TERMS OF REFERENCE (TOR)

Consultancy services for Dam Safety, Civil, Electro-Mechanical Works and Capacity Building
Kali Gandaki A Hydropower Rehabilitation Project (KGAHPPRP)
(KGAHPPRP/S/QCBS-1)

Background

1. The World Bank is considering funding the rehabilitation of the Kali Gandaki A Hydropower Plant in Nepal. The Kali Gandaki “A” is a 144 MW Hydropower Plant, located in central Nepal. It includes a 44 m tall dam with high-level radial gates, an intake and desander, tunnel, and powerhouse equipped with Francis turbines operating under a net head of 115 m of design head at a discharge of 142 m$^3$/s. The dam site is located at approximately 83° 36' East and 27° 57’ north, some 180 km west of Kathmandu. Commissioned in 2002, today it is the largest hydroelectric power station in Nepal. The project was funded by the Asian Development Bank, designed by a consortium of international firms and also constructed by international contractors. It operates as a run-of-river plant with pondage sufficient to provide 6 hours of peak power, and generates about 750 GWh of electric energy annually. Nearly 25% of the total country’s generation and 40% of Nepal Electricity Authority’s (NEA) generation is supplied by this plant. Nepal experiences a severe electrical power shortage with daily nationwide load-shedding, and this shortage is most severe during the low-flow winter months.

2. The Kali Gandaki hydropower plant suffers from high sediment loads during the monsoon season, which causes severe damage to the hydro machinery. During the dry season turbines are further damaged by cavitation attributed to the seasonally low tailwater elevation. The dam impounds a 7.7 Mm$^3$ reservoir, of which 3.1 Mm$^3$ consists of live storage, sufficient for 6 hours of peak power. The dead storage pool is fully sedimented, and the live pool has lost about 7% of its volume to sedimentation. These sediments consist primarily of medium to fine quartz sands. Sediment accumulation within the live pool is controlled though reservoir drawdown during the monsoon season. The plant also experiences seasonally reduced power production due to excessive clogging of the trash rack. It is desired to optimize plant operation to maximize energy production and sustain long-term operations.

3. Modifications have been proposed by NEA to the headworks and the desilting basins with the objectives of: (a) reducing the sediment load reaching the turbines, and (b) reducing operational interruptions and excess head loss due to clogging of trash racks.

4. The rehabilitation also involves replacement/refurbishment of the turbines and other electro-mechanical equipments and upgradation of PLC automation System including instrumentation and communication system, improved trash rack cleaning system, some hydraulic modifications to the inlet zone of the desanders as well as mitigation measures to resolve cavitation issues.

5. A draft Operating Manual was developed in 2001 but was not updated to incorporate plant operating experience, especially with respect to procedures to maximize power production while achieving sustainable sediment management. The dam also lacks a dam
safety plan which includes an instrumentation plan, emergency preparedness plan.

6. Approximately 100 m of the intake access road has been affected by a landslide immediately upstream of the headworks, and a portion of the road collapsed into the reservoir. This slope continues to be unstable and requires treatment. Two factors are thought to have contributed to this slope instability: scour at the toe of the slope by the river and the multiple road cuts across the face of the slope for construction of the intake access road.

A. Project Components

7. **Component A: Civil Works** will address the main items related to civil works and will consist of the following sub-components.

   - Sub-Component A1: Headworks Modifications.
   - Sub-Component A2: Improving Dam Safety Monitoring & Instrumentation.
   - Sub-Component A3: Maintenance Works.

8. **Component B: Electro-Mechanical Works.** This component consists of mechanical and electrical works divided into two sub-components.

   - Sub-Component B1: Mechanical Works.
   - Sub-Component B2: Electrical Works.

9. **Component C: Technical Assistance and Capacity-Building.** Component consists of the following three sub-components.

   - Consulting Services for Dam Safety, Civil & Electro-Mechanical works.
   - Safeguard Implementation.
   - Capacity-Building.

