

## **REQUEST FOR EXPRESSIONS OF INTEREST (CONSULTING SERVICES – INDIVIDUAL)**

### **NEPAL**

Power Sector Reform and Sustainable Hydropower Development Project (PSRSHDP)  
Loan No./Credit No./ Grant No.:5728-NP

**Assignment Title: Hydrologist** as a member of Panel of Experts to provide independent technical review for the consultancy of Detailed Engineering Design and Preparation of Bidding Documents for Construction of Upper Arun Hydroelectric Project and Ikhuwa Khola Hydropower Project

**Reference No.:** PSRSHDP/ NEA/S/IND-7

The Government of *Nepal* has received financing from the World Bank toward the cost of the Power Sector Reform and Sustainable Hydropower Development Project, and intends to apply part of the proceeds for consulting services.

The consulting services (“the Services”) include providing independent technical review of the reports and deliverables of the Design Consultant with intermittent input spanning 33 month as a **Hydrologist**, information on which can be found in detail in the TOR attached. The Expert shall be a member of the Dam Safety Panel of Experts (DSPOE).

The Nepal Electricity Authority, an implementing agency of the Client, now invites eligible “Consultants” to indicate their interest in providing the Services. Interested Consultants should provide up to date CV with information demonstrating that they have the required qualifications and relevant experience to perform the Services. The broad shortlisting criteria are as follows:

- Minimum of bachelor’s degree in civil engineering and preferably have Master's degree or equivalent in hydrology civil engineering discipline.
- At least 20 years of professional experiences with adequate experience as a hydrologist preferably in large/mega hydropower projects.

The attention of interested Consultants is drawn to paragraph 1.9 of the World Bank’s *Guidelines: Selection and Employment of Consultants [under IBRD Loans and IDA Credits & Grants] by World Bank Borrowers*, January 2011 revised July 2014 (“Consultant Guidelines”), setting forth the World Bank’s policy on conflict of interest. A Consultant will be selected in accordance with the Individual Consultant’s Selection method set out in the Consultant Guidelines.

Further information and Terms of Reference can be obtained at the address below during office hours 10:00 to 17:00 on Sunday to Thursday and during office hours 10:00 to 15:00 on Friday Local time (Nepal Standard Time).

Expression of Interest must be delivered in a written form along with a detailed resume to the address below in person, or by mail, or by e-mail by May 24, 2018.

Upper Arun Hydroelectric Project  
Nepal Electricity Authority  
Attn: Mr. Biswa Dhoj Joshi, Director  
United World Trade Center  
Tripureshwor, Tripura Marg  
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**Nepal Electricity Authority (NEA)**  
**Upper Arun Hydroelectric Project**

**TERMS OF REFERENCE<sup>1</sup>**

**For the**

**Dam Safety Panel Experts (DSPOE) for the Upper  
Arun Hydroelectric Project and Ikhuwa Khola  
Hydropower Project**

**Project** : PSRSHDP  
**Credit No.** : 5728-NP  
**Ref. No.** : PSRSHDP/ NEA/S/IND-4 (Hydropower Engineer/Civil Engineer covering dam safety)  
PSRSHDP/ NEA/S/IND-5 (Geotechnical Engineer/Geologist)  
PSRSHDP/ NEA/S/IND-6 (Hydraulics/Sediment Expert)  
*as core group and additional experts to comprise:*  
PSRSHDP/ NEA/S/IND-7 (Hydrologist)  
PSRSHDP/ NEA/S/IND-8 (GLOF specialist)  
PSRSHDP/ NEA/S/IND-9 (Seismologist) and  
PSRSHDP/ NEA/S/IND-10 (Electro-mechanical engineer)

**Assignment:** **Provide independent technical review for the consultancy of Detailed Engineering Design and Preparation of Bidding Documents for Construction of Upper Arun Hydroelectric Project and Ikhuwa Khola Hydropower Project**

**February, 2018**

<sup>1</sup>This Terms of Reference are to be read in conjunction with the Terms of Reference for the Detailed Engineering Design and Preparation of Bidding Documents for UAHEP and IKHPP.



*[Signature]*  
Project Director

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Project Director

## 1. BACKGROUND

The World Bank is providing financial support to the Government of Nepal, Ministry of Energy, through the Nepal Electricity Authority (NEA), to carry out environmental and social assessment, detailed design studies, and preparation of bidding documents for the proposed Upper Arun Hydroelectric Project (UAHEP) and the Ikhuwa Khola Hydroelectric Project (IKHPP).

The proposed UAHEP project site was first identified by the Master Plan Study of Koshi River Water Resources Development by JICA in 1985. A subsequent reconnaissance study was conducted by NEA in the summer of 1986. In 1991, a feasibility study of the project was completed on behalf of NEA by a Joint Venture of Morrison Knudsen Corporation, Lahmeyer International, Tokyo Electric Power Services Co., and NEPECON. A preliminary Environmental Assessment was also carried out. NEA had intended to develop the UAHEP only well after completion of the Arun III Hydropower Project. The two projects are not interdependent, and no specific sequencing is required to ensure the viability of each. After failing to achieve financial closure on Arun III, NEA shifted focus to the development of other hydropower projects outside the Arun Valley. In 2011, in order to meet increasing electricity demands and mitigate load shedding, NEA revisited and reviewed the feasibility study of UAHEP and re-affirmed it as a priority project due to its relatively low cost of generation, its availability of high firm energy and potential to contribute to the Integrated Nepal Power System, and its location in the power deficient eastern region of Nepal. The review also identified changes in available infrastructure at and around the project site, and collected additional information contributing towards the detailed engineering design of the project. In February 2013, a cabinet decision granted the NEA permission to implement the UAHEP under the ownership of the Government of Nepal. The Department of Electricity Development informed NEA that a Survey License would not need to be issued to NEA since NEA would be implementing the project on behalf of the Government of Nepal. The associated IKHPP would be developed under the umbrella of the UAHEP.

UAHEP's detailed design and ESIA is proposed to be prepared with the financial assistance of World Bank (WB). World Bank has approved Project Appraisal Document on the proposed credit number 5728- NP in the amount of USD 20 million to Nepal for the Power Sector Reform and Sustainable Hydropower Development Project (PSRSHDP). UAHEP and IKHPP are proposed to be developed under the Component A: Preparation of Hydropower and Transmission Line Investment Projects of PSRSHDP. Under the proposed project, the Bank will support the preparation of these two projects, including study of one new transmission line project.

For the implementation of PSRSHDP, the financing agreement between Government of Nepal and World Bank was signed on February 4, 2016. Likewise, the project agreement between Nepal Electricity Authority and World Bank has also been signed to develop UAHEP and IKHPP under PSRSHDP in same date February 4, 2016. As per the financing agreement between GoN and World Bank for the implementation of PSRSHDP, the loan of USD 20 million sanctions for GoN will be provided to Nepal

Electricity Authority (NEA) as a subsidiary loan under the subsidiary loan agreement between GoN and NEA on date of 5 may 2016. The subsidiary loan agreement has been effective from June 2, 2016.

The UAHEP and IKHPP Projects have now reached its detailed-design phase and the Nepal Electricity Authority (NEA) wishes to appoint a Panel of Experts (DSPOE) for this phase of the project's development. The primary function of the DSPOE will be to provide independent review and recommendations on all activities relevant to the design of the project, with the overall objective of achieving, in accordance with modern practices cost effectiveness, adequacy, high technical efficiency and safety of the project structures and components over the life of the project.

## 2. PROJECT DESCRIPTION

The project components to be covered under the *Detailed Engineering Design and Preparation of Bidding Documents* will include Upper Arun Hydroelectric Project (UAHEP), Ikhuwa Khola Hydroelectric Project (IKHPP), various ancillary activities related to each hydroelectric component, and the required project roads and transmission line from the powerhouses of UAHEP and IKHPP to the proposed substation of Koshi Corridor Transmission Line at Tumlingtar. These are described below and referred to collectively thereafter as “the Project,” unless otherwise specified.

### 2.1 Upper Arun Hydroelectric Project (UAHEP)

The UAHEP is a proposed 335 MW hydroelectric facility to be located on the Arun River in Sankhuasabha District of eastern Nepal. The project area is situated within Longitude 87°20'00” to 87°30'00” East and Latitude 27°38'24” to 27°48'09” North, about 15 km south of the international border with Tibet and 220 km east of Kathmandu. The proposed dam site is located in the Chepuwa Village, in a narrow gorge about 350 m upstream of the Arun River's confluence with the Chepuwa River. The proposed power plant site is located in the Hatiya Village 16 km downstream of the dam site, near the Arun River's confluence with the Leksuwa River. The right bank of the Arun River at the proposed UAHEP site falls within the Makalu Barun Buffer Zone, which is adjacent to the Makalu Barun National Park. The proposed UAHEP dam site is therefore located at the edge of the Buffer Zone.

As informed by an initial feasibility study completed in 1991, the proposed UAHEP is designed to be a Peaking Run of the River (PRoR) project with gated weir across the Arun River. Intakes on the left bank of the river are proposed to divert the design discharge of 78.8 m<sup>3</sup>/s through an intake tunnel to three underground desanding basins, a headrace tunnel of 7.8 km, surge tank, drop shaft, pressure tunnel, and ultimately to the underground powerhouse for power generation. Water would be retained for a period of a few hours only in a peaking pond and then released through the tunnel during peak hours. After power generation, water will be released back to the Arun River. Review study in 2011 suggested that the proposed UAHEP with 335 MW of installed capacity can generate total annual energy of 2598 GWh. The salient features of the proposed project as informed by the initial feasibility study are listed in Annex A. NEA will be assisted by an international engineering consulting firm, being contracted in parallel to the consultancy of ESIA, CIA and social planning studies, to inform the final decisions about siting and design of these salient features. For the power evacuation of UAHEP, a 220 kV double circuit

transmission line shall be constructed from the powerhouse to a proposed substation at Tumlingtar. Total length of the proposed transmission line is about 49 km.

## 2.2 Ikhuwa Khola Hydroelectric Project (IKHPP)

NEA has also proposed to develop the 30 MW IKHPP, a medium sized hydropower project, as an integral part of the UAHEP (Annex A). The proposed IKHPP site is located on a tributary to the Arun River approximately 8 km downstream of the proposed UAHEP powerhouse site, and 5 km upstream of the proposed Arun III Hydropower Project headwork. While developing hydropower projects in Nepal, it is a common practice to involve local communities as shareholders so that the benefit from the project could be shared with the local people. As per the cabinet decision of Government of Nepal (GON), UAHEP will be developed as a public sector project under the ownership of GON through the NEA as an implementing agency. Since the project is completely owned by the GON, local communities will not be able to participate as shareholders in this project. In order to share the benefit of UAHEP development with the local communities, NEA plans to develop IKHPP with UAHEP. NEA proposed to develop IKHPP in a public private participation mode by establishing a special purpose vehicle, where local communities would be shareholders of this project. NEA plans to combine this project with UAHEP into a package so as to deliver other benefits as needed to the local communities in addition to the shareholding. The Department of Electricity Development (DoED) of the Government of Nepal has recently completed the feasibility study and an initial environmental examination for IKHPP.

### 3. WORLD BANK POLICY REQUIREMENTS FOR INDEPENDENT PANEL OF EXPERTS

Given the size and complexity of the Project and its potential impacts, in compliance with the World's Bank Environmental Assessment OP4.01, the project has been classified as EA Category "A". Further, also in accordance with OP4.01 for projects that may pose high environmental risks, an independent advisory panel, to be known as the Environmental and Social Panel of Panel of Experts (referred to throughout this document interchangeably as the ESPOE or "the Panel"), will be established. The ESPOE will be contracted separately by NEA to advise it and to provide guidance on: (a) the final terms of reference for the ESIA, CIA and social planning studies ("the studies"), (b) key issues and methods for preparing the studies, (c) recommendations and findings of the studies, (d) implementation of the studies' recommendations, and (e) development of environmental and social management capacity.

Under World Bank OP 4.37 on Safety of Dams, the NEA will also be required to retain an Independent Panel of Experts to review the investigation, design and construction of the dam, and the start of operations for all projects involving new dams over 15 meters height. The Upper Arun dam is 37m high with a gross volume of 760 × 103 m<sup>3</sup>. The Dam Safety Panel (DSPOE) and the ESPOE will operate as two separate panels but would be required to work closely together, recognizing the importance and close relationship among technical, economic, environmental and social considerations throughout the

preparation of the project. The DSPOE will therefore draw from the technical expertise and knowledge of the Dam Safety Panel members as required on issues such as dam engineering, engineering geology and rock mechanics, tunnelling and dam construction, dam monitoring instrumentation, dam safety inspections, and hydrology. The DSPOE will also be contracted separately by NEA to advise it and to provide guidance on Detailed Engineering Design and Preparation of Bidding Document for preparing UAHEP and IKHPP for construction. These Terms of Reference cover the specific scope of work for the DSPOE only.

The DSPOE will initially be contracted for the duration of the preparation phase of the UAHEP and IKHPP. However, the DSPOE is expected to be extended to cover the construction of the UAHEP and IKHPP at a later date.

#### 4. OBJECTIVES OF THE DAM SAFETY PANEL OF EXPERTS

The purpose of the DSPOE will provide an independent review of the detailed design of the Upper Arun and Ikhuwa Khola projects. In particular, the DSPOE will provide review of key consultancy reports of 'Detail Engineering Design and Preparation of Bidding Documents' at different timelines and reports as per the requirement of NEA at key phases of the consultancy. The DSPOE will also review the feasibility design of both HPPs at the Inception Phase of the Consultancy and advice on any critical aspects that should be further studied for design optimization under this Consultancy. The DSPOE also has to review and advise NEA on matters related to dam safety and other critical aspects of the dam, its appurtenant structures including spillways, all major structures of the said hydropower projects, the catchment area, the area surrounding the reservoir, and downstream areas. In addition the POE will also advise NEA for integrating environmental and social considerations in the feasibility, design, construction and operation of the Project through the meetings with the ESPOE reports and meetings with them as advised by NEA. The DSPOE may also comment on any other matter which it perceives to be important to the successful design, construction and operation of the projects and to the long-term safety of the dams and appurtenances.

The DSPOE core group consists of (i) Hydropower/Civil Engineer covering dam safety (ii) Geotechnical Engineer/Geologist (iii) Hydraulics/ Sedimentologist. Besides these core group members, the following experts will be required: (iv) Hydrologist, (v) GLOF expert, (vi) Seismologist, and (vi) Electro-mechanical engineer. Additional experts maybe needed as required and the need will be established by the core group. The Hydropower/Civil Engineer covering dam safety will be appointed to chair the DSPOE. The DSPOE chair will coordinate with other panellists to ensure the memberships objectivity and to provide balance to its reviews and recommendations, and will be responsible for the DSPOE reports.

#### 5. SCOPE OF WORK OF THE DAM SAFETY PANEL OF EXPERTS

NEA requires the DSPOE to provide an independent design review including the feasibility study and detailed design, bidding documents, and other reports submitted by the Detailed Engineering Design Consultant. The scope of the Panel also covers all aspects of dam safety as per WB safeguard policy (OP4.37) in addition to those specific of the Client viz. NEA. The Panel will be expected, in addition to any other items which they deem pertinent, to:

- a) Review the overall layout, design criteria and parameters, specifications and hydraulic design of the project structures, including river diversion structures, dam, spillway, energy dissipater, outlets, intake, fish passage, desanding basin, tunnels, caverns, surge tank, pressure shaft, hydraulic elements of the powerhouse and tailrace.
- b) Review all hydraulic data, including sediment data, hydraulic model studies and sedimentation studies;
- c) Evaluate the impact of the expected sediments on the choice of hydraulic turbines. Review of the general layout of the powerhouse, including the transformer gallery. Review pre- proposed instrumentation to monitor the performance of project structures, including turbine flows.
- d) Review and if necessary upgrade the seismic hazard assessments and required inputs for seismic design of the major structures.
- e) Review potential landslide areas along the river in the upstream of the dam, etc. and required remedial measures including survey and monitoring.
- f) Evaluate all field and laboratory investigations designed to review the geological conditions of the dam site, tunnels, hydropower plants, etc. as well as construction materials of quarries/borrow areas in order to ascertain their properties.
- g) Evaluate all field and laboratory investigations designed to describe the geological conditions and design parameters at and along the extent of the project structures. Review the design of the project structures in so far as they adequately satisfy the engineering geological requirements. Evaluate the adequacy both in quantity and quality of all geotechnical construction materials.
- h) Review the adequacy of designs proposed by the consultants to deal with expected seismic forces and potential landslide areas.
- i) Review the proposed instrumentation to monitor the performance of the dam. Review of quality and sufficiency of the geological investigations and the interpretation thereof; correctness of the geological and hydrological models of the region, reservoir area and dam site; engineering implications with respect to foundation design, stability of natural and excavated slopes; and support of surface and underground excavations.
- j) Carry out a critical review of the structural adequacy of all structures and non-geotechnical construction materials.
- k) Evaluate all tender and specification documents for the construction of the project structures. Review the adequacy of the construction schedule, the sequence of diversion, construction installation of equipment and overlapping activities and the time allocated - review the adequacy given for the preparation of the bids and the adequacy of design as required to limit possible danger during construction to a minimum - Evaluate the quality control methods envisaged.
- l) Review the final hydrological evaluation of the project namely; monthly flows, flood flows, including GLOF, power and energy evaluations.



- m) Review the choice of generating equipment, namely, turbine, generators, auxiliary equipment, valves, gates, cranes, control equipment. Review of the optimal number of generating units consistent with the system profile, domestic and export load demands, Review the specification of all electrical and mechanical equipment.
- n) Review the maintenance and safety program proposed- Assess the ability of NEA staff to adequately maintain and routinely check the safety of the structures. Recommend for training, if necessary.
- o) Review of dam design: (a) adequacy of field and laboratory investigations in relation to materials for construction of the dam and cofferdams, appropriateness of materials selected, proportioning and composition of the various zones, static and dynamic analyses of the dam section; selection of foundation excavation levels, proposed measures of grouting, cut-offs, etc. and other seepage control measures of the foundations and abutments; construction procedures specified in relation to the dam and its foundations, instrumentation of the dam and proposed monitoring programme; (b)hydraulic design and specifications of the spillway and energy dissipation facilities, diversion, power conduit and drawdown facilities, regulating pond, fish passage and tailrace facilities; (c)Construction planning studies, temporary facilities, access to the site, master schedule for implementation, conditions of contract; contractors proposals in relation to construction procedures, schedule, river diversion; organisation, staffing and procedures for managing the construction of the Project, methodology and organisation for quality control of the construction; (d) geological and seismological considerations;
- p) Review the overall risk management. Provide guidance on the risk register and the geotechnical baseline report.
- q) Review the various detailed plans required to be prepared in accordance with the plan for construction supervision and quality assurance, the instrumentation plan, the operation and maintenance plan, and an emergency preparedness plan.

The services carried out by the Consultant shall be reviewed periodically by DSPOE. The reports submitted by the consultant shall be accepted by NEA after approved by the DSPOE.

The tenure of the DSPOE will span until the end of the design phase (excluding interface phase).It is a good practice that the same DSPOE will be maintained during construction supervision up to the commissioning of HPPs and initial operational periods for one year.

## 6. ORGANIZATION AND MEMBERSHIP OF THE PANEL

### 6.1 General Organization

As stated earlier, the composition of the DSPOE will be that of a "core group" of three highly experienced international class experts comprising (i) Hydropower/Civil Engineer covering dam safety (ii) Geotechnical Engineer/Geologist, and (iii) Hydraulics/ Sedimentologist. Besides these core group members, the following experts will be required on a temporary basis: (iv) Hydrologist, (v) GLOF expert, (vi) Seismologist, and (vi) Electro-mechanical engineer. The experts will have extensive experience with design of hydropower facilities, and having the following background with varying degree for each position:

- (a) General overall engineering experience in design and construction of large hydropower projects including optimization and feasibility studies in respective fields;
- (b) Engineering experience in design and construction of similar types of dams and hydropower projects;
- (c) General understanding of design consideration of minimizing the environment/resettlement impacts familiar with the Bank Safeguard Policies;

The Panel members should have practical and technical expertise in reviewing project reports produced by consulting firms; and have strong analytical and reporting skills as well as an ability to work in teams. The Panel shall also identify any new expertise on an ad hoc basis needed according to the findings of the Panel and ongoing studies, and recommend to NEA to hire experts with relevant experience and knowledge for a certain period to assist with relevant issues. The constitution of the Panel may thus change over the project period, but it is highly desirable that a strong continuity of knowledge of the Project problems and progress be maintained.

The Panel will undertake a comprehensive review of the designs of the Upper Arun dam and related structures, with the objective of ascertaining and reporting on their general safety and performance, including consideration of structural, geologic, soil mechanics, hydrologic, hydraulic aspects, and Environmental/Resettlement aspects. The tasks and reports to be reviewed by the DSPOE are attached in **Annex B**.

The presently scheduled mandatory meetings, with respect to the start of the design Consultants contract primarily focusing on UAHEP but not limited to, are:

Month 7 : After the submission of the Optimization Study and Updated Feasibility Study Report by the Consultant. A site visit is scheduled during this meeting.

Month 11 : After the submission of the Draft Final Detail Engineering Design Report of IKHPP and initial field investigation report of UAHEP by the Consultant.

Month 16 : Before the end of the hydraulic model tests.

Month 20 : Before the end of the field investigations. The review of geotechnical investigations should be done in a phased manner from earlier phase of this consultancy.

Month 23 : After the submission of the Draft Final Detail Engineering Design Report of UAHEP by the Consultant.

*Review by the DSPOE at Home office in addition to above scheduled meeting are expected on following months as well:*

Month 0: NEA will submit the relevant report to the DSPOE at the beginning of the consultancy in order to check the adequacy of feasibility design and all required investigations/analyses, etc. be covered by the detailed design consultancy.

All key studies, such as seismic hazard assessment, hydrological/GLOF review, sedimentation, geology including foundation, tunnels, powerhouse, upstream of the dam, quarries/borrow areas, etc. shall be reviewed by the DSPOE in a timely manner. Key studies in hydrology/GLOF, seismic hazard assessment reports, etc. will be submitted to the DSPOE prior to the Consultant starting the optimization study.

Month 2: after the submission of the inception Report: Confirm the consultancy program/schedule based on the review of FS reports and TORs for the detailed design consultancy

Month 4 After the submission of the Updated Feasibility Study Report and DBM of IKHPP.

Month 33 : After the submission of the Draft Bid Evaluation Report t of UAHEP by the Consultant.

## 6.2 Technical qualifications of the members

All panel permanent members should be internationally renowned experts familiar with the WB Safeguard Policies and related guidance documents, as well as modern design practices; have practical and technical expertise in carrying out and/or reviewing Engineering Design reports; have strong analytical and reporting skills; as well as an ability to work in teams; and have fluency in both written and spoken English. The permanent members should demonstrate experience of working as a member of Panel of experts in hydropower projects.

### **Core Members**

#### **Hydropower Engineer/Civil Engineer covering dam safety**

The expert shall have minimum of post graduate degree in Civil engineering or equivalent and preferably civil/hydropower/water resources/hydraulic engineering discipline and must have at least 20 years of professional experience. The experience should be as a team leader in planning, designing and supervision of successfully completed large hydropower projects with dams and as a member of Panel of Experts for reviewing the plan, design/ construction supervision of large hydropower projects with dams. S/he should be a renowned expert who has worked with experts from different disciplines in hydrological, geotechnical, mechanical and other fields. The expert should have adequate experience in dam safety. The expert will head the Panel of Experts as a chair.

The expert will focus on the following tasks:

- Review the General layout of diversion dam, cofferdams and appurtenances.
- Review Spillway configuration and its adequacy (from a structural viewpoint only) to handle the design flood.
- Review of the structural design of the dam, spillway and cofferdams to include analyses of both static and dynamic design. The design needs to be reviewed vis-à-vis international technical standards and practices.
- Review of foundation design and treatment technique. Suggest alternate technologies for optimization of time and cost.

- Review of proposed instrumentation arrangement and monitoring provisions.
- Review of dam safety measures recommended by the consultant.
- Review of dam construction schedule, methodology and technology to be adopted.

Additional factors may also be considered by the Consultant.

### **Geotechnical Engineer/Geologist**

The Geotechnical Engineer shall have minimum of bachelor's degree in civil engineering or equivalent and preferably has Master's degree or equivalent in Geotechnical or civil engineering discipline and must have at least 20 years of professional experience. Work experience as a member of DSPOE for review of design or construction supervision of large Hydropower Projects is highly preferred. His/her main task would be as follows but not limited to:

- Developing geotechnical standards and criteria to guide in the implementation and performance of the various infrastructural works.
- Review the regional and local geological characteristics and seismic conditions for all hydraulic infrastructures to be built under the project;
- Review the analytical results of foundation conditions and material sources including results of borehole excavation, laboratory testing, in-situ tests for all hydraulic infrastructures under the project;
- Review the proposed designs of foundation treatment, proposed excavation, foundation strength parameters and seepage control measures for all hydraulic facilities under the project;
- Review the identified and tested results of burrow materials for concrete aggregates and embankment materials for all hydraulic infrastructures under the project
- Critically review testing results, design recommendations and documents detailing the studies conducted.
- Review of the potential landslide areas in the upstream of the dam.

The expert shall have experience in geotechnical investigation, tests, and design, supervision of large hydropower projects with dams and tunnels among its main components.

### **Hydraulics/ Sediment Engineer**

The expert shall have minimum of bachelor's degree in civil engineering and preferably have Master's degree or equivalent in hydrology/ hydraulic/ hydropower/ Sediment/ civil engineering discipline and must have 20 years of professional experience. Work experience as a member of DSPOE for review of design or construction supervision of large Hydropower Projects is highly preferred. The specialist will review the intake, spillway, and de-sanding /sediment flushing design arrangements including hydraulic model test. The expert should demonstrate expertise and experience in hydraulics, model study analysis, sediment study including investigation, analysis and interpretation and design of reservoir sedimentation and its management.

### **Other Members**

#### **Hydrologist**

The Hydrologist shall have minimum of bachelor's degree in civil engineering and preferably have Master's degree or equivalent in hydrology and must have 20 years of professional experience. The

expert will review available hydro-meteorological data, long term hydrological series developed and adopted for energy generation, flood peaks adopted for statistical analysis of return period floods, assess probability of occurrence of 'GLOF' in the project catchment and its impact on design flood if any. The expert will also review the available daily flow data of hydrological stations, rainfall data of stations in the catchment and other available hydro-meteorological data. Inspection of the gauging station and quality of historical data, rating curves.

