CHAPTER-1
INTRODUCTION

1.1 BACKGROUND

Uganda is a landlocked country in East Africa, bordered on the east by Kenya, on the north by Sudan, on the west by the Democratic Republic of the Congo, on the southwest by Rwanda, and on the south by Tanzania. Uganda has a total landmass of 241,000 sq. km, 18 percent of which is covered by freshwater bodies. Lying astride the equator, Uganda offers exceptional diversity, combining some of the best features of Africa, including the source of the River Nile(the second longest river in the World) and Lake Victoria(the second largest fresh water lake in the World). The country's geographical diversity is great. In the East, it overlaps the tropical Savannah and in the West, African rain-forest zones lies. Moreover, there are many existing contrasting physical features, ranging from extensive plains with undulating hills to snow-capped mountains, waterfalls, meandering rivers and spectacular flora and fauna.

The country is endowed with abundant renewable energy resources. These include plentiful biomass supplies, extensive hydrological resources, favorable solar conditions and large quantities of biomass residues from agricultural production, among others.

With about 43,942 km^2 of wetlands and open water (18% of total area), Uganda is considered fairly well endowed with water resources. Major water bodies include lakes Victoria, Kyoga, Albert, George and Edward while major rivers include the Nile, Ruizi, Katonga, Kafu, Mpologoma and Aswa. Almost the whole of Uganda lies within the Nile basin, which is shared by 10 countries. Favorable atmospheric conditions and mighty river provides abundant hydropower potential estimated at about 2,000 MW mainly along River Nile that can be developed to supply isolated areas or feed into the national grid. Although, Uganda has plentiful hydropower, solar and biomass resource potential; however it has one of the world's lowest levels of electricity development. At present just 3-5 percent of the population have access to electricity and many towns, especially in the North of the country are without electrical power and in the rural areas only about 2 percent had access to electricity, of which less than half was provided through the national grid, the remainder coming from household generators, car batteries or solar photovoltaic (PV) units. Whereas with the developments in the oil sector, future additional power supply is likely to be provided from thermal powered plants using heavy oils. But in terms of cost effectiveness and environmental friendliness, Hydropower plant remains the better alternative. Therefore, carefully planned hydropower development can make a vast contribution for improving living standard in the country by not only contributing to the Treasury resources and foreign exchange earnings (power exports), but also promises to be a large source of employment for Ugandans and infrastructure development.

1.2 THE POWER SCENARIO

The Energy Sector is one of the key sectors in the Ugandan economy. The present peak demand of Uganda is about 400 MW which has been growing at an annual rate of 8%.Therefore to meet this growth in demand, about 20 MW of new generating capacity needs to be added each year. The year wise peak power demand forecast in MW up to the year 2026 done by Ministry of Energy and Mineral Development (MEMD) of Govt. is indicated in **Figure 1.1**:

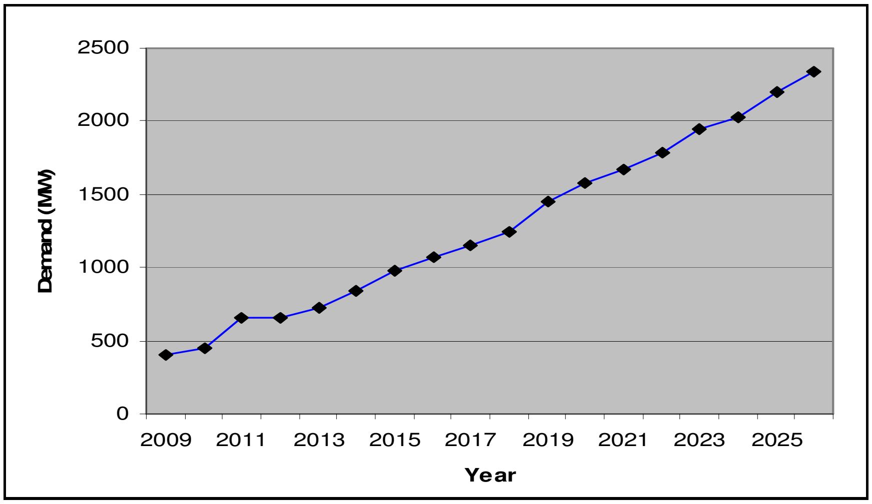

Figure 1.1: Uganda Power Demand forecast 2009-2026

According to the National Development Plan (NDP- 2010/11-2014), the energy sector is one of the complementary sectors. The NDP highlights the limited access and use of energy as a factor that significantly slows down economic and social transformation. The low energy consumption per capita in Uganda is identified as a major contributing factor to the slow economic transformation by limiting industrialization as well as value addition. The energy exploitation and consumption patterns indicate that Uganda is still in infancy stages of energy application in production processes. The current exploitation pattern of energy in Uganda is Biomass - 92%, Fossil Fuels - 7%, Electricity - 1%.

Most of the residential/domestic energy consumption is biomass used in form of wood as charcoal and firewood, a situation that is not sustainable as this form of energy is non renewable, costly and has significant negative impacts on the environment. The NDP identifies low level of access, high tariff and low generation as the main reasons why there is a lot of reliance on biomass energy. This pattern also explains the low levels of industrialization and commercial production in the country. For Industrial and commercial production, the main source of energy is electricity and not biomass.

Uganda has one of the lowest per capita electricity consumption, the 2008 statistics show that the electricity consumption pattern was 57.5% in industrial and 29.3% in residential whereas commercial usage are limited to 13.2% **(Figure 1.2).**

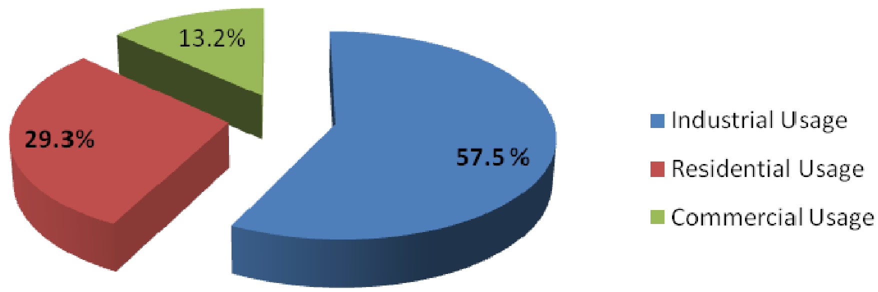

Figure 1.2: Sector wise electricity consumption in Uganda (2008) Source: National Development Plan (2010/11-2014/15)

The current installed generating capacity of the country is 575.5 MW **(Table 1.1)**, of which at present about 380MW of the annual demand is met by various hydropower plants including the Kira and Nalubale. Small hydro contributes only 28.5MW while thermal power plants have 150 MW capacity generations. A hydropower plant of 250MW is under development at Bujagali.

Table 1.1: Present Installed capacity of power generation in Uganda

S. No.	Type of Plant	Installed Capacity (MW)
1	Large Hydro	380
2	Thermal Diesel	150
3	Small hydro	28.5
4	Cogeneration	17
Total		**575.5**

From above it is clear that the current levels of electricity supply cannot support heavy industries like steel mills, textile mills and aluminium processing plants of the country. Power therefore is an indispensable parameter in attracting and sustaining investment in heavy industrial development. Therefore to create a favorable environment for investment in such industries, there is need for a policy shift/reform to ensure that there is sufficient electricity generation capacity.

The NDP clearly identifies limited generation capacity and corresponding limited transmission and distribution network as among other key constraints to the performance of the energy sector in the country. In this regard, the NDP further sets out increasing power generation capacity as the first objective to address this problem and construction of larger hydropower plants as the first intervention strategy.

1.3 CONSIDERING ALTERNATIVE POWER GENERATION TECHNOLOGIES

Given the large, and growing, gap between electricity supply and demand in Uganda, a number of electricity generation alternatives studies over various planning horizons has been completed and options examined and prioritised for the country under the Hydropower Master Plan. The generation alternatives explored under Rural Electrification programme for the next 20 years in Uganda include:

- Wind-generated electricity;
- Geothermal electricity;
- Solar-generated electricity;
- Small scale hydroelectric development;
- Co-generation facilities;
- Biomass-generated electricity;
- Thermal power plants;
- Large scale hydroelectric development.

Developing these alternatives will have a long term significant effect on the economy and the people of Uganda. However, general conclusions from the evaluation of these generation alternatives indicates that large scale hydroelectric development remains the most economical way forward for the country in the short-medium term and the River Victoria Nile is the primary hydrological resource available in Uganda to meet the growing electricity demand in the country by way of hydroelectric development.

1.4 POTENTIAL HYDROPOWER DEVELOPMENT SITES ON RVER NILE

About seven potential hydropower sites along the Victoria Nile have been examined in some detail by a number of studies; the most recent being done under the Hydropower Master Plan is by Japan International Cooperation Agency (JICA). According to the Plan, the discharge and cost requirements of developing these sites are given as below in **Table 1.2 (Figure 1.3).**

Table 1.2: Comparison of the seven sites under the Master Plan

Site	Type of Scheme	Maximum Output (MW)	Discharge for the Output (m^3/s)	Cost (000, USD)
Kalagala	Dam	330	1375	**656,203**
Isimba	Dam	138	1375	**617,940**
Karuma	Run of the River	600	840	**1,976,565**
Oriang	Run of the River	392	840	**1,754,255**
Ayago	Run of the River	616	840	**1,618,468**
Kiba	Run of the River	292	840	**2,265,578**
Murchison	Dam & Waterway	655	840	**1,137,727**

Figure 1.3: Cascade Development on River Nile

1.5 KARUMA HYDRO POWER PROJECT

Karuma hydropower Project was earlier entrusted to M/S NORPAK for development under the private sector in the year 1996. M/S NORPAK an Independent Power Producer envisaged this Project as a run-off the river hydropower generation scheme with an installed capacity of 200 MW on Kyoga Nile River, downstream of Lake Kayoga. The Project Definition Report was submitted by M/S NORPAK in the year 1999. Environment and Social Impact Assessment study was undertaken, project affected people were also compensated and Environmental and Social Impact Assessment (ESIA) report prepared was submitted to NEMA for approval in the year 1999. This ESIA and the other related permits were duly approved by NEMA in the year 1999 itself. In the year 2006, NORPAK revised the project proposal, which envisaged the development of the project in two phases with 100 MW installed capacity in the first phase and 100 to 200MW capacity development in the second phase. However, due to host of reasons NORPAK decided not to pursue the project any further and it was reverted back to Govt. of Uganda for implementation.

A review of the past efforts by M/S NORPAK is presented in a separate volume titled “Review of NORPAK REPORT”. Govt. of Uganda then decided to take over the Karuma hydropower project and proceeded with its own plan for development of this project in the public sector. The Ministry of Energy and Mineral Development (MEMD) together with the Uganda Electricity Generation Company Limited (UEGCL) jointly proposed a new Karuma Hydro Power Project of 600-700 MW installed capacity with changed layout and location. The new layout now envisages harnessing of about 70m Gross head of the project as compared to about 29 m in the NORPAK Report.

The project, as now envisaged by the MEMD, GoU, has the following broad features and guidelines:

(a) Type of Scheme – Run-off-the River scheme with diurnal pondage.

(b) Submergence area – Should not adversely affect the Lake Kyoga and the Full reservoir level / Maximum water level of the project should remain below the Lake Kyoga elevations at all times.

(c) Tail Race Outfall – The Tail race outfall be planned at a location on the Kyoga Nile where river bed elevation is about ± 945 m. This location will be within the Karuma Wildlife reserve.

(d) Care to be taken that the impacts on the Karuma wildlife due to this project are minimised and adequate mitigation measures to be implemented after conducting suitable studies.

Evacuation of power from the Karuma Hydro Power plant will require construction of appropriate power transmission lines of adequate capacity to evacuate power from Karuma and other power stations that will be constructed in the area. The transmission line project will be carried out under a separate arrangement that will run concurrently with the Karuma generation project.

1.5.1 Project Location

The new Karuma Hydro Power Project is located at Karuma at Latitude 2^0 15' N and 32^0 15' E on River Kyoga Nile with project area falling in Kiryandongo and Oyam Districts of Uganda (**Figure 1.4**). The Project is a run-off the river scheme with utilisation of water of River Kyoga Nile, an outflow of Kyoga Lake. The diversion site is approximately 1.5km upstream of the Karuma Bridge and at about 2.5 km upstream of Masindi – Gulu highway. The Project area is within the vicinity of two conservation areas, the Karuma Wildlife Reserve and the Murchison falls National Park. The Project will utilise a gross head of about 70 m and design discharge of 1128 cumecs for generation of 600 MW (six units of 100MW each).