B. OBJECTIVES / PURPOSE OF ASSIGNMENT

10. The objective of the service will be to: i) prepare detailed design, cost estimates, bill of quantities, bidding documents and assist in the bidding process and supervision of construction of civil works; ii) develop plans for Sustainable Sediment Management and Sediment Guided Operations at Kali Gandaki A; iii) assess the slope stability problem and develop a design for remedial measures to control the unstable slopes upstream of the headworks; iv) determine if there is any significant rock scour problem in the channel immediately
below the dam and propose concept and design to remedy the problem; v) develop a dam safety plan for Kali Gandaki A dam and assist in the formulation of a national dam safety plan; vi) assist NEA to supervise the installation of electro-mechanical works; vii) assess the automation control system, upgradation requirement and assist in the preparation of specifications, bid documents, supervision, installation and commissioning; viii) supervise the quality of the spare parts procurement under electromechanical works; ix) supervise the thermodynamic tests of the turbine; x) develop the final operating manual for Kali Gandaki dam which includes optimization of power production operations, sediment-guided power production to minimize damage to hydro machinery, to sustain long-term capacity in the reservoir live pool, and to minimize flooding at the Village of Seti Beni; xi) capacity building of NEA counterpart staffs both at assistant and officer level through involvement in all phases of the project and undergoing specialized training at manufacturers’ premises; and xii) training NEA personnel in implementation of the recommended procedures contained in the final Operating Manual including sampling, data collection protocols and operation and maintenance practices in hydropower stations;

C. SCOPE OF THE SERVICE

11. Modifications to Civil Works

(i) The Consultant shall review the recommendations on headworks modifications made by Hydrolab based on the results of physical modeling, and by Dr. Gregory Morris, independent Consultant. A physical model is still present at Hydrolab and the Sediment Expert should study the model and suggest any additional tests that may be needed on the physical model.

(ii) The Consultant shall Prepare detailed design drawings of the recommended headworks modifications, prepare technical specifications, BOQ, estimate project cost, estimate construction timetable focusing on minimizing power plant outage, and prepare bidding documents. Headworks modifications include civil works to modify the intake configuration, installation of improved machinery for cleaning trash racks, and the fabrication and installation of hydraulic deflectors in the inlet area of the desanders.

12. Dam Safety Plan

(i) To resume appropriate dam safety management at KGAHPP and to draw lessons for preparing guidelines for a national dam safety program and shall include:

a) The Consultant shall review Technical Archive of the project; recommend electronic system for data storage, retrieval and use to be housed centrally in a newly created cell in NEA head office.

b) The Consultant shall inspect existing instrumentation and put back in service what can be made good by resources available on site (e.g. open type piezometers, benchmarks for global movement survey, seepage monitoring devices).
c) The Consultant shall prepare technical specifications, bill of quantity and cost estimates of recommended instrumentation rehabilitation/ addition requiring procurement.

d) The Consultant shall prepare Instrumentation Plan and train operators in its use.

e) The Consultant shall conduct a PFMA (Potential Failure Mode Analysis) Workshop according to the methodology developed by US FERC (Federal Energy Regulatory Commission) and described in www.ferc.gov/industries/hydropower/safety/guidelines/eng-guide/chap14.pdf.

f) The Consultant shall prepare a Dam Safety Plan to include an Operation and Maintenance Plan, and Emergency Preparedness Plan of KGHPP, train operators in implementing the provisions of the plans.

g) The Consultant shall recommend establish a Central Unit in NEA in charge of Dam Safety and Quality Management in the portfolio of hydropower projects operated by NEA.

13. National Dam Safety Regulations

(i) The Consultant shall help formulate a National Dam Safety Plan and building on the a) long-term capacity-building in NEA on sustainable dam operation and safety management; b) regulatory procedures for dam safety management to be followed by operators; and c) setting up a regulating entity for dam safety; d) conduct workshops to discuss the findings from Kali Gandaki on Dam Safety and organize workshop on dam safety awareness and the need for a National Dam Regulator and policy.


(i) The Consultant shall (a) develop plans for Sustainable Sediment Management and Sediment Guided Operations at Kali Gandaki. This plan will be developed from a review of the operation manual prepared by Khali Mahmood and Damodar Shrestha in 2001, the Hydrolab physical model and report, the reports prepared by Bank’s consultants during 2012 and 2013, bathymetric and other data collected by NEA, and information collected during interviews and field observations during the monsoon. (b) Incorporate recommended Sediment Management activities into the final Operating Manual (c) Monitor installation of Real Time Sediment Monitoring equipment (LISST real-time sampler) and upgrading of the sediment laboratory, and be present at the site for a period of several days during the monsoon to observe sediment transport phenomena and to guide and assist NEA in the collection, reporting, and interpretation of hydrologic and suspended sediment data as it relates to implementing sediment guided operations to maximize power production while minimizing turbine damage. This activity will also include sampling in the desanders to better document their performance during periods of high sediment loading. Based on observations during the site visit, the Consultant shall develop or consider improving any protocols considered necessary to meet the plant’s operational objectives.
(ii) The Consultant shall prepare sediment management plans incorporating measures that can be implemented to minimize the sedimentation problem and flood levels at Seti Beni and Holy Stone pilgrimage site located at the edge of the Kali Gandaki River at the upstream limit of the reservoir pool, the area of delta deposition.

