Kathmandu Valley Water Supply Management Board

Kathmandu Valley Water Security Improvement Project (KV WaSIP) – Sisnery Water Supply Project

Jawlakhel, Lalitpur

Terms of Reference

Consulting Services for Detail Engineering Design of Dam and its Ancillary Components for Sisneri Water Supply Project

Client: Kathmandu Valley Water Supply Management Board (KVWSMB)

Financing: International Development Association (IDA) – World Bank Group

Date: September 2026

List of Acronyms

Acronym	Full Form
AASHTO	American Association of State Highway and Transportation Officials
AS	Australian Standard
AS/NZS	Australian/New Zealand Standard
AWLR	Automatic Water Level Recorder
BOQ	Bill of Quantities
BRBIP	Bagmati River Basin Integrated Master Plan
CAD	Computer-Aided Design
CBR	California Bearing Ratio
CDA	Canadian Dam Association
CFD	Computational Fluid Dynamics
CFRD	Concrete Face Rockfill Dam
CRD	Core Rockfill Dam
CSQAP	Construction Supervision and Quality Assurance Plan
CVC	Conventional (Mass) Concrete
DBA	Dam Break Analysis
DBE	Design Basis Earthquake
DCPT	Dynamic Cone Penetration Test
DEM	Digital Elevation Model
DHM	Department of Hydrology and Meteorology
DSHA	Deterministic Seismic Hazard Assessment
ECRD	Earth Core Rockfill Dam
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
EOI	Expression of Interest
EPP	Emergency Preparedness Plan
ERT	Electrical Resistivity Tomography

Acronym	Full Form
ESIA	Environmental and Social Impact Assessment
FIDIC	Fédération Internationale Des Ingénieurs-Conseils
FIRR	Financial Internal Rate of Return
FSL	Full Supply Level
GIS	Geographic Information System
GON	Government of Nepal
GPS	Global Positioning System
HSL	High Supply Level
ICOLD	International Commission on Large Dams
IDA	International Development Association
IDF	Intensity-Duration-Frequency
IP	Instrumentation Plan
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
KV WaSIP	Kathmandu Valley Water Security Improvement Project
KVWSMB	Kathmandu Valley Water Supply Management Board
LDOF	Landslide Dam Outburst Flood
LSL	Low Supply Level
MASW	Multichannel Analysis of Surface Waves
MCE	Maximum Credible Earthquake
MDDL	Minimum Drawdown Level
MLD	Million Liters per Day
MPL	Maximum Pool Level
MS	Mild Steel
NEA	Nepal Electricity Authority
NPV	Net Present Value
OBE	Operating Basis Earthquake
OP	Operational Policy (World Bank)
PAR	Population at Risk
PGA	Peak Ground Acceleration

Acronym	Full Form
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PS	Provisional Sum
PSHA	Probabilistic Seismic Hazard Assessment
QA	Quality Assurance
QC	Quality Control
RCC	Roller Compacted Concrete
RESCON	Reservoir Conservation (model/tool)
RFP	Request for Proposals
RL	Reduced Level
RQD	Rock Quality Designation
RVT	Reservoir Tank
SCADA	Supervisory Control and Data Acquisition
SEE	Safety Evaluation Earthquake
SI	International System of Units
SMP	Sediment Management Plan
SNNP	Shivapuri Nagarjun National Park
SPT	Standard Penetration Test
ToR	Terms of Reference
UCS	Uniaxial (Unconfined) Compressive Strength
USBR	United States Bureau of Reclamation
WMO	World Meteorological Organization
WSP	Water Supply Project
WTP	Water Treatment Plant

1 Background

The demand of drinking water in the valley is increasing with the increase in population, while the existing water supply is not sufficient in terms of both quantity and quality. Water supply is intermittent from one to six hours in three alternate days in wet season up to ten alternate days during dry season. Main reasons for water deficit in the valley are, to name a few, insufficient production of potable water, growing demand due to the fast-growing population, increased demand due to rise in the living standard of the people, increasing commercial and industrial activities including tourism, wastage and high leakage of water in the system. Also, the quality of water supplied needs substantial improvement. The only, under consideration, long-term solution to the problem of drinking water scarcity in the valley is the "Melamchi Water Supply Project" which has been facing severe delays for the past few years. Melamchi 1st phase has been completed recently and 2nd and 3rd phase is expected to be completed by 2025 and 2030 respectively. Even after completion of Melamchi 1st phase there is still deficit of water supply and the situation is expected to continue even after completion of Melamchi third phase. Also considering high hazard exposure of Melamchi Water Supply Project, it would be unscrupulous to depend totally on Melamchi Water Supply Project, as only long-term source of water. This was proven true, by 2021 land slide, debris flow and flood in the upper reach of Melamchi river which, some experts think, may have been indirectly triggered by 2015 Gorkha Earthquake. Because of these imminent hazards, timely completion of Melamchi 2nd and 3rd Phase is questionable. So there has been a need of immediate and urgent water supply project by investigating and utilizing alternative sources.

In this context, the KVWSMB intends to implement Sisneri Water Supply Project which is situated in Makawanpur district. This project is launched to ensure water distribution in scarce area of Kathmandu valley, mostly focusing on Lalitpur district.

The water supply component of the Detailed Engineering Study for the Sisneri Water Supply Project has been completed. The study has identified the need for regulating and augmenting the available water flow to ensure a reliable and adequate water supply throughout the year. Accordingly, the Project intends to construct a dam at a suitable location within the project area to regulate the flow and secure the required water quantity during both wet and dry seasons.

In this regard, the Kathmandu Valley Water Supply Management Board (KVWSMB) intends to procure the services of an international consulting firm to undertake the "Detailed Design of Dam and its Ancillary Components" to be constructed as an integral component of the Sisneri Water Supply Project. The assignment will include the detailed engineering design and associated studies necessary to ensure that the proposed dam and its ancillary components are technically sound, safe, resilient, and suitable for implementation.

1.1 Previous Studies and Project Information

1.1.1 Bagmati River Basin Integrated Master Plan (BRBIP)

Under the Bagmati River Basin Integrated Master Plan (BRBIP), a study was conducted from 2015 to 2019 with one of the aims of the project to address the problem of scarcity of drinking water in Kathmandu valley. Among many of the alternative sources studied during this project, Sisneri Water Supply Project was identified as one of the projects.

In this project, a dam of 65 m situated upstream of the Bagmati River confluence, was designed to supply water to the southern part of the Kathmandu Valley, utilizing the downstream basin of the Kulekhani Dam. The water supply calculations for the dam indicate that during the monsoon season, the yield can reach 153 million liters per day (MLD), and during the dry season, yield is estimated at 121 MLD. The required reservoir volume for the dam is estimated to be 10.9 million cubic meters (MCM).

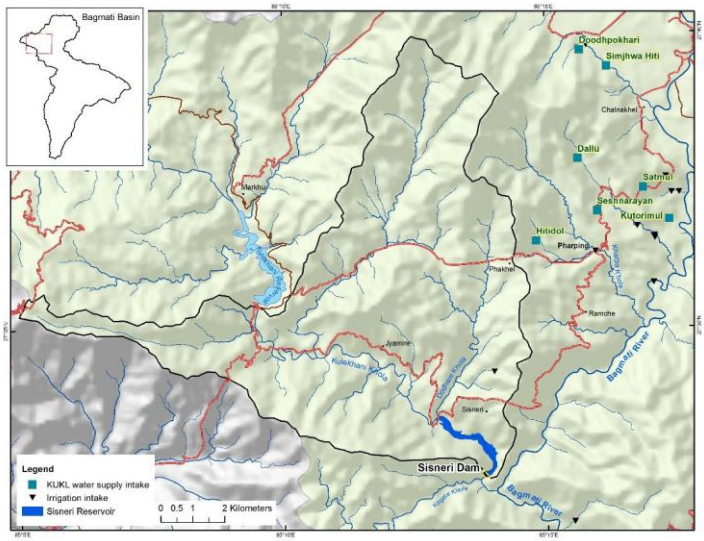

Figure 1: Location map of Sisneri dam

The BRBIP, study proposed pipelines with pumping, to convey the water from Sisneri Dam to the planned Water Treatment Plant (WTP) in Pharping, with proposal to increase the capacity of and the reservoir volume at Pharping.

An economic analysis was conducted for the different schemes. The annual economic benefit for water supply was evaluated based on a unit cost ranging from 70 NRs/m^3 to 100 NRs/m^3, the discount rate as 12%, and the project life as 50 years. The economic analyses revealed that at a unit price of 70 NRs/m^3, the Sisneri dam exceeded the discount rate with an Economic Internal Rate of Return (EIRR) of 13.6%.

1.1.2 Study for Design of components of Sisneri WSP

Working on the BRBIP projections and proposals, a study has been commissioned for preparation of ToR for Detailed Design of Dam along with Design of Water Supply Components of the project. The study has concluded the field investigation works and some recommendations has been made based on its finding. However, Water Supply Component Design works are still under way. Based on limited field investigation and analysis of multiple scenarios both for Dam and Water Supply System Sizing and Schematics, the following has been proposed by the study.

1.1.2.1 Dam and Reservoir

The study, firstly inferred that, the study by BRBIP was carried out considering a catchment area of 82.9 sq.km without deducting the river diversion to Kulekhani Hydropower through Sim Intake and Chakhel Diversion. Had it been considered, the catchment area under study would reduce to 53 sq. km. So as to account for this limitation of BRBIP report, the study has recommended shifting the dam axis location downstream the Sisneri and Kogate river confluence so that water availability could be maximized. Based on geological/geotechnical reconnaissance supplemented by basic hydrological assessment a dam was proposed at Latitude: 27^0 32’ 17”, Longitude: 85^0 13’ 42.20” (Figure 4 Proposed Alternative Dam Axes Locations). Further Hydrological analysis and modelling of the area done by the study proposed 80m high Dam with 9.89 Mm3 g gross storage volume. The proposed dam was estimated to yield maximum water supply of 140 MLD for approximately 3 months' time and 80 MLD for rest of the year.

On further field verification, a second viable alternative dam axis 300m upstream of Kogate-Sisneri confluence, at Latitude: 27^0 32’ 36”, Longitude: 85^0 13’ 49”, was observed (Figure 4

Proposed Alternative Dam Axes Locations) Further technical assessment has led to proposition of 65m high dam with gross reservoir volume of 12.36 Mm^3. However, in order to compensate for missed Kogate catchment, the reservoir inflow was proposed to be supplemented by additional water intake from Kogate River. The estimated water supply yield for the option was 140 MLD for 5 months and 80 MLD for 7 months.

A separate Feasibility Study has been conducted for evaluating the two alternatives and as state in 1.1.3: Sisneri WSP Feasibility Study and the second alternative has been recommended. Albeit, based on limited field data the feasibility study recommendation was considered for further water supply components design.

1.1.2.2 Other Components of Water Supply System

The final destination of long-distance water transmission was changed to Sainbu Reservoir instead of Pharping (as proposed by BRBIP), because of larger reservoir capacity and connected distribution network.

A comprehensive analysis of multiple layout options of Water Treatment Plant (WTP) and Intermediate Reservoir (RVT) location was done. Most viable 2 alternatives were proposed.

First Alternative proposed pumping water from Dam Reservoir to Water Treatment Plant (WTP), at Dabrung Dada at Sisneri (elevation: 1220m). Further, pumping was proposed from WTP to an Intermediate Reservoir Tank (RVT) located 1400m North-East of WTP (elevation: 1450m). Finally, Gravity Flow based water transmission pipe was proposed from RVT to Sainbu Reservoir.

Second Alternative proposed pumping from Dam Reservoir to an Intermediated RVT at 1290m. Gravity flow, long distance water transmission from the RVT was proposed till WTP at Makkubesi (elevation: 1226 m). Further, water was to be pumped from WTP till Sainbu Reservoir at 1375m elevation.

The Sisneri WSP Feasibility Study, conducted concurrent with the Design of WSP Components, further analyzed the two alternatives for WSP component schematics and has recommended Alternative 2 as more viable option. Further, Detailed Design of WSP Components (other than Dam and Dam Intake) is being carried out for the selected alternative 2. The project layout and schematics of the selected alternative are as shown in Figure 2 and Figure 3.

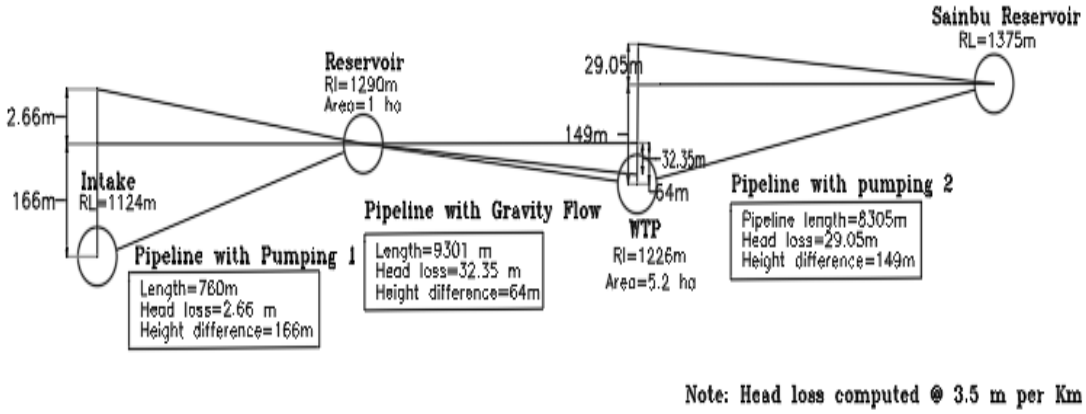

Figure 2: Sisneri WSP Overall Schematics

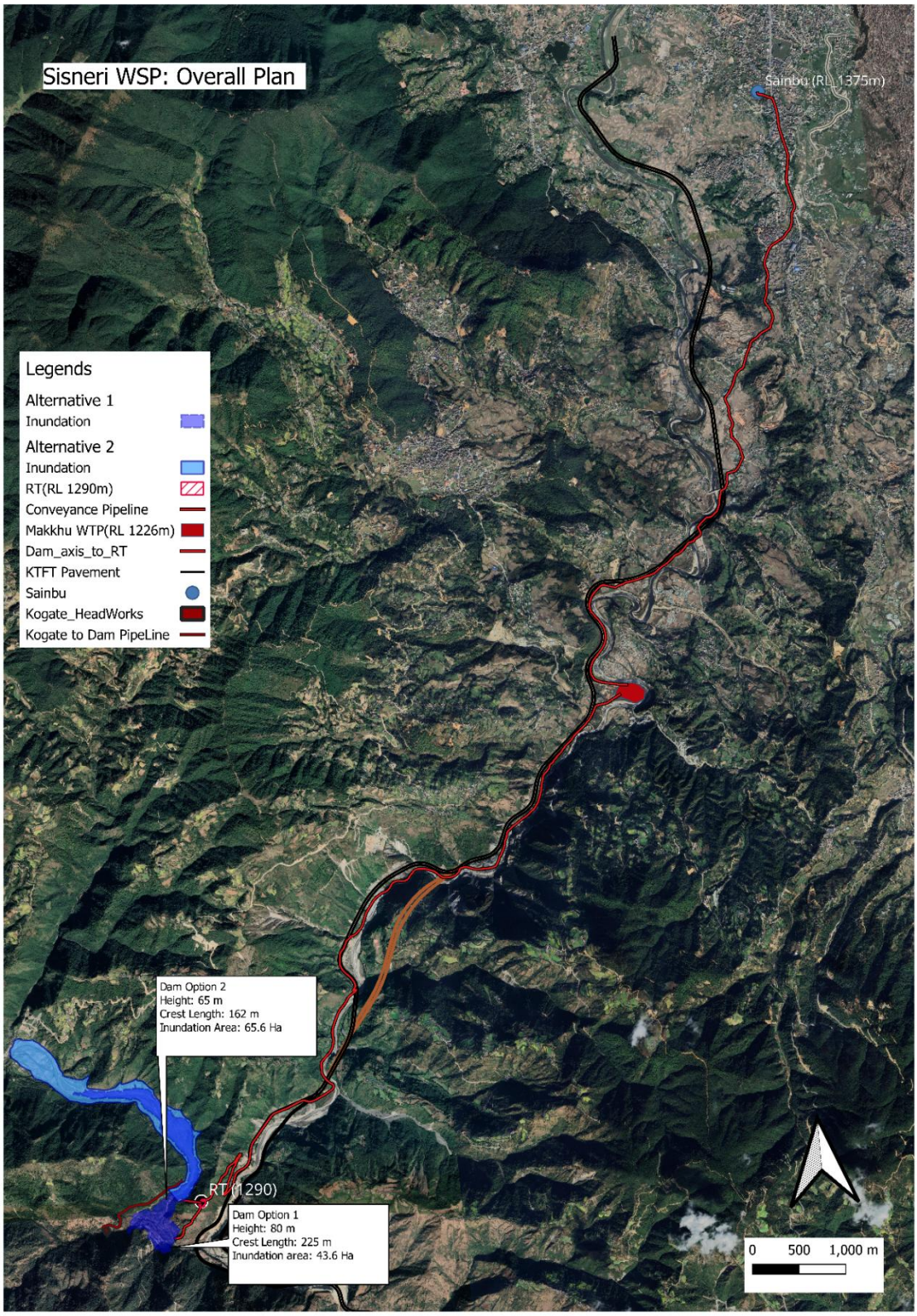

Figure 3: Overall layout of Sisneri Water Supply Project- Overall Scheme

1.1.3 Sisneri WSP Feasibility Study

As stated earlier, a separate Feasibility Study was commissioned to further analyze the proposed schematics of Sisneri WSP.

Analysis of the proposed alternatives of Sisneri WSP has been done, considering various technical, financial, environmental and socio-economic aspects. The study has recommended the Alternative 2 for all project components which included, dam option at Latitude: 27^0 32' 36" and Longitude: 85^0 13' 49" with crest length of 162m and height of 65m, reservoir capacity of 12.36 Mm^3 along with water transmission alignment from Dam to RVT to WTP at Makkubesi to Sainbu Reservoir as shown in Figure 3. Detailed Design of WSP Components is being carried out based on the recommendation. The table presented in Table 1 Summary of Project Information) only includes the parameters of the selected alternative for WSP Components.

The conducted study for Dam Alternatives was based on limited geological and geotechnical field investigation and needs further validation.

1.1.4 Project Information

Relevant project information as was formalized by Sisneri WSP Feasibility Study are as follows:

1.1.4.1 Dam Alternatives

Based on feasibility study of Sisneri Dam, following two dam options were closely studied.

The Salient Features of the explored options of Sisneri Water Supply Project and the Dam to be constructed are as tabulated.

Table 1 Summary of Project Information

S. N.	Parameters	Alternative 1	Alternative 2
1	**General**		
	Project name	Sisneri Water Supply Project	
	Location	Bhimphedi Rural Municipality-8 and Indrasarovar Rural Municipality- 3,	

S. N.	Parameters	Alternative 1	Alternative 2
		Bagmati, Nepal	
	Co-ordinates of the Project area	Latitude: 27^0 32' 17"	Latitude: 27^0 32' 36"
		Longitude: 85^0 13' 42.20"	Longitude: 85^0 13' 49"
	Nearest Settlement	Sisneri Village	
	River	Kulekhani (Sisneri) River	
	Climate	Moderate	
	Type of project	Storage	
2	**Organization**		
		Kathmandu Valley Water Supply Management Board	
3	**Water Supply Components**		
	Benefit Area	Kathmandu Valley (specially Lalitpur District)	
	Type of Source	Surface Water (Reservoir)	
	Expected Yield	140 MLD 27.1% of time, 80 MLD 93.1% of time, Runoff Equivalent 6.9% of time (from long term daily flow of 50 years)	140 MLD 65.1% of time, 80 MLD 90.5% of time, Runoff Equivalent 9.5% of time (from long term daily flow of 50 years)
	Type of WSP Scheme	Dam storage with multi stage pumping system from Sisneri dam to Sisneri Reservoir Tank and by Gravity from Sisneri reservoir to Makkubesi Water Treatment Plant. Pumping from WTP to Sainbu Reservoir Tank.	

S. N.	Parameters	Alternative 1	Alternative 2
	Intake		
	Type of intake	Integrated with Dam based on dam parameters and site condition. (21 Nos – 110 lps)	
	Dry season design discharge (min)	0.93 m^3/s	
	Wet Season design discharge (max)	1.63 m^3/s	
	Minimum Drawdown Level (MDDL)	1093 masl (Nepal MUTM84)	1124 masl (Nepal MUTM84)
	Maximum Pool Level (MPL)	1122 masl (Nepal MUTM84)	1157 masl (Nepal MUTM84)
	Water Treatment Plant		
	Type	Conventional type consists of Flocculation & Sedimentation tank, Rapid Sand Filter	
	Location	Makhubesi, Lalitpur	
	RL	1220 masl (Nepal MUTM84)	
	Sisneri Intermediate Reservoir Tank (RVT)		
	Type	RCC, Above Ground Storage Tank	
	Low Supply Level (LSL)	1285 masl (preliminary) (Nepal MUTM84)	
	High Supply Level (HSL)	1290 masl (preliminary) (Nepal MUTM84)	

S. N.	Parameters	Alternative 1	Alternative 2
	Water Transmission Destination		
	Sainbu Reservoir	Existing Reservoir at 1375 masl (Nepal MUTM84)	
	Pipe Alignment		
	Intake to RVT	Pumped Flow, 2 Nos- 800mm dia MS Pipe	
		Length: 760m (preliminary)	
	RVT to WTP	Gravity flow, 2 Nos- 800mm dia MS Pipe	
		Length: 9300m (preliminary)	
	RVT to Sainbu Reservoir	Pumped Flow, 2 Nos- 800mm dia MS Pipe	
		Length: 8300m (preliminary)	
4	**Hydrology**		
	Catchment area	69.3 sq. km. (excluding Kulekhani Reservoir Catchment and Diverted Chakhel and Sim Khola Watershed)	54.96 sq. km. (excluding Kulekhani Reservoir Catchment and Diverted Chakhel and Sim Khola Watershed above Kulekhani-Kogate confluence)
	Supplementary Reservoir Inflow		Diversion of Kogate River to the proposed dam reservoir. (For Dry Season source augmentation from Kulekhani Reservoir may be explored)
	Estimated Mean Annual Flow	1.97 m^3/s	1.84 m^3/s (20% Kogate Discharge for riparian flow

S. N.	Parameters	Alternative 1	Alternative 2
	Estimated Maximum average monthly discharge	5.60 m^3/s	3.31+1.84 m^3/s
	Estimated Minimum average monthly discharge	0.55 m^3/s	0.44+0.09 m^3/s
	Estimated 1 in 200 years flood (Q_{200})	1140 m^3/s (Snyder's Method from Log-Logistic Distributed Basin Average Rainfall)	
	Estimated 1 in 500 years flood (Q_{500})	1431 m^3/s (Snyder's Method from Log-Logistic Distributed Basin Average Rainfall)	
	Estimated 1 in 1000 years flood (Q_{1000})	1751 m^3/s (Snyder's Method from Log-Logistic Distributed Basin Average Rainfall)	
	Estimated Probable maximum flood (Q_{PMF})	17354 m^3/s (Kulekhani Dam Break Study; Pandey B.R., 2024)	
5	**Reservoir (Preliminary)**		
	Projected Gross storage volume	9.89 Mm^3	17.77 Mm^3
	Projected Live storage volume	7.36 Mm^3 (Storage between 1093m and 1122m)	15.35 Mm^3 (Storage between 1124m and 1145m)
	Length of reservoir at FSL	2.77km (Nepal MUTM84)	3.43km (Nepal MUTM84)

S. N.	Parameters	Alternative 1	Alternative 2
	Projected Maximum Pool Level	1122 masl (So as to not resettle Sisneri Village with buffer of 20m)	1157 masl
	Projected Minimum Drawdown Level	1093 masl (Storage between 1093m and 1122m)	1124 masl (Storage between 1124m and 1157m)
6	**Dam (Preliminary)**		
	Type of dam	Based on Dam feasibility (Both Technical and financial) compatible with site condition	Based on Dam feasibility (Both Technical and financial) compatible with site condition
	Location of dam	300m u/s of confluence of Bagmati and Kulekhani (Sisneri)	300m u/s of confluence of Kogate and Kulekhani (Sisneri)
	Dam crest length	225 m (preliminary)	162 m (preliminary)
	Effective Dam height	80 m from riverbed (excluding free board)	65 m from riverbed (excluding free board)
		(Nepal MUTM84)	(Nepal MUTM84)
	Top width	10m	10m
	Dam top elevation	1127 masl (Nepal MUTM84)	1162 masl (Nepal MUTM84)
7	**Spillway (Preliminary)**		
	Main Spillway		
	Type	Overflow Spillway (Radial Gate)	Overflow Spillway (Radial Gate)
	Crest elevation	1110masl	1145masl

S. N.	Parameters	Alternative 1	Alternative 2
	Number and size of gates	3 @ 8m × 12m (B × H)	3 @ 8m × 12m (B × H)
	Energy dissipation	Flip Bucket (Throw Angle 30^o, Bucket Invert 1070.0 masl, Radius 19m)	Flip Bucket (Throw Angle 30^o, Bucket Invert 1100.0 masl, Radius 19m)
	Bottom Outlet	2m × 2m (B × H)	2m × 2m (B × H)
8	**Geology**		
		Wide valley with steep slope on right bank and gentle slope on left bank	Narrow valley with rocks exposure in both bank, steep slope
		Siltation problem from the Kogate Khola is problematic	Siltation problem only from the Sisneri Khola
		Inundation area covers downstream from the Sisneri Bazaar.	Inundation area is upto Sisneri Bazaar and submerge the infrastructures like settlement, road, bridge
		Geology of the area cover granite and far from the geological boundary between Tistung Formation and Ipa Granite	Geology of the area cover granite and very near from the geological boundary between Tistung Formation and Ipa Granite

1.1.4.2 Analysis of Dam Alternatives

As shown in Figure 4, two alternatives of dam location upstream and downstream the Kulekhani (Sisneri) Khola – Kogate Khola Confluence were analyzed during the feasibility study.