1.6 THE NEED AND JUSTIFICATION FOR THE PROJECT

Uganda is currently facing a huge electricity supply deficit, as over 90 percent of the country's population is not connected to the national grid. The current situation of the power demand and power supply options for Uganda indicate that the Karuma HPP which will add up to 600MW to the National Grid is a very justified development, and that it is the preferred and least cost solution to address the short, medium and long term power shortages in the country. The Karuma project is likely to be the largest power development project in Uganda in the near future and will provide more power to the National Grid than all the other currently installed projects. The other major generation facilities in Uganda are all on the Nile and they include the Kirra HPP (200MW) and Nalubale HPP (180MW), upstream on the exit of the Nile out of Lake Victoria. The other dam, the Bujagali Hydropower project will be completed soon and will add another 250MW on to the Grid. The 600 MW to be provided by the Karuma Project would therefore be an essential addition to the country's generating capacity as it would not only meet the electricity demands of Uganda in future, but also trigger rapid industrialization of the country.

1.7 PROJECT DESCRIPTION

1.7.1 Project Layout

The proposed scheme consists of a Concrete Dam of maximum height of 20.0 m and length of 311.53 m at the Top elevation of 1032.00 m. The Overflow bays have been proposed to discharge the design flood of 4700 cumecs, and constitutes of 14 surface bays of 7.0 m width and 10.0 m height with the crest at EL 1020.0 m. 2 under sluices of 3.0m wide and 4.0m height have also been proposed as a silt flushing arrangement for the power intake structure. The Non overflow length of

33.74m covers the left abutment and 96.56m on the right abutment. For energy dissipation, stilling basin with end sill has been proposed.

The Diversion arrangement of the Kyoga Nile for the construction of Concrete Dam has been planned in two stages. In the first stage, the diversion flood of 2500 cumecs would be diverted partly through an open channel of base width 10 m and partially through the river channel on the right bank, while the left bank comprises of part of the concrete dam, Power intake will be covered by a coffer dam of 15.0 m height. The remaining portion of the concrete dam will be built after barricading right bank with a cofferdam of the same height as that of the first stage, and the diversion flood will be diverted through 8 numbers of spillway gates and through the right bank diversion channel.

For power generation, water is planned to be conveyed through 6 concrete lined pressure shafts of 7.70 m diameter and length varying from 379 m to 328 m. These pressure shafts would feed 6 vertical Francis turbines of 100 MW capacity installed within an underground powerhouse located on the Left bank of Kyoga Nile. A surge chamber with 3 nos. of 12.0 m dia and 2000 m long surge tunnels has been proposed to take care of the surges due to sudden closure/opening during operation of the power plant. The Tail water from the Power house will be carried through 6 individual tunnels of 7.70m diameter and 276.81m length up to the surge chamber. After the surge chamber the tail water will be conveyed through 2 nos. of 12.50m dia tunnels of 8.3 km long up to the river through an open channel.

The Open channel will convey the tail water to the river whose base width is 100.00 m and length of 140.0 m. At the end of the tail race channel a weir has been proposed to maintain the minimum tail water level during all conditions and the crest level of the weir is kept at El. 959.50 m. The Power generated would be evacuated into the national grid through a 400 kV Switchyard to the nearest proposed sub-station of Uganda Electricity Transmission Company Limited (UETCL) and for onward transmission to the energy deficient Regions. The Project Layout and L-section of the scheme are shown in **Annexure 1.1** and **Annexure 1.2** respectively.

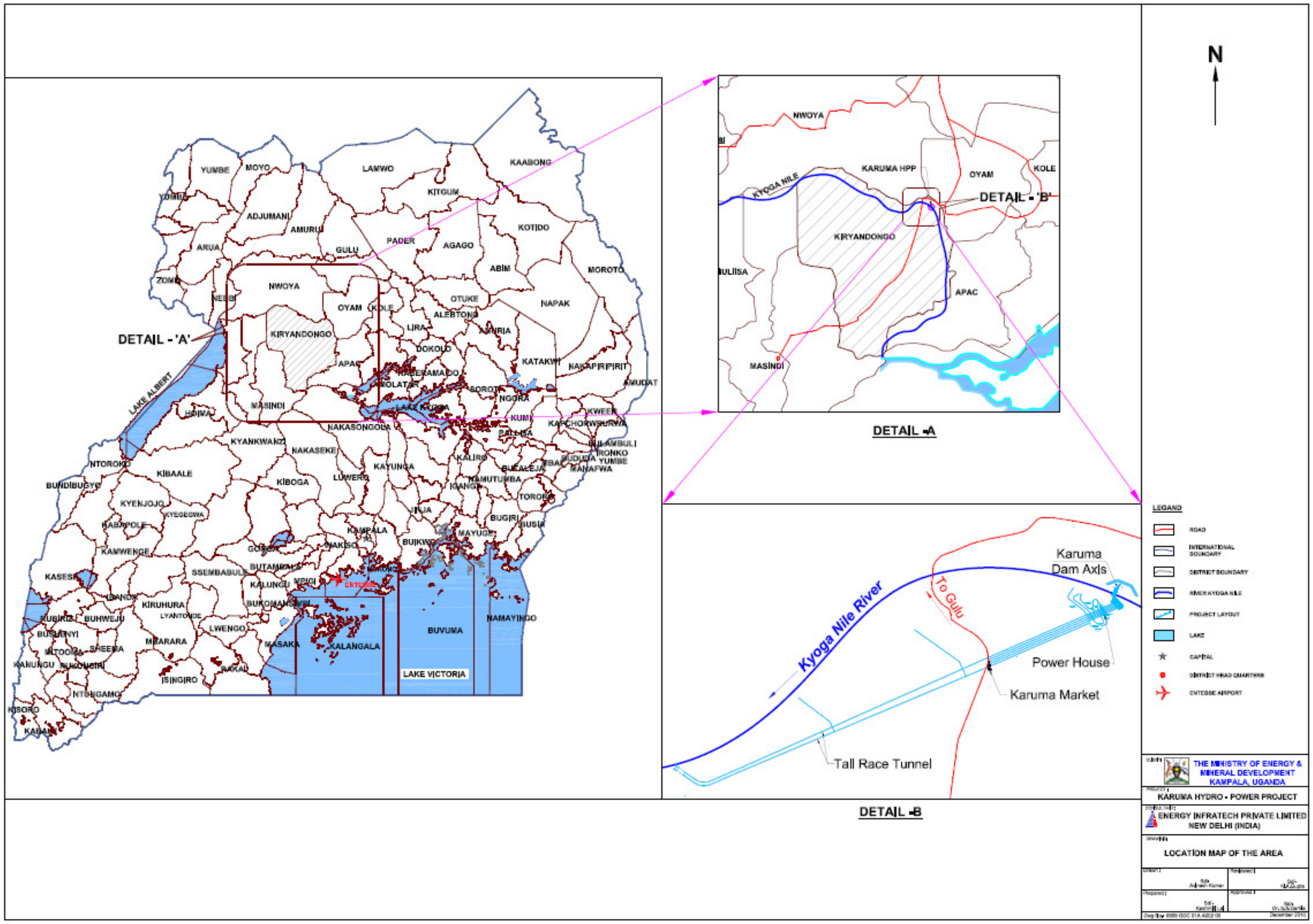

Figure 1.4: Location map of Karuma HPP

1.7.2 Concrete Gravity Dam

A Concrete Gravity dam has been proposed to divert the river water to the power station. The Length of the dam at top is 311.53m and maximum height from the deepest foundation is 20.00m high. The dam comprises of 8 numbers of Non-overflow blocks and 16 numbers of overflow bays. The overflow bays comprise 14 surface bays of 7.0m X 10.0m with crest at EL 1020.00 m and 2 numbers under sluices each of 3.0m X 4.0m with crest at EL. 1012.00m. The under sluices are proposed as a silt flushing arrangement for the Power intake and the Spillway gate are proposed to discharge the flood discharge. Stilling Basin with end sill will be provided as an Energy dissipation arrangement for the spillway discharge. A Fish Ladder arrangement is also proposed in the dam complex for the fish migration. The Layout Plan showing the Concrete Dam and Section along Dam axis is shown in **Annexure 1.3** and **Annexure 1.4** respectively.

1.7.3 Power Intake

A Rectangular fore-bay type power intake has been proposed to feed the design discharge to the pressure shafts which is located in the left bank of river Kyoga Nile. The Power Intake structure consists of six numbers of independent intakes each 29.20m wide and 20.0m high for the pressure shafts. The total width of power intake is 175.20m with an inclined trash rack which is proposed to prevent the entry of floating debris in to the water conductor system. All intakes are proposed in one line and side by side to each other in order to facilitate the use of common trash cleaning machine and stop-log hoisting arrangement. The Power Intake and its details are shown in Annexure 1.5.

1.7.4 Pressure Shafts

Since the total discharge for power generation is quite high, all six generating units of the powerhouse will be fed through six independent pressure shafts. Each pressure shaft is of 7.70m diameter and centre to center distance between the pressure shafts at intake is 29.20m near inlet and reduced to 25.0m till the power house. The Length of the Pressure shaft varies from 328m to 379m.The L-section of the pressure shaft is shown in **Annexure 1.6**.

1.7.5 Power House

As the topography of the project area is not suitable for a Surface Power House, an Under Ground Power House has been proposed to accommodate six Vertical Francis turbines of 100MW capacity each. The Power House cavern comprises a machine hall, service bay and a control bay. The total length of the power house cavern will be 215m long and 21m wide. The total height of the power house is worked out to be 49.0m from the lowest level of Draft tube elbow. A transformer cavern has also been proposed for power evacuation which is located at 50.0m downstream of the Power house cavern. The length of the Transformer cavern is 200m and 18.0m wide with a height of 14.4m to accommodate the transformers. Separate access tunnel have been proposed to the power house and transformer cavern to facilitate the accessibility during Power plant operations. The Longitudinal and Cross section details of Power house are shown in **Annexure 1.7** and **Annexure 1.8** respectively.

1.7.6 Tail Race System

Each vertical Francis turbine will have independent 7.70m tunnel with the Length of 276.81m from the Draft tube to the Surge Chamber as a primary tail race tunnel. The surge Chamber is part of the tail race system, which is designed to accommodate the surge effect in the tail race tunnels during power plant operations. The surge chamber consists of 3 numbers of surge tunnels of horse shoe shape with 12.0m diameter and 2000m length each. The width of the surge chamber is 20.0m with a length of 200.0m and 29.0m high. The Longitudinal and Cross sections of Surge chamber are shown in **Annexure 1.9**. After the surge chamber the Tailrace system will have 2 Nos. of 12.50m dia horse shoe shaped tunnels with the Length of 8.3km following by a tail race channel as the geological condition near the outlet area will not allow driving the tunnels up to the river. The tail race channel will have a base width of 100.0m with the length of 140.0m and average depth is 10.0m with the side slope of 1:1. Before the outfall structure a weir has been proposed to maintain the minimum tail water level during all conditions and the crest level of the weir is kept at El. 959.50 m.

1.7.7 Reservoir

For this project, the reservoir has been designed based on the Full Reservoir Level (F.R.L.). To fix the F.R.L. of the project an important consideration was given to the flow of the river outside lake Kyoga, it was important that the river outlet at Lake Kyoga is not affected by the dam height corresponding to the design flood of this project. For this, water level was studied for two situations i.e. at Flood discharge and secondly at Design Discharge which is presented in **Table 1.3** and **Table 1.4** respectively.

For a F.R.L. of EL. 1030.00m the water elevation 35kms upstream of the dam axis is anticipated. From the modelling studies (Details in Engineering Report), this reservoir level would be almost the same as for the virgin condition and dam condition (F.R.L. at EL. 1030.00m) in both the conditions. Also the reservoir extending up to 35kms upstream of the dam axis and the reservoir will not reach L. Kyoga. As such, therefore the F.R.L. of EL. 1030.00m has been selected for the project.