The expert will review the hydrological study reports carried out the Consultant including but not limited to the following:

- Analysis of the flow duration curve used for power generation.
- The criteria and methods by which the data were used to estimate Maximum Probable Flood, Design Flood, reservoir inflow and flows to be diverted during project construction, and the need to use other methods to improve accuracy of results,.
- Assessment of peaking energy is possible and if it is possible to maintain the head-pond free of sediments taking the inputs of sedimentologist into consideration
- Low flow hydrology, availability of water for flow releases

### **GLOF Expert**

The GLOF Expert shall have minimum of bachelor's degree in civil engineering, Alpine Geology, Applied Geomorphology, Engineering Geology, hydrology or other relevant discipline and preferably have Master's degree in Alpine Geology, Applied Geomorphology, Engineering Geology, hydrology or other relevant discipline and must have minimum of twenty (20) years of professional experience. Work experience as a member of DSPOE for review of design or construction supervision of large Hydropower Projects/GLOF related projects is highly preferred. The expert shall have extensive experience in the study and analysis of GLOF projects including mapping of glaciers, glacial lakes and field investigation. Experience in GLOF studies in the Himalayan Hindu Kush region as a GLOF expert will be an added advantage of the expert. The experts will complete the GLOF review at the initial phase of the consultancy to determine the spillway discharge capacity / arrangement before going to detailed design.

### **Seismologist**

The Seismologist/ Seismic Expert shall have minimum of bachelor's degree in civil engineering or equivalent and preferably has Master's degree or equivalent in engineering /geo technical/geology/soil science/seismology and must have twenty (20) years of professional experience. The expert shall have experience of seismological investigation, studies and design in as part of detailed engineering design of large hydropower projects with remarkable high dams. The experience in seismological investigation and studies of hydropower project in Himalayan Region will be an added advantage.

The Consultant shall review the work of the consultant in the following areas: quality and quantity data used in the seismic study; determination of seismic impact zones, seismic sources, and the estimated maximum earthquake, the design maximum earthquake during project operation, the earthquake speed, ground acceleration, and earthquake grades as basis for design parameters; seismicity zones maps for the project area; the current seismic network in the region, project area and make suggestions for improving monitoring seismic activity in the project region and area.

### **Electro Mechanical Engineer**

The Electro Mechanical Engineer shall have minimum of bachelor’s degree in electrical/ mechanical engineering or equivalent and preferably has Master’s degree or equivalent in electrical/mechanical engineering discipline and must have twenty (20) years of professional experience.

The expert shall have extensive experience in the design, preparation of specifications and installation of powerhouse electro-mechanical equipment of large hydropower projects.

The Expert will review the choice of generating equipment, namely, turbine, generators, auxiliary equipment, valves, gates, cranes, control equipment. Review of the optimal number of generating, units consistent with the system profile, domestic and export load demands, review the specification of all electrical and mechanical equipment.

**Chair person**

The Hydropower Engineer/Civil Engineer covering dam safety will be nominated as the Chair of the panel. The chair will coordinate with other panelists to ensure the memberships objectivity and to provide balance to its reviews and recommendations. The Chair will coordinate the activities and communications of the Panel, call and chair its meetings, and liaise as appropriate with the Chair of the Environmental and Social panel, inviting as deemed necessary experts relevant for each meeting.

His/her main tasks would be in the following but not limited to:

- Lead in reviewing the design, costs, and construction procedures of all infrastructures including hydraulic ones to be built under the project;
- Review the updated feasibility study reports, draft final Detailed Engineering Design reports, field investigation and recommendations made by the Consultant;
- Review the Dam’s design and stability analysis with due consideration to seismicity and geology of the area; the review will include assessing the safety of the spillway gates;
- Facilitate discussions among the DSPOE members; summarize key findings and recommendations including additional investigations if required;
- Review each panel member’s report
- Lead in preparing the minutes /summary report of DSPOE meeting in coordination with all participating panel members; and

**6.3 Tentative working days for DSPOE members**

S. No.	POE member	Days
	Core Group	
1	Team Leader (Hydropower Engineer/Hydraulics Engineer)	35
2	Geotechnical Engineer/Geologist	25
3	Hydraulics/Sediment Expert	20
	Others	
4	GLOF Expert	10
5	Hydrologist	15
6	Seismologist	10
7	Electro mechanical Engineer	10



*[Signature]*  
Project Director

## 7. APPROACH AND METHODOLOGY

The DSPOE will commence its work through in-house reviews of relevant documents, meetings with technical staff and other stakeholders as well as field visits to the project areas. The schedule of meetings will be coordinated jointly with the NEA, the Consultants, and the two Panels (e.g., Dam Safety Panel and ESPOE) as relevant. The Panel shall meet as frequently as necessary during the preparation of the Consultants' work and deliverables of each Project phase to assess the quality, due diligence, timeliness and status of the works and to present recommendations. The meetings will normally take place at the Kathmandu office, and shall be attended by relevant members of the Panel, the World Bank, the NEA, and any other parties as authorized by NEA (which may, for example, include the ESIA and social planning consultants).

Meetings should be held:

- When important decisions regarding key aspects of the Project must be made;
- When draft reports become available for each deliverable of the Consultants' work (e.g. updated feasibility Study Report, draft Final Report, Filed Investigation and Hydraulic model test report, etc.).

The schedule of the meetings should be arranged well in advance, taking into account the work program of the Project. The DSPOE will carry out its necessary field visits to the site. After each meeting, the panel will prepare a report and the chair will be responsible for getting the signatures of the panel members.

The services of the individual members of the Panel may be used as necessary or desirable during intervals between meetings, as agreed with NEA, with copies of their comments being sent to the other members of the Panel and to NEA.

## 8. SELECTION PROCESS

The selection of the members of the DSPOE will be carried out as per the Guidelines for Selection and Employment of Consultants under IBRD Loans and IDA Credits & Grants by World Bank Borrowers, dated January 2011 Revised July 2014 ("Consultants' Guidelines"). NEA shall directly contract the members of the DSPOE on an individual basis. The selection will be based on the requirements, qualification and capability of the individual to carry out the assignment. The World Bank will provide *no objection* to the final selection of the members.

## 9. SUPPORT SERVICES

The Nepal Electricity Authority (NEA) shall make available its authorized personnel and that of the Consultants of the Project for discussions at the request of the Dam Safety panel and they shall be present during all meetings with the Panel. The NEA, the Environmental and Social Consultants, and the Engineering Design Consultant shall provide the necessary documentation such as background information, relevant data, engineering design reports (criteria and calculations), laboratory tests and minutes of consultation meetings. The NEA will facilitate the interaction of the Panel with all project

consultants as well as any other key stakeholders which the Panel members identify as necessary to consult directly in order to fulfil the objectives of the assignment.

The UAHEP shall take necessary actions to allow prompt travel clearances (if necessary) of the members of the Panel or specialists requested by the Panel, and shall provide full safe physical access to the Project area and sites.

## 10. REPORTING REQUIREMENTS

The Panel members will share technical expertise and knowledge through meetings, consultations and field visits. The Panel shall document the results of each of its visits and of the overall conclusions and recommendations. The Panel will also provide a consolidated report at the conclusion of its meeting schedule. The draft shall be shared by NEA with the World Bank for their comments. The minutes and reports of the meetings shall be prepared by the Panel. The minutes shall be signed by participating members of the Panel and presented to the NEA, the environmental and social Consultants, and reviewed with them prior to the departure of the members. The chair will be responsible for reaching consensus and getting the signatures. The Panel shall be expected to maintain the confidentiality of any commercial or proprietary information of the project that the members may have received from NEA or any government entity.

## 11. PROJECT DOCUMENTS

The following project documents are to be made available to the Dam Safety Panel of Experts:

- Terms of Reference for Engineering Consultant for Engineering Study (Annex C);
- Terms of Reference for Consultants for the preparation of the ESIA, CIA and social planning studies;
- All available and updated feasibility study reports for UAHEP and IKHPP prepared by NEA and DOED;
- Consultation Report(s) prepared at different stages;
- All draft and final deliverables of the Engineering Design and Environmental and Social consulting teams contracted by NEA to prepare the project; and
- Other relevant documents that the Panel may request, as available.

Reports and Time Schedule of reports of the Design Consultant to be made available to the DSPOE are attached in Annex B.



## 12. ANNEXES

ANNEX A: (i) Salient features of the Upper Arun Hydropower Project, as derived from the feasibility study completed in 1991.

TYPE OF PROJECT	Peaking Run-of-River (PRoR)
RIVER	Arun River (left bank)
TOTAL CATCHMENT AREA	25,700 sq km (25,300 in Tibet)
AVERAGE FLOW	200 m <sup>3</sup> /s
FIRM FLOW (95%)	58.7 m <sup>3</sup> /s
PROBABLE MAXIMUM FLOOD (PMF)	4000 m <sup>3</sup> /s
GLACIAL LAKES OUTBURST FLOOD (GLOF)	6900 m <sup>3</sup> /s
DAM	37m high; * m in crest length, radial gated concrete weir
CREST LENGTH	
RADIAL GATES	Three gates: each 12 m W × 22 m H
GROSS STORAGE VOLUME	760 × 10 <sup>3</sup> m <sup>3</sup>
ACTIVE STORAGE VOLUME	440 × 10 <sup>3</sup> m <sup>3</sup>
DESIGN HEAD	492m
RATED DISCHARGE	58.7 m <sup>3</sup> /s
DESIGN DISCHARGE	78.8 m <sup>3</sup> /s
FULL SUPPLY LEVEL	1598 masl
MINIMUM OPERATING LEVEL	1588 masl
NORMAL TAILWATER LEVEL	1089 masl
INTAKE SILL LEVEL	1583 masl
DESANDING BASIN	Three caverns: 128 m long, 24 m wide, and approximately 32 m high, each housing two settling basins
HEADRACE TUNNEL	Length: 7840 m, Diameter: 5.5 m

SURGE TANK	Height: 91 m, Diameter: 18 m, simple circular
PRESSURE SHAFT	Height: 454 m, Diameter: 2.8 m, steel lined
PENSTOCK TUNNEL	Length: 60m, Diameter: 2.8 m , steel lined
POWERHOUSE TYPE	Underground powerhouse
TURBINES	Four units of pelton turbine
INSTALLED CAPACITY	335 MW (4 × 83.75 MW)
ANNUAL FIRM ENERGY	2,050 GWh
TAILRACE TUNNEL	Length: 850 m, area 50 m <sup>2</sup> /s, horseshoe
ACCESS ROAD	23.4 km between UAHEP powerhouse and dam site, including 1.7 km road tunnel

(ii) Salient features of the Ikhuwa Khola Hydropower Project, as derived from the feasibility study completed in 2016.

LOCATION	District: VDCs	Sankhuwasabha PawaKhola-5 and 7
	Geographical Location	Latitude 27°35'07" and 27°37'12" Longitude 87°21'16" and 87°25'07"
METEOROLOGY AND HYDROLOGY	Average Annual Precipitation, mm	1440
	Catchment Area , km <sup>2</sup>	127.6
	Average Annual Flow , m <sup>3</sup> /s	7.52
	Design Flow (40% exceedance) , m <sup>3</sup> /s	6.02
	Design Flood Flow, m <sup>3</sup> /s (with 100 yrs return period)	346
	90% Firm Flow , m <sup>3</sup> /s	1.6
	Riparian Release , m <sup>3</sup> /s	0.20
HEADWORKS	Type	Uncontrolled Concrete gravity structure diversion weir
	Spillway length, m	26.0
	Crest elevation, m	EL 1493.0
	High flood level, m	EL 1496.80
	Crest length ,m	28.0
	Maximum height, m	6.0
	Design flow, m <sup>3</sup> /s	346
UNDERSLUICE	Section (BxH)m	2.0m X 3.0m (2 Nos.)
	Crest Level	1490.0EL
INTAKE STRUCTURE	Location	Immediately upstream from the under sluice at an angle of 110° with weir axis
	Type	Side intake, orifice type
	Size of each bay , (BxH)m	3.0 x 1.7
	Intake bays, Nos.	2
	Intake Sill Level, m	EL 1491.30
	Normal Water Level, m	EL 1493.0
	Approach Velocity, m/s	0.7
APPROACH CANAL	Type	Rectangular, open
	Length,m	12.0 m
	Size (BxH)m	2.5 x 2.0
	Canal Bed Slope	1 in 1000
	Geology	Alluvial and Colluvial deposit
GRAVEL TRAP CHAMBER	Type	Surface
	Size (LxBxH)m	10 x 3 x 3

CONNECTING CANAL	Type	Rectangular, open
	Length, m	20.0
	Size ,(BxH)m	2.5 X 2.0
	Canal Bed Slope	1 in 1000
	Geology	Alluvial and Colluvial deposit
DESILTING BASIN	Type	Surface
	No of bays	2
	Dimension(L x B x H) m	56 x 8 x 4
	Particle size to be settled,mm	0.2 (90% trap efficiency)
	Water level at Desilting Basin, m	EL 1492.70
HEADRACE CANAL	Geology	Alluvial and Colluvial deposit
	Type	RCC
	Length ,m	392.0
	Size ,(BxH)m	2.2 X 2.0
	Canal bed slope	1 in 1000
HEADRACE POND	Geology	Alluvial and Colluvial deposit
	Length, m	20.0
	Size mxm	4.0 x 3.0
HEAD RACE TUNNEL	Geology	Alluvial and Colluvial deposit
	Section	Inverted D-shaped
	Size , (BxH)m	2.5x2.5
	Gradient	1;1000
SIPHON CROSSING	Length, m	3624.0
	Diameter, m	1.6
	Thickness, mm	12
FOREBAY	Length, m	126
	Water level, m	1487.30
	Section	Rectangular
	Size (BxH) m	10 x 4
	Length, m	58
	Spillway	With a design capacity of 1.5 times design discharge
PENSTOCK	Geology	Alluvial and colluvial deposit
	Type	Partly buried and partly exposed
	Internal Diameter ,m	1.4m and 1.0m after bifurcation
	Length, m	1650.0 m up to bifurcation and then 33 m
	Thickness, mm	12 to 32
POWERHOUSE AND	Geology	Colluvial deposit
	Type	Surface
	Size(LxBxH)m	35 x 20 x 28
	Turbine centre level, m	874.0
	Installed capacity, MW	30
	Number of generating units, Nos	2
	Tailrace water level, m	871.9
Net Head, m	60	



*[Signature]*  
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TAILRACE	Tailrace canal	Rectangular
	Section	Covered, concrete lined
	Size (B x H)m	2.5 x 2.0
	Gradient	1:1000
	Length, m	48
	Geology	Alluvial and colluvial deposits
TURBINES	Type	Vertical axis, Pelton
	Number	2
	Rated output capacity per unit, MW	15.0
	Rated Net Head, m	601.0
GENERATORS	Type	synchronous 3 phase
	Number of units, Nos	2
	Rated output capacity per unit, Mw	15 each
	Power Factor	0.85
	Voltage, KV	11
	Frequency, Hz	50
	Excitation system	Brushless
POWER TRANSFORMER	Type	Outdoor, oil immersed
	Number, Nos	2
	Rated Output, MVA	16.76 each
	Rated voltage, KV	11/132
TRANSMISSION LINE	Voltage Level, KV	132, single circuit
	Conductor	ACSR "BEAR"
	Length, Km	37
	From - To	NEA proposed substation at Tumlingtar
ENERGY GENERATION	Net Annual Energy,GWh	181.74
	Dry season,GWh	40.72
	Wet season,GWh	141.02
PROJECT COST	Total cost of project in NRs (excluding Tax & duties at 2014 price level)	5,410,122,876
CONSTRUCTION PERIOD	(In months)	36
ECONOMIC INDICATORS	Net Present Value (NPV) in '106	NRs. 1968.782
	Benefit-Cost Ratio (B/C)	1.403
	Economic Internal Rate of Return (EIRR)	15.05%
FINANCIAL INDICATORS	Net Present Value (NPV) in '106	NRs. 1032.64
	FIRR	14.59%
	B/C Ratio	1.25
ACCESS ROAD	Length, km From Dovan to PH	8.1
PROJECT ROAD	Length, km From PH to Headworks	12.5



*[Signature]*  
Project Director

## Annex B: Summary of Tasks and Reports of Detailed Engineering Design Consultant

(I) The summary of Tasks to be carried out by the Engineering Consultant:

### **Upper Arun Hydroelectric Project**

- |         |   |
|---------|---|
| Task 1  | Inception of Assignment   |
| Task 2  | Field Investigation and Data Collection for Engineering Studies             |
| Task 3  | Hydrological and Sedimentological Studies                                   |
| Task 4  | Hydraulic Model Test  |
| Task 5  | Project Optimization & Review and Update of Feasibility Studies             |
| Task 6  | Detail Engineering Design, Specifications and Drawing                       |
| Task 7  | Power Evacuation Study  |
| Task 8  | Construction Planning and Scheduling inclusive of construction power supply |
| Task 9  | Project Cost & quantity Estimation  |
| Task 10 | Economic and Financial Analysis of the Project                              |
| Task 11 | Environmental Impact and Safeguard Studies                                  |
| Task 12 | Preparation of Complete Tender Documents & Tender Drawings                  |
| Task 13 | Analysis of Institutional Arrangement for Project Implementation            |
| Task 14 | Assist NEA for technical evaluation of bids and contract negotiation.       |

### **Ikhuwa Khola Hydro Project**

- |        |   |
|--------|---|
| Task 1 | Inception of Assignment   |
| Task 2 | Field Investigation and Data Collection for engineering studies |
| Task 3 | Hydrological and Sedimentological Studies                       |
| Task 4 | Project Optimization Study                                      |
| Task 5 | Detail Engineering Design, Specifications and Drawing           |
| Task 6 | Power Evacuation Study  |

Task 7	Construction Planning and Scheduling inclusive of	construction power supply
Task 8	Project Cost Estimate	
Task 9	Economic and Financial Analysis of the Project	
Task 10	Environmental Impact & Safeguard Study	
Task 11	Preparation of Complete Tender Documents & Tender Drawing	
Task 12	Analysis of Institutional Arrangement for Project	Implementation

**(2) Reporting Requirements and Time Schedule for Deliverables by Engineering Consultant:**

**(i) UAHEP**

The consultant shall discuss their interim findings at review meetings to be held with NEA project management team on regular basis, and provide the following final deliverables.

- Inception Report within three (3) months of commencement of services covering activities as stipulated in Task 1.
- Topographical Survey Report within four (4) months of commencement of services.
- Geological Mapping Report within six(6) months of commencement of services
- Construction Material Survey Report within six (6) months of commencement of services
- Project Optimization & Review and Update of Feasibility Studies report within seven (7) months of commencement of services covering activities as stipulated in Task 5
- Design Basis Memorandum (DBM) within seven and half months (7.5) months of commencement of services.
- Field Investigation Report I within twelve (12) months of commencement of services covering most of the activities as specified in Task 2.
- Report on Hydraulic Model Test within sixteen (16) months of commencement of services covering activities as specified in Task 4.
- Field Investigation Report II within twenty (20) months of commencement of services covering all activities as specified in Task 2.
- Cost Estimation Report within twenty (20) months of commencement of services covering activities as stipulated in Task 9.
- Economic and Financial Analysis Report within twenty (20) months of commencement of services covering activities as stipulated in Task 10.

- Draft Final Detailed Engineering Design Report within twenty one (21) months of commencement of services. The report shall include the following
  - Final Report on Field Investigation
  - Design Criteria Report
  - Hydraulic Model Test Report
  - Project Layout, Hydraulic Design of Civil Works, Civil Works Design, Stability Calculations, Structural Calculations and Detailed Design
  - Hydraulic Steel Structure, Mechanical and Electrical Equipment and Transmission Line
  - Methods used in design, reasons for technical decisions and reference to all technical memoranda and design reports
  - Detailed Quantity Estimate
  - Detailed Cost Estimate
  - Construction Planning and Scheduling
  - Economic and financial analysis
  - Engineering Drawings
- Final Detail Engineering Design Report after incorporating comments from NEA within twenty four (24) months of commencement of services.
- Draft Tender Documents/Drawings within twenty one (21) months of signing the contract
- Final Tender Documents after incorporating comments from NEA within twenty four (24) months of signing the contract
- The monthly progress report in agreed format covering all the activities of the consultant in the previous month within 15 days of the end of the reporting month.
- Trimester Report in agreed format summarizing all activities of the consultant in the previous trimester.

**(ii) IKHPP**

- Inception Report within six (6) weeks of commencement of services covering activities as stipulated in Task 1.
- Project Formulation Report within eight (8) weeks of commencement of services covering activities as stipulated in Task 2, 3 and 4.
- Design Basis Memorandum (DBM) within three months (3) months of commencement of services.
- Field Investigation Report within five (5) months of commencement of services covering activities as specified in Task 2.



- Cost Estimation Report within Nine (9) months of commencement of services covering activities as stipulated in Task 8.
- Economic and Financial Analysis Report within Nine (9) months of commencement of services covering activities as stipulated in Task 9.
- Draft Final Detailed Engineering Design Report within ten (10) months of commencement of services. The report shall include the following
  - ❖ Final Report on Field Investigation
  - ❖ Design Criteria Report
  - ❖ Project Layout, Project Road Design, Hydraulic Design of Civil Works, Civil Works Design, Stability Calculations, Structural Calculations and Detailed Design
  - ❖ Hydraulic Steel Structure, Mechanical and Electrical Equipment and Transmission Line
  - ❖ Methods used in design, reasons for technical decisions and reference to all technical memoranda and design reports
  - ❖ Detailed Quantity Estimate
  - ❖ Detailed Cost Estimate
  - ❖ Construction Planning and Scheduling
  - ❖ Economic and financial analysis
  - ❖ Engineering Drawings
- Final Detail Engineering Design Report after incorporating comments from NEA within twelve (12) months of commencement of services.
- Draft Tender Documents/Drawings within eleven (11) months of signing the contract
- Final Tender Documents after incorporating comments from NEA within twelve (12) months of signing the contract
- The monthly progress report in agreed format covering all the activities of the consultant in the previous month within 15 days of the end of the reporting month.
- Trimester Report in agreed format summarizing all activities of the consultant in the previous trimester.

**ANNEX C:** Detailed Terms of Reference for the Detailed Engineering Design and preparation of Budding Documents for Construction of IKHPP and UAHEP (To be attached separately).



*[Signature]*  
Project Director

**ANNEX D:** Expected Involvement of the POE members in Review of Deliverable and Reports submitted by the Consultant.

Month	Report	Team Leader	Geo-tech. Er./ Geologist	Hydraulics/ Sediment Er.	GLOF Expert	Hydrologist	Seismo- logist	Electro mechanical Er.	Total
0	Before Contract								
3	Inception Rep	√	√	√					3
4	Update of FS & DBM of IKHPP								
7	Update of FS & DBM of UAHEP	√	√	√	√	√	√	√	7
10	Draft Final of IKHPP	√							1
11	Field Investigation initial UA	√	√			√			3
16	Hydraulic Model Test			√					1
20	Field Investigation final UA	√	√						2
23	Draft Final of UAHEP	√	√	√	√	√	√	√	7
33	Draft Bid Evaluation Report	√							1
	<b>Total</b>	<b>7</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>25</b>

- Notes:
1. The DSPOE is expected to review and approve the deliverables and reports or provide comments on them within five days of the submission the documents to DSPOE.
  2. The Consultant for the Detailed Engineering Design and Preparation of Bidding Documents has begun carrying out the services from March 1, 2018.



## **Section 7. Terms of Reference (ToR)**

**7A. Term of Reference for Upper Arun Hydroelectric Project**

**7B. Terms of Reference for Ikhuwa Khola Hydropower Project**

## **7A. Term of Reference for Upper Arun Hydroelectric Project**

## 1. Background

Nepal has enormous hydropower potential due to numerous rivers flowing south from the Himalayas and favorable topographical features. The total hydropower potential has been tentatively estimated to be 83,000 MW of which 43,000 MW has been assessed to be techno-economically feasible. However, only 733 MW (including isolated micro and small hydropower plants), has been exploited so far and only 58 percent of the total population have access to electricity supply through the national grid. The present capacity and energy generation is far less than the current electricity demand for both base and peak load and hence the country is forced to have 14 hours of load shedding during dry season. As the electricity demand is projected to grow by 10 percent per year, the situation will worsen in days to come, if the electricity generation is not increased and added to the system at the earliest. Therefore; NEA, an undertaking of Government of Nepal responsible for generation, transmission and distribution of electricity has decided to initiate the detail engineering study of hydropower projects which could be implemented at the earliest.. Upper Arun Hydro Electric Project (HEP) is one of such attractive projects in Eastern Development Region, which has very high head and firm river flow. The Government of Nepal (GoN) has decided to implement the project through NEA. Further, NEA has also envisaged to develop Ikhuwa Khola Hydropower Project (IKHEP) under the umbrella of Upper Arun Hydroelectric Project (UAHEP).

In this backdrop, Nepal Electricity Authority (NEA) desires to procure the services of internationally recognized consulting firm ("Consultant"), having competent team of specialists, to i) review and update the Feasibility study of Upper Arun Hydroelectric Project (UAHEP) and Ikhuwa Khola Hydropower Project (IKHEP), ii) carryout Detail Engineering Design of both the projects (UAHEP and IKHEP), and iii) prepare Bidding Documents for development of the projects. The Consultant's services shall be performed in close co-ordination with NEA, the Project Executing Agency. This Terms of Reference (TOR) attempts to outline the details of the Consultant's tasks during execution of the services. However, the Consultant shall note that the detailed list of tasks and activities shall not be considered as the complete and comprehensive description of the Consultant's duties. It shall be the consultant's responsibility to critically verify the scope of required services necessary to fulfill the objectives of the consultancy assignment so as to include them in the consultant's Technical and Financial Proposals.

## 2. Objective

The main objective of present assignment is to update the Feasibility Study and complete the necessary design and documentations to meet NEA, GoN and leading multilateral agencies requirements for implementation of Upper Arun Hydroelectric Project at the earliest.

