellier)
  - [Assessment of the Existing Rogun HPP Works \(Summary\) Phase I Report](#) by (Coyne Et Bellier)
  - [Phases 0 & I Considerations and Assessment Status Update](#) by (Engineering and Dam Safety Panel of Experts)
  - [Next Steps](#) (by World Bank)
- Consultations report (including Matrix of comments and responses)