The summary of the Salient features of the Karuma Reservoir are as follows:

a) Length of the Reservoir = 35kms.
b) Reservoir Area at F.R.L. of EL. 1030.00m = 2737.35 Ha.

c) Reservoir Area at M.D.D.L of EL. 1028.00m = 1790.35 Ha.

d) Gross Reservoir volume = 79.87 M. Cum

e) Dead Storage below M.D.D.L. = 34.34 M.Cum

Table 1.3: Water level at flood discharge under different scenario

Discharge	4700 m^3/s- Virgin Condition (No Dam)	4700 m^3/s with F.R.L. at El. 1030.00	4100 m^3/s with F.R.L. at El. 1028.00 (M/s NORPAK design)
Water Surface Elevation at 35 kms upstream of Dam axis(m)	1035.49	1035.07	1034.93
Water surface Elevation at Dam axis(m)	1032.49	1030.00	1032.00

Table 1.4: Water level at design discharge under different scenario

Discharge	1178 m^3/s - Virgin Condition (No Dam)	1178 m^3/s with F.R.L. at El. 1030.00	890 m^3/s with F.R.L. at El. 1028.00 (M/s NORPAK design)
Water Surface Elevation at 35kms upstream of Dam axis(m)	1031.49	1031.71	1030.96
Water surface Elevation at Dam axis(m)	1028.05	1030.00	1028.00

The reservoir would therefore extend up to 35kms and the maximum area of submergence would be 2737 Ha. The submergence area will remain within the river banks and as such the reservoir does not significantly alter the natural environment of the river especially, given that in the 35Km stretch, the river is slow and flat with well defined river banks.

1.7.8 Transmission

As per the master plan developed by Uganda Electricity Transmission Company Limited (UETCL), and reiterated in the National Development Plan (NDP 2010/11-2014/15), the following transmission lines are planned to take off from Karuma HPP.

a) Karuma- Kawanda 400KV double circuit line (264 Km)

b) Karuma- Lira 132 KV double circuit line (80 Km)

c) Karuma- Olwiyo 132 KV double circuit line (60 Km)

For this purpose, three 400 KV circuits would be brought to switchyard through 400 KV XLPE cables from 420KV GIS provided in the transformer cavern. Two circuits would be utilized for 400

KV line to Kawanda. Necessary terminal equipment and take off structure will be provided in the switchyard.

One 400 KV circuit will be connected to a bank of three single phase, 91 MVA, 400/√3 / 132KV, interconnecting transformers, located in switchyard. Necessary 400 KV and 132 KV switchgear and take off structures will be provided in the switchyard for taking off two double circuit 132 KV lines to Lira and Olwiyo. A drawing showing the switchyard layout is enclosed as **Annexure 1.10**.

1.7.9 Fish Ladder

A Fish ladder with a gate opening of 5.0m width and 5.0m height is provided adjacent to the overflow blocks on the right side so as to allow the migration of aquatic life from the upstream to the downstream or vice-versa. The following points according to USBR serve as guidelines for satisfactory design of a fish ladder:

a. The fish ladder should be provided near the deep channel through which they always move about.
b. The entrance and the exit of the fish ladder should be away from the range of heavy over fall of water from the diversion structure and usually placed at the divide wall of the structure between sluice bay and spillway bays.
c. The gradient of the fish ladder should preferably be 1:10.
d. The flow velocity in any part of the fish ladder should not be more than 1.8m/s.
e. The width of the opening shall be between 6.0m to 12.0m.
f. The length of the pool shall not be more than 6.0m.
g. The depth of the pool shall be between 1.0m – 2.0m.

For Karuma dam, to understand the hydraulics of the fish ladder, a model was created in the USBR's HEC-RAS river modeling software. The parameters considered for the model were as follows:

a) Gradient of the fish ladder is fixed as 1:10.
b) The width of the opening is 5.0m.
c) The depth of the opening is 5.0m.
d) Discharge considered: 15cumecs.
e) The baffle walls are spaced 4.0m apart.
f) The height of the baffle walls is 2.0m.
g) The slot opening is of 1.5m.
h) Water elevation at the entry of the pool: EL.1022.64m.
i) Water elevation at the exit of the fish ladder: EL.1030.00m.

With the above mentioned parameters the depth of water and the velocity of water flow were checked for different discharges through the proposed Fish ladder. The results of the model for a design discharge of 15cumecs were as follows:

j) Water velocity at entry: 0.9m/s.
k) Water velocity at exit: 1.16m/s.

From the above results it may be deduced that the velocity of flow at entry and exit remain within the limits as recommended by USBR, however the presence of turbulence and flow velocities in intermediate pockets have to be checked by performing hydraulic model studies. It is therefore proposed that a detailed hydraulic model study of the fish ladder is done so as to achieve the flow velocities, spacing of baffle walls and width of slot opening in the baffle wall in the fish ladder are adhered to as recommended by USBR. The section along the proposed fish ladder block for Karuma Dam is shown in **Annexure 1.11.**

1.8 ELECTRO - MECHANICAL WORKS

The generating equipment of Karuma HPP would be installed in an underground powerhouse. There will be two caverns, one for housing six generating units of 100 MW each and other auxiliary equipment and the second cavern would house generator step up transformers.

The turbines would be vertical Francis type working under gross head of 70.0m with a speed of 150 rpm. The 100 MW synchronous generators would be vertical type with 11kV generation voltage and 0.9 power factor (lag) directly connected with turbine shaft. It is proposed to provide 19 Nos. of single phase transformers (including one spare) each of 41MVA, 11/ 400/ √3 kV, Forced Oil forced water cooled generator step up transformers to be housed in Transformer cavern. Choice for single phase transformers has been made to reduce the width of the transformer cavern and associated access tunnels. The connection between the generator terminals and 11 kV terminals of generator step up transformers would be made through 11kV bus ducts laid in the interconnecting tunnels between the two caverns.

The 400 kV EHV switchgear is proposed to be gas insulated switchgear mounted on the floor above the transformers in the Transformer cavern. Necessary 400 kV feeders would be taken to pothead yard through 400 kV XLPE cables.

Two numbers EOT cranes of suitable capacity would be provided in the machine hall cavern and one crane will be provided for gas insulated switchgear for installation of the equipment and for subsequent maintenance.

Following auxiliary systems would be provided:

1. Control and protection system
2. Fire protection system
3. Ventilation and air conditioning system

4. Compressed air system
5. Unit auxiliary transformers and station auxiliary transformer with associated HT and LT switchgear to supply auxiliary power
6. Station illumination system
7. Earthing system
8. Drainage and dewatering system
9. Plant communication system
10. Power line carrier communication system to supply auxiliary power during starting of generating units as well as for emergency power, two diesel generating sets of appropriate capacity are proposed to be provided.

1.9 CAMPS, ROADS AND INFRASTRUCTURE

In addition to the hydropower schemes, the Infrastructure and Construction Facilities for Karuma Hydro Power Project have been divided into the following components:-

1.9.1 Project Roads

The following roads have been proposed in the Project Area to facilitate various construction activities and details of the road is presented in **Table 1.5.**

a) Access Road to left bank dam site - 3.65 km
b) For accessing the left bank dam site and also to connect all the construction facilities and muck disposal area etc. located on the left bank, main Access road has been proposed. This road will be gravel road to start with and will subsequently be converted to black topped specifications. This road will be on flat terrain till it reaches the plateau area and after that it will negotiate a height of about 40-45 m to reach to the proposed Dam Top. This road starts from the Gulu highway with 10.0 m wide foundation on the flat terrain (3.0km) and it will reduced to 6.0 width (0.65km) while negotiating the slope, so as to minimize the surface excavation. Construction roads will branch out from this stretch and will be subsequently constructed as the work progresses and river is diverted.
c) Access Road to the Main Access and tunnels and Construction Adit for Surge Chamber - 1.60 km.
d) An Access road of 1.60 km has been proposed to Main access & Construction tunnels to Power house and construction Adit to surge chamber for various construction activities. This road will have a foundation width of 6.0m.
e) Access Road to Labor Camp, Fuel Station - 2.50 km
f) An access road of 10.0m width has been proposed to labor camp, fuel station. It is aligned from the left bank main access road and provides continuity to muck disposal area also.

g) Access Road to Explosive Magazine - 0.5 km

h) The access road to explosive magazine will be 10.0m foundation width and would take off from the left bank main access road.

i) Access Road to Muck dumping yard - 0.60 km

j) This road has been proposed to as an additional access to the muck disposal yard because since muck will be generated from various sites, the area needs to have additional entrance to the muck dumping yard for smooth flow of traffic during construction stage.

k) Access Road to Diversion Channel, Dam Right Bank and Right Bank Quarry - 1.80 km

l) The Access to the Right bank where the diversion channel, rock quarry and dam abutment are located will be through a road branching out from Karuma-Gulu Highway. It is also important to point out here that at some locations the existing Karuma-Gulu highway from Karuma trading center to the bifurcation point on the right bank (about 4 km) may be required to be widened so that this heavy traffic of construction material from quarry to left bank muck dumping area / crushing plant area can be catered to. This right bank road is also proposed to be 10 m foundation width gravel road to dam site and diversion channel. This road will further branch out to quarry areas of upstream and downstream locations.

m) Access Road to Steel Yard and Fabrication Yard - 0.90 km

n) The Access road to Steel and Fabrication yard is a branch road from the left bank main access road to the dam site. This road would be of 10.0m foundation width. The length of the road is 0.90 km.

o) Access Road to TRT outfall - 7.0 km

p) The access to TRT outfall from Karuma-Gulu highway has already been constructed within the Karuma wildlife reserve area by UWA. However this existing murum road needs to be considerably improved by providing suitable cross drainage works, improving its gradient at many locations so as to suit heavy construction traffic etc. The pavement may be required to be re-laid by putting layers of stone metal and ensuring proper compaction. Since this road will be the lifeline of the project and will also provide accesses to Adits and other work fronts, upgrading of this road to higher standards of about 10 m width will be necessary before the commencement of active construction works.

q) Access Road to Adit I – 1.40km

r) The Access road to Adit-I will branch out from the Main Road to TRT outfall mentioned above. This road will provide access to one of the most important work fronts from where tunneling of more than 10 km length will be involved.

s) Access Road to Adit II – 1.00km: To sum it up, a total of 20.95km of new roads will required to be constructed.

t) The Access road to Adit-I will branch out from the Main Road to TRT outfall. This road will provide access to 12.50m tailrace tunnels and provide 2 work faces.

Table 1.5: Details of the proposed approach road for Karuma HPP

S.No.	Road Description	Road Type	Length (Km)	Foundation Width (m)
1	Access Road to left bank dam site	Gravel	3.65	10
2	Access Road to MAT & CAT to Power House and Construction Adit for Surge Chamber		1.60	6
3	Access Road to Labor Camp, Fuel Station		2.50	10
4	Access Road to Explosive Magazine		0.5	10
5	Access Road to Muck dumping yard		0.60	10
6	Access Road to Diversion Channel, Dam Right Bank and Right Bank Quarry		1.80	10
7	Access Road to Steel Yard and Fabrication Yard		0.90	10
8	Access Road to TRT outfall		7.00	10
9	Access Road to Adit I		1.40	10
10	Access Road to Adit II		1.00	10
	Total Road Length		20.95 Km	

1.9.2 Offices and Residential / Non-residential complexes

Karuma Hydro Power Project will have its head quarters in its Permanent camp area at the Project Site. Some of the infrastructure will be utilized during construction phase while others will be during Operation & Maintenance (O&M) stage of the project. The Permanent camp is well connected with Gulu Highway by an access road. The accommodations in the permanent camp are broadly classified into two categories as residential and non-residential. The Permanent camp is proposed at suitable place, which will accommodate dwelling units of different types for officers and staff, Administrative office building, Hospital/Dispensary, Guest House. School, Officers Club & Auditorium, Staff Club/ Union Office, Shopping Centre, Bank, Telephone Exchange, Canteen, Model Room, Stores, Sub-station, Fire Station, Filtration Plant, Workshop, DG Building, Quality Control Laboratory, etc. Field hostels will also be constructed to accommodate sufficient number of personnel.

(a)*Project Headquarters*

The project headquarter will be on the left bank of the River near the dam site and powerhouse site flat area. The accommodations are broadly classified into two categories: residential and non-residential. Most of the residential and non-residential buildings are proposed to be constructed in double/triple stories at the project site keeping in view the limited availability of land.