(iii) The Consultant shall provide onsite training to NEA operational personnel in implementing the procedures which are outlined in the final Operational Manual, including tasks such as data collection, record-keeping, and data interpretation to optimize plant operation and safety.

15. Operation of the Reservoir

(i) The Consultant shall develop optimum operating guidelines based on sediment management. More detailed sediment modeling outcome will establish whether the operating level can be held at 518 for a shorter time period to increase generation without adversely affecting the water levels and sedimentation at Seti Beni. The operating rule is relevant because Francis turbines have steep hill curves, i.e. small change in discharge and in head result in large changes in efficiency. The design net head at Kali Gandaki is stipulated as 115 meters, which provides 94% turbine efficiency. But given the operating levels of the reservoir, waterway head losses, corresponding tail water level, the corresponding turbine efficiency decreases. The Consultant shall study the operating rules to help design the best approach to maximize generation.

16. Slope Stability

(i) The Consultant shall (a) analyze the slope stability problems on the left bank of Kali Gandaki reservoir immediately upstream of the headworks based on site visit and review of prior reports (b) Prepare detail designs, technical specifications for remedial measures and bidding documents for the slope stability works. One option under consideration by NEA is relocation of the intake access road, and the Consultant shall review this option in conjunction with NEA personnel (c) study geological mapping and characterization of the rock slope on the right side of the spillway; detailed mapping of rock mass joints and defects (orientation, spacing, persistence and other defect characteristics) to determine failure modes and recommend rock mass reinforcement measures to counteract progressive failures.

17. Rock scouring below the dam

(i) The Consultant shall (a) inspect Rock Scouring at the area immediately below the dam to determine if any rock scour problems exist which require treatment, and recommend a treatment strategy if a problem is considered to exist. (The river bed below the dam
will not be accessible or visible during the monsoon period.) (b) review river bed bathymetric surveys and assess evolution of scouring processes, compare with design expectations, develop criteria for measurement interpretation and use.

18. The Consultant shall assist in the (i) procurement process and supervise installations and commissioning of the following:

OEM works which is supported by a contract with Toshiba and covers:
- The supply of spare parts for the turbines: modified wicket gates, shaft seal labyrinth liner
- The supply of spare parts for generator: mainly generator air cooler set and temperature gauges.
- The modification of the main inlet valves: new modified servo motors, main seals

Turbines component consisting of the following:
- Repair and hard coating of runners and wicket gates
- Supply and hard coating of wearing rings and facing plates.

New trash rack raking machine:
- An automatic new trash rack racking machine will be installed at the intake of the de-sander beside the intake dam.

(ii) Factory fabrication control, transport, erection at site and commissioning and identifying sets of spare parts for electromechanical equipments specified by NEA.

(iii) Resolve cavitation issues at the plant by: (a) Reviewing available data for tailwater levels and compare these levels to the turbine’s hydraulic requirement for minimum tailwater level; (b) Coordinating with the turbine manufacturer to insure that the manufacturer makes a thorough assessment of remedial options in addition to increasing downstream tailwater, with the objective of selecting the option which maximizes power generation during the dry season. If an increase in the downstream tailwater elevation is selected as the preferred alternative, prepare the hydraulic and civil design for the placement of a concrete sill or other structure immediately downstream of the plant discharge to establish the required tailwater elevation. (c) Determining the actions to be taken to solve cavitation problem by adjustment of the tailwater and/or by adjunction of compressed air system with effect in the spiral case.

The Consultant shall have access to the turbine manufacturer data.

Measurement of tailwater will be organized under the responsibility of the Consultant to check the existing situation at the confluence between the hydropower tail water and the Kali Gandaki River.