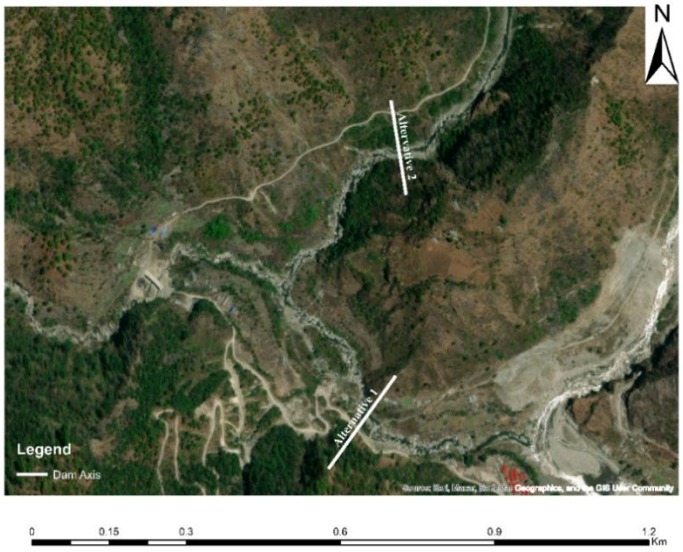

Figure 4 Proposed Alternative Dam Axes Locations

The alternative 1 was set forth for the project considering minimum resettlement from Sisneri village area at the upstream compromising the aim of the project of meeting 140 MLD demand. This consideration had restricted the dam height at alternative 1 to 80m. The second alternative proposed upstream was based on the site investigation and visual inspection by experts. Dam height at the second dam alternative was restricted based on the gross volume of reservoir required to reserve inflow from the catchment above. Additionally, diversion from the Kogate was considered for alternative 2 in order to explore scenarios of demand augmentation.

Based on the geological stability of alternative locations, inferred from geological, geotechnical and geophysical investigations, both locations seem feasible. Further assessment of these alternatives was carried out for hydrological and economic feasibility. Based on these assessments, Alternative 2 was found to be better. However, limitation of associated field investigation during feasibility study calls for further validation of the study. So, the consultant is expected to review the feasibility report prepared by the earlier consultant and if needed conduct additional studies / investigation for detail analysis of both dam alternatives and recommend the most suitable/feasible alternative. The recommended alternative shall be considered for detailed design.

1.1.5 Interface with Other Sisneri Water Supply Project Components

The Detailed Engineering Design of the Sisneri Water Supply Project components other than the dam and dam intake is being undertaken under a separate consultancy. The Consultant shall therefore establish close technical coordination with the Consultant responsible for the Detailed Design of the other Sisneri Water Supply Project components to ensure consistency and proper interface between the dam and the downstream water supply system.

The scope of the present consultancy shall primarily cover the Sisneri Dam, reservoir, dam intake and associated/appurtenant structures and facilities required for the safe and reliable operation of the dam and reservoir. The downstream bulk water transmission system, water treatment plant, intermediate/retention reservoir and other water supply components covered under the separate consultancy shall not be duplicated under this assignment.

Nevertheless, the Consultant shall review and coordinate all relevant information from the other Sisneri Water Supply Project design studies and shall ensure that the design of the dam and dam intake is compatible with the downstream system. This shall include, as applicable, coordination of design flows, intake capacity, pump requirements, operating water levels, hydraulic conditions, pipeline connection arrangements, access requirements, power requirements, construction interfaces, operation and maintenance requirements, and other physical and functional interfaces.

The Consultant shall clearly define the limits of responsibility and interfaces between the present consultancy and the other Sisneri Water Supply Project design consultancy in consultation with the Client. Any component or activity for which responsibility is shared or interfaces with another consultancy shall be clearly identified, and the Consultant shall ensure that all information required for integrated design and implementation of the overall Sisneri Water Supply Project is exchanged and appropriately incorporated.

The Consultant shall also coordinate, as necessary, with the consultant undertaking the Environmental and Social Impact Assessment and other relevant project consultants so that the engineering design, environmental and social requirements, reservoir operation, construction arrangements, quantities and cost estimates remain consistent across the project.

2 Objective of Consulting Services

The primary objective of the consultancy services is to produce necessary detailed engineering design, estimation, economic/financial feasibility, procurement document required for effective implementation of Construction of Dam and its ancillary components along with any supplementary river diversion for source augmentation (Kogate/Kulekhani), water supply intake integrated in the dam, access road and administrative/camping/staff accommodation area.

The consultant is expected to perform following tasks to fulfill above mentioned objective:

i. Review all existing project documents, field investigation reports, and other technical/non-technical reports.

ii. Evaluate and if necessary, conduct additional feasibility level field investigation works (topographic, geophysical, geotechnical, hydrological, etc.) and revise the previous feasibility report considering technical, economic, social and ecological factors for all proposed dam alternatives. The Optimization report shall recommend best alternative for subsequent detailed design of dam and its ancillary structures and shall include diversion structures from Kogate River and WSP intake structures to be incorporated in the dam. The intake should accommodate 21 submersible pumps as proposed by Detailed Design of Components of Sisneri WSP.

iii. Undertake Detailed Engineering Design works of proposed dam and all other ancillary project components including Kogate Diversion (and if needed source augmentation from Kulekhani Reservoir) and Water Supply Intake incorporated in the dam, elaborating its Civil, Hydraulic, Electromechanical and Electric Works based on the approved Optimization study report. Evaluate and, if required, amend/refresh field investigation data/report by gathering new field data pertaining to various aspects for detailed design stage.

   a. Review available Topographic survey of the project area and conduct new survey in case of Topographic changes or if deemed necessary

   b. Engage companies for the geotechnical site investigation and supervise the execution of the investigations, paying close attention to the management of its timely implementation and quality, based on available site investigation and test

data.

c. Review and verify, and if deemed necessary revise available hydrology and sediment studies, models and calculation based on any additional data available at the onset of the services under this ToR

d. Conduct studies related to (preparation of), but not limited to, Dam Break Analysis, Emergency Preparedness Plan, Sediment Management Plan, Climate Change Impact Mitigation Plan, River Channel Routing and Diversion.

e. Undertake topographic surveys and design of the access road, to serve as the basis for planning of works

f. Prepare Hydrology and water availability for dry season augmentation in D/S river;

g. Re-evaluate the engineering proposals of the earlier study,

h. Select the dam type as per geological/geotechnical report;

i. Undertake detailed engineering design calculations related to all project components, elaborating its Civil, Hydraulic, Electromechanical and Electric Designs

j. Prepared necessary design drawings for all designed components

k. Prepare necessary design drawings for access road, power supply and communication.

l. Construction Planning and scheduling including, but not limited to material handling and disposal, construction access, power supply, camp staging, etc.

m. Prepare detailed cost estimate for implementation of the project incorporating its direct and indirect costs including.

n. Prepare tender documents to be applied in recruiting the services of a Consultant/Contractor to undertake construction of the project works.

o. Prepare other contract management, scheduling and cost control documentation.

3 Scope of Consulting Service

The scope of services of the Consultant will comprise of two major tasks to be undertaken in two stages.

Stage 1: Evaluate and update Feasibility Study Report (6 months)

Stage 2: Detailed Engineering Design of Proposed Dam and other ancillary structures. (8 months)

The tasks to be carried out include but not necessarily be limited to the following:

3.1 Stage 1: Evaluate and Update Feasibility Study Report

3.1.1 Review of Previous Studies

Under this task the consultant shall:

- Collect previous study reports, drawings, legislations, maps, data etc. The consultant should thoroughly examine all prior studies, field works, field data analysis, simulations, calculation, etc. conducted for the project.
- Review and analyze available information and identify data gaps and propose alternative solutions.
- Conduct a field reconnaissance study to familiarize with project area.
- Prepare and review the following plans and schedules in consultation with KVWSMB
    - Approach and methodology and detailed work plan for field investigation
    - A quality assurance and quality control (QA/QC) plan for the services to be rendered
    - Detailed schedules for each task/ discipline.
    - Detailed manning schedule for field and office works.
- The consultant will then create a concise Inception Report that outlines the project's development process, provides an overview of the project, outlines project benefits, and presents updated detailed method statement, work plan, detailed schedule, etc. All previous studies along with drawings should be included in the report, along with

drawings and description depicting possible modifications.

- Consultant shall make a presentation of the Inception Report, including use of appropriate visual aids, to KVWSMB and shall obtain approval on the inception report.

3.1.2 Field Investigation and Study

The field investigations to be performed by the Consultant (required to supplement the prior investigation reports) shall include but not limited to the following. The recommend tests and studies shall not be binding and the consultant may propose their own set of tests/studies elaborating the rational for such alteration, based on technical assessment of existing studies and past experiences.

3.1.2.1 Topographic Survey

A detailed topographical survey of the project site and its watershed should be conducted to define the geographical boundaries of the project and to establish horizontal and vertical control points (benchmarks) on both sides of the project site. These benchmarks are critical to monitor vertical and horizontal displacements of the dam axis. The scale of the topographical survey should be fine enough to carry layout of dam and its appurtenant structures, borrow and disposal areas, and staging areas. The topographical survey should document:

- Geographical boundaries of the survey area, indicating the extent of the land that will be covered by the topographical survey.
- Description of survey techniques and instruments used to collect topographical data, such as land surveying, GPS (Global Positioning System), and LiDAR (Light Detection and Ranging), or aerial photogrammetry using drone.
- Topographical map, DEM data and locations of survey benchmarks.
- Satellite imagery, aerial photographs, and pictures from dam and watershed.
- Stream gaging stations, precipitation stations, and other meteorological stations.
- Power supply, communication, and utilities.
- Major roads and their design capacities.
- Identification of borough and disposal areas

- Identification of staging and borough areas.
- To facilitate analysis and interpretation, the survey results should be digitized using GIS tools.

The project has conducted topographic survey of the dam axis and its inundation area during initial study phase. The consultant shall review the previous survey documents and plan further topographic survey works as per standards and requirement for generating detailed design of all components included in the scope of work, if deemed necessary.

The Consultant shall perform, among others, the following activities, if deemed necessary:

- Establish Bench Marks for survey control network at different location of the study area.
- Detailed mapping of the dam site including foundation area, intake area, spillway area in scale of 1:500 and 1m contour interval or in the scale which the Consultant determines appropriate,
- Detailed mapping of the regulating dam site including all associated structures in scale of 1:1000 and 1m contour interval or in the scale which the Consultant determines appropriate,
- Survey and mapping of reservoir area and its periphery including possible resettlement area in scale 1:10,000.
- Survey and mapping of other major structural components of the projects in scale 1:500.
- Survey and mapping of the borrow areas.
- L-section profile and X-section survey at gauging stations, U/S and D/S of dam axis up to 1 Km U/S and 1 Km D/S at intervals of 50 m.
- L-section profile and X-section of the river covering a stretch of 500 m starting from 1 km upstream up to 1 km downstream of regulating dam axis along river course at intervals of 50 m

Topographic Survey shall be carried out to precision of the 3rd order and the admissible error of closure shall not exceed 12 mm of K, where k is the distance in kilometers. The area shall be covered by traverse net, triangulation net and a few random lines to establish the location of the items related to the investigation and key structures. Horizontal control survey shall be tied into

existing geodetic net. Benchmark shall be adopted for vertical survey control. Coordinates of all stations marked as triangles shall be provided by the survey. The expatriate trigonometric points, a necessary for ground control and for mapping with stereo plotting machine shall be connected. Contour lines on the maps shall have intervals of 5 or 10 meters, geodetic and geophysical sections, drill holes location; theoretical rim of the reservoir shall be shown. Mapping relevant to the terrestrial survey of the dam site, and diversion area and appurtenant shall be with a counter interval of 1 or 2 meters. Rim elevation benchmarks shall be numbered and painted at intervals on rocks around the perimeter. Rim location shall be shown on the maps. Drill holes and seismic refraction sections shall be located on map.

The topographical maps shall clearly depict all major geographical as well as anthropogenic features (viz. landslides area, land uses in the surveyed area, temples, schools, hospitals, Civil structures/ facilities like roads, canals, bridges etc.) with appropriate legends to represent each feature. The features to be presented in topographical map shall also be produced in GIS/ satellite imagery along with GPS data.

The topographic survey shall also cover, to the extent required for the engineering assessment and subsequent detailed design, all areas potentially affected by the proposed dam and its appurtenant structures, including temporary and permanent access arrangements, construction areas, diversion arrangements, excavation footprints, spoil/muck disposal areas, borrow and quarry areas, camps and other ancillary facilities. The survey shall be sufficiently detailed to support assessment of land requirements, potential impacts on existing infrastructure and settlements, and subsequent preparation of detailed engineering designs and cost estimates.

3.1.2.2 Hydrological, Meteorological and Sedimentation Investigation and Study

The consultant shall review all prior studies and if deemed necessary carry additional field investigation and analysis to produce a report that comprehensively includes the following. The report can be based on review of prior studies, but will have to be supplemented by further field data and its analysis available during tenure of this consulting service.

3.1.2.2.1 Hydrological Survey of Watershed

Different physical characteristics of the hydrological basin shall be studied which are essential for analysis. Such data shall preferably be spatially distributed and should include but not be limited to followings:

- Soil Type
- Gradation of Top Soil (Selected from different locations. Such location shall be selected based on expert judgement. Location based on sub-tributaries and geological formation shall be one criteria)
- Land use Patterns
- Vegetation Types (percentage area covered with different vegetation types)
- Possible Landslide Prone Areas and Possibility of Blockage of Landslide Dam (Mostly preferred Landslide Modelers widely used in the country)
- Areas with Historical Landslides and Forest Fires

The Consultant shall undertake a water resources assessment for the individual and intermediate catchments associated with the alternative dam axes and reservoir configurations. The assessment shall quantify the incremental contribution of each catchment to the proposed reservoir and shall distinguish between the natural inflow generated from the Sisneri catchment and inflows associated with potential diversion schemes. The assessment shall distinguish, as appropriate, between the overall upstream Kulekhani catchment, the catchment contributing to the Kulekhani Reservoir, the catchment downstream of the Kulekhani Reservoir, the areas affected by the existing Sim/Sin Khola Intake and Chakhel Diversion, the direct Sisneri catchment, and the Kogate catchment.

The Consultant shall assess the implications of the existing Kulekhani Reservoir, its operating regime and associated diversion structures on the inflow, flood and sediment regimes at the proposed Sisneri Dam. The catchment delineation adopted for hydrological, flood and sediment analyses shall be clearly presented and justified, recognizing that different catchment extents may be applicable to different analyses.

The assessment shall consider seasonal and monthly variations in runoff, dependable water availability, dry-season flows, wet-season flows, extreme flows and the contribution of each

intermediate catchment to the overall project yield. The results shall be used to assess and compare the alternative dam axes, reservoir configurations, diversion arrangements and potential augmentation sources and shall form part of the basis for determining the reliable yield of the preferred project configuration.

3.1.2.2.2 Hydrologic and Climate Data Collection

The Consultant shall collect, review, validate and analyze the hydrological and climatic data required for the feasibility assessment, optimization, detailed design and dam safety assessment of the Sisneri Water Supply Project. The data collection and analysis shall cover, as applicable, the Sisneri catchment, relevant intermediate and upstream catchments, Kogate catchment, Kulekhani system and other areas influencing the water balance, flood hydrology and reservoir operation of the Project.

The Consultant shall review all available data and previous studies and shall supplement them with additional field measurements, monitoring and data collection where necessary. The Consultant shall clearly document the source, period of record, quality, reliability, spatial and temporal coverage, limitations, data gaps, methods of data infilling or extension, adopted datasets and assumptions.

A. Precipitation

The Consultant shall identify precipitation stations within and around the relevant watershed and collect all available historical rainfall data. The assessment shall include, as applicable, data from the Department of Hydrology and Meteorology (DHM), Nepal Electricity Authority (NEA), previous project studies and other reliable sources.

The Consultant shall:

- Review rainfall records for completeness, consistency, homogeneity and reliability.
- Identify and address missing records using appropriate interpolation, correlation, statistical or other technically justified methods.
- Identify and correct inconsistencies resulting from measurement errors, changes in datum, calibration problems, changes in instruments, station relocation or other known causes.
- Undertake appropriate consistency and homogeneity tests and document the adopted

methods and results.

- Analyze precipitation at appropriate temporal intervals, including hourly, daily, monthly, seasonal and annual time scales.
- Analyze rainfall characteristics, including the length of the rainy season, rainfall intensity and duration, number and duration of rainfall events, dry intervals between rainfall events, seasonal distribution and spatial variability across the watershed.
- Develop appropriate spatial rainfall estimates for the relevant catchments and project locations.
- Develop Intensity-Duration-Frequency (IDF) relationships using appropriate rainfall records and methods.
- Estimate precipitation corresponding to appropriate return periods, including at least 10-, 25-, 50-, 100-, 500- and 1,000-year events, for relevant durations such as 1-hour, 24-hour and 96-hour, or other durations justified by the hydrological and dam-safety assessments.
- Estimate Probable Maximum Precipitation (PMP) using an appropriate and technically justified methodology, where required for PMF estimation.
- Assess the uncertainty associated with rainfall-frequency analysis and PMP estimation and clearly document the adopted methodology, assumptions and limitations.
- Assess projected changes in precipitation under appropriate climate-change scenarios and provide the rainfall inputs required for the climate-adjusted hydrological and flood assessments.

B. Stream Flow and Water Availability Data

The Consultant shall review, collect, continue and supplement streamflow measurements required to establish reliable water-availability and flood-hydrology series for the Project.

Daily streamflow data shall be collected or generated at an appropriate daily time interval and shall be used to establish:

- mean, minimum and maximum daily flows and relevant instantaneous/momentary peak flows;

- monthly and seasonal flow characteristics;
- monthly flow-duration/exceedance curves;
- seasonal and annual water availability;
- low-flow characteristics and dependable flows; and
- other flow statistics required for reservoir yield and operation assessment.

The Consultant shall review and compile all available hydrometeorological data relevant to the Project, including information from DHM, NEA, existing project studies and investigations and data generated under the present assignment.

The Consultant shall assess the quality, consistency, spatial and temporal coverage, reliability and suitability of available datasets. Differences, gaps and inconsistencies between datasets shall be identified and reconciled using appropriate technical methods.

The Consultant shall clearly identify:

- adopted datasets and sources;
- periods of record;
- catchment areas and delineation basis;
- data limitations and uncertainties;
- methods of infilling or extending records; and
- assumptions used in developing the updated hydrological assessment.

C. Discharge Measurement and Water-Level Monitoring

The Consultant shall review the existing discharge measurements and water-level monitoring program. Previous measurements have included monthly velocity-area measurements over a 12-month period, high-flow measurements using the slope-area method, daily staff-gauge observations and continuous water-level observations using an AWLR. The existing rating curve developed from these measurements shall be reviewed and updated.

The Consultant shall:

- Continue discharge measurements and stage observations at existing gauge stations in accordance with applicable WMO guidelines.

- Update the existing stage-discharge rating curve using additional discharge measurements and stage observations.
- Install additional manual gauge stations and AWLRs and undertake discharge measurements at other representative locations where required for the hydrological assessment.
- Undertake seasonal and high-flow measurements as far as practicable.
- Where direct velocity measurements are not practicable during high flows, apply appropriate alternative methods, including slope-area or other internationally recognized methods, to estimate peak discharges.
- Continue discharge and water-level monitoring throughout the project duration, with the frequency adjusted where necessary to capture seasonal variability and significant hydrological events.

The Consultant shall maintain proper records of field measurements, equipment, calibration, rating-curve development, quality control and data processing.

D. Catchment and Inflow Assessment

The Consultant shall verify the catchment delineation and reservoir inflow balance for the Project. The assessment shall consider the individual and intermediate catchments contributing to alternative dam axes and reservoir configurations and shall identify the effects of:

- the existing Kulekhani Reservoir;
- Sim/Sin Khola Intake;
- Chakhel Diversion;
- existing and proposed upstream abstractions or diversions;
- Kogate diversion, where applicable; and
- other relevant upstream or downstream water-resource developments.

The Consultant shall distinguish natural catchment runoff from water already abstracted, diverted, stored or regulated upstream.

The operating characteristics and available operating rules of the Kulekhani Reservoir shall be reviewed and incorporated into the hydrological assessment and, where relevant, reservoir and flood-routing assessments.

The Consultant shall establish the assumptions regarding Kulekhani Reservoir initial water levels, operating rules, spillway operation and other relevant conditions and shall document their implications for flows reaching the proposed Sisneri Dam.

The Consultant shall also review and update the existing rainfall-runoff model of the watershed. Where necessary, the model shall be revised, recalibrated or redeveloped using the updated hydrometeorological data and shall be used to estimate reservoir inflows under multiple precipitation, watershed and climate scenarios.

E. Flood Hydrology

The Consultant shall undertake the flood-frequency and extreme-flood analysis required to establish the design flood basis for the Project.

Peak flows corresponding to at least the 10-, 20-, 25-, 50-, 100-, 200- and 500-year return periods shall be estimated. The Consultant shall recommend appropriate design and construction flood events considering the dam safety classification, failure consequences, construction risks, applicable national and international standards and the relative costs of providing additional flood protection.

The Consultant shall also assess extreme flood hazards using the 10,000-year return-period flood and Probable Maximum Flood (PMF), as appropriate to the dam safety classification and applicable internationally recognized dam-safety guidance.

The methodology for estimating extreme floods shall be justified considering:

- available hydrometeorological records;
- watershed characteristics;
- rainfall characteristics;
- statistical uncertainty;
- rainfall-runoff modelling;
- reservoir routing;

- upstream regulation and diversion; and
- other relevant hydrological factors.

The Consultant shall establish the hydrological inputs required for spillway, outlet, diversion and temporary works design.