(b)*Residential Accommodation at Project Site*

The Residential Complex is proposed at suitable place, which will accommodate dwelling units of different types for officers and supervisory staff, School, Bank, Post Office and Telephone exchange etc. as well. All accommodation for Owner and its representative will be constructed by the Engineering Procurement and Construction (EPC) Contractor. The Contractor will also have his separate labour camps which have been shown in the designated area. Field hostels will also be constructed to accommodate sufficient number of personnel. Both temporary and permanent types of residential buildings are planned. The details of these buildings are given below in **Table 1.6** and **Table 1.7.**

Table 1.6: Permanent Residential Building for Karuma HPP

S.N.	Item	No of Units	No of Buildings	Plinth Area / Building	Total Area (Sq m)
1	Type A @100 sqm/unit (Ground + 2 storey's); 2 flats on each floor	60	10	562.50	5625.00
2	Type B @ 250 sq m/unit	40	40	125.00	5000.00
3	Type C @ 300 sq m/unit	20	20	175.00	3500.00
4	Type D @ 400 sq m/unit	5	5	201.00	1005.00
5	Type E @ 500 sq m/unit	1	1	400.00	400.00
Bachelor Accommodation					
6	HOSTEL - A @ 30 sqm /unit (Ground Floor + 2 Storeys)	24	4	225	900.00
7	HOSTEL - B @ 50 sqm /unit (Ground Floor + 2 Storeys)	30	5	375	1875.00
				Total	**18305.00**

Table 1.7: Temporary Residential Building required during Construction Phase of Karuma HPP

S.N.	ITEM	No of Units	No of Buildings	Plinth Area / Building	Total Area (Sq m)
1	Type I @ 75 sqm/unit	70	70	75.00	5250.00
2	Type II @ 100 sq m/unit	50	50	100.00	5000.00
3	Type III @ 200 sq m/unit	25	25	175.00	4375.00
4	Type IV @250 sq m/unit	8	8	201.00	1608.00
5	Type V @ 300 sq m/unit	1	1	300.00	300.00
Bachelor Accommodation					
6	Dormitory - category -1	100	100	100	10000.00
7	Dormitory - category -2	60	10	100	1000.00
				Total	**27533.00**

(c) *Non-Residential Accommodation at Project Site*

Non-residential accommodations at Project Site will include Administrative/office building, Hospital/Dispensary, Guest House, School, Officers Club & Auditorium, Staff Club/ Union Office, Shopping Centre, Bank, Telephone Exchange, Canteen, Model Room, Stores, Sub-station, Fire Station, Filtration Plant, Workshop, DG Building, Quality Control Laboratory, CISF store/office, LPG Godown etc. and all these structures will be needed during construction and Operation phases of the KHPP. Non-residential accommodation is planned on multi-storied pattern for Administrative Building, Guest House, Officers Club & Auditorium, School and Hospital keeping in view the limited land at the project site. The total land requirement for Non-residential permanent and temporary buildings at Project Site is as given below in **Table 1.8 and Table 1.9.**

Table 1.8: Detail of the land requirement for Permanent Non-Residential Buildings in Karuma HPP

S No.	Item	Land Requirement (Sq m)
1	Office building	4000
2	Store / Ware House 2 nos	1000
3	School	2000
4	Police Outpost	500
5	Post Office	250
6	Bank	250
7	Telephone Exchange	250
8	Hospital	1000
9	Guest House	2500
10	Field Hostels	1000
11	Community centre/Auditorium	1000
12	Co-operatives 2 nos	500
13	Market	1000
14	Testing Laboratory	250
15	Magazine Building	500
17	Canteen	500
18	Library Study centre	500
19	Play ground	100
20	Gymnasium and Swimming Pool Complex	250
21	Children Park	100
		17450

Table 1.9: Detail of the land requirement for Temporary Non-Residential Buildings in Karuma HPP

S. No	Item	Land requirement (sq. m)
1	Office buildings	5000
2	Hospital cum dispensary 1 no	1000
3	Store / Ware House	3000
4	Community center, library etc.	1500
5	Work Shop	2000
6	Silos	1500
7	Workers Welfare Center	1500
8	Clubs, Playground etc	500
(a)	Office buildings	1000
(b)	Open Yard	5000
(c)	General Stores	2000
(d)	Weigh Bridge/POL station	200
(e)	Check Post	50
		24250

1.9.3 Other Infrastructure

a) Explosive Magazine.

The proposed Explosive magazine has been located on left bank of River Kyoga Nile. The Left bank main access road will provide the accessibility to explosive magazine.

b) Workshops

Central workshop for heavy earth moving equipment and transport vehicles shall be set up at the left bank. The area shall be developed including open space and parking area. The workshop shall comprise of covered/semi-covered repair sheds.

The workshop shall comprise facilities for the engine repairs and overhauling, transmission, Torque converter repair shops, auto-electrical shops, machine shop, tyre repair shop, welding and fabrication shops, chassis repairs, body and seat repairs, denting/painting, maintenance yard etc. The workshop shall be securely fenced with control of operations.

c) Warehouses/Stores Complex

Space for construction of transit stores for Cement, Steel and other materials including Chemicals downstream of the dam site have been provided on the left bank flat area. The steel and other store items like bitumen etc. which do not require covered area would be kept outside in open. For the purpose of cement storage covered sheds shall be developed enabling storage of adequate quantity of cement.

d) Muck Disposal Area

The construction of various hydraulic structures like diversion channel, concrete dam, Intake, HRT, powerhouse cavern, transformer cavern, surge chamber, surge tunnels, TRT etc. will require large excavation; a part of which would be used for concreting in wearing/non wearing faces and part of it would be disposed off in designated muck disposal areas. The summary calculation in respect of total muck generated and required to be disposed in the designated areas is given below in **Table 1.10.**

Table 1.10: Summary of Excavation Quantity in construction of Karuma HPP

S.N.	Description	Excavation Quantity (Cu.m)		
		Open Excavation		Underground Excavation
		in Soil	in Rock	
1	Coffer Dam and Diversion Channel	82200.00	422,080	-
2	Concrete Dam	17380	172900	-
3	Power Intake	399030	135680	-
4	Pressure Shafts	-	-	144089.00
5	Power House Cavern & Transformer Cavern	-	-	507190.81
6	Tailrace tunnels between Power House and Surge Chamber	-	-	125610.00
7	Surge Chamber		-	1267321.00
8	Tailrace tunnels from Surge Chamber	128600.00	-	3341390.00
9	Tailrace Channel	403540.00	144780.00	-
	Total	**1030750**	**875440**	**5385600.81**

1.10 SITE SERVICES

a) Project Power Requirements

The requirement of peak construction power is 20 MW which will be met through Diesel Generators (DG) sets is tabulated as below:

Table 1.11: Construction Power required for Karuma HPP

No	Area	Maximum Load Demand(in MW)
1	Dam Complex	0.50
2	Adit – 1	4.00
3	Adit – 2	2.00
4	Main Access Tunnel	2.00

5	Construction Adit to Powerhouse	2.00
6	Construction Adit to Surge Chamber	1.00
7	Colony Area	2.00
8	Quarry Area	2.00
9	Cooling and Batching Plant	3.00
10	Tailrace Outlet Area	1.50

All Construction power for main works, ancillary works and colonies etc. would be arranged by the EPC Contractor. Given the unreliability of the local electricity grid, the Contractor will have to put in place a fulltime backup generation and distribution capacity for all requirements during implementation. Temporary thermal generation arrangement using Diesel generators will be put in place and should be removed from site by the EPC contractor after the construction phase.

b) Water Supply

Treated water will be needed for various purposes including drinking and other domestic requirements. The EPC Contractor will be responsible for providing all water supplies required during the construction phase of the project. It is expected that the raw water source will be the flow of river Nile.

The raw water will be collected from Kyoga Nile with sufficient Intake arrangement and it will be filtered through fine filters installed within the treatment plan and filtered water will be further treated by reverse osmosis process. The quality of the water from the treatment plan will be checked with standards before supplying for utility purposes.

The EPC contract will install a water treatment plant of sufficient capacity to meet the water demands of the project, especially the office and residential complex. Water will also be required for the powerhouse, workshop and stores, washrooms, mess and toilets, kitchen facilities and to provide make-up water for cooling and for the HVAC systems and other powerhouse systems.

The proposed treatment plant will be fully automatic and with a good process capability. The plant design will incorporate features to prevent any potentially hazardous chemicals used in treatment from impacting operating staff and the environment.

c) Wastewater

The waste water from various locations like, permanent colony, office area, work shop, batching plant, etc., will be collected to the wastewater treatment plant through a well defined sewer system. The collected wastewater will be treated in the wastewater treatment plant and quality will be ensured with the standards before discharging into the River Kyoga Nile. The capacity of the Wastewater Treatment Plant shall be designed to handle approx. 0.14 MLD (million liters/day) of water based on the assumption that 100% of the water supplied ends up as wastewater.

It is proposed that a system with a continuous population of about 32 people and a time interval for the removal of sludge from septic tanks of about 12 months will be used. The discharged effluent should meet the discharge quality that meets both the Uganda and World Bank Standards.

d) Security & Safety Arrangements

The size of this project, the associated facilities and its sensitivity will require a full time and alert security presence and surveillance. Security gates and a guardhouse will control entrance into the project complex. The guard house will have a good view of the access roads and if deemed necessary, a watch tower will be put in place to give a better view of most of the sensitive project areas. Good external lighting will be provided to the powerhouse, power intake, spillway, sub-station and guardhouse areas; security lights will be provided on the main roads within the project area.

e) Telecommunication

During construction of Karuma hydropower Project, it is proposed to have a multi channel VSAT connection at site in addition to local radio/wireless communication. Karuma is well covered by many mobile operators and care will be taken to augment the existing towers wherever required especially in the TRT area. All the communication facilities would be provided by the EPC contractor to his personnel as well as to owner's representatives and other contractors. The contractor will also provide and maintain the VSAT and Video-conferencing connections between site and MEMD, Kampala.

1.11 LAND REQUIREMENT FOR CONSTRUCTION FACILITIES

Total land requirement of Karuma Hydro Power Project for construction facilities is tabulated below and the Layout Plan showing the Land requirement for the construction facilities is given in **Table 1.12** and **Annexure 1.12**.

Table 1.12: Land Requirement for Construction Facilities in Karuma HPP

No	Project Component	Total Area (Ha)
1	Main Dam & Power Intake area	4.83
2	Quarry area and Quarry access Road	28.20
3	Project Area – 1	53.70
4	Project Area – 2	15.44
5	Project Area - 3	238.60
6	Equipment Yard	5.00
7	Work shop area	5.00
8	Steel Yard	5.00
9	Fabrication yard	5.00
10	Fuel & Consumables area	5.00

No	Project Component	Total Area (Ha)
11	Labor Camp	10.00
12	Office Colony	2.00
13	Permanent Office/Colony Area	10.00
14	Explosive Magazine area	2.00
15	Muck Disposal Area	71.75
16	Construction Facilities area	4.00
Total Required Land Area for Construction facilities		**465.52**
Land already acquired as per NORPAK Proposal is 123.23 ha, of which land to be used as per present layout		34.17
Additional area to be Acquired for Construction facilities		**431.35**
Of this 431.35 ha, Land under Karuma Wild Life Reserve		238.60
Of this 431.35 ha, Land to be acquired from private owners		192.75

1.12 MATERIAL SOURCING FOR CONSTRUCTION

By nature and size, the Karuma HEP will require huge quantities of aggregate and other construction materials for various project uses, such as the main dam, the diversion canal, power station, intake structure, tunnels, access road, various temporary and permanent camps, etc. Several material sites and sourcing areas will be required for both extraction and delivery of these materials.