19. The Consultant will assist NEA in (i) defining the scope of the work, preparing preliminary designs and assuring that all the steps are undertaken properly, so that the completed works will deliver the quality, capacity, performance, reliability and economic life required.
The assistance covers studying existing PLC automation System including instrumentation and communication system; (ii) identifying the requirements for upgradation in the existing control system and analyzing available solutions/scenarios possibly specific upgrading of Controllers; (iii) proposing the optimal migration solution; (iv) preparing cost estimates for hardware/software modernization, technical specifications and bidding documents; (v) support in the tendering process and bid evaluation; (vi) review and approval of contractor’s detailed scheme; (vii) supervision of erection, testing and commissioning works from the owner’s engineer perspective; and (viii) handing over the completed projects including issuance of provisional acceptance certificates and final acceptance certificates.

20. The Consultant shall assist in Capacity Building of NEA counterpart staffs through involvement during all the phases of the project. The Consultant shall perform skills assessment and prepare a training program for NEA counterpart staffs at both the assistant and officer level. The Consultant will be expected to work closely with the NEA staffs and shall ensure that the NEA staffs achieve higher skill levels as a result of project involvement. The Consultant shall prepare and recommend specialized training of equipments supplied from abroad at respective manufacturers’ premises to NEA staffs at officer levels.

21. The Consultant shall work closely with the NEA Project Coordination Committee (PCC), the Project Manager and NEA’s concerned Departments and Business Groups through all stages of the assignment. The Consultant shall (i) review all the existing documentation on Hydrology, Hydraulics and Sediment Management of KGAHPP; (ii) Data Collection (iii) Consultations with NEA; and (iv) Home design.

22. Site Visit

The consultant is required to make initial site visit to familiarize with the site conditions, scope of works, preparation of inception report, skill assessment of NEA staffs and preparation of subsequent training program, then short visits for the remainder of the project until commissioning is completed.

The Sediment Consultant will be required to spend several days at the Kali Gandaki project site during the monsoon to observe and monitor sedimentation conditions during the period of high hydraulic and sediment loading.

The site visit by geotechnical engineer to examine slope stability and potential downstream rock of water will take place during the monsoon.

NEA staffs will provide information and assistance to the Consultant while at site. A visit to the village of Seti Beni, a critical site from the standpoint of flooding, is also recommended. Scour issues should be scheduled during periods of low water, since the river below the dam will be full.
D. Services provided by the Client

As an element of capacity development, NEA will depute counterpart staffs to work closely with the Consultant. NEA will identify qualified counterparts in their respective organizations to liaise with the consultant, respond to questions, supply unpublished information and reports, and assist with logistics and contacts for site visits. NEA will provide all documentation and in-house data related to the project. NEA will also assist the consultant with contacts and other relevant stakeholders. All costs for data and information, such as hydrological and rainfall data, sourced from other authorities, must be covered by the Consultant.

NEA will facilitate provision of site access to Kali Gandaki plant and will accompany the consultant during the field visits. The Consultant shall arrange transport and logistics for their own team during field visits.

The Client and other stakeholders will cover their own cost in regard to participation in project workshops. The Consultant shall arrange the workshops, including venue, food and beverages and needs to accommodate costs related to their own participation.

23. Tentative Staffing Requirements whose CVs and experience are to be provided.

The consultant shall be an internationally recognized firm, supported by local expertise, with experience in dam safety, hydropower, civil and electromechanical engineering, refurbishments, power station automation and control system, sediment management in the Himalayas, and preferably in Nepal. The consultant shall use the services to carry out the assignment from at least the following key specialists in the team:

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<tr>
<th>Team Member (Team Leader)</th>
<th>Qualifications</th>
<th>Expected Person Months (P M)</th>
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<tr>
<td>Senior Civil Engineer</td>
<td>University degree, at least Bachelor’s and preferably Master’s degree in civil engineering</td>
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<td>At least 20 years of relevant work experience in planning, detail design, tendering and supervision of construction works and 10 years of which shall have been in projects outside the Consultant’s home country</td>
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<td>Familiar with donor supported hydropower projects, MDB and FIDIC conditions of contract and contract management, financial management of hydropower projects and social and environmental safeguards issues</td>
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<td>Experience in rehabilitation projects, sediment management,</td>
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| **Senior Geotechnical/Rock mechanic specialist** | - Having knowledge of Procurement guidelines of World Bank under IBRD loans and IDA credits.  
- University degree, at least Bachelor’s and preferably Master’s degree in geotechnical engineering  
- At least 15 years relevant experience in geotechnical engineering especially in the area of slope stability assessment and stabilization works  
- Experience in slope engineering and rock mechanics desirable | 1.5        |
| **Senior Structural Dams Engineer/ Dam Safety Specialist** | - University degree, at least Bachelor’s and preferably Master’s degree in civil/structural engineering with specialization in both reinforced and mass concrete structures including concrete dams and their appurtenant works  
- At least 15 years relevant experience in all phases of project implementation including detail design, tendering, supervision and evaluation of laboratory and field tests in dam engineering including safety assessments and rehabilitation of dams and appurtenant structures. | 1.5        |
| **Senior Sediment/Hydraulics Expert**         | - At least University Master’s Degree preferably PhD in hydraulics/river engineering/ sedimentation engineering  
- At least 15 years relevant experience in sediment management in run-of-river hydro power plants, interpretation of results from physical and numerical model studies and field monitoring programs | 3.5        |
| **Mechanical Engineer**                       | - A least Bachelor’s Degree in Mechanical Engineering  
- At least 15 years relevant experience in electro-mechanical erection, testing and commissioning works  
- Having knowledge on electro-mechanical repair and maintenance of ROR hydropower plants in the sub-continent | 1.5        |
| **Electrical Engineer**                       | - At least Bachelor’s Degree in Electrical / Electronics / Instrumentation / Industrial automation Engineering  
- At least 15 years relevant experience in PLC automation projects  
- Experience in PLC automation, SCADA System, instrumentation, communication and control system erection, | 1.5        |
testing and commissioning in new and/or rehabilitation projects

- Having Knowledge of with PLC automation system design, specifications in power stations and/or process industries

| Environmental Engineer | University degree, at least Bachelor’s and preferably Master’s degree in environmental engineering
- At least 10 years relevant experience in environmental and safeguard implementation projects. | 1 |

| Operation and Maintenance Expert | At least Bachelor’s Degree in Electrical/Mechanical Engineering
- At least 10 years relevant experience in electro-mechanical operation and maintenance works of hydropower stations
- Experience in providing training for capacity building of operation and maintenance personnel. | 1 |

| Electrical Supervisor | At least Diploma Degree in Electrical Engineering
- At least 10 years relevant experience in PLC automation, SCADA System, instrumentation, communication and control system erection, testing and commissioning in new and/or rehabilitation projects | 3.5 |

The Consultant shall engage local support staffs of corresponding expertise for regular supervision of works.

E. FINAL OUTPUT REQUIRED OF THE CONSULTANT

24. The Consultant shall prepare an Inception Report within 4 weeks of assignment, monthly and quarterly progress reports as applicable based on field data and preparation of progress reports in a format and details acceptable to NEA and WB.

25. The Consultant shall maintain records documenting decisions made at meetings, progress on project implementation, financial records and changes to the contract plans. The Consultant shall assist WB in preparing a project completion report and monitoring and evaluation reports as required.

26. The consultant shall produce the detail scope of works of the project, cost estimates, technical specifications and bid documents.

27. All documents and reports would be made available on electronic format to WB.

All reports will be in English language.
Deliverables to be submitted by the Consultant

a. Inception Report
b. Technical report including all of the technical products delivered during the consultancy
c. Design Document
d. Detailed Design and drawings
e. Technical Specifications
f. Edited version of Operation Manual
g. Guidelines for O&M practices
h. Bidding Documents
i. Draft Final of project completion
j. Final Report

28. Reporting

The Consultant shall submit Monthly Progress Reports. The list of documents required in different phases is given below:

Mobilization Phase (within four months of Contract Effective date)
- Inception Report
- Draft Master Schedule
- Master Manual
- Cost Control System

Design Phase (within ten months of Contract Effective date)
- Final Master Schedule
- Design Report
- Project Activities list with cost estimation report
- Bid Documents
- Responding to requests for clarification in the bidding period

Implementation Phase (including review of contractor’s design, supervision of workshops activities and tests and supervision of site works) (within 18 months of Contract Effective Date)
- Factory tests reports
- Supervision reports
- Provisional Acceptance certificate complete with punch list
- Completion Report
All reports will be in English language

The Consultant shall report to the Project Coordinator, NEA.

29. Counterpart

The main government counterpart will be Nepal Electricity Authority (NEA).

F. Time and implementation plan

30. The work will be conducted during a period of 30 months, expected to start in April 2014. The consultant will work in close collaboration with the NEA staff as well as a team from the World Bank.