7.8 Design

7.8.1 Intake Water Level

The intake water level is determined by adding on the following height and water depth to an intake bottom slab level.

- Intake inner height,
- Required water depth to prevent vortex due to water suction of an intake,
- Allowance of water depth against water surface waving,
- And allowance of water depth against water surface fluctuation by intake operation during power generation.

The intake bottom slab level is determined by adding on the allowance of water depth to a riverbed level in front of the intake so that the sediment will not be sucked into the intake.

(1) Riverbed Level in front of Intake

Sand flushing gate is planned to be located at lower end of the intake facade in order to prevent clogging of the inlet of the intake sediment. Hence, the bottom slab level of the sand flush gate is nearly at the same level with the riverbed level in front of the intake. Layout of the intake and sand flush gate is shown in Figure 7.8.1-1.

In order to minimize submerged area due to water rising behind the intake weir, the riverbed just facing the intake is will be excavated and the intake water level will be determined as low as possible. The excavated level of the riverbed in front of the intake should be higher than the riverbed level at downstream of the sand flushing gate so as to achieve sand flushing operation. Hence, the excavation depth is determined taking into consideration the upstream and downstream riverbed level of the sand flushing gate.

As shown in Figure 7.8.1-2, average level of riverbed just in front of the intake is at EL.843m and it should be easy to excavate about 5.0m depth. On the other hand, as shown in Figure 7.8.1-3, the riverbed level at downstream of the sand flushing gate is lower than EL.838m (843m -5m). It is possible to keep sand flushing operation, even when the riverbed in front of the intake is excavated to 5.0m depth.

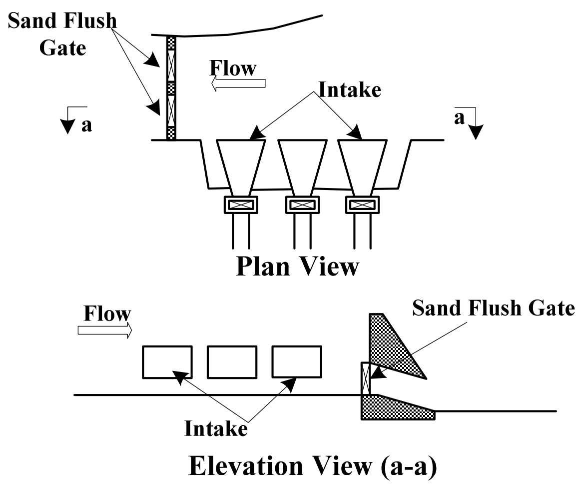
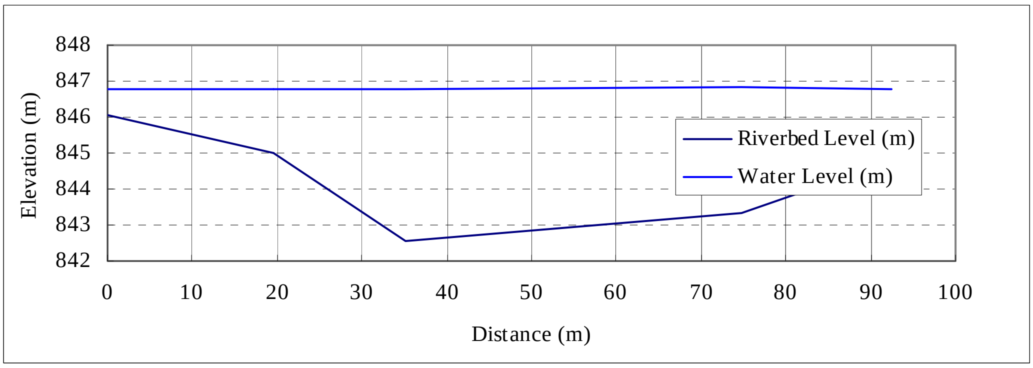


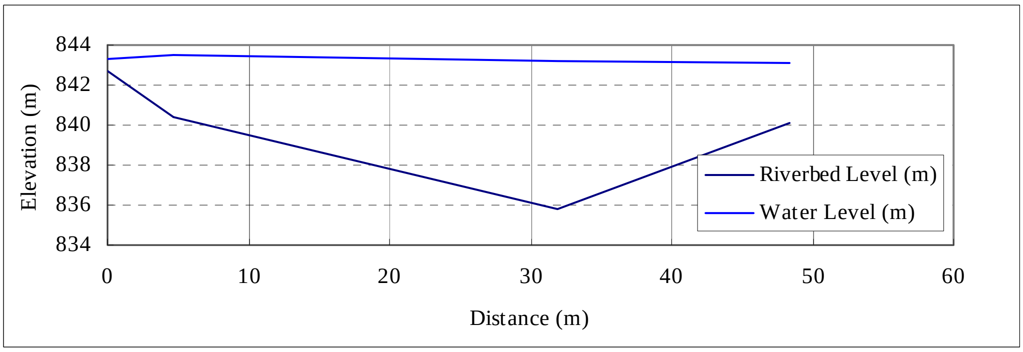
Figure 7.8.1-1 Intake Plan and Elevation Image

As a reason mentioned above, excavated level of the riverbed in front of the intake and the bottom level of the sand flush gate is planned to be at EL.838.0m.



(Source: Study Team)

Figure 7.8.1-2 River Cross Section around Intake Structure



(Source: Study Team)

Figure 7.8.1-3 River Cross Section at Downstream of Intake Weir

(2) Size of Intake Inlet

Inner area of the intake inlet is designed so that the average velocity at inlet section, where just upstream of the inlet screen, is around 1.0m/s in order to avoid screen vibration and air entraining.

The inlet is planned to consist of two sections, and each section will be 7.0m wide so that horizontal angle of each inlet should be about 10 degree in accordance with hydraulic practice of the intake design in Japan. Maximum discharge of one intake is 140m3/s. Hence intake inner height is planned to be 10 m (=140m^3/s / (7m x 2nos. x 1.0m/s)) so that the velocity at inlet section will be around 1.0m/s in accordance with the above described criteria.

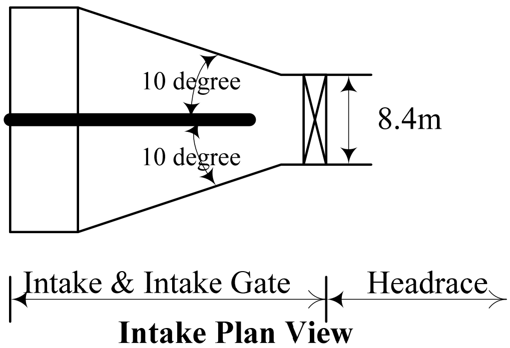


Figure 7.8.1-4 Intake Plan View Image

(3) Intake Water Level

Intake water level for the power generation is determined by adding on following required height and depth to the riverbed level in front of the intake.

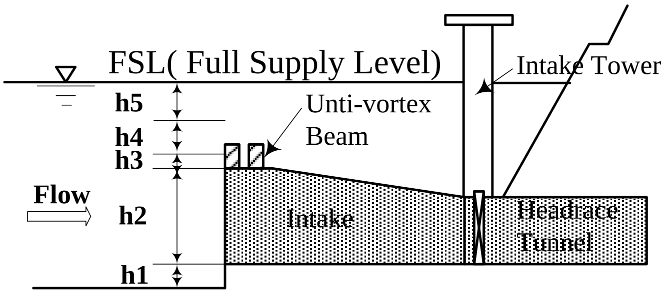


Figure 7.8.1-5 Required Depth at Intake Entrance

FSL = RLl + h1 + h2 + h3 +h4 + h5

Where,

FSL : Intake water level (Full supply level) (m)

RL : Riverbed level in front of the intake
(EL.838m, described in (1) of in this section)

h1 : Allowance of height between riverbed level
and bottom slab level of the intake. (m)

h2 : Inner height of intake inlet (10m, described in (2) of this section)

h3 : Required water depth to prevent vortex. (m)

h4 : Allowance of water depth against water surface waving (m)

h5 : Allowance of water depth against water surface fluctuation
by intake operation during power generation (m)

Height (h^1) between the riverbed and bottom slab level of intake inlet should be taken about 1.0m in accordance with design practice in Japan. Required water depth (h) to prevent the vortex should be taken more than 0.5D (D: diameter of the headrace tunnel, 0.5 x 8.4m =4.2m) in accordance with common design practice in Japan. The height (h3) can be minimized up to 0.5m by means of installing unit-vortex beam, as illustrated in Figure 7.8.1-5, according to the "Hydraulic design of Intake/Outlet for pumped storage power station, No.161 Electric Power Civil Engineering, July 1979, Japan". In addition, the allowance of water depth (h4) against water surface waving and the allowance of water depth (h5) against water surface fluctuation by intake operation is planned to be 0.5m and 2.0m respectively. Hence intake water level is planned to be EL.852m (= 838m + 1.0+10.0+0.5+0.5+2m).

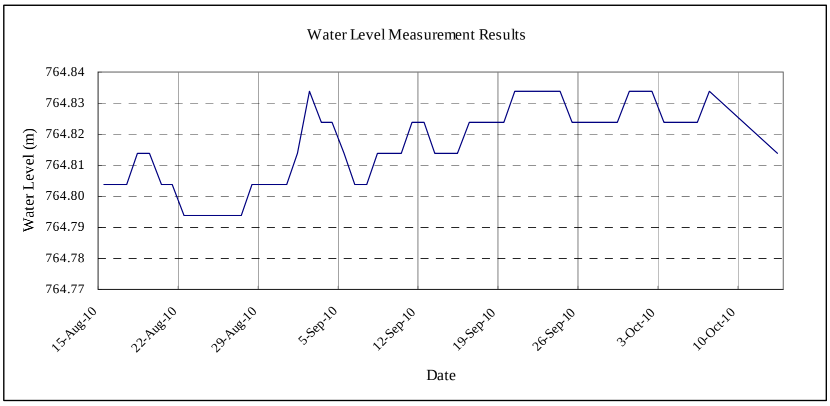
The above described intake water level shall be optimized in further study based on the results of the hydraulic model test. The hydraulic model shall be made by the detailed topographic survey results of river channel around intake area.

7.8.2 Tail Water Level

The tail water level should be higher than river water level during flood season so that the stable power output shall be generated over a long period.

Observed water levels around the outlet from 15 August 2010 to 13 October 2010 are shown in Figure 7.8.2-1. The observed period is classified into rainy season. In addition, amount of discharged water from the Lake Victoria is relatively-large volume according to the operation record of the Owen Falls Dam. The JICA study team observed water level around the tailrace and the level was higher than normal draft (means historical line of normal water level of the river) on 13 October 2010. Hence, the observed water levels around the outlet are concluded as the water level during flood season.

Highest water level is 764.834m and average water level is 764.817m during the observation period. Hence, the tail water level is planned to be EL.765.00m taking into consideration of some allowance adding on the observed water levels.



(Source: Study Team)

Figure 7.8.2-1 Observation Record of River Water Level around Tailrace Outlet

7.8.3 Loss of Head, Effective Head and Maximum Output

(1) Loss of Head

Summary of the loss of head calculation along the waterway are shown as follows. (Details are described in Appendix G1)

Table 7.8.3-1 Summary of Head Loss Calculation

Items	Mark	Unit	No.1 to No.3 Waterway	No.4 to No.6 Waterway	Note
A. Head Loss at Intake, Headrace, Pressure Shaft, Penstock and Draft Tunnel					
A.1 Entrance Loss at Intake	he	m	0.010	0.010	
A.2 Screen Loss at Intake	hr	m	0.059	0.059	
A.3 Cross Section Reduction Loss					
a) At Intake	hgc1	m	0.004	0.004	
a) At Penstock	hgc2	m	0.057	0.057	
A.4 Friction Loss from Intake to Draft Tunnel	hf	m	1.086	1.086	
A.5 Bifurcation Loss at Penstock	h_B	m	0.958	0.958	
A.6 Outlet Loss at Draft Pond	ho	m	0.648	0.648	
A.7 Sub-total		m	2.822	2.822	
A.8 Allowance			0.008	0.008	
A.9 Total			2.830	2.830	A.7+A.8
B. Head Loss from Draft Pond to Tailrace Outlet					
B.1 Entrance Loss at Tailrace	het	m	0.354	0.354	
B.2 Friction Loss at Tailrace Tunnel	hft	m	2.960	3.156	
B.3 Sub-total			3.314	3.510	
B.4 Allowance			0.006	0.010	
B.5 Total			3.320	3.520	B.3+B.4
C. Ground Total of Head Loss	hloss	m	**6.150**	**6.350**	A.9 + B.5

(Source: Study Team)

(2) Effective Head and Maximum Output

Maximum output and effective head are estimated by following equations.

Calculation results of the maximum output par one unit and the effective head are shown in Table 7.8.3-2.

$$P = 9.8 \times Q_{\max} \times H_e \times \eta_c$$

$$H_e = H_g - h_{loss}$$

$$H_g = FSL - TWL$$

Where,

P : Maximum output (kW)

Qmax : Maximum discharge ($m^{3/}s$)

He : Effective head (m)

ηc : Combined efficiency of turbine and generator (%)

Hg : Gross head (m)

hloss : Loss of head (m)

FSL : Intake water level (m)

TWL : Tail water level (m)

Table 7.8.3-2 Results of Power Generation Output Calculation

Items	Mark	Unit	No.1 to No.3 Waterway	No.4 to No.6 Waterway	Note
1. Full Supply Water Level	FSL	m	852.000	852.000	
2. Tail Water Level	TWL	m	765.000	765.000	
3. Gross Head	Hg	m	87.000	87.000	FSL - TWL
4. Head Loss	hloss	m	6.220	6.420	
5. Effective Head	He	m	80.780	80.580	Hg - hloss
6. Maximum Discharge par Unit	Qmax	m^3/s	70.000	70.000	
7. Combined Efficient	η	%	90%	90%	Turbine and Generator
8. Maximum Output par Unit	Pg	MW	50	50	9.8 x Qmax x He x η

(Source: Study Team)

7.8.4 Intake Weir

(1) Type of Intake Weir

Overflow type concrete weir is selected as the intake weir of the Ayago Hydropower Project, since it is generally applied to an intake weir of the run of river type hydro power station.

Crest level of the right bank side of the intake weir is planned to be 500mm lower than the intake water level of EL.852.0m so that the weir will always be submerged in the water with attention to beauty of the landscape from the view of tourists. As described in section 7.8.1, sand flush gates, 10m wide x 5m height x 2sets, are planned to be equipped at left bank side of the intake weir. Upstream elevation view and typical cross sections of the intake weir are illustrated in Figure 7.8.4-1.

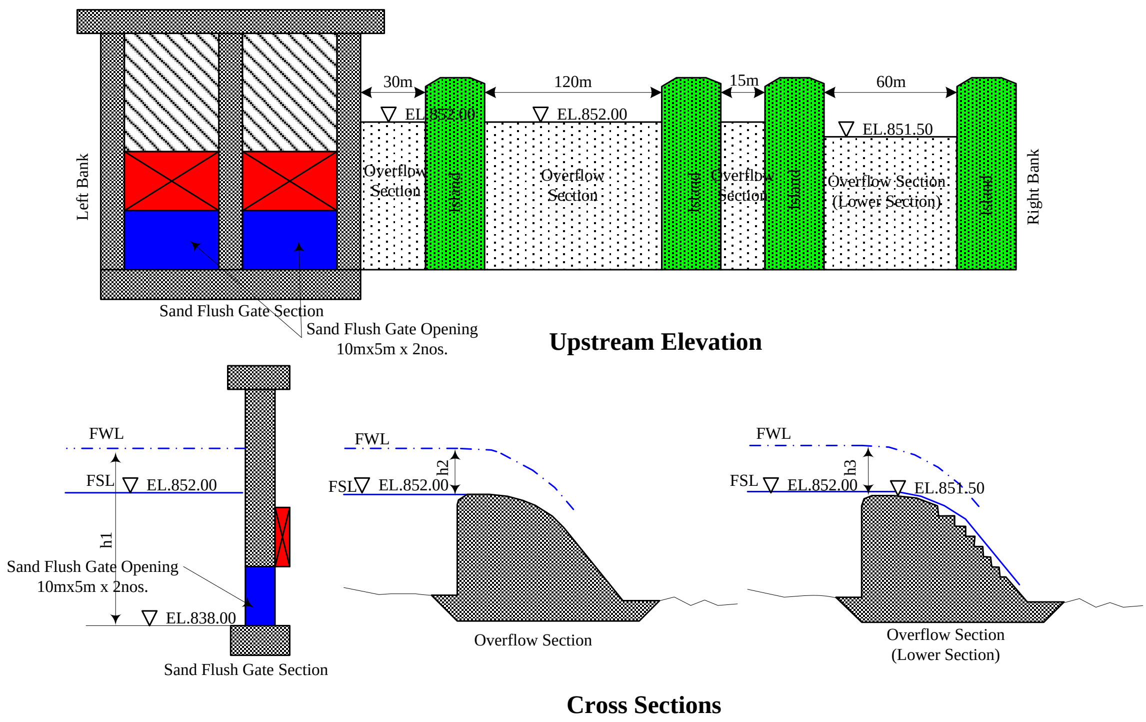


Figure 7.8.4-1 Outline of Intake Weir Sections

(2) Design Flood Water Level at Intake Weir Site

Flood discharge for an intake weir design should be taken more than 100-year probable flood in accordance with Japanese criteria. On the other hand, the other countries apply the 1,000-year probable flood for an intake weir design. The 100-year probable food and 1,000-year probable food discharges are estimated by 2,900m^3/s and 4,100m3/s respectively as a result of the hydrological analysis.