The potential effects of climate change on extreme precipitation, flood peaks, flood volumes, reservoir inflows and flood routing shall be assessed using appropriate climate-change scenarios. The implications for spillway capacity, freeboard, reservoir operation and dam safety shall be identified and coordinated with the Climate Study.

The Consultant shall also identify project-induced floods associated with construction, diversion works and reservoir operation and establish appropriate design frequencies and protection requirements.

F. Reservoir and Downstream Hydraulic Data

The Consultant shall collect and review river profiles, cross-sections, topographic data and other hydraulic information required for downstream hydraulic modelling and flood assessment.

The Consultant shall develop or update a hydraulic model of the downstream river channel to establish water-surface elevations, depths and velocities for representative minimum, normal, maximum and relevant flood releases.

Additional river cross-sections and topographic surveys shall be undertaken where existing data are insufficient for reliable modelling.

The detailed Dam Break Analysis, including breach scenarios, inundation mapping and consequence assessment, shall be undertaken under Section 3.1.2.2.3.

G. Landslide Dam Outburst Floods

The Consultant shall assess the potential for Landslide Dam Outburst Floods (LDOFs) within the relevant upstream watershed.

The assessment shall identify potentially unstable slopes and locations where landslide material could obstruct rivers or tributaries and form temporary landslide dams.

Where such hazards are identified, the Consultant shall assess, as appropriate:

- potential blockage size and duration;

- impounded volume;
- potential breach mechanisms;
- resulting outburst flood hydrograph;
- flood propagation and downstream consequences; and
- implications for the Sisneri Reservoir, dam and associated facilities.

The LDOF assessment shall be coordinated with the geological, geotechnical, geomorphological and sediment studies and shall identify appropriate monitoring, warning, mitigation and/or design measures where warranted.

H. Data Management and Hydrological Reporting

The Consultant shall establish a structured hydrological and climatic database for the Project. All field measurements, processed datasets, rating curves, rainfall-runoff models, flood-frequency analyses and other relevant digital data shall be maintained in formats that can be readily reviewed and used by the Client.

The Consultant shall prepare a Hydrological and Climate Data Assessment documenting:

- data sources and periods of record;
- data quality and reliability;
- catchment delineation;
- rainfall and streamflow characteristics;
- data gaps and methods of infilling/extension;
- adopted hydrological datasets;
- rainfall-runoff modelling;
- flood-frequency and extreme-flood analysis;
- uncertainties and limitations; and
- the adopted hydrological design basis for subsequent studies and design.

The findings shall be integrated with the Sediment Study, Climate Study, Reservoir Operation Plan, dam-safety assessment and overall project optimization.

3.1.2.2.3 Sediment Study

The Consultant shall review the existing sedimentation assessment undertaken under previous studies and supplement it with additional field investigations, measurements, laboratory testing and modelling as necessary to establish sediment yield, sediment characteristics, sediment transport processes and long-term sedimentation behaviour of the proposed reservoir.

The Consultant shall undertake the following:

- Sediment investigations shall cover the Sisneri River catchment and other relevant contributing catchments, including the Kogate catchment where diversion to the proposed reservoir is considered.
- The assessment shall consider geology, geomorphology, land use, road and infrastructure development, forest fires, landslides, debris flows, riverbank erosion and other natural and anthropogenic processes affecting sediment generation and transport.
- The sediment assessment shall be closely linked with the geological, geotechnical and geomorphological hazard assessments. Areas susceptible to landslides, debris flows, rockfalls, bank instability, gully erosion or other mass-movement processes shall be assessed for their potential contribution to sediment generation and sudden sediment/debris inflows.
- Where practicable, the Consultant shall quantify sediment contributions from significant identified geo-hazard sources and incorporate episodic sediment inputs into sediment-yield and reservoir-sedimentation assessments, including appropriate uncertainty and sensitivity analyses.
- Satellite-based monitoring techniques, including InSAR or equivalent remote-sensing techniques, shall be used where appropriate to identify active or potentially active slope movements and sediment-generating hazards.
- The Consultant shall review available information on major flood, landslide and sediment events, including the 2024 flood event, and undertake event back-analysis where sufficient data are available.
- The Consultant shall undertake necessary field investigations and measurements to establish reliable sediment concentration, sediment discharge and sediment yield

relationships. Existing sediment monitoring data shall be reviewed for adequacy and representativeness, and additional sampling shall be undertaken where required, including during seasonal, monsoon and significant high-flow events.

- Sediment sampling undertaken as part of the geological, geotechnical and geomorphological investigations shall be coordinated with the sediment study. Sampling shall cover representative locations in the Sisneri River, Kogate River, tributaries and significant sediment-source areas, as appropriate.
- Sediment samples shall be tested for concentration and particle-size distribution. Appropriate field and laboratory investigations shall distinguish suspended sediment, wash load and coarse bed-material/bed-load contributions.
- The Consultant shall update/develop sediment rating curves using measured sediment concentration and corresponding discharge data and shall undertake field measurements and laboratory testing in accordance with applicable WMO guidelines and internationally recognized sediment measurement practices.
- The Consultant shall undertake sediment transport and reservoir sedimentation modelling using suitable one-dimensional and/or two-dimensional numerical models, as justified by the characteristics of the river and reservoir.
- The sediment transport assessment shall explicitly distinguish suspended sediment, wash load and coarse bed-material/bed-load transport. The Consultant shall apply the Wilcock and Crowe formulation, or another technically equivalent and internationally recognized formulation appropriate for mixed-size and coarse sediment transport, and shall justify the selected methodology.
- Sediment transport and reservoir sedimentation models shall be calibrated and/or validated against available field observations, including sediment concentration, grain-size distribution, observed deposition, river morphology and other available sedimentation information. Model assumptions, boundary conditions, calibration/validation methods, uncertainties and limitations shall be clearly documented.
- Reservoir sedimentation modelling shall determine the quantity and spatial distribution

of sediment deposition within the reservoir and assess delta formation and its implications for reservoir storage, water quality, intake operation and reservoir operation.

- Sedimentation estimates shall be provided for at least 10, 25 and 50 years and, where appropriate, for the expected design/operational life of the reservoir. The analysis shall quantify projected loss of gross, active and/or effective storage, as applicable, for each technically feasible dam/reservoir configuration considered during optimization.
- The Consultant shall assess the influence of the existing Kulekhani Reservoir and associated upstream diversions on the sediment regime of the Sisneri River, including the extent to which sediment is retained, released or redistributed upstream.
- Where Kogate diversion is proposed, the Consultant shall separately assess Kogate sediment characteristics and yield and the quantity and type of sediment expected to enter the Sisneri Reservoir through the diversion. Appropriate sediment exclusion, trapping, flushing or other control measures shall be assessed.
- The Consultant shall assess debris, floating material, landslides, debris flows and other geomorphological processes that may affect the reservoir and appurtenant structures. Sudden sediment and debris inflows resulting from extreme rainfall and geo-hazard events shall be considered.
- The Consultant shall assess the effects of dam construction and reservoir operation on the downstream sediment regime, including potential downstream degradation, upstream aggradation and changes in channel morphology.
- The Consultant shall assess potential changes in sediment yield under future climate and land-use conditions, including changes in rainfall intensity, extreme precipitation, flood frequency, landslide occurrence, vegetation cover and wildfire.
- The Consultant shall prepare a comprehensive **Sediment Management Plan (SMP)** to support sustainable reservoir capacity and long-term reservoir operation. The SMP shall be based on field measurements, laboratory testing and sediment modelling.
- The SMP shall evaluate, as appropriate:

- catchment erosion-control measures;
- bioengineering and nature-based sediment management;
- check dams and sediment retention structures;
- sediment exclusion and trapping;
- sediment bypass/diversion;
- sediment sluicing;
- drawdown flushing;
- pressure flushing or other flushing methods;
- dredging or mechanical sediment removal; and
- combinations of the above measures.

- The feasibility of flushing and sediment removal shall consider reservoir geometry, sediment characteristics, deposition patterns, hydraulic gradients, required flushing discharge, downstream channel conditions, environmental and social impacts, water quality, operation and maintenance requirements and dam safety.
- Where applicable, the Consultant shall use **RESCON 2**, or an equivalent internationally recognized reservoir sediment-management tool, to assess the feasibility of flushing and related measures. Assumptions, input data, methodology and limitations shall be documented.
- The Consultant shall assess whether a low-level outlet, bottom outlet, flushing outlet or other sediment-release facility is required. Where such a facility is recommended, preliminary design criteria and operating requirements shall be established during Stage 1 and incorporated into the Stage 2 detailed design.
- The Consultant shall assess environmental and social implications of sediment release, flushing, sluicing and mechanical removal, including downstream sediment concentration, river morphology, water quality, aquatic ecology, downstream users and communities.
- Alternative sediment-management scenarios shall be evaluated in terms of sediment-

control/removal effectiveness, capital cost, operation and maintenance requirements, environmental and social impacts, technical feasibility and contribution to extending reservoir useful life.

- The Consultant shall prepare a long-term adaptive sediment-management strategy covering measures for initial construction, permanent works and reservoir operation.

The SMP shall, as a minimum, define:

- baseline and projected annual sediment inflow;
- major sediment-source areas and erosion-control measures;
- expected spatial and temporal sediment deposition;
- projected reservoir-storage losses;
- sediment monitoring requirements;
- sediment trapping and exclusion measures;
- flushing or sluicing requirements, where applicable;
- operation of low-level/bottom outlets, where provided;
- downstream environmental and social considerations;
- institutional responsibilities and operational procedures;
- operation and maintenance requirements and indicative costs; and
- an adaptive long-term sediment-management strategy.

The Consultant shall prepare a sediment monitoring and management program for subsequent detailed design, construction and operation, including monitoring locations, parameters, frequency, sampling methods, laboratory testing and procedures for periodic updating of the reservoir sedimentation assessment.

The sediment study findings shall be integrated with the hydrological study, reservoir operation, geological and geotechnical investigations, dam and intake design, environmental and social assessment, economic and financial analysis and overall project optimization.

3.1.2.2.4 Climate Study

The Consultant shall assess the potential implications of climate change on the hydrology and water resources of the Project. The assessment shall be coordinated with the hydrological, sediment, reservoir operation, dam safety and optimization studies.

The assessment shall consider projected changes in precipitation, temperature, runoff, seasonal water availability and extreme hydrological events using appropriate climate-change scenarios and available national, regional and international climate projections.

The climate assessment shall include, as applicable:

- Minimum, mean and maximum daily temperature data from selected stations representative of the project site and surrounding area.
- Review of available secondary data and studies on climate change and its projected consequences for the Project area.
- Monthly and seasonal analysis of temperature.
- Evapotranspiration data representative of the project area, including a description of the method used to derive or estimate the data and seasonal analysis of evapotranspiration.
- Wind-speed and wind-direction data representative of the project site. The assessment shall consider wind conditions for reservoir freeboard determination along the maximum fetch, evaporation losses and potential shoreline/beach erosion.
- Assessment of projected climate-change impacts on hydrological characteristics under appropriate scenarios, including baseline/no-climate-change, lower-impact and higher-impact scenarios, drawing on available national studies, IPCC information and other internationally recognized climate projections.
- Assessment of climate-change implications for dependable yield, dry-season water availability, flood peaks and volumes, reservoir inflows, sediment yield, reservoir operation, spillway capacity, freeboard and other relevant hydraulic structures.
- Identification and evaluation of appropriate climate-resilience and adaptation measures.
- Incorporation of the climate-change assessment into the evaluation of dam height, reservoir configuration, operating regime and preferred project configuration.

The Consultant shall clearly document the selected climate scenarios, datasets, downscaling/bias-correction methods where applicable, modelling assumptions, uncertainties and implications for project design.

3.1.2.2.5 Reservoir Operation Plan

The Consultant shall review existing reservoir operation studies and undertake an updated reservoir water-balance and operation simulation using the latest reliable observed and simulated hydrological data available for the longest representative period. The analysis shall incorporate the adopted climate-change scenarios and the findings of the hydrological, sediment and optimization studies.

The Consultant shall:

- Define minimum, normal and maximum reservoir elevations and corresponding storage levels.
- Determine dead-storage requirements, including allowance for sedimentation.
- Determine minimum operating storage requirements necessary to meet project water-supply objectives and other applicable downstream or environmental obligations.
- Prepare reservoir area-capacity/elevation-storage curves for the dam heights and reservoir configurations considered.
- Develop and apply a reservoir operation model to determine reservoir yield under multiple inflow scenarios, dam heights and relevant spillway/outlet configurations.
- Determine reservoir storage allocations and corresponding elevations.
- Determine outlet capacities at relevant reservoir water-surface elevations and required sill/invert elevations.
- Establish minimum releases required to meet downstream flow obligations, environmental requirements, water rights and water-quality requirements.
- Identify physical, economic, legal and operational limitations on maximum reservoir water-surface elevation.
- Assess the anticipated occurrence of floating debris and its potential effects on outlets, spillways and other appurtenant structures.

- Determine operating reservoir levels, including minimum, normal and maximum levels, under the adopted hydrological and climate-change scenarios.
- Establish monthly and cumulative water demand, monthly inflows, releases, evaporation and other losses, reservoir storage and reservoir water levels throughout the operating year.
- Present the variation in available freeboard throughout the operating year and under relevant flood and reservoir operating scenarios.
- Establish reservoir operating rule curves and demonstrate the reliability of the proposed water supply under dry, normal and wet hydrological conditions and relevant climate-change scenarios.
- Determine the feasible water-supply yield for the concluded dam height and reservoir configuration and, where necessary, assess alternative dam heights.
- Determine the safe-yield trajectory under different hydrological and climate-change scenarios, with particular attention to minimum reliable dry-season supply and cumulative annual water supply.
- Assess the relationship between dam height, reservoir storage, reliable yield, operating levels, flood-management requirements, sediment-management requirements and downstream environmental-flow obligations.
- Identify the maximum technically and operationally feasible dam height based on inflows, reservoir storage, water balance, dam safety, environmental and social constraints and other relevant factors.
- Where alternative dam heights are assessed, evaluate their incremental benefits and costs, including construction cost, reservoir capacity, water-supply yield, environmental and social impacts, inundation, geological and geotechnical conditions, sedimentation, dam safety, operation and maintenance requirements and economic and financial returns.

The reservoir operation analysis shall be undertaken in accordance with relevant national and internationally recognized guidelines and dam-safety requirements.

The reservoir operation study shall be updated following completion of the Stage 1 optimization study using the dam height and reservoir configuration concluded by the Consultant and approved by the Client. The final analysis shall establish the operating basis for Stage 2 detailed design.

3.1.2.2.6 Dam Break Analysis

The Consultant shall undertake the preliminary and detailed Dam Break Analysis (DBA) to assess the potential consequences of failure of the proposed Sisneri Dam and relevant upstream dam infrastructure. The DBA shall be treated as a separate dam-safety task and shall not duplicate the general flood-hydrology assessment.

The Consultant shall:

- Establish and justify the dam-breach parameters and failure mechanisms, including breach location, geometry and shape, breach width, formation time, breach development, reservoir initial water level, downstream boundary conditions and other parameters governing the breach hydrograph.
- Adopt breach parameters based on the dam type, dimensions, construction materials, foundation conditions, reservoir characteristics, accepted engineering practice and relevant international guidance.
- Undertake sensitivity analysis for key breach parameters where these may materially affect predicted inundation and consequences.

The DBA shall consider, as a minimum:

- failure of the Sisneri Dam alone;
- cascade failure involving the upstream Kulekhani Dam and the proposed Sisneri Dam;
- failure of the Sisneri Dam during sunny-day/normal reservoir conditions;
- failure during wet-day/high reservoir conditions;
- failure coincident with or following extreme flood conditions, including PMF and/or 10,000-year flood conditions, as appropriate; and
- other credible failure scenarios identified through the dam safety and risk assessment.

For the Kulekhani–Sisneri cascade scenario, the Consultant shall assess the sequence and interaction of potential failures, including propagation of the Kulekhani dam-break wave towards

Sisneri, resulting reservoir and hydraulic conditions at Sisneri, potential overtopping or structural failure of Sisneri and the combined downstream flood wave. The assessment shall consider timing and magnitude of successive failure events and their implications for downstream flood depths, velocities, arrival times and Population at Risk.

The Consultant shall assess resulting flood hydrographs and downstream flood propagation and determine:

- flood arrival time;
- peak discharge;
- flood depth;
- water-surface elevation;
- flood velocity;
- flood duration; and
- Population at Risk (PAR).

Potentially affected settlements, infrastructure, roads, bridges, water-supply facilities and other significant receptors shall be identified.

The Consultant shall assess sensitivity and uncertainty associated with dam-breach characteristics, reservoir initial water levels, downstream hydraulic roughness, topographic data and other significant assumptions. Governing or bounding scenarios for dam safety and emergency planning shall be identified and assumptions, limitations and uncertainties clearly documented.

The downstream modelling and assessment shall extend sufficiently far downstream to capture the potential consequences of dam failure and, where technically relevant, shall extend to the international border with India. Appropriate downstream cross-sections and topographic information shall be established and supplementary data collected where necessary.

Where predicted inundation or other consequences extend towards or across the international boundary with India, the Consultant shall identify and characterize the potential transboundary consequences. The Consultant shall provide technical information and mapping required by the Client and the World Bank to support any applicable assessment, notification or consultation requirements relating to international waterways and transboundary impacts, including OP 7.50, as applicable.

Stage 1

During Stage 1, the Consultant shall undertake a preliminary DBA sufficient to establish:

- potential failure mechanisms;
- governing dam-break scenarios;
- preliminary breach parameters;
- downstream flood propagation;
- potentially affected areas;
- Population at Risk;
- transboundary implications; and
- principal requirements for dam safety and emergency preparedness.

The Stage 1 DBA shall include preliminary inundation mapping and identification of potentially affected areas and critical infrastructure.

At completion of Stage 1, the Consultant shall clearly identify the additional data, surveys, investigations, modelling, mapping and emergency-planning requirements to be carried forward into Stage 2.

Stage 2

During Stage 2, the Consultant shall undertake the full and detailed DBA based on the confirmed dam configuration, dam-safety design, reservoir operating conditions and improved topographic and hydraulic data.

The detailed DBA shall provide detailed inundation and consequence mapping suitable for the Emergency Preparedness Plan and final dam-safety documentation.

The DBA shall provide information necessary for development of the Emergency Preparedness Plan, including:

- available warning time;
- flood-wave arrival time at downstream settlements and critical facilities;
- areas requiring emergency evacuation;
- potential evacuation constraints; and
- suitable locations for emergency warning and communication systems.

The results shall be presented in a form suitable for preparation of inundation maps, evacuation maps and emergency-response procedures.

The DBA results shall support dam-safety assessment, emergency preparedness planning, warning and evacuation requirements, downstream risk assessment and identification of appropriate mitigation measures.

3.1.2.2.7 Independent Dam Safety Assessment of Kulekhani Dam

Prior to project appraisal, an Independent Dam Safety Assessment of the existing Kulekhani Dam shall be undertaken in accordance with applicable dam-safety requirements.

The Consultant shall review the findings and recommendations of the Independent Dam Safety Assessment and assess their relevance to the Sisneri Water Supply Project, particularly with respect to:

- hydrology and flood management;
- seismic hazard;
- geological and geotechnical conditions;
- reservoir operation;
- sedimentation;
- dam safety;
- downstream consequences;
- emergency preparedness; and
- interaction between the Kulekhani and Sisneri systems.

Relevant findings and recommendations of the Independent Dam Safety Assessment shall be incorporated into the updated Feasibility Study, design criteria, reservoir operation studies, hydraulic and hydrological assessments, dam-safety provisions and other relevant components of the Sisneri Project.

Any implications for the proposed use of supplementary flows from the Kulekhani system shall be clearly identified and addressed.

The Consultant shall coordinate with the Employer, relevant Kulekhani system agencies and the Independent Dam Safety Assessment team, as necessary, to obtain information required for incorporation of the assessment findings into the Sisneri Project.

3.1.2.2.8 Dam Safety Plan

The Consultant shall recognize that the Dam Safety Plans for the Project will be developed progressively in accordance with the project implementation schedule and applicable dam-safety requirements. The Dam Safety Plans shall comprise the Construction Supervision and Quality Assurance Plan (CSQAP), Operation and Management Plan (O&MP), Instrumentation Plan (IP) and Emergency Preparedness Plan (EPP).

The Consultant shall provide the technical basis and prepare the required frameworks, terms of reference and design inputs for progressive development of these plans rather than requiring all plans to be fully completed by the end of the Detailed Engineering Design stage.

By the time of project appraisal, the following shall be sufficiently developed to support appraisal and subsequent implementation:

- Terms of Reference for preparation and implementation of the Construction Supervision and Quality Assurance Plan (CSQAP);
- a Framework Operation and Management Plan (Framework O&MP), including preliminary cost estimates and identification of resources and activities required for operation and management of the completed dam and associated facilities; and
- a Framework Emergency Preparedness Plan (Framework EPP), clearly identifying emergency preparedness arrangements, required works, equipment, institutional responsibilities and activities to be completed during subsequent project phases.

The Instrumentation Plan (IP) shall be developed to the level required for incorporation into the Detailed Engineering Design and shall be completed prior to tendering of the Construction Supervision Consultant and Main Contractor. The Plan shall define:

- the proposed instrumentation system;
- monitoring parameters;
- instrumentation locations;
- installation requirements;

- data acquisition and monitoring arrangements;
- data management and reporting; and
- data interpretation requirements.

The CSQAP shall be developed and finalized prior to procurement/tendering of the Construction Supervision Consultant and Main Contractor, in accordance with the agreed project implementation schedule.

The final Operation and Management Plan and Emergency Preparedness Plan shall be completed during construction and prior to first impoundment of the reservoir. The timing and detailed requirements shall be agreed during project appraisal and incorporated into the project implementation schedule.

The Consultant shall ensure that the Detailed Engineering Design provides all necessary technical information, design parameters, instrumentation requirements, operating criteria, emergency scenarios and other inputs necessary for subsequent preparation and completion of the CSQAP, O&MP, IP and EPP.

3.1.2.3 Geological, Seismological, Geotechnical and Construction Material Investigation and Study

The tentative scope shall be to review existing study and supplement it with further investigations and study related to the following:

1	Drilling on the dam axis (upstream toe) to confirm the nature and strength of the residual soils and the variability in the depth of overburden
2	Confirm the hydraulic conductivity of the abutment soils by carrying out in-situ permeability tests and install standpipe piezometers to obtain static water levels within the abutments
3	Confirm the hydraulic conductivity of the rock in the dam foundations by drilling and in-situ permeability testing
4	Carry out drilling investigations along the proposed spillway alignment to assess foundation conditions; similarly, for the alternative of a spillway if required
5	Drilling in the quarry areas to confirm the extent of the rock fill resource (if dam type is rock fill)
6	Laboratory testing of soil and rock samples obtained from drill core and borrow sources to confirm material properties
7	Carry out (i) large size Proctor test on the available dam construction materials to provide information for preparation of a compaction specification, assess the breakdown of the material by unconfined compressive strength test and Los Angeles abrasion tests to determine the suitability of the material for dam construction and if required (ii)Carry out on-site compaction trials of the rock fill materials using a heavy roller compactor to assess the breakdown of the rock ill, the physical characteristics of the compacted rock fill and provide information for preparation of a compaction specification
8	Deep trenching in the abutments with a large excavator to expose the weathered gneiss so that defects can be mapped and samples obtained for laboratory testing
9	Undertake testing including petrographic examination, of sources of aggregate for drainage/filter materials and concrete to confirm their suitability
10	Preparation of detail TOR and procurement documents for construction of audit tunnel if recommended.

The consultant shall review prior studies and conduct additional field investigation works and prepare a report that shall include the following (source can be review of prior study or supplementary investigation).