The specific objectives of the consulting services are outlined as follows:

- Review/update Feasibility Study and other available relevant reports/data ;

- Prepare topographic maps for dam site, powerhouse site and other project areas as necessary;
- Conduct geological and geotechnical studies/ investigations inclusive of excavation of Test Adit at dam and powerhouse sites. Conduct seismological investigation and studies;
- Carry out hydrological, sedimentological and GLOF studies,
- Carry out physical modeling of dam, spillway and associated headwork structures including desanding basin;
- Conduct project optimization study;
- Prepare Detail Engineering Design and drawings of the project components;
- Conduct power evacuation study;
- Prepare project cost estimate and construction plan;
- Assist the Consultant carrying out the consulting services for Environmental Impact Assessment (EIA), Social Impact Assessment (SIA) and Planning Studies of Upper Arun Hydroelectric Project and Ikhuwa Khola Hydropower Project. Consultant for this study is required to conduct design and investigation works in close coordination with the Consulting Firm carrying out Environmental and Social Study of the project.
- Prepare a complete set of tender documents,
- Prepare economic/financial analysis based on detailed project cost, implementation schedule, risk analysis, etc.
- Analyze financial structure, financing plan and recommend the most appropriate structure/plan
- Analyze and recommend appropriate institutional arrangement for project implementation,
- Assist NEA for evaluation of bids and contract negotiation.

### **3. Project Information and Previous Studies**

Following Project Information are based on the Feasibility Study carried out in 1991 and some other studies carried out recently.

#### **3.1 Location & Access**

Upper Arun Hydroelectric Project is located in Sankhusabha District of Koshi Zone in Eastern Development Region along the Arun River of Nepal. The project area is situated within Longitude

87°20'00" to 87°30'00" East and Latitude 27°38'24" to 27°48'09" North. The proposed dam site is located in a narrow gorge about 350 m upstream of the confluence with Chepuwa Khola in Chepuwa Village. The powerhouse lies in Hatiya Village, nearby the confluence of Arun River with Leksuwa Khola.



The project area is located approximately 700 km east of Kathmandu and approximately 300 km north from Biratnagar. No motorable access is available to the project area at present. The nearest road head to the Upper Arun HEP is at Num Bazaar, the dam site of Arun III HEP. The road from Num Bazaar to the Upper Arun powerhouse site is about 23.4 km, which is under construction under North-South Koshi Road Project of Department of Road. Furthermore, project road of about 24 km including road tunnel of 1.7 km and a bridge across the Arun River will be required to reach the dam site of Upper Arun HEP.

### 3.2 Previous Studies

The project site was identified during the master plan study of Koshi River Water Resources Development carried out by JICA in 1985. The site was subsequently the subject of a reconnaissance study conducted by the NEA in summer of 1986. In 1987, Morrison Knudsen Engineers (MKE) carried out the first phase of the feasibility.

The Morrison Knudsen Corporation completed the Feasibility Study Phase II of in December 1991 under the financing services provided by UNDP. For this study, MKE sub contracted part of the work to Lahmeyer International, Germany; Tokyo Electric Power Services Company, Japan; NEPECON, Nepal; and New ERA, Nepal.

A Review Study was carried out by NEA in the year 2011 to identify the changes in available infrastructures mainly road and transmission line facilities in the vicinity of the project area, collect necessary information for the technical upgrading and updating project cost estimates. A



reconnaissance site visit was made in the year 2013 to assess the conditions of road infrastructures, hydrological gauging stations established during the feasibility study and camp facilities area.

Nearest proposed substation for the evacuation of power from UAHEP is substation at Tumlingtar. This substation is the part of Koshi Corridor transmission line and is intended to evacuate the power from several hydo projects proposed in this area. Koshi Corridor Transmission Line connects the Tumlingtar substation with the Integrated Nepal Power System at Inarwa Substation. This is a 220 kV transmission line and is 107 km long. This line is proposed to be financed by Indian Exim Bank. Implementation for the construction of this line is ongoing. Inarwa substation, Tumlingtar substation as well as the 107 km Koshi Corridor transmission line will be the part of national grid.

NEA has completed 220kV route alignment survey for 49 km long transmission line from Upper Arun Powerhouse to Tumlingtar sub-station in 2015. For the power evacuation of UAHEP, a 220 kV double circuit transmission line is proposed from the powerhouse to a proposed substation at Tumlingtar. Total length of the proposed transmission line is about 49 km. According to the proposed alignment, the transmission line will start from the powerhouse site of Upper Arun at Sibrung at the left bank of Arun River and immediately follows the right bank of Arun River. The transmission line will cross the Arun River to the left bank in the vicinity of the proposed dam site for Arun-3 HEP and heads towards the proposed substation of Koshi Corridor Transmission line at Tumlingtar. There will be 55 angle points in this route.

### **3.3 Topography**

The project area is located within the Middle and High Mountains Region. Elevation ranges from about 1,100 m at the Powerhouse site to over 1,600 m at headwork site along the ridgeline separating the powerhouse and dam site. Elevations along the Milke Dande ridge that separates the Arun drainage from that of the Tamor River exceed 4,000 m altitude. Arun river forms a deep and narrow gorge at the dam site, and a wider valley at the powerhouse site. Topographically the outgain slopes of the project area are steep to very steep, dissected by drainages and pocket of landslide areas are visible. This area is rich in bio diversity, animal habitats and micro climatic environment.

Some topographical surveys were carried out during the feasibility study phase-I and the detail topographical survey and mapping were carried during Feasibility Study Phase II by MKO and associate Consultant to produce topographical maps required for the project planning and design. The topographical maps produced are as follows:

- Detail topographical maps at a scale of 1:500 with 1 m contour intervals of the proposed dam site and outlet areas

- Topographical strip survey to produce topographical maps at a scale of 1:5000 with 10 m contour intervals for the routing of a road from Arun 3 dam site via Upper Arun powerhouse site to Upper Arun dam site.

All the topographical maps prepared are in printed copies and no computerized digital topographical maps are available.

### 3.4 Hydrology & Sediment Study

Arun River is one of the major tributary of the Saptkosi River basin. It originates from a glacier on the North Slope of Mt. Xixabangma Feng at an elevation of 8,012 m, part of this Himalayan range in the south part of the Tibetan highland. Locally the river is called Pum Qu within Tibet. The river flows eastward almost parallel to the Himalayan range in the upper reach within Tibet before flowing southward crossing the Himalayan range into Nepal. The total length of the Arun river is about 510 km, and the total drainage area is about 30,400 km<sup>2</sup>.

The drainage areas evaluated for the hydrological investigations are as follows:

<b>Arun River Basin</b>	<b>Drainage area ( km<sup>2</sup> )</b>
Upstream of border ( Tibet)	25,300
From border to Chepuwa gauging station ( about 500 m upstream of dam site)	400
From border to powerhouse site	970
From border to Uwa Gaon	1,320
From border to Tumingtar	2,840

Department of Hydrology & Meteorology (DHM) has established following gauging stations on Arun River:

<b>S.N.</b>	<b>Station</b>	<b>Drainage Area (km<sup>2</sup>)</b>	<b>Year</b>
600.1	Uwa Gaon	26,750	1985-2006
604.5	Turkighat	28,200	1975-2006
606	Simle	30,380	1975-2006

A gauging station was established at Chepuwa, about 500 m upstream of the proposed dam site during Phase II feasibility study. The station was, however, operational during 1989-1990. As the long term stream flow measurements are not available at the dam site itself, Stream flow estimates for the Upper Arun dam site were derived extending available flow data at Uwa Gaon gauging station which is

located approximately 25 km downstream from the dam site. The generated mean monthly flows at the intake of Upper Arun HEP are as follows:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flow (m <sup>3</sup> /s)	62.7	63.2	73.8	90.5	133	285	459	464	377	193	107	76.8

The annual mean flow at the intake site has been estimated to be 198.7m<sup>3</sup>/s. The minimum average monthly flow with 95% probability of exceedance is estimated as 52.8 m<sup>3</sup>/s. The river discharge corresponding to 90 % probability of exceedance is derived as 62.5 m<sup>3</sup>/s, whereas the river discharge corresponding to 40 % probability of exceedance is computed as 150 m<sup>3</sup>/s.

The annual maximum 1-day discharges of the gauging station 600.1 at Uwa Gaon available from the year 1975 to 1988 are used to perform the frequency analysis in order to generate flood hydrology for Upper Arun Hydroelectric Project. The estimated flood values at different return periods are as follows:

Ret. Period(Years)	5	10	20	50	100	1000
Dam Site (m <sup>3</sup> /s)	1000	1100	1200	1250	1350	1550
PH Site (m <sup>3</sup> /s)	1500	1650	1750	1900	2000	2300

Likewise the Probable Maximum Flood (PMF) at the dam site and the powerhouse site are estimated as 4,400 m<sup>3</sup>/s and 5,800 m<sup>3</sup>/s respectively. Based on three years of sediment sampling of gauging station 600.1 at Uwa Gaon, the total suspended load is estimated as 12.5 million tons/year for Upper Arun HEP.

### 3.4 Glacier Lake Outburst Floods (GLOFs)

The geomorphology of Arun River in Tibet is characterized by glacial or periglacial landforms. There are about 737 glaciers in Arun basin with an area coverage of 1357 km<sup>2</sup> and water storage of about 121 km<sup>3</sup>. Except for two small lakes in Nepal, all of these Glacier Lakes are located in the Tibetan part of China. Of these glacier lakes, six hazard potential glaciers are selected for GLOF analysis in Phase II feasibility study. The analysis estimated the GLOF discharge of 6,300 m<sup>3</sup>/s at the dam site of Upper Arun HEP. The damage is likely to be caused by large boulders directly impacting the engineering structures. The safety of dam and other structures will depend on timely opening of main gates so that GLOF is released safely without overtopping the diversion structure.

### 3.5 Geology

Upper Arun Hydroelectric Project area belongs to Higher Himalayan Crystalline Zone, and Lower

Himalayan Meta-sediments consisting of mostly Rolwaling Granites, Rolwaling Paragneisses, Rolwaling Migmatites, Khare Phyllites and Khandbari Augen Gneiss. The main orientation of rock mass in the project area is NW-SE and the dip direction is SE.

The rocks observed at the headworks site consist of mainly fair to very good Quartzite and Mica Kyanite Gneiss along with poor to fair Gamet Biotite Schist. The headrace tunnel alignment passes through mostly quartzite and kyanite gneiss, muscovite schist, mica schist, amphibolite and carbonatic rock mass. The rocks at the power house site consist of fair to very good Augen and granitic Gneiss and very poor to fair Muscovite and Graphite Schist along with Amphibolites Gneiss and Calc Silicates in fault and shear zones.

The geological investigations carried out during Phase II feasibility study comprised the following activities:

- General geological map of the project area and geological profile from intake to outlet site in 1:10,000 and 1:12,500 respectively;
- Geological maps of the main project structure areas in scale of 1:1,000;
- Four seismic lines with total length of 920 m at the dam site and three seismic lines with total length of 2,065 m at the surge tank and powerhouse sites;
- Four core drilling with total length of 166 m at the dam site, one 77.5 m long core drilling over the headrace tunnel and six core drilling with total length of 448 m to cover the surge tank-outlet area;

A seismic risk study was performed during the Phase II feasibility study to determine the seismic parameters required for the feasibility level design of Upper Arun HEP. Following the "Guidelines for selecting seismic parameters for large dams" of ICOLD, the seismic horizontal coefficient is recommended as 0.18 g as operating base peak ground acceleration and 0.12 g as the pseudo-static design factor.

### **3.6 Layout & Project Configuration**

Upper Arun Hydroelectric Project is a peaking Run-of-River type hydroelectric project allowing the daily peaking operation of four hours twice a day. The general arrangement of the project comprises of gated diversion structure, underground desalting basin, headrace tunnel, surge tank, drop shaft and horizontal steel lined tunnel, underground powerhouse housing four vertical axis Pelton turbines, tailrace tunnel releasing water back to Arun River.

The main civil components of the project are as follows:

- A diversion concrete weir of crest length 80 m and height of 37 m equipped with three radial gates of size 22 m x 12 m having the active storage volume of 440,000 m<sup>3</sup>;

- RCC intake structure 24.0 m wide, 23.4 m long and 30.0 m high on the left bank housing trashracks, control gates and stoplogs operated by gantry crane;
- Three underground caverns 128 m long, 24 m wide and 32 m high, each housing two settling to trap at least 90% of silt particles greater than 0.2 mm
- Water conveyance system consisting of circular reinforced concrete lined headrace tunnel of length 7,840 m and finished diameter of 5.5 m;
- Circular cross section lined with concrete surge tank at the end of headrace tunnel of internal diameter 18.0 m and height of 91.0 m;
- Two steel lined vertical pressure shafts of finished diameter 2.8 m and height 454 m (with provision of third shaft for future plant expansion) and steel lined horizontal pressure tunnel of length 60 m each bifurcating to 1.7 m diameter prior to reaching the powerhouse;
- Powerhouse cavern of dimension 105.0m x 21.0 m x 35.0 m (L x B x H) housing all electro-mechanical equipment;
- Switchgear cavern accommodating GIS and transformers;
- Horseshoe shape 7.5 m finished diameter tailrace tunnel of length 850 m ending with an outlet structure releasing water back to Arun river;

The electro-mechanical equipment consists of four sets of vertical Pelton Turbines (Rated Power of 83.7 MW each) coupled with four sets of 3-phase synchronous generators (Rated Power of 99 MVA each) having power factor of 0.85 over excited. The generation voltage of 13.8 kV will be stepped up to 220 kV by three single phase transformer of rated capacity 33 MVA per pole. The rated efficiencies adopted for selected turbines, generators and transformer are 89.5 %, 98 % and 99.5 % respectively.

### **3.7 Power & Energy Generation**

The optimization study carried out in the Phase II feasibility study adopts the optimum plant capacity as 335 MW with due consideration of the system demand characteristics. The design discharge has been adopted as 78 m<sup>3</sup>/s (75 % Probability of Exceedance). The net head is computed as 492 m after deducting all probable head losses from the available gross head. With the firm discharge of 58.7 m<sup>3</sup>/s, the firm plant is computed as 245 MW generating firm energy of about 2,050 GWh annually. The total energy generation inclusive of the secondary energy generation from the project is recomputed as 2,597 GWh after deducting loss and outages in the review study.

As per the Feasibility Study the plant arrangement allows future plant expansion to a total installed capacity of 500 MW for additional domestic consumption or export of the wet season surplus energy. Expansion will be accomplished by addition of two more units in the powerhouse, one pressure shaft, and one power intake with desalting basin.

### **3.8 Construction Schedule**

The project construction shall be preceded by detailed engineering study, which will require a period of twenty four months. It is envisaged that arrangement of funds will be made during the same period. Preparatory works like access road, camp, and construction power will be undertaken through a separate contract ahead of the main construction. Total construction time required for the completion of the project is estimated to be 5 years from the date of initiation of actual project construction at site. The critical path determining the overall duration of the project commences with the construction of the access road to the site and includes the construction of the 7.84 km m long headrace tunnel, for which careful attention should be given during project implementation.

### **3.9 Project Cost Estimate/Evaluation**

The estimated project cost is based on the bill of quantities derived during the Phase II feasibility level study and the revised unit rates of items in the present context. The total estimated project cost for Upper Arun HEP excluding financing costs is US \$ 445.53 million at the price level of 2011. The specific project cost is US\$ 1,330 US\$/kW.

In scenario of project development by NEA through financing from subsidiary loan agreement with Government of Nepal (GoN), the required energy price is NRs. 2.10/kWh as of the year 2011 and NRs. 2.74/kWh from the year 2020 onwards in order to get the expected the return of equity of 14%.

### **3.10 Environmental and Social Considerations**

As a simple Run-of-River type hydroelectric without a large dam or reservoir structure, Upper Arun Hydroelectric Project will by its nature have less environmental impacts. The project along with the proposed access road is located within buffer zone of Makalu-Barun Conservation Area. Some environmentally issues of the project comprise: (i) dewatering of about 15 km river and regime changes (ii) increased potential of soil and slope destabilization (iii) Spoil deposits in river and steep terrains; (iv) appreciable loss of forest resources;(v) threat to some rare and indigenous plants and wild life; (vi) loss of fisheries and aquatic life and (vii) threat to local culture by influx of people. Some environmentally favourable features of the project comprise: (i) local job opportunities (ii) increase in economic active ties (iii) extended and improved GLOF surveillance and warning system and (iv) community development and local access.

The Environmental Assessment (EA) Study was conducted during the Phase II feasibility study according to World Bank's Operational Directive, 1989. As per Environment Protection Rules (1997),

Environmental Impact Assessment (EIA) of the project will be required for project implementation.

Accordingly, it is proposed that Environmental and social study will be conducted by a separate Consulting Firm and the Firm for this study is required to carry out its design and investigation in close coordination with the Consulting Firm carrying out Environmental Study and Social Study of the project.

#### 4. Scope of Services

The scope of consulting services for the Detail Engineering Design and preparation of the Tender Documents including specifications and Tender Drawings shall be based on the updated Feasibility study carried out by the consultant based on the Feasibility Study conducted by NEA in 1991 and the field investigation and studies carried out as part of the current study. The Consultant can refer the data/information and the past studies but shall be responsible to check, verify and confirm their authenticity. The services to be provided by the consultant shall comprise but not be limited of following tasks. **The Consultant shall include in the financial proposal all costs required to carry out the activities required under the scope of services and to complete the assignment as per the terms of reference.**

- Task 1      Inception of Assignment
- Task 2      Field Investigation and Data Collection for Engineering Studies
- Task 3      Hydrological, Meteorological and Sedimentological Studies
- Task 4      Hydraulic Model Test
- Task 5      Project Optimization & Review and Update of Feasibility Studies
- Task 6      Detail Engineering Design, Specifications and Drawing
- Task 7      Power Evacuation Study
- Task 8      Construction Planning and Scheduling inclusive of construction power supply
- Task 9      Project Cost & quantity Estimation
- Task 10     Economic and Financial Analysis of the Project
- Task 11     Environmental Impact and Safeguard Studies
- Task 12     Preparation of Complete Tender Documents & Tender Drawings
- Task 13     Analysis of Institutional Arrangement for Project Implementation

Task 14 Assist NEA for technical evaluation of bids and contract negotiation.

The services carried out by the Consultant shall be reviewed periodically by independent Panel of Experts (POEs) appointed by NEA and approved by the World Bank. The reports submitted by the consultant shall be accepted by NEA after approved by the POEs.

**Task 1: Inception of Assignment**

Main activities under this task shall include review of existing reports, applicable guidelines/norms, available data, project review, planning and initiation of the field work and up-dating of the work plan submitted with the proposal on the basis of the findings of the review.

The Consultant shall, immediately upon initiation of the inception assignment, begin collection of all relevant reports, data and maps. NEA will make available to the Consultant existing study reports, in particular the Feasibility Study Report, and other available information/ data/maps.

In the project review, all information/data of the project should be subjected to critical scrutiny in order to establish a realistic understanding of the type and scope of additional information/data required for subsequent analysis/design. As part of the project review, the Consultant shall:

- a. Identify key areas, which will require additional fieldwork or demand major efforts in data collection/ investigation;
- b. Review the Feasibility Study Report and other documents, information, data provided by NEA;
- c. Establish methods and procedures for further studies

The Consultant shall undertake a field reconnaissance and visit to the project site covered by all project components and carry out engineering studies with respect to the topographical and geographical features, geological, hydrological, meteorological and sedimentological aspects of the project area.

In parallel with data collection and field reconnaissance, the Consultant shall prepare a time schedule with milestones and specific key dates. This schedule shall be based on that submitted by the Consultant as part of the proposal, suitably updated to reflect the additional information/ data needs.

The Inception Report shall summarize the results of the review of existing data/ reports, summarize the results of the field reconnaissance, discuss the key data/information gaps requiring additional field work/investigation, data collection, data verification, and describe the approaches and methodology that the Consultant intends to follow in carrying out various activities to complete the assignment. The Inception Report shall also include the updated methodology and work plan for the ongoing studies, detailed schedule for each task, detailed field investigation plan, manning schedule of each personnel for effective mobilization. All collected data/information, reports, documents should be subject to



critical scrutiny in order to establish a realistic understanding of the field situation, data gap, additional investigation and studies to be included in the study. Therefore, the Consultant shall make a presentation of the Inception Report, including use of appropriate visual aids, to NEA.

## **Task 2: Field Investigation and data collection for Engineering Studies**

The following field investigations, among others, shall be performed by the Consultant:

### **a) Topographical Survey**

The Consultant shall perform, among others, the following activities:

- Establishment of datum points for survey control network within the project area connecting the national grid for topographic mappings;
- Detailed mapping of the project sites including dam site, intake area, powerhouse area, surge tank area, impoundment area of daily peaking pondage and portal areas in scale of 1:500 and 1m contour interval, Bathometry surveys of river cross section (at an interval of 100 m or the places where the topography changes) from 1 km downstream of the dam site to 1 km upstream from the upstream end of the pondage area created by the dam. Detail mapping of the tunnel alignment strip in scale of 1:5000 and 5m contour interval; (Item 4B3-3- 200 ha)
- Cross section survey at the interval of 50 m around the dam and tailrace sites from 500 m upstream to 500 m downstream of the dam axis and the tailrace outlet; including water depth & highest flood mark.
- Detail mapping of project road alignment, camp facilities, spoil disposal area, borrow area and so on; in a scale of 1:500
- Additional transmission line route alignment survey based on the review study of transmission line route alignment survey of 220 KV carried out by NEA.

### **b) Hydrological, Meteorological and Sedimentological Investigation**

The Consultant shall perform, *inter alia*, the following activities:

- Acquire all the data related to stream flow and other hydro-meteorological data (Precipitation, temperature, relative humidity, evaporation, solar radiation, wind speed etc.) from the gauging and climatic stations in the catchment area of the Upper Arun HEP and relevant to the Upper Arun HEP.

- Install automatic gauging station (using radar sensor) at the dam site and establish gauge station at the powerhouse site at appropriate locations where river beds are stable and flow pattern stable;
- Install cableway for discharge measurement and sediment sampling at the dam site.
- Establish and conduct program for continuous water level observations and river flow measurements at these locations for minimum 8 times in 24 months covering all seasons to develop a rating curves;
- As a part of sediment investigation, study and monitoring, the consultant shall:
  - Collect the historical suspended and bed load sediment data/information on Arun river
  - Study catchment characteristics from sediment point of view
  - The tentative methodology for depth integration sediment sampling method for each year period, in total 2 years period is as follows:

<b>SN</b>	<b>Period</b>	<b>Description</b>
1.	Monsoon (4 months)	10 regular samples a day from 10 verticals and 30 additional samples in a month for concentration analysis for 4 months
		At least 6 samples in a month for PSD for 4 months
		At least 6 samples in a month for mineral content analysis for 4 months
2.	Post Monsoon (3 months)	10 regular samples from 10 verticals in every 2 days and no additional sample for concentration analysis for 3 months
		At least 4 samples in a month for PSD for 3 months
		At least 4 samples in a month for mineral content analysis for 3 months
3.	Dry Season (3 months)	10 regular sample from 10 verticals in every 1 week and no additional sample for concentration analysis for 3 months
		At least 2 samples in a month for PSD for 3 months
		At least 2 samples in a month for mineral content analysis 3 months
4.	Pre Monsoon (2 months)	10 regular sample from 10 verticals in every 2 days and no additional sample for concentration analysis for 2 months
		At least 4 samples in a month for PSD for 2 months
		At least 4 samples in a month for mineral content analysis for 2 months

- Develop a rating curve of suspended sediment load of the river;
  - Estimate the bed load contribution to the total sediment load by means of site measurements or other means appropriate;
  - Estimate the possible ranges of sediment load to the power stations and recommend suitable value for design;
  - Carryout the water quality analysis to determine the corrosive effectiveness (hardness).
- Establish meteorological stations in the project area for recording of temperature, precipitation, humidity, evaporation etc.;
  - Start dry season program for water level observations and water flow measurements in nearby smaller tributaries like Chepuwa and Leksuwa Khola;
  - Collect secondary data on climate change to examine its potential impact on the project;
  - Follow up recommendations to improve reliability of current observations at DHM gauging stations in Arun;
  - Investigation on possibility of aggravated erosion in the catchment area due to change in land use pattern, road and other infrastructure construction in the catchment' which may result in rapid sedimentation. The consultant shall make a comprehensive investigation of the problems with a view to propose measures to reduce the long-term sedimentation.
  - Installation of Cable Way, Automatic Hydrological Gauging Station at dam site and gauging station at powerhouse site shall be completed by 6 weeks after commencement of the services.

### c) **Geological, Geotechnical, and Construction Material Investigation**

The Consultant shall perform, *inter alia*, the following activities:

- Mobilize, locally transport machines at site, construct helipads, construct tracks and demobilize machines after completion of work. Lease necessary land for above purposes.
- Core drilling in rock/overburden at dam site, surge tank site, powerhouse site, and other areas deemed necessary by consultant to determine rock profile, quality of rock, minimum rock stress at various elevations, wherever necessary. It has been estimated that a total of 850 linear meter (proposed at 12 different locations, 5 at dam site, 1 at tunnel alignment, 1 at surge tank, 5 at Test Adits) of core drilling will be required for the investigation. It is the responsibility of the Consultant to determine the requirement of core drilling at different sites and to propose additional core drilling if deemed necessary. Necessary in-situ and laboratory tests in the drill holes and core

samples including but not limited to permeability test, lugeon test, UCS of core sample, point load test, 'C' and ' $\phi$ ' determination, Dynamic Cone Penetration Test (DCPT) and SPT.

Measurement of core drilling will be made on the basis of the actual lengths of boreholes recorded by the Consultant. The price rates for core drilling shall include for the costs of all labors, materials, tools and equipment and all operations required for drilling the holes, removing cores, keeping accurate logs of drill holes, provision of boxes, core logging, labelling, transporting, and storing the cores and all incidental work connected therewith. The payment of drilling includes all the works required for drilling, lugeon or water pressure tests and core box logging and storing of core boxes until handover to the Client. The Core box should be clearly marked the No. of hole and depth with the permanent marker and stored securely on the boxes.

The Consultant after completing the holes shall request for the payment only after submission of final drilling report with the complete core boxes. Payment for grouting of core holes shall not be made separately and shall be included on the unit rate of drilling.