The 100-year probable flood will occur at a relatively-high probability. When the sand flush gate is utilized for the 100-year flood release, lag time for the gate operation should be considered. On the other hand, the 1,000-year probable flood will occur at a relatively-low probability and peak flood concentration time seems to be very long. The sand flush gate can be utilized for the 1,000-year flood release operation.

Taking into consideration of the above circumstances, the design flood water level at intake weir is determined so that the flood discharge can be released with following conditions.

- The 100-year probable flood can be released by only over flow section of the intake weir.
- The 1000-year probable flood can be released by the over flow section and the sand flush gate section.

$$Q_{SG} = C_a \times A_{SG} \times \sqrt{2 \cdot g \cdot h_s}$$

$$Q_C = C_c \times L \times h_c^{\frac{3}{2}}$$

Where,

Q_{SG}	: Flood release volume from sand flush gate (m^3/s)
C_{SG}	: Discharge coefficient of sand flush gate (0.55)
A_{SG}	: Gate opening area (m^2)
hs	: Height between gate bottom slab and flood water level (m)
Q_c	: Overflow discharge from overflow section (m^3/s)
C_c	: Overflow discharge coefficient of overflow section (2.0)
L	: Crest of overflow section (m)
hc	: Overflow depth of overflow section (m) (Height between flood water level and crest level of overflow section）

Calculation results of released flood volume from the sand flush gate and overflow section are shown in Table 7.8.4-1.

As seen the table, both flood discharges, 100-year and 1,000-year, can be released at the water level of EL.855.50m. Hence, flood water level for the intake weir design is planned to be EL.855.50.

Table 7.8.4-1 Flood Discharge Volume Calculation

Item	Mark	Unit	100year flood	1000year flood	Note
1. Design Flood Discharge	Q_F	m	2900	4100	
2. Flood Water Level	FWL	m	855.50	855.50	
3. Sand Flush Gate Section					
3.1 Gate Bottom Level	$EL._{SG}$	m	838.00	838.00	
3.2 Water depth between FSL and Gate Bottom	hs	m	17.50	17.50	FWL - $EL._{SG}$
3.3 Gate Opening Area	A_{SG}	m^2	0.00	100.00	closed at 100 flood, 5m x 10m x 2nos.
3.4 Discharge Coefficient of Sluice Gate	C_{SG}		0.55	0.55	
3.5 Discharge Volume at Flood Water Level	Q_{SG}	m^3/s	0.00	1,018.61	Refer to above formula
3. Overflow Section					
3.1 Crest Elevation	EL.c	m	852.000	852.000	
3.2 Crest Length	Lc	m	165	165	30m +120m +15m, See figure 8.8.4-1
3.3 Overflow Water Depth at Flood Water Level	hc	m	3.500	3.500	FWL-EL.c
3.4 Discharge Coefficient of Overflow Weir	C_c		2.000	2.000	
3.5 Overflow Discharge Volur at Flood Water Level	Q_{C1}	m^3/s	2,161	2,161	Refer to above formula
4. Overflow Section (Lower Section)					
4.1 Crest Elevation	EL.c	m	851.500	851.500	See figure 8.8.4-1
4.2 Crest Length	Lc	m	60	60	See figure 8.8.4-1
3.3 Overflow Water Depth at Flood Water Level	hc	m	4.000	4.000	
3.4 Discharge Coefficient of Overflow Weir	C_c		2.000	2.000	
3.5 Overflow Discharge Volur at Flood Water Level	Q_{C2}	m^3/s	960	960	
5. Total Discharge Volume at Flood	Q_{Spill}		3,121	4,139	
6. Judge			OK	OK	Q_{Sipll} > Q_F -> OK

(Source: Study Team)

7.8.5 Tailrace Tunnel

(1) Type of Tailrace Tunnel

Generally, pressure flow or free flow type is selected for type of a tailrace tunnel that is more than 500m long. (For a tunnel below 500m long, pressure type is generally selected,) The pressure type of tailrace tunnel should be selected where seasonal fluctuation in tail water level is high. On the other hand, free flow type should be selected where the fluctuation is low, according to the common design practice of a tailrace tunnel.

If the free flow type of tailrace is planned at the river where the water level fluctuation is high, the tailrace outlet should be located at high level so as to keep free flow condition for long period. As a result, the effective head by applying the free flow type will be reduced. On the other hand, the pressure flow type of tailrace tunnel can fully utilize the high fluctuated water level for the effective head.

The pressure tunnel requires longer lengths and more secure structures than the free flow tunnel, since tailrace tunnel is located below the minimum tail water level. In terms of construction cost, the pressure tunnel requires larger amount of reinforcement bars in the concrete lining and grouting volume than the free flow tunnel. In addition, hydraulically, the cross section area of free flow tunnel with 1:2500 of gradient is smaller than the area of pressure tunnel with 1:2500 of friction gradient (means; hydraulic gradient considering the friction head loss. The major reason is that the pressure tunnel has longer wetted perimeter than the free flow tunnel and, as a result, the pressure tunnel causes higher friction head loss.

Estimated result of required cross section for the pressure flow tunnel, with conditions of 140m3/s of discharge capacity and 1:2500 of friction gradient, is shown in Table 7.8.5-1 and figure of the required cross section of the pressure and free flow tunnels are shown in Figure 7.8.5-1.

Table 7.8.5-1 Required Diameter for Pressure Tunnel

Item	Mark	Unit		Note
Maximum Discharge	Q	m^3/s	140	
Inner Diameter	D	m	8.64	
Velocity	V		2.388	$Q/(\pi*D^2/4)$
Tunnel Length	L	m	1	Unit Length
Roughness coefficient	n		0.014	Concrete Lining
Friction loss coefficient	f'		0.011892	$124.5*n^2/D^{1/3}$
Friction loss	hf	m	0.0004	$f*L/D*V^2/2g$
Friction gradient	1/hf		2,497	

(Source: Study Team)

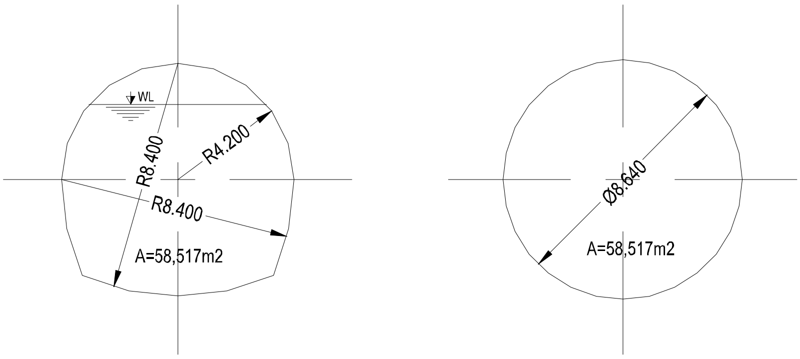


Figure 7.8.5-1 Required Area of Free Flow and Pressure Tunnel

Since seasonal runoff in the River Nile around the tailrace outlet is relatively-low and the river channel around the outlet is very wide, water level fluctuation around the outlet is low, within few meters height and the free flow type has economical advantages with negligible loss of head. Hence, free flow type was selected for the structural type of the tailrace tunnel.

The above result is tentative. Study for type of the tailrace tunnel closely depends on topographic and geological conditions, construction method of the tunnel, and design of the powerhouse as well as the other structures. The study should be re-determined based on the geological investigation along the tailrace route as well as the above mentioned study items.

(2) Number and Diameter of Tailrace Tunnel

Unit capacity of one generator/turbine of the Ayago Hydropower Project is planned to be 50MW taking into consideration of the power grid system in Uganda. In case of 50MW of unit capacity, maximum discharge of one turbine unit is around 70m^3/s. Due to hydraulic characteristics and layout, up to three units of turbines, at a maximum, can be released the power discharge into one tailrace tunnel. Hence, three discharge cases, 70, 140 and 210m3/s, are considered as alternatives of discharge capacity for one tailrace tunnel.

Diameter of the free flow tunnel is determined taking into consideration the discharge capacity, roughness coefficient, cross section shape, maximum velocity and freeboard. Hydraulic calculation is performed by the Manning’s uniform formula as follows;

$$V = \frac{1}{n} R(h)^{\frac{1}{3}} \cdot I^{\frac{1}{2}}$$

$$Q = A(h) \cdot V$$

where,

V : Average velocity in free flow channel/tunnel (m^3/s)

n : roughness coefficient

R(h) : Hydraulic radius (m) (as a function of water depth (h))
I : Gradient of channel/tunnel
Q : Discharge (m^3/s)
A(h) : Cross section area (m^2) (as a function of water depth (h))

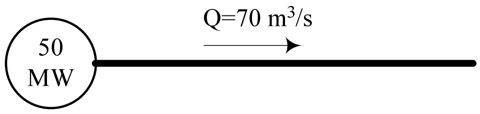
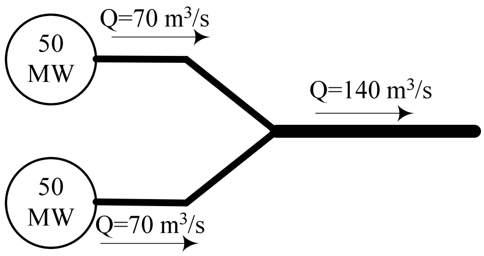
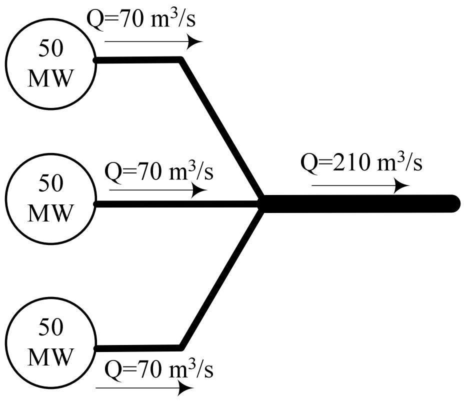
The cross section area of the tailrace tunnel in each case is estimated by the above formula considering with the following conditions;

- Roughness coefficient of concrete lining: 0.014
- Cross Section Shape: 2R- horseshoe
- Allowable velocity in concrete lined free flow tunnel: 3.0m/s at a maximum
- Freeboard: water depth / inner height of tunnel ≤ 0.83[3]

Number and diameter of the tailrace tunnel in each case is determined based on the above conditions. Results are summarized in Table 7.8.5-2.

[3] *Maximum discharge capacity for free flow type of the 2R-hoseshoe section is observed at a water depth of 93% of the inner height. Size of cross section area in each case was estimated so that the design discharge can be released below a water depth of 83% of the inner height and allowance of the discharge capacity was taken around 10% of the inner height. It is common practice for free flow tunnel of hydropower project in Japan*

Table 7.8.5-2 Alternatives of Tailrace Tunnel Lane and Diameter

Case	Figure	Lane (nos.)	Inner Diameter (m) / Inner Area (m^2)
Case1		12	6.5 / 35.039 (35.039m^2/unit)
Case2		6	8.4 / 58.517 (29.258m^2/unit)
Case3		4	9.8 / 79.648 (26.59m^2/unit)

(Source: Study Team)

As seen in the above table, Case 3 can be minimized, and the cross sectional area per one unit in this case may be the most economical. However, excavated diameter and inner diameter including thickness of concrete lining, of the Case3 is larger than 10m. In case of bad geological condition, excavated diameter of over 10m for the aqueduct tunnel has a higher construction risks and a disadvantage in economical aspects. In addition, the geological condition along the tunnel is not so clear at this early stage of the design work. Therefore, the excavated diameter for performing tunnel layout study should be smaller than 10m is common practice of hydropower development study in Japan.

Hence, Case 2, which is 6 numbers of tailrace tunnel and 8.4m of inner diameter, is selected so as to keep relatively-secure construction with good economy in accordance with the Japanese practice, since geological conditions along the tailrace tunnel is unclear at this pre-feasibly study.

(3) Temporary Rock Support for Tailrace Tunnel

Temporary rock support for the tailrace tunnel is determined by referring to "Technical Criteria of Road Tunnel, Japan Road Association (refer to Table 7.8.5-3)".

Temporary rock support pattern classified into each rock classification is shown in Table 7.8.5-4.

Table 7.8.5-3 Temporary Support Pattern (D=8.5 to 12.5m) for Road Tunnel by Japan Road Association

Support Pattern	Rock Bolt		Shotcrete (mm)	Steel Rib
	Circumferential Pitch (m)	Longitudinal Pitch (m)		
B	1.5	2.0	5	-
CI	1.5	1.5	10	-
CII-a	1.5	1.2	10	-
CII-b	1.5	1.2	10	
DI-a	1.2	1.0	15	H-125 @ 1.2m Upper Section Only
DI-b	1.2	1.0	15	H-125 @1.0m
DII	1.2	less than 1.0	20	H-150 @ less than 1.0m

(Source: Technical Criteria of Road Tunnel, Japan Road Association)

Table 7.8.5-4 Temporary Support Pattern for Tailrace Tunnel of Ayago HEPP

Rock Classification	Support Pattern by JRA	Rock Bolt		Shotcrete (mm)	Steel Rib
		Circumferential Pitch (m)	Longitudinal Pitch (m)		
B	B to CI	Random Rock Bolt		100	-
CH	CI to CII-a	1.5	1.2	100	-
CM	CII-b to D1-a	1.2	1.0	150	H-150 @1.0m
CL to D and Portal	D1-b to DII	1.2	0.8	200	H-150 @0.8m

(Source: Study Team)

7.8.6 Headrace Tunnel, Pressure Shaft and Penstock Pipe

(1) Number and Diameter of Waterway

Number and diameter of the headrace tunnel and pressure shaft are planned to be six number and 8.4m diameter respectively as same plan as the tailrace tunnel. Length of the headrace tunnel and pressure shaft is 113m in total. Since it is too short to change tunnel type on the tunnel/shaft, the pressure type is selected to the whole section of the tunnel/shaft and circular cross section is adopted.

In order to reduce construction cost, inner diameter of penstock tunnel should be minimized. Size of the diameter is determined so that the average flow velocity in the penstock may reach around 6.0m/s, which is maximum design velocity of penstock for typical hydropower project (except pumped storage hydropower project).

Principal feature of headrace tunnel, pressure shaft and penstock pipe is shown in Table 7.8.6-1.

Table 7.8.6-1 Principal Feature of Headrace/Pressure Shaft and Penstock

Structures	Maximum Discharge (m3/s)	Lane (Nos.)	Diameter (m)	Velocity (m/s)	Length (m)	Note
Headrace Tunnel /Pressure Shaft	840	6	8.4	2.5	113	
Penstock Section-1	840	6	6.9	3.7	6.9	Average Diameter
Penstock Section-2	840	6	5.4	6.1	44	
Penstock Section-3	840	12	3.8	6.2	33/37	Tunnel Length / Pipe Length

(Source: Study Team)

The above described number and inner diameter of the tunnels are tentative values for estimating work quantity. The number and the diameter should be optimized based on cost-benefit analysis in further feasibility study.

(2) Temporary Support

Since the headrace tunnel is close to tunnel portal and ground cover along the tunnel is thin, temporary support of the tunnel is determined so as to support rock mass classified into “CL to D and Portal” in accordance with the “Technical Criteria of Road Tunnel, Japan Road Association”.

Rock mass along the pressure shaft and penstock tunnel consists of “Class B” and weathered zone. Content rate of the weathered zone seems to be slightly and the rock mass along the shaft and tunnel can be estimated more than “Class CH” on average. Hence temporary support type along the shaft and tunnel is determined so as to support rock mass classified into “Class CH”.

Temporary support pattern for the headrace tunnel, pressure shaft and penstock tunnel is shown in Table 7.8.6-2.

Table 7.8.6-2 Temporary Support Pattern for Headrace Tunnel / Pressure Shaft and Penstock Tunnel

Structures	Assumed Rock Class	Rock Bolt		Shotcrete (mm)	Steel Rib
		Circumferential Pitch (m)	Longitudinal Pitch (m)		
Headrace Tunnel	CL to D and Portal	1.2	0.8	200	H-150 @0.8m
Pressure Tunnel	CH	1.5	1.2	100	-
Penstock Tunnel	CH	1.5	1.2	100	-

(Source: Study Team)

7.8.7 Underground Powerhouse

(1) Layout plan around Intake to Powerhouse

As shown in Figure 7.8.7-1, there are two ridge lines running toward north-east direction and one deep ravine between the ridge lines is running toward south-west direction. Due to the above topographic condition, there is no space to layout six numbers of power intakes in one ridge. Hence, the intake structures are located in the two ridges separately and each ridge area contains three intake structures respectively.

The Size of underground powerhouse cavern is 23m wide, 40m high, and 440m long in total, the length includes transformer and GIS room. The cavern is relatively-large in size and construction of the underground cavern requires good topographic and geological conditions so as to achieve secure construction work. The powerhouse cavern should be located just under the ridge peak, avoiding being located under the ravine, so as to obtain good topographic and geological conditions by taking enough rock cover above the cavern as much as possible. Due to topographic condition, there is not enough space to place 440m long of the powerhouse cavern in one ridge peak. In such case, half of the cavern has no other choice to be located under the ravine. Hence, the powerhouse cavern also divides into two caverns and each cavern is located in each ridge separately as same layout as the power intake.

There are six numbers of turbines, generators, transformers, and GISs in two powerhouses respectively. The powerhouses connected by one access tunnel and one cable connection tunnel. The connection tunnel will be utilized for the power line and communication line connection. The high voltage cable will be led out from the GIS room to the transmission line via cable shaft. The transmission line connects to the steel tower locating on the surface ground just above the powerhouse.

Layout plan around the powerhouse is shown in Figure 7.8.7-1.