Construction Materials

The dam being small in size will require coarse and fine aggregates in small quantities, most of it will be available from the compulsory excavation of the right bank diversion channel itself. This project will require substantial amounts of construction materials for concrete works. The materials include cement, sand and aggregate. The different concrete categories, the quantities of such concrete and the respective quantities of materials are given in the table below;

Table 1.13: Estimated Quantities of Construction Material for Concrete Works in Karuma HPP

S. No.	Description	Quantity	Cement (in Bags)	Sand (m^3)	Aggregates (m^3)
1	Concrete grade M10 A40	4640	16564.80	2088.00	4176.00
2	Mass concrete M15 A80	101680	497825.28	45756.00	91512.00
3	Concrete grade M20 A20	15280	93513.60	6876.00	13752.00
4	Concrete grade M20 A40	11378	63828.40	5119.93	10239.85
5	Concrete grade M25 A20	1487207	9860185.33	669243.35	1338486.70
6	Concrete grade M30 A20	37893	289881.83	17051.87	34103.74
7	HPC Concrete grade M60	4460	50041.20	2007.00	4014.00

S. No.	Description	Quantity	Cement (in Bags)	Sand (m^3)	Aggregates (m^3)
8	Precast RCC Lagging	15899	97304.66	7154.75	14309.51
9	Shot-creting	135257	1517588.31		
10	Grouting	929782	929782.00		
		Total Quantities	**13416515.41**	**755296.9**	**1510593.8**
			Say 14 Million bags	Say 0.80 Million **m³**	Say 1.6 Million **m³**
			0.70 Million tons		

In addition to the estimated quantities of material for concrete works, there will also be substantial rock material that will be required for gabions, dumped rock fill and stone pitching in Coffer Dam, Diversion Channel, Concrete Dam, Power Intake and Tail Race Channel, these materials are indicated below in **Table 1.14**

Table 1.14: Estimated Quantities of Construction Material (rock materials) for other works in Karuma HPP

Item	Coffer Dam & Diversion Channel	Concrete Dam	Power Intake	Tail Race Channel	Total (cum)
Gabions	15280	31350	-	-	46630
Dumped rockfill	413810	-	-	-	413810
Stone pitching	-	-	9370	6270	15640

Most of the concrete aggregates for wearing as well as non-wearing surfaces will be obtained through the compulsory excavations of various underground project components and partially by developing rock quarries in the near vicinity of the Project. The rock materials excavated from different underground structures will be utilized through using crushers to generate the required quantity of the coarse (***1.60 Million* m³**) and fine (***0.80 Million* m³**) aggregates required for different components of the project. To minimize the impact of excavation on environment, proper muck disposal areas have been identified, where the muck generated during excavation will be disposed off. This area is shown on the layout of the project at **Annexure 1.1**.

In addition to the aggregates described above, an area on the right bank (north bank) was identified where bed rock is exposed or is available at shallow depth (0.5 m – 2 m). Rock reserve estimation has been carried out down to 15 m depth. A 700 m long Diversion Channel with 10 m base width, 10 m height and top width varying between 36 m and 64 m has been designed to pass a flood of 2500 cumecs. Excavation of the Diversion Channel will generate about 0.0488 Million m^3 of soil and weathered rock mass (not suitable as concrete aggregate) and 0.42 Million m^3 all in aggregates. Out of 0.42 Million m^3 of all in aggregate excavated along the Diversion Channel, 0.27 Million m^3 will be usable as coarse and fine aggregates and 0.15 Million m^3 muck will be generated during mining and processing through the crushers and sand classifiers.

Compulsory excavation to construct various surfaces and sub-surface structures of the Karuma Hydropower Project will produce huge quantities of usable aggregates and muck. Summary of all surface and underground project components and their dimensions are tabulated below.

Surface excavations in residual soil and bed rock have been estimated for each structure separately as below.

Table 1.15: Summary of Open Excavation in Karuma HPP

Structure	Coffer Dam & Diversion Channel (m^3)	Concrete Dam (m^3)	Power Intake (m^3)	TRT with 12.50 m dia (m^3)	TRC (m^3)	Total (m^3)
Open Excavation in all type of soils	82200	17380	399030	128600	403540	**1,030,750**
Open excavation in bed rock	422,080	172900	135680	-	144780	**875,440**

Similarly, underground excavation in Power House and Transformer Hall caverns and Surge System have been estimated separately. Excavation quantities along the proposed tunnels, viz., Pressure Shaft and TRT's are shown below,

Table 1.16: Summary of Underground Excavation in Karuma HPP

Structure	Underground excavation	Tunnel excavation
Pressure Shaft (m^3)	-	144089
Power House & Transformer Hall (m^3)	335044	172147
TRT 7.70m (m^3)	-	125610
TRT 12.50m (m^3)	-	3341390
Surge System (m^3)	12537	1142284
Total (m^3)	**460081**	**4925520**

From compulsory excavation, about ***1.031 Million m^3*** residual soil and ***6.261 Million m^3*** rock material will be generated. Due to the Drill and Blast method tunneling of the rock mass only 40 %

of the total generated rock mass will be available as usable aggregates, such as, ***2.50 Million m^3*** and balance ***3.761 Million m^3*** muck will be generated.

Looking at the project aggregate requirement vs the excavated and usable rock (as aggregate), most of the concrete aggregates for wearing as well as non-wearing surfaces will be obtained through the compulsory excavations of various underground project components and partially by developing rock quarries in the near vicinity of the Project. The rock materials excavated from different underground structures will be utilized to generate the required quantity of the coarse (***1.60 Million*** **m^3**) and fine (***0.80 Million*** **m^3**) aggregates required for different components of the project.

During open cast mining operations and processing of rock material in crushers and sand classifier's, 40% of the available rock material will get converted in to waste and only 60% of the available rock material will get converted in to coarse and fine aggregates. The rock materials estimated from compulsory excavations during construction of different project components and from the proposed rock quarry are tabulated below.

Table 1.17 – Rock Material from Compulsory Excavation and Quarry area in Karuma HPP

Material	Source	Location	Available Quantity (in M m^3)	Usable Quantity (in M m^3)
Rock	Underground Structures & open excavation in rock	Left Bank + Diversion channel	6.261	2.50
Rock	Right Bank Quarry	Right Bank of River Kyoga Nile, near Dam axis(60% usable)	1.748	1.048
Total estimated quantity			***8.009***	***3.548***

In addition to the estimated quantities of material for concrete works, rock material required for gabions, dumped rock fill and stone pitching in Coffer Dam, Diversion Channel, Concrete Dam, Power Intake and Tail Race Channel has been estimated as ***0.476Million*** **m^3**.

Out of the available ***8.00Million*** **m^3** all in aggregate, ***3.548Million*** **m^3** rock materials will be required to generate fine, coarse aggregates and rock material. With this background, judicious planning to utilize maximum quantities from the compulsory excavations is required to construct various project components so that minimum quantities are exploited from the proposed rock quarry located on the right bank. Maximum utlisation of rock material from compulsory excavation will in addition to minimising extraction from the quarry, also reduce the volume of muck to be disposed off. The sites that have been identified for these materials are shown in **Annexure 1.13**.

The raw materials that are expected to be used for the construction of the project and their sources are summarized in **Table 1.18** below.

Table 1.18: Other materials needed during construction of Karuma HPP

S.N.	Raw Material	Source	Mode of Delivery
1.	Laterite (for construction e.g access roads)	Approved borrow pits / quarries	Road truck
2.	Cement	Local approved supplier	Road truck
3.	Bricks	Local approved supplier	Road Truck
4.	Concrete blocks	To be manufactured on and off-site	Road truck
5.	Diesel and petrol for operation of plant, machinery and vehicles	Local approved Service Station	Road truck
6.	Water for construction, dust suppression and workers domestic use	Onsite abstraction rate 2.0 l/s	Pump
7.	General building materials (e.g. timber, polythene sheeting, brick force and mesh reinforcement, pipes, paint, etc.)	Local approved suppliers	Road truck
8.	Equipment (e.g. Earth Moving Equipment)	Local approved contractor	Road truck

During Operational Phase, the main raw materials inputs required will include:

- Water for power generation (the main input), domestic and commercial use.
- Fuels and oils

1.13 BY – AND WASTE PRODUCTS

Both during construction and operation, the project is expected to generate huge amounts of different kinds of waste and by products. Various disposal areas have been proposed, both within the proximity of the dam site and others at a distance. The proposed locations of disposal sites are indicated in **Annexure 1.14**.

Construction Phase

The following waste and by-products are expected to be generated during the project construction cycle:

- ***Topsoil:***Topsoil resulting from scarifying and excavation of the site.
- ***Rock material:***As a result of tunneling and blasting
- ***Building Rubble:***This will include sub-soil removed and any rock rubble generated by blasting (or other rock breaking activities) during excavation of trenches for foundation

strips and the laying of water reticulation pipes, excavations for water features, ground storage tanks for water and fuel, etc. and other spoils such as rejected concrete, broken blocks etc.

- ***Solid waste*****:** other solid construction waste will include material such as scrap timber and various off cuts and refuse such as discarded packaging (e.g. cement bags), workers garbage, debris etc.
- ***Sewage*****:** Sanitary waste generated by the construction workforce.
- ***Runoff:***Storm water runoff from the site
- ***Dust:*** Dust will be generated on the site from delivery of material and various construction activities.
- ***Exhaust emissions*****:** from operation of vehicles and machinery on site.

Operational Phase

The following by- and waste products are expected to be generated during operation:

i. ***Sewage*****:** Sanitary waste generated by the workforce and visitors to the project during operational phase.

ii. ***Solid wast*****e:** other solid waste will include material such as scrap timber and various off cuts and refuse such as discarded packaging materials, workers garbage etc.

iii. ***Storm Water:*** An increase in storm water runoff will result from the site due to the development of reservoirs, roofed and paved areas which do not allow infiltration of rain water. Storm water runoff from the fuel storage and dispensing area (service station) as well as parking areas may contain some hydrocarbons from minor oil or fuel leaks/spills. Storm water run-off typically also contains silt and suspended solids.

iv. ***Green waste:***will include leaves and grass cuttings from maintenance of the areas around the main project facilities and other landscaped areas of the project.

1.13.1 Hazardous Waste and Oils

The envisaged waste is not what can be considered as extremely hazardous. The wastes that could be of a hazardous nature are the fuels, oils and other motor vehicle or machinery lubricants. Significant amounts of fuels and oils will be used or generated from the different equipment on site. Diesel fuel for the backup generators and site vehicles will be stored in bulk storage tanks. The tank area will be enclosed by secondary containment capable of storing the entire tank capacity in case of leakage or other accident, and a one cubic meter capacity sump with a central drain, to collect any diesel spilled during filling operations. Construction vehicles will be re-fuelled by tankers that will collect diesel from this central store and distribute it to vehicles around the site. Chemicals, such as hydraulic fluid, will be stored in locked buildings, which will also be bunded to contain spills.

The site drainage will be designed so that all overland flow will pass through the settlement ponds that will be established on site as part of the wastewater management system. This will also serve as an interceptor, and will hold back oil or other chemicals from being released into the environment in the event of a significant spill. This will provide sufficient time to attend to such accidental release and be able to contain and control the incident before getting out of hand. Some of the emergency response would involve pumping out trapped oil and disposing of it appropriately in approved sites. For the Karuma HPP, the nearest area designated for handling hazardous waste is the Ministry of Defence Facility in Nakasongora. The EPC contract will work out the framework modalities on how to use this facility and engage the relevant authorities.

1.13.2 Explosives

A certificate to import and use explosives will have to be procured from the relevant government agency i.e. the Ministry of Internal Affairs. In accordance with Ugandan law, explosives such as the dynamite charges used in blasting, will be left in the custody of the Army. On the day when the blasting is to take place, the police will deliver the amount of supplies of explosives to Karuma site. Protocols will be developed by the EPC Contractor with respect to the storage, transportation and handling of explosives. The EPC Contractor will also develop a Blasting Notification Procedure to be used to inform local persons about the blasting schedule. This will include among others, siren and alert sounds on time to allow people to move to safer distances. The use of community mechanism to alert community members prior to the exercise e.g. local radio stations, LCI representatives and churches amongst others will also be utilized.

1.14 PROJECT ACTIVITIES

Activities during Construction Phase

Initial activities during this phase relating to construction management will include:

- Establishment of the construction Project Management Team (PMT).
- Establishment of a professional Site Inspection Team.
- Establish and agree management, inspection and reporting procedures.