- Engineering geological mapping based on topographic maps at 1:500 scale at the dam site, MCT, shear zone sites, surge tank area, powerhouse and tailrace area in order to obtain more data in respect to rock mass condition.
- Engineering geological mapping based on topographic maps at 1: 5,000 scale of the headrace tunnel alignment for assessment of slope stability and leakage.
- Necessary rock mechanical tests including initial ground stress measurement, hydro fracture tests, Deformation tests (block shear, plate bearing, and Dilatometer tests) shall be performed in test adits and test chambers at Dam site and Powerhouse site as decided by Geotechnical Expert. Following tests are to be done:
  - Hydro fracture Tests: Minimum three (3) nos. of Hydro fracture tests at each powerhouse cavern test chamber;
  - Block Shear Tests: Minimum three (3) nos. of tests at one of the powerhouse cavern test chamber / test adit;
  - Plate Bearing Tests: Minimum three (3) nos. of tests at Desanding Basin cavern test chamber / test adit;
  - Dilatometer Tests: Minimum three (3) nos. of test at Dam site cavern and Desanding basin cavern test chambers
- Geophysical Survey (2D Electrical Resistivity Tomography (ERT) including topo survey for ERT profiles for assessment of depth of overburden and rock quality in the project area and borrow areas.

- Identification of borrow areas and quarry areas for construction materials such as sand, aggregates, filter materials etc. and investigation/tests related to suitability of construction materials and determination of their physical, chemical properties, strength etc. The Consultant shall assess and make fair estimate of volume of each material from each of the borrow areas available for use during construction. Laboratory test on fines and aggregate of various locations shall be done.
- Further testing of construction material for concrete aggregate for alkali aggregate reaction test and evaluating requirements for crushing and milling and type of cement and admixtures to be used in order to obtain required quality of concrete and shotcrete.
- Consultant shall mobilize, demobilize equipment/machines all necessary for the test adits exploration, access / track to portals construction and shall arrange security of explosives including arrangement for two Bunkers and Two Army Camps at dam site and powerhouse site. Consultant shall lease necessary land to complete the test adits excavation work.
- Excavation of test adits tunnels (inverted D shaped of size  $D=2.5\text{m}$ ) with necessary niches and enlargement to sizes of  $W\ 4.0\ \text{m} \times H\ 7.0\ \text{m} \times L\ 6.0\ \text{m}$  caverns (proposed 4 Nos, 2 at Dam site and 2 at Power House) and determination of relevant rock properties for the design of the desanding and powerhouse caverns. It has been estimated that a total of about 1,430 m linear meter long test adit excavation/enlargement will be required to be carried out. It is estimated that two test adits at dam site with length of 80 m a right bank and 450 m at left bank, and one test adit of 900m at the powerhouse site. However, it is consultant's responsibility to determine the location, size and length of the test adit required for this propose accordingly. While fixing the alignment of the test adits, future use of these test adits in the form of access tunnel and other tunnel need to be considered while planning.
- The Consultant shall be responsible for recording the geological face mapping of the test adit tunnel on every advance. The Consultant shall prepare drawings showing plan and sections of Test adit, support class etc. The Consultant shall record the all excavation activities, explosives, support structure and the face mapping of the tunnel profile. The Consultant shall also maintain the ventilation, drainage and proper illumination in the test adit tunnels and shall carry out all tests deemed necessary for the design of underground structures.

#### **d) Seismological Investigation**

Dam site, headrace tunnel, surge tank, powerhouse and its peripherals will be the major structures of Upper Arun Hydroelectric Project with a potential vulnerability for extreme event earthquakes. The security of all aspects of the design under such conditions is of paramount importance and must be fully investigated. After review of the seismological study carried out during Phase II feasibility study, the Consultant shall perform, among others, the following activities:

- Detailed investigation of MCT shear zones, fault structure etc in the project area and its surrounding.
- Assessment of magnitudes and locations of past earthquake events. The program should include determination of fault plane and focal depth for some of the larger events near the dam site, headrace tunnel alignment, powerhouse site, within and in the vicinity of project area. Information available from Department of Mines, Government of Nepal and any other reliable sources may be used for this purpose. Information and the data of recent earthquake that occur in April 25, 2015 need to be used for this purpose. Determination of dynamic response profiles for accelerations and velocities applicable at different elevations shall be carried out for the Design Basis Earthquake (DBE) and Maximum Credible Earthquake (MCE) including likely damage to structures for each case.
- Recommends on the needs for establishment of the seismic network in the project area and preparation of the technical specification of the equipment, its installation and monitoring schemes (seismographs, accelerometers etc.).

#### **e) Investigation Related to Glacier Lake Outburst Flood (GLOF)**

Detail investigation on existence and possibility on development of glacial lakes which may prove to be a considerable risk for the project and recommendation on the measures to minimize the risks of potential GLOF. The activities to be carried out by the consultant shall include but not limited to the followings:

- Develop digital database and summary report on the database on the glaciers and glacial lakes of the Arun Basin in Nepal and Pumqu Basin in China based on the recent satellite images, DEM and maps.
- Compile the Glacial Lake Outburst Floods (GLOF), Cloud Burst Floods (CBF), Landslide Dammed Outburst Floods (LDOF) events in the Arun/ Pumqu basin with the details of the outburst phenomena and downstream impacts
- Prioritization of the Critical Lakes (Potential Dangerous Glacial Lakes) in Arun/Pumqu basin.
- Compile the geo-physical characteristics of the Critical Lakes based on available field reports, literatures, high-resolution images, DEM, maps, etc.
- Perform GLOF Modeling by applying a hydraulic mathematic model for selected Critical Lakes with details of: input data, methodology, models, results, sensitivity analysis and evaluation of results of hydraulic behavior on the Arun river and project sites.
- Down Stream Vulnerability Assessment and Analyze and estimate potential GLOF hazard for the project components.

- Perform a feasibility study of technical systems and operation of a comprehensive early warning of GLOFs to the communities along the Arun valley and propose a solution.
- Recommends on the needs for field monitoring of the potential glacier lake in Arun Basin within Nepal and preparation of the technical specification of the equipment for procurement and installation by NEA.

### **Task 3: Hydrological Meteorological & Sedimentological Study**

The hydrological study shall focus on direct measurement and re-assessment of the stream flow and flood. Daily peaking operation and power studies considering system needs using the long-term series of daily stream flow shall be performed to verify the Feasibility Study analysis. Detail analysis and study of the sediment for the design of the settling basin and other related structures shall be performed. Dam Break analysis shall be performed for the GLOF and PMF studies as necessary

The activities to be carried out by the Consultant under this task include but not limited to the followings:

- Review relating Hydrological, Meteorological and Sedimentological studies carried out in Feasibility Study;
- Assess the adequacy of available data and identify gaps, if any, in data;
- Assessment and estimation of long term mean flow of Arun River as well as other tributaries that could be tapped by Upper Arun HEP for power generation using appropriate methods in appropriate locations;
- Flood frequency analysis for determination of floods at different return periods and calculation of probable maximum flood (PMF) of Arun River in appropriate locations particularly at the dam and powerhouse sites; and determination of design flood for spillway and diversion during construction considering, among others, the economic aspects.
- Assessment and estimation of flood flow due to Glacier Lake Outburst Floods (GLOFs), Cloud Outburst Floods (CLOFs) and Landslide Dam Floods (LDFs) for dam spillway design & safety.
- Dam break analysis (DBA) for the planned UAHEP dam to determine the possible peak flood and associated water stages in the downstream reaches in the event of dam failure. The analysis shall generate, among others, necessary data leading to recommendation of a framework for early warning system and evacuation plan.

- Assessment of sediment characteristic including estimation of sediment yield of Arun River using appropriate methods and identification of the needs of sediment management measures;
- Investigation of alternative sediment management options.
- The consultant shall investigate the possibility of application of flushing, sluicing, density current venting, etc through mathematical calculations or numerical modeling to determine the most appropriate method to be applied. Assessment of effect of dam construction on the river flow regime, particularly downstream degradation and upstream aggradations, and recommendation for appropriate measure to minimize the adverse effects shall be presented.
- Assessment of possible impact of climate change on hydrological characteristics using different scenarios (without climate change, low climate change and high climate change) drawing from existing literature and data; Assessment of meteorological aspects relevant during construction phase, such as length of the rainy season, rainfall characteristics, number and duration of rainfall events, dry interval between rainfall events, temperature etc.
- Assessment of possible impact of upstream hydropower projects on UAHEP

#### **Task 4: Hydraulic Model Tests**

The hydraulic laboratory shall design and build a physical model of the dam, intake, reservoir and desilting basins to analyze and optimize multiple aspects of the design and perform the following studies.

1. In a model of 1:50 scale, evaluate the hydraulics of the spillway and plunge pool, and the hydraulic behavior of the intake (e.g. vortexing).
2. In the same model evaluate sediment transport phenomena in the vicinity of the intake, and specifically analyze the ability of the design to prevent the accumulation of bed material in front of the intake structure as well as design and operational strategies to generate secondary currents which can minimize the entrainment of suspended sediment into the intake.
3. Evaluate sediment transport and removal during reservoir drawdown for sluicing and/or flushing, depending on which measures are recommended for sediment management.
4. In a further model of 1:15 scale, evaluate the hydraulic behavior of the desanding basins – such as flow splitting – and also minimize hydraulic short-circuiting and maximize the sedimentation efficiency within each desanding basin.

For both models: Design deficiencies encountered in the physical modeling will be evaluated, and alternative configurations will be recommended after being tested and confirmed in the model.



**Task 5: Project Optimization, and Review and Update of Feasibility Study**

The Consultant shall review the design concept of the project established in the feasibility study and carry out the optimization study to determine the optimum capacity of the plant so as to maximize the power and energy benefits. Ranges of probable options shall be selected, for each of which standards design shall be prepared for determining costs and benefits at the prevailing market prices. The parameters for selecting the optimum option namely EIRR, B/C ratio, specific energy cost etc. shall be determined for each option to determine the best option. However, due consideration shall be given to the present energy demand scenario/export options with reasonable energy pricing while selecting the optimum plant capacity.

The consultant has to review and update the Feasibility Study of the Project based on the Optimum Installed Capacity.

The major activities to be performed by the Consultant shall include but not limited to the followings during the Optimization of the Installed and update the Feasibility Study of the project:

1. Identify the alternatives layouts and select the best layout of the project. The consultant shall carryout optimization studies including optimization of project capacity, dam height, tunnel and penstock diameter etc. and the number and size of the turbine units.
2. While Optimization of the Installed Capacity of the Plant and selecting the poundage capacity, its effect on the hydropower projects planned on downstream and upstream of this project, need to be studied. Operation of this project should not affect the operation of the projects located downstream and upstream of this project
3. The Consultant shall carry out hydraulic structural design of each components including but not limited to main dam, spillway facilities, intake, headrace tunnel, surge tank(s), powerhouse, tailrace, and other associated structures. The task shall also include design of access roads and bridges (if any), cofferdams, diversion tunnels, electrical and Mechanical equipment, substations and other components.
4. The design of each component shall be based on outcome of field investigation results and considering best engineering design and standards. The design shall include, but not limited to, the complete design of hydraulic structures, foundation treatment and grouting, instrumentation, seepage analyses, stability analysis, deformation and stress analysis and architectural work and finishing. Structures shall be designed for steady state and transient conditions. The designs shall conform to and be suitable for the site conditions and shall aim at achieving minimum overall cost and a minimum consumption of land, without adversely affecting safety, security, efficiency or longevity of the works or the environment The

consultant shall prepare detailed calculation regarding design of each component. The consultant shall carryout

5. Carryout Hydro-Mechanical and electro-Mechanical design of gates, valves, turbine, generator, substation, and transmission line etc.
6. Prepare engineering drawings of all the components of the project including Hydro and electro-Mechanical works, transmission lines and substations.
7. Identify the most appropriate technology for successful implementation and operation of this project for Hydropower and other multipurpose uses through analysis of existing techniques
8. Analyze different alternatives and recommend best alternative for dam type such as Rock fill, Concrete Gravity, Arch, etc. and best site, for the dam and other components based on prevailing geological condition and availability of construction materials.
9. Identify, review previous reports and finalize / reconfirm the location of camp for client and contractors (Civil, electro-Mechanical, Hydro-Mechanical etc.), spoil disposal and establish the need for construction of additional access road and bridge including finalization of road alignment and site for bridge.
10. The quantum of construction power required shall be assessed and the method of supplying temporary power determined by previous studies shall be reviewed and recommend appropriate option along with cost estimates and other details if necessary.

The consultant has to update the Feasibility Study of the Project based on the above mentioned activities and the result of site investigations and studies.

### **Task 6: Detail Engineering Design, Specifications & Drawings**

The primary objective of this task is to refine, update and supplement and prepare detailed design and drawings of the project configuration option finalized in the updated feasibility study based on the results of detailed field investigation and studies that are not completed during the period of update of the Feasibility Study. The detailed design including reinforcement details where applicable shall cover each component of major structures e.g. dam and reservoir including spillway and other outlets, intake, water ways, surge tank, powerhouse, tailrace, Hydro-Mechanical structures, electro-Mechanical works and transmission line and substations for power evacuation, roads, bridge, employer's camp, landscaping in necessary areas, and so on. The drawings shall be prepared on the basis of detailed design and shall be adequate in coverage for use in construction.

For every component of the project, the consultant shall formulate prior to detail engineering design, a Design Base Memorandum (DBM) to record the basis on which a design will be developed. It shall establish the design and functional criteria, and prepare the layout and design concepts of all project facilities/ components; state the assumptions, parameters, and standards applied, loading conditions, factors of safety, allowable stresses, stability criteria, and all other factors which are necessary to fully carry out the detailed design. The design criteria shall describe in sufficient detail methodologies and analysis methods, database and international standards or codes and prudent practices employed. The design criteria shall be submitted to NEA for review, comments and approval and shall not be modified unilaterally after it has been approved.

Detail Design and Technical Performance Specifications shall be prepared to the international standards. They shall be carried out to a level of detail such as to enable contractors and suppliers to clearly interpret type and scope of works involved and to submit competitive tenders.

The consultant shall prepare confirmatory stability, stress analysis and reinforcement design and details for the various features including main dam, spillway facilities, intake, settling basins, headrace tunnel, surge tank, pressure shaft and steel lined tunnel, powerhouse, tailrace, and other associated structures using the state of the art techniques in consistent manner by matching the methods to needs.

The consultant shall perform engineering study of each component of the project. The Consultant shall carry out hydraulic design of main dam, spillway facilities, intake, settling basins, headrace tunnel, surge tank, pressure shaft and steel lined tunnel, powerhouse, tailrace, and other associated structures. The study shall also include cofferdams, diversion tunnels, electrical and mechanical equipment, substations, transmission lines to connect to the national grid and other components that are required for the proper functioning of the project.

The design shall include, but not limited to, the complete design of hydraulic structures, foundation treatment and grouting, instrumentation, seepage analyses, stability, deformation and stress analysis and architectural work and finishing. Structures shall be designed for steady state and transient conditions. The designs shall conform to and be suitable for the site conditions and shall aim at achieving minimum overall cost and a minimum consumption of land, without adversely affecting safety, security, efficiency or longevity of the works or the environment. The consultant shall prepare detailed calculation regarding design of each component.

The consultant shall carry out optimization studies including headrace tunnel and penstock diameter etc and the number and size of the turbine units.

Hydraulic design for all hydraulic **structures/water conveyance system** including hydraulic transient analysis with water hammer effect for surge tank shall be performed as necessary to verify the principal dimensions, design parameter and proper hydraulic performance of the project. The consultant shall

carryout hydro-mechanical and electro-mechanical studies to determine the type of trash racks, gates, turbine, generator, substation, and transmission line etc.

The Consultant shall carry out the necessary hydraulic, structural, electrical and mechanical detailed design works of project components to determine the optimum scheme based on updated database and specific requirements of the detail engineering design.

The project components will include but not limited to:

- Temporary facilities; i.e., camps, road, water supply and sanitary facilities etc.
- Construction power supply
- Cofferdam and Diversion Tunnel
- Dam, Spillway, Stilling basin, intake and intake tunnels
- Desanding basins
- Headrace tunnel and adits
- Surge tank
- Pressure shaft/pressure tunnel
- Underground Powerhouse/Transformer Cavern
- Tailrace Tunnel/Outlet Structure
- Gates/ stoplogs/ trashracks and valves
- Electrical and Mechanical Generating Equipment with all Accessories
- Switchyard and Substations
- Transmission Line.

Electro-Mechanical, Hydro-Mechanical, transmission line and substation design work shall be based on internationally accepted practice and shall include drawings and supporting calculations. The Electro-Mechanical design shall involve, among others, selection of proper electrical and mechanical systems and equipment, dimensioning/sizing of the equipment, etc. Electro-Mechanical works including transmission line and sub-station station design work shall be based on the approved design criteria and internationally accepted practice and shall include drawings and supporting calculations.

It is proposed that 49 km long double circuit 220 kV transmission line from the switchyard to Proposed Tumlingtar Sub-station will be required for the evacuation of power generation from the project. However, possibility of other options needs to be studied as well. It is a Consultant responsibility to recommend and design the suitable transmission line to evacuate the power generation from the project to the national grid. The electro-mechanical and transmission line design effort shall involve selecting the proper electric and mechanical systems and equipment, determining limiting dimensions and setting, and determine plant control and performance.

NEA has completed 49 km long 220kV route alignment survey for transmission line from Upper Arun Powerhouse to Tumlingtar sub-station in 2015. After the project optimization, review study and power evacuation studies, the consultant shall review and if needed resurvey part of the previously surveyed transmission line route, and design transmission line substation for 220 KV voltage capacity.

However, if resurvey of the whole transmission line alignment is needed due to change in required voltage capacity (more than 220 KV) and power evacuation study, on the consultant recommendation NEA will make necessary arrangement for route alignment survey for transmission line from Upper Arun Powerhouse to Tumlingtar sub-station. Based on the new survey the consultant shall do the detailed design of transmission line and substation.

The consultant shall have full discretion on the method, procedure, tools and approaches for the performance of the design work. The performance of the designs ultimately accepted, shall be demonstrated by a “Confirmatory Analyses” with the state-of-art structural and hydraulic methods.

The consultant shall prepare and be responsible for Detail Engineering Design and Technical and Performance Specification describing the work in terms of the objectives, needs and performance as well as for the design criteria, loading conditions.

The Consultant shall review and finalize the location of camp for client and contractors (civil, electro-mechanical, hydro-mechanical etc.), spoil disposal and establish the need for construction of project road and bridge including finalization of project road alignment. The quantum of construction power required shall be assessed and the method of supplying the power shall be proposed along with cost estimates and other details.

The Consultant shall prepare Engineering Drawings and Specifications of all the components of the project including hydro and electro-mechanical works, transmission lines and substations; describing work in terms of measurements, tolerance, and material and as necessary in process tests. Engineering drawings shall be prepared in accordance with the Design Base Memorandum and show the general outline and enough detail regarding the structures, material and equipment to enable the contractors and suppliers to prepare and submit competitive bids.

### **Task 7: Power Evacuation Study**

The consultants shall carry out the grid impact study and plan for the transmission system for the evacuation of power with assistance of NEA In particular the study shall include:

- (i) Load flow analysis
- (ii) Short circuit study
- (iii) Transient Stability analysis

The Consultant shall also carry out a comprehensive study of INPS to identify reinforcement needs and suggest the appropriate measures. The Consultant shall carry out power evacuation studies to determine the proper power evacuation route.

### **Task 8: Construction Planning and Scheduling**

Notwithstanding the fact that the contractor will eventually develop his own construction operation and plan, the Consultant shall prepare, from a contractor's point of view of operation, a realistic and practical construction and equipment procurement plan along with construction power supply. The plan shall serve to establish construction schedules, with start and finish and interim critical milestone dates as well as key dates for interfaces between civil, hydro-mechanical and electro-mechanical works.

The Consultant shall carry out material handling studies which will aid the contractor to efficiently quarry, store, haul, use and dispose huge amount of construction material required for construction of the physical project. The result of material handling studies shall be incorporated in the construction plan which shall be supported by network and logic diagram showing the sequence in which construction activities are to be performed, their interdependencies, constraints and the critical path of the execution of the work, and so on.

### **Task 9: Project Cost Estimate**

The consultant shall, parallel to the development of the construction plan and schedules, prepare an Engineer's cost estimate for Upper Arun Hydroelectric Project based on the Bill of Quantities (BOQs) and unit rates, consistent with the construction plan and schedule. The estimates shall serve as a baseline for comparing and valuating the bid prices and be suitable for presenting to international financing agencies and organizations, commercial banks and export credit.

The Consultant shall prepare detail quantity estimate based on detail engineering design and tender drawings for the purpose of cost estimate. Preparation of the BoQ shall be in accordance with recognized standard method of measurement of civil engineering works and shall be appropriate to the level of information available.

For civil works, the unit cost for each individual item shall be composed of labor and staff costs, construction materials, plant and equipment costs, fuel and lubrication, transport, electrical power etc. Custom duties, taxes, fees, royalties, and levies due in Nepal shall be presented separately. The cost estimate needs to be based on construction methodology and planning as determined in Task 8. The cost for turbines, generators, substation equipment, switchgear, gates, and so on shall be based on prevailing market prices.

The cost estimates shall be prepared from a contractor's point of view using resource based costing and shall follow international standard practice (Cost and Performance Calculations of the Construction Industry) and Nepalese practices including other recognized estimating methods. The Consultant shall add an appropriate sum as price and physical contingencies to allow for potential physical or design conditions requiring additional funding for the execution of the project of this nature and for unforeseen conditions.

### **Task 10: Economic and Financial Analysis of the Project**

The consultant shall analyze demand, supply, and economic viability, and assess tariff pricing. The Consultant shall also analyze the financial viability and suggest the financing structuring of the project. The Consultants shall perform the following major activities:

- Analyze the economic viability of the project. Identify all economic costs and benefits with sensitivity analyses and evaluate economic internal rates of return;
- Review the forecasted load growth and revenues and costs in relation to tariffs, cost recovery. Determine future sustainable tariffs to support the project;
- Assess and analyze the financial viability of the project. Identify all risks for revenues and costs with sensitivity analyses, and evaluate financial internal rates of return. Include risk mitigation and risk transfer plans as necessary;
- Analyze the alternative possibilities of promoting the project, ranging from the public sector development to the public and private development approach. Simulate and evaluate optimal financial structuring and modeling in terms of profits, costs, and risks through all measures such as equity, loans, or an insurance (guarantee) mechanism from private investors and lenders, export credit agencies, multilateral development banks, and bilateral donors;
- Develop financial projection models comprising financial statements and financial ratios for the next 10 years to assess the project and its institutional financial viability and impacts using key performance indicators.

### **Task 11: Environmental Impact & Safeguard Study**

The consultant is required to design, investigation, cost estimation in close coordination with the EIA and Social Studies Consultant. The EIA and Social Studies Consultant is responsible for the Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) and Planning Studies of Upper Arun Hydroelectric Project and Ikhuwa Khola Hydropower Project fulfilling the requirements of GoN and lending agencies. The consultant shall assist the EIA and Social Studies Consultant.

While preparing the Tender Document, the consultant shall include all the issues, mitigation plans and outcome of the Environmental and Social Studies of the project. The mitigation measures/monitoring clauses outlined in the environmental Impact Assessment report should be incorporated in the Tender Document and Specifications providing the Environment and Social Mitigation/Enhancement requirements for the contractors to implement and bid on.

### **Task 12: Preparation of Complete Tender Documents & Tender Drawings**

The Consultant shall prepare complete Tender/Bidding Documents complete with Tender Drawings for all works with appropriate details and specifications, BoQ and other necessary documents based on applicable standard bidding documents for bidding purpose. The title and contents of the Tender Documents shall be finalized in consultation with NEA.

The Consultant shall make his recommendations and discuss in detail with NEA for the extent to which bidders should be permitted to suggest alternative designs, construction methods or temporary works. The Tender Documents shall describe the works, including temporary works as necessary in sufficient detail to allow bidders to confidently determine the cost of construction and ensure competitive and comparable tenders.

The number of Lots shall be decided with consultation with NEA. However, at least following lots will be considered in the formulation of the Tender Documents

- Civil works
- Hydro-mechanical Equipment
- Electro-mechanical Equipment
- Transmission Line
- Substations and Switchyard
- Temporary and Permanent Infrastructure inclusive of power supply during construction

### **Task 13: Analysis of Institutional Arrangement for Project Implementation**

The Consultant shall make an assessment of the institutional arrangement required for implementation of physical project of this magnitude in line with the requirement specified in Task 10. In doing so, the consultant shall analyze critically alternative institutional setups to smoothly carryout the implementation of the project. In the proposed optimal institutional setup, the consultant shall propose organizational structure clearly defining the role of each position and responsibility and chain of command linking the entire organizational hierarchy. The consultant shall also clearly identify the requirement of resources including but not limited to capacity building measures (Trainings, Workshops etc.), physical infrastructures, requirement of software, equipment etc.



**Task 14: Assist NEA for technical evaluation of bids and contract negotiation**

The Consultant shall assist NEA for the evaluation of tenders for the procurement of the lots as defined in TOR of two projects separate for UAHEP (task 12 of the Scope of Services) and IKHPP (task 11 of the Scope of Services) . The Consultant shall also assist NEA in Contract negotiation to finalize both Contract agreements of both projects for the lots mentioned above. For this task it is expected that the experts: Team Leader, Hydropower Engineer and Contract Specialist will be resident in Kathmandu for different periods totaling to approximately three (3) person months. The Consultant shall submit separate Tender Evaluation and Contract negotiation Reports of each project for the above-mentioned lots.

**5. Team Composition & Qualification Requirements for the Key Experts****5.1 General Remarks**

The work shall be performed by an integrated team of Nepali and expatriate professional and support staff. The local participation shall be maximized within the framework of quality, timely performance of the services and liability. The local staff shall be assigned to and perform clearly defined tasks, commensurate with their background, qualification and experience.

**5.2 Organization & Team Composition**

The services shall be provided and managed with a functional organization directly responsive and responsible through the Team Leader. NEA shall be informed of the status of the project design in regular basis. For effective implementation, works shall be carried out by as fully integrated team of expatriates and Nepali personnel and shall operate as an independent and self-sufficient entity with the Team Leader entrusted with full responsibility and authority to act on behalf of the consultant.