3.1.2.3.1 Regional Geology study:

The regional geological study should be conducted, and a report should be prepared. The report should provide:

- An overview of the dam project, its purpose, and the need for a geological study.
- Description of the geographical location of the dam project, including the region's topography, and geological features.
- Overview of the regional geology, including the geological history, rock formations, and tectonic activity in the area.
- Site characterization study should provide a detailed assessment of the dam specific site including geological mapping, subsurface investigations (such as drilling and sampling), and geophysical surveys to identify the geological and geotechnical properties of the site. The study should also identify potential geological hazards that may affect the dam project, such as seismic activity, landslides, fault zones, and groundwater conditions. This section also explores potential risks and recommend measures for mitigating measures.
- Assessment of the implications of identified geological hazards for the dam axis, reservoir, spillway, intake and other appurtenant structures and recommendation of appropriate mitigation measures.

The Consultant shall undertake a systematic geological and geomorphological hazard assessment covering the wider catchment, reservoir area and areas influencing the proposed dam and associated infrastructure. The assessment shall identify and characterize landslides, rockfalls, debris flows, erosion, unstable slopes, reservoir rim instability, seismic-induced slope instability and other geological processes that may affect reservoir storage, dam safety, water quality, sediment yield or the operation of the Project.

The geological hazard assessment shall be directly linked with the assessment of sediment sources and sediment yield. Areas identified as major or potentially active sources of sediment, including landslide-prone areas, eroding slopes and debris-flow source areas, shall be identified and considered in the sedimentation assessment and development of sediment management measures.

The Consultant shall prepare a geological hazard inventory and hazard zonation, identifying areas requiring further field investigation, monitoring or mitigation and shall recommend appropriate measures for the management of identified hazards.

Where suitable satellite data are available, the Consultant shall assess and utilize Interferometric Synthetic Aperture Radar (InSAR) and other appropriate remote sensing techniques to screen the

catchment, reservoir area, dam site and other potentially unstable areas for evidence of ground deformation, slope movement or other geological instability.

The results shall be integrated with geological mapping, geomorphological assessment, field investigations and other available information to identify areas requiring further investigation or monitoring. InSAR shall be used as a screening and prioritization tool and shall not replace detailed field investigations where significant instability is identified.

3.1.2.3.2 Ground Water Simulation

Groundwater information required to determine construction methods and to establish baseline conditions on the downstream of dam shall be developed.

The Consultant shall assess groundwater conditions in the dam foundation, abutments, reservoir area and downstream area, including groundwater levels, groundwater flow paths, permeability and potential interaction between groundwater and reservoir water.

The assessment shall support the design of foundation treatment, seepage control, drainage, excavation, construction dewatering and monitoring systems.

3.1.2.3.3 Development of geotechnical information:

The consultant shall review/conduct detailed geotechnical investigations (DCPT, SPT and Boring), in-situ and laboratory tests to determine pertinent soil properties. The laboratory and in-situ test should consider as many locations as possible, and findings should be documented in an engineering report. The core samples collected during the geotechnical investigations should be properly stored for future references. The studies should be planned to collect and determine following soil properties:

- Strike, dip, thickness, continuity, and composition of all faults and shears in the foundation.
- Compressive and tensile strength
- Shear strength (direct and triaxial)
- specific gravity, porosity and solubility.
- cohesion and internal friction

- Elastic modulus and poison's ratio
- Consolidation of foundation material
- Depth of overburden and alluvial deposits.
- Depth and degree of weathering throughout the foundation.
- Joint orientation and continuity.
- Lithologic variability.
- rock mass classification and engineering geological characteristics;
- permeability and hydraulic conductivity;
- deformability and stiffness characteristics; and
- other parameters required for the stability and structural design of the dam and its appurtenant structures.

The consultant should recommend the following properties:

- Controlled blasting method of the foundation rock.
- Grouting areas of the foundation rock, depth and length of grouting cutoff wall to control seepage through the foundation.
- Location and size of seepage collection galleries, audits, chambers, shafts, and design monitoring ways, such as instrumentation and seepage monitoring wells.
- appropriate drainage arrangements;
- design monitoring systems, including instrumentation and seepage monitoring wells;
- Performance thresholds (seepage quantities, uplift, consolidation of foundation, and movement) of dams during initial filling period and over the life of the dam.
- Recommend operating basis earthquake, peak ground acceleration (PGA), and maximum credible earthquake parameters.
- Excavatability analysis, anticipated construction technique and limitations.
- Seepage from the dam foundation

- Filter design on the downstream of dam
- other foundation treatment and construction requirements arising from the investigations.

3.1.2.3.4 Geophysical Survey

The consultant shall conduct **Seismic refraction survey** for assessment of depth of overburden and rock quality in the project areas of all components including borrow area and determination of possible faults covered by overburdens. In addition, in order to obtain more confirmation of the output obtained from seismic refraction survey and analysis additional **2D ERT/ MASW** (Multi Channel Analysis of Surface Wave) survey shall also be conducted if needed.

The Consultant shall assess the adequacy of the geophysical investigations previously undertaken under the feasibility study and shall supplement the investigations where the available coverage or resolution is insufficient for feasibility confirmation or detailed engineering design.

The geophysical investigations shall, as appropriate, cover the dam axis, abutments, spillway, intake, diversion works, access tunnels, quarry and borrow areas and other major structures.

3.1.2.3.5 Core drilling

In rock/overburden at dam site, spillway site, regulating diversion headwork sites and other structure areas where necessary. Observation of the water level at the drilling holes on the both banks of the dam/ headwork's site. Necessary in- situ tests in the drill holes and laboratory tests on core sample including permeability tests and others and triaxial test, if necessary. It has been estimated that a total of 1000 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. The consultant should take prior approval of the drilling depth and locations from KVWSMB.

Based on the findings of the investigations and the requirements of the Feasibility Update and Detailed Engineering Design, the Consultant shall identify any additional ground investigations required beyond the investigations included under this assignment. Where additional investigations are to be procured separately by the Employer, the Consultant shall prepare the required technical specifications, investigation locations, depths, testing requirements, quantities and cost estimates to facilitate independent procurement and implementation. The Consultant shall

review and incorporate the results of such investigations into the geological and geotechnical assessment and subsequent design.

Review and additional investigation related to availability and suitability of **construction materials** including but not limited to confirmation of previously identified and identification of new borrow areas for construction materials for dam construction (for e.g., clay for the core, material for filter and rock fill, etc), concrete aggregates, determination of their physical, chemical, mineralogical, properties, strength etc. The Consultant shall assess and make fair sustainable estimate of quantity and quality of each material from each of the borrow areas available for use during construction.

3.1.2.3.6 Seismic Study:

Sisneri dam will be a major structure located in an environment with a potential 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 review/update, among others, the following activities:

- Detailed investigation of fault structure 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. Information available from Department of Mines, Government of Nepal may be used for this purpose. Determination of dynamic response profiles for accelerations and velocities applicable at different elevations on the dam for the Design Basis Earthquake (DBE) and Maximum Credible Earthquake (MCE) including likely damage to structures for each case.
- Investigation on possibility of reservoir induced seismicity after the impoundment of reservoir.
- Recommendation 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 KVWSMB.
- The Consultant shall undertake a comprehensive Seismic Hazard Assessment during Stage 1, including both Probabilistic Seismic Hazard Assessment (PSHA) and Deterministic Seismic Hazard Assessment (DSHA), to establish the seismic hazard parameters required for the

feasibility assessment and subsequent detailed design. The assessment shall consider the regional and local tectonic setting, identified and potential active faults, historical and instrumental seismicity, earthquake recurrence, maximum credible earthquake potential, site conditions and other relevant seismic sources.

- The PSHA shall establish seismic hazard curves and appropriate seismic hazard parameters for the project site for the return periods required for dam safety and design. As a minimum, the assessment shall consider the 145-year, 200-year, 475-year, 1,000-year, 2,000-year and 10,000-year return periods, or other return periods required by the applicable dam safety standard. The Consultant shall clearly state the probability of exceedance, reference time period and methodology associated with each adopted hazard level.
- The DSHA shall identify the controlling seismic sources and credible maximum earthquake scenarios relevant to the project. The Consultant shall review the available geological, seismological and tectonic information and shall assess the potential for surface fault rupture and other near-field seismic hazards where relevant to the dam site and major appurtenant structures.
- The Consultant shall review the adequacy and reliability of available seismic records and shall compile and evaluate historical and instrumental earthquake catalogues for the region. Earthquake magnitude, epicentral location, depth, focal mechanism and other relevant parameters shall be reviewed for significant events that may contribute to the seismic hazard at the project site.
- The Consultant shall establish the appropriate seismic design levels and terminology for the project, including the Operating Basis Earthquake (OBE), Design Basis Earthquake (DBE) and Safety Evaluation Earthquake (SEE), as applicable to the selected dam type and dam safety classification. Where Maximum Credible Earthquake (MCE) terminology is used, its relationship with the adopted SEE/DBE criteria shall be clearly defined and justified.
- The Consultant shall recommend the appropriate design ground motions for the dam site, including peak ground acceleration, spectral acceleration and other parameters required for structural and geotechnical analysis. The adopted seismic parameters shall be consistent with the results of the PSHA/DSHA and the applicable international dam safety guidance and design standards.

- The Consultant shall assess site-specific effects, including local geological and geotechnical conditions, depth and characteristics of overburden, rock mass properties, groundwater conditions and potential amplification of seismic ground motion. Where justified by the site conditions and hazard level, site response analysis shall be undertaken to establish appropriate design response spectra at the foundation and relevant elevations.
- Where required for the adopted seismic design level, the Consultant shall develop appropriate acceleration time histories for dynamic analysis. The selected time histories shall adequately represent the magnitude, duration, frequency content and spectral characteristics of the controlling earthquake scenarios and shall include the required three components of ground motion.
- The Consultant shall assess the potential for reservoir-induced seismicity associated with impoundment of the Sisneri Reservoir. The assessment shall consider the geological structure, existing seismicity, reservoir depth and storage volume, changes in groundwater conditions and pore pressure, and experience from comparable reservoirs. Appropriate monitoring and mitigation measures shall be recommended where warranted.
- The Consultant shall review the potential interaction between seismic hazards and other dam safety hazards, including slope instability, landslides, liquefaction where applicable, foundation instability, reservoir rim instability and potential blockage of waterways. The implications of earthquake-induced landslides, rockfalls or debris flows for reservoir operation, spillway capacity and dam safety shall be assessed.
- The Consultant shall identify the seismic instrumentation and monitoring requirements for the project, including the need for strong-motion accelerographs, seismographs, foundation and dam-body instrumentation and other monitoring equipment. The Consultant shall prepare technical specifications and recommend appropriate locations, installation requirements, data acquisition arrangements and maintenance requirements for the proposed seismic monitoring network.
- The Consultant shall prepare a Stage 1 Seismic Hazard Assessment Report presenting the seismic source model, historical and instrumental seismicity, PSHA and DSHA methodologies, seismic hazard curves, controlling seismic sources, adopted seismic design parameters, recommended design earthquake levels, site-specific considerations, uncertainties and recommendations for Stage 2 detailed seismic analysis.

- The Stage 1 assessment shall clearly identify the additional seismic investigations and analyses required during Stage 2. Where the Stage 1 assessment identifies active or potentially active faults, significant near-field effects or other conditions requiring more detailed assessment, the Consultant shall undertake or recommend appropriate detailed fault studies, site-specific seismic response analysis, fault rupture assessment and/or other investigations required for final design.
- The Consultant shall ensure that the seismic hazard parameters adopted for Stage 2 detailed design are consistent with the final dam height, dam type, foundation conditions and dam safety classification established following completion of the Stage 1 investigations and optimization studies.

3.1.2.3.7 Prior Tests

Following geo-physical and geotechnical investigation have been conducted during initial study phase based on which a geological assessment report has been prepared.

Along Alternative 1

- 15 m depth of each hole and conducted 5 drill holes at dam axis and 3 holes upstream (inundation area) and 1 hole down stream of dam axis
- DCPT and Permeability and packer test has been done in each 3 m interval depth
- In core drill, fractured rocks and low RQD values sample is found
- SRT and ERT as well as MASW has been done in certain area that is not sufficient for detailed design. There is no mention about the MAM investigation.
- Down hole test has been done in one in dam side.
- Lab Tests: Rock- Point Load Index, UCS, Specific Gravity and Water Absorption
- Lab Tests: Index -Classification, Particle Size, Moisture Content, Bulk Density, Specific Gravity Direct Shear Test.

Along Alternative 2

- 1 drill hole of 15 m depth at dam axis
- ERT (3 Nos), SRT (2 Nos) and MASW (2 Nos) have been done.

Construction Material

- Samples from 7 different locations have been tested as sources of Aggregate, Sand and Clay. Conducted tests (as applicable for different construction materials) include Sieve Analysis, Specific Gravity, Absorption, Los Angeles Abrasion Test, Sulphate Soundness Test, Alkali-Aggregate Reactive Test, Elongation Index and Flakiness Index, Aggregate Impact Values, Aggregate Crushing Value, CBR, Point Load Test, Atterberg Limit.

3.1.2.3.8 Recommended Tests

Assessment of alternative dam axes has been **recommended** for Updating Feasibility Report. The recommended investigations (including prior tests) for the first stage of the project shall be as follows:

- At least 3 core drill is required along dam axis. Drill depth shall be of approximately 15-20m but at least one should be above 30m.
- Packer and permeability test in each 3 m interval depth to find out the Lugeon value and compare with the standard value to find out the fractureness of the rock.
- Measurement of in situ properties: shear strength, permeability, shear modulus, and instrumentation
- Laboratory tests at 5m interval: index properties, mechanical properties, and compaction tests including Average Bulk Density, Average Water Content at Saturation, Average Specific Gravity, Average Void Index, Average Porosity & Slake Durability Index, Uniaxial Compressive Strength, Tensile Strength (Brazilian Test), Triaxial Shear Strength Parameters Triaxial Shear Strength Parameters, Elastic Parameters, Dynamic Modulus, Direct Shear Strength Parameters of Rock, Petrography
- 3 Seismic Refraction Test, 3 Electrical Resistivity Test, 2 Multichannel Analysis of Seismic Wave (MASW) and 1 Down hole seismic test is recommended for estimation of PGA value.

Based on findings of prior studies the following further study at the recommended dam axis, inter alia, have been **recommended** for detailed design of chosen dam alternative

- The depth of the drill shall be more than 50m depending upon the height of proposed dam

and is recommended to be 2/3rd of dam height. At least nine core drill is required at dam axis and 2 inclined and horizontal core drilling is required on each banks. Additional 4 drills along upstream and downstream of the dam axis (at 30m distance) is recommended, to cover the spread of dam foundation

- Packer and permeability test in each 3 m interval depth is required to find out the fractureness of the soil and rock in each drill hole
- Optical Borehole Scan of all the drill holes for the measuring the frequency of the joints in the rocks of subsurface is recommended
- The requirement of adit tunnels shall be assessed by the consultant and if found critical, the consultant shall be responsible for preparation of detailed set of contract document as per prevailing national and international standards
- Measurement of in situ properties: shear strength, permeability, shear modulus, and instrumentation
- Laboratory tests at 5m interval: index properties, mechanical properties, and compaction tests including Average Bulk Density, Average Water Content at Saturation, Average Specific Gravity, Average Void Index, Average Porosity & Slake Durability Index, Uniaxial Compressive Strength, Tensile Strength (Brazilian Test), Triaxial Shear Strength Parameters Triaxial Shear Strength Parameters, Elastic Parameters, Dynamic Modulus, Direct Shear Strength Parameters of Rock, Petrography
- Numerical modeling of groundwater flow analyses
- For Seismic considerations in dams, seismic hazard analysis is required
- Geophysical investigation: At least 6 lines SRT, 6 lines ERT, 3 points of MASW, 3 points MAM and 3 down hole test are recommended to estimate the PGA values and show the response spectrum. Investigation line interval of 15 m along upstream and downstream from the dam axis is recommended.
- At least six each of ERT, MASW and SRT investigation is required in inundation area to find out the depth of bedrocks, bearing capacity, deformation modulus, elastic modulus and other.

- MASW investigation in holes of inundation and dam is required at depth of 50 m.
- At least two lines of ERT and Two lines of the SRT and a MASW is recommended along the boundary between rocks of the Tistung Formation in north and granite of the Ipa Ganite in south.
- Dilatometer deformability test in the drill hole, plate bearing or flat-jack test to measure the strain modulus of the rock in various directions;
- Landslide hazard map and morphotectonic map are required in 1:5000 scale in the project area.
- Pithole and trenches is required to determine the volume of the construction materials along with relevant lab tests based on relevant AASHTO and other national and international standards. At least 5 locations are to be identified and tested for construction materials in the Sisneri Khola riverbed.

3.1.3 Investigation of Alternative Dam Axes and Structures

- The Consultant shall review the geological and geotechnical suitability of all dam axes and major alternatives identified during the feasibility study. The investigations shall be sufficient to support comparison of the alternatives and shall not be limited to the currently preferred dam axis.
- The Consultant shall assess whether the available geological and geotechnical information is adequate to confirm the suitability of each alternative. Where information is insufficient, additional drilling, trenching, geophysical surveys, mapping and laboratory testing shall be undertaken.
- The investigations shall also cover the proposed spillway, intake, diversion arrangements, outlet structures, access tunnels and other major appurtenant structures associated with the alternatives.

3.1.4 Kogate River and Diversion Investigation

- The Consultant shall undertake a detailed assessment of the realistic diversion potential from Kogate to the proposed Sisneri reservoir. The assessment shall be undertaken at a

daily time step, or at a finer time step where necessary, using the available hydrological data and the characteristics of the proposed diversion arrangement.

- The assessment shall consider the nature and limitations of the proposed diversion system, which is anticipated to comprise a Tyrolean weir or similar diversion arrangement with limited or no effective storage. Accordingly, the assessment shall not rely solely on theoretical mean or design flows but shall determine the realistically divertible flow under varying hydrological conditions.
- The Consultant shall assess:
    - daily flows available for diversion;
    - seasonal and annual variation in available flows;
    - diversion efficiency and hydraulic limitations;
    - minimum downstream flow requirements;
    - flood and high-flow conditions;
    - sediment and debris considerations affecting diversion reliability;
    - operational limitations of the proposed diversion arrangement; and
    - the resulting incremental contribution to the Sisneri reservoir and reliable project yield.
- The Consultant shall develop an appropriate hydrological and hydraulic representation of the proposed Kogate diversion arrangement and shall estimate realistic daily, seasonal and annual diversion volumes.
- The results shall be incorporated into the reservoir water balance and yield assessment and shall be used in the optimization and economic evaluation of the project. The Consultant shall also define the design requirements for the Kogate diversion necessary to achieve the assessed realistic diversion volumes.
- Where the Kogate River diversion is retained as part of the recommended project configuration, the Consultant shall undertake sufficient geological and geotechnical investigation of the Kogate intake/diversion site, connecting structures, tunnel/channel or pipeline alignment and associated structures.
- The investigation shall establish foundation conditions, rock mass quality, discontinuities, groundwater conditions, slope stability, tunnelability/excavatability and construction

material requirements and shall identify any geological or geotechnical conditions that could materially affect the feasibility, cost or safety of the Kogate diversion.

3.1.5 Additional Requirement

- The Consultant shall undertake a study of the potential for supplementary flow from the Kulekhani system to the Sisneri Water Supply Project and assess the corresponding impact on the generation and operation of the Kulekhani Hydropower System.
- The assessment shall consider the available hydrological data, existing Kulekhani reservoir characteristics, existing reservoir operating rules, hydropower generation requirements, downstream releases, existing water uses and the proposed requirements of the Sisneri Water Supply Project.
- The Consultant shall develop a range of operating and water transfer scenarios to assess the potential supplementary contribution from the Kulekhani system. The scenarios shall include, as a minimum, a range of supplementary flow conditions up to a scenario providing the full desired additional project yield, subject to the physical, hydrological and operational constraints of the Kulekhani system.
- For each scenario, the Consultant shall assess:
    - available supplementary water;
    - timing and duration of supplementary releases;
    - impact on Kulekhani reservoir levels and storage;
    - impact on downstream releases and existing water uses;
    - impact on Kulekhani Hydropower generation;
    - implications for firm and average energy generation;
    - implications for Sisneri reservoir operation and reliable yield;
    - operational constraints and required coordination between the two systems; and
    - potential economic implications of the supplementary flow arrangement.
- The Consultant shall develop appropriate reservoir operation and water balance scenarios to quantify the trade-off between supplementary water supply to Sisneri and impacts on Kulekhani Hydropower generation.

- The results shall be incorporated into the overall water resources assessment, reservoir operation study, optimization study and economic and financial analysis of the Project.

3.1.6 Construction Materials Investigation

- The Consultant shall review and supplement previous investigations relating to the availability and suitability of construction materials, including confirmation of previously identified and identification of new borrow areas for dam construction materials such as clay for core material, filter materials, rock fill and other fill materials, as applicable.
- The Consultant shall investigate sources of concrete aggregates, sand, rock and other materials required for the proposed dam and appurtenant structures.
- The Consultant shall determine the physical, chemical, mineralogical and engineering properties, strength, durability and other relevant characteristics of the materials and shall assess the suitability of each source for the intended use.
- The Consultant shall make a realistic and sustainable estimate of the quantity and quality of each material available from each borrow area or quarry, taking into account stripping, overburden, wastage, accessibility, environmental and social constraints and expected construction losses.
- The Consultant shall undertake appropriate laboratory testing, including, as applicable, sieve analysis, specific gravity, water absorption, Los Angeles abrasion, sulphate soundness, alkali-aggregate reactivity, aggregate impact value, aggregate crushing value, flakiness and elongation indices, Atterberg limits, CBR, point-load strength, petrographic examination and other tests required for the proposed use.
- The Consultant shall assess the suitability of construction material sources under the selected dam type and shall identify alternative sources where the quantity or quality of any required material is inadequate.

3.1.7 Slope Stability and Geo-hazard Assessment

- The Consultant shall undertake slope stability assessment for the dam abutments, reservoir rim, spillway, intake, access roads, construction areas, spoil disposal areas, quarry and borrow areas and other locations where slope instability may affect the project.

- The assessment shall consider both static and relevant seismic loading conditions and shall address potential landslides, rockfalls, debris flows, wedge failures, planar failures and other relevant instability mechanisms.
- Potential reservoir-induced slope instability shall be assessed, including the effect of reservoir impoundment and fluctuations in reservoir water level on potentially unstable slopes.

Where unstable or potentially unstable slopes are identified, the Consultant shall recommend appropriate stabilization, drainage, monitoring and/or other mitigation measures.

3.1.8 Investigation Management and Quality Assurance

- The Consultant shall be responsible for planning, coordinating and supervising all supplementary geological, geotechnical, geophysical and construction-material investigations required under this assignment.
- Where specialized investigation contractors or testing laboratories are engaged separately, the Consultant shall prepare the technical specifications and investigation quantities, support the procurement process, review the proposed methodology and equipment, supervise the field investigations, verify the quality and completeness of the investigation data and review and certify the resulting investigation reports and laboratory test results.
- The Consultant shall maintain appropriate quality assurance and quality control procedures for drilling, sampling, core logging, in-situ testing, laboratory testing, geophysical surveys and other investigations.
- All investigation data, including borehole logs, core photographs, test results, geological mapping, geophysical profiles and laboratory results, shall be compiled in a systematic digital database and shall be made available to KVWSMB for future reference and use during detailed design and construction.
- The Consultant shall clearly identify any residual geological or geotechnical uncertainties following completion of Stage 1 and shall specify any additional investigations required before or during Stage 2.