Site Establishmentwill include the initial construction of the following facilities:

- Mobilisation and site preparation
- Establishment of site management office and facilities.
- Maintenance workshop sheds and stores.
- Fuel depot / kerb site
- Establishment of temporary services and builders supply i.e. water supply, power and sanitary facilities

- Establishment of temporary fencing around the site

Various plant and equipment to be used during the execution of civil works is given in **Table 1.19** as below:

Table 1.19: Plant and Equipment to be used in civil works during construction of Karuma HPP

Structure/Activity	Proposed Equipment	Number
Diversion Channel – Right Bank	Excavator – 6 cum	02
	Excavator – 1 cum	01
	Dumpers, 25 tons	10
	Crawler drill machine	01
	Hydra Mobile Crane	01
	Explosive van	01
	Dewatering pumps – 20 HP, 10 HP and 5 HP	01
	Jack hammers	10
	Loader cum excavator	03
	Concrete Pump 60 cum/hr	02
	Concrete Batching and Mixing plant – 300 cum/hr	01
	DG set – 500 KVA	01
Upstream Coffer Dam	Excavator – 6 cum	02
	Excavator – 1 cum	03
	Dumpers, 25 tons	20
	Hydra Mobile Crane	01
	Vibratory Rollers of 10t	03
	Dewatering pumps – 20 HP, 10 HP and 5 HP	02
	Loader cum excavator	03
	Crawler Dozer – 320 HP	02
	DG set – 500 KVA	01
Concrete Gravity Dam (Excavation of left bank abutment and river bed)	Excavator – 6 cum	02
	Excavator – 1 cum	01
	Dumpers, 25 tons	10
	Crawler drill machine	02
	Explosive van	02
	Dewatering pumps – 20 HP, 10 HP and 5 HP	01
	Jack hammers	05
	Loader cum excavator	03
	Air Compressor – 500 cfm	02

	DG set – 500 KVA	01
Transport And Placing Of Concrete In Dam	Transit mixers of 6 cum	15
	Tower cranes of 20 MT	03
	Vibrator gangs	
Excavation of right bank abutment	Equipment same as for left bank excavation	
Excavation of MAT	2 boom drill jumbo	01
	Single boom rock bolter	01
	Excavator cum loader of 1 cum capacity	01
	Wet shotcreting machine with robot arm	01
	25 t dumpers	05
	DG sets – 1000 KVA	01
Adit to the powerhouse and transformer cavern crown	2 boom drill jumbo	01
	Single boom rock-bolter	01
	Excavator cum loader of 1 cum capacity	01
	Wet shotcreting machine with robot arm	01
	25 t dumpers	05
	DG sets – 1000 KVA	01
Access Tunnel to the Surge chamber	2 boom drill jumbo	01
	Single boom rock-bolter	01
	Excavator cum loader of 1 cum capacity	01
	Wet shotcreting machine with robot arm	01
	25 t dumpers	05
	DG sets – 1000 KVA	01
Tunnel excavation (From the TRT outfall area)	Three boom Drill Jumbos	01
	Wagon drills	01
	25 t Dumpers	08
	Hydraulic excavators 2 cum	01
	Air compressors – 1000 cfm	01
	DG set - 2 x 500 KVA	01
	Single boom Rockbolter	01
	Shotcrete machine with Robo Arm	01
	Loader cum excavator	01
	Concrete Pump 60 cum/hr	01

	Concrete Batching and Mixing plant – 100 cum/hr	01
	Ventilation Fan and ducts	01
	Concrete shutters for overt concreting	01
From the Adit-II A(additional to what is used for TRT outfall)	Three boom Drill Jumbos	01
	Wagon drills	01
	25 t Dumpers	08
	Hydraulic excavators 2 cum	01
	Air compressors – 1000 cfm	01
	DG set - 2 x 500 KVA	01
	Single boom Rockbolter	01
	Shotcrete machine with Robo Arm	01
	Loader cum excavator	01
	Concrete Pump 60 cum/hr	01
	Concrete Batching and Mixing plant – 100 cum/hr	01
	Ventilation Fan and ducts	01 sets
	Concrete shutters for overt concreting	01
From the Adit-I (additional to what is used for TRT outfall)	Three boom Drill Jumbos	01
	Wagon drills	01
	25 t Dumpers	0 8
	Hydraulic excavators 2 cum	01
	Air compressors – 1000 cfm	01
	DG set - 3 x 500 KVA	01
	Single boom Rockbolter	01
	Shotcrete machine with Robo Arm	01
	Loader cum excavator	01
	Concrete Pump 60 cum/hr	01
	Concrete Batching and Mixing plant – 100 cum/hr	01
	Ventilation Fan and ducts	0 1 sets
	Concrete shutters for overt concreting	01

The main anticipated project construction activities that will have potential impacts on the environment are:

i. *Site Preparation and Leveling*

Initial site preparation will entail removal of the existing vegetation, scarifying of topsoil and earthworks to establish the required levels. Apart from the tunneling, the project will be constructed by-and large on the existing level requiring minimal basic earthworks, which will minimise the need for filling of areas with laterite and aggregates. Earthworks will for the most part involve the use of heavy machinery such as bull dozers and graders.

ii. *Construction of Access Roads and Drainage*

Construction of the access roads will involve earth moving and shaping of formation and shoulders, and stabilization of the base with the piling, spreading and compaction of gravel and aggregate materials. Construction of drainage channels will involve excavation and shaping of drains and soil compaction. Lined drains/channels will require the preparing and pouring of concrete.

iii. *Crusher and Batching Plant*

The crusher plant and batching plant has been located nearby Muck disposal area as transportation of raw material would be minimized. The capacity of the crusher plant is 500TPH as to supply the aggregates to batching plant sufficiently. The Batching plant has been designed to produce 300 Cu.m per hour to meet the concrete requirement for various project components without any delay.

iv. *Tunneling, Excavation and foundations*

This will involve the excavation of trenches for foundation strips for buildings, canals, tunneling of tail race, etc. The geotechnical survey of the sites is indicative that the bearing capacities of soils are good and the foundation depth and design for the intended structures will be simple and straight forward, in accordance with acceptable/required engineering standards. Construction of foundations will involve the compaction of underside of foundation trenches and the mixing, pouring and compaction of concrete. A significant amount of earth moving will be required for construction of the main hydropower scheme components such as the power house and intake.

v.Sub-structural works

This will involve block work, mixing, pouring and compaction of concrete, backfilling and compaction of material according to specifications. Construction of services will include the foundation and various piping installations.

vi. Construction of Superstructures (Buildings and Houses)

This will involve preparing of mortar and concrete, laying of concrete block walls, landscaping.

vii. *Maintenance of Machinery*

A workshop facility will be constructed on site for the maintenance of construction vehicles and machinery. This workshop will be very well designed to handle any oil and fuel leakages that will occur during vehicle and machinery servicing. The workshop will be part of the temporary buildings to be erected by the EPC contractor.

viii.Movement of Construction Traffic and Heavy Machinery

Transportation of construction materials / waste to and from the sites will involve the movement of heavy vehicles on access roads to the project sites as well as within the sites. Construction activities such as clearing, excavation, earth moving and mixing of concrete will involve the movement and operation of heavy plant and equipment around the sites.

ix. Water Abstraction

As mentioned earlier, water will be required for construction, workers domestic and dust suppression measures. Water will be abstracted on site from the River Nile, at an abstraction rate not exceeding 2.0 l/s. Water for drinking and other domestic purposes will be treated and the quality of water shall be examined with standards before supplying to domestic purposes.

x. Wastewater Management

Waste management during the construction phase will include:

- Provision of temporary workers sanitation in the form of portable PVC toilets
- Collection and disposal of domestic waste (from septic tanks) at approved disposal sites
- Transportation and disposal of building waste and rubble.
- Collection and disposal of used oils / lubricants according to national requirements and standards.

Activities during Operation Phase

Activities during operation that are likely to have an impact on the environment include:

i. Operation of the weir and the reservoir

The operation of the intake, the weir and the small reservoir will result in changes of water flow hence might lead to flooding the natural habitats, high rates of evaporation, silting etc. The impacts will be minimal since the system does not have a lot of construction as in the usual dam systems. The tunnel system will allow continuous movement of water especially during heavy rains when the water level in the river would have otherwise gone over the banks.

ii. Access Roads Maintenance and Management

The access roads shall be cleaned routinely and monitored on a day to day basis for damage to the road surface. Any repairs necessary shall be carried out by an approved road contractor in conjunction, where necessary, with the respective authorities.

iii. Health and Safety

During the construction phase, the EPC Contractor will be responsible for the prevention of unhealthy or unsafe conditions and practices and for the promotion of healthy and safe working practices at the Site. The EPC Contractor will develop an Emergency Preparedness and Response Plan and procedure that include training of workers.

To handle minor injuries and other related cases, first aid kits will be provided at strategic places within the project facilities. In addition, a clinic will be maintained on site to provide basic treatment and first aid only. An ambulance will be on sight fulltime and incase of any serious/major cases the patients will be transferred to either Lira or Gulu referral hospitals for advanced handling. The clinic will be staffed and operated by the EPC Contractor.

The following staffs are proposed, as a minimum:

- A part time Doctor who is fluent in English and probably having knowledge of the local language
- A clinical/medical assistant who is fluent in English and probably having knowledge of the local language
- An experienced wound dresser/ trained first aid person.

Vector /Pest Control: Malaria control and prevention measures will be instituted by use of a number approaches including; the removal of breeding grounds (ensuring that pools of standing water are dried up), spraying the inside of houses with residual insecticide and provision of pre-treated mosquito bed nets. An awareness and sensitization programme to ensure that workers understand modes and risk of infection, and prevention will be put in place. Construction techniques that minimize creation of pools of standing water and other breeding grounds for vectors will be emphasized. Among the areas of concern are the borrow pits and quarry areas; these will be kept well drained in order to prevent this occurring.

1.15 PROCUREMENT AND MATERIAL DELIVERY TO SITE

This project will require huge amounts of construction materials and inputs that will need to be delivered and stored onsite. Gravel, laterite and stone aggregates will be acquired and transported to the site from approved quarrysites within the project area/project neighborhood. Provision will be made for bulk storage of materials such as sand, aggregate and laterite.

Petroleum products for trucks (such as petrol/diesel) will require transportation and storage on site. A storage facility for petroleum products has been provided in the designs for the project and the storage will be on site for stocks of about one week. Given the sensitivity and the dangers related to petroleum products, the services to run the petroleum products storage facility will be contracted out to reputable/licensed Petroleum Company, which will also ensure regular and sufficient supplies. Other materials that will be transported and stored include sand, cement, blocks and timber.

Although some of the materials for the civil engineering components of the hydropower facility such as aggregates will be produced on site, and others such as sand will be procured locally within the project area, the mechanical and electrical components will be sourced from different countries around the world. Most of the project inputs that will be sourced from outside the region (East

Africa) and will be imported through the port of Mombasa and transported either by road or rail to Uganda.

Some smaller components, especially for electrical installations will be transported by air through Entebbe Airport. The imported materials will be transported to the project site and stored in the established warehouses on site.

1.16 STAFFING

The recruitment policy for Project construction and operation shall be prepared based on the current practice specified by Ugandan law for workers or other guidelines followed by Government of Uganda. The local communities neighboring the project area should be given the first priority.

Construction Phase Labour force

Construction of the scheme will provide employment and career opportunity for several thousands of local people. The initial personnel requirement during construction is approximately 750-900, while at peak construction periods approximately 3000 personnel will be employed on the project. The number of skilled (technical and administrative) workers will be around 50 - 75 in the construction phase at peak periods. The number of semi-skilled and semi skilled workers, including the workers for supporting services will reach about 270 in the peak construction periods.

The construction workforce peaks just two years into the project with a maximum of more than 2000. Of the latter, a substantial part will be local personnel. The planned camp facilities will house local and international staffs.

A labour camp will be established in the project area and there will be a lot of social interaction between the project workers and the local community. The project will as much as possible hire labour from within local communities.

Site Organizationfor the EPC Contractor

The organization at Project site would be headed by a Project Director, who will be the nominee of the Owner. The main site works will be supervised by the Owner's engineer, which is EIPL. The head of EIPL will be designated as Project Manager and its staffing will be in line with the existing Contract with MEMD. The works will be carried out by the EPC Contractor. The EPC contractor's site organization is proposed to be in eight dedicated teams/ modules:

Table 1.20: Summary of key staff during construction phase Karuma HPP

Module	Department/Module Description	Number Required
1	Procurement, Stores and Logistics	30
2	Workshop, Mechanical and Hydro-	26

	Mechanical Works	
3	All underground caverns	34
4	Dam, diversion channel and Infrastructure works.	29
5	HRT, Tail Race System and surge tunnels	62
6	Project Monitoring, Liaisoning and Administration	38
7	Electro-Mechanical works	31
8	Finance	20
	Total	**270**

Local market transactions will take place between construction workers and local communities. Casual relationships may also result from interactions between workers and the community. A canteen will be established on site to cater for construction workers. The presence of construction workers will require the provision of water for food preparation and domestic purposes as well as the provision of sanitation and health services.