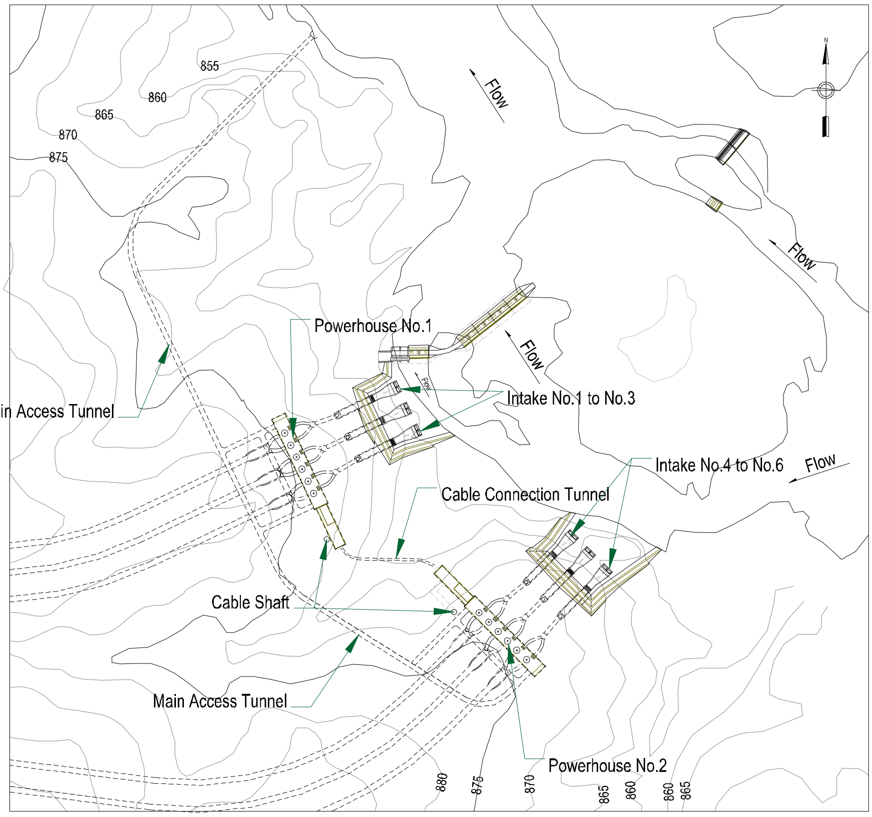


Figure 7.8.7-1 Layout Plan around Underground Powerhouse

(2) Layout of Powerhouse

As described in (1) of this section, the powerhouse cavern is divided into two caverns due to topographic and geological conditions. There are six numbers of turbines and generators, which unit capacity is 50MW, in each powerhouse cavern. Two erection bays are planned to be located both side of the powerhouse machine bay so as to shorten the installation period of the turbines and generators. Transformer and GIS cavern is planned to be located in the immediate vicinity of the powerhouse cavern.

As described in Section 7.8.4, there are draft tunnels, which connect with each turbine, at immediate downstream of the powerhouse cavern. Two lanes of the draft tunnels are combined at downstream and one draftpond was planned to be located at the junction of the tunnels. Draft gate is planned to be equipped at outlet of each draft tunnel and operation room for opening and closing of the draft gate is located immediate above the draft gate.

Layout plan of the Powerhouse No.1 is shown in Figure 7.8.7-2 and typical cross section of the powerhouse machine bay is shown in Figure 7.8.7-3.

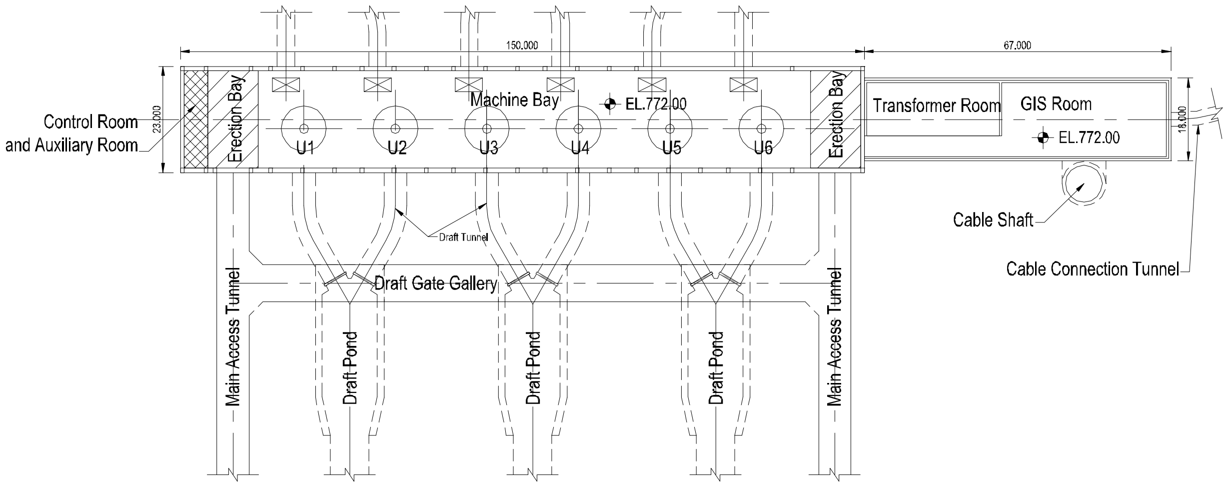


Figure 7.8.7-2 Layout Plan of Powerhouse No.1

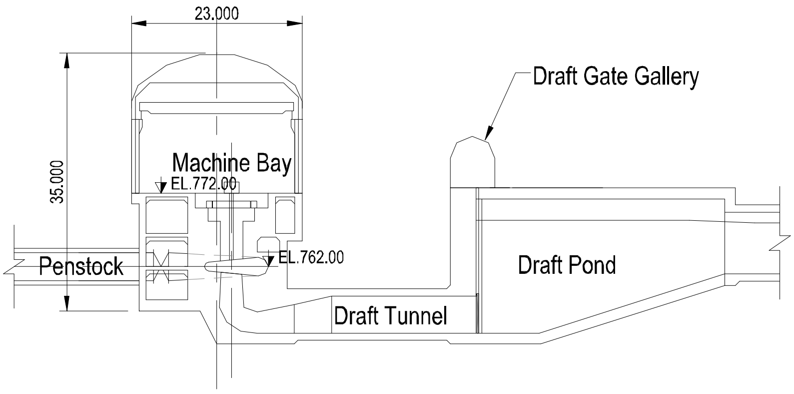


Figure 7.8.7-3 Typical Section of Powerhouse Machine Bay

(3) Case Study for Unit Capacity

As described in section 7.9, 50MW of generating unit capacity is applied to the powerhouse layout of the Ayago Project in this JICA Study so as to avoid damage of the power grid system in Uganda. However, in case that the grid system will be developed more than expected, 100MW of unit capacity can be applied to the Ayago Hydropower Project. Therefore, the supplemental case study for the powerhouse layout applying 100MW of unit capacity is carried out.

Alternative layout plan and typical cross section of the Powerhouse No.2 applying 100MW of unit capacity is shown in Figures 7.8.7-4 and 7.8.7-5 respectively.

Comparing f the power house cross section for the 50MW unit layout, and the cross section area of the 100MW layout, the cross section of the later is lager than the 50MW layout but the general layout plan of the 100MW is considerably smaller than the 50MW layout. Main reason is that the generating units of the 100MW layout are half the number of the 50MW

Units giving a 15% reduction in excavation volume of the cavern and decreasing the generating unit by half can be achieved by applying 100MW of unit capacity. It seems very possible that applying the 100MW of unit capacity will make advantages in terms of economy and construction work progress. However, the unit capacity for the underground powerhouse should be determined not only by capacity of the power grid system but also by structural stability of the powerhouse cavern. The structural stability should be carried out based on the results of detailed geological investigation. In addition, construction procedure, schedule, and construction cost of the powerhouse cavern also should be comprehensively estimated in the determination of the unit capacity in further study..

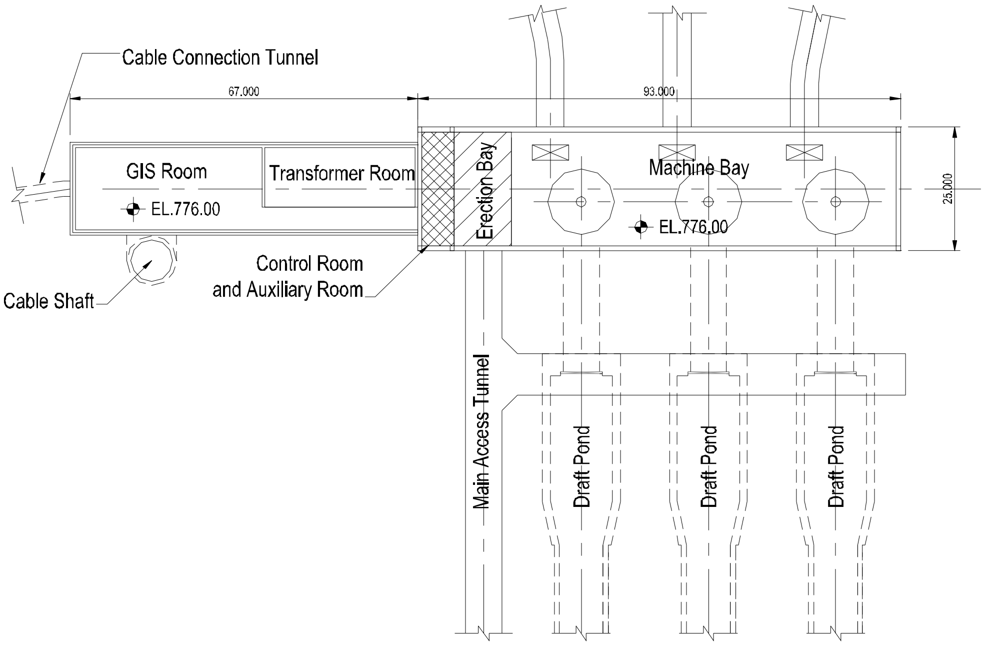


Figure 7.8.7-4 Layout Plan of Powerhouse No.2 Alternative (100MW/Unit)

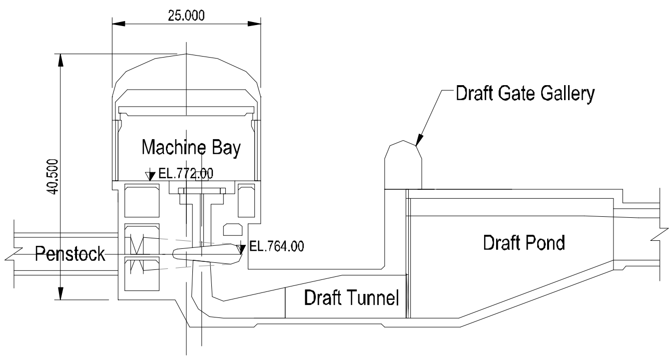


Figure 7.8.7-5 Typical Section of Powerhouse No.2 Alternative (100MW/Unit)

7.8.8 Layout of the Principals Structure

Through the above examination, layout drawings of the principal structures of the Ayago Hydropower Project are designed as shown in the Figures 7.8.8-1 to 7.8.8-7.

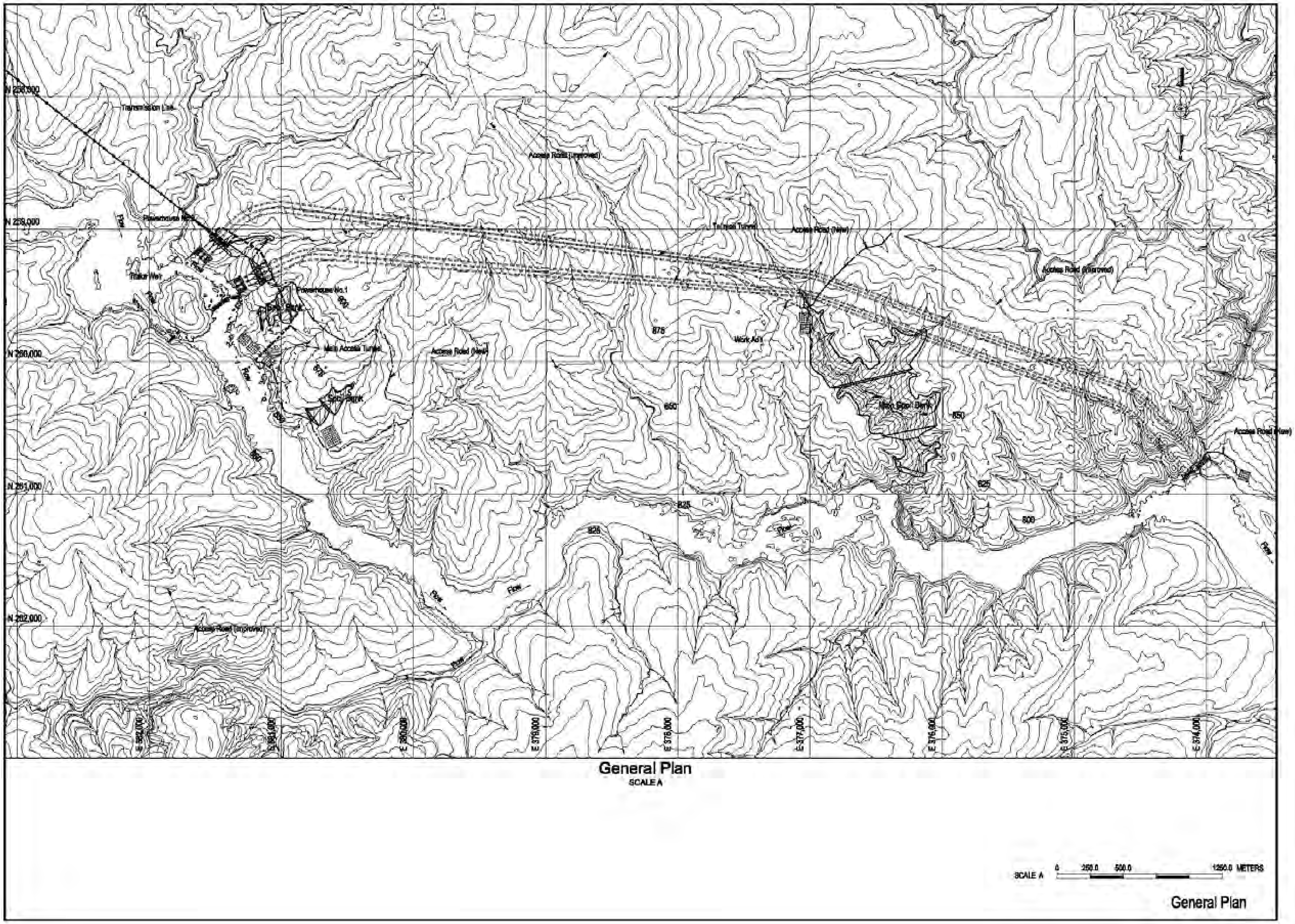


Figure 7.8.8-1 General Layout Plan

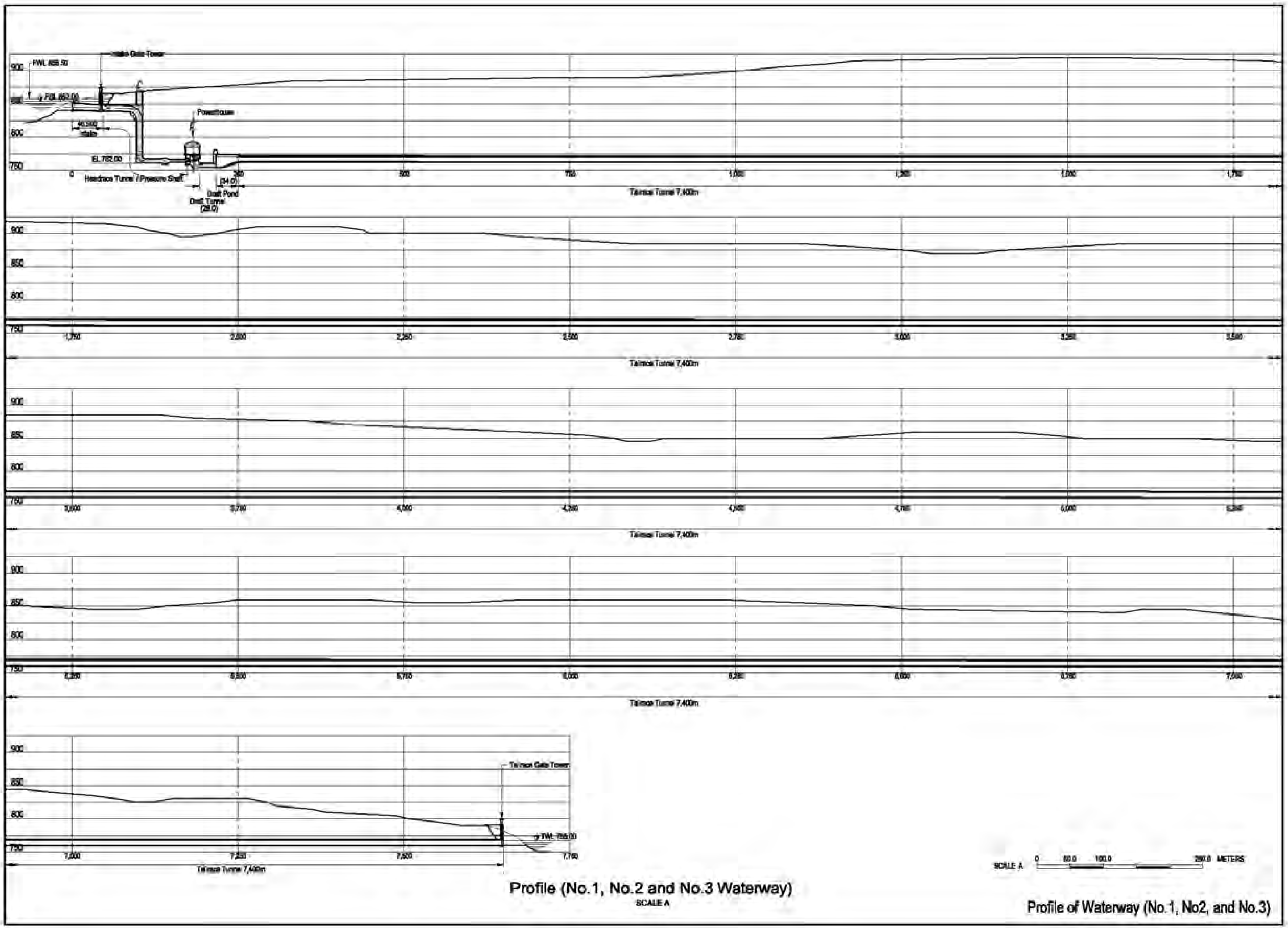


Figure 7.8.8-2 Profile of Waterway (No.1, No.2 and No.3)