3.1.9 Optimization Study

Based on the findings of field investigations and the review of previous studies, the Consultant shall undertake a comprehensive and systematic optimization study of the proposed Sisneri Dam and associated reservoir system. The optimization shall consider technical, hydrological, geological, geotechnical, seismic, hydraulic, construction, environmental and social, economic, financial and dam-safety aspects, and shall include, but not necessarily be limited to, the following:

- Assessment of alternatives: Assess alternatives for the dam and reservoir in terms of all relevant parameters, including dam axis, height, orientation, reservoir operating levels, storage capacity, dam type, spillway and outlet arrangements, and potential water-supply augmentation through diversion structures from other watersheds, including the potential Kogate diversion. The assessment shall also consider the interfaces with the WSP intake and other associated water-supply components. Field investigations shall be planned and undertaken to provide sufficient information for the assessment of all technically feasible alternatives.
- Systematic optimization: Undertake a systematic optimization of the proposed Sisneri Dam and reservoir configuration, considering alternative dam axes, dam heights, reservoir operating levels, reservoir capacities, dam types, spillway arrangements, outlet arrangements and water-supply augmentation options. The optimization shall be based on the results of the Stage 1 hydrological, sedimentological, geological, geotechnical and seismic investigations and shall not assume that the currently preferred 65 m dam configuration is final.
- Dam height and reservoir optimization: Specifically assess the relationship between dam height, reservoir storage, reliable water-supply yield, inundation, geological and geotechnical conditions, sedimentation, dam safety, environmental and social impacts, construction cost, operation and maintenance cost and overall project economics. Alternative dam heights shall be assessed sufficiently to establish the optimum configuration and determine whether an increase or reduction in dam height provides a technically, economically, environmentally and socially justified improvement in project performance. The assessment shall establish the relationship between dam height, storage, reliable yield and incremental project benefits and costs.

- Dam type alternatives: Assess alternative dam types appropriate to the site conditions, including Conventional Mass Concrete (CVC) Gravity Dam, Roller Compacted Concrete (RCC) Gravity Dam, and Rockfill Dam, including Earth Core Rockfill Dam (ECRD) and/or Concrete Face Rockfill Dam (CFRD), where technically feasible. The assessment shall consider geological, topographical, seismic, hydrological, construction, material availability, environmental and social, economic and dam-safety conditions.
- Dam type comparison: The comparison of feasible dam types shall consider foundation requirements, abutment conditions, seismic performance, seepage control, stability, deformation, construction methodology, availability of construction materials, construction duration, diversion requirements, environmental and social impacts, capital cost, operation and maintenance requirements, construction and operational risks and overall life-cycle cost. The current preference for a Concrete Dam shall be treated as a preliminary preference only and shall be validated through the Stage 1 comparative assessment.
- Preliminary dam configurations: For each technically feasible dam type and shortlisted dam height, develop preliminary dam sections and principal structural configurations and assess their suitability considering the applicable seismic hazard and design criteria. The assessment shall consider seismic stability, deformation, foundation conditions, reservoir-induced hydrodynamic effects and other relevant seismic loading effects. The results shall contribute to selection of the preferred dam type, dam height and principal dam section at the end of Stage 1.
- Dam Type Selection Report: Prepare a standalone Dam Type Selection Report as a component of the Stage 1 Optimization Study. The report shall present a systematic comparison of the technically feasible dam types, including CVC Gravity, RCC Gravity and Rockfill Dam, including ECRD/CFRD where applicable, together with the assessment of alternative dam heights and preliminary dam sections considering seismic loading. The report shall document the geological, geotechnical, seismic, hydraulic, structural, construction, environmental and social, economic, dam-safety and life-cycle considerations supporting the recommended dam type and dam height. The report shall clearly identify the advantages, limitations, risks and uncertainties associated with each alternative.
- Reservoir operation and yield optimization: Integrate the findings of the Reservoir Operation Plan and water-balance assessment into the optimization study. The Consultant shall assess

the relationship between dam height, reservoir storage, operating levels, sedimentation, dependable yield, dry-season supply, flood storage and downstream/environmental flow requirements. The assessment shall establish a safe and realistic yield trajectory over the project life and shall consider the effects of alternative dam heights and storage configurations on project performance and viability.

- Coordination with other consultants and project components: Maintain continuous coordination with the consultants responsible for the detailed design of the water-supply components and the EIA/ESIA processes being undertaken under separate consultancy services. The optimization shall consider the interfaces between the dam, reservoir, intake, Kogate diversion, pumping arrangements, transmission system, treatment facilities, Sainbu Reservoir and the existing downstream water-supply system. Relevant findings of the approved EIA scoping documents and subsequent environmental and social studies shall be incorporated into the optimization.
- Construction materials: Assess the suitability, availability, quantity and quality of construction materials required for the principal dam alternatives, including concrete aggregates, rockfill, earthfill and other relevant materials, and consider the implications for quarry development, transportation, processing and construction cost.
- Seismic hazard and design criteria: Undertake and/or utilize the seismic hazard assessment and seismic design criteria established under the project studies. The optimization shall ensure that alternative dam types, heights and principal sections are assessed against the applicable seismic hazard, loading and performance requirements.
- Hydrological design parameters: Verify the hydrological parameters applicable to the optimization and preliminary design of the principal dam components, including diversion design flood, spillway design flood, reservoir filling conditions, operational conditions and relevant extreme flood conditions, using the adopted hydrological datasets and rainfall information from nearby and other representative gauges.
- Spillway and outlet optimization: Assess and optimize the spillway configuration, capacity, location, crest level, discharge arrangements and energy dissipation system, together with the principal outlet arrangements, considering flood safety, reservoir operation, sediment management, constructability, seismic conditions and dam safety.

- Dam risk assessment: Incorporate the findings of the preliminary Dam Risk Assessment into the optimization. The assessment shall consider identified failure modes, flood consequences, geological and seismic hazards, sedimentation risks, reservoir rim instability and other relevant dam-safety risks. The Consultant shall assess how alternative dam configurations and appurtenant structures affect the overall risk profile and identify appropriate risk-reduction or remedial measures.
- Construction planning: Based on the preferred alternatives and optimization findings, prepare a preliminary construction plan, including construction sequence and program, construction methods, plant, equipment, materials and labour requirements, temporary works, diversion arrangements and quarry development requirements.
- Project implementation plan: Prepare a project implementation plan in consultation with the Client, identifying the principal implementation stages, interfaces, approvals, procurement requirements, construction activities and key implementation risks.
- Cost estimates: Prepare line-item cost estimates for the principal alternatives considered under the optimization study, including capital and operation and maintenance costs. The cost estimates shall, as applicable, include dam and foundation works, spillway and energy dissipation arrangements, outlet works, intake and diversion structures, tunnels/pipelines, access works, power supply, construction facilities, land acquisition/resettlement implications, environmental and social mitigation measures, and operation and maintenance requirements.
- Comparative economic and financial assessment: Undertake a comparative economic and financial assessment of the principal alternatives to support selection of the preferred configuration. The assessment shall consider the incremental costs and incremental water-supply benefits associated with alternative dam heights, dam types, reservoir capacities and augmentation/diversion options. Where applicable, the assessment shall include economic and financial indicators such as EIRR, FIRR and NPV, together with appropriate sensitivity and scenario analysis.
- Economic and financial sensitivity: The sensitivity and scenario analysis shall consider key uncertainties and variables affecting project viability, including hydrological inflows, climate-change scenarios, sedimentation and storage loss, water-supply demand, construction costs, operation and maintenance costs, electricity prices, bulk water tariffs and other relevant

assumptions. Where applicable, the analysis shall also consider the implications of different cost-sharing or financing arrangements, including any potential viability gap funding or similar mechanisms.

- Kogate diversion assessment: Undertake a preliminary hydraulic and water-availability assessment for the Kogate diversion option to establish the realistic achievable diversion volumes to the Sisneri Reservoir. The assessment shall consider the seasonal and annual flow regime of Kogate, available water after maintaining applicable environmental or downstream flow requirements, intake/offtake capacity, conveyance capacity, sediment and debris conditions, flood conditions, hydraulic losses, operational constraints and other relevant limitations. The Consultant shall distinguish between theoretical diversion capacity and realistic diversion volumes under dry, normal and wet hydrological conditions. The resulting realistic diversion volumes shall be incorporated into the reservoir water balance, yield assessment, optimization and economic analysis.
- Kogate economic and technical justification: For the Kogate diversion option, assess the incremental water-supply benefit against the additional capital and operating costs, geological and geotechnical risks, sediment load, environmental and social impacts, construction requirements and long-term operational requirements. The Kogate diversion shall be retained only where the overall assessment demonstrates that it provides a technically feasible, environmentally and socially acceptable, and economically justified contribution to the project.
- Catchment and water availability: The optimization shall consider the existing Kulekhani Reservoir and its operating regime, the Sim/Sin Khola Intake and Chakhel Diversion, the Sisneri catchment and the potential Kogate diversion. The Consultant shall establish the actual net water availability at the project site and shall ensure that catchment areas and flows already diverted to the Kulekhani Hydropower system are not double-counted. The effects of existing and proposed diversions and operating regimes shall be incorporated into the water balance and yield assessment.
- Sensitivity and uncertainty analysis: Undertake sensitivity and uncertainty analysis for key parameters influencing project performance and selection of the preferred configuration, including hydrological inflows, sediment yield and storage loss, dam height, reservoir storage, water-supply demand, construction costs, operation and maintenance costs, climate-change

scenarios and other material uncertainties. The Consultant shall identify the parameters having the greatest influence on project viability and the preferred configuration.

- Optimization Report: Prepare the Optimization Report presenting the complete results of the optimization study. The report shall clearly identify the alternatives investigated, technical and economic criteria adopted, comparative results, key risks and uncertainties, and the preferred dam axis, dam height, dam type, reservoir configuration, spillway and outlet arrangements and any required flow augmentation/diversion scheme.
- Basis for Stage 2: The Optimization Report shall provide sufficient justification for each selected parameter and establish the design basis for Stage 2 detailed design. The Consultant shall also identify the investigations, studies, surveys, modelling and design development that remain necessary during Stage 2 for the selected configuration. Any unresolved uncertainties that could materially affect the selected dam configuration, cost, safety or performance shall be clearly identified together with recommendations for their resolution.
- Stage 1 decision: At the completion of Stage 1, the Consultant shall recommend and, subject to Client approval, confirm the selected dam type, dam height, principal dam section, reservoir configuration and principal appurtenant works. The recommended dam type shall be established before commencement of Stage 2 detailed dam design. Although a Concrete Dam is currently preferred, any recommendation to adopt an alternative dam type shall be supported by geological, geotechnical, structural, seismic, construction, economic, environmental and social, and dam-safety considerations.
- Stage 2 changes: Stage 2 detailed design shall be based on the configuration approved by the Client at the completion of Stage 1. Any fundamental change to the selected dam type or principal configuration during Stage 2 shall only be proposed where subsequent investigations identify a material technical, geological, geotechnical, safety or other constraint that could not reasonably have been established during Stage 1, and shall be subject to prior approval of the Client.
- Independent review: The Consultant shall finalize the Optimization Report incorporating comments and recommendations from the Client and the designated independent reviewer/Panel of Experts, as applicable. The final Optimization Report and Dam Type Selection Report shall constitute the principal technical basis for proceeding to Stage 2 detailed design.

3.1.10 Economic and Financial Analysis

The consultants shall analyze demand, supply, and economic viability, and assess tariff pricing for different uses i.e., bulk supply for drinking water and irrigation etc. The Consultants shall 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.
- The economic analysis shall be undertaken for the preferred project configuration identified through the Optimization Study and shall also be undertaken for the principal technically feasible alternatives considered during Stage 1. The analysis shall demonstrate the economic justification for the selected dam height, dam type, reservoir configuration, augmentation/diversion options and other major project components.
- The Consultant shall assess the incremental economic costs and benefits associated with alternative project configurations and shall identify the least-cost option capable of providing the required reliable water-supply service, subject to technical, environmental, social and dam-safety constraints.
- Review the forecasted water demand and revenues and costs in relation to tariffs, cost recovery. Determine future sustainable tariffs to support the project.
- The Consultant shall review the projected water-supply yield and demand assumptions used in the project and shall establish the relationship between available reliable yield, projected demand, bulk water supply requirements and the proposed reservoir operating regime. The analysis shall consider the implications of dry-year conditions, sedimentation-related loss of storage and climate-change scenarios on the long-term water-supply yield.
- The Consultant shall assess the affordability and willingness/ability to pay of relevant water users, where applicable, and shall recommend a tariff structure that balances financial sustainability, cost recovery, affordability and the public-service objectives of the project.
- Evaluate 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.
- The financial analysis shall include a detailed assessment of capital expenditure, operation and maintenance costs, periodic replacement costs, financing costs, revenues and other

relevant cash flows over the economic and financial assessment period. The Consultant shall identify the principal financial risks and assess their potential effects on project viability and financing requirements.

- Sensitivity and risk analysis shall consider, at a minimum, changes in project cost, construction period, financing conditions, interest rates, water demand, water-supply yield, tariff levels, operation and maintenance costs, sedimentation, climate-change impacts and other key parameters identified through the project risk assessment.
- Analyze the alternative possibilities of promoting the project, ranging from the public sector development to the public and private partnership 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.
- The Consultant shall assess the suitability of alternative financing and implementation arrangements in accordance with the institutional framework applicable to the project and shall identify the preferred financing structure considering affordability, fiscal implications, financial sustainability, risk allocation and long-term operation and maintenance requirements.
- 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.
- The financial model shall be sufficiently flexible to test alternative project configurations, financing structures, tariff assumptions, water-supply yields and implementation schedules. The model shall be provided to the Client in an editable format together with all assumptions, input data, calculations and supporting documentation.
- The Consultant shall carryout detailed assessment of impact of flow regulation due to construction of impounding reservoir dam on the existing and planned downstream facilities. The benefit which will accrue due to reduction of flood peak in the downstream shall also be assessed.
- The economic analysis shall quantify, where practicable, the economic benefits associated with improved reliability of water supply, reduction in water shortages, improved service

levels, flood-risk reduction and other identifiable project benefits. Benefits and costs that cannot be reliably monetized shall be identified and assessed qualitatively.

- The Consultant shall ensure that economic costs and benefits are assessed using appropriate economic rather than purely financial values. Where applicable, appropriate shadow prices, conversion factors, opportunity costs and other economic valuation adjustments shall be applied and their basis shall be clearly documented.
- The economic analysis shall clearly distinguish between financial cash flows and economic costs and benefits and shall avoid double counting of benefits, particularly where benefits are associated with existing water-supply systems, downstream facilities or other components of the Kathmandu Valley water-supply system.
- The Consultant shall assess the economic implications of environmental and social mitigation measures identified through the EIA/ESIA and shall incorporate material mitigation, compensation, land acquisition and resettlement costs into the appropriate economic and financial analyses.
- The Consultant shall undertake appropriate risk and uncertainty analysis for the economic viability of the project. At a minimum, the assessment shall examine the effects of variations in hydrological yield, construction cost, dam height, dam type, sedimentation rate, water demand, tariff, implementation period and climate-change conditions. Where appropriate, probabilistic or scenario-based analysis shall be used to demonstrate the robustness of the economic viability of the preferred project configuration.
- The Consultant shall establish the economic assessment period and appropriate discount rate in accordance with applicable Government of Nepal requirements and relevant international/World Bank guidance. The basis for the adopted economic life, discount rate, residual value and major economic assumptions shall be clearly stated.
- The Consultant shall undertake an assessment of the project's value for money and affordability, taking into account the total life-cycle cost of the proposed dam and associated water-supply infrastructure. The assessment shall consider capital cost, operation and maintenance costs, major rehabilitation/replacement requirements, sediment management and other long-term costs necessary to maintain the intended level of service.
- The Consultant shall prepare a comparative economic assessment of the principal alternatives identified in the Optimization Study and shall present the results in a manner that allows the

Client to clearly understand the economic consequences of the major design decisions. The comparison shall include, as applicable, capital cost, annual O&M cost, reliable water-supply yield, unit cost of water, EIRR, NPV, benefit-cost ratio, financial indicators and key risk/sensitivity results.

- The findings of the economic and financial analysis shall be integrated into the Optimization Report and Updated Feasibility Report. The preferred configuration shall be justified not only on the basis of technical feasibility but also on economic efficiency, financial sustainability, affordability, environmental and social considerations and dam safety.

3.1.11 Environmental and Social Requirements / Coordination with EIA

- The Consultant shall coordinate closely with the separate EIA/ESIA Consultant throughout the assignment and shall ensure that the findings, recommendations and requirements arising from the environmental and social assessment are appropriately incorporated into the feasibility assessment, optimization study and detailed engineering design.
- The Consultant shall provide the EIA/ESIA Consultant with all technical information required for assessment of environmental and social impacts, including alternative dam configurations, reservoir levels and inundation areas, dam and diversion arrangements, construction requirements, access roads, quarry and borrow areas, spoil disposal areas, construction camps, power and water requirements and other project-related facilities.
- The Consultant shall ensure that environmental and social considerations are incorporated into the evaluation of project alternatives from the earliest stage of project optimization. Alternative dam axes, dam heights, dam types, reservoir operating levels, Kogate diversion arrangements, construction material sources and other major alternatives shall be assessed with due consideration of their environmental and social implications, and the results shall be incorporated into the comparative optimization of alternatives.
- The Consultant shall maintain alternatives register identifying the principal technical alternatives considered during Stage 1 and shall provide the EIA/ESIA Consultant with sufficient information to assess the environmental and social impacts of each relevant alternative. The preferred alternative shall demonstrate consideration of avoidance and minimization of significant environmental and social impacts in addition to technical and economic criteria.

- The Consultant shall incorporate all relevant environmental and social design requirements identified through the EIA/ESIA into the engineering design, specifications, cost estimates and construction planning. This shall include, as applicable, requirements relating to environmental flows, sediment release, downstream impacts, slope stabilization, construction material sources, spoil disposal, access roads, construction camps, water quality, biodiversity, community health and safety, occupational health and safety, land acquisition, physical and economic displacement and other project-specific mitigation measures.
- The Consultant shall specifically coordinate with the EIA/ESIA Consultant on downstream impacts associated with regulation of the Sisneri River and any diversion of water from the Kogate River or other sources. The engineering design shall incorporate the agreed environmental flow requirements and other measures necessary to maintain downstream river functions and minimize adverse impacts on downstream users and ecosystems.
- The Consultant shall assess the environmental and social implications of reservoir sediment management measures, including sediment flushing, sluicing, sediment removal and downstream sediment release, and shall provide the technical information required for the EIA/ESIA Consultant to assess these impacts. Where the selected sediment management arrangement requires specific engineering or operational measures to reduce impacts, these shall be incorporated into the design and operating requirements.
- The Consultant shall coordinate with the EIA/ESIA Consultant regarding the environmental and social implications of construction material extraction. The location, size, capacity and operation of quarries and borrow areas shall consider environmental and social constraints, access requirements, land requirements, rehabilitation requirements and impacts on nearby communities and natural resources.
- The Consultant shall incorporate environmental and social mitigation measures that have direct engineering implications into the relevant drawings, technical specifications, bills of quantities, cost estimates and construction planning documents. Such measures shall not be treated as separate or optional requirements where they form part of the approved project design.
- The Consultant shall ensure that changes to the engineering design arising during Stage 1 or Stage 2 are communicated promptly to the EIA/ESIA Consultant so that the environmental and social assessment remains consistent with the final project configuration. Any material

changes in dam height, dam type, reservoir extent, diversion arrangement, intake location, construction footprint or other major project component shall be reviewed jointly with the EIA/ESIA Consultant.

- The Consultant shall review the approved EIA scoping/ToR and subsequent EIA/ESIA findings relevant to the engineering works and shall ensure that the final design is consistent with the conditions and commitments arising from the applicable environmental approval process. Where the EIA/ESIA identifies additional engineering studies or design measures, the Consultant shall incorporate these requirements into the appropriate engineering activities.
- The Consultant shall participate in relevant stakeholder consultations, public consultations and technical meetings organized as part of the EIA/ESIA process where engineering input is required. The Consultant shall provide technical explanations regarding the proposed dam, reservoir operation, alternatives, construction activities, downstream flow regulation and other engineering matters within its scope.
- The Consultant shall maintain an Environmental and Social Design Compliance Matrix identifying each environmental and social requirement having an engineering implication, its source, the responsible discipline, the corresponding design response, location in the drawings/specifications/cost estimates and status of implementation. The matrix shall be updated throughout Stage 1 and Stage 2 and submitted as part of the relevant reports.
- The Consultant shall account for engineering requirements of EIA findings in close coordination with separate EIA consultant team. Also reference to approved EIA scoping documents shall be made.
- The Consultant shall ensure that the final Updated Feasibility Report and Detailed Engineering Design Report clearly demonstrate how the applicable environmental and social requirements have been incorporated into the selected project configuration and engineering design.

3.1.12 Stage 1–Stage 2 Decision Point

At the completion of Stage 1, the Consultant shall provide a clear technical basis for confirming the scope and configuration to be taken forward into Stage 2. Stage 1 shall therefore conclude with a consolidated Feasibility Update and a formal recommendation on the preferred project configuration.

The Stage 1 recommendation shall, as a minimum, clearly establish:

- preferred dam axis and reservoir configuration;
- preferred dam type and preliminary dam section;
- recommended dam height and reservoir levels;
- updated water availability and dependable yield, including contributions from Kogate and potential supplementary flows from the Kulekhani system;
- updated flood hydrology and design flood criteria;
- updated geological, geotechnical and seismic conditions and the implications for dam foundation and design;
- updated sediment yield, sedimentation rates, storage loss and sediment management requirements;
- principal hydraulic structures and their preliminary design criteria;
- updated environmental and social constraints relevant to the selected configuration;
- updated cost estimate and economic/financial justification; and
- identification of residual uncertainties, additional investigations and design studies required during Stage 2.

The Consultant shall prepare a Stage 1 Feasibility Update and Stage 2 Design Basis/Scope Confirmation Report consolidating the above findings. Stage 2 Detailed Engineering Design shall proceed on the basis of the confirmed preferred configuration and agreed scope. Any significant change to the preferred configuration identified during Stage 2 shall be supported by a technical justification and submitted to the Employer for review and approval.