Operational Phase Labour force

Like the Construction phase, the operation of the scheme will provide employment and career opportunity for a significant number of people, including the local people. MEMD and UEGCL will be responsible for the operation and maintenance of the plant. During the operation phase, approximately 150 staff persons are needed to operate the power plant and the auxiliary facilities of the dam. Around 50 of these will be highly skilled staff (engineers, mechanics, and hydromechanics, electricians, and electronics specialists) and administrative staff, and the remaining will be unskilled workers and support staff (guards, cooks, gardeners, etc) that will, preferably, be hired locally. An effort will be made to ensure that for unskilled labour, the priority is given to the locals.

1.17 SITE RESTORATION

Landscaping

Though by nature, this project has minimal vegetation cover destruction and other surface disturbing activities, there will be some excavations for construction of different facilities and obtaining construction materials. All areas disturbed by construction activities will be restored to a natural appearance by landscaping, top soil spreading, grassing and planting of trees, as appropriate. Particular care will be exercised in restoring the power station and switchyard environments. All of the EPC Contractor's temporary facilities, including batching and crushing plants, crane foundations, workshops, offices and other buildings will be removed from site upon completion of the hydropower facility.

EPC Contractor will produce a restoration plan for the quarry on the west bank. One possibility is connecting the quarry pit with the river channel, and profiling the borrow areas in such a way that they provide spawning and nursery habitat for commercially-important fish species.

Access Roads

The access roads provided for the construction facilities will be maintained or closed based on the requirement during operation stage of the Project.

Management of Excavated Material

As highlighted already, some of the excavated material will be used in construction. The material, which is unsuitable for construction purposes, will be kept separate and disposed of in designated spoil areas, such as the exhausted quarry areas. Such material will be put in proper layers and compacted to reduce the volume and thus the required space. The surfaces will be finished and graded to the extent necessary to enhance surface drainage and vegetated to prevent future erosion of the materials.

Construction Schedule/Programme

The Project is to be completed in 64 months time. The project is scheduled to be completed in six years from date of commencement of construction (**Table 1.21**). The infrastructure facilities shall be developed concurrently with the process of obtaining various Government clearances.

Table 1.21: Construction Schedule of Karuma HPP

Activity Description	Duration (Months)	Early Start	Early Finish	Late Start	Late Finish	Total Float
Selection of Concept to Commissioning Consultant	0	1-Sep-09		1-Sep-09		0
Site Survey & Inv & Engg. / ESIA Report	16	1-Sep-09	31-Dec-10	1-Sep-09	31-Dec-10	0
Approval of Engg. Report and ESIA Report	2	1-Jan-11	28-Feb-11	1-Jan-11	28-Feb-11	0
Tender Processing & Award of Work	1	1-Mar-11	31-Mar-11	1-Mar-11	31-Mar11	0
Site Infra & Mobilization by Contractor	1	1-Apr-11	30-Apr-11	1-Apr-11	30Apr-11	0
Construction. of diversion channel on Right Bank	8	1-May-11	31-Dec-11	1-May-11	31Dec-11	0
Const of Dyke on Left. Bank & River Div on Right bank	2	1-Jan-12	29-Feb-12	1-Jan-12	29-Feb-12	0
Excavation, Concrete & Gate erection of Left bank Blocks	18	1-Mar-12	31-Aug-13	1-Mar-12	31-Aug-13	0
Construction of HRT Intake, Trash Rack etc.	18	1-Mar-12	31-Aug-13	1-Mar-12	31-Aug-13	0
Const of Dyke on Rt. bank & River Div on Left bank	4	1-Sep-13	31-Dec-13	1-Sep-13	31-Dec-13	0
Excavation, Concrete & Gate erection of Right Bank Dam Blocks	24	1-Jan-14	31-Dec-15	1-Jan-14	31-Dec-15	0
HRT excavation from Intake face -All 6 Nos full face	8	1-Jan-14	31-Aug-14	1-May-14	31-Dec-14	4
Steel Lining, Backfilling and Contact grouting	12	1-Sep-14	31-Aug-15	1-Jan-15	31-Dec-15	4

Excavation of Main Access Tunnel and other access	10	1-May-11	29-Feb-12	1-May-11	29-Feb-12	0
Excavation of powerhouse and Transformer Caverns	24	1-Mar-12	28-Feb-14	1-Mar-12	28-Feb-14	0
Pothead yard civil works and E&M equipment erection	36	1-May-11	30-Apr-14	1-Jan-13	31-Dec-15	20
Erection of Crane beam	4	1-Mar-14	30-Jun-14	1-Mar-14	30-Jun-14	0
Concreting in sub-structure	10	1-Jul-14	30-Apr-15	1-Jul-14	30-Apr-15	0
Concreting in Super structure	8	1-May-15	31-Dec-15	1-May-15	31-Dec-15	0
Erection of E&M equipment	18	1-Jul-14	31-Dec-15	1-Jul-14	31-Dec-15	0
Pre-commissioning Testing	1	1-Jan-16	31-Jan-16	1-Jan-16	31-Jan-16	0
Commissioning of Unit-I	1	1-Feb-16	29-Feb-16	1-Feb-16	29-Feb-16	0
Commissioning of Unit-II	1	1-Mar-16	31-Mar-16	1-Mar-16	31-Mar-16	0
Commissioning of Unit-III	1	1-Apr-16	30-Apr-16	1-Apr-16	30-Apr-16	0
Commissioning of Unit-IV	1	1-May-16	31-May-16	1-May-16	31-May-16	0
Commissioning of Unit-V	1	1-Jun-16	30-Jun-16	1-Jun-16	30-Jun-16	0
Commissioning of Unit-VI	1	1-Jul-16	31-Jul-16	1-Jul-16	31-Jul-16	0
Excavation of Access to Surge Chamber & Surge Tunnels	10	1-May-11	29-Feb-12	1-Jul-11	30-Apr-12	2

Excavation of Surge Chamber	24	1-Mar-12	28-Feb-14	1-Jan-14	31DEC15	22
Heading excavation of Surge Tunnels	24	1-Mar-12	28-Feb-14	1-May-12	30-Apr-14	2
Benching excavation of Surge Tunnels	8	1-Mar-14	31-Oct-14	1-May-14	31DEC14	2
Concrete lining of Surge tunnels	12	1-Nov-14	31-Oct-15	1-Jan-15	31-Dec-15	2
Excavation of Adit – I and II	10	1-May-11	29-Feb-12	1-Jul-11	30-Apr-12	2
Face Opening at TRT outfall portal	2	1-May-11	30-Jun-11	1-Mar-12	30-Apr-12	10
Heading excavation from TRT outfall portal side	18	1-Jul-11	31-Dec-12	1-May-12	31-Oct-13	10
Heading excavation from Adit I; u/s and d/s	18	1-Mar-12	31-Aug-13	1-May-12	31-Oct-13	2
Heading excavation from Adit II; u/s and d/s	18	1-Mar-12	31-Aug-13	1-May-12	31-Oct-13	2
Benching – All faces(Adit-I,II and TRT portal)	8	1-Sep-13	30-Apr-14	1-Nov-13	30-Jun-14	2
Concrete lining from All faces of Adit-I and II	12	1-May-14	30-Apr-15	1-Jul-14	30-Jun-15	2
Construction. Of Tailrace outfall structure and Channel	6	1-May-15	31-Oct-15	1-Jul-15	31-Dec-15	2

1.18 COMMISSIONING OF THE SCHEME

The Karuma HEP with installed capacity of 6x100 MW is likely to get commissioned in the year 2016. The peak demand projected in 2016 is 1069 MW and in 2017 is 1151MW. It would be possible to meet the peak demand mainly with generation at Kiira HEP (200 MW), Bujagali HEP (250 MW), Karuma HEP (600 MW) and Nalubale HEP (180 MW). The surplus power available can be exported to neighboring countries. The diesel based thermal stations can be operated to supplement generating capacity in case of outages. Karuma Hydro Power Project has been planned as a Run-of-the River scheme and it would not only meet the electricity demands of Uganda in future, but also trigger rapid industrialization of the country.

1.19 OPERATION AND MAINTENANCE OF THE SCHEME

1.19.1 Concrete Dam and Spillway

The proposed concrete dam is a main diversion structure by which the river water will be diverted for the power generation. The water way provided in the concrete dam comprises of 14 numbers of surface spillways, 2 numbers of under sluices and one fish pass. The design flood of the project is estimated as 4300cumecs which can be passed through 13 numbers of surface spillways and remaining one gate has been provided as a stand by unit to take care of mechanical or human failure during operation of spillways. The spillway gate will be maintained periodically with the guidelines stipulated by the gate manufacturer. For maintenance of spillway gates sufficient arrangements for stop log gates also been provided with in the Dam structure.

The initial reservoir filling will be carried out before the project commissioning, during which the reservoir rim will be continuously monitored to ensure the stability of the reservoir fringe. The water level in the reservoir shall be maintained at EL.1030.00 during power generation and no case it will not be drawn below El.1028.00m. The reservoir level will be continuously monitored with the gauges installed with the dam Site accordingly the power plant will be operated. Automatic and remote controlled radial gates will ensure reservoir level maintenance.

The under sluices are proposed at the intake pool as a silt flushing arrangement for power Intake. The intake pool shall be flushed periodically, to ensure availability of clear water to the turbines. For periodic and emergency maintenance of under sluices, sufficient arrangements have been provided for stop log erection and the maintenance shall be done as per the manufacturer recommendations.

The fish pass will always be in operation and through which the mandatory environmental flow of 50 cumecs will be discharged to the downstream reach, however, which is now revised to 100 cumecs after the recommendation of Directorate of Water Resource Management. The periodic maintenance will be carried out for the fish pass gates as per the manufacturer’s recommendations.

1.19.2 Water Conductor System

The design discharge for power generation will be supplied through the power intake to the pressure shafts. The floating debris which is likely to be accumulated in front of power intake will be removed with the mechanically operated trash rack cleaning machine. The trash rack and intake gates will be continuously monitored and sufficient arrangements are provided to carry out the periodic / emergency maintenance work.

The initial filling for pressure shaft will be done as per the international practices, during which the entire alignment of pressure shaft will be continuously monitored for leakages. The pressure shafts will always be operated with full flow conditions and sufficient arrangements have been provided for dewatering purposes which may required for carried out the maintenance works.

The tail water from the power house will be conveyed through 7.70m dia tailrace tunnels to the surge chamber which is provided to accommodate the surges during power plant operations. The tail water from the surge chamber will be conveyed through two numbers of 12.5m horse shoe shaped tunnels which are 8.30m long and designed for pressurized full flow condition. The construction adits to the tailrace tunnels will be plugged with the gate provision which will be required for drain the tailrace tunnels for periodic/emergency maintenance.

1.19.3 Power House

The power house is planned for 600MW installed capacity with six Francis turbines. The machines are designed with 10% overload capacity to achieve the installed capacity of the project even unavailability of one of the machine during maintenance. The Draft tube gates are provided to facilitate the dewatering process in the power house during maintenance of turbines and its accessories. If the national grid rejects the power house will be shutdown within 12sec and the machines will initiated with the defied sequence after receiving the clearance from the national grid. The initiation process will be begins with the first unit and it will take 60sec and the remaining units will be operated with 300sec interval. Thus the total initiation time for all the machines will take 26min.

1.20 DECOMMISSIONING PLAN

After completion of life of the project, the retrievable entities like power house equipments will be taken out and passage to the power house and other tunnels will be suitably plugged to prevent unauthorised entries. The spillway gates and its hoisting arrangements will be retrieved and the River Kyoga will be guided to its natural downstream reach.