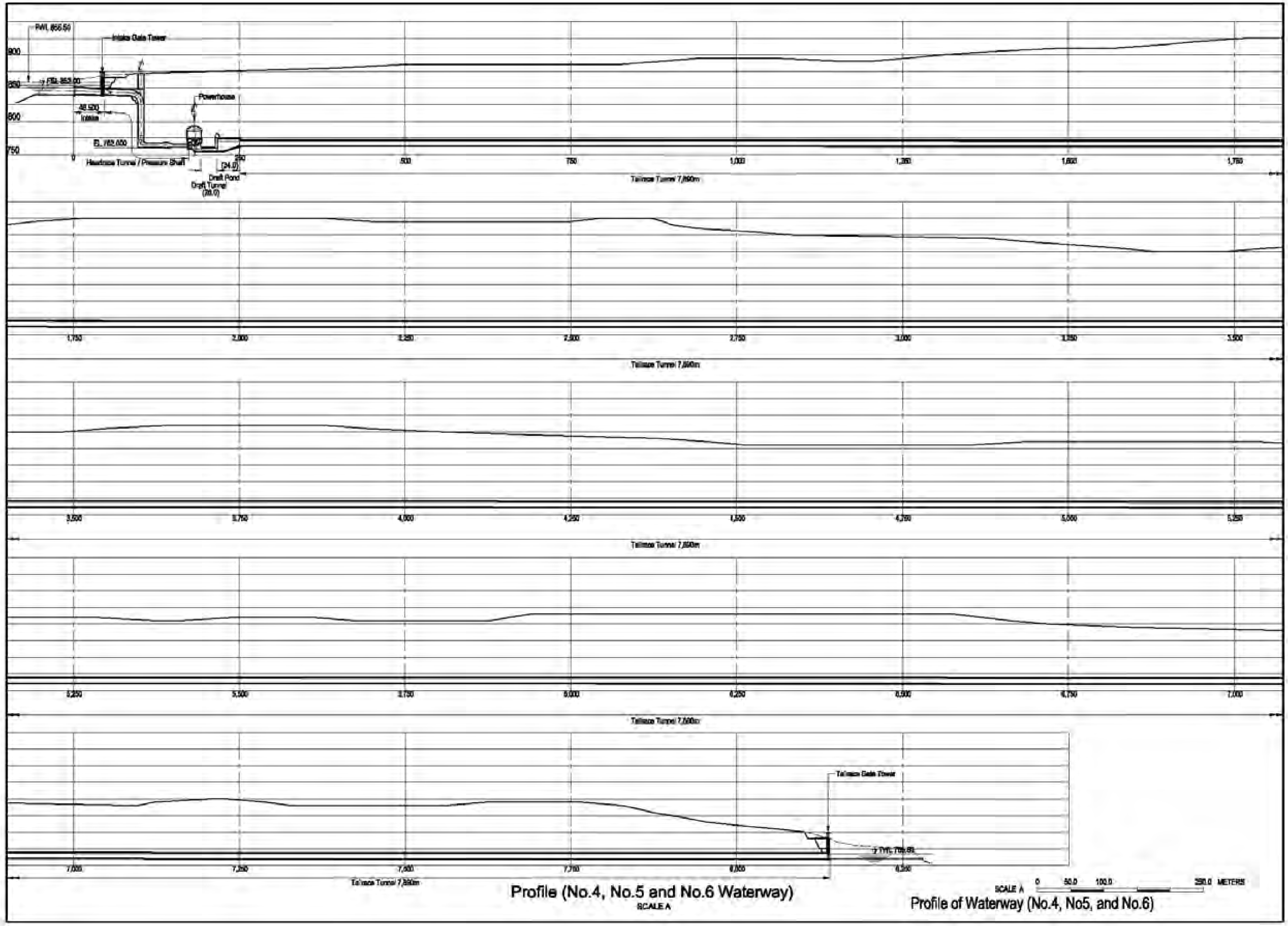


Figure 7.8.8-3 Profile of Waterway (No.4, No.5 and No.6)