3.2 Stage 2: Detailed Engineering Design

3.2.1 Detailed Design

3.2.1.1 Dam Design

The scope of consultancy services for detailed engineering design of the dam and its ancillary structures, river diversion structures for source augmentation from Kogate River (and if necessary Kulekhani Reservoir), Dam integrated Sisneri WSP Intake structures, including the preparation of tender documents for construction will include but not necessarily be limited to the following;

3.2.1.1.1 General Requirements

i. Undertake design of all project elements (including any environmental mitigation measures arising from the EIA) in accordance with Nepal laws, codes and standards and relevant

international guidelines, standards and codes;

ii. Prepare and documental design calculations and preparation of a Design Report;

iii. Prepare design and working/shop drawings for various components of the Works and obtaining approval in respect thereof from the client, inclusive of incorporation of all modifications, alterations, changes, etc. that may be required to be carried as directed;

iv. Prepare Bidding Documents including Technical Specifications as per standard format for large civil works;

v. Implement a quality assurance (QA) program, including preparation of a QA Plan that will cover roles and responsibilities, quality control (QC) testing of materials and other components of the Works, documentation and reporting requirements, corrective actions as well as undertaking all QC testing as specified or directed;

vi. Preparation of Operation, Maintenance and Surveillance Manuals and Dam Risk Assessment, Dam Surveillance, Emergency Preparedness and Emergency Response Plans.

vii. Any other item of work as may be required to be carried out for completing the design of the project works, including all necessary interfaces works with the client in all respects in accordance with the provisions of the contract and/or to ensure the structural stability and safety of the works;

3.2.1.1.2 Design Standards, Regulations, Requirements, Guidelines and Codes

i. All consultancy services shall be performed in accordance with Nepal laws, codes and standards. The hierarchy of documents, procedures and regulations shall be:

   a. Nepal statutory requirements

   b. Nepal codes and standards

   c. International guidelines, standards and codes

ii. The Dam shall be designed in accordance with modern International Dam Design Technical Bulletins and Guidelines. The following are recommended, albeit recognizing that other International Guidelines, standards and codes may be considered, subject to approval by the Client:

a. Canadian Dam Association (CDA) Dam Safety Technical Bulletins published in 2007 that cover:

- Inundation, Consequences, and Classification for Dam Safety
- Flow Control Equipment for Dam Safety
- Public Safety and Security Around Dams
- Dam Safety Analysis and Assessment
- Hydro-technical Considerations for Dam Safety
- Seismic Hazard Considerations for Dam Safety
- Geotechnical Considerations for Dam Safety
- Structural Considerations for Dam Safety

b. International Commission on Large Dams (ICOLD) Bulletins including but not limited to (based on dam type):

- ICOLD Bulletin 141 (2010) Concrete Face Rock Fill Dams Concepts for Design and Construction
- ICOLD Bulletin 126 on Roller (2003) Compacted Concrete dams
- ICOLD Bulletin 148 (2010) Selecting Seismic Parameters for Large Dams
- ICOLD Bulletin 58 (1987) Spillways for Dams
- ICOLD Bulletin 150 Cutoffs for Dams
- ICOLD Bulletin 91 (1993) Embankment Dams. Upstream Slope Protection
- ICOLD Bulletin 183, Selection of dam type

iii. If weathered nature of the foundations found, special consideration will be required to be given to the potential for internal erosion and filter design. Design guidelines on this subject are provided in various textbooks and technical publications including Fell, R., MacGregor, P., Stapledon, D., Bell, D. (2005) Geotechnical Engineering of Dams, Balkema

iv. The applicable standards for design and construction of structural concrete are as follows:

a. AS 3600 Concrete Structures

b. AS3610 Formwork for Concrete

c. AS3972 Portland and Blended Cements

d. AS1012 Methods of Testing Concrete

e. AS2758 Aggregates and Rock for Engineering Purposes

f. AS4671 Steel Reinforcing Materials

v. The applicable standards for testing of soils and aggregates are as follows:

a. AS1289 Methods of Testing Soils for Engineering Purposes

b. AS1141 Methods for Sampling and Testing of Aggregates

c. AS1726 Geotechnical Site Investigations

d. AS4133 Methods of Testing Rocks for Engineering Purposes

vi. The Consultant shall prepare draft Dam Management System Plans, covering Operation, Maintenance and Surveillance and Emergency Preparedness and Emergency Response. These Plans shall be in accordance with modern International Dam Technical Bulletins and Guidelines. The following are recommended, albeit recognizing that Other International Guidelines, standards and codes may be considered subject to approval by the Client:

a. Canadian Dam Association (CDA) Dam Safety Guidelines published in 2007

b. International Commission on Large Dams (ICOLD) Bulletins including:

- ICOLD Bulletin 60 (1988) Dam Monitoring-General Considerations
- ICOLD Bulletin 138 (2009) Surveillance: Basic Elements in a "Dam Safety" Process
- ICOLD Bulletin 158 (2010) Dam Surveillance Guide
- ICOLD Bulletin 130 (2005) Risk Assessment in Dam Safety Management.

vii. The review of seismic hazards shall be undertaken in accordance with the following ICOLD Bulletins:

a. ICOLD Bulletin 72 (1989) Selecting Seismic Parameters for Large Dams-

Guidelines

b. ICOLD Bulletin 112 (1998) Neotectonics and Dams

c. ICOLD Bulletin 148 (2012) Selecting Seismic Parameters for Large Dams-Guidelines, Bulletin 72 Revision

3.2.1.1.3 Design Criteria

For every component of the project the Consultant shall formulate, prior to detail designing, the design criteria 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 KVWSMB for review, comments and approval and shall not be modified unilaterally after it has been approved.

Loads to be analyzed: The following loads should be considered in the analysis.

- Dead load
- Headwater and tailwater pressures along with silt pressures
- Uplift pressures
- Temperature, ice, and wind pressure
- Earthquake forces
- Wave pressure
- Reaction of foundation (deformation induced load to dam section)
- Internal hydrostatic pressures

The design should be done for following **load combinations:**

- Usual load combination (Normal reservoir elevation, dead loads, earth pressures, uplift, silt, ice, wind wave pressures, temperature, and tailwater).

- Unusual load combination (Maximum reservoir elevation, dead loads, uplift, silt, ice, temperatures, and tailwater, plus the load due to wind waves).
- Extreme load combination (Normal reservoir elevation, dead loads, uplift, silt, ice, temperatures, and tailwater, plus the load due to the Maximum Credible Earthquake).
- Any other load combinations as seen appropriate by the consultant and design team.

Factor of Safety: The consultant should establish factor of safety for material, load combinations, and at all dam elevations.

Stability analysis: The basic safety requirements of a dam section for all load conditions of loading include:

- That the dam is safe against overturning at any horizontal plane within the structure, at the base, or at a plane below the base.
- That dam is safe against sliding on any horizontal or near-horizontal plane within the structure at the base or on any rock seam in the foundation.
- The allowable unit stresses in the concrete or in the foundation material shall not be exceeded.

The stability analysis should show that the dam section wells during all locations with ample factor of safety. The analysis should also show that the differential movements (both vertical and horizontal) of the adjacent dam sections are within acceptable limits.

Stress analysis: A stress analysis of gravity dams must be performed to examine the magnitude and distribution of stresses throughout the structure and foundation during multiple static and dynamic load conditions. The analysis should include twist method of analysis for grouted and un-grouted joints. Detailed finite element analyses should be conducted for linear elastic static, and dynamic analyses. The study must include nonlinear analyses to account for the dam foundation interactions. The gravity dam should survive an MCE without a catastrophic failure that would result in loss of life or significant damage to property. Additionally, the dam should be capable of resisting the OBE within the elastic range, remain operational, and not require extensive repairs. For this purpose, two- and three-dimensional finite element programs (such as, Ansys, SAP, Adina, etc.) can be used.

Risk Assessment: Any infrastructure inherently come with deterministic and probabilistic risks. While the deterministic risks are inherently considered in safety parameters of design calculations, probabilistic risks, which mostly arises from uncertainties, may or may not be included in the design safety and impact analysis. Dam analysis is never free of uncertainties and hence chance of failure is never zero. Similarly, probability of other secondary risks and impacts is not governed by certainty. Some of these, Probable Risk/Impact/Issues associated with the dam, inter alia, are as follows:

- Dam breach of upstream Dam Infrastructures, may exceed PMF
- Flooding risk to neighboring areas in case of PMF level rain events.
- Upstream Land use change due to Urbanization (after reservoir construction), Construction of Transport Infrastructure, etc may considerably change discharge and sedimentation parameters.
- Weathering of feldspar rich rock in the vicinity of dam may trigger shallow land slide along neighboring slopes.
- reservoir may change soil saturation level of neighboring areas and leave them susceptible to landslide.
- Loss of forest, agricultural, infrastructure and housing area within inundation and neighboring high-risk areas.
- Loss/Change of biological environment in and around the reservoir area (aquatic, aerial and terrestrial)
- Social and Environmental risk associated with construction activities will be considerable
- Dam breach and sediment flushing impact to downstream infrastructure such as Fast Track and Mandu Hydropower
- Dam breach impact on downstream area in regional and local scale.
- Climate change and its impacts may exacerbate all associated risks.

The consultant should assess the above-mentioned risks and any other additional risks directly or indirectly related with the dam at local and regional level. The consultant shall include measures to or mitigate eliminate unacceptable risks to acceptable limit.

3.2.1.1.4 Environment Consideration

The consultant shall work in co-ordination with the project EIA team to evaluate the physical, biological and socio-economic impacts of the dam construction. The consultant shall address any mitigation measures, that needs to be incorporated in design of dam, so as to minimize those impacts.

3.2.1.1.5 Detail Dam Design

The major activities to be performed by the Consultant shall include but not limited to the followings:

i. Finalize the conceptual design by identifying potential area for dam construction and selecting the best location. The consultant shall carryout optimization studies including optimization of project with dam height, dam types and other necessary hydraulic structures. The selected layout should include:
    - Cross section of dam at overflow and non-overflow locations.
    - Dam axis with overflow and non-overflow section
    - Determine the freeboard for the dam to account for reservoir elevation during design flood, wave actions and, wave run-ups during high winds.
    - Crest elevation (above design flood elevation plus freeboard) and crest width
    - Dam face slopes (upstream and downstream)
    - Outlet works (primary and secondary)
    - Drainage, and accesses to galleries
    - Primary and secondary spillways (spillway location, number, and chute/tunnel).
    - Energy dissipators
ii. 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. The consultant must provide the values major properties of the material including:

- Unit weight
- Strength (compressive, tensile, and shear strengths)
- Elastic properties (modulus of elasticity, creep, and Poisson's ratio)
- Thermal properties (coefficient of thermal expansion, thermal conductivity, specific heat, and diffusivity).

iii. As necessary, carry out the study of seismic hazard and the seismic design standard applicable to the dam;

iv. Check the hydrological parameters applicable to design of the dam components (e.g. diversion design flood, spillway design flood, reservoir filling and operational, etc.), accounting for rainfall data from the nearby gauge of proposed dam;

v. The Consultant shall carry out hydraulic structural design of each components including but not limited to main dam, source augmentation structures, spillway facilities, intake, pipeline, and other associated structures. The task shall also include design of access roads and bridges (if any), cofferdams, diversion tunnels, electrical and Mechanical equipment, and other components.

vi. The consultant shall perform the initial reservoir filling test of the dam to perform the functions for which it was designed and the consultant should provide following lists:

- Preliminary performance thresholds (seepage quantities, uplift, internal phreatic levels, and movement).
- Reservoir regulations during project construction stage(s)
- Water control plan.
- Project surveillance and monitoring plan.
- Emergency Action Plan. It should be accompanied by the dam break studies (arrival of flood, flood peak flow, peak elevation, and receding time at key locations).
- Public affairs and communications

vii. The consultant must provide the following details of intake structures along with the pump. The designed structures/electrotechnical installations shall be well coordinated with water transmission pipe design commissioned as separate consulting service.

- Detail design of intake structure.
- Number and type of pumps
- Specific speed of selected pump
- Pump operating head
- Net positive suction head and minimum operating water surface elevation to avoid cavitation.
- Priming of pumps
- Sump geometry (minimum water volume, pump separations, avoidance of air-entertainment, uniformity of flow, and avoidance of turbulence)
- Surge protection devices on the downstream of pumps (vacuum breakers, surge tanks, etc)
- Diameter and material of discharge pipe.

viii. 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. The quantum of construction power required shall be assessed and the method of supplying temporary power shall be determined and recommend appropriate option along with cost estimates and other details if necessary.

3.2.1.2 Hydraulic Structures and related Electromechanical Components

The consultant shall carryout hydraulic model studies of spillway, intake and other structures as applicable to finalize the design. The design of spillway must include:

- Type of spillway (gated or ungated). If gated the gate width and height and pier width supporting the gates should be specified.

- Inlet geometry (open channel Ogee weir, or orifice inlet)
- Number of spillways
- Crest elevation, crest length
- Stage discharge for each spillway
- Elevation of discharge point for each spillway
- Chute type (open chute, stepped, morning glory, tunnel)
- Energy dissipator type (USBR type, flip bucket type, or fixed cone type)
- Cavitation of surfaces and aerator need (determined based on operation duration, concrete type, and cavitation index)
- Details of longitudinal and transverse joints along the spillway profile
- Design of underdrain systems to collect and discharge seepage flows through joints.
- Flow depths, bulking of flows due to air entrainments.
- Lifts and drag forces along flow path.
- The consultant should use advanced commercially available computational fluid dynamic tools, such as Ansys Fluent, Flow3D, or Star CCM along with scaled physical models to refine the design. These studies should be used to avoid flow separation areas, vortex formation at inlet, cavitation studies along flow path, and adequacy of energy dissipators.

The consultant should design trash racks, gates, valves, pipes, and energy dissipators to safely regulate outflows from the dam. The design includes location of outlet, vertical position, number of outlets (primary and secondary), purpose (to meet the minimum downstream release), and to meet the water supply demands. The design should summarize:

- Location of outlet (numbers and types).
- Elevation at inlet and elevation at discharge location.
- Size and length of pipe and material for each outlet.
- Trash rack and size of flow control device (gate or valves) at inlet.

- Type of valve at the outlet.
- Energy dissipator at the outlet.
- Means to control of surges and water hammer (operation speed, location of vacuum breakers, locations of hydropneumatics tanks or surge towers, strengthening of bypass pipes, steel grades and locations of pressure release valves). The design should be verified using advanced numerical tools such as Bentley HAMMER.
- Controlling vibrations of gates (for the gates of this head either advanced CFD modeling or a scaled physical modeling of the gates are required to mitigate gate vibration problems).
- Air demand of the gate.
- Provide anchorage forces for the valves.
- Stage discharge curve for gates.
- Stage-discharge curves for emergency drawdown of the reservoir.

3.2.1.3 Instrumentation

The consultant should recommend the instrumentation plan including recording and acquisition remotely using SCADA. The planned instrumentations should consist of the following:

- Layout of electrical and fiberoptic wires to acquire the data.
- Strain and deflection measurement
- Expansion and contraction measurement
- Stress measurement
- Vertical pressure and uplift measurement
- Hydraulic leakage measurement (locations of piezometers and flow measurement weirs)
- Bending, tilting and deflection measurement
- Horizontal and vertical alignment measurement
- Movement indicators (at conduit joints, outlet works, and intake tower)

- Temperature measurement
- Seismic time history and magnitude measurement
- Fire and rescue instruments

3.2.1.4 Access Road and Camp Staging

The Consultant shall undertake design studies on the access road and camp/staging areas, accounting for the following:

a. Plant requirements for quarrying and dam construction

b. Peak labor force

c. Areas required for workers camp, contractors/consultants' offices and construction staging (i.e. for plant, materials storage, concrete batching plant, etc.) – and identify appropriate locations (subject to SNNP approval)

d. Design requirements for access road upgrading (i.e. accounting for transporting plant and materials to site) – proposed requirements are to be submitted to the client for approval. The ancillary facilities are expected to be handed to clients to utilize those facilities during the operation phase.

e. The current access road to the dam site is anticipated to be submerged by the dam's inundation. Thus, the consultant is required to complete a detailed design for an alternate access road. The access road should be planned to accommodate both the needs of local traffic and the access requirements for the dam after completion of construction phase.

3.2.1.5 Power Supply

Power supply system for operation and construction stage shall be assessed and supply systems shall be designed accordingly. The scope of work for power supply system shall also include HV Transmission from nearest NEA Tapping point. Previous studies related to HV Transmission for operation of Water Supply System Components are to be referred and coordinated with.

3.2.2 Estimation

The quantity and cost estimate shall be prepared for the entire project. The Consultant shall prepare detailed quantity estimate based on detailed design and tender drawings for the purpose of cost estimate and preparation of Bill of Quantities (BOQ). The Consultant shall prepare an Engineer's cost estimate based on the district rate, quantity estimate, and drawings. The estimates shall be suitable for presenting to international/national financing agencies for funding.

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.

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.

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. Customs duties, taxes, fees, royalties, and levies due in Nepal shall be presented separately. The cost for all necessary equipment, switchgear, gates, and so on shall be based on prevailing market prices/district rate.

The Consultant shall add an appropriate sum as Price and Physical Contingency to allow for potential physical or design conditions requiring additional funding for the execution of the project of this nature and for unforeseen conditions.

3.2.3 Construction Planning and Schedule

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. This plan shall serve to establish construction schedules, with start and finish and interim critical milestone dates.

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.

3.2.4 Institutional Arrangement for Project Implementation

The Consultant shall assess the institutional arrangement required for implementation of physical project of this magnitude. 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.

3.2.5 Design Drawings and Specification

The Consultant shall prepare detailed drawings that elaborates the findings/design of all field investigation and analysis, numerical modellings, hazard risk analysis, construction sequencing and detail design of dam and its components, intake and its components at suitable scales. The design drawings shall be prepared in electronic format using a template approved by KVWSMB. The specifications for the drawings shall be based on relevant international practice.

3.2.6 Tender Document

The Consultant shall prepare complete Tender/Bidding Documents complete with tender drawings with appropriate details and specifications, BoQ and other necessary documents for bidding purpose considering adequate packaging/slicing of works. The title and contents of the Tender Documents shall be finalized in consultation with KVWSMB.

4 Organization, Communication and Reporting

The Consultant shall provide a Project Organization Chart, identifying lines of communications between the Consultant and investigation contractors, Peer Reviewer and the Client;

The Consultant shall submit to the client the following documents, to match the timelines set out in this TOR (and to be set out in the Project Schedule to be prepared by the Consultant):

4.2 Inception Report

Within 30 days from mobilization, the Consultant shall prepare and submit a draft inception report to the Client. The draft inception report should include appropriate review of proposed tasks and objectives of the TOR, contract documents, and other documents and information as required related to the work to be carried out. The draft inception report will include a proposed work program including schedule of personnel, and will identify issues which require attention of the authorities for decision. The Client will provide its comments on the draft inception report and the consultant will incorporate these comments and finalize the Inception Report within 2 weeks of receipt of the comments.

In the schedule of the personnel, the duration of the presence of the international experts in Nepal, shall be clearly mentioned, in compatible with the schedule of the reporting / deliverables stated in the para 4.15 as well as 'preferable duration requirements' stated in the para 5.1

4.3 Monthly Progress report

The Consultant will prepare Monthly Progress Reports based on a format to be agreed between the Client and the consultant. The Monthly Progress Reports will be submitted within 1 week of the end of each month and will summarize the major issues and problems affecting or likely to affect implementation of the work, including the work of the contractors and will recommend action to overcome any problem identified.

4.4 Topographic Survey Reports

The consultant will prepare and submit detailed topographic survey reports, as part of First Field Report. The report shall be submitted within 4 months from start of assignment along with First Field Report and along with Final Field Report 8 months after signing of contract.

4.5 Geological Mapping Report

This shall include Regional, Engineering Geological and Geology Survey of Project Area

Regional Geological Mapping, Geological Mapping & Engineering Geological Mapping of the Project Area, Detailed Engineering Geological Survey & mapping and Geomorphologic & Geological Hazard Mapping of the project area along with delineation of area for construction

material source and muck disposal. The report shall be submitted within 4 months from start of assignment along with First Field Report.

4.6 Drilling/Testing Reports

The consultant will prepare and submit detailed reports of the drilling and site testing. The reports will contain results from drilling and site testing; results from laboratory testing; and machine excavator trenching and compaction trials. The report containing tests relevant for Feasibility Update shall be submitted within 4 months from start of assignment along with First Field Report. The tests as per requirements of Detailed Design shall be submitted with Final Field Report within 8 months from signing of contract.

4.7 Hydrological Reports

The consultant will prepare and submit detailed report elaborating all hydrological field data, their analytical studies and their inferences. The reports will also contain detailed description of various modelling/simulation techniques employed, their output and inferences. The intermediate hydrological report should be submitted within 4 months from start of assignment along with First Field Report and Final Report shall be submitted with Final Field Report within 8 months from start of contract.

Field data related to hydrology and sediment shall be collected through out consulting service duration and related monthly report shall be furnished as per schedule for Monthly Progress Report.

4.8 Optimization Study

The draft Optimization Study Report will be presented to the Client along with selection of dam type, configuration, material, etc. elaborated in **3.1.9 Optimization Study.** The reports should be submitted within 5 months from start of assignment as a part of Draft Updated Field Report. After receiving comments on the draft report that final report shall be submitted within 1 month of receiving the comments.

4.9 Economic/Financial Analysis Report

This shall be prepared and submitted as per requirements outlined in **0 Based on the findings** of field investigations and the review of previous studies, the Consultant shall undertake a comprehensive and systematic optimization study of the proposed Sisneri Dam and associated

reservoir system. The optimization shall consider technical, hydrological, geological, geotechnical, seismic, hydraulic, construction, environmental and social, economic, financial and dam-safety aspects, and shall include, but not necessarily be limited to, the following:

- Assessment of alternatives: Assess alternatives for the dam and reservoir in terms of all relevant parameters, including dam axis, height, orientation, reservoir operating levels, storage capacity, dam type, spillway and outlet arrangements, and potential water-supply augmentation through diversion structures from other watersheds, including the potential Kogate diversion. The assessment shall also consider the interfaces with the WSP intake and other associated water-supply components. Field investigations shall be planned and undertaken to provide sufficient information for the assessment of all technically feasible alternatives.
- Systematic optimization: Undertake a systematic optimization of the proposed Sisneri Dam and reservoir configuration, considering alternative dam axes, dam heights, reservoir operating levels, reservoir capacities, dam types, spillway arrangements, outlet arrangements and water-supply augmentation options. The optimization shall be based on the results of the Stage 1 hydrological, sedimentological, geological, geotechnical and seismic investigations and shall not assume that the currently preferred 65 m dam configuration is final.
- Dam height and reservoir optimization: Specifically assess the relationship between dam height, reservoir storage, reliable water-supply yield, inundation, geological and geotechnical conditions, sedimentation, dam safety, environmental and social impacts, construction cost, operation and maintenance cost and overall project economics. Alternative dam heights shall be assessed sufficiently to establish the optimum configuration and determine whether an increase or reduction in dam height provides a technically, economically, environmentally and socially justified improvement in project performance. The assessment shall establish the relationship between dam height, storage, reliable yield and incremental project benefits and costs.
- Dam type alternatives: Assess alternative dam types appropriate to the site conditions, including Conventional Mass Concrete (CVC) Gravity Dam, Roller Compacted Concrete (RCC) Gravity Dam, and Rockfill Dam, including Earth Core Rockfill Dam (ECRD) and/or Concrete Face Rockfill Dam (CFRD), where technically feasible. The assessment shall

consider geological, topographical, seismic, hydrological, construction, material availability, environmental and social, economic and dam-safety conditions.

- Dam type comparison: The comparison of feasible dam types shall consider foundation requirements, abutment conditions, seismic performance, seepage control, stability, deformation, construction methodology, availability of construction materials, construction duration, diversion requirements, environmental and social impacts, capital cost, operation and maintenance requirements, construction and operational risks and overall life-cycle cost. The current preference for a Concrete Dam shall be treated as a preliminary preference only and shall be validated through the Stage 1 comparative assessment.
- Preliminary dam configurations: For each technically feasible dam type and shortlisted dam height, develop preliminary dam sections and principal structural configurations and assess their suitability considering the applicable seismic hazard and design criteria. The assessment shall consider seismic stability, deformation, foundation conditions, reservoir-induced hydrodynamic effects and other relevant seismic loading effects. The results shall contribute to selection of the preferred dam type, dam height and principal dam section at the end of Stage 1.
- Dam Type Selection Report: Prepare a standalone Dam Type Selection Report as a component of the Stage 1 Optimization Study. The report shall present a systematic comparison of the technically feasible dam types, including CVC Gravity, RCC Gravity and Rockfill Dam, including ECRD/CFRD where applicable, together with the assessment of alternative dam heights and preliminary dam sections considering seismic loading. The report shall document the geological, geotechnical, seismic, hydraulic, structural, construction, environmental and social, economic, dam-safety and life-cycle considerations supporting the recommended dam type and dam height. The report shall clearly identify the advantages, limitations, risks and uncertainties associated with each alternative.
- Reservoir operation and yield optimization: Integrate the findings of the Reservoir Operation Plan and water-balance assessment into the optimization study. The Consultant shall assess the relationship between dam height, reservoir storage, operating levels, sedimentation, dependable yield, dry-season supply, flood storage and downstream/environmental flow requirements. The assessment shall establish a safe and realistic yield trajectory over the

project life and shall consider the effects of alternative dam heights and storage configurations on project performance and viability.