Members of the project team shall be assigned for the full duration of their involvement. They shall report to the Team leader directly, or to assigned supervisors within the project team. This accountability shall be binding on each team member regardless of origin. It holds equally for expatriates and Nepali professionals, for duration of the project or recruited elsewhere.

The Consultant shall provide qualified and competent staff to fully carry out all the Services. Key positions which are considered to be appropriate as part of the Consultant's team are listed in the following Table. International Key Experts will be evaluated. ***The consultant is free to propose the same or different International Key Experts, International Non Key Experts and National Non Key Expert both for Upper Arun and Ikhuwa Khola HEPs fulfilling the evaluation criteria. However, the same person is not allowed to position in more than one Key Expert position in one project.***

***Among the Key Experts, the Team Leader must have at least 15 years of professional experience. All other key experts must have at least 10 years of professional experience. Year of Professional experiences shall be counted up to the last date of submission of RFP.***

The Consultant in this proposal shall state all categories and numbers of staff and personnel, which they considers necessary to perform the services. The list of Key Experts mentioned presents a tentative estimate.

For every key position, the Consultant shall provide a brief, approximately ¼ of a page long, position description of the expatriate personnel stating functions, tasks and responsibilities and depict this staff-task relationship in a responsibility matrix showing clearly the assignments of each staff member. ***Experience and past achievements of each individual shall be presented exclusively in the CV following the format given in the technical proposal standard forms and Personal Information Sheet.*** The Consultant shall provide qualified and competent staff to fully carry out all the Services. Key positions which are considered to be appropriate as part of the Consultant's team is listed in the Tables: The International Key Expert will be evaluated.

It is estimated that about Sixty-Three (63.0) Person-Months of Key Experts (International), about Eight (8.0) of Non Key Experts (International) and about One Hundred Sixteen (116) Person-Months of Non Key Experts (National) will be needed to complete the assigned tasks. The tentative breakdown of the estimated inputs (person months) of International Key Experts, Non Key Experts (International) and National Non Key experts are given in the following tables:

<b>S. No.</b>	<b>A. Key Expert (International)</b>	<b>Person Months</b>
1	Team Leader/Hydropower expert	22.0
2	Hydropower Engineer	5.0
3	Structural Engineer	5.0
4	Dam Design Engineer	1.5
5	Hydraulic Engineer	4.0
6	Geologist	4.0
7	Geotechnical Engineer	5.0
8	Hydrologist & Sediment Engineer	4.0
9	Contract Specialist/ Engineer	4.0
10	Electrical Engineer	2.0
11	Mechanical/ Hydro- mechanical Engineer	2.5
12	Cost Engineer	2.0
13	GLOF expert	2.0
	<b>Total Key Experts (International)</b>	<b>63.0</b>

<b>S. No.</b>	<b>B. Non Key Expert (International)</b>	<b>Person Months</b>
1	Transmission Line & Sub-station Engineer	2.0
2	Construction Planner	2.0
3	Seismic Engineer/ Expert	1.0
4	Economist/ Financial Analyst	1.0
5	Road Engineer	1.0
6	Survey Engineer	1.0
	<b>Total Key Experts</b>	<b>8.0</b>

<b>S. No.</b>	<b>C. Non Key Expert (National)</b>	<b>Person month</b>
1	Hydropower Engineer	24.0
2	Geologist	8.0
3	Geotechnical Engineer	6.0
4	Hydrologist/Sedimentologist	6.0
5	Electrical/ Control Power System Engineer	4.0
6	Mechanical/ Hydro Mechanical Engineer	5.0
7	Hydraulic Engineer	6.0
8	Structural Engineer	8.0
9	Transmission Line/Substation Engineer	4.0
10	Road Engineer	3.0
11	Survey Engineer	3.0
12	Cost Engineer/ Quantity Surveyor	6.0
13	Contract Engineer	4.0
14	Construction Planner	4.0
15	Communication Engineer	1.0
16	Civil Engineers	24.0
	<b>Total National Non Key Expert</b>	<b>116.0</b>

**Note:** *The above estimates are indicative and the Proposal shall be based on the Consultant's own estimates for the same.*

### **5.3 Qualification/Experience of Each Expert**

The following paragraphs are brief descriptions of the responsibility and duties considered to be required by the Team Leader and Key Experts.

**(A) International Key Expert****(i) Team Leader/ Hydropower Expert:**

The focal point of the project organization is the Team Leader, the principal contact and communication channel with NEA.

The Team Leader is common for both Upper Arun HEP and Ikhuwa Khola HPP. The Team Leader shall have total project responsibility for the work in Nepal and for providing the requisite leadership, direction and supervision. He shall be accountable to the NEA and Consultant for day-to-day performance of the project team and shall be vested with sufficient authority to act. He shall exercise all standard management functions including planning, scheduling, directing, organizing, and controlling, and as much as possible shall be involved in technical activities and assigned to specific technical tasks to achieve maximum efficiency and benefit to the project. *The Team Leader shall be dedicated full time to Upper Arun Hydroelectric Project and Ikhuwa Khola Hydropower Project with full time residence in Kathmandu / site office.*

The Team Leader shall have minimum of Bachelor degree in Civil engineering or equivalent and preferably has Master's degree or equivalent in civil/hydropower/water resources/hydraulic/geotechnical/structural engineering discipline and must have fifteen (15) *years of professional experience*

The expert shall have experience as team leader / project manager in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 300 MW. The expert shall have experience in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects as hydropower engineer with capacity not less than 300 MW. The team leader must have professional experience as team leader / project manager in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 100 MW in Asian countries other than the expert's home country. The team leader's involvement in the previous assignment as the team leader and hydropower engineer in the individual hydropower projects with capacity mentioned above need to be equal or more than 12 and 4 man months, respectively. The team leader's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The team leader shall be resident in Kathmandu for approximately twenty two (22) months with frequent visits to the project site. This includes one man-month to assist NEA in the Evaluation of Bids and Contract negotiation to finalize the Contract agreement for the construction of the project.

**(ii) Hydropower Engineer:**

The Hydropower Engineer who will work as the Deputy Team Leader. The Hydropower Engineer shall have minimum of Bachelor degree in Civil engineering or equivalent and preferably has

Master's degree or equivalent in civil/hydropower/water resources engineering and ***must have ten (10) years of professional experience.***

The expert shall have previous experience of working as hydropower engineer in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 300 MW .The Hydropower Engineer's involvement in the previous assignment as the hydropower engineer in the individual hydropower project with capacity mentioned above need to be equal or more than 4 man months. The hydropower engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert will be resident in Kathmandu for approximately five (5) months, with frequent visits to the project site. This includes one man-month to assist NEA in the Evaluation of Bids and Contract negotiation to finalize the Contract agreement for the construction of the project.

### **(iii) Structural Engineer**

The Structural Engineer shall have minimum of Bachelor degree in civil engineering or equivalent and preferably has Master's degree or equivalent in civil/structural engineering discipline and ***must have ten (10) years of professional experience.***

The expert shall have previous working experience in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 300 MW and project with dam height not less than 50 m, as a structural engineer. The Structural Engineer involvement in the previous assignment as the structural engineer in the individual hydropower project with capacity and dam height mentioned above need to be equal or more than three (3) man months and one (1) man month, respectively . The Structural Engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately five (5) months, with frequent visits to the project site.

### **(iv) Dam Design Engineer**

The Dam Design Engineer shall have minimum of Bachelor's degree in Civil Engineering or equivalent and preferably has Master's degree or equivalent in civil/dam/hydropower/hydraulic engineering discipline and ***must have ten (10) years of professional experience.***

The expert shall have previous working experience as Dam Engineer in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with dam height of at least 50m. The Dam Engineer shall involve in the previous assignment as the dam design engineer

in the individual hydropower projects having dam height mentioned above need to be equal or more than 1 man month. The hydropower engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately one and half (1.5) months, with frequent visits to the project site.

**(v) Hydraulic Engineer**

The Hydraulic Engineer shall have minimum of bachelor's degree in civil engineering or equivalent and preferably has Master's degree or equivalent in civil/hydraulic engineering discipline and ***must have ten (10) years of professional experience.***

The expert shall have previous working experience in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 300 MW as a hydraulic engineer. The Hydraulic Engineer shall involve in the previous assignment as the hydraulic engineer in the individual hydropower project mentioned above need to be equal or more than three (3) man months. The Hydraulic Engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately four (4) months, with frequent visits to the project site.

**(vi) Geologist**

The Geologist shall have minimum of bachelor's degree in geology or equivalent and preferably has Master's degree or equivalent in geology discipline and ***must have ten (10) years of professional experience.***

The expert shall have experience of geological investigation, studies and design in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with extensive underground structures (Hydraulic Tunnel length of at least 2 Km or underground power house/ desanding basin cavern) and installed capacity not less than 100 MW as a geologist. The Geologist shall involve in the previous assignment as the geologist in the individual hydropower projects mentioned above need to be equal or more than three (3) man months. Experience in detailed engineering design of hydropower in the Himalayan region as a geologist will be added advantage for the expert. The geologist's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with

capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately four (4) months, with frequent visits to the project site.

**(vii) Geotechnical Engineer**

The Geotechnical Engineer shall have minimum of bachelor's degree in civil engineering or equivalent and preferably has Master's degree or equivalent in Geotechnical or civil engineering discipline and *must have ten (10) years of professional experience.*

The expert shall have experience in geotechnical investigation, tests, and design in the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 100 MW, hydropower projects with hydraulic tunnel of at least 4 km length and hydropower projects with underground cavern with width not less than 20m as geotechnical engineer. The Geotechnical Engineer shall involve in the previous assignment as the geotechnical engineer in the individual hydropower project with capacity, tunnel length and cavern width as mentioned above need to be equal or more than four (4), two (2) and two (2) man months, respectively. The geotechnical engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately five (5) months, with frequent visits to the project site.

**(viii) Hydrologist & Sediment Engineer**

The Hydrologist shall have minimum of bachelor's degree in civil engineering and preferably have Master's degree or equivalent in hydrology/ hydraulic/ hydropower/ Sediment/ civil engineering discipline and *must have ten (10) years of professional experience.*

The expert shall have experience in hydrological investigation, analysis and study, sediment study including investigation, analysis and interpretation and design of reservoir sedimentation and its management in the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 100 MW as hydrologist/ Sedimentologist. The Hydrologist & Sediment Engineer shall involve in the previous assignment as the hydrologist & sediment engineer in the individual hydropower projects mentioned above need to be equal or more than three (3) man months. Experience in detailed engineering design of hydropower projects in the Himalayan region as a hydrologist and sedimentologist will be added advantage for the expert. The hydrologist and sediment engineer's general experience in any field of the detailed

engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately four (4) months, with frequent visits to the project site.

**(ix) Contract Specialist/ Engineer**

The Contract Specialist/ Engineer shall have minimum of bachelor's degree in civil engineering and preferably has Master's degree or equivalent in construction management or law or engineering or other relevant discipline and ***must have ten (10) years of professional experience.***

The expert shall have experience in tender document preparation for international contract based on FIDIC or equivalent of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 100 MW as contract specialist. The Contract Specialist/ Engineer shall involve in the previous assignment as the Contract Specialist/ engineer in the individual hydropower projects mentioned above need to be equal or more than three (3) man months. The contract specialist/ engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately four (4) months, with frequent visits to the project site. This includes one man-month to assist NEA in the Evaluation of Bids and Contract negotiation to finalize the Contract agreement for the construction of the project.

**(x) Electrical engineer**

The Electrical Engineer shall have minimum of bachelor's degree in electrical engineering or equivalent and preferably has Master's degree or equivalent in electrical engineering discipline and ***must have ten (10) years of professional experience.***

The expert shall have experience in the design and preparation of specifications of powerhouse electrical equipment at the detailed engineering study of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 300 MW as an electrical engineer. The Electrical Engineer involvement in the previous assignment as the electrical engineer in the individual hydropower projects mentioned above need to be equal or more than one and half (1.5) man months. The Electrical Engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.



The expert shall be resident in Kathmandu for approximately two (2) months, with frequent visits to the project site.

**(xi) Mechanical/ Hydro-mechanical Engineer**

The Hydro-mechanical Engineer shall have minimum of bachelor's degree in mechanical engineering or equivalent and preferably have Master's degree or equivalent in mechanical engineering or other related discipline and ***must have ten (10) years of professional experience.***

The expert shall have experience in the preparation of hydro-mechanical design and specifications of hydro-mechanical components in the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 300 MW as mechanical/hydro-mechanical engineer. The Mechanical/ Hydro-mechanical Engineer involvement in the previous assignment as the mechanical / hydro-mechanical engineer in the individual hydropower projects mentioned above need to be equal or more than two (2) man months. The mechanical/ hydro-mechanical engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately two and half (2.5) months, with frequent visits to the project site.

**(xii) Cost Engineer**

The Cost Engineer shall have minimum of bachelor's degree in civil engineering or equivalent and preferably has Master's degree or equivalent in civil/cost engineering or other relevant discipline and ***must have ten (10) years of professional experience.***

The expert shall have previous professional experience in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with complex underground structures (Hydraulic Tunnel length of at least 2 Km or underground power house/ desanding basin cavern) with Installed Capacity not less than 100 MW as a Cost Engineer. The Cost Engineer involvement in the previous assignment as the cost engineer in the individual hydropower projects mentioned above need to be equal or more than one and half (1.5) man months. The cost engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation

The expert shall be resident in Kathmandu for approximately two (2) months, with frequent visits to the project site.

**(xiii) GLOF Expert**

The GLOF Expert shall have minimum of bachelor's degree in civil engineering, Alpine Geology, Applied Geomorphology, Engineering Geology, hydrology or other relevant discipline and preferably have Master's degree in Alpine Geology, Applied Geomorphology, Engineering Geology or other relevant discipline and ***must have minimum of ten (10) years of professional experience.***

The expert shall have experience in the study and analysis of GLOF projects including mapping of glaciers, glacial lakes and field investigation. Experience in GLOF studies in the Himalayan region as a GLOF expert will be an added advantage of the expert. The GLOF expert's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 50 MW will also be accounted. The expert shall be resident in Kathmandu for approximately two (2.0) months, with frequent visits to the project site. All these qualifications and experiences will be considered in the evaluation

**(B) Non Key Expert (International)****(i) Transmission Line & Sub-station Engineer**

The Transmission Line & Sub-station Engineer shall have minimum of bachelor's degree in electrical engineering or equivalent and preferably has Master's degree or equivalent in high voltage/electrical engineering discipline and ***must have ten (10) years of professional experience.***

The expert shall have experience in design of transmission lines and substations of 200 kV or above voltage class at least two projects as the transmission line & substation engineer in the detailed engineering design stage.

The expert shall be resident in Kathmandu for approximately two (2) months, with frequent visits to the project site.

**(ii) Construction Planner**

The Construction Planner shall have minimum of bachelor's degree in civil engineering and preferably has Master's degree or equivalent in civil engineering or construction management or planning engineering or other engineering discipline and ***must have ten (10) years of professional experience.***

The expert shall have experience in preparation of construction plan and schedule in the detailed engineering design of at least two successfully completed (Constructed and Commissioned) hydropower projects having capacity not less than 300 MW as construction planner.

The expert shall be resident in Kathmandu for approximately two (2) months, with frequent visits to the project site.

**(iii) Seismic Engineer/ Expert**

The Seismic Engineer/Expert shall have minimum of bachelor's degree in civil engineering or equivalent and preferably has Master's degree or equivalent in engineering /geo technical/geology/soil science/seismology and *must have ten (10) years of professional experience.*

The expert shall have experience of seismological investigation, studies and design in as part of detailed engineering design of at least one successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 300 MW and at least two hydropower project with dam height not less than 50 m.

The Expert shall have experience in seismological investigation and studies of hydropower project in Himalayan Region as Seismic Engineer/ Expert.

The expert shall be resident in Kathmandu for approximately one (1) month, with frequent visits to the project site.

**(iv) Economist/ Financial Analyst**

The Economist/ Financial Analyst shall have minimum of bachelor's degree in Civil Engineering, Economics/ Finance or economics or business administration or engineering economics or equivalent and preferably has Master's degree or equivalent in finance or economics or business administration or engineering economics *and must have ten (10) years of professional experience.*

The expert shall have previous experience as Economist/ Financial Analyst in the detailed engineering design of at least two successfully completed (Constructed and Commissioned) hydropower projects with capacity not less than 300 MW as Economist/ Financial Analyst.

The expert shall be resident in Kathmandu for approximately one (1) month, with frequent visits to the project site.

**(v) Road Engineer**

The Road Engineer shall have minimum of bachelor's degree in civil engineering and preferably has Master's degree or equivalent in civil/road/transportation engineering discipline and *must have ten (10) years of professional experience.*

The expert shall have working experience in planning and design of project roads of at least one hydropower project with capacity of not less than 100 MW.

The expert shall be resident in Kathmandu for approximately one (1) month, with frequent visits to the project site.

**(vi) Survey Engineer**

The Survey Engineer shall have minimum of bachelor's degree in engineering survey or equivalent and preferably have Master's degree or equivalent in surveying /civil engineering and ***must have ten (10) years of professional experience.***

The expert shall have experience in surveying of at least two successfully completed (Constructed and Commissioned) hydropower projects having capacity not less than 300 MW in the detailed engineering design stage.

The expert shall be resident in site / Kathmandu office for approximately one (1.0) month, with frequent visits to the project site.

**(C) National Non-Key Expert****(i) Hydropower Engineer**

The Hydropower Engineer shall have Master's degree or equivalent in water resources/hydropower engineering, ten (10) years of professional experience and five (5) years of specific experience in detailed design of hydropower projects.

**(ii) Geologist**

The Geologist shall have Master's degree or equivalent in geology discipline, ten (10) years of professional experience and five (5) years of specific experience in detailed design of hydropower projects.

**(iii) Geotechnical Engineer**

The Geotechnical Engineer shall have Master's degree or equivalent in geotechnical engineering, ten (10) years of professional experience and five (5) years of specific experience in detailed design of hydropower projects.

**(iv) Hydrologist/ Sedimentologist**

The Hydrologist/ Sedimentologist shall have Master's degree or equivalent in civil engineering/hydrology/sediment study discipline, ten (10) years of professional experience and five (5) years of specific experience in hydrological analysis/sediment analysis of hydropower projects.

**(v) Electrical/ Control Power System Engineer**

The Electrical Engineer shall have at least bachelor degree or equivalent in electrical engineering or power system and preferably Master's degree or equivalent in electrical engineering/power system, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(vi) Hydraulic Engineer**

The Hydraulic Engineer shall have Master's degree or equivalent in hydropower/water resources engineering, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(vii) Structural Engineer**

The Structural Engineer shall have Master's degree or equivalent in structural engineering, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(viii) Transmission line/Sub-station Engineer**

The Transmission line/Sub-station Engineer shall have Master's degree or equivalent in electrical engineering/power system, ten (10) years of professional experience and five (5) years of specific experience in transmission line/ substation projects.

**(ix) Road Engineer**

The Road Engineer shall have Master's degree or equivalent in civil/road/transportation engineering discipline, ten (10) years of professional experience and five (5) years of specific experience in road projects.

**(x) Survey Engineer**

The Survey Engineer shall have Master's degree or equivalent in surveying /civil engineering, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(xi) Cost Engineer/Quantity Surveyor**

The Cost Engineer/Quantity Surveyor shall have Master's degree or equivalent in civil engineering, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(xii) Contract Engineer**

The Contract Engineer shall have Master's degree or equivalent in construction management, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(xiii) Construction Planner**

The Construction Planner shall have Master's degree or equivalent in civil engineering, ten (10) years of professional experience and five (5) years of specific experience in construction planning of hydropower projects.

**(xiv) Communication Engineer**

The Communication Engineer shall have at least bachelor degree or equivalent in electronics/communication engineering and five (5) years of professional experience.

**(xv) Civil Engineers**

The Civil Engineers shall have at least bachelor degree or equivalent in civil engineering with minimum five (5) years of professional experience and specific experience in design and construction of hydropower projects.

**(C) Backup Support**

Home office back-up support shall be made available to the project to facilitate communications between the project office in Kathmandu and the respective corporate office, for responding to requests and directives from Nepal with respect to technical data, publications, specialized assistance, communications, travel arrangements necessary government documentation and general logistics etc.

**6.0 Reporting Requirements and Time Schedule for Deliverables**

The consultant shall discuss their interim findings at review meetings to be held with NEA project management team on regular basis, and provide the following final deliverables.

- Inception Report within six (6) weeks of commencement of services covering activities as stipulated in Task 1.
- Design Basis Memorandum (DBM) within three months (3) months of commencement of services.
- Topographical Survey Report within four (4) months of commencement of services.
- Geological Mapping Report within six(6) months of commencement of services
- Construction Material Survey Report within six (6) months of commencement of services
- Project Optimization & Review and Update of Feasibility Studies report within seven (7) months of commencement of services covering activities as stipulated in Task 5
- Field Investigation Report I within twelve (12) months of commencement of services covering most of the activities as specified in Task 2.
- Report on Hydraulic Model Test within sixteen (16) months of commencement of services covering activities as specified in Task 4.
- Field Investigation Report II within twenty (20) months of commencement of services covering all activities as specified in Task 2.
- Cost Estimation Report within twenty (20) months of commencement of services covering activities as stipulated in Task 9.
- Economic and Financial Analysis Report within twenty (20) months of commencement of services covering activities as stipulated in Task 10.

- Draft Final Detailed Engineering Design Report within twenty one (21) months of commencement of services. The report shall include the following
  - Final Report on Field Investigation
  - Design Criteria Report
  - Hydraulic Model Test Report
  - Project Layout, Hydraulic Design of Civil Works, Civil Works Design, Stability Calculations, Structural Calculations and Detailed Design
  - Hydraulic Steel Structure, Mechanical and Electrical Equipment and Transmission Line
  - Methods used in design, reasons for technical decisions and reference to all technical memoranda and design reports
  - Detailed Quantity Estimate
  - Detailed Cost Estimate
  - Construction Planning and Scheduling
  - Economic and financial analysis
  - Engineering Drawings
- Final Detail Engineering Design Report after incorporating comments from NEA within twenty four (24) months of commencement of services.
- Draft Tender Documents/Drawings within twenty one (21) months of signing the contract
- Final Tender Documents after incorporating comments from NEA within twenty four (24) months of signing the contract
- The monthly progress report in agreed format covering all the activities of the consultant in the previous month within 5 working days of the end of the reporting month.
- Trimester Report in agreed format summarizing all activities of the consultant in the previous trimester.

The consultant shall identify the report milestones in his design schedule. When any work falls behind the schedule, the Consultant shall make recommendations in writing to the Employer as to the action to be taken to expedite progress

The following are the number of copies of each report to be submitted by the consultant to NEA:

- |  |             |
|--|-------------|
| 1. Inception Report                    | : 15 Copies |
| 2. Design Basis Memorandum (DBM)       | : 15 Copies |
| 3. Topographical Survey                | : 15 Copies |
| 4. Geological Mapping Report           | : 15 Copies |
| 5. Construction Material Survey Report | : 15 Copies |

6. Project Optimization & Review and Update of Feasibility Studies report	: 15 Copies
7. Field Investigation Report I	: 15 Copies
8. Field Investigation Report II	: 15 Copies
9. Report on Hydraulic Model Test	: 15 Copies
10. Cost Estimation Report	: 15 Copies
11. Economic and Financial Analysis	: 15 Copies
12. Draft Design Criteria Report	: 15 Copies
13. Draft Final Detailed Design Report	: 15 Copies
14. Final Design Criteria Report	: 25 Copies
15. Final Detailed Design Report	: 25 Copies
16. Draft Tender Documents	: 15 Copies
17. Final Tender Documents	: 25 Copies
18. Monthly Progress Report	: 10 Copies
19. Trimester Report	: 10 Copies
20. Tender Evaluation Report	: 5 Copies

Each report shall also be accompanied by the electronic copy. All reports, submissions and discussions shall be in English. All dimensions and quantities shall be expressed in the SI system of units. Standard shall be those of the International Standards Organization (ISO) except where no suitable ISO standards exist, in which case suitable widely known national standard may be used. All drawings shall be in A3 size.

The services carried out by the Consultant shall be reviewed periodically by independent Panel of Experts (POEs) appointed by NEA. The main reports except periodic reports (monthly, trimester and etc.) submitted by the consultant shall be accepted by NEA after the approval of the POEs.

## **7 Client's Input, Counterpart Personnel, Training and Capacity Building**

### **7.1 Counterpart Staff**

NEA will provide counterpart staffs particularly technical personnel in carrying out the works related to the study. The consultant shall carry out the works including but not limited to following activities:

- Involve NEA counterpart staffs in the technical and related field from the beginning of the project for On the Job Training in Kathmandu / site;
- Provide on the job training to the NEA engineers during the course of the assignments in Kathmandu / site;



## 7.2 Training and Capacity Building

One of the basic objectives of the consulting services is transfer of technology in the field of hydropower planning, design and development to the NEA's engineers. This will be achieved by involving the NEA's engineers in various activities of the project implementation during the execution of detailed engineering design in the field investigation as well as in the home office of the consultant.

During the inception phase of the contract, the consultant shall perform a skills assessment and develop a training program for NEA counterpart staff. All international experts are expected to work closely with the NEA counterpart and shall ensure that the NEA counterpart will achieve higher skill levels as result of their involvement in the project.

Training and Capacity Building of the NEA executive / engineers will be carried by the consultant through two ways. One by "On the Job Training" to the NEA engineers as counterpart staff during the course of the assignments in Nepal. Second one is through organizing study tour / training NEA executive and engineers in related fields at Consultant's home country; or at appropriate country.