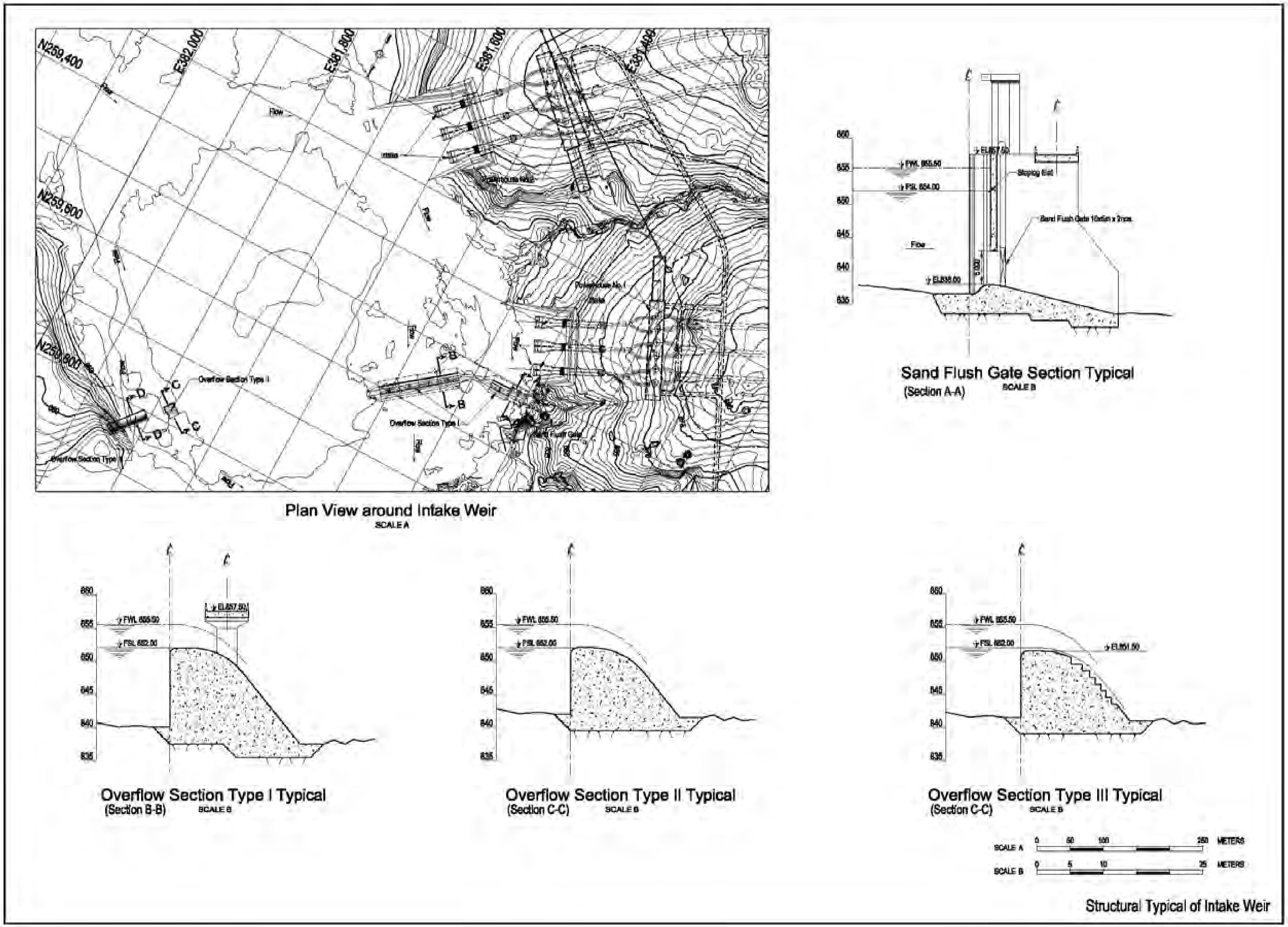


Figure 7.8.8-4 Structural Typical of Intake Weir

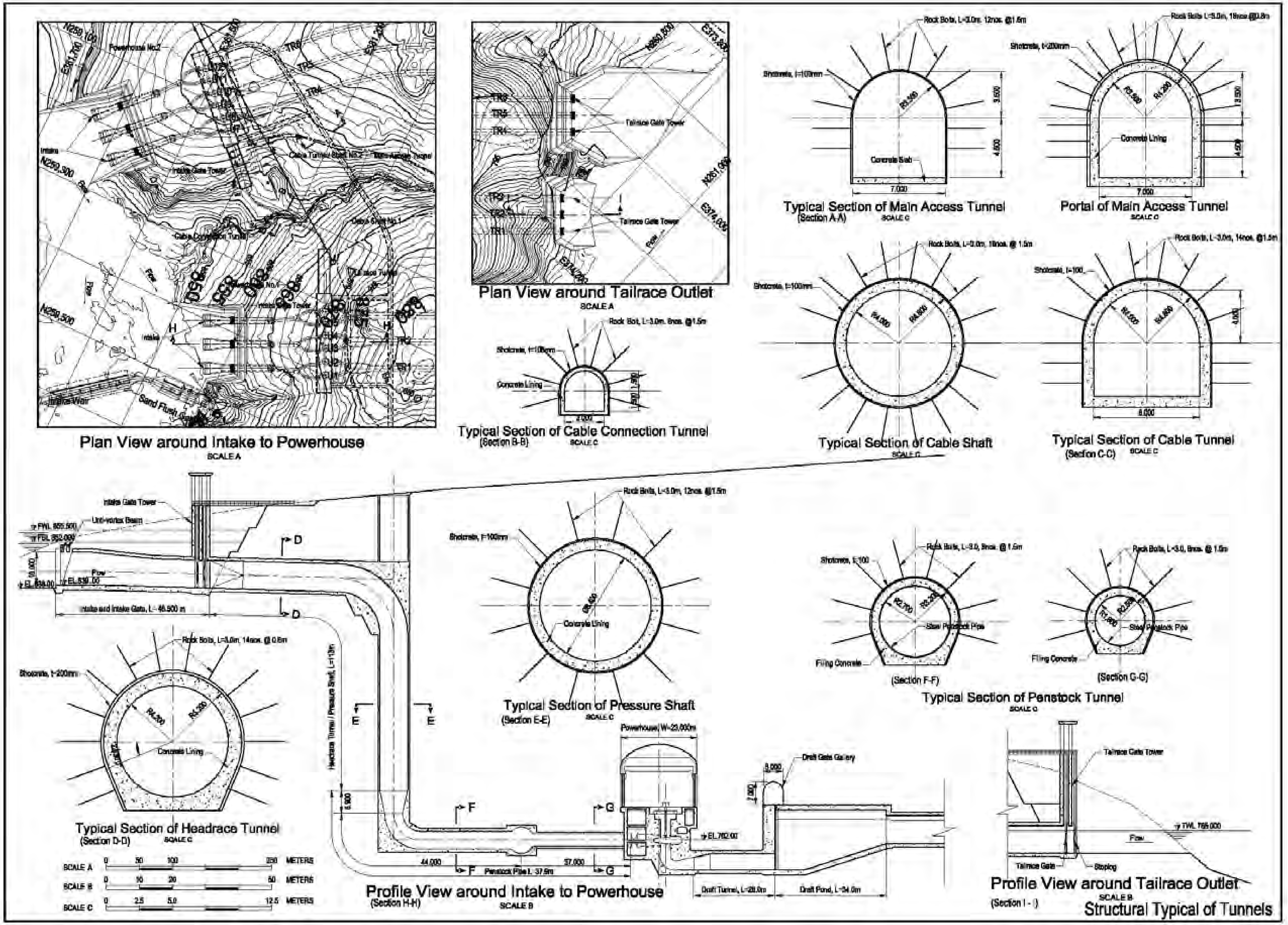


Figure 7.8.8-5 Structural Typical of Tunnels

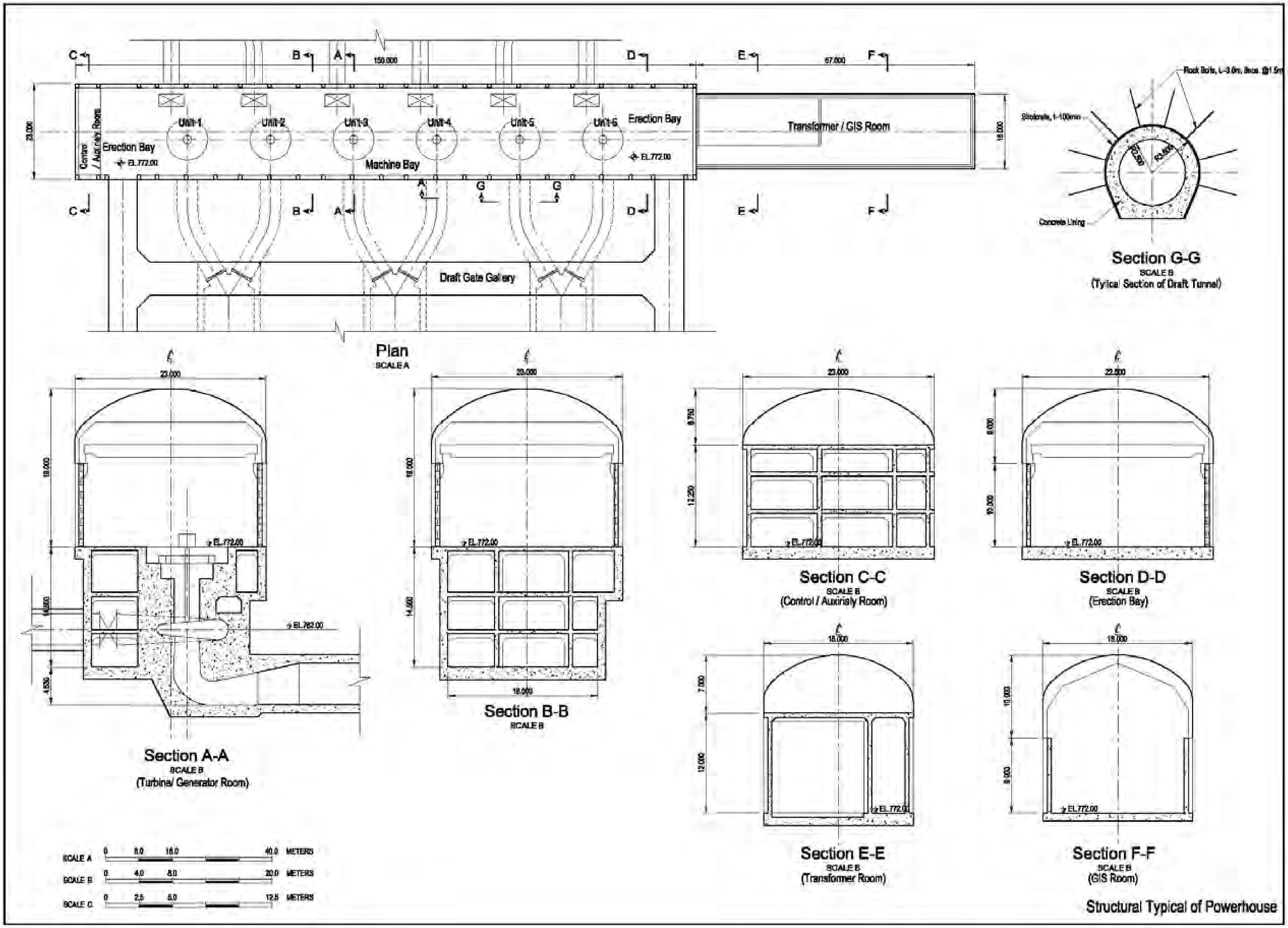


Figure 7.8.8-6 Structural Typical of Powerhouse

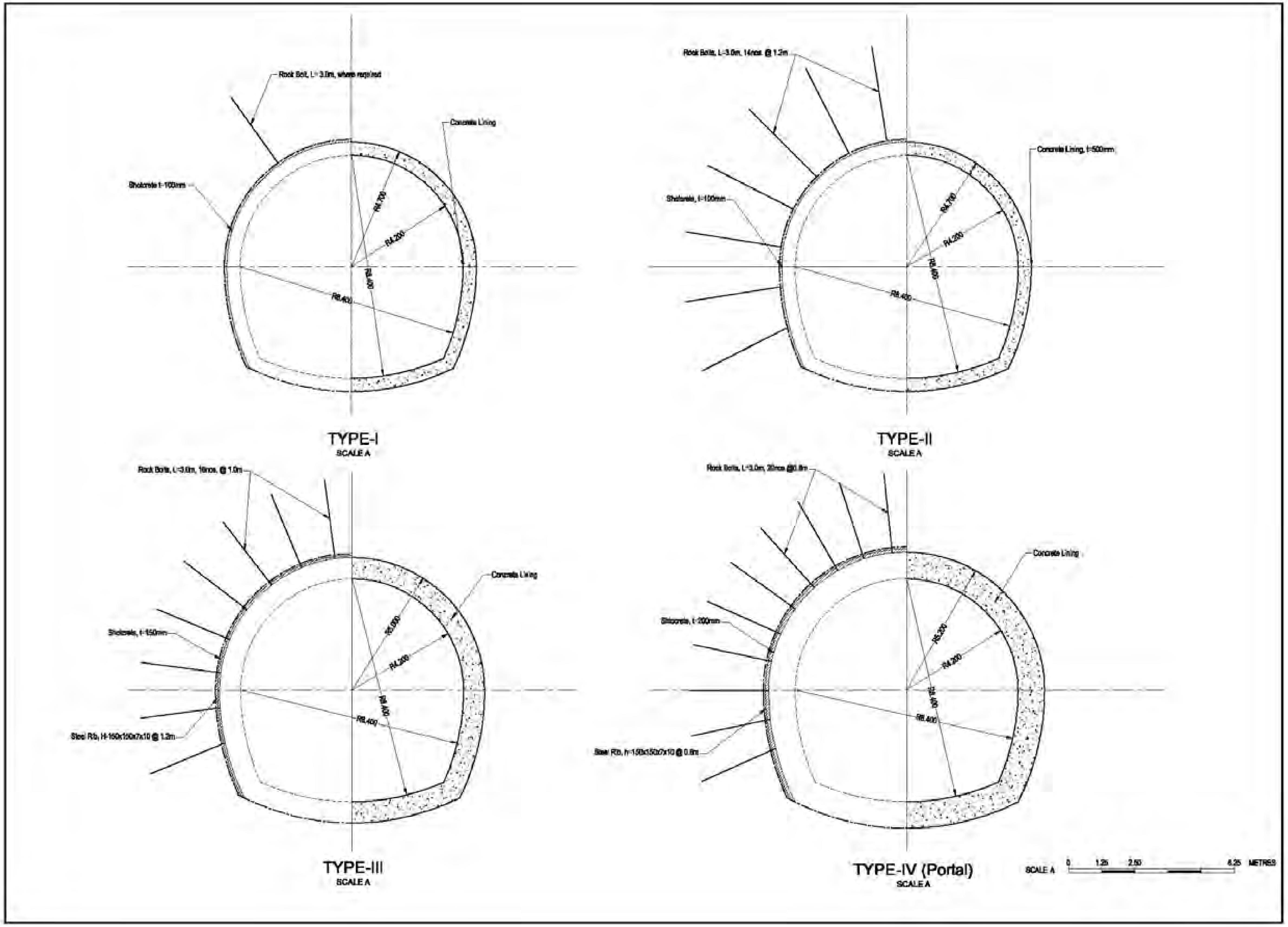


Figure 7.8.8-7 Structural Typical of Tailrace Tunnel

7.9 Electrical Equipment and Transmission Line

7.9.1 General

Ayago hydropower station is run of river type and has a maximum output of 600MW, using gross head of 83m and discharge of 840m^3/s. Electrical equipment of Ayago hydropower station consists of the following main equipment.

a. Turbine
b. Generator
c. Main Transformer
d. High Voltage Switching Gear

7.9.2 Unit Capacity and Number of Unit

Generally, for a turbine-generator, a large unit capacity is said to be more economical in terms of merits of scale. However, optimum unit capacity of the turbine-generator is determined in consideration of the following subjects.

a. Influence of the unit capacity to the power system
b. Transportation route of the heavy equipment
c. The level of current manufacturing technology
d. The reliability and flexibility of maintenance and operation

In terms of A, the influence of the unit capacity to the power system, the 100MW×6 units or 200MW×3 units can in general both be applicable in the power system. However, in case of tripping of the turbine-generator from power system, it will cause a huge impact on the power system stability and it is necessary to choose the unit capacity which will not cause great instability in the power system.

On the assumption that first unit into the power system for Ayago is as follows;

: Peak load	900MW
: Off-peak load	440MW
: Constant characteristics of power system frequency	5%
: Allowable minimum power system frequency	-1.5Hz (48.5Hxz)
: No connection to Kenyan power system	

Therefore, optimum unit capacity can be calculated from following formula.

$Cap._{accept}$(MW) = constant characteristics of power system frequency (%MW/Hz)
× allowable minimum power system frequency (Hz) × off-peak load (MW)

$Cap._{accept}(MW) = 0.05 \times 1.5 \times 440 = 33.00MW$

According to the above calculated results, unit capacity of Ayago hydropower station should not be exceeding 33.00MW from point of view of the power system stability. However, the unit capacity of Ayago hydropower station shall be of 50MW due to the number of units and economical reason.

Regarding the subject of transportation route of the heavy equipment, it is anticipated that heavy equipment will be unloaded at Mombasa in Kenya, and then will be transported by road through Kenya, and Uganda, to near Karuma project site. After that, they will be transported on newly constructed access road to the Ayago hydropower station.

As for the load limit and width of the roads and bridges along which various equipments for the Ayago Project will be transported, a detailed study shall be conducted during the Feasibility Studies

As per the subject c) of the level of current manufacturing technology, the unit capacity of 50MW is not a serious problem.

Finally regarding the subject d) of the reliability and flexibility of maintenance and operation, the smaller Units offer more flexibility in maintenance and operation

According to the above study results, influence of the unit capacity to the power system is the most an important factor and the unit capacity of 50MW, 12 units is appropriate for the Ayago hydropower station.

In this study, unit capacity and number of unit was evaluated by above mentioned simplified method on condition that Ugandan power system is not connected to Kenyan power system and re-evaluation of the unit capacity and number of unit is desirable in the next feasibility study stage by detail power system analysis.

7.9.3 Turbine

(1) Turbine Output

The rated turbine output per unit can be calculated as follows;

i) Unit 1-6

$$Pt = 9.8 \times Hn \times Qt \times \eta t$$
$$= 9.8 \times 80.79 \times 70.0 \times 0.924$$
$$\fallingdotseq 51{,}200 \text{ kW}$$

Where,

Pt : Rated turbine output per unit (kW)
Hn : Rated effective head (m)
Qt : Rated water discharge per unit (m^3/s)
ηt : Turbine efficiency (%)

ii) Unit 7-12

$$Pt = 9.8 \times Hn \times Qt \times \eta t$$
$$= 9.8 \times 80.60 \times 70.0 \times 0.925$$
$$\fallingdotseq 51{,}100 \text{ kW}$$

Where,

Pt : Rated turbine output per unit (kW)
Hn : Rated effective head (m)
Qt : Rated water discharge per unit (m^3/s)
ηt : Turbine efficiency (%)

(2) Turbine Type

Generally, the turbine type is determined based on the relation between the effective head and output. The vertical-shaft, single-runner, Francis type is selected as the turbine type in consideration of the effective head and turbine output.

7.9.4 Generator

The rated generator capacity can be calculated from the rated turbine output, power factor and generator efficiency as follows;

i) Unit 1-6

$$Pg = Pt \times \eta g / p.f \text{ (kVA)}$$
$$= 51{,}200 \times 0.977 / 0.90$$
$$\fallingdotseq 55{,}600 \text{ kVA}$$

Where,

Pg : Rated generator capacity per unit (kVA)
Pt : Rated turbine output per unit (kW)
ηg : Generator efficiency (%)
p.f : Power factor (%), lag

ii) Unit 7-12

$$Pg = Pt \times \eta g / p.f \text{ (kVA)}$$
$$= 51{,}100 \times 0.977 / 0.90$$
$$\fallingdotseq 55{,}400 \text{ kVA}$$

Where,

Pg : Rated generator capacity per unit (kVA)
Pt : Rated turbine output per unit (kW)
ηg : Generator efficiency (%)
p.f : Power factor (%), lag

7.9.5 Main Transformer

One (1) main transformer for each turbine-generator is desirable from the point of view of the operation. However, the main transformer needs to be installed at limited space of underground govern and one (1) main transformer for two (2) turbine-generator shall be adopted for the Ayago hydropower station.

Therefore, the total number of main transformer shall be 6 units. The rated capacity of the main transformer is decided based on the rated generator capacity as follows,

i) Unit 1-3

– Rated voltage : Primary 13.2 kV
: Secondary 400 kV

– Rated capacity : Primary 55.6MVA
: Primary 55.6MVA
: Secondary 111.2MVA
– Rated frequency : 50 Hz
– Cooling system : Indoor、OFWF（forced oil, water cooled type）

ii) Unit 4-6

– Rated voltage : Primary 13.2 kV
: Secondary 400 kV
– Rated capacity : Primary 55.4MVA
: Primary 55.4MVA
: Secondary 110.8MVA
– Rated frequency : 50 Hz
– Cooling system : Indoor、OFWF（forced oil, water cooled type）

7.9.6 High Voltage Switching Gear

Generally, the high voltage switching gear can be installed at outside if there is not any scenic disturbance. However, Ayago hydropower station is within the national park and needs to avoid scenic disturbance. Therefore, the high voltage switching gear shall be located within an underground carven same as the turbine-generators and the main transformers.

Moreover, Gas Insulated Switchgear shall be adopted as the high voltage switching gear due to limited space of underground govern and to be connected to transmission line via 400kV cable and outgoing steel structure.

Whole single line diagram (Figure 7.9.6-1) including generator, main transformer, bus and transmission are shown as follows;

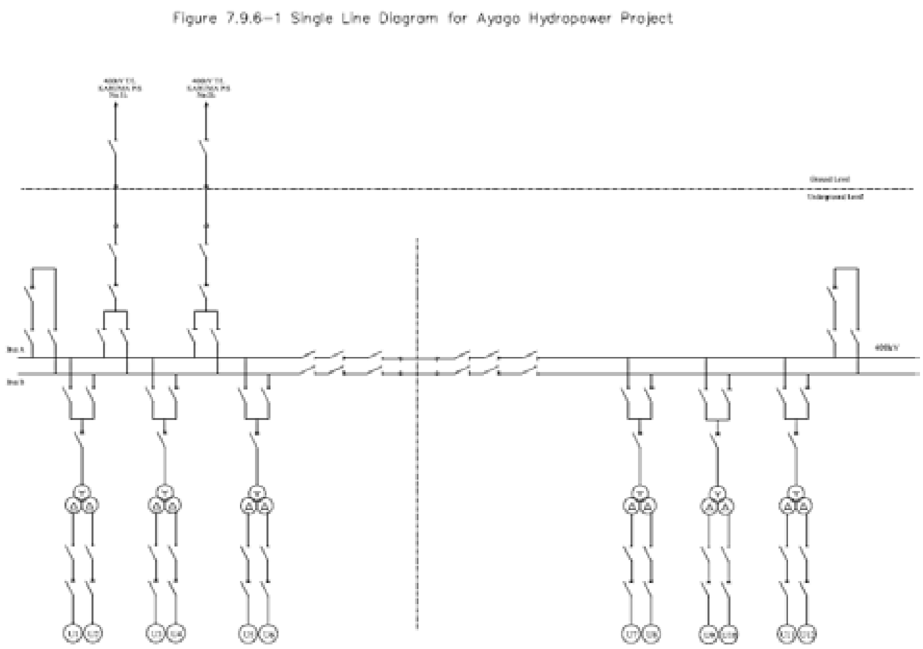


Figure 7.9.6-1 Single Line Diagram for Ayago Hydropower Project

7.9.7 Transmission Line

(1) Transmission Line Route

Generated power at Ayago hydropower station will be connected to Karuma switchyard and to be transmitted to Kawanda substation which is in suburbs of Kampala. The length of transmission line of the Ayago hydropower station is between Ayago and Karuma is 58km.

The transmission line route is located on south side of Victoria Nile River same as Ayago hydropower station which is less an inhabitant in the national park and also to be constructed new access road. Some section of the transmission line will be constructed along the access road and other section will be a shortest distance route.

Outline of the transmission line is shown as follow;

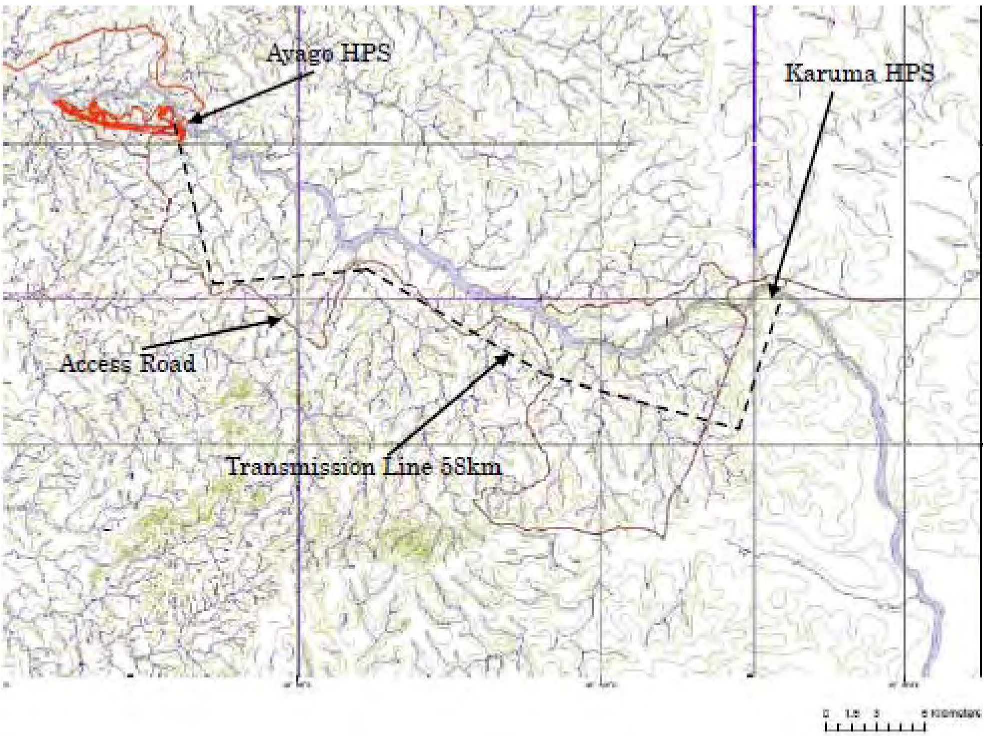


Figure 7.9.7-1 Transmission Line Rout Map of Ayago Project

Although scope of construction of transmission line for the Ayago hydropower station is between Ayago hydropower station and Karuma switchyard, transmission line network of East Africa is shown in Figure 7.9.7-2.

According to the transmission line network of East Africa, generated power at Ayago hydropower station will be connected to metropolitan area of Kampala via Karuma switchyard, Kafu substation and Kawanda substation.

Regarding to the connection to the East Africa, especially to Kenya, generated power at Ayago hydropower station will be connected Kenya via Karuma substation, Kafu substation, Kawanda substation, Bujagali substation and Tororo substation and another route is via Karuma substation, Lira substation, Opuyo substation and Tororo substation likewise.

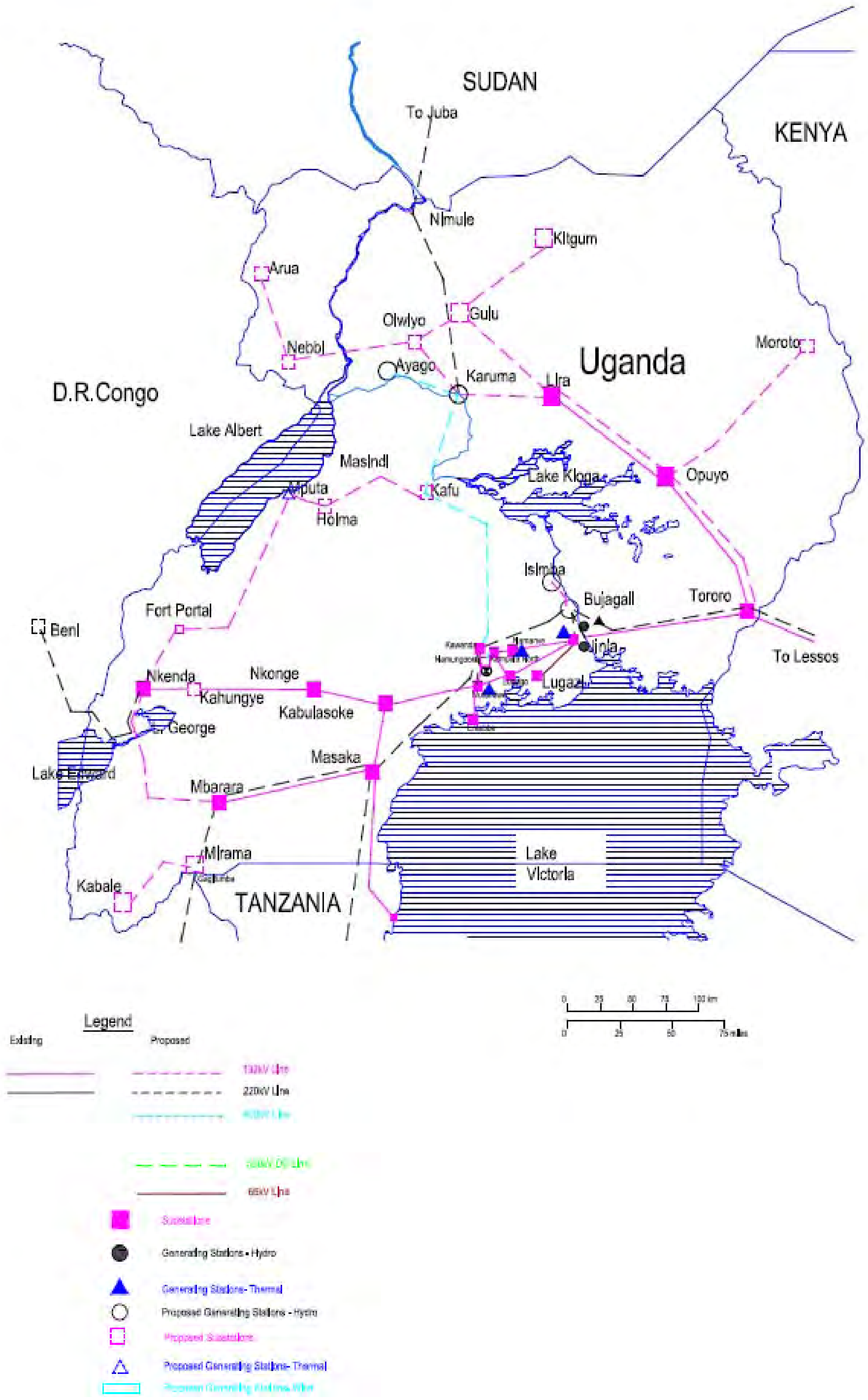


Figure 7.9.7-2 Transmission Line Network of East Africa

(2) Specification

The outline for basic specification of the Transmission line is shown as follows;

1) Basic Specification

Section :	From Ayago switchyard to Karuma switchyard
Length :	58 km
Nominal Voltage :	400 kV
Electrical System :	AC, Three-phase, Three-wire system
Number of Circuit :	2
Structure of Phase Conductor :	4 conductors
Number of Overhead Ground Wire :	2 wires
Frequency :	50Hz

2) Conductor

Because Uganda is a landlocked country, conductor corrosion caused by the sea salt needs not to be taken in consideration. As a result of the site survey, no factor generating corrosive gases, such as factories and volcanoes, are considered to exist around the route, meaning normal aluminum conductor steel reinforced (ACSR) is adopted.