- Coordination with other consultants and project components: Maintain continuous coordination with the consultants responsible for the detailed design of the water-supply components and the EIA/ESIA processes being undertaken under separate consultancy services. The optimization shall consider the interfaces between the dam, reservoir, intake, Kogate diversion, pumping arrangements, transmission system, treatment facilities, Sainbu Reservoir and the existing downstream water-supply system. Relevant findings of the approved EIA scoping documents and subsequent environmental and social studies shall be incorporated into the optimization.
- Construction materials: Assess the suitability, availability, quantity and quality of construction materials required for the principal dam alternatives, including concrete aggregates, rockfill, earthfill and other relevant materials, and consider the implications for quarry development, transportation, processing and construction cost.
- Seismic hazard and design criteria: Undertake and/or utilize the seismic hazard assessment and seismic design criteria established under the project studies. The optimization shall ensure that alternative dam types, heights and principal sections are assessed against the applicable seismic hazard, loading and performance requirements.
- Hydrological design parameters: Verify the hydrological parameters applicable to the optimization and preliminary design of the principal dam components, including diversion design flood, spillway design flood, reservoir filling conditions, operational conditions and relevant extreme flood conditions, using the adopted hydrological datasets and rainfall information from nearby and other representative gauges.
- Spillway and outlet optimization: Assess and optimize the spillway configuration, capacity, location, crest level, discharge arrangements and energy dissipation system, together with the principal outlet arrangements, considering flood safety, reservoir operation, sediment management, constructability, seismic conditions and dam safety.
- Dam risk assessment: Incorporate the findings of the preliminary Dam Risk Assessment into the optimization. The assessment shall consider identified failure modes, flood consequences, geological and seismic hazards, sedimentation risks, reservoir rim instability and other relevant dam-safety risks. The Consultant shall assess how alternative dam configurations and

appurtenant structures affect the overall risk profile and identify appropriate risk-reduction or remedial measures.

- Construction planning: Based on the preferred alternatives and optimization findings, prepare a preliminary construction plan, including construction sequence and program, construction methods, plant, equipment, materials and labour requirements, temporary works, diversion arrangements and quarry development requirements.
- Project implementation plan: Prepare a project implementation plan in consultation with the Client, identifying the principal implementation stages, interfaces, approvals, procurement requirements, construction activities and key implementation risks.
- Cost estimates: Prepare line-item cost estimates for the principal alternatives considered under the optimization study, including capital and operation and maintenance costs. The cost estimates shall, as applicable, include dam and foundation works, spillway and energy dissipation arrangements, outlet works, intake and diversion structures, tunnels/pipelines, access works, power supply, construction facilities, land acquisition/resettlement implications, environmental and social mitigation measures, and operation and maintenance requirements.
- Comparative economic and financial assessment: Undertake a comparative economic and financial assessment of the principal alternatives to support selection of the preferred configuration. The assessment shall consider the incremental costs and incremental water-supply benefits associated with alternative dam heights, dam types, reservoir capacities and augmentation/diversion options. Where applicable, the assessment shall include economic and financial indicators such as EIRR, FIRR and NPV, together with appropriate sensitivity and scenario analysis.
- Economic and financial sensitivity: The sensitivity and scenario analysis shall consider key uncertainties and variables affecting project viability, including hydrological inflows, climate-change scenarios, sedimentation and storage loss, water-supply demand, construction costs, operation and maintenance costs, electricity prices, bulk water tariffs and other relevant assumptions. Where applicable, the analysis shall also consider the implications of different cost-sharing or financing arrangements, including any potential viability gap funding or similar mechanisms.

- Kogate diversion assessment: Undertake a preliminary hydraulic and water-availability assessment for the Kogate diversion option to establish the realistic achievable diversion volumes to the Sisneri Reservoir. The assessment shall consider the seasonal and annual flow regime of Kogate, available water after maintaining applicable environmental or downstream flow requirements, intake/offtake capacity, conveyance capacity, sediment and debris conditions, flood conditions, hydraulic losses, operational constraints and other relevant limitations. The Consultant shall distinguish between theoretical diversion capacity and realistic diversion volumes under dry, normal and wet hydrological conditions. The resulting realistic diversion volumes shall be incorporated into the reservoir water balance, yield assessment, optimization and economic analysis.
- Kogate economic and technical justification: For the Kogate diversion option, assess the incremental water-supply benefit against the additional capital and operating costs, geological and geotechnical risks, sediment load, environmental and social impacts, construction requirements and long-term operational requirements. The Kogate diversion shall be retained only where the overall assessment demonstrates that it provides a technically feasible, environmentally and socially acceptable, and economically justified contribution to the project.
- Catchment and water availability: The optimization shall consider the existing Kulekhani Reservoir and its operating regime, the Sim/Sin Khola Intake and Chakhel Diversion, the Sisneri catchment and the potential Kogate diversion. The Consultant shall establish the actual net water availability at the project site and shall ensure that catchment areas and flows already diverted to the Kulekhani Hydropower system are not double-counted. The effects of existing and proposed diversions and operating regimes shall be incorporated into the water balance and yield assessment.
- Sensitivity and uncertainty analysis: Undertake sensitivity and uncertainty analysis for key parameters influencing project performance and selection of the preferred configuration, including hydrological inflows, sediment yield and storage loss, dam height, reservoir storage, water-supply demand, construction costs, operation and maintenance costs, climate-change scenarios and other material uncertainties. The Consultant shall identify the parameters having the greatest influence on project viability and the preferred configuration.

- Optimization Report: Prepare the Optimization Report presenting the complete results of the optimization study. The report shall clearly identify the alternatives investigated, technical and economic criteria adopted, comparative results, key risks and uncertainties, and the preferred dam axis, dam height, dam type, reservoir configuration, spillway and outlet arrangements and any required flow augmentation/diversion scheme.
- Basis for Stage 2: The Optimization Report shall provide sufficient justification for each selected parameter and establish the design basis for Stage 2 detailed design. The Consultant shall also identify the investigations, studies, surveys, modelling and design development that remain necessary during Stage 2 for the selected configuration. Any unresolved uncertainties that could materially affect the selected dam configuration, cost, safety or performance shall be clearly identified together with recommendations for their resolution.
- Stage 1 decision: At the completion of Stage 1, the Consultant shall recommend and, subject to Client approval, confirm the selected dam type, dam height, principal dam section, reservoir configuration and principal appurtenant works. The recommended dam type shall be established before commencement of Stage 2 detailed dam design. Although a Concrete Dam is currently preferred, any recommendation to adopt an alternative dam type shall be supported by geological, geotechnical, structural, seismic, construction, economic, environmental and social, and dam-safety considerations.
- Stage 2 changes: Stage 2 detailed design shall be based on the configuration approved by the Client at the completion of Stage 1. Any fundamental change to the selected dam type or principal configuration during Stage 2 shall only be proposed where subsequent investigations identify a material technical, geological, geotechnical, safety or other constraint that could not reasonably have been established during Stage 1, and shall be subject to prior approval of the Client.
- Independent review: The Consultant shall finalize the Optimization Report incorporating comments and recommendations from the Client and the designated independent reviewer/Panel of Experts, as applicable. The final Optimization Report and Dam Type Selection Report shall constitute the principal technical basis for proceeding to Stage 2 detailed design.

Economic and Financial Analysis. The draft version shall be submitted along with Draft Updated Feasibility Report (5 months after contract) and Final Version shall be submitted with Final Updated Feasibility Report.

4.10 Draft and Final Detailed Design Reports

The consultant will prepare draft detailed engineering design report to be submitted within 13 months from start of assignment. The draft report will be reviewed by the Client and comments from the Clients will be incorporated in the final detailed design report. The final report incorporating comments from the Client must be submitted within 1 month from the receipt of comments from the Client. The draft and final reports should present adopted design standards, rationale for major design decisions, design methodology, and include all drawings. estimation and specifications for physical works for the works along with construction schedule and planning as stated in 3.2.3 Construction Planning and Schedule.

4.11 Auto CAD Design Drawings and other Documents

All plans and drawings shall be prepared using Computer-Aided Design (CAD) software. The drawing should be prepared and printed as required in the appropriate formats for incorporation in bidding documents, as well as for project execution. After completion of the survey works and detailed design, all electronic files of reports, plans and drawings and other relevant documents shall be turned-over by the Consultant to the client. The drawing is to be submitted along with Draft/Final Detailed Design Report

4.12 Project Implementation Plan

This shall be prepared and submitted as per requirements outlined in **3.2.4 Institutional Arrangement for Project Implementation** and shall be submitted along with Final Report

4.13 Operation and Maintenance and Surveillance Manuals

The consultants will prepare a operation and maintenance manual for all project assets, as well as a Surveillance Manual, Dam Surveillance, Dam Risk Assessment, Emergency Preparedness and Emergency Response Plans. The O+M, Surveillance, Dam Surveillance manuals, Dam Risk Assessment and Emergency Preparedness and Response Plans will be submitted **with the Draft / Final Detailed Design Report.**

4.14 Bidding Documents

The consultant will prepare draft Bidding Documents for contracts to be procured under the project will be submitted **along with Draft / Final Detailed Design Report**. Final bidding documents will be submitted at the same time as the final report. Bidding documents prepared in accordance with standard bidding document standards for International Competitive Bidding and National Competitive Bidding procedures as applicable. The Document set shall also include Recommended Construction Schedule and Planning, and other Forms and Standard Document Formats.

4.15 Draft and Final Report

The consultant will prepare and submit a draft Final Report within 13 months from start of assignment. The report will contain all results of entire scope of services related to field investigation, data analysis and inferences, modelling and simulations, detailed design calculation and drawings, estimation, the draft report will be reviewed by the Client and comments from the Client will be incorporated in the Final Report. The Final Report incorporating comments from the Client will be submitted within 1 months from receipt of the comments from the Client.

4.16 Reporting Schedule

Table 2: Reporting Schedule

Submission	Content	Time (After Signing of Contract)
First	Inception Report	1.0 month
Second	First Field Report (as required for updating Feasibility Study Report and shall include the following) • Topographic Survey Report • Geological Mapping Report • Drilling/Testing Report • Hydrological Report	4 months

Submission	Content	Time (After Signing of Contract)
Third	Draft Updated Feasibility Report (including the following) • Summary of First Field Report and its findings • Optimization Study Report • Economic/Financial Analysis Report	5 months
Fourth	Final Updated Feasibility Report	6 months
Fifth	Final Field Report (as required for detailed design and shall include entire scope of works related to field investigation and related study) • Topographic Survey Report • Geological Mapping Report • Drilling/Testing Report • Hydrological Report	8 months
Sixth	Draft Detailed Design Report (including the following) • Design Report • Drawings, Project Implementation Plan • Operation and Maintenance and Surveillance Manual • Bidding Documents	13 months
Seventh	Final Detailed Design Report	14 months
Monthly	Monthly Progress Report	First Week of Every Month

4.17 Review and Approval

The consultant shall make all submissions to the client, and also organize a presentation (power point) to a review committee appointed by the client. The review committee shall give their comments during the presentation and also on the submitted documents in writing. The comments so received shall be duly incorporated in the submitted document and the revised report and submitted within 1 week after receiving the comments.

5 Project Team Composition

The composition of the Consultant's team is set out below.

5.1 Summary of Consulting Services Input

The Sisneri Dam Feasibility Investigation and Detail Design Consultancy will be for a period of 14 months to be provided during the Project implementation. Outline terms of reference for individual specialists are given below in subsequent pages and a summary of specialist inputs is shown in Table below.

Table 3: Summary of consulting services inputs

No.	Position	No. of Personnel	Minimum Person Month	Minimum Stay Duration in Nepal	Qualification
A	**International Professional**				
	Key International Experts				
1	Dam Specialist / Team Leader	1	9.00	80%	Minimum of Master's degree in Civil, Hydropower, Water Resources, Hydraulic, Structural Engineering or related field and Professional certification training related to dam shall be preferred ; Minimum 15 years of general professional experience, including substantial experience in detailed engineering design and construction supervision of concrete dam/CFRD projects. Experience as Team Leader in detailed engineering design or construction supervision of dam projects, with experience in concrete dam/CFRD projects shall be preferred
2	Dam Design Specialist	1	7.50	80%	Minimum Master's degree or equivalent in Civil, Hydropower, Water Resources, Geotechnical Engineering or related discipline. Professional certification training related to dam shall be preferred, Minimum 10 years of general professional experience, including relevant experience in detailed engineering design and construction supervision of concrete dam/CFRD projects.
3	Hydrologist and Sedimentologist	1	2.00	50%	Minimum of Master's degree or equivalent in Civil, Hydrology, Water Resources or related

					discipline. PhD in Water Resources or hydrology related field is an advantage. Minimum 10 years of general professional experience, including relevant experience in hydrology, water resources and sedimentology for concrete dam/CFRD projects.
4	Hydraulic Engineer	1	3.50	50%	Minimum Bachelor's degree in Civil, Mechanical, Hydraulic Engineering or related discipline and preferably Master's degree or equivalent in Hydraulic, Water Resources or related discipline. Minimum 10 years of general professional experience, including relevant hydraulic design experience for concrete dam/CFRD projects.
5	Structural Engineer	1	5.00	50%	Minimum Master's degree in Structural Engineering or related discipline; PhD in Structural Engineering or related field is an advantage. Minimum 10 years of general professional experience, including relevant structural design experience for concrete dam/CFRD projects.
6	Dam Seismic Design Specialist	1	1.50	50%	Master's degree in Structural, Earthquake, Geotechnical Engineering or related field. Professional certification training related to dam modelling or similar shall be preferred, Minimum 10 years of general professional experience and relevant experience in seismic design/analysis of concrete dam/CFRD projects.
7	Project Economist	1	1.50	50%	Minimum Bachelor's degree in Business Studies, Business Administration, Engineering, Economics or related discipline

					and preferably Master's degree in Economics, Finance, Business Administration or similar. Minimum 10 years of general professional experience, including relevant experience in financial analysis, feasibility studies of concrete dam/CFRD projects.
8	Electrical Engineer	1	2.00	50%	Minimum Bachelor's degree in Electrical Engineering or related discipline and preferably Master's degree in Electrical Engineering, Power System Engineering or related field. Minimum 10 years of general professional experience, including relevant electrical engineering experience in concrete dam/CFRD projects.
9	Dam Break Modeler	1	1.00	50%	Minimum Master's degree in Structural, Water Resources, Hydraulic Engineering or related field. Professional certification training related to dam break modelling or similar shall be preferred, Minimum 10 years of general professional experience, including relevant experience in dam-break modelling/analysis for dam projects.
10	Geotechnical Engineer	1	2.00	50%	Minimum Master's degree in Geotechnical Engineering or related field. PhD in Geotechnical related field is an advantage. Minimum 10 years of general professional experience, including relevant geotechnical engineering experience in detailed design/construction supervision of concrete dam/CFRD projects.
11	Mechanical Engineer	1	2.00	50%	Bachelor's degree in Mechanical Engineering or related discipline and preferably Master's degree in Mechanical Engineering or related

					field. Minimum 10 years of general professional experience, including relevant mechanical engineering experience in detailed design/construction supervision of concrete dam/CFRD projects.
	Non-Key International Experts				
	Total of International Professionals' Person Months		**37.00**		
B	**National Professional**				
	Key National Experts				
1	National Dam Specialist / Deputy Team Leader	1	14.00	—	Minimum Master's degree or equivalent in Civil, Hydropower, Water Resources, Geotechnical Engineering or related discipline. Professional certification training related to dam shall be preferred, Minimum 10 years of general professional experience, including relevant experience as Team Leader/Deputy Team Leader in detailed engineering design or construction supervision of dam projects, with experience in concrete dam/CFRD projects.
2	Project Economist	1	4.00	—	Minimum Bachelor's degree in Business Studies, Business Administration, Engineering, Economics or related discipline and preferably Master's degree in Economics, Finance, Business Administration or similar. Minimum 10 years of relevant professional experience in project economic/financial analysis, preferably for large infrastructure or dam projects.

3	Environmentalist	1	8.00	—	Minimum Bachelor degree in Environmental Science, Environmental Engineering, Environmental Management, Natural Resources or related discipline and preferably Master's degree in Environmental Science, Environmental Engineering, Environmental Management, Natural Resources or related discipline. Minimum 10 years of general professional experience, including relevant experience in environmental assessment and management of infrastructure/dam projects.
4	Engineering Geologist	1	10.00	—	Minimum Master's degree in Geology or related physical/natural science discipline; PhD in Geology or related field is an advantage. Minimum 10 years of general professional experience, including relevant experience in engineering geology for dam projects.
5	Hydrologist and Sedimentologist	1	10.00	—	Minimum Master's degree in Civil, Hydrology, Water Resources or related discipline; PhD in Water Resources, Hydrology or related discipline is an advantage. Minimum 10 years of general professional experience, including relevant experience as Hydrologist/Water Resources Expert/Sedimentologist in dam projects.
6	Structural Engineer	1	10.00	—	Minimum Master's degree in Structural Engineering or related discipline; PhD in Structural Engineering or related field is an advantage. Minimum 10 years of general professional experience, including relevant structural engineering experience in dam projects.

7	Hydraulic Engineer	1	6.00	—	Minimum Bachelor's degree in Civil/Hydraulic Engineering or related discipline, preferably with a Master's degree in Hydraulic/Water Resources Engineering or related field. Minimum 10 years of general professional experience, including relevant hydraulic engineering experience in dam projects.
8	Geotechnical Engineer	1	10.00	—	Minimum Master's degree in Geotechnical Engineering or related field. PhD in Geotechnical related field is an advantage. Minimum 10 years of general professional experience, including relevant geotechnical engineering experience in dam projects.
9	Road Engineer	1	5.00	—	Minimum Bachelor's degree in Civil Engineering, preferably with Masters in Transportation/Road Engineering or related field, Minimum 10 years of general professional experience, including relevant professional experience in road infrastructure design and construction.
10	Procurement Specialist	1	3.00	—	Minimum Bachelor's degree in Engineering, Business Administration, Management, Economics, Law or related discipline; preferably with Masters degree in Engineering, Management, Business Administration or related field is preferred. Minimum 10 years of general professional experience, including relevant professional experience in Procurement of various infrastructure projects
11	Electrical Engineer	1	6.00	—	Minimum Bachelor's degree in Electrical Engineering or related discipline, preferably

					with a Master's degree in Electrical/Power System Engineering or related field. Minimum 10 years of general professional experience in electrical design and implementation of infrastructure/dam projects.
12	Mechanical Engineer	1	6.00	—	Minimum Bachelor's degree in Mechanical Engineering or related discipline, preferably with a Master's degree in Mechanical Engineering or related field. Minimum 10 years of general professional experience in mechanical design and implementation of infrastructure/dam projects.
13	Cost Estimator	1	5.00	—	Minimum Bachelor's degree in Civil Engineering or related discipline, preferably with relevant postgraduate qualification/training in Quantity Surveying, Construction Economics, Cost Estimation or related field. Minimum 10 years of general professional experience and Relevant experience in preparation of cost estimates, BOQs and construction cost analysis for infrastructure projects.
14	Senior Surveyor	1	6.00	—	Minimum Bachelor's degree in any field with preferably recognized professional qualification in Surveying/Geomatics or related discipline; Minimum 10 years of general professional experience with substantial professional experience in topographical, engineering and construction surveys and survey data processing.
15	GIS Expert	1	4.00	—	Minimum Bachelor's degree in any field and preferably Master's degree in Geomatics,

					GIS, Geography, Civil Engineering or related discipline. Minimum 10 years of general professional experience with relevant professional experience in GIS database development, spatial analysis, mapping and infrastructure project applications.
	Total of National Professionals' Person Months		**107.0**		

The presence of the international experts in Nepal, as shown in the table above as "Preferable stay duration in Nepal" shall be made compatible with the 4.15 Reporting Schedule, such that the related international experts are in Nepal, during the presentation of the various reports. The consultant shall inform in advance and take approval for every international expert's visit to Nepal from the client along their inputs for the project.

The above key staff composition and estimated total key staff man-month is Client's estimate. The consultants are advised to assess their own requirement and propose their own staff composition and staff input requirement for efficient performance of their job as per the Terms of Reference. If the proposed consultant's team is found inadequate or not sufficient during the performance of the services then additional staff shall be provided by the consultant at their own cost.

5.2 International Key Experts

i. Dam Specialist/ Team Leader

The Dam Specialist /Team Leader will be based in Kathmandu but may be required to travel frequently to the project site. He/she will be responsible for overall management and delivery of the defined tasks of the assignment. He/ she will lead the Consultant's and will be the main point of contact in liaising with the Client on all aspects of the Project. He/she will be responsible for quality assurance, document preparation and coordination, project management and ensuring timely implementation of the assignment. Specifically, the candidate will be responsible reviewing/updating for the following tasks:

- responsible for overall direction of the consultant team, coordination of inputs, and management of individual specialists;
- liaison and communication with the Client, the government and other stakeholders;
- keeping the client updating on the progress of the fieldwork and engineering studies;
- overseeing decisions by the dam engineering team on geotechnical drilling/testing investigation programs;
- overseeing the design and implementation of the QA to the dam engineering inputs and preparation of cost estimates;
- reviewing and updating the hydrological parameters for the dam;
- supervising the engineering design for the access road upgrading;
- supervising the engineering inputs (i.e. as may be needed from any changes to the dam arrangement/details as envisaged earlier if any)
- establishing the project implementation plan
- leading the preparation of the review of the feasibility study and report
- working with the National Procurement Specialist to prepare tender documents for consultancy services to prepare detailed engineering designs for the project works.
- oversee and QA the preparation of contracts for fieldwork activities;

- oversee the execution of the fieldwork activities;
- identify tasks on the critical path and ensure that implementation schedules follow an integrated approach
- Ensure timely delivery of specified reports in a format acceptable to Client.

ii. Dam Design Specialist

The Dam Design Specialist will report to the Team Leader. He/she be responsible for:

- Review of the previous seismic hazard analyses if any;
- Working with the Engineering Geologist to establish the need for dam foundation treatment measures and the availability of suitable local dam construction materials and selecting the appropriate material parameters to be applied in the dam analysis/design
- Working closely with the Engineering Geologist, and Hydraulic Engineer, deciding the type of dam suitable based on the results from the site geotechnical drilling/testing investigation programs;
- Firming-up the dam layout and details including the foundation treatment, embankment zoning, seepage control measures, toe slab, concrete face, parapet wall
- Carrying out dam stability analysis
- Working with the Hydraulic Engineer on the engineering of the diversion facilities, water outlet works and spillway
- Preparation of quantity and cost estimates and construction schedule;
- Preparation of the detailed layout and design of the dam, including static and dynamic stability analysis
- Undertaking quantitative analyses and interpretations to establish proposed fill and filter/drainage zonings, accounting for the properties of the materials available from the proposed quarry.
- Designs and detailing for dam foundation treatment, embankment zoning, seepage control measures, toe slab, concrete face and parapet wall;

- Undertaking analyses to estimate the long-term stress-strain behavior of the dam;
- Following-up of the timely and accurate execution of the design work;
- Ensuring, as the design proceeds, that it represents a safe and economical design that meets all the applicable codes/standards/guidelines;
- Formulation and documentation of the dam instrumentation and monitoring program (e.g. covering the likes of groundwater levels/pressures, seepage, deformation, etc.);
- Work closely with the Structural Engineers on the engineering design of the hydraulic structures of the Project;
- Ensuring compliance with the Project QA/QC Plan;
- Preparation of the Design Report;
- Receiving dam stability analysis results from the Seismic Design Specialist on preliminary CFRD designs, and progressively refining the fill and filter/drainage zonings to reach the optimum safe CRD design
- With the Construction Engineer, identification of plant and materials requirements for construction of the dam and appurtenant works
- Quantity and cost estimate for the dam and preparation of the Bill of Quantities (BOQ) for all electrical components of the Project

iii. Hydrologist and Sedimentologist

The Hydrologist will report to the Team Leader and supervise the work done by the national hydrologist expert. The hydrologist will be responsible to review/update the hydrological analyses. In particular, the tasks will include:

- Design flood hydrograph for the river diversion works during construction
- Design flood hydrograph for the river diversion spillway and spillway routing (the latter working with the Hydraulics Engineer)
- Reservoir initial filling time, for a range of start-of-filling month scenarios
- Availability of supply of drinking water for the optimum installed pumping capacity accounting for existing downstream water uses and in-stream residual flow requirements;