- **On the job training to the NEA Engineers as Counterpart staff in Kathmandu/ site office.**

NEA professional staff will be seconded to the Consulting Firm in the following disciplines in Nepal. The tentative total man month for this would be 104 MM, whose remuneration, allowances and other benefits will be provided by NEA. Though the NEA counterpart staffs are seconded to the consultant for "On the Job Training", the consultant is responsible to complete the "Services" through its own Key and Non-Key experts. List of the NEA professional staff that will be seconded to the Consulting Firm is as follows:

1	Hydropower Engineer-
2	Design Engineer
3	Geologist
4	Geotechnical Engineer
5	Hydrologist/ Sedimentologist
6	Electrical Engineer /Control Power System Engineer
7	Mechanical Engineer /Hydro-mechanical Engineer
8	Hydraulic Engineer
9	Structural Engineer
10	Transmission Line/Substation Engineer
11	Survey Engineer
12	Cost Engineer/ Quantity Surveyor
13	Contract Engineer

14	Construction Planner
15	Civil Engineer
16	Draft Person

- **Study Tour / training to NEA Executive and Engineers**

NEA's fifteen (15) executive / senior engineers will visit the consultant's home office for observation and study of hydropower projects in the consultant's home office country for total period of nineteen (19) days per individual including transit. Main objective of this visit is to observe the working environment, design team, construction supervision and planning procedures of the project adopted by consultant.

In addition to above mentioned study tour, the consultant shall arrange two workshops session/s in its home office/ other country for the twenty (20) engineers in the following disciplines for twenty four (24) days per individual including transits.

- Project planning and design
- Hydraulic and structural design of hydropower projects
- Transient analysis
- Power transmission system
- Project management and contract administration for engineers

The cost for "**Study Tour / training to NEA Executive and Engineers**" shall be proposed by the consultant in **the FORM Financial Proposal FIN - 4 (4A4. Breakdown of Office Operation, Logistics, Allowances, Flights and Others) of UAHEP**. This price components shall include **but not limited to the** cost of training, training materials, lodging and food, international travel cost (in economy class) of the trainees and internal transportation cost in the country of training, insurance of the trainees for the entire training period and during travel.

## **8. Inputs to be made by the Concerned Authorities**

For the execution of the project, the following inputs shall be made by the consultant and the NEA respectively.

### **8.1 Inputs by NEA**

- Available Data – All existing reports, maps, drawing and other relevant information of the project would be made available to the consultant.

- NEA will provide full time counterpart staff mainly technical personnel -civil engineers, hydrologists, geologists, electrical engineers and mechanical engineers as far as possible ***for the purposes of on the job training in Kathmandu and site***. In order to improve the capabilities of NEA engineers and technicians it is desirable that both NEA and consultant's teams work together as one single team in all matters related to the project. The NEA technical personnel for the on the job training will be assigned to Consultant as per the program of the On the Job Training prepared by the consultant in its technical proposal. ***The NEA technical personnel for on the Job Training shall not be responsible for the services that need to be provided by the Consultant.***

## **8.2 Inputs by the Consultant**

- Staffing – the expatriate and local staff shall comprise of qualified and experienced professionals from relevant disciplines.
- Software – The provision of suitable software shall be made to undertake any related analysis required for the studies, which shall be handed over to NEA after completion of the services.
- Facilities - All logistics and facilities such as vehicles, computers, photocopy machines, fax machines, furniture, office space, office equipment required to carry out the assignment shall be managed by the Consultant for its own purpose and logistic support to establish office for the Consultant in Kathmandu and site and including office space for the client at site. The cost of all the facilities required by the consultant to carry out the assignment and the office space required to the client shall be included in the consultant's proposal.

## **9. Duration of Services**

The estimated time for completion of the complete assignment is about thirty six (36) months. The first twenty four (24) months is assigned for detailed Engineering and preparation of bidding documents. The next twelve (12) months is allocated for assisting NEA for tender evaluation and Contract negotiation for the procurement of Lots of Works as defined in task 14 of TOR of UAHEP and task 12 of TOR of IKHPP as well if the task (for IKHPP) not completed in the previous twenty four (24) months. Out of the total twenty-four months, it has been estimated that twenty one (21) months will be utilized in inception, field investigation, detail engineering design, preparation of tender documents and three (3) months for finalization of all reports incorporating the comments from NEA. The Consultant shall finish all the Field Investigation Work: Task 2 and provide Field Investigation Report II within twenty (20) months of commencement of services covering all activities as specified in Task 2. However, discharge measurement and sediment sampling works shall be carried out for the period of 24 months.

## **7B. Terms of Reference for Ikhuwa Khola Hydropower Project**

## **1. Background**

Nepal has been endowed with enormous hydropower potential due to numerous rivers flowing south through Himalayas and favorable topographical features. The total hydropower potential has been tentatively estimated to be 83,000 MW of which 43,000 MW has been assessed to be technoeconomically feasible. In reality, however, only 733 MW (including isolated micro and small hydropower plants), which is less than 1.0 % of the total potential, has been exploited so far resulting only 58 percent of the total population having access to electricity supply through the national grid. The present capacity and energy generation is far less than the current electricity demand for both base and peak load and hence the country is forced to have 14 hours of load shedding during dry season. As the electricity demand is projected to grow by 10 percent per year, the situation will worsen in days to come, if the generation is not added to the system at the earliest. Therefore; NEA, an undertaking of Government of Nepal responsible for generation, transmission and distribution of electricity has decided to initiate the detail engineering study of hydropower projects that could be implemented at the earliest possible date. Upper Arun HEP is one of such attractive projects in Eastern Development Region, which has very high head and firm river flow. The cabinet has also decided to implement the project through NEA under the ownership of GoN. In this connection, to harness the hydropower potential of the country and to satisfy the increasing domestic power demand, NEA has envisaged to develop Ikhuwa Khola Hydropower Project (IKHEP) as well under the umbrella of Upper Arun Hydroelectric Project (UAHEP).

In this backdrop, Nepal Electricity Authority (NEA) desires to procure the services of internationally recognized consulting firm ("Consultant") having competent team of specialists to review and update the Feasibility study of Upper Arun Hydroelectric Project (UAHEP) and Ikhuwa Khola Hydropower Project (IKHEP) and then perform Detail Engineering Design of both projects (UAHEP and IKHEP) and prepare Bidding Documents for both projects for development of them. All services of the Consultant described in the following shall be performed in close co-operation with NEA, the Project Executing Agency. This Terms of Reference (TOR) attempts to outline the Consultant's tasks during execution of the services as detailed as possible. However, the Consultant shall note that the list of tasks and activities can by no means be considered as the complete and comprehensive description of the Consultant's duties. It is rather the consultant's responsibility to critically verify the scope of services indicated and to extend, reduce or amend it wherever he deems necessary, according to his own professional judgment and the knowledge he will acquire during preparation of the proposal. It is understood that the Consultant performs all works as necessary to fulfill the objectives of the Project.

## **2. Objective**

The main objective of present study is to prepare the project for early implementation of Ikhuwa Khola Hydropower Project (IKHPP) from the current stage of Feasibility Study. The overall objective of the consulting service is to carry out Detail Engineering Design along with necessary field investigation

works and to prepare tender documents inclusive of tender drawings and construction plan to meet NEA, GoN and leading multilateral agencies requirements for construction of the project.

The objective of the present Consultancy Services is to complete the Detailed Design of this project including the project road of the Ikhuwa khola Hydropower Project. The specific objectives of the consulting services are outlined as follows:

- Review of Feasibility Study and other available relevant reports/data, documents and identify the gaps in data,
- Prepare topographic maps for hydropower structures, road alignment and its adjoining area as necessary,
- Conduct geological and geotechnical / geo-physical studies/ investigations within the project area,
- Update hydrological and sedimentological studies,
- Update the Feasibility Study of Ikhuwa Khola HEP based on the field investigation and studies to meet the requirement of financing agencies for funding the projects for their implementation
- Conduct power evacuation study,
- Prepare Detail Engineering Design of the project components,
- Prepare Detailed Engineering Design of Project road,
- Prepare quantity and cost estimate and construction plan,
- Assist the Consultant carrying out the consulting services for Environmental Impact Assessment (EIA), Social Impact Assessment (SIA) and Planning Studies of Upper Arun Hydroelectric Project and Ikhuwa Khola Hydropower Project. Consultant for this study is required to conduct design and investigation works in close coordination with the Consulting Firm carrying out Environmental and Social Study of the project.
- Prepare complete tender documents and tender drawings,
- Prepare updated economic/financial analysis based on detailed project cost, refined implementation schedule, risk analysis, etc.
- Analyze financial structure, financing plan and recommend the most appropriate structure/plan

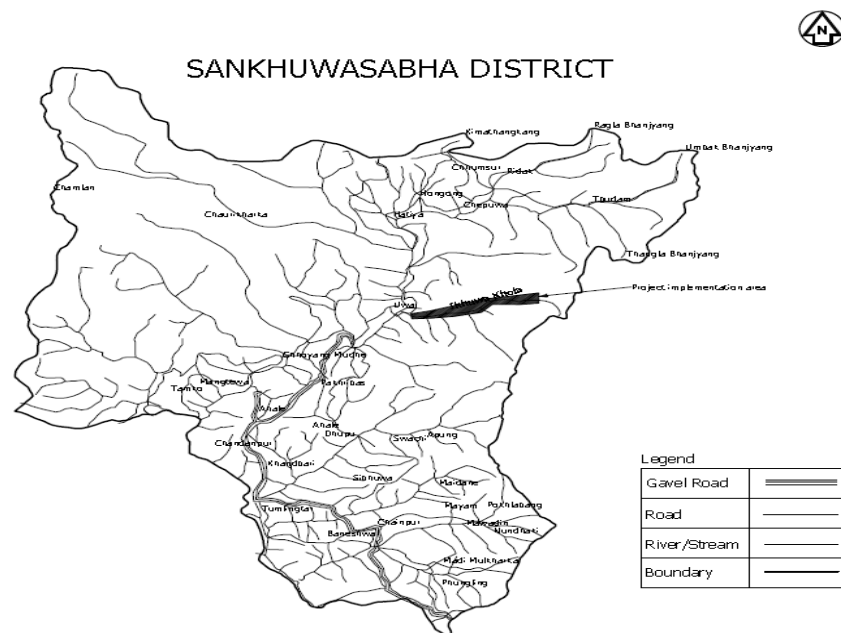
- Analyze and recommend appropriate institutional arrangement for project implementation,

### 3. Project Information and Previous Studies

Following Project Information are based on the Feasibility Study carried out in 2016 by Department of Electricity Development (DoED)

#### 3.1 Location and Access

The project is located on IkuwaKhola a tributary of Arun river in PawaKhola VDC of Sankhuwasabha District in the Eastern Development Region of Nepal within 27° 35' 07" N to 27° 37' 12" N Latitude and 87° 21' 16" E to 87° 25' 07" E Longitude. The project and its area location is shown below:



The nearest road head to the Ikuwa Khola HEP is at Num Bazaar, the dam site of Arun III HEP. The road from Num Bazaar to the Ikuwa Kkhola powerhouse site is about 18 km, which is under construction under North-South Koshi Road Project of Department of Road. Powerhouse site is 8.1 Km from Dovan in Num VDC. Construction of one permanent bridge over Ikuwa Khola is required. The headworks site could be reached by constructing a 12.5 km long project road along the right bank of Ikuwa Khola from the powerhouse site.

The nearest air service is at Tumlingtar. Scheduled air services operate from Kathmandu and Biratnagar.

### 3.2 Previous Studies

Feasibility Study of this project was carried out by local Consultants under a study conducted for Government of Nepal, Ministry of Energy (former Ministry of Water Resource), Department of Electricity Development (DoED) as “The study of Small Hydropower Projects of 5-10 MW Capacity”. The feasibility study was completed in April 2016.

### 3.3 Topography

The detailed topographical mapping of headwork and powerhouse sites was carried out in the required scale during Feasibility Study Phase conducted by DOED. A strip survey was also carried out for the canal alignment. During the survey, Right of Way (RoW) of approximately 100m on either side of the centerline of the canal alignment was maintained along the entire canal alignment. For the entire alignment, the elevation of 920 m was considered as the proposed centerline.

A list of the maps available for reference both in hard and digital copy:

Proposed Headwork site	Scale 1:1000	2 sheet (A3 size)
Proposed Powerhouse site	Scale 1:1000	2 sheet (A3 size)
Proposed Canal Alignment	Scale 1:1000	5 sheet (A3 size)
Project Layout Map	Scale 1:20000	1 sheet (A3 size)
Access Road	Scale 1:10,000	
Headrace Tunnel	Scale 1:10,000 with 5m contour interval	

### 3.4 Hydrology and Sediment study

Ikuwa Khola is one of the tributaries of Arun River. Kanduwa Khola, Khanduwa Khola, Panchpokhari Khola and Pawa Khola are the main tributaries of the Ikuwa Khola. The catchment area of the Ikuwa Khola at the proposed intake site is calculated to be 127.41 km<sup>2</sup>. Geographically, the basin is located between latitudes 27°40'17" and 27°30'31" North and longitudes 87°32'54" and 87°24'51" East in the Sankhuwasabha District, Eastern Development Region, Nepal. The Ikuwa Khola is a perennial type of Khola where the river level does not drastically drop throughout the year. The catchment area of Ikuwa Khola is bounded by JaljaleHimal in the East, Jorkhabe Dada in the North and Jaljale Himal and JauleLangur Dada in the South direction.

The catchment area of Ikuwa Khola at intake area is calculated to be 127.6 km<sup>2</sup>. The catchment area of Ikuwa Khola is a fan-shaped. It has elevations ranging from 1525 m to about 5233 masl. The catchment is covered with dense forest with hills to a highest elevation of 5233 masl at Jaljale Himal. However, the area above the 3000 masl is noted to be nearly 96.9 km<sup>2</sup>. The hills are covered with forests and very little plain land is available for cultivation. Most of the reach of the river is covered with large boulders. However, in some reaches the riverbed comprises of cobbles and gravels.



**Table 3-1: Characteristics of the Ikhuwa Khola catchment at the proposed intake site**

Elevation, masl	Intake Area		Powerhouse area	
	Area in km <sup>2</sup>	%	Area in km <sup>2</sup>	%
Above 3000	96.90	76.05	104.50	63.12
Below 3000	30.71	23.95	61.06	36.88
Total catchment area	127.61	100.00	165.56	100.00

Two gauging station with 2 meter staff gauge each were established. One station was installed on 10<sup>th</sup> April 2012 at proposed powerhouse site. Next staff gauge was installed on 11<sup>th</sup> April 2012 near proposed intake site.

Observed gauge height and measured discharge were used to develop the rating curve and the equation obtained from the rating curve was used to determine the discharge at intake site of Ikhuwa Khola HPP.

**Table 3-2: Observed Mean monthly Discharge (m<sup>3</sup>/s) at Intake Site**

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
3.13	2.67	2.70	4.52	8.75	13.3	24.6	20.7	17.3	10.5	6.05	4.28

The average annual flow is 7.52 m<sup>3</sup>/s , the design discharge is 6.02 m<sup>3</sup>/s with design flood discharge of 346 m<sup>3</sup>/s.

There is no meteorological station above the head work site of Ikhuwa Khola HPP. The nearest meteorological station from the study basin is Tumlingtar with index number of 1321. The other meteorological stations nearest to the study basins are at Num (index number 1301), Chainpur (index number 1303), Therathum (index no. 1314, Chepuwa (index no. 1317) and Dingel (Index number 1325).

Taking the monsoon sediment concentration of 0.39g/l, maximum average monsoon flow of 29.5 m<sup>3</sup>/s, sediment yield calculations showed the total sediment yield of 325 tonnes during the monsoon season of 2013. Considering the bed load of 15% of the suspended sediment load, the total sediment load of the Ikhuwa Khola basin found to be to be 374 tonnes. The sediment and flow rate in non-monsoon season are small. Hence, the sediment yield during the non-monsoon seasons is negligible. The specific sediment yield for the Ikhuwa basin was found to be about 8.79 t/km<sup>2</sup>/yr.

Maximum and minimum concentration of suspended sediment measured during feasibility study period was found to be 1243 and 4 PPM respectively.

The suspended river sediment was light grey to brownish grey in color with shape Sub-rounded to sub-angular, Flaky. About 68 percent of sediment lies within the range of 0.45mm and .0075mm. Suspended Sediments contents about 16% of fine particle as silt and clay. In silt and clay size, clay minerals are predominant with granular particle of quartz grain.

### **3.5 Flood**

The annual maximum instantaneous flood discharges at Tumlingtar available from DHM were correlated using catchment area method. These correlated data has been used for flood frequency analysis for different return periods by using statistical analysis. The calculation needs annual observations, e.g. Annual Maximum Flood. A number of different statistical distributions are fitted to the observed data sets, and goodness of fit for each distribution is computed. The theoretical statistical distributions can be used for extrapolation up to extreme return periods, 100 years, 500 years or even 1000 years.

### **3.6 Glacier Lake Outburst Flood (GLOF)**

There is no chance of GLOF in Ikhuwa Khola catchment as no glacial lakes are seen by Google Earth. During the geological survey it was concluded that the upstream geology of the project area is governed by rock mass so there is less chance of soil erosion and landslides. In case of Nepal, geology seems to be unpredictable so the upstream geology is recommended to be studied before the construction work is commenced.

### **3.7 Geology**

Ikhuwa Khola Hydropower Project area belongs to Higher Himalayan Crystalline Zone, and Lower Himalayan Meta-sediments consisting of mostly Rolwaling Granites, Rolwaling Paragneisses, Rolwaling Migmatites, Khare Phyllites and Khandbari Augen Gneiss. The main orientation of rockmass in the project area is NW-SE and the dip direction is SE.

Gneiss and quartzite are the main rock types in the project area. Quartzite band has been observed in the project area near the powerhouse site on the penstock alignment. The quartzite observed is light grey, medium-to-coarse-grained. It is highly jointed with three sets. The whole tunnel passes through the gneiss and there are three major joint sets along the tunnel alignment.

The geological investigations carried out during feasibility study comprised the following activities:

- General geological map of the project area in 1:20,000;

- Engineering geological mapping of whole project was carried out in the 1:1000;
- Geological maps of the main project structure areas in scale of 1:1,000;
- Four seismic lines with total length of 920 m at the dam site and three seismic lines with total length of 2,065 m at the forebay and powerhouse sites;
  - ii. Three core drilling with total length of 50 m at the dam site, two core drilling of total length of 45 m long over the headrace tunnel and two core drilling with total length of 45 m to cover the forebay-outlet area;

Geophysical exploration using 2D electrical resistivity survey was performed before commencing the core drilling work. For the subsurface exploration of the Ikhuwa Khola Hydropower Project 2D-ERT survey was carried out along 19 profiles of total length of 3000 m.

A seismic risk study was performed during feasibility study to determine the seismic parameters required for the feasibility level design of Ikhuwa Khola HPP. Ikhuwa Khola HEP is located in the second seismic risk zone of Nepal and the soil foundation at the headwork site belongs to average soil type. Therefore, the basic horizontal seismic coefficient is considered to be 0.08. For the maximum acceleration of 250 - 275 gal, according to Seismic Hazard Map of Nepal, Published by DMG, National seismological Center, September 2002 and reduction factor of 0.6, the calculated effective design seismic coefficient for Ikhuwa Khola Hydro Electric Project is approximately 0.15 to 0.16.

### 3.8 Project layout and configuration

Ikhuwa Khola HPP is a Run-of River type hydroelectric project. The general arrangement of the project comprises of non-gated weir including under sluice, gravel trap, desilting basin, headrace canal, forebay, penstock pipe and powerhouse housing two vertical axis Pelton turbines, tailrace tunnel releasing water back to Ikhuwa Khola.

The main civil components of the project are as follows:

- The length of weir including a under sluice structure at the right bank of the river is 28m of which 22m is provided for the non-gated weir with its crest fixed at an elevation of 1493 masl and rest 6 m is provided to accommodate two bays (each of 2m width) of under sluice structures along with two separation piers. The crest of under sluice structure is fixed at elevation of 1490 masl. Each bay of under sluice is provided with stop logs and a vertical gate to be operated by hoist installed at an elevation of 1497.8masl. The width and height of the gate is 2.3m x 3.3m. A RCC side intake withdraw the design discharge of 6.92m<sup>3</sup>/s including the discharge required for flushing at normal water level of 1493.0m. The intake will have two orifice openings each of which is 3.0m wide and 1.7m high, separated by a 1m wide pier. The intake structure downstream of the trash rack is designed an intake chamber. The width of intake chamber varies from 7.0m at the upstream to 3.0m at the end of the chamber, matching with the width of intake canal. The total length of the intake chamber is 16 m.

- Immediately after gravel trap, a box type closed approach canal is provided to connect with inlet transition of Desilting Basin. The total length of approach canal is 20.0m. The free flow rectangular section is 2.5m wide and 2.0m high including a freeboard of 0.30m. The section is designed with a longitudinal slope of 1 in 1000.
- The desilting basin is designed to remove the silt particle larger than 0.2mm in size. For the design discharge of 6.93m<sup>3</sup>/s, the size of a two chamber desilting basin has been calculated as 56m long, 8m wide and 4m deep.
- Water conveyance system consisting of siphon pond of 20.0m long, 5.0m wide and 30.0m deep, steel siphon pipe of 126.0m long crossing with a diameter 1.9m and thickness 12mm convey the flow from siphon pond to inlet portal D-shaped reinforced concrete lined headrace tunnel of length 3,624 m and finished width of 2.5m and height of 2.5m.
- A 58m long 10m wide, and 4.0m deep forebay accommodating a volume required for the storage of 3 minutes is designed.
- Two 1.4m diameter of steel Penstock Pipe found to be of optimum size diameter prior to reaching the powerhouse;
- IKHPP has surface Powerhouse of dimension 35.0m x 20.0 m x 28.0 m (L x B x H) housing all electro-mechanical equipment in two unit;
- A tailrace canal 48 m long with rectangular section of dimension 2.5x2.0 (BxH)m. It is covered concrete lined with longitudinal gradient of 1:1000.
- An 11KV/132KV outdoor switch yard is planned to be located on flat terrace on the western corner of the powerhouse;
- The transmission line will be 132KV single circuit transmission line of about 37Km length connecting the switch yard to proposed Tumlingtar substation

### **3.9 Access Road and Project Road**

Dharan-Tumlingtar Highway having length of 120 km is the main access to the project site. Powerhouse site is 8.1Km from Dovan in Num VDC. The Headworks site could be reached by constructing a 12.5km long project access road along the right bank of Ikhuwa Khola from the powerhouse site.

### **3.10 Power & Energy Generation**

The optimization study carried out in the feasibility study adopts the optimum plant capacity as 30 MW. The design discharge has been adopted as 6.02 m<sup>3</sup>/s (40 % Probability of Exceedance). The net head is computed as 601 m after deducting all probable head losses from the available gross head. With the given input parameters and assumption the calculations for the monthly power and energy generation have been carried out the total annual average energy generation is estimated as 181.74 GWh of which 40.72 GWh is generated during dry and 141.02 GWh in wet season respectively.

### **3.11 Construction Schedule**

The project construction shall be preceded by detailed engineering study, which will require a period of twelve (12) months. Preparatory works like access road, camp, and construction power will be undertaken through a separate contract ahead of the main construction. Total construction time required for the completion of the project is estimated to be three (3) years from the date of initiation of actual project construction at site. The critical path determining the overall duration of the project commences with the construction of the access road to the site and includes the construction of the 3.624 km m long headrace tunnel, for which careful attention should be given during project implementation.

### **3.12 Project Cost Estimate/Evaluation**

The estimated cost of the project at March 2014 price level including contingencies and VAT is estimated to be NRs**5,410,122,876** equivalent to US\$54101228.76 at exchange rate of 1US\$=100NRs. The financial Internal Rate of Return (FIRR) is 14.59% and Benefit Cost Ratio is 1.25. The sensitivity analysis was carried out considering the project cost variation of ±10%.

### **3.13 Environmental Considerations**

As a simple Run-of River type hydroelectric without a large dam or reservoir structure. Ikhuwa Khola Hydroelectric Project will by its nature have less environmental impacts. Some environmentally issues of the project comprise: (i) inadequate water at the stretch of the river from intake to powerhouse for 7 months from November to May (ii) increased potential of soil and slope destabilization (iii) Spoil deposits in river and steep terrains; (iv) appreciable loss of cultivated land and forest resources;(v) threat to some rare and indigenous plants and wild life; (vi) loss of fisheries and aquatic life and (vii) threat to local culture by influx of people. Some environmentally favourable features of the project comprise: (i) local job opportunities (ii) increase in economic active ties (iii) slope stabilization due to use of various protection works in the project area and (iv) community development and local access. The Initial Environmental Examination (IEE) Study was conducted during the feasibility study conducted by DOED.

As per Environment Protection Rules (1997), Environmental Impact Assessment (EIA) of the project

will be required for project implementation. As the Ikhuwa Khola HPP is going to be developed under the umbrella of Upper Arun HEP, Environmental Assessment of Ikhuwa khola HPP is jointly conducted with Upper Arun HEP under the separate task.

#### **4. Scope of Services**

The scope of consulting services for the Detail Engineering Design and preparation of the Tender Documents including specifications and Tender Drawings shall be based on the Feasibility Study conducted by DOED in 2016 and the field investigation and studies carried out as part of the current study. The Consultant can refer the data/information and the past studies but shall be responsible to check, verify and confirm their authenticity. The services to be provided by the consultant shall comprise but not be limited of following tasks:

- Task 1      Inception of Assignment
- Task 2      Field Investigation and Data Collection for engineering studies
- Task 3      Hydrological, Meteorological and Sedimentological Studies
- Task 4      Project Optimization Study and update the Feasibility Study
- Task 5      Detail Engineering Design, Specifications and Drawing
- Task 6      Power Evacuation Study
- Task 7      Construction Planning and Scheduling inclusive of construction power supply
- Task 8      Project Cost Estimate
- Task 9      Economic and Financial Analysis of the Project
- Task 10     Environmental Impact & Safeguard Study
- Task 11     Preparation of Complete Tender Documents & Tender Drawing
- Task 12     Analysis of Institutional Arrangement for Project Implementation

The services carried out by the Consultant shall be reviewed periodically by independent Panel of Experts (POEs) appointed by NEA and approved by the World Bank. The reports submitted by the consultant shall be accepted by NEA after approved by the POEs.

##### **Task 1: Inception of Assignment**

Main activities under this task shall include review of existing reports, applicable guidelines/norms, available data, project review, planning and initiation of the field work and up-dating of the work plan submitted with the proposal on the basis of the findings of the review.

The Consultant shall, immediately upon initiation of the inception assignment, begin collection of all relevant reports, data and maps. NEA will make available to the Consultant existing study reports, in particular the Feasibility Study Report, and other available information/ data/maps.