Size and number of conductor is selected based on the thermal capacity, maximum surface potential gradient (15kV/cm or less) as follows;

	Maximum surface potential gradient	Transmission Line Capacity (current)	Allowable Transmission Line Capacity (kW)
Wolf, 150mm^2, 4 Conductors	15.99 kV/cm	451A×4=1,803A	1,186,697kW
Bear, 260mm^2, 4 Conductors	12.94 kV/cm	623A×4=2,492A	1,640,182kW
Bison, 380mm^2, 4 Conductors	11.50 kV/cm	761A×4=3,044A	2,003,498kW
Moose, 597mm^2, 4 Conductors	10.08 kV/cm	934A×4=3,736A	2,458,958kW

As a result of above comparison, there are Bear, Bison and Moose conductors which are 15kV/cm or less for the maximum surface potential gradient and rest of factor is allowable transmission line capacity.

Bison, 380mm2, 4 conductors (2,000MW/1 circuit) is selected for the transmission line from Ayago to Karuma because generated power from Kiba and Oriang to be constructed other than Ayago hydropower station in the future will also be connected to Ayago transmission line via Ayago switchyard to metropolitan area

ACSR Bison 4Conductors	380mm^2 × 4
Allowable Conductor Current	761A × 4（at 75°C）
Thermal Capacity of Transmission Line	2cct (continuous) 4,000 MW

3) Scenic Countermeasure for Transmission Line

Transmission line route of south side of the Victoria Nile is less conspicuous than north side of Victoria Nile because of existing of tall tree. As for the detail scenic design for the transmission line, it is desirable to cooperate with local district and stakeholder in the next feasibility study stage.

4) Steel Tower

The steel tower is considered to be of the square type tower and expected steel tower is shown as follows. Moreover, the steel tower shall be designed in consideration for the safety distance from house, trees or other objects according to the Ugandan regulation.

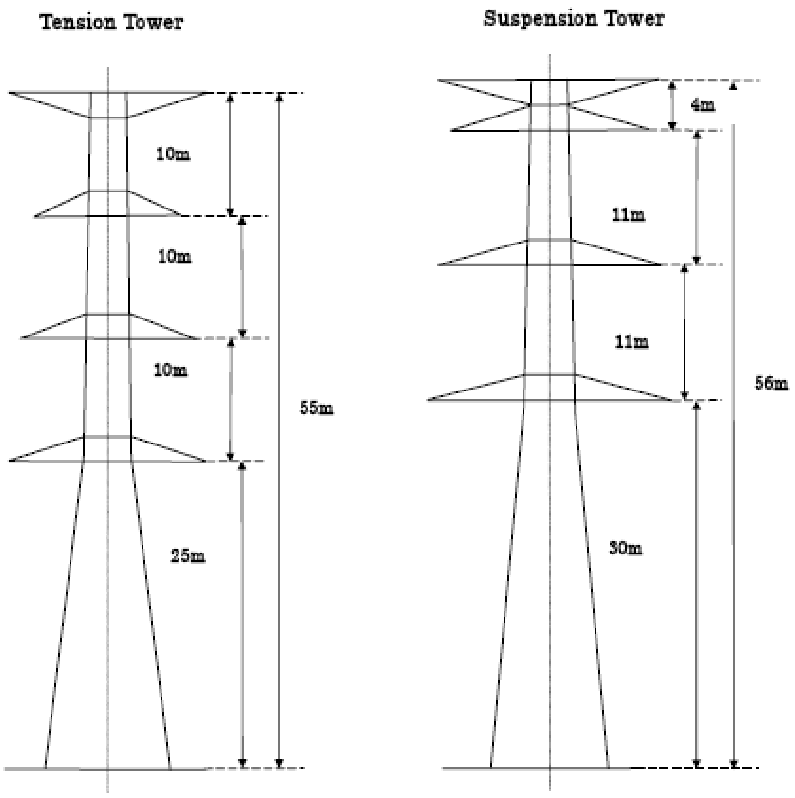


Figure 7.9.7-3 Typical Transmission Tower of Ayago Project

7.10 Construction Plan and Cost

7.10.1 Access to the project site

(1) Airway

Entebbe Airport, which is located 40 km apart from the capital city Kampala, is the only international airport in Uganda. There are some airports for domestic flights in major cities, however no airport near the site. It takes 20 hours by direct flight from Narita Airport in Japan to Entebbe Airport.

(2) Road

The Ayago project site is located in the main stream of the Nile River originated from Victoria Lake, and the site is about 250 km north-northeast from Kampala.

The electromechanical equipment, construction machines and construction materials imported from foreign countries are to be transported to the site after they are unloaded at Mombasa Port. It takes about 5.5 hours to transport them from Kampala to the site through the route A104 via Karuma.

The route A104 from Kampala to Karuma is almost paved. There seems to be no restriction in terms of weight limits and minimum turning radius. However the access road of 75 km from Karuma to the site shall be widened and improved. The route of the access road shall be determined in consideration of environmental impact because it is located in Murchison Fall National Park.

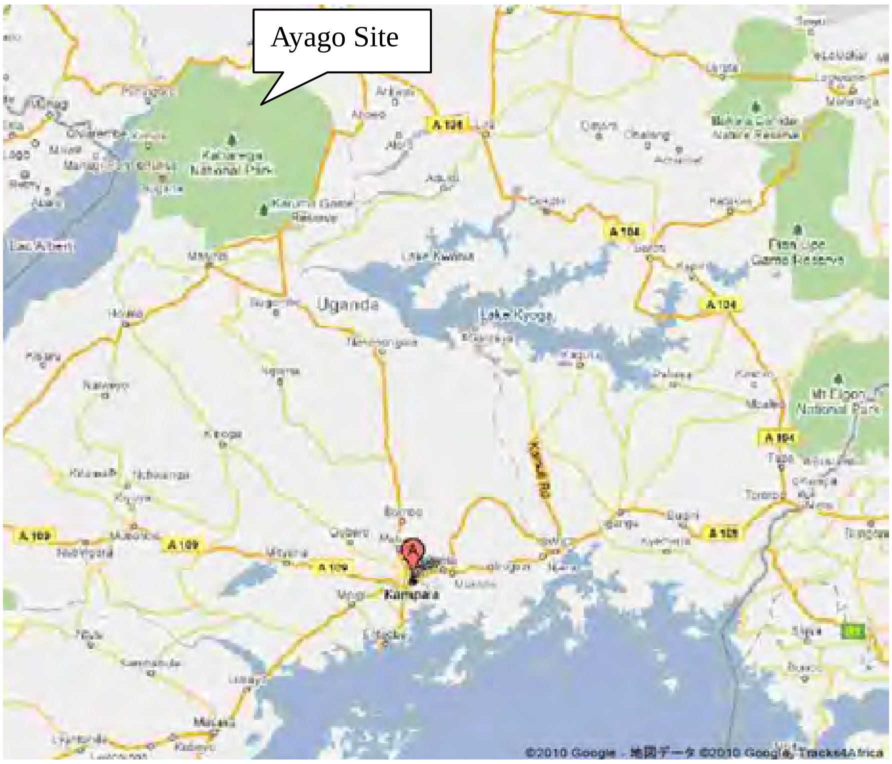


Figure 7.10.1-1 Location of Ayago Site

7.10.2 Temporary Power Supply during Construction

There is no power line near the Ayago site because it is located in the National Park and no resident there. Therefore temporary distribution lines shall be installed from the substation in Karuma; otherwise private power generators shall be installed.

7.10.3 Concrete Aggregate

The Ayago site forms gentle hilly terrain and no outcrops are found except at the river bed. Large alteration of terrain such as quarries shall be avoided in the National Park to minimize environmental impacts. Hence, mucks from the waterway tunnels and the underground powerhouse will be temporarily stocked in the yard and processed into fine and coarse aggregates in the crushing plant.

The volume of rock excavation and concrete for each main structure is shown in Table 7.10.3-1.

Table 7.10.3-1 Excavation and Concrete Volume for Main Structures

(Unit: m^3)

Structure	Rock excavation	Concrete
1. Weir	10,500	83,400
2. Intake	433,500	25,700
3. Headrace	80,800	25,600
4. Penstock	26,000	13,100
5. Powerhouse	278,720	68,300
6. Draft Tunnel/Pond	122,400	30,900
7. Tailrace Tunnel	3,578,360	689,400
8. Outlet	125,800	7,800
9. Access Tunnel	99,100	7,000
Sub Total	4,755,180	951,200

The required aggregates volume is estimated using concrete volume as follows.

$$V = 951{,}200 \times 2.046 / 2.6 \times 1.125 = 842{,}086 \fallingdotseq 843{,}000 \text{ m}^3$$

Where,

Aggregates mass per 1 m^3 concrete = 2.046 t/m^3

Aggregates specific gravity = 2.6

Loss at aggregates production = 12.5%

Assumed that the only 50% of mucks can be available for concrete aggregates due to loss and time delay between production and usage, the potential volume of excavated rocks usable for aggregates is estimated by the following equation:

$$4{,}755{,}180 \times 0.5 \fallingdotseq 2{,}380{,}000\ m^3 > 843{,}000\ m^3$$

Therefore, the volume of mucks from the waterway tunnel works will be sufficient for concrete aggregates.

7.10.4 Spoil Bank

(1) Required Volume for Spoil Bank

It is estimated that the required volume for the spoil bank would exceed 5 million m^3 as shown in Table 7.10.4-1.

Here, the volume of mucks to be disposed in the spoil bank is calculated 1.5 times as much as the excavated volume in consideration of the over excavation and the expansion ratio of soil and rock. The required capacity is then calculated by deducting the volume for concrete aggregate and road base from the volume of mucks.

Table 7.10.4-1 Excavation and Spoil Bank Volume for Main Structures

(Unit: m^3)

Excavation	4,755,180 x 1.5
Concrete Aggregate	843,000
Road Base (0.25m×6m×100km)	150,000
Required Volume	5,873,000

The following three candidates for spoil banks are selected in consideration of environmental impact and accessibility.

(A) Exit of tailrace work adit, (B) Exit of powerhouse access tunnel, (C) Downstream of weir

The location of candidate spoil banks are shown in Figure 7.10.4-1. The estimated area (m^2) and capacities (m^3) of each candidate for the spoil bank are shown in Table 7.10.4-2. The above 3 candidates might accommodate the total required capacity 5,873,000 m^3, but it is necessary that the more detailed topographic investigation and environmental evaluation will be conducted in the next stage.

Table 7.10.4-2 Estimated Area and Volume of Spoil Bank

No	Location	Estimated Area (m^2)	Estimated Volume (m^3)
(A)	Tailrace Work Adit	318,000	5,088,000
(B)	Powerhouse Work Adit Downstream	52,000	298,000
(C)	Weir Downstream	61,000	536,000
	Total	431,000	5,922,000

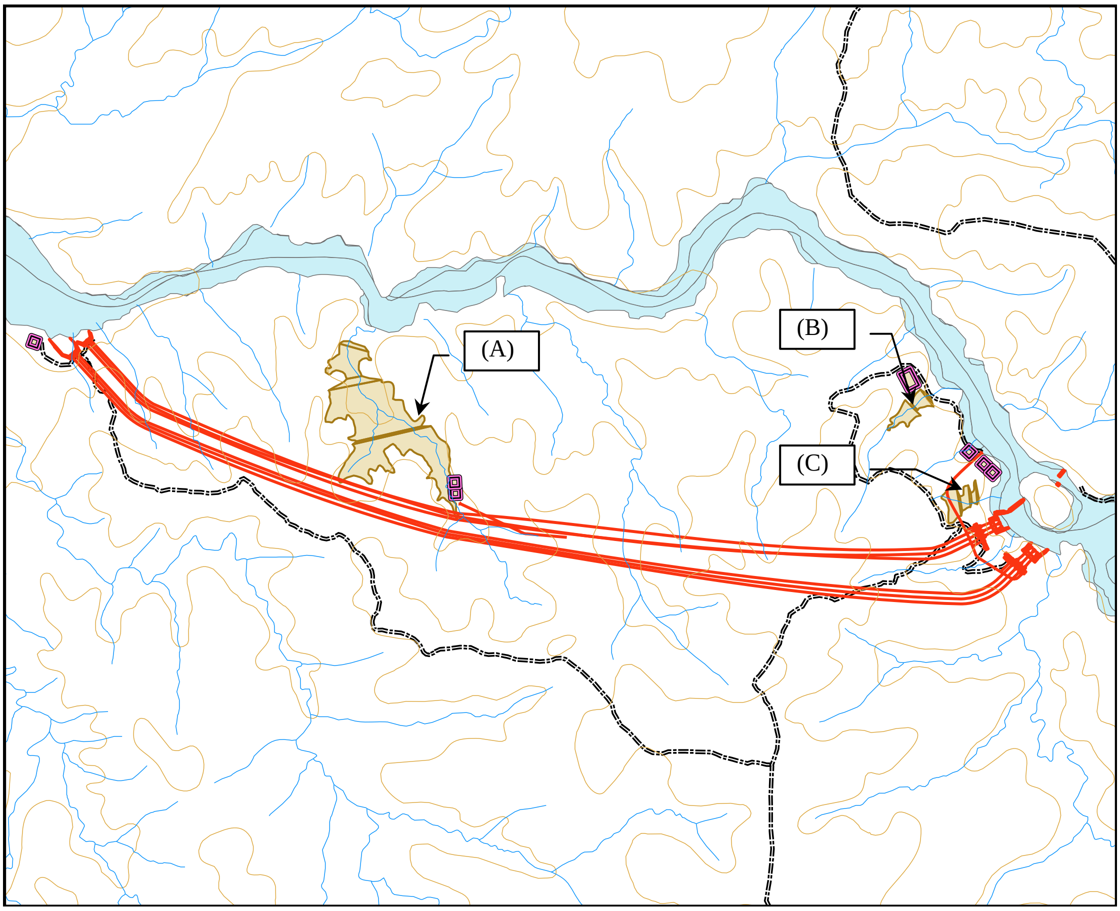


Figure 7.10.4-1 Location of Spoil Bank

(2) Transportation Plan

The candidate spoil banks are arranged close to the exit of work addict to tailrace and powerhouse so that the impact for animals due to the transportation shall be avoided as much as possible. As for the transportation on the tourism roads, it is necessary to repair and improve them as well as to take heed noise and safety.

7.10.5 Temporary Facility Area

The items of main temporary facilities and their required area are shown in Table 7.10.5-1. The candidates for the temporary facilities area are shown in Figure 7.10.5-1.