- Evaluations, with the Environmental Specialist, to assess the in-stream residual flow requirement to be released from the dam
- In the foregoing, quantifying the potential impacts of forecast climate change
- Design flood estimates for culverts on access roads
- Sediment rating curve
- Sediment yield from the catchment and subsequent sediment load at the river section in the vicinity of dam site along with evaluation of anticipated residual sediment due to change in land use, landslides occurrence and forest fires and carrying out the modeling of sediment transport through the reservoir
- Reservoir operation policy along with sediment monitoring rule so that optimum water allocation throughout the year will be achieved
- Sediment modeling using suitable software/model including propagation of delta formation and its consequences in storage and water quality
- Sediment Management Plan ensuring long-term sustainable reservoir capacity and option plans to remove or flush out the sediment safely with assessment to social and environmental impacts of the sediment flushing
- River bed variation due to effect of dam construction (particularly downstream river bed degradation and upstream aggradation) and proposing strategies to minimize such effects

iv. Hydraulic Engineer

The Hydraulic Engineer will report to the Team Leader and supervise the work function carried out by the local Hydaulic Expert. He/she will be responsible for:

- Working closely with the Engineering Geologist and Dam Specialist, deciding hydraulic structures of the Project, based on the results from the site geotechnical drilling/testing investigation programs and verification of hydrological basic data.
- Dimensioning and design of the hydraulic structures of the Project such as diversion facilities, spillway and water outlet work, hydropower penstock and hydropower plant
- Advising on construction aspects for the components of the dam and hydraulic

structures, including schedules and plant/labor/materials requirements

- Applying QA checks to project engineering inputs
- Optimizing, dimensioning, analysis and design of the appurtenant hydraulic structures such as river diversion facilities, spillway, water intake structure, hydropower penstock, hydropower plant hydraulic structures, access road culverts etc.
- Hydraulic design of the hydropower plant
- Design of any required erosion protection works
- Preparation of the Hydraulic Design Report

v. Structural Engineer

The Structural Engineer will report to the Team leader and supervise the assignment carried out by the National Structural Engineer. He/she will be responsible for:

- Working closely with the Engineering Geologist and the Dam Engineer in the layout and design of concrete structures appurtenant to the dam (spillway, water outlet, road culverts, bridges etc.)
- Prepare the layout and design the concrete structures of the Project
- Undertaking static and dynamic preliminary stability analysis of the concrete structures
- Applying QA checks to the structural engineering inputs
- Embedment details as needed for mechanical components (egg gates, valves)
- Structural steel components
- Quantity and cost estimate for the concrete structures

vi. Dam Seismic Design Expert

The Dam Seismic Design Expert will report to the Team Leader and will be responsible for providing the following specialist inputs:

- Prepare site-specific seismic hazard analysis, including seeking comment from Government specialists, leading to the finalization of the dam seismic design parameters/standards, including minimum dam stability factors of safety;

- Performing seismic performance analyses on the evolving dam design whereby the Dam Design Engineer can refine the design in order to meet the specified seismic design parameters/standards, accounting also for variations in dam fill material properties (including weathering over time)
- Advising the Dam Design Engineer on design details to be incorporated to enhance dam stability under seismic conditions

vii. Project Economists

The Project Economist will report to the Team Leader and supervise the work performed by the National Project Economist. The Project Economist will be responsible for economic and financial analysis for the proposed dam and assist in the finalization of the feasibility study of the project. In particular, he/she will be responsible for the following tasks:

- Prepare the dam detailed budget and investment plan based on the sub-project cost estimates
- Prepare detail economic and financial analysis of the Dam;
- Identify the economic and financial risks associated with the project subproject(s) and conduct a sensitivity and risk analysis

viii. Electrical Engineer

The Electrical Engineer will be mobilized during Stage 2 and will report to the Team Leader. He/she will work closely with the Mechanical Engineer, to review and update/expand the electrical engineering inputs undertaken in Stage 1. In particular he/she will be responsible for:

- Electrical engineering design of all electrically-powered gates/valves and pump in the dam;
- Preparation of the Bill of Quantities (BOQ) for all electrical components of the Project
- Preparation of electrical single-line diagram for the dam gates/valves and pump;
- Overseeing the preparation of design drawings and specifications for the above-mentioned components
- Other required work as mentioned in the TOR

ix. Dam Break Modeler

The Dam Break Modeler will report to the Team Leader. In particular, his responsibility will include:

- Estimation of analysis parameter for dam breach simulation and the consequent dam breach flood
- Modelling of channel routing of the dam break flood wave, involving model set-up, calibration and running of dam break scenarios to produce flood hazard maps
- Interpretation of the dam break results, including identification of potential countermeasures to reduce dam break impacts, if considered to be warranted

x. Geotechnical Engineer

The Geotechnical Engineer will report to the Team Leader and supervise the National Geotechnical Engineer. He/she will be responsible for:

- Working closely with the dam design specialist,
- Providing geotechnical engineering advice on the likes of parameter and suitability of construction materials, dam foundation design and the stability measures of various cut and/or fill slopes (e.g. dam abutment cut slopes, reservoir margin slopes, access road cut/fill slopes, etc.)
- Providing advice on seepage control provisions to be incorporated into the design of the dam and dam foundation
- Design of geotechnical features in the dam and related works (e.g. seepage blankets, rock bolting, etc.

xi. Mechanical Engineer

The Mechanical Engineer will report to the Team Leader and supervise the National Mechanical Expert and oversee the work of the national expert. His or her specialist inputs will include but not limited to

- Provide international level standard practice to prepare the mechanical engineering inputs for all the mechanical components in the design of the dam like permanent water

intakes, conduits and outlets, gates/valves, protection system

- Prepare layout and design of mechanical equipment like crane, governor system etc. in close relation with electrical engineer

  Preparation of design drawings and technical specifications for the above-mentioned components

5.3 National Experts

i. Dam Specialist / Deputy Team Leader

The Dam Specialist (National) will work closely and assist the Team Leader in the management of the project activities and personnel. In particular, he/she will be responsible for the following:

As delegated by the Team Leader, be responsible for coordination between the Consultant and the Client, and other parties to the Project

- As delegated by the Team Leader, oversee the execution of the fieldwork activities
- Assist with the completion of local cost databases
- Manage the inputs of the local project team members
- Manage logistical arrangements supporting the execution of the project services
- Manage the translation of project documentation into Nepali, where required

ii. Project Economist

The Project Economist will report to the Team Leader and the Deputy Team Leader. He/she will work closely with the international Project Economist in the preparation of financial and economic analysis of the project. In particular, the national Project Economist will assist the international Project Economist in the following:

- Prepare the dam detailed budget and investment plan based on the sub-project cost estimates
- Prepare detail economic and financial analysis of the Dam;
- Identify the economic and financial risks associated with the project subproject(s) and conduct a sensitivity and risk analysis

iii. **Environmentalist**

The National Environmental Specialist will report to the Team Leader and the Deputy Team Leader. He/she will be responsible for the following:

- Prepare environmental requirements for the drilling and testing works according to rules and regulations
- Oversee the preparation of necessary documents to obtain permit(s) from concerned agency;
- Ensure the requirements of the EMP are included in the contracting documents for the drilling and testing activities in dam site area;
- Oversee the implementation of the EMP by the drilling and testing contractor.
- Review any additional information made available related to the EIA of the project;

He/she must be familiar with the GON and 's environmental safeguard requirements. He/she will ensure that the site investigations are carried out in accordance with the environmental laws of Nepal and the environmental safeguard policy by overseeing implementation of the EMP for the site investigations. He/she will have extensive experience working with teams of international consultants and preferably projects.

iv. Engineering Geologist

The local Site Geologist will report to the team leader and the deputy team leader. He/she will work closely with, and assist the international Engineering Geologist with the conduct of in-situ investigations. In particular, the Site Geologist will be responsible to assist the Engineering Geologist in:

- Managing and controlling in-situ investigations
- Logging of drill holes, to international best practice standards
- Inspection, photographing and storage of drill core
- Selection of drill core samples to undergo lab testing
- Supervision of in-situ testing
- Deciding when the required maximum drilling depth has been reached

v. Hydrologist and Sedimentologist

The Hydrologist will report to the international consultant and the Deputy Team Leader. The hydrologist will be responsible to support the international consultant in the hydrological analyses. In particular, the tasks will include:

- Design flood hydrograph for the river diversion works during construction
- Design flood hydrograph for the river diversion spillway and spillway routing (the latter working with the Hydraulics Engineer)
- Reservoir initial filling time, for a range of start-of-filling month scenarios
- Availability of supply of drinking water for the optimum installed pumping capacity accounting for existing downstream water uses and in-stream residual flow requirements;
- Evaluations, with the Environmental Specialist, to assess the in-stream residual flow requirement to be released from the dam
- In the foregoing, quantifying the potential impacts of forecast climate change
- Design flood estimates for culverts on access roads
- Sediment rating curve
- Sediment yield from the catchment and subsequent sediment load at the river section in the vicinity of dam site along with evaluation of anticipated residual sediment due to change in land use, landslides occurrence and forest fires and carrying out the modeling of sediment transport through the reservoir
- Reservoir operation policy along with sediment monitoring rule so that optimum water allocation throughout the year will be achieved
- Sediment modeling using suitable software/model including propagation of delta formation and its consequences in storage and water quality
- Sediment Management Plan ensuring long-term sustainable reservoir capacity and option plans to remove or flush out the sediment safely with assessment to social and environmental impacts of the sediment flushing
- River bed variation due to effect of dam construction (particularly downstream river bed

degradation and upstream aggradation) and proposing strategies to minimize such effects

vi. Structure Engineer

The Structure Engineer will work in liaison with the International Structure Engineer. He/she will be responsible for:

- Working closely with the dam design specialist and Engineering Geologist in the layout and design of concrete of the dam
- Prepare layout and design in concrete structures of the project
- Undertaking static and dynamic preliminary stability analysis of the concrete structures
- Embedment details as needed for mechanical components
- Structural Steel Components
- Quantity & Cost Estimate for the concrete Structures

vii. Hydraulic Engineer

The National Hydraulic Engineer will report to the Team Leader and the Deputy Team Leader. He/she will work closely with the International Hydraulic Engineer. He/she will assist the International Hydraulic Engineer in the following:

- Optimizing, dimensioning, analysis and design of the appurtenant hydraulic structures such as river diversion facilities, spillway, water intake structure, hydraulic structures, access road culverts etc.
- Design of any required erosion protection works
- Preparation of the Hydraulic Design Report

viii. Geotechnical Engineer

The Geotechnical Engineer will report to the International Geotechnical Engineer. He/she will be responsible for:

- Working closely with the dam design specialist,
- Providing geotechnical engineering advice on the likes of parameter and suitability of construction materials, dam foundation design and the stability measures of various cut

and/or fill slopes (e.g. dam abutment cut slopes, reservoir margin slopes, access road cut/fill slopes, etc.)

- Providing advice on seepage control provisions to be incorporated into the design of the dam and dam foundation
- Design of geotechnical features in the dam and related works (e.g. seepage blankets, rock bolting, etc.

ix. **Road Engineer**

The Road Engineer will report to the Team Leader. He/she will be responsible for the design of the access road to the dam site, temporary roads (e.g. the dam site to the quarry). In particular, the Road Engineer will be responsible for:

- Establishing the applicable design standards for the various sections of road, accounting for the applicable vehicle sizes/loadings
- Firming-up routes and horizontal/vertical alignments for the new sections of road and existing sections requiring re-routing (e.g. widening and/or easing of bends), involving interpreting the topographic survey data for the roads, accounting for geotechnical conditions (with Geotechnical Engineer) etc.
- Designing the access roads and related earthworks
- Designing the drainage components of the road (based on design discharges computed by the Hydrologist), including the roadside drains, culverts, gabions, outlet energy dissipation measures, etc.
- Establishing the appropriate road construction materials, accounting for the availability and cost of local materials
- In the foregoing, with the Construction Specialist, considering construction aspects, including maintaining local access during construction
- Preparation of design drawings and specifications for the above-mentioned components
- QA/QC of design drawings
- Preparation of the Bill of Quantities (BOQ) for all access roads related components of

the Project

x. Procurement Specialist

The National Procurement Specialists will report to the team leader. He/she will work closely and assist the International Procurement Specialist with:

- Establishing and agreeing with the Client and the applicable contractual framework to be applied to bidding and construction of the project works, the minimum requirements to be met by bidders and the evaluation/selection basis
- With inputs from the engineering design team, tailoring the documents under (ii) to the special needs of the proposed dam project.
- Preparation of bidding documents, covering invitation to bidders, instructions to bidders, data sheets, tender forms, BOQ/schedule of prices, client's requirements including scope of work Project information and technical specifications, general and particular conditions of contract, forms of agreement, performance security, and advance payment guarantee, drawings, etc.
- Establishing the tender evaluation basis and prepare the requisite forms
- QA'ing the assembled draft tender documentation and submittal to the Client for approval
- Support Client in obtaining concurrence on the bid documents and issuance of the tender.

He/she will have extensive knowledge and experience on preparation of tender documents for infrastructure development, dam and hydropower projects. He/she will be familiar with procurement guidelines, the Government of Nepal (GON) procurement system, and FIDIC contract conditions for civil works. He/she will have extensive experience working with teams of international consultants and preferably projects.

xi. Electrical Engineer

The Electrical Engineer will be mobilized during Stage 2 and will report to the Team Leader. He/she will work closely with the Mechanical Engineer, to review and update/expand the electrical engineering inputs undertaken in Stage 1. In particular he/she will be responsible for:

- Electrical engineering design of all electrically-powered gates/valves and pump in the dam;
- Preparation of the Bill of Quantities (BOQ) for all electrical components of the Project
- Preparation of electrical single-line diagram for the dam gates/valves and pump;
- Overseeing the preparation of design drawings and specifications for the above-mentioned components

xii. Mechanical Engineer

The Mechanical Engineer will report to the Deputy Team Leader and Team Leader. His or her specialist inputs will include but not limited to

- Prepare the mechanical engineering inputs for all the mechanical components in the design of the dam like permanent water intakes, conduits and outlets, gates/valves, protection system
- Prepare layt and design of mechanical equipments like crene, governor system etc. in close relation with electrical engineer
- Preparation of design drawings and technical specifications for the above-mentioned components;
- Preparation of the Bill of Quantities (BOQ) for all mechanical components of the Project

xiii. Cost Estimator

The Cost Estimator will report to the Team Leader. He/she will be responsible for:

- Working with parallel inputs on quantities by the Dam Specialist, Mechanical Engineer, Electrical Engineer, Road Engineer etc.
- Researching local and international unit costs for works comparable to those in the proposed dam project, accounting for type and location of the works, local conditions (e.g. seasonal weather patterns), plant and labor needs, productivities and costs, possible risk premiums, etc.
- Preparing unit costs for various construction items and material/equipment supplies and cost estimate of lump sum items, Contractor site establishments, contingencies etc.

- Incorporating the unit rate, lump sums and quantities into the confidential priced BoQ
- With the Deputy Team Leader (National), making provisions for other local costs (e.g. Clients administration)

xiv. Senior Surveyor

Carry out activities described in and/or that follows from the activities in the scope of work related to Survey Engineering; and those assigned by Team Leader.

The scope of work will include, but not be limited to, the following:

- Collect and review available data, study reports and make reconnaissance survey of all survey sites including topographic survey, of the project
- Verify the accuracy of survey data including measurements and calculations conducted at survey sites
- Prepare or supervise preparation of all data, charts, plots, maps, records, and documents related to surveys
- Proactively anticipate and carry out any other activity as per the scope of work

xv. GIS Expert

Carry out activities described in and/or that follows from the activities described in the scope of work related to the GIS and those assigned by Team Leader.

The scope of work will include, but not be limited to, the following:

- Collect and review available data/reports and investigations related with GIS data management of Project
- Formulate GIS data basis for various civil structures related to all components
- Coordinate with Team Leader and Design Engineers to carry out surveys, field works and investigations necessary for GIS data management
- Carry out web-based GIS data management of all required components using latest available software in the best techno-economic manner
- Prepare GIS map as required in the project

- Proactively anticipate and carry out any other activity as per the scope of work

xvi. Technical Support Group

The consultant shall mobilize other different experts as required by the assignment like Legal Experts, Watershed Experts etc.

xvii. Specialist Drafts persons

The consultant is responsible to determine the number Specialist Drafts persons required for the detailed engineering drawings to be completed in a timely fashion. The cost of all Drafts persons, including cost of equipment and software should be itemized as reimbursable cost in the financial proposal together with other eligible out of pocket expenses. Costs not identified in the Financial Proposal will be deemed to be borne by the consultant at no cost to the Client. The Drafts persons report to the Team Leader and will work in close cooperation with the technical specialists and the survey teams. Their main tasks will include:

- Prepare work with the dam engineering team to modify /review the outline design drawings for all project components.
- From the drawings revise/prepare the bills of quantities
- Assist the dam engineering team to apply unit costs to the BOQ to establish the revised cost estimates for each component of the Project.

5.4 Panel of Experts for Dam Safety and Technical Review

A Panel of Experts (PoE) shall be established to provide independent technical review and advice during the updating of the Feasibility Study and the preparation of the Detailed Engineering Design. The Panel shall be engaged after mobilization of the Consultant and commencement of preparation and submission of the key project deliverables.

- The initial Panel shall comprise at least three internationally experienced specialists with demonstrated experience in major dam projects, comprising:
    - Dam Engineering / Dam Safety Expert;
    - Engineering Geologist / Geotechnical Expert; and
    - Hydrologist with strong experience in sediment management and reservoir

hydrology.

- The initial composition of the Panel may be expanded, as required, by additional specialists in areas such as seismic engineering, hydraulic engineering, structural engineering, emergency preparedness, instrumentation, or other specialist fields depending on the findings of the Feasibility Study update and Detailed Design.
- The Panel shall independently review the key technical studies, design criteria, major design decisions, dam safety aspects, and other critical deliverables at agreed review stages. The Panel shall provide written comments, recommendations and technical advice to the Consultant and the Employer. The Consultant shall consider and appropriately incorporate the recommendations of the Panel into the relevant studies and designs, with any unresolved technical issues clearly identified and documented.
- The Panel shall provide particular attention to the selection of the dam type and axis, hydrological and seismic design criteria, foundation and geological conditions, sedimentation and sediment management, spillway and outlet arrangements, dam safety considerations, construction methodology, reservoir operation and other issues having a material bearing on the safety and long-term performance of the project.
- The establishment and review function of the Panel shall not relieve the Consultant of its responsibility for the adequacy, accuracy and completeness of the studies, designs and recommendations prepared under this assignment.

5.5 Client's Input and Counterpart Personnel

The Client will provide qualified counterpart staff to work with the Consultant. The counterpart staff will not work as members of the Consultant team for delivering the services and their salaries will be paid by the organization who assign counterpart. The cost of counterpart staff will be paid by the Client it is not to be included in the Consultant's financial proposal and contract.

The Client will provide all relevant existing reports and available data relating to the project to the Consultant at the commencement of the consultancy contract. The client will facilitate access of the Consultant to project site, and other Government's agencies for communications, collecting of relevant information, data, documents, etc. and other activities related to the Consultant's assignment.

6 Equipment and Services to be Provided by the Consultant

The Consultant will provide its own insurance, subsistence, office consumables, and make provision for the cost of office rental and operation, including the cost of equipment and furniture, utilities, security and support staff, and other costs to fulfill the consultancy services. Further, the Consultant will provide all necessary computers, printers, and other equipment required by its experts as well as Auto CAD and other software necessary to carry out detailed design and preparation of detailed engineering drawings for the project. The consultant should include all necessary costs in the financial proposal including the cost of vehicle rental and operation, etc.

The Consultant shall lease office space of suitable size in the vicinity of the Sisneri WSP Office at Jawlakhel, furnished with all necessary amenities including adequate parking. The cost of the office rental has been provided for under the Provisional Sum (PS) component of the cost estimate. The Consultant shall propose suitable location options, with the final selection to be made in consultation with the Client.

7. Minimum Requirement For The Consulting Firm, Qualifications And Experience

The consulting services shall be carried out by an international firm. Firm must have sufficient qualification and experience to carry out the assignment. International firms are encouraged to form association with national consultants. Estimated 144 person-months of Experts are estimated to carry out the assignment. However, the firm should assess their own estimates of professional input requirements. The Tentative person-month detail required for assignment and qualification requirement for evaluation of key experts is set out in Table 3, however, the consultant to assess and proposed the required input to complete the scope of services.

The Consulting firm shall have the following minimum qualifications and experience:

7.1 Core business and years in business: The firm shall be duly registered/incorporated as a consulting firm with core business in the fields of dam engineering, water resources, civil engineering, hydropower, water supply, hydraulic infrastructure, or closely related engineering services. The firm shall demonstrate experience in consulting assignments related to dams/reservoirs, water supply, hydropower, irrigation, water conveyance, hydraulic structures or other major water resources infrastructure for a minimum period of five (5) years.

7.2 Relevant experience: The firm shall demonstrate having successfully executed and completed consulting assignment related to (i) Detailed engineering design of concrete/RCC/CFRD dams having minimum height of 35 m (ii) Detailed engineering design of Dam where the Dam was subsequently constructed and commissioned, (iii) Construction supervision / construction management / detailed design review of major dams, and (iv) dam or water resources infrastructure projects outside the Consultant's home country

Details of similar assignments—including the name and address of the client, scope of services, contract value, implementation period, and key outputs/deliverables—should be provided in Official Use Only the submitted Expression of Interest (EOI), together with a clear description of the relevance of the assignments to the scope of this consultancy.

7.3 Technical and managerial capability of the firm: The firm shall demonstrate as having the requisite technical and managerial capacity to undertake the assignment in the submitted company profile(s). Key Experts will not be evaluated at the shortlisting stage

8 Information to facilitate proposal preparation

The Client shall provide the Consultants with access to all relevant data, information, and reports pertaining to the project. To facilitate the preparation of proposals, the Client has made available the following inputs, including project data and reports, strictly for reference purposes only. The content and information contained in these documents shall not, under any circumstances, be considered contractually binding:

1. Main Report – Final Field Report (Feasibility)
2. Topographical Survey Report and Topographic Maps
3. Hydrological and Sedimentation Study Report
4. Geotechnical Investigation Report
5. Geological, Geophysical, and Seismological Field Report
6. Hydraulic Study Report

The Consultants shall not rely solely on the documents provided by the Client but should conduct their own assessments as necessary to ensure the accuracy and appropriateness of their proposed methodology and approach.

The Consultant shall bear full responsibility for the proposal submitted in response to this RFP, including the proposed methodology. The contents of the aforementioned documents shall not take precedence in any matter related to the proposal.

9 Supporting Information and Requirements

Site Information: The Project site is located in Sisneri, south of Kathmandu valley, around 3 hours' drive. The Consultant shall plan his works keeping in view of restrictions and limitations of approach and availability of space, time and local resources. Special care is to be taken by the Consultant if there are any protected zone. The hydrological and climatic data related to the project can be obtained from the Department of Hydrology and Meteorology, Government of Nepal. General geological information of the project site can be obtained from Department of Mine and Geology. The Consultant is required to verify the information provided in accordance with the conditions stipulated in the Contract.

Units: The work shall be undertaken in International System of Units (SI units)

Language: All documentation and communications shall be in English.

Design Life: The Project shall be designed for a nominal life of 50 years. Where it is impractical for elements of the Project to meet this life, a review will be undertaken by the Client.

Health and Safety: The Consultant shall work within a formally documented Health and Safety Management System which will be subject to the approval of the Client.

Document Control and Management: The Consultant and any nominated Sub-Consultants and Contractor for investigations and survey shall work within a formally documented Management System that is, as a minimum, equivalent to the requirements of AS/NZS ISO 9001:2008, Quality Management Systems. All documents must be controlled by a recognized Document Management System and all correspondence should be through a single point contact.

Record Copies: The Consultant shall maintain and made available to the Client at all times a record copy - both hard paper and electronic versions -of the following:

- Geotechnical Investigations
- Geodetic Survey
- Design Calculations
- Design Reports
- Drawings

Drawings: Drawing practice shall conform to the standards subject to the approval of the Client. All electronic Drawings prepared shall be in AutoCAD 2011 or later drawing file format. Drawing templates, drawing numbers and Drawing file specifications shall be subject to the approval of the Client.

Survey Datum: The survey datum point taken for the Project needs to be given to the Client. Design and construction and all Drawings including as-built records shall be prepared based on given survey datum.