In the project review, all information/data of the project should be subjected to critical scrutiny in order to establish a realistic understanding of the type and scope of additional information/data required for subsequent analysis/design. As part of the project review, the Consultant shall:

- a. Identify key areas, which will require additional field work or demand major efforts in data collection/ investigation;
- b. Review the Feasibility Study Report and other documents, information, data provided by NEA;
- c. Establish methods and procedures for further studies

The Consultant shall undertake a field reconnaissance and visit to the project site covered by all project components and carry out engineering studies with respect to the topographical and geographical features, geological, hydrological, meteorological and sedimentological aspects of the project area. In parallel with data collection and field reconnaissance, the Consultant shall prepare a time schedule with milestones and specific key dates. This schedule shall be based on that submitted by the Consultant as part of the proposal, suitably updated to reflect the additional information/ data needs.

The Inception Report shall summarize the results of the review of existing data/ reports, summarize the results of the field reconnaissance, discuss the key data/information gaps requiring additional field work/investigation, data collection, data verification, and describe the approaches and methodology that the Consultant intends to follow in carrying out various activities to complete the assignment. The Inception Report shall also include the updated methodology and work plan for the ongoing studies, detailed schedule for each task, detailed field investigation plan, manning schedule of each personnel for effective mobilization. All collected data/information, reports, documents should be subject to critical scrutiny in order to establish a realistic understanding of the field situation, data gap, additional investigation and studies to be included in the study. Therefore, the Consultant shall make a presentation of the Inception Report, including use of appropriate visual aids, to NEA

## **Task 2: Field Investigation and data collection for Engineering Studies**

The following field investigations, among others, shall be performed by the Consultant:

**a) Topographical Survey**

The Consultant shall perform, among others, the following activities:

- Establishment of survey control network within the project area connecting the national grid for underground works and other topographic mappings;
- Detailed mapping of the project sites including Headworks, forebay area, penstock alignment, powerhouse area and portal areas in scale of 1:500 and 1m contour interval;
- Detail mapping of the tunnel alignment strip in scale of 1:5000 and 5m contour interval including whole project area.
- Cross section survey at the interval of 25 m around the dam and tailrace sites from 200 m upstream to 200 m downstream of the dam axis and the tailrace outlet with water level & highest flood marks.
- Detail mapping of project road alignment, camp facilities, spoil disposal area and so on; in a scale of 1:500. The consultant shall conduct detail topographical and alignment survey of project road proposed by the consultant & approved by NEA. The alignment of the project road preferably follows the route alignment designed in the feasibility study. The extent of the survey shall be good enough for the detailed engineering design of the road alignment, river crossings, cross drainage & bridge and other necessary structures as required.
- Transmission line route survey in 1:1000 scale from Ikhuwa powerhouse to powerhouse of Upper Arun area.

**b) Hydrological, Meteorological and Sedimentological Investigation**

The Consultant shall perform, *inter alia*, the following activities:

- Establish the gauging stations both at the headwork site and the powerhouse site at appropriate locations where river beds are stable and flow pattern stable;
- Install cableway for discharge measurement and sediment sampling at the dam site.
- Establish and conduct program for continuous water level observations and river flow measurements at these locations for minimum 8 times in 24 months covering all seasons to develop a rating curves;
- As a part of sediment investigation, study and monitoring, the consultant shall:



- Collect the historical suspended and bed load sediment data/information on Ikhuwa Khola
- Study catchment characteristics from sediment point of view.
- The tentative methodology for point sediment sampling method for one year period is as follows:

<b>SN</b>	<b>Period</b>	<b>Description</b>
1.	Monsoon (4 months)	2 regular samples a day and 2 additional samples in a week for concentration analysis for 4 months
		At least 6 samples in a month for PSD for 4 months
		At least 6 samples in a month for mineral content analysis for 4 months
2.	Post Monsoon (3 months)	1 regular sample in every 2 days and 1 additional sample in a week for concentration analysis for 3 months
		At least 4 samples in a month for PSD for 3 months
		At least 4 samples in a month for mineral content analysis for 3 months
3.	Dry Season (3 months)	1 regular sample in every 1 week and no additional sample for concentration analysis for 3 months
		At least 2 samples in a month for PSD for 3 months
		At least 2 samples in a month for mineral content analysis for 3 months
4.	Pre Monsoon (2 months)	1 regular sample in every 2 days and 1 additional sample in a week for concentration analysis for 2 months
		At least 4 samples in a month for PSD for 2 months
		At least 4 samples in a month for mineral content analysis for 2 months

- Develop a rating curve of suspended sediment load of the river;
  - Estimate the bed load contribution to the total sediment load by means of site measurements or other means appropriate;
  - Estimate the possible ranges of sediment load to the power stations and recommend suitable value for design;
  - Carryout the water quality analysis to determine the corrosive effectiveness (hardness).
- Collect secondary data on climate change to examine its potential impact on the project;

- Investigation on possibility of aggravated erosion in the catchment area due to change in land use pattern, road and other infrastructure construction in the catchment' which may result in rapid sedimentation. The consultant shall make a comprehensive investigation of the problems with a view to propose measures to reduce the long term sedimentation.
- The Consultant shall perform all the necessary hydrological investigations and studies required for the proper design of the project road, bridges and cross drainage structure.
- Installation of Cable Way at dam site and gauging station at dam site and powerhouse site shall be completed by 6 weeks after commencement of the services.

**c) Geological, Geotechnical, and Construction Material Investigation**

The Consultant shall perform, *inter alia*, the following activities:

- Mobilize, locally transport machines at site, construct helipads, construct tracks and demobilize machines after completion of work. Lease necessary land for above purposes.
- Engineering geological mapping based on topographic maps at 1:500 scale at the headwork site, forebay area, penstock alignment, powerhouse and tailrace area in order to obtain more data in respect to rock mass confirmation;
- Engineering geological mapping based on topographic maps at 1: 5,000 scale of the headrace tunnel alignment for assessment of slope stability and leakage;
- Additional engineering geological mapping in the project area, if required, in order to obtain more details with respect to rock mass characteristics at surface and details at location of portals for tunnels;
- About 4 km 2D Electrical Resistivity Tomography (ERT) for assessment of depth of overburden and rock quality in the project area particularly at headwoeks, penstock, fore bay, penstock and powerhouse sits and borrow areas;
- Core drilling in rock/overburden at headwork, forebay, powerhouse sites, and other areas to determine minimum rock stress at various elevations, wherever necessary. It has been estimated that a total of 180 linear meter of core drilling will be required for the investigation. It is the responsibility of the Consultant to determine the requirement of core drilling at different sites and to propose additional core drilling if deemed necessary;

Measurement of core drilling will be made on the basis of the actual lengths of boreholes recorded by the Consultant. The price rates for core drilling shall include for the costs of all labour, materials, tools and equipment and all operations required for drilling the holes, removing cores, keeping accurate logs of drill holes, provision of boxes, boxing, labelling, transporting, and storing the cores and all incidental work connected therewith. The payment of drilling includes all the works required for drilling, lugeon or water pressure tests and core box logging and storing of core boxes until handover to the Client. The Core box should be clearly marked the no. of hole and depth with the permanent marker and stored securely on the boxes. The Consultant after completing the holes shall request for the payment only after submission of the complete core box logging.

Payment for grouting of core holes shall not be made separately and shall be included on the unit rate of drilling.

- Necessary in-situ and laboratory tests in the drill holes and core samples including but not limited to permeability test, lugeon test, UCS of core sample, point load test, Dynamic Cone Penetration Test (DCPT) and SPT.
- Identification of borrow areas and quarry areas for construction materials such as sand, aggregates, filter materials etc. and investigation/tests related to suitability of construction materials and determination of their physical, chemical properties, strength etc. The Consultant shall assess and make fair estimate of volume of each material from each of the borrow areas available for use during construction;
- Further testing of material for concrete aggregate for evaluating requirements for crushing and milling and type of cement and admixtures to be used in order to obtain required quality of concrete and shotcrete;
- The Consultant shall perform all the necessary engineering geological investigations, geo-technical investigations required for the proper design of the project road, bridges and cross drainage structure.

#### **d) Seismological Investigation**

Dam site, headrace tunnel, forebay, penstock, powerhouse and its peripherals will be the major structures of Ikhuwa Khola Hydropower Project with a potential vulnerability for extreme event earthquakes. The security of all aspects of the design under such conditions is of paramount importance and must be fully investigated. The Consultant shall perform, among others, the following activities:

- Detailed investigation of shear zones, fault structure etc. in the project area and its surrounding.

- Assessment of magnitudes and locations of past earthquake events. The program should include determination of fault plane and focal depth for some of the larger events near the dam site, headrace tunnel alignment, powerhouse site, within and in the vicinity of project area. Information available from Department of Mines, Government of Nepal and any other reliable sources may be used for this purpose. Information and the data of recent earthquake that occur in April 25, 2015 need to be used for this purpose. Determination of dynamic response profiles for accelerations and velocities applicable at different elevations shall be carried out for the Design Basis Earthquake (DBE) and Maximum Credible Earthquake (MCE) including likely damage to structures for each case.
- Recommends on the needs for establishment of the seismic network in the project area and preparation of the technical specification of the equipment (seismographs, accelerometers etc) for procurement and installation by NEA.

**e) Investigation Related to Glacier Lake Outburst Flood (GLOF)**

Investigation related to GLOF is to be done as per necessity. Detail investigation on existence and possibility on development of glacial lakes which may prove to be a considerable risk for the project and recommendation on the measures to minimize the risks of potential GLOF.

**Task 3: Hydrological, Meteorological & Sedimentological Study**

The hydrological study shall focus on direct measurement and re-assessment of the stream flow and flood. Daily peaking operation and power studies considering system needs using the long-term series of daily stream flow shall be performed to verify the Feasibility Study analysis. Detail analysis and study of the sediment for the design of the settling basin and other related structures shall be performed

The activities to be carried out by the Consultant under this task include but not limited to the followings:

- Review relating Hydrological, Meteorological and Sedimentological studies carried out in Feasibility Study;
- Assess the adequacy of available data and identify gaps, if any, in data;
- Assessment and estimation of long term mean flow of Ikhuwa Khola as well as other tributaries that could be tapped by Ikhuwa Khola HPP for power generation using appropriate methods in appropriate locations;

- Flood frequency analysis for determination of floods at different return periods and calculation of probable maximum flood (PMF) of Ikhuwa Khola in appropriate locations particularly at the dam and powerhouse sites;
- Assessment and estimation of sediment yield of Ikhuwa Khola using appropriate methods and identification of the needs of sediment management measures;
- Assessment of possible impact of climate change on hydrological characteristics using different scenarios (without climate change, low climate change and high climate change) drawing from existing literature and data;
- Assessment of meteorological aspects relevant during construction phase, such as length of the rainy season, rainfall characteristics, number and duration of rainfall events, dry interval between rainfall events, temperature etc.

#### **Task 4: Project Optimization Studies and update the Feasibility Study**

The consultant has to review and update the Feasibility Study of the Project based on the Optimum Installed Capacity. The major activities to be performed by the Consultant shall include but not limited to the followings during the Optimization of the Installed and update the Feasibility Study of the project:

1. Identify the alternatives layouts and select the best layout of the project. The consultant shall carryout optimization studies including optimization of project capacity, dam height, tunnel and penstock diameter etc. and the number and size of the turbine units.
2. While Optimization of the Installed Capacity of the Plant and selecting the poundage capacity, if any, its effect on the hydropower projects planned on downstream and upstream of this project need to be studied. Operation of this project should not effect the operation of the projects located downstream and upstream of this project.
3. The Consultant shall carry out hydraulic structural design of each components including but not limited to main dam, spillway facilities, intake, headrace tunnel, surge tank(s)/ forebay, penstock, powerhouse, tailrace, and other associated structures. The task shall also include design of access roads and bridges (if any), cofferdams, diversion tunnels, electrical and Mechanical equipment, substations and other components.
4. The design of the each component shall be based on outcome of field investigation results and considering best engineering design and standards. The design shall include, but not limited

to, the complete design of hydraulic structures, foundation treatment and grouting, instrumentation, seepage analyses, stability analysis, deformation and stress analysis and architectural work and finishing. Structures shall be designed for steady state and transient conditions. The designs shall conform to and be suitable for the site conditions and shall aim at achieving minimum overall cost and a minimum consumption of land, without adversely affecting safety, security, efficiency or longevity of the works or the environment. The consultant shall prepare detailed calculation regarding design of each component. The consultant shall carryout

5. Carryout Hydro-Mechanical and electro-Mechanical design of gates, valves, turbine, generator, substation, and transmission line etc.
6. Prepare engineering drawings of all the components of the project including Hydro and electro-Mechanical works, transmission lines and substations.
7. Identify the most appropriate technology for successful implementation and operation of this project for Hydropower and other multipurpose uses through analysis of existing techniques
8. Analyze different alternatives and recommend best alternative for dam / weir type and best site, for the dam and other components based on prevailing geological condition and availability of construction materials.
9. Identify, review previous reports and finalize / reconfirm the location of camp for client and contractors (Civil, electro-Mechanical, Hydro-Mechanical etc.), spoil disposal and establish the need for construction of additional access road and bridge including finalization of road alignment and site for bridge.
10. The quantum of construction power required shall be assessed and the method of supplying temporary power determined by previous studies shall be reviewed and recommend appropriate option along with cost estimates and other details if necessary.

The consultant has to update the Feasibility Study of the Project based on the above mentioned activities and the result of site investigations and studies.

#### **Task 5: Detail Engineering Design, Specifications & Drawings**

The primary objective of this task is to refine, update and supplement and prepare detailed design and drawings of the project configuration option finalized in the updated feasibility study. The detailed design including reinforcement details where applicable shall cover each component of major structures e.g. dam, weir and including spillway and other outlets, intake, water ways, surge tank / forebay, powerhouse, tailrace, Hydro-Mechanical structures, electro-Mechanical works and transmission line and substations for power evacuation, roads, bridge, employer's camp, landscaping

in necessary areas, and so on. The drawings shall be prepared on the basis of detailed design and shall be adequate in coverage for use in construction

For every component of the project, the consultant shall formulate prior to detail engineering design, a Design Base Memorandum (DBM) to record the basis on which a design will be developed. It shall establish the design and functional criteria, and prepare the layout and design concepts of all project facilities/ components; state the assumptions, parameters, and standards applied, loading conditions, factors of safety, allowable stresses, stability criteria, and all other factors which are necessary to fully carry out the detailed design. The design criteria shall describe in sufficient detail methodologies and analysis methods, data base and international standards or codes and prudent practices employed. The design criteria shall be submitted to NEA for review, comments and approval and shall not be modified unilaterally after it has been approved.

Detail Design and Technical Performance Specifications shall be prepared to the international standards. They shall be carried out to a level of detail such as to enable contractors and suppliers to clearly interpret type and scope of works involved and to submit competitive tenders.

The consultant shall prepare confirmatory stability, stress analysis and reinforcement design and details for the various features including diversion weir, intake structure, , settling basins, headrace tunnel, forebay, penstock, powerhouse, tailrace, and other associated structures using the state of the art techniques in consistent manner by matching the methods to needs.

The consultant shall survey and design 12.5km long project access road along the right bank of Ikhuwa Khola from the powerhouse site including all road components. The consultant shall carry out detail design of the project access road, permanent road bridges, cross drainage structures and other related works, prepare detail cost estimate, prepare tender documents and drawings, and assist Employer in procurement of contractor. The access road, bridges and other structures should meet the requirements for the construction of 30 MW hydroelectric project. The geometry of the road, size / and bridge capacity shall meet these requirements. Ensure high standards of quality assurance in the execution of works and completion of works within stipulated time limit;

The consultant shall perform engineering study of each component of the project. The Consultant shall carry out hydraulic design of main dam, spillway facilities, intake, settling basins, headrace tunnel, fore bay, penstock, powerhouse, tailrace, and other associated structures. The study shall also include cofferdams, river diversion, electrical and mechanical equipment, substations, transmission lines to connect to the national grid and other components that are required for the proper functioning of the project.

The design shall include, but not limited to, the complete design of hydraulic structures, foundation treatment and grouting, instrumentation, seepage analyses, stability, deformation and stress analysis

and architectural work and finishing. Structures shall be designed for steady state and transient conditions. The designs shall conform to and be suitable for the site conditions and shall aim at achieving minimum overall cost and a minimum consumption of land, without adversely affecting safety, security, efficiency or longevity of the works or the environment. The consultant shall prepare detailed calculation regarding design of each component.

The consultant shall carry out optimization studies including headrace tunnel and penstock diameter etc. and the number and size of the turbine units.

Hydraulic design for all hydraulic structures/water conveyance system including hydraulic transient analysis with water hammer effect for fore bay shall be performed as necessary to verify the principal dimensions, design parameter and proper hydraulic performance of the project. The consultant shall carry out hydro-mechanical and electro-mechanical studies to determine the type of trash racks, gates, turbine, generator, substation, and transmission line etc.

The Consultant shall carry out the necessary structural, electrical and mechanical detailed design works of project components to determine the optimum scheme based on updated database and specific requirements of the detail engineering design.

The project components will include:

- Temporary facilities; i.e., camps, water supply and sanitary facilities etc.
- Project road from the powerhouse site / bridge on Arun River to the dam site and other major structure and sites of the project
- Construction power supply
- River diversion work
- Diversion weir and intake
- Intake and Gravel trap
- Approach Canal
- Desilting Basin
- Headrace Canal
- Siphon Pond
- Siphon Pipe
- Headrace tunnel and adits
- Forebay
- Penstock
- Anchor Blocks and Saddle Supports
- Powerhouse and Tailrace
- Hydraulic Steel Structure
- Gates/ stoplogs/ trashracks and valves
- Electrical and Mechanical Generating Equipment with all Accessories
- Switchyard and Substations



- Transmission Line.
- Project road

Electro-Mechanical, Hydro-Mechanical, transmission line and substation design work shall be based on internationally accepted practice and shall include drawings and supporting calculations. The Electro-Mechanical design shall involve, among others, selection of proper electrical and mechanical systems and equipment, dimensioning/sizing of the equipment, etc. Electro-Mechanical works including transmission line and sub-station station design work shall be based on the approved design criteria and internationally accepted practice and shall include drawings and supporting calculations.

Electro-Mechanical works including 132 kV transmission line and sub-station station design work shall be based on the approved design criteria and internationally accepted practice and shall include drawings and supporting calculations. As this project shall be developed along with Upper Arun HEP and will be commissioned earlier than the Upper Arun HEP, the transmission line of this project need to connect to the powerhouse site of the Upper Arun HEP and the project area for the Construction Power Supply. Apart from this, the power from this project can be evacuated to the INPS from the transmission line of Upper Arun HEP. Apart from these options, the consultant is required to carry out possibility of other options. It is a Consultant responsibility to recommend and design the suitable transmission line to evacuate the power generation from the project to the national grid. The electro-mechanical and transmission line design effort shall involve selecting the proper electric and mechanical systems and equipment, determining limiting dimensions and setting, and determine plant control and performance.

The consultant shall have full discretion on the method, procedure, tools and approaches for the performance of the design work. The performance of the designs ultimately accepted, shall be demonstrated by a “Confirmatory Analyses” with the state-of-art structural and hydraulic methods.

The consultant shall prepare and be responsible for Detail Engineering Design and Technical and Performance Specification describing the work in terms of the objectives, needs and performance as well as for the design criteria, loading conditions.

The Consultant shall review and finalize the location of camp for client and contractors (civil, electro-mechanical, hydro-mechanical etc.), spoil disposal and establish the need for construction of project road and bridge including finalization of project road alignment. The quantum of construction power required shall be assessed and the method of supplying the power shall be proposed along with cost estimates and other details.

The Consultant shall prepare Engineering Drawings and Specifications of all the components of the project including hydro and electro-mechanical works, transmission lines and substations; describing work in terms of measurements, tolerance, and material and as necessary in process tests. Engineering drawings shall be prepared in accordance with the Design Base Memorandum and show the general outline and enough detail regarding the structures, material and equipment to enable the contractors and suppliers to prepare and submit competitive bids.

**Task 6: Power Evacuation Study**

The consultants shall carry out the grid impact study and plan for the transmission system for the evacuation of power. In particular the study shall include:

- Load flow analysis
- Short circuit study
- Transient Stability analysis

The Consultant shall carryout power evacuation studies to determine the proper power evacuation route. This study can be done along with the power evacuation study of Upper Arun hydropower project.

**Task 7: Construction Planning and Scheduling**

Notwithstanding the fact that the contractor will eventually develop his own construction operation and plan, the Consultant shall prepare, from a contractors point of view of operation, a realistic and practical construction and equipment procurement plan along with construction power supply. The plan shall serve to establish construction schedules, with start and finish and interim critical milestone dates as well as key dates for interfaces between project road, civil, hydro-mechanical and electro-mechanical works and all other components of the hydropower project.

The Consultant shall carryout material handling studies which will aid the contractor to efficiently quarry, store, haul, use and dispose huge amount of construction material required for construction of the physical project. The result of material handling studies shall be incorporated in the construction plan which shall be supported by network and logic diagram showing the sequence in which construction activities are to be performed, their interdependencies, constraints and the critical path of the execution of the work, and so on.

**Task 8: Project Cost Estimate**

The consultant shall, parallel to the development of the construction plan and schedules, prepare an Engineer's cost estimate for Ikhuwa khola HPP based on the Bill of Quantities (BOQs) and unit rates, consistent with the construction plan and schedule. The estimates shall serve as a baseline for comparing and valuating the bid prices and be suitable for presenting to international financing agencies and organizations, commercial banks and export credit.

The Consultant shall prepare detail quantity estimate based on detail engineering design and tender drawings for the purpose of cost estimate. Preparation of the BoQ shall be in accordance with

recognized standard method of measurement of civil engineering works and shall be appropriate to the level of information available.

For civil works, the unit cost for each individual item shall be composed of labor and staff costs, construction materials, plant and equipment costs, fuel and lubrication, transport, electrical power etc. Custom duties, taxes, fees, royalties, and levies due in Nepal shall be presented separately. The cost estimate needs to be based on construction methodology and planning as determined in Task 8. The cost for turbines, generators, substation equipments, switchgear, gates, and so on shall be based on prevailing market prices.

The cost estimates shall be prepared from a contractor's point of view using resource based costing and shall follow international standard practice (Cost and Performance Calculations of the Construction Industry) and Nepalese practices including other recognized estimating methods. The Consultant shall add an appropriate sum as price and physical contingencies to allow for potential physical or design conditions requiring additional funding for the execution of the project of this nature and for unforeseen conditions.

### **Task 9: Economic and Financial Analysis of the Project**

The consultant shall analyze demand, supply, and economic viability, and assess tariff pricing. The Consultant shall also analyze the financial viability and suggest the financing structuring of the project. The Consultants shall perform the following major activities:

- Analyze the economic viability of the project. Identify all economic costs and benefits with sensitivity analyses and evaluate economic internal rates of return;
- Review the forecasted load growth and revenues and costs in relation to tariffs, cost recovery. Determine future sustainable tariffs to support the project;
- Assess and analyze the financial viability of the project. Identify all risks for revenues and costs with sensitivity analyses, and evaluate financial internal rates of return. Include risk mitigation and risk transfer plans as necessary;
- Analyze the alternative possibilities of promoting the project, ranging from the public sector development to the public and private development approach. Simulate and evaluate optimal financial structuring and modeling in terms of profits, costs, and risks through all measures such

as equity, loans, or an insurance (guarantee) mechanism from private investors and lenders, export credit agencies, multilateral development banks, and bilateral donors;

- Develop financial projection models comprising financial statements and financial ratios for the next 10 years to assess the project and its institutional financial viability and impacts using key performance indicators.

### **Task 10: Environmental Impact & Safeguard Study**

The Initial Environmental Examination (IEE) Study was conducted during the feasibility study conducted by DOED. As per Environment Protection Rules (1997), Environmental Impact Assessment (EIA) of the project will be required for project implementation. As the Ikhuwa Khola HPP is going to be developed under the umbrella of Upper Arun HEP, Environmental Assessment of Ikhuwakhola HPP is jointly conducted with Upper Arun HEP under the separate task. The consultant shall review EIA study report carried out.

The consultant shall assist the consultant carrying out the consulting services consisting of undertaking and completing the Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) and Planning Studies of Upper Arun Hydroelectric Project and Ikhuwa Khola Hydropower Project fulfilling the requirements of GoN and lending agencies. The consultant is required to carry out its design, investigation, cost estimation in close coordination with the consulting firm carrying out Environmental Study and Social Study of the project.

While preparing the Tender Document, the consultant shall include all the issues, mitigation plans and outcome of the Environmental and Social Studies of the project. The mitigation measures/monitoring clauses outlined in the environmental Impact Assessment report should be incorporated in the Tender Document and Specifications providing the Environment and Social Mitigation/Enhancement requirements for the contractors to implement and bid on.

### **Task 11: Preparation of Complete Tender Documents & Tender Drawings**

The Consultant shall prepare complete Tender/Bidding Documents complete with Tender Drawings for all works with appropriate details and specifications, BoQ and other necessary documents (e.g. FIDIC yellow book and red book) for bidding purpose. The title and contents of the Tender Documents shall be finalized in consultation with NEA.

The Consultant shall make his recommendations and discuss in detail with NEA for the extent to which bidders should be permitted to suggest alternative designs, construction methods or temporary works. The Tender Documents shall describe the works, including temporary works as necessary in sufficient detail to allow bidders to confidently determine the cost of construction and ensure competitive and comparable tenders.

The number of Lots shall be decided with consultation with NEA. However, at least following lots will be considered in the formulation of the Tender Documents

- Civil works
- Hydro-mechanical Equipment
- Electro-mechanical Equipment
- Transmission Line
- Substations and Switchyard
- Temporary and Permanent Infrastructure inclusive of power supply during construction

### **Task 12: Analysis of Institutional Arrangement for Project Implementation**

The Consultant shall make an assessment of the institutional arrangement required for implementation of physical project of this magnitude in line with the requirement specified in Task 10. In doing so, the consultant shall analyze critically alternative institutional setups to smoothly carryout the implementation of the project. In the proposed optimal institutional setup, the consultant shall propose organizational structure clearly defining the role of each position and responsibility and chain of command linking the entire organizational hierarchy. The consultant shall also clearly identify the requirement of resources including but not limited to capacity building measures (Trainings, Workshops etc.), physical infrastructures, requirement of software, equipments etc.