Table 7.10.5-1 Temporary Facility Area

No.	Item	Necessay Area (m^2)
A	Weir, Intake	2,600 m^2
A-1	Motor Pool for Construction Machinery	
A-2	Repair Shop	
A-3	Fabricating Yard for Reinforcement Bars	
A-4	Carpentory Shop	
A-5	Water Treatment	
A-5	Materials Storage Yard	
A-7	Other Buildings (Contractor's Office, Parking Lots etc.)	
A-8	Spillway and Intake Gate Assembly Yard	
B	Headrace, Penstock	3,500 m^2
B-1	Motor Pool for Construction Machinery	
B-2	Repair Shop	
B-3	Fabricating Yard for Reinforcement Bars	
B-4	Carpentory Shop	
B-5	Explosives Warehouse	
B-6	Other Warehouse	
B-7	Water Treatment	
B-8	Materials Storage Yard	
B-9	Other Buildings (Contractor's Office, Parking Lots etc.)	
B-10	Penstock Assembly Yard	
B-11	Welding Shop	
C	Powerhouse Access Tunnel, Powerhouse, Tailrace (Up stream)	3,300 m^2
C-1	Motor Pool for Construction Machinery	
C-2	Repair Shop	
C-3	Fabricating Yard for Reinforcement Bars	
C-4	Carpentory Shop	
C-5	Explosives Warehouse	
C-6	Other Warehouse	
C-7	Water Treatment	
C-8	Materials Storage Yard	
C-9	Other Buildings (Contractor's Office, Parking Lots etc.)	
D	Tailrace Tunnel (Middle stream)	3,200 m^2
D-1	Motor Pool for Construction Machinery	
D-2	Repair Shop	
D-3	Fabricating Yard for Reinforcement Bars	
D-4	Carpentory Shop	
D-5	Explosives Warehouse	
D-6	Other Warehouse	
D-7	Water Treatment	
D-8	Materials Storage Yard	
D-9	Other Buildings (Contractor's Office, Parking Lots etc.)	
E	Tailrace Tunnel (Down stream), Outlet	3,200 m^2
E-1	Motor Pool for Construction Machinery	
E-2	Repair Shop	
E-3	Fabricating Yard for Reinforcement Bars	
E-4	Carpentory Shop	
E-5	Explosives Warehouse	
E-6	Other Warehouse	
E-7	Water Treatment	
E-8	Materials Storage Yard	
E-9	Other Buildings (Contractor's Office, Parking Lots etc.)	
F	Concrete Facilities	11,000 m^2
F-1	Batching Plant	
F-2	Crushing Plant	
F-3	Aggregate Stock Yard	
F-4	Laboratory	
G	Construction Buildings	45,000 m^2
G-1	Owner's & Engineer's Office & Camp	
G-2	Contractor's Office & Camp	
G-3	Laboir's Camp	

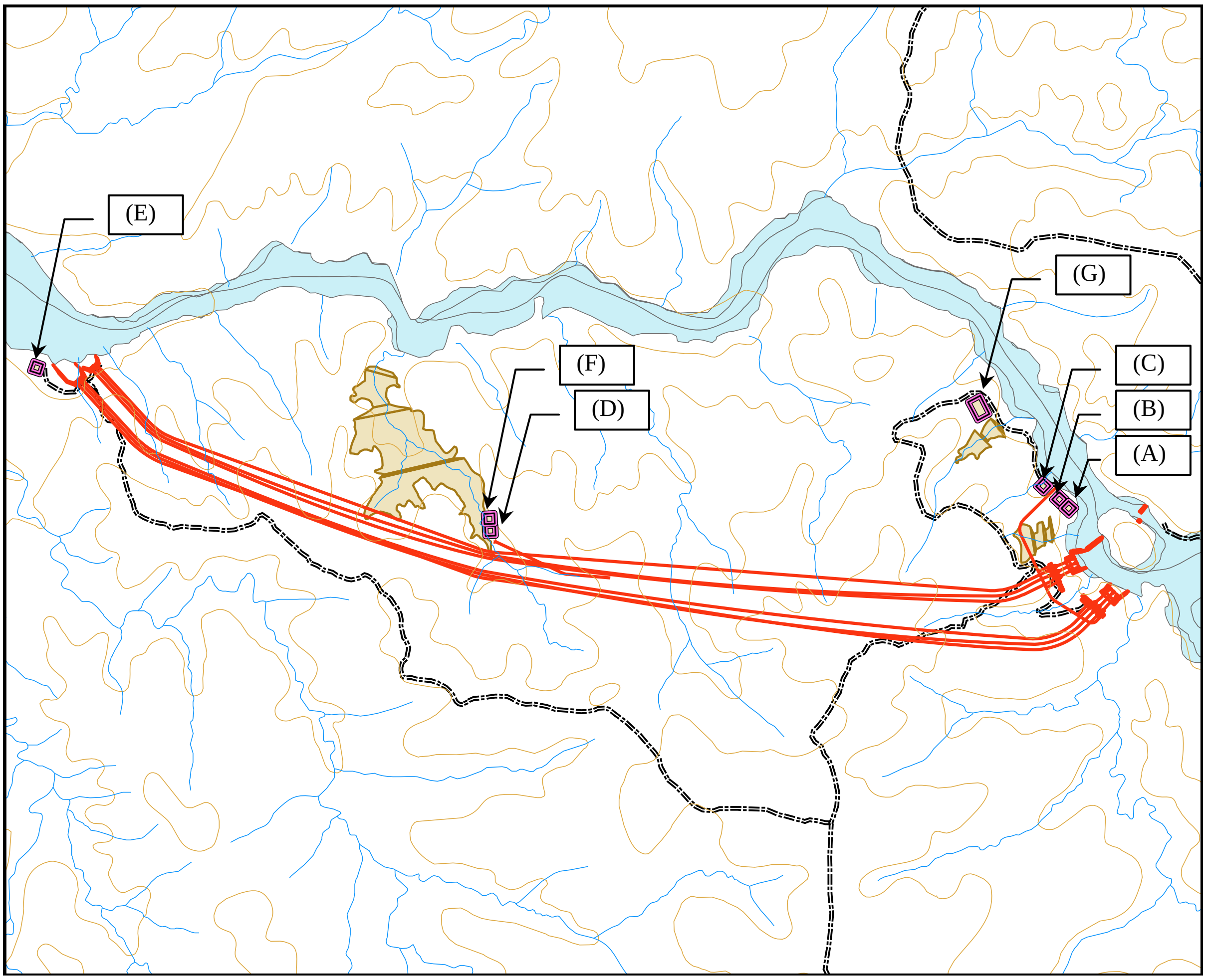


Figure 7.10.5-1 Location of Candidate Temporary Facilities Area

These temporary facilities will be demolished after the completion of the construction works, but the office and camp for MEMD in the area G will remained, because they shall be utilized for the operation and maintenance of the plant.

7.10.6 Improvement of Access Road

Most of construction equipment, machines and materials etc. will be transported from Route A104 near Karuma to the site through the existing access path at south side of Nile River (approximately 75 km). In addition another access at north side (approximately 40 km) and working roads in the construction area (20 km) will be required.

The existing access path will be improved for the construction use in order to minimize environmental impacts. The route of the existing access path is shown in Figure 7.10.6-1 Access Road Route

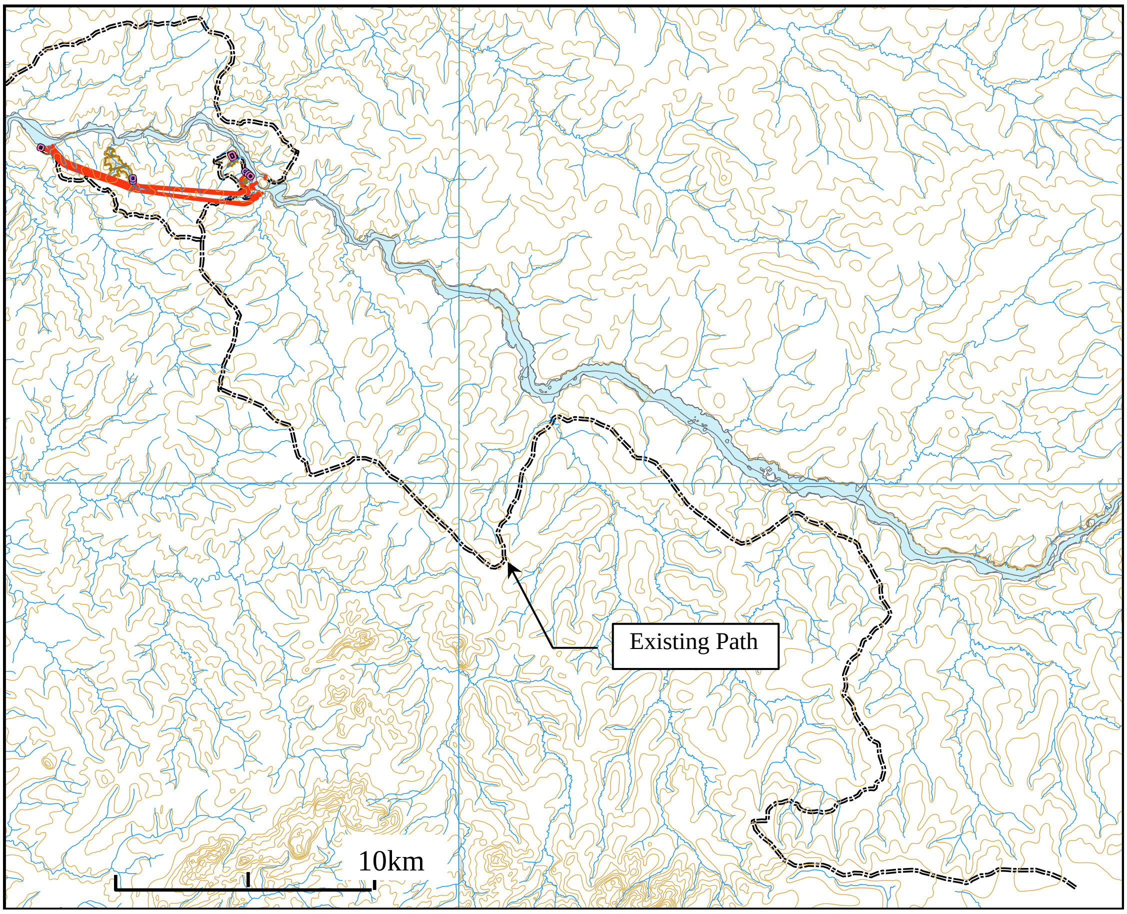


Figure 7.10.6-1 Access Road Route

7.10.7 Basic Conditions

Main structures to be constructed in the Project are weir, intake, headrace tunnel, penstock, underground powerhouse, tailrace tunnel and outlet etc. The total excavation volume is about 4,164,000 m^3, and the total concrete volume is about 1,060,000m^3.

The items which affect to the construction planning and term are described below.

(1) Meteorology

The annual mean temperature at the Project site is 25°C. The monthly average maximum and minimum temperatures are 33°C and 18°C respectively. In addition, the annual average rainfall is 1,300 mm in which more than 150 mm/month during April to October and less than 50 mm/month during December to February. It does not constitute any negative meteorological conditions to cause major impacts on the schedule of open-air works but the countermeasures such as cooling water for concrete placement works during high-temperature periods may be required.

(2) Construction Materials

Although cement and reinforcement bars seem to be available from factories in Uganda, the quantities might be inadequate and therefore consideration for both local and external procurement. The construction materials such as heavy machinery, electrical and hydro mechanical equipment are to be fully procured from outside the country. Most of the aggregates for concrete will be produced from mucks generated from the tunnel and other excavation works, with crushing rocks at on-site aggregate plants.

(3) Working Day

The working conditions are defined as follows based on the actual situation in Uganda.

- 8:00 to17:00 except day-and-night work such as tunnel and underground powerhouse

From Monday to Saturday except national holidays

7.10.8 Salient Feature of Main Structures

Main structures are shown below.

Weir.................................. Concrete gravity type Height:15 m、Length:250 m

Intake .... Side intake type 6units

Headrace Tunnel Concrete lining type 6 lines, Inner diameter:8.4 m, Length: 113 m/line

Steel Penstock................... 6 lines－12 lines, Inner diameter:8.4 ~ 3.8m, Length:85 m/line

Draft Pond......................... Underground type 12 m wide ×10-18 m high × 34 m long× 6units

Tailrace Tunnel .... Concrete lining type 6 lines, Inner diameter:8.4 m, Length:7,400-7890 m/line

Powerhouse....................... Underground type 23 m wide ×40 m high × 150 m long×2 units

Turbine.............................. Vertical Fransis
51.2 MW/unit × 6 units, 250 r/min (Unit 1-6)
51.1 MW/unit × 6 units, 250 r/min (Unit 7-12)

Generator .... 55.6MVA /unit × 6 units (Unit 1-6),
55.4MVA / unit × 6 units (unit7-12)

Main Transformer .... Underground
13.2kV/400kV, Capacity:111.2MVA 3 units (Unit 1-3)
13.2kV/400kV, Capacity: 110.8MVA 3 units (Unit 4-6)

Cable Tunnel..................... Vertical & horizontal tunnel type, Inner diameter:8.0m

7.10.9 Outline of Construction Plan

Outline of main construction works is mentioned below. However construction plan shall be reviewed depending on the future topographical and geological investigation which is closely related to the planning.

(1) Preparatory Work

The preparatory work includes the improvement of the existing path, the temporary power supply facilities for construction works, and the camp for MEMD and engineers. These works should be completed under another contract before starting main civil works.

(2) Intake Weir

1) River Diversion

Temporary closure work for weir construction will be conducted in 3 steps utilizing 2 small islands in the river.

In the first step, as shown in Figure 7.10.9-1, Section-1 will be closed then the intake weir and the flushing gate will be constructed. After that, river flow will be diverted through the flushing gate. In the second and third steps, Section-2 and Section-3 are closed in turns then the weir body will be constructed. It is not difficult relatively to construct the closure works.

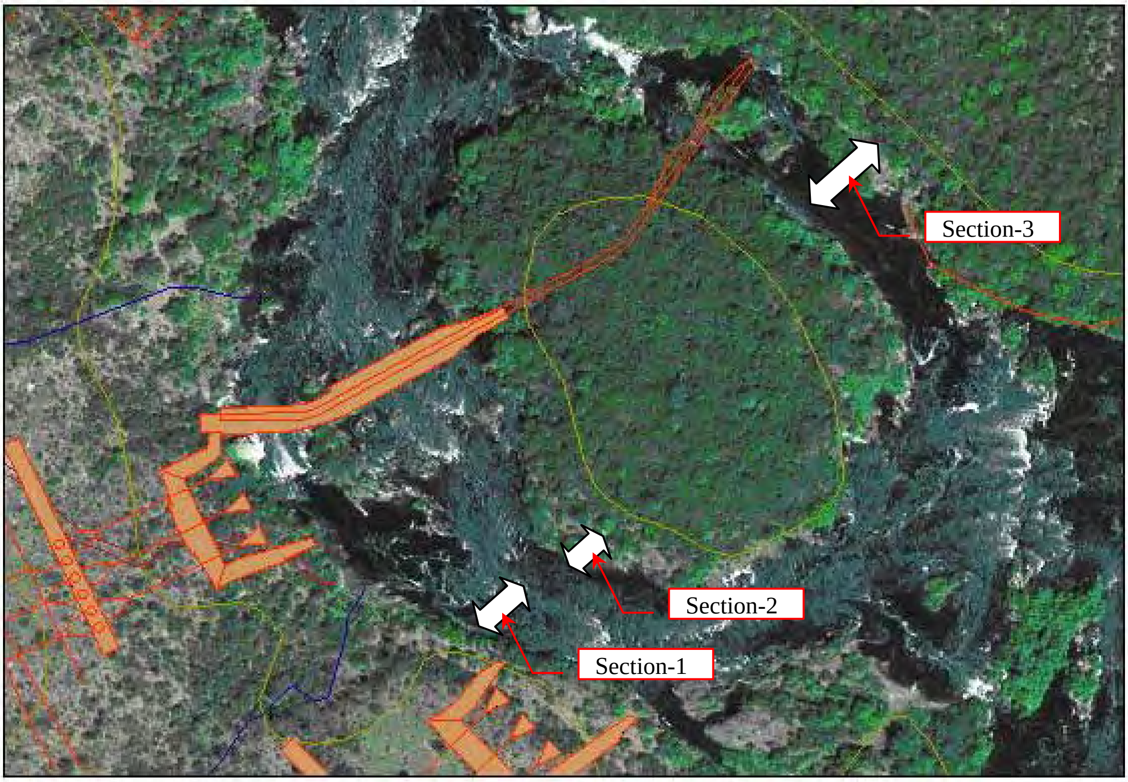


Figure 7.10.9-1 Closure Work Plan

2) Excavation

After the completion of the river works, excavation works will commence at both abutments. As surface deposit is assumed to be little according to the geological investigation results, excavation works should be done by short bench cut method using backhoe from top of the slopes. Weathered rock shall be removed by bulldozer with ripper and/or explosive until sound bearing ground appears.

The example of machine use is shown in Table 7.10.9-1.

Table 7.10.9-1 Machines for Weir Excavation

Process	Machine
Drilling	Crawler drill with oil pressure 150kg class
	Leg-hammer
Bulling	Bulldozer with lipper 32t class
Loading	Backhoe mounting volume 1.6m^3
Carrying	10t Dump track

Excavation works of total 11,000m^3 are scheduled for about 5 months separating 3 times in parallel with the closure works.

3) Concrete

Concrete works, which volume is 83,000m^3, will be casted separating 3 times corresponding to the closure works. Concrete will be transported by agitator cars from the concrete plant which is assembled at the temporary facility area 4km downstream of weir site.

4) Flushing Gate

2 flushing gates are installed after concrete lift reach to EL.857.50 m. The gates shall remain open for the diversion of river flow.

(3) Intake

The intake will be constructed in the condition that a part of existing mountain shall remain as the temporary closure.

The headrace tunnel will be commenced after excavation of the intake. Concrete works start after completion of headrace tunnel works including lining concrete.

The hydro mechanical works such as gates and screens are installed after concrete works.

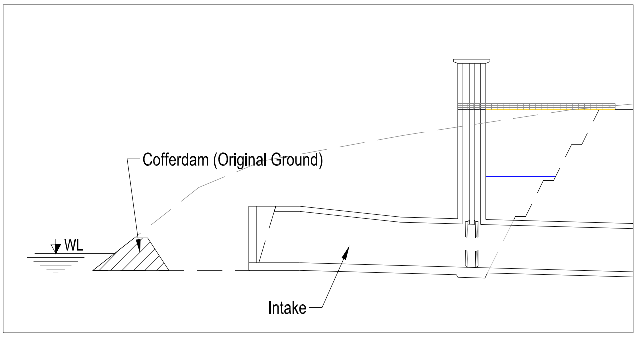


Figure 7.10.9-2 Intake

(4) Headrace Tunnel / Vertical Shaft

The headrace tunnel is 113 m long with inner diameter of 8.4 m.

The headrace tunnel will be excavated by drilling and blasting method by using 3-boom wheel jumbos, side dump type muck loaders and 20t dump trucks. The tunnel supporting works will be done with shotcrete and rock bolts. The vertical shaft will be excavated by using raise-borer machine in which mucks is dropped in the shaft and carried to the outside from the lower penstock tunnel.