1.21 SALIENT FEATURES

The salient features of Karuma Hydro Power Project have been tabulated below,

Table 1.22: Salient Features of Karuma HPP

1	**Location**	
	Country	Uganda
	District	Kiryandonga
	Village	Karuma
	Airport	Entebbe - 300 km (Via Kampala)
	Road Head	1. From Kampala – 270 km 2. From Gulu – 75.0 km
	Latitude (N)	1^0 29'45''
	Longitude (E)	32^0 49'45''
	Map reference	Department of Lands and Survey of Uganda topo-sheet No. 31/3
2	**Meteorology**	
	Maximum Rainfall	2000mm
	Minimum Rainfall	900mm
	Average Maximum Temp.	28^0C (at Kampala)
	Average Minimum Temp.	17^0 C (at Kampala)
3	**Hydrology**	
	Catchment Area	346,000 sq. km
	PMF	4700 cumecs
4	**Reservoir**	
	Maximum Water Level	El. 1030.00
	Full Reservoir Level	El. 1030.00
	Minimum Drawdown Level	El. 1028.00
	Water Spread at FRL	2737.35 Ha
	Water Spread at MDDL	1790.35 Ha
	Storage at FRL	79.87 MCM
	Storage at MDDL	34.34 MCM
	Live Storage	45.53 MCM
5	**Dam**	
	Type	Concrete Gravity
	Length at top	311.53 m
	Overflow	169.39 m
	Non-overflow	142.14 m
	Top Width	6.00 m
	Top of Dam	El. 1032.00
	Maximum Height above deepest foundation	20.00m

	River Bed Level (average)	El. 1019.00 m
6	**Coffer Dam**	
	Type	Dumped Rockfill with Concrete Membrane on upstream face and jet grouting in foundation
	Maximum Height	15.00m
	Top Width	4.00 m
7	**Diversion Channel**	
	Size & Shape	A diversion channel of base width 10.00m, length of about 700.00m, side slope of 1:1 and bed slope of 1:130 on the right bank.
	Diversion Discharge	2500.0 cumecs
8	**Spillway Arrangements**	
	Type	Submerged Ogee Spillway
	No. of Gates	14Nos.
	Size of Gates	7.50m(W) X 10.00 m(H)
	Crest Level	El. 1020.00 m
9	**Silt-Flushing Arrangements**	
	Type	Under Sluice
	No. of Gates	14Nos.
	Size of Gates	3.00m(W) X 4.00 m(H)
	Crest Level	El. 1012.00 m
10	**Power Intake**	
	Type and Location	Rectangular fore bay type with inclined trash rack on Left Bank of Kyoga Nile and inclined at 112 degree to dam axis.
	Size	175.20m long and 20.0 m high
11	**Pressure Shafts**	
	Nos., Diameter and type	6 Nos.,7.70 m diameter, Underground
	Length	Length varying from 328.59m to 379.18m
	Liner	Steel liner thickness of 22.0mm in the bends and Concrete Liner of 500mm on straight reach.
12	**Power House**	
	Type and Location	Under Ground Powerhouse on Left bank of Kyoga Nile about 400.0m downstream of Power Intake.
	Design Discharge	1128.02 cumecs
	Design Head	59.83 m

	Size	215.0m (l) x 21.0m (w) x 49.0m(h)
	Type of Turbine and no. of units	Vertical Francis, 6 units of 100 MW each
	Installed Capacity	600 MW
	Turbine Centre Line Level	EL. 925.09 m
	Service Bay Level	EL. 962.55 m
	Tailrace system Between Power House and Surge Chamber	Six Individual 7.70m horseshoe shaped tunnels with 276.81m long each
13	**Surge Arrangements**	
	Surge Chamber with Tunnels	A Down Stream Surge Chamber of 200.0m (L) X 20.0m (W) X 29.00 m (H) with 3 Nos of 12 m dia Horse shoe shaped tunnels of 2km each.
14	**Tailrace System**	
	Tailrace Tunnels	Two Numbers of 12.50m Horse shoe shaped tunnels and 8.3km Length
	Tailrace Channel	Open Channel of 100m wide with side slope of 1:1 and 140.0m length.
15	**Power Generation**	
	Rated net head at Design Discharge	59.83 m
	Installed Capacity	6 X 100 MW = 600 MW
	Design Energy: Annual generation in 50% Dependable Year at 95% plant availability	4309.33 Million Unit

1.22 PROJECT COSTS

Break up of cost estimates for Karuma HPP is given in **Table 1.23**

Table 1.23: Summary of cost for Karuma HPP

Item	Description	Cost (Million USD)
Works	Preliminary & Preoperative Expenses	15.23
	Land	0.37
	Civil Works	99.0
	Power Plant Civil Works	1022.50
	Buildings	33.89
	Plantation	0.05
	Miscellaneous	13.94
	Maintenance	11.22
	Special T&P	0.50
	Communication	10.0
	Environment & Ecology	19.42

	Losses on Stock:	2.80
Establishment		49.0
Indirect Charges: Audit & Account:		3.07
Electro-Mechanical Works		330.78
Total Cost (Basic as Dec.2010)		**1,611.77**

Based on the above mentioned hard cost of the project on December 2010 Price level financial analysis was done during the feasibility stage for 4 different scenarios. The summary of these option is. shown in **Table 1.24** below.

Table1.24:– Completed Cost

Sl No	Parameter	Unit	Option - 1	Option - 2	Option - 3	Option - 4
1	Hard Cost @ Dec'10 Price Level	US$ Mn	1612	1612	1612	1612
2	Escalation	US$ Mn	188	188	188	188
3	Hard Cost @ Jun'16 Price Level	US$ Mn	1800	1800	1800	1800
4	Hard Cost per MW	US$ Mn	3.000	3.000	3.000	3.000
5	Soft Costs	US$ Mn	323	240	384	284
6	Total Project Cost	US$ Mn	2123	2040	2184	2084
7	Project Cost per MW	US$ Mn	3.54	3.40	3.640	3.473
8	Debt (70%)	US$ Mn	1486	1428	1747	1667
9	Equity (30%)	US$ Mn	637	612	437	417
10	Construction Period	Months	62	62	62	62
11	First Full Year Tariff	US$ / kWh	0.0821	0.0721	0.0752	0.0638
12	Levellised Tariff for 40 Years	US$ / kWh	0.0642	0.0583	0.0564	0.0494

1.23 EVALUATION OF ALTERNATIVE HYDROPOWER CONFIGURATIONS

Alternative project configurations at, and around, the Karuma HPP site also been investigated. The objective was to compare and evaluate possible options to provide the rationale for selection of the preferred design approach. Key considerations in the comparison were the potential power output of the different options, their financial costs and their relative environmental and socio-economic implications. Five Alternative layouts had been studied and summary of these studies is presented in **Table 1.25**. Of the alternatives studied, Alternative No. 2 had been recommended for the approval of MEMD. The reason for the selection of the Alternative No. 2 is provided in the comparison table as under; Drawing showing alternatives layout of the Karuma HPP is given as **Annexure 1.15-1.19**.

Table 1.25: Summary of the Alternative studies for the Karuma Hydropower project

Alternatives	I	II	III	IV	V
FRL	1029.5m	1029.5 m	1029.5m	1029.5m	1029.5m
Design discharge	840 m3/s	840 m3/s	840 m3/s	840 m3/s	840 m3/s
Pressure shafts	5 nos., each 8 m dia & 401.32 m long	5 nos., each 8 m dia & 371.9 m long	5 nos., each 8 m dia & 170.87 m long	5 nos., each 8 m dia & 157.66 m long.	5 nos., each 8 m dia & 204.20 m long
Tail Race Tunnel	5 nos., circular in shape, each 8 m dia & 490.65 m long				
-before Surge chamber		5 nos., circular in shape, each 8 m dia & 78.56 m in length			
-after Surge Chamber		2 nos., each 12.5 m dia. & 11277.48 m long	2 nos., each 12.5 m dia. & 8696.80 m in length.	2 nos., each 12.5 m dia. & 5032.50 m long	2 nos., each 12.5 m dia. & 5627.04 m in length.
Installed Capacity	605 MW	570 MW	570MW	570MW	585MW
Environmental consideration	Worst (construction of an open channel of 20 m base width and 91.5 m top width for conveying almost the entire river discharge of 840 m3/s traversing through the	Best (construction of underground structures will have least impact on the Wildlife reserve and conservation area)	Good (construction ofunderground structures will have less impact on the Wildlife reserve and conservation area. However powerhouse is located close to the Conservation	Worst (Construction of a large open channel of 20 m base width and 91.5 m top width, traversing through some parts of wildlife reserve and conservation area for	Worst (Power channel and the underground powerhouse with all its accesses will be located inside the wildlife reserve area. The power channel will cut across the

	Wildlife reserve and conservation area and also involving realignment of the Kampala-Gulu Highway will have serious adverse effect on the wild life as		area therefore the accesses to the underground powerhouse will have some impact.	conveying river discharge of 840m3/s will adversely affect the Wildlife area.)	Kampala-Gulu highway and enter into the Wildlife reserve area. The TRT will be underground going to the proposed Outfall area. As such this Alt. will adversely affect the wildlife area and will also cause major disruption of the highway.)
Ease of construction	Easy to execute but will hamperedmovement of wild life & reserve forest, and will require continuous maintenance. It will be prone to subversion activity.	Difficult to execute due to large underground works but will have least impact on the wild life & reserve forest. It will be a safer option requiring little maintenance.	Difficult to execute due to large underground works but will have small impact on the wild life & reserve forest. It will be a safer option requiring little maintenance	Most Difficult to execute due to combination of large tunneling works in addition to Open channel. Open channel subject to danger due to subversion activity.	Moderately difficult to execute due to substantial tunneling works in addition to Open channel. Will adversely affect wild life & reserve forest, and will involve continuous maintenance. It will be prone to subversion activity
Cost of components	621.89 (M.USD)	691.54 (M.USD)	737.27 (M.USD)	757.59 (M.USD)	671.56(M.USD)

Considering the sensitivity related to serious adverse effect on the Karuma Wildlife reserve and Environmental problems all alternatives having an open channel within the Wildlife reserve and/or Conservation area are not recommended. Thus Alternative number –I, IV and V were not pursued further. Thus, the two viable alternatives considered were Alternatives - II and III. The benefits of alternatives II and III were almost similar as each of them required almost similar length of tunnelling but, there is a marginal difference in cost with the cost of Alternative-II being a little lower. Also, in Alternative- II, the underground Power House is located substantially far away from Kampala Gulu Highway and all the access tunnel, cable tunnel etc. will be located away from the Highway and the conservation zone. While in case of Alternative III due to longer length of HRT, the Power House is located close to Kampala Gulu Highway and the access tunnel may be too close to the Conservation area. In addition to this, the new location of the Power House will require fresh investigation while some investigations at the older location of the Power House had already been carried out by NORPAK. Since the cost and benefit of both alternatives II and III were comparable to each other, Alternative II had been adopted for further survey and investigations.

1.24 STRUCTURE OF THIS REPORT

This report has been developed mainly following the guidelines and EIA requirements as stipulated and operationalised in the various environmental requirements of Uganda, especially the guidelines for environmental impact assessments in Uganda (NEMA, 1997). However, the requirements for EIA for such a project as stipulated in International Guidelines especially of the multilateral lending institutions and development agencies such as the World Bank and the African Development Bank (AfDB) have been given due consideration.

The report comprises different parts describing all the key elements considered as being required to assess potential effects that might be generated from the implementation of the Karuma Hydro Power Project, both on the immediate surroundings and on the downstream environment. The overall study is presented in four different volumes;

- Volume 01: Review of NORPAK report;
- Volume 02: ESIA Report including EMMP
- Volume 03: The RAP Report

The content of the ESIA report is presented under the following key chapters:

Chapter 2 - The relevant legal, policy and institutional/administrative framework for undertaking ESIA and implementation are reviewed and presented. The chapter discusses both the general requirements for implementation and also the specific requirements for EIA, as outlined under the National Environment Act and the EIA guidelines for Uganda. It further discusses relevant international guidelines, agreements and treaties.

Chapter 3 - The methods used for collecting the baseline information on various environmental parameters and assessing the potential impacts in this study are presented.

Chapter 4 - The baseline information regarding the existing environment of the Physical environment such as land, soil, geology, air, water and noise environment.

Chapter 5 - Baseline information biological environment viz. Flora and fauna including aquatic ecology.

Chapter 6 - Baseline information on socio-economic environmental situation of the project area are presented. The information presented in this chapter is mainly derived from the field/baseline studies conducted in the study area as part of this overall ESIA study. However, where deemed up to date and applicable, information gathered from literature and other previous studies has also been used to define the existing environment.

Chapter 7- Furnish information related to the public consultation and participation.

Chapter 8 - The potential environmental impacts, both the beneficial impacts and negative impacts of the proposed project are analyzed and presented. These impacts are identified with the objective to define the extent of the impacts, which items need attention, so that benefit enhancement and mitigation measures may be properly addressed during design implementation, construction and operation phases.

Chapter 9 - Furnish elements for appropriate environmental management and monitoring activities, including the roles and responsibilities of the various stakeholders. Elaborates on the required foreseeable actions and mitigation measures; proposal for enhancement of the positive/beneficial impacts and mitigation of the negative impacts are presented and discussed. The cost of implementing the EMMP; presents the costs associated with the different environmental mitigation, management, monitoring and training actions.