## **5. Team Composition & Qualification Requirements for the Key Experts**

### **5.1 General Remarks**

The work shall be performed by an integrated team of Nepali and expatriate professional and support staff. The local participation shall be maximized within the framework of quality, timely performance of the services and liability. The local staff shall be assigned to and perform clearly defined tasks, commensurate with their background, qualification and experience based on shared responsibility.

### **5.2 Organization & Team Composition**

The services shall be provided and managed with a functional organization directly responsive and responsible through the Team Leader. NEA shall be informed of the status of the project design in regular basis. For effective implementation, works shall be carried out by as fully integrated team of expatriates and Nepali personnel and shall operate as an independent and self-sufficient entity with the Team Leader entrusted with full responsibility and authority to act on behalf of the consultant.

Members of the project team shall be assigned for the full duration of their involvement. They shall report to the Team Leader directly, or to assigned supervisors within the project team. This accountability shall be binding on each team member regardless of origin. It holds equally for expatriates and Nepali professionals, for duration of the project or recruited elsewhere.

***The Team Leader for Upper Arun Hydroelectric Project shall be responsible as the Team Leader also for Ikhuwa Khola Hydropower Project. The same person will be the team leader for both projects.***

The Consultant shall provide qualified and competent staff to fully carry out all the Services. Key positions which are considered to be appropriate as part of the Consultant's team are listed in the following Table. International Key Experts will be evaluated. ***The consultant is free to propose the same or different International Key Experts, International Non Key Experts and National Non Key Expert both for Upper Arun and Ikhuwa Khola HEPs fulfilling the evaluation criteria. However, the same person is not allowed to position in more than one Key Expert position in one project.***

***Among the Key Experts, the Team Leader must have at least 15 years of professional experience. All other key experts must have at least 10 years of professional experience. Year of Professional experiences shall be counted from the last date of submission of RFP.***

The Consultant in this proposal shall state all categories and numbers of staff and personnel, which they considers necessary to perform the services. The list of Key Experts mentioned presents a tentative estimate.

For every key position the Consultant shall provide a brief, approximately ¼ of a page long, position description of the expatriate personnel stating functions, tasks and responsibilities and depict this staff-task relationship in a responsibility matrix showing clearly the assignments of each staff member. . ***Experience and past achievements of each individual shall be presented exclusively in the CV following the format given in the technical proposal standard forms and Personal Information Sheet.***

The temporal assignment of the staff shall be shown on a Staff Time Schedule and will become part of the Consultant Contract.

The Consultant shall provide qualified and competent staff to fully carry out all the Services. Key positions which are considered to be appropriate as part of the Consultant's team is listed in the Tables: The International Key Expert will be evaluated.

It is estimated that about Fifteen and half (15.5) Person-Months of International Key Experts, about Four (4.0) Person-Months of Non Key Expert (International) and about Fifty Seven (57) Person-

Months of Non Key Expert (National) will be needed to complete the assigned tasks. The tentative breakdown of the estimated inputs (person months) of International Key Expert, Non Key Expert (International) and Non Key Expert (National) are given in the following table.

<b>S. No.</b>	<b>Key Expert (International)</b>	<b>Person Months</b>
1	Hydropower Engineer	2.5
2	Hydrologist & Sediment Engineer	1.5
3	Hydraulic Engineer	2.0
4	Geologist	1.0
5	Geotechnical Engineer	1.0
6	Cost/ Quantity Engineer	2.0
7	Contract/ Specification Engineer	1.5
8	Structural Engineer	2.0
9	Electrical Engineer	1.0
10	Mechanical/ Hydro- mechanical Engineer	1.0
	<b>Total of Key Expert (International)</b>	<b>15.5</b>

<b>S. No.</b>	<b>Non Key Expert (International)</b>	<b>Person Months</b>
1	Transmission Line & Sub-station Engineer	1.0
2	Construction Planner	1.0
3	Road Engineer	0.5
4	Survey Engineer	0.5
5	Economist/ Financial Analyst	1.0
	<b>Total of Non Key Expert (International)</b>	<b>4.0</b>

<b>S.N.</b>	<b>Non Key Expert (National)</b>	<b>Person month</b>
1	Hydropower Engineer	12.0
2	Design Engineer	3.0
3	Geologist	3.0
4	Geotechnical Engineer	2.0
5	Hydrologist/Sedimentologist	3.0
6	Electrical/ Control Power System Engineer	2.0
7	Mechanical/ Hydro Mechanical Engineer	2.0
8	Hydraulic Engineer	3.0
9	Structural Engineer	3.0
10	Transmission Line/Substation Engineer	2.0

11	Road Engineer	3.0
12	Survey Engineer	1.0
13	Cost Engineer/ Quantity Surveyor	1.0
14	Contract Engineer	3.0
15	Construction Planner	2.0
16	Civil Engineers	12.0
	<b>Total of Non Key Expert (National)</b>	<b>57.0</b>

**Note:** *The above estimates are indicative and the Proposal shall be based on the Consultant's own estimates for the same.*

### 5.3 Qualification/Experience of Each Expert

The following paragraphs are brief descriptions of the responsibility and duties considered to be required by team leader and expatriates.

#### (A) Key Expert (International)

##### (i) Team Leader

The focal point of the project organization is the team Leader, the principal contact and communication channel with NEA. The Team Leader is common for both Upper Arun HEP and Ikhuwa Khola HPP. Details of the Team Leader is given in Section 5.2 **Qualification / Experience of Each Expert under UAHEP**. Evaluation of the Team Leader shall be carried out in Upper Arun HEP.

##### (ii) Hydropower Engineer:

The Hydropower Engineer shall have minimum of Bachelor degree in Civil engineering or equivalent and preferably have Master's degree or equivalent in civil/hydropower/water resources engineering and ***must have ten (10) years of professional experience.***

The expert shall have previous experience of working as hydropower engineer in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 30MW. The hydropower engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 10 MW will also be accounted. The Hydropower Engineer's involvement in the previous assignment as the hydropower engineer in the individual hydropower project with capacity mentioned above need to be equal or more than two and half (2.5) man months. All these qualifications and experiences will be considered in the evaluation.



The expert will be resident in Kathmandu for approximately two and half (2.5) months, with frequent visits to the project site.

**(iii) Hydrologist & Sediment Engineer**

The Hydrologist shall have minimum of bachelor's degree in civil engineering or equivalent and preferably have Master's degree or equivalent in hydrology/ hydraulic/ hydropower/ Sediment/ civil engineering discipline and *must have ten (10) years of professional experience.*

The expert shall have experience in hydrological investigation, analysis and study, sediment study including investigation, analysis and interpretation and design of reservoir sedimentation and its management in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 30 MW as hydrologist/ Sedimentologist. The Hydrologist & Sediment Engineer involvement in the previous assignment as the hydrologist & sediment engineer in the individual hydropower projects mentioned above need to be equal or more than one and half (1.5) man months. Experience in detailed engineering design of hydropower projects in the Himalayan region as a hydrologist and sedimentologist will be added advantage for the expert. The hydrologist and sediment engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 10 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately one decimal five zero (1.5) months, with frequent visits to the project site.

**(iv) Hydraulic Engineer**

The Hydraulic Engineer shall have minimum of bachelor's degree in civil engineering and preferably have Master's degree or equivalent in civil/hydraulic engineering discipline and *must have ten (10) years of professional experience.*

The expert shall have previous working experience in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 30MW as a hydraulic engineer. The Hydraulic Engineer involvement in the previous assignment as the hydraulic engineer in the individual hydropower project mentioned above need to be equal or more than two (2) man months. The Hydraulic Engineer general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned)hydropower projects with installed capacity not less than 10 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately two (2) months, with frequent visits to the project site.

**(v) Geologist**

The Geologist shall have minimum of bachelor's degree in geology or equivalent and preferably have Master's degree or equivalent in geology discipline and ***must have ten (10) years of professional experience.***

The expert shall have experience of geological investigation, studies and design in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with hydraulic tunnel length of at least 2 Km and installed capacity not less than 30 MW as a geologist. The Geologist involvement in the previous assignment as the geologist in the individual hydropower project mentioned above need to be equal or more than one (1) man month. Experience in detailed engineering design of hydropower in the Himalayan region as a geologist will be added advantage for the expert. The geologist's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 10 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately one (1) month, with frequent visits to the project site.

**(vi) Geotechnical Engineer**

The Geotechnical Engineer shall have minimum of bachelor's degree in civil engineering and preferably have Master's degree or equivalent in Geotechnical or civil engineering discipline and ***must have ten (10) years of professional experience.***

The expert shall have experience in geotechnical investigation, tests, and design in the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 30MW and hydropower projects with hydraulic tunnel of at least 2 km length as geotechnical engineer. The Geotechnical Engineer involvement in the previous assignment as the geotechnical engineer in the individual hydropower projects and hydropower projects with hydraulic tunnel mentioned above need to be equal or more than one (1) man month each . The geotechnical engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned)hydropower projects with installed capacity not less than 10 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately one (1) month, with frequent visits to the project site.

**(vii) Cost/ Quantity Engineer**

The Cost Engineer shall have minimum of bachelor's degree in civil engineering and preferably have Master's degree or equivalent in civil/cost engineering or other relevant discipline and ***must have ten (10) years of professional experience.***

The expert shall have previous experience as cost engineer/estimator in the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with at least 2 km long hydraulic tunnel and installed capacity not less than 30MW as cost engineer/estimator. The Cost Engineer involvement in the previous assignment as the cost engineer in the individual hydropower projects mentioned above need to be equal or more than one and half (1.5) man months. The cost engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 10 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation

The expert shall be resident in Kathmandu for approximately two (2) months, with frequent visits to the project site.

**(viii) Contract/ Specification Engineer**

The Contract Specialist/ Engineer shall have minimum of bachelor's degree in civil engineering and preferably have Master's degree or equivalent in construction management or law or engineering or other relevant discipline and ***must have ten (10) years of professional experience.***

The expert shall have experience in tender document preparation for international contract based on FIDIC or equivalent of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 30MW as contract specialist. The Contract/ Specification Engineer involvement in the previous assignment as the Contract/ Specification engineer in the individual hydropower projects mentioned above need to be equal or more than two (2) man months. The contract specialist/ engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 10 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately two (2) months, with frequent visits to the project site.

**(ix) Structural Engineer**

The Structural Engineer shall have minimum of bachelor's degree in civil engineering and preferably have Master's degree or equivalent in civil/structural engineering discipline and ***must have ten (10) years of professional experience.***

The expert shall have previous working experience in detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 30 MW as a structural engineer. The Structural Engineer involvement in the previous assignment as the structural engineer in the individual hydropower projects mentioned above need to be equal or more than two (2) man months. The Structural Engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned)hydropower projects with installed capacity not less than 10 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately two (2) months, with frequent visits to the project site.

**(x) Electrical engineer**

The Electrical Engineer shall have minimum of bachelor's degree in electrical engineering or equivalent and preferably have Master's degree or equivalent in electrical engineering discipline and *must have ten (10) years of professional experience.*

The expert shall have experience in the detail electrical engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 30 MW as an electrical engineer. The Electrical Engineer involvement in the previous assignment as the electrical engineer in the individual hydropower projects mentioned above need to be equal or more than one (1) man month. The Electrical Engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned)hydropower projects with installed capacity not less than 10 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately one (1) month, with frequent visits to the project site.

**(xi) Mechanical/ Hydro-mechanical Engineer**

The Hydro-mechanical Engineer shall have minimum of bachelor's degree in mechanical engineering or equivalent and preferably have Master's degree or equivalent in mechanical engineering or other related discipline and *must have ten (10) years of professional experience.*

The expert shall have experience in the preparation of hydro-mechanical design specifications of hydro-mechanical components in the detailed engineering design of successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 30 MW as mechanical/hydro-mechanical engineer. The Mechanical/ Hydro-mechanical Engineer

involvement in the previous assignment as the mechanical / hydro-mechanical engineer in the individual hydropower projects mentioned above need to be equal or more than one (1) man month. The mechanical/ hydro-mechanical engineer's general experience in any field of the detailed engineering design of successfully completed (Constructed and Commissioned)hydropower projects with installed capacity not less than 10 MW will also be accounted. All these qualifications and experiences will be considered in the evaluation.

The expert shall be resident in Kathmandu for approximately one (1) month, with frequent visits to the project site.

**(B) Non Key Expert (International)**

**(i) Transmission Line & Sub-station Engineer**

The Transmission Line & Sub-station Engineer shall have minimum of bachelor's degree in electrical engineering and preferably have Master's degree or equivalent in high voltage/electrical engineering discipline and *must have ten (10) years of professional experience.*

The expert shall have experience in design of transmission lines and substations of 132 kV or above voltage class of at least two projects as the transmission line & substation engineer in the detailed engineering design stage.

The expert shall be resident in Kathmandu for approximately one (1) month, with frequent visits to the project site.

**(ii) Construction Planner**

The Construction Planner shall have minimum of bachelor's degree in civil engineering or equivalent and preferably have Master's degree or equivalent in civil engineering or construction management or other engineering discipline and *must have ten (10) years of professional experience.*

The expert shall have experience in preparation of construction plan and schedule in the detailed engineering design of at least two successfully completed (Constructed and Commissioned) hydropower projects having installed capacity not less than 30 MW as construction planner.

The expert shall be resident in Kathmandu for approximately one (1) month, with frequent visits to the project site.

**(iii) Road Engineer**

The Road Engineer shall have minimum of bachelor's degree in civil engineering and preferably have Master's degree or equivalent in civil/road/transportation engineering discipline and *must have ten (10) years of professional experience.*

The expert shall have working experience in planning and design of project roads of at least two hydropower projects with installed capacity of not less than 30 MW.

The expert shall be resident in Kathmandu for approximately half (0.5) month, with frequent visits to the project site.

**(iv) Survey Engineer**

The Survey Engineer shall have minimum of bachelor's degree in engineering survey or equivalent and preferably have Master's degree or equivalent in surveying /civil engineering and ***must have ten (10) years of professional experience.***

The expert shall have experience in surveying of at least two successfully completed (Constructed and Commissioned) hydropower projects having installed capacity not less than 30 MW in the detailed engineering design stage.

The expert shall be resident in site/Kathmandu for approximately half (0.5) month, with frequent visits to the project site.

**(v) Economist/ Financial Analyst**

The Economist/ Financial Analyst shall have minimum of bachelor's degree in Civil Engineering, Economics/ Finance or economics or business administration or engineering economics or equivalent and preferably have Master's degree or equivalent in finance or economics or business administration or engineering economics ***and must have ten (10) years of professional experience.***

The expert shall have previous experience as Economist/ Financial Analyst of at least two successfully completed (Constructed and Commissioned) hydropower projects with installed capacity not less than 30 MW as Economist/ Financial Analyst in the detailed engineering design stage.

The expert shall be resident in Kathmandu for approximately one (1) month, with frequent visits to the project site.

**(C) Non Key Expert (National)**

**(i) Hydropower Engineer**

The Hydropower Engineer shall have Master's degree or equivalent in water resources/hydropower engineering, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(ii) Geologist**

The Geologist shall have Master's degree or equivalent in geology discipline, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(iii) Geotechnical Engineer**

The Geotechnical Engineer shall have Master's degree or equivalent in geotechnical engineering, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects..

**(iv) Hydrologist/Sedimentologist**

The Hydrologist/Sedimentologist shall have Master's degree or equivalent in civil engineering/hydrology/sediment study discipline, ten (10) years of professional experience and five (5) years of specific experience in hydrological analysis/sediment analysis.

**(v) Electrical/ Control Power System Engineer**

The Electrical Engineer shall have at least bachelor degree or equivalent in electrical engineering or power system and preferably Master's degree or equivalent in electrical engineering/power system, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(vi) Hydraulic Engineer**

The Hydraulic Engineer shall have Master's degree or equivalent in hydropower/water resources engineering, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(vii) Structural Engineer**

The Structural Engineer shall have Master's degree or equivalent in structural engineering, ten (10) years of professional experience and five (5) years of specific experience in hydropower projects.

**(viii) Transmission line/Sub-station Engineer**

The Transmission line/Sub-station Engineer shall have Master's degree or equivalent in electrical engineering/power system, ten (10) years of professional experience and five (5) years of specific experience in transmission line/ substation projects..

**(ix) Road Engineer**

The Road Engineer shall have Master's degree or equivalent in civil/road/transportation engineering discipline,, ten (10) years of professional experience and five (5) years of specific experience in road projects..

**(x) Survey Engineer**

The Survey Engineer shall have Master's degree or equivalent in surveying /civil engineering, ten (10) years of professional experience and five (5) years of specific experience in surveying of hydropower projects.

**(xi) Cost Engineer/Quantity Surveyor**

The Cost Engineer/Quantity Surveyor shall have Master's degree or equivalent in civil engineering, ten (10) years of professional experience and five (5) years of specific experience in quantity surveying or cost estimating of hydropower projects.

**(xii) Contract Engineer**

The Contract Engineer shall have Master's degree or equivalent in construction management, preferably ten (10) years of professional experience and five (5) years of specific experience in hydropower projects..

**(xiii) Construction Planner**

The Construction Planner shall have preferably Master's degree or equivalent in civil engineering, ten (10) years of professional experience and five (5) years of specific experience in construction planning of hydropower projects.

**(xiv) Civil Engineers**

The Civil Engineers shall have at least bachelor degree or equivalent in civil engineering, minimum five (5) years of professional experience and specific experience in hydropower projects..

**(xv) Backup Support**

Home office back-up support shall be made available to the project to facilitate communications between the project office in Kathmandu and the respective corporate office, for responding to requests and directives from Nepal with respect to technical data, publications, specialized assistance, communications, travel arrangements necessary government documentation and general logistics etc..

**Reporting Requirements And Time Schedule For Deliverables**

The consultant shall discuss their interim findings at review meetings to be held with NEA project management team on regular basis, and provide the following final deliverables.

- Inception Report within six (6) weeks of commencement of services covering activities as stipulated in Task 1.
- Project Optimization & Review and Update of Feasibility Studies report within four (4) months of commencement of services covering activities as stipulated in Task 4
- Design Basis Memorandum (DBM) within three months (3) months of commencement of services.
- Field Investigation Report within five (5) months of commencement of services covering activities as specified in Task 2.
- Cost Estimation Report within Nine (9) months of commencement of services covering activities as stipulated in Task 8.
- Economic and Financial Analysis Report within Nine (9) months of commencement of services covering activities as stipulated in Task 9.
- Draft Final Detailed Engineering Design Report within ten (10) months of commencement of services. The report shall include the following
  - Final Report on Field Investigation



- Design Criteria Report
  - Project Layout, Project Road Design, Hydraulic Design of Civil Works, Civil Works Design, Stability Calculations, Structural Calculations and Detailed Design
  - Hydraulic Steel Structure, Mechanical and Electrical Equipment and Transmission Line
  - Methods used in design, reasons for technical decisions and reference to all technical memoranda and design reports
  - Detailed Quantity Estimate
  - Detailed Cost Estimate
  - Construction Planning and Scheduling
  - Economic and financial analysis
  - Engineering Drawings
- Final Detailed Engineering Design Report after incorporating comments from NEA within twelve (12) months of commencement of services.
  - Draft Tender Documents/Drawings within eleven (11) months of signing the contract
  - Final Tender Documents after incorporating comments from NEA within twelve (12) months of signing the contract
  - The monthly progress report in agreed format covering all the activities of the consultant in the previous month within 5 days of the end of the reporting month.
  - Trimester Report in agreed format summarizing all activities of the consultant in the previous trimester.

The consultant shall identify the report milestones in his design schedule. When any work falls behind the schedule, the Consultant shall make recommendations in writing to the Employer as to the action to be taken to expedite progress

The following are the number of copies of each report to be submitted by the consultant to NEA:

- |   |             |
|---|-------------|
| 1. Inception Report   | : 15 Copies |
| 2. Project Optimization & Review and Update of Feasibility Studies report | : 15 Copies |
| 3. Design Basis Memorandum (DBM)  | : 15 Copies |
| 4. Field Investigation Report   | : 15 Copies |
| 5. Draft Design Criteria Report   | : 15 Copies |
| 6. Cost Estimation Report   | : 15 Copies |
| 7. Economic and Financial Analysis  | : 15 Copies |

8. Draft Final Detailed Design Report	: 15 Copies
9. Final Design Criteria Report	: 25 Copies
10. Final Detailed Design Report	: 25 Copies
11. Draft Tender Documents	: 15 Copies
12. Final Tender Documents	: 25 Copies
13. Monthly Progress Report	: 10 Copies
14. Trimester Report	: 10 Copies

Each report shall also be accompanied by the electronic copy. All reports, submissions and discussions shall be in English. All dimensions and quantities shall be expressed in the SI system of units. Standard shall be those of the International Standards Organization (ISO) except where no suitable ISO standards exist, in which case suitable widely known national standard may be used. All drawings shall be in A3 size.

The services carried out by the Consultant shall be reviewed periodically by independent Panel of Experts (POEs) appointed by NEA and approved by the World Bank. The main reports except periodic reports (monthly, trimester and etc.) submitted by the consultant shall be accepted by NEA after the approval of the POEs.

## **7 Client's Input, Counterpart Personnel, Training and Capacity Building**

### **7.1 Counterpart Staff**

NEA will provide counterpart staffs particularly technical personnel in carrying out the works related to the study. The consultant shall carry out the works including but not limited to following activities:

- Involve NEA counterpart staffs in the technical and related field from the beginning of the project for On the Job Training in Kathmandu / site;
- Provide on the job training to the NEA engineers during the course of the assignments in Kathmandu / site;

### **7.1. Training and Capacity Building**

One of the basic objectives of the consulting services is transfer of technology in the field of hydropower planning, design and development to the NEA's engineers. This will be achieved by involving the NEA's engineers in various activities of the project implementation during the execution of detailed engineering design in the field investigation as well as in the home office of the consultant.

During the inception phase of the contract, the consultant shall perform a skills assessment and develop a training program for NEA counterpart staff. All international experts are expected to work closely with the NEA counterpart and shall ensure that the NEA counterpart will achieve higher skill levels as result of their involvement in the project.

Training and Capacity Building of the NEA executive / engineers will be carried by the consultant through two ways. One by “On the Job Training” to the NEA engineers as counterpart staff during the course of the assignments in Nepal. Second one is through organizing study tour / training NEA executive and engineers in related fields at Consultant's home country; or at appropriate country.

- **On the job training to the NEA Engineers as Counterpart staff in Kathmandu/ site office.**

NEA professional staff will be seconded to the Consulting Firm in the following disciplines in Nepal. The tentative total man month for this would be 40 MM, whose remuneration, allowances and other benefits will be provided by NEA. Though the NEA counterpart staffs are seconded to the consultant for "On the Job Training", the consultant is responsible to complete the "Services" through its own Key and Non-Key experts. List of the NEA professional staff that will be seconded to the Consulting Firm is as follows:

1	Hydropower Engineer
2	Design Engineer
3	Geologist
4	Geotechnical Engineer
5	Hydrologist/ Sedimentologist
6	Electrical Engineer /Control Power System Engineer
7	Mechanical Engineer /Hydro-mechanical Engineer
8	Hydraulic Engineer
9	Structural Engineer
10	Transmission Line/Substation Engineer
11	Cost Engineer/ Quantity Surveyor
12	Contract Engineer
13	Construction Planner
14	Civil Engineer

- **Study Tour / training to NEA Executive and Engineers**

NEA’s five (5) Executive / senior engineers will visit the consultant’s home office for observation and study of hydropower projects in the consultant’s home office country for total period of nineteen (19) days per individual including transit. Main objective of this visit is to observe the working

environment, design team, construction supervision and planning procedures of the project adopted by consultant.

In addition to above mentioned, consultant shall arrange one (1) workshop session in its home office/ other country for the total number of seven (7) engineers in the following disciplines for twenty four (24) days per individual including transit.

- Project planning and design
- Hydraulic and structural design of hydropower projects
- Transient analysis
- Power transmission system
- Project management and contract administration for engineers

The cost for "**Study Tour / training to NEA Executive and Engineers**" shall be proposed by the consultant in **the FORM: Financial Proposal FIN - 4 (4B4. Breakdown of Office Operation, Logistics, Allowances, Flights and Others) of IKHPP**. This price components shall include but not limited to the cost of training, training materials, lodging and food, , international travel cost (in economy class) of the trainee and internal transportation cost in the country of training, insurance of the trainee for the entire training period and during travel.

## **8.0 Inputs to be made by the Concerned Authorities**

For the execution of the project, the following inputs shall be made by the consultant and the NEA respectively.

### **8.1 Inputs by NEA**

- Available Data – All existing reports, maps, drawing and other relevant information of the project would be made available to the consultant.
- NEA will provide full time counterpart staff mainly technical personnel -civil engineers, hydrologists, geologists, electrical engineers and mechanical engineers as far as possible *for the purposes of on the job training in Kathmandu and site*. In order to improve the capabilities of NEA engineers and technicians it is desirable that both NEA and consultant's teams work together as one single team in all matters related to the project. The NEA technical personnel for the on the job training will be assigned to Consultant as per the program of the On the Job Training prepared by the consultant in its technical proposal. *The NEA technical personnel for on the Job Training shall not be responsible for the services that need to be provided by the Consultant.*

## **8.2 Inputs by the Consultant**

- Staffing – the expatriate and local staff shall comprise of qualified and experienced professionals from relevant disciplines.
- Software – The provision of suitable software shall be made to undertake any related analysis required for the studies, which shall be handed over to NEA after completion of the services.
- Facilities - All logistics and facilities such as computers, photocopy machines, fax machines, furniture, office space, office equipment, transport, etc shall be managed by the Consultant for its own purpose in Kathmandu and Site including office space for the client at the site. The cost of all the facilities required by the consultant to carry out the assignment shall be included in the consultant's proposal..

## **9.0 Duration Of Services**

The estimated time for completion of the complete assignment is about twelve (12) months. Out of the total twelve months, it has been estimated that ten (10) months will be utilized in inception, field investigation, detail engineering design, preparation of tender documents and two (2) months for finalization of all reports incorporating the comments from NEA. The Consultant shall finish all the Field Investigation Work: Task 2 and provide Field Investigation Report within five (5) months of commencement of services covering all activities as specified in Task 2. However, discharge measurement and sediment sampling works shall be carried out for the period of 12 months.