The monthly progress of the horizontal tunnel and the vertical shaft is expected to be 80 m/month and 30 m/month respectively. The horizontal tunnel will be excavated after the completion of intake excavation and the vertical shaft will be done after the completion of lower penstock excavation.

Typical flow of tunnel excavation and arrangement of machineries are shown in Figure 7.10.9-3 and Figure 7.10.9-4.

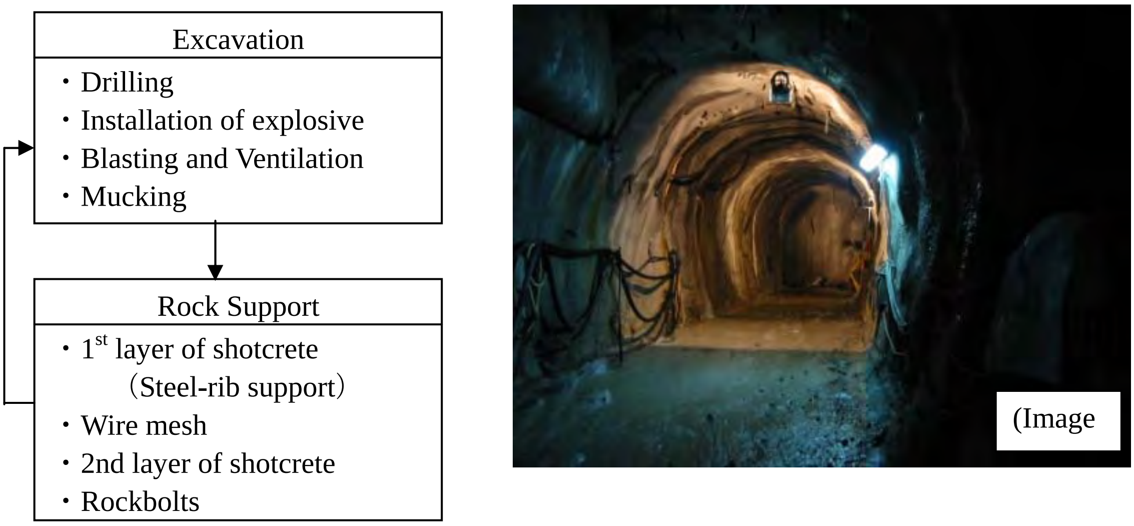


Figure 7.10.9-3 Tunnel Procedure

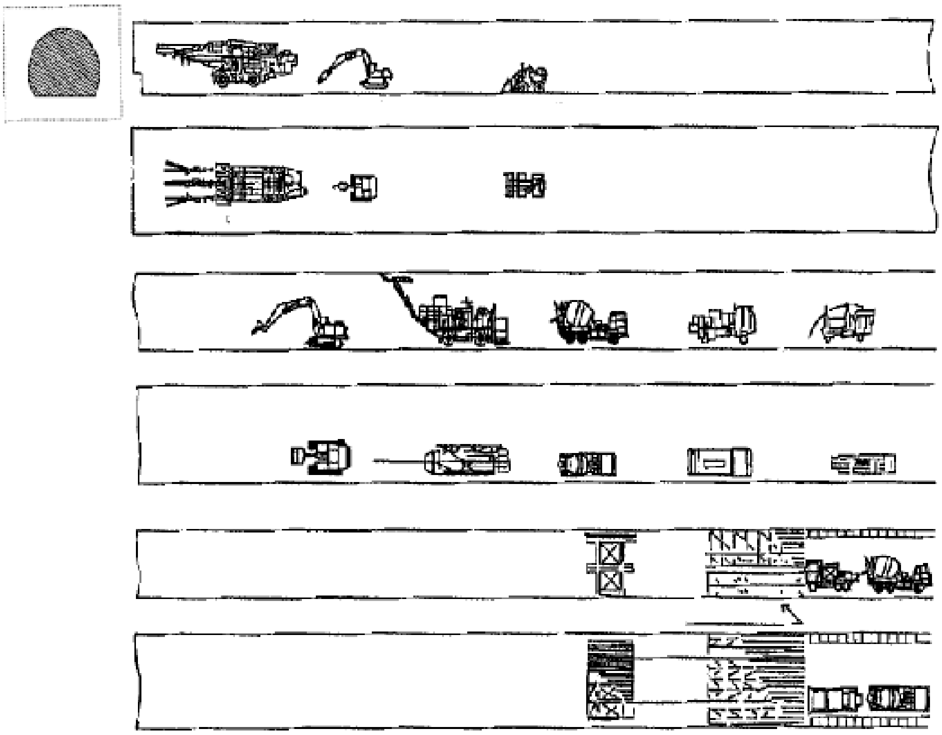


Figure 7.10.9-4 Arrangement of Tunnel Excavation Machine

The lining concrete will be placed with a traveling steel form continuously after excavation. The monthly progress of the lining concrete is expected to be 110 m/month.

The consolidation grout shall be executed to prevent water from leaking.

(5) Penstock Tunnel

Penstock tunnel consists of 2 parts as shown below.

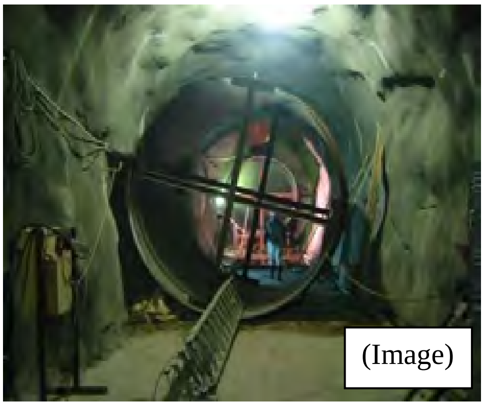
Upstream of bifurcation	44m long × 6lines, Inner diameter: 5.4 m
Downstream of bifurcation	37m long× 12lines, Inner diameter: 3.8 m

The excavation of the lower penstock tunnel will be executed with the same method as the headrace tunnel excavation. The monthly progress of the penstock tunnel excavation is expected to be 80 m/month as which is the same as the headrace tunnel excavation.

The salient features of the steel penstock are shown below.

Type..Embedded Type Steel Penstock
Component ....1 line (upstream of bifurcation),
2 lines (downstream of bifurcation)
Length..37.9 m
Inner diameter ....8.4 m to 5.4 m (upstream of bifurcation)
to 3.8 m (downstream of bifurcation)
Material & Sharing ratio of internal pressure by bedrock
....To be determined

The steel lining and the steel penstock are fabricated in the temporary factory near the site and transported to the respective tunnel with trailers.


(Image)

The section with 5.4 m in diameter is brought from the vertical shaft and installed at the given location in the tunnel. The installation will be executed from the downstream end.

The monthly progress of the installation work is expected to be 36 m/month based on the estimated cycle-time of 15 days (12 days for steel pipe installation (6 m/unit × 3 units) and 3 days for backfill concrete work.).

(6) Access Tunnel to Powerhouse

The access tunnel is a road tunnel connecting the erection bay of the underground powerhouse, with a length of about 1,090 m. The inner tunnel size is 7.0 m wide and 8.0 m high. Work adit tunnels are provided in order to connect the access tunnel with the powerhouse arch, powerhouse bottom, lower penstock horizontal tunnel and draft pond respectively.

The access and work adit tunnels will be driven by the same drilling and blasting method as for the headrace tunnel. The access tunnel shall be commenced as soon as possible because it is on a critical path for the whole construction. The construction period for both the access tunnel and work adit is expected at 14 months provided that the monthly progress of the tunnel excavation is 80 m/month. In addition the required construction period for lining concrete work is 10 months provided that the monthly progress is 110 m.

(7) Powerhouse

The powerhouse is of a bullet type having a dimension of 23 m wide, 40 m high and 150 m long for 1 cavern. The cavern excavation work will be carried out in two steps: arch excavation and body excavation as shown in Figure 7.10.9-5.

The arch excavation will be carried out with a center drift heading and side enlargement method, approaching from the upper work tunnel branching off from the access tunnel to the powerhouse. The setting of PS anchors, rockbolts and shotcrete shall be made in parallel with the excavation work. Construction period for arch excavation is expected at about 8 months. After the arch excavation, the powerhouse body will be lowered to its bottom level by the bench cut method which height would be restricted 2.5 m - 3.0 m depending on the geological condition. The PS anchors, rockbolts and shotcrete shall be applied to the wall to secure the cavern stability.

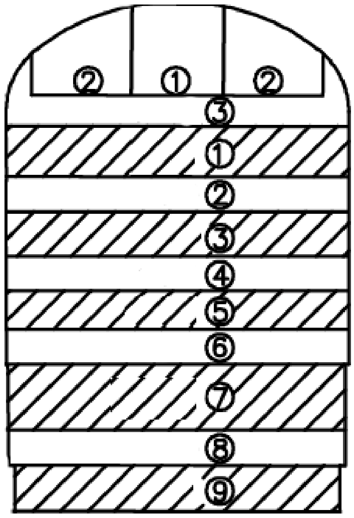


Figure 7.10.9-5 Excavation

The muck will be loaded by wheel loader into 20 ton dump truck, and hauled to the outside through each work adit tunnel and access tunnel. The seepage water during construction will be gathered into the ditch and drained to outside using a submersible pump. The construction period for body excavation is estimated at about 7 month.

Once excavation is completed, base concrete will be commenced using temporary ceiling crane or truck crane. The concrete work will be carried out, floor by floor, from the powerhouse bottom. The concrete placing around electromechanical equipment such as draft tube, casing and turbine will be done separating 1st and 2nd concrete. The mixed concrete will be delivered to the cavern by agitator truck and placed by concrete pump car.

After the civil work, architectural and utility work including the electrical work will be carried out. These works are planned to take about 15 months for excavation, 27 months for concrete and 10 months for architectural and utility works.

(8) Cable Tunnel

The cable tunnel is composed of vertical shaft of 100 m long and horizontal tunnel of 70 m. the tunnel section is 8m of inner diameter. The vertical shaft will be excavated by using a raise-borer, which is constructed by same method of the vertical shaft of headrace tunnel. On the other hand the horizontal part will be excavated by blasting method. The required period for the excavation is estimated at 8 months for vertical shaft and horizontal tunnel.

After completion of the excavation work, lining concrete will be placed which period is estimated at 5 months.

(9) Draft Tunnel and Draft Pond

The draft tunnel is 5 m in diameter, 26 m/line in length and the draft pond is 12 m in width, 10-18 m in height and 34 m in length.

The draft tunnel will be excavated by the blasting method as same as the headrace tunnel. The draft pond will be carried out by applying the same method as that for the powerhouse, approaching from the work adit tunnel branch off from the access tunnel. The excavated rock material will be dropped to the tailrace tunnel through the pilot hole and then hauled to the outside by dump truck.

The construction period for the draft tunnel and draft pond is expected at 7 months for the excavation and another 7 months for the concrete work.

The draft gate will be installed at the end of draft tunnel and the beginning of draft pond.

(10) Tailrace Tunnel

The tailrace is non-pressure tunnel which consists of 6 lines with 8.4 m in diameter and 7,400m - 7,890m in length respectively.

The tailrace tunnel will be driven by the same drilling and blasting method as that for the headrace tunnel with 3-boom wheel jumbos, side dump type muck loaders and 20t dump trucks. The tunnel supporting works will be done with shotcrete, rock bolts and steel rib supports. The progress rate of the excavation for the tailrace tunnel is estimated at 80 m/month. After completion of the excavation work, lining concrete will be placed by the sliding steel form. The monthly progress of lining concrete is expected to be about 110 m/month.

As shown in Figure 7.10.9-6 the work adit approaches to the halfway point of the tailrace tunnel then the tunnel will be driven simultaneously separating 4 parts (A, B-1, B-2, C) to shorten the construction term. The construction period is estimated at 24 months for the excavation and 18 months for the concrete work.

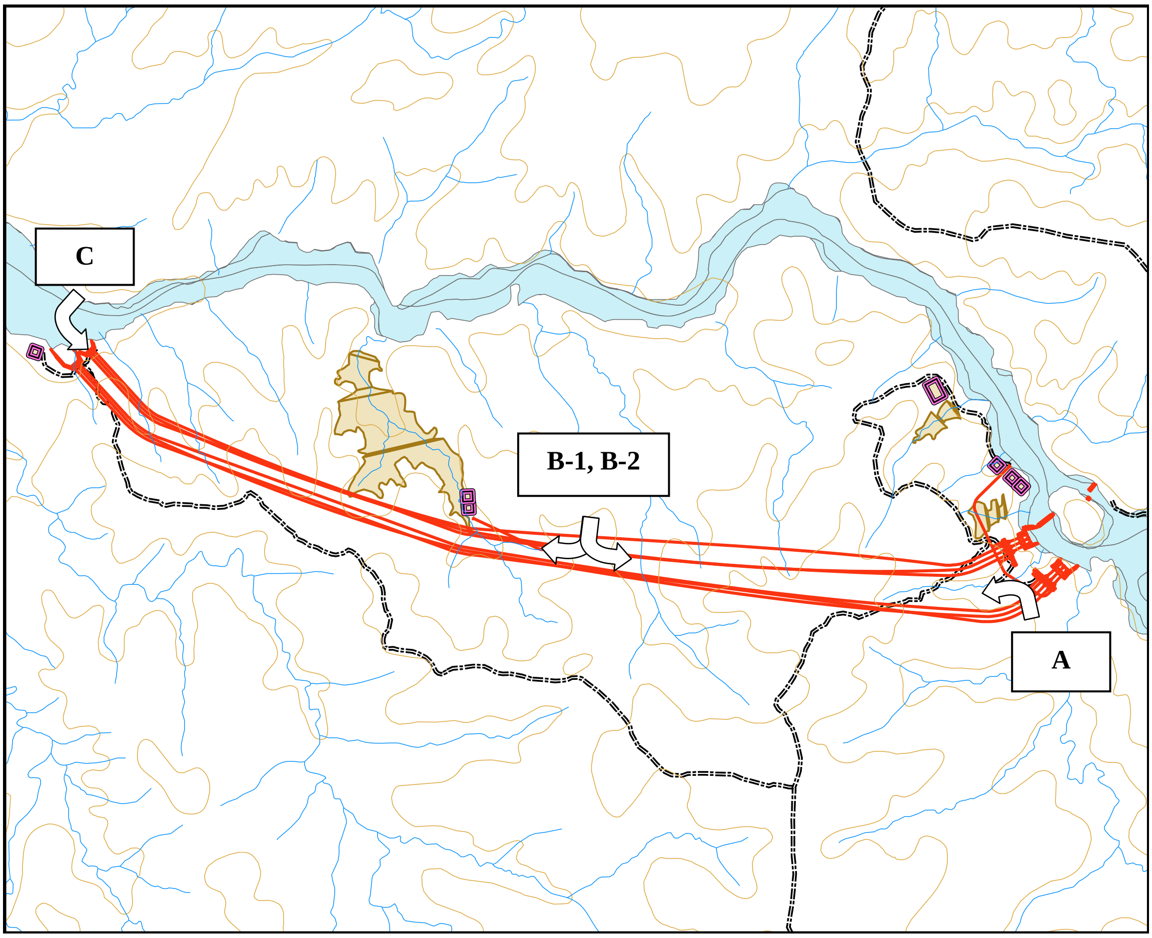


Figure 7.10.9-6 Segments of Tailrace Tunnel

(11) Outlet

The outlet will be constructed in the condition that a part of existing mountain shall remain as the temporary closure.

The tailrace tunnel will be commenced after excavation of the outlet. Concrete works start after completion of tailrace tunnel including lining concrete. The hydro mechanical works such as gates and screens are installed after concrete works.

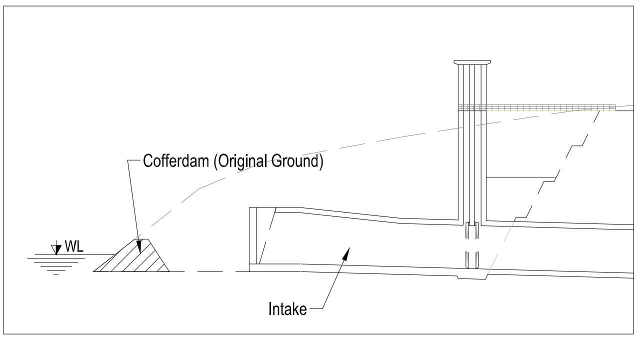


Figure 7.10.9-7 Outlet

(12) Turbine, Generator

1) Overhead Traveling Crane

The Overhead traveling crane will be used for the installation of draft tube, turbine and generator etc. The installation of overhead traveling crane will start after completion of powerhouse's excavation and a crane garter's foundation. The overhead traveling crane will be used for the installation of draft tube firstly.

2) Draft tube

The draft tube will be installed by the overhead traveling crane. After the various kinds of check and test, concrete casting around the draft tube will be done by the civil contractor.

3) Spiral Casing

The spiral casing will be installed after the completion of foundation for the concrete casting. After the installation of the spiral casing, concrete casting around the spiral casing will be done by the civil contractor.

4) Turbine, Generator

The installation of turbine and generator will commence after the completion of spiral casing installation. The installation of first unit will start 40 month after the commencement of construction works. The installation of second unit will start two month after the first unit.

As for the assembling of the generator, safety consideration shall be taken due to the conflicting assembling work to the other unit at erection area.

5) Main Transformer, High Voltage Switchgear

The main transformer and high voltage switchgear will be installed at underground govern other than turbine and generator govern. The installation works will commence after excavation of underground govern and it shall be completed before the start of dry test of the turbine and generator.

6) Auxiliary and Control Equipment

The installation of auxiliary equipment for the turbine will start after the completion of installation of the turbine. The installation of control equipment will commence after the completion of installation of generator. This period is hectic time due to installation of control cable, check/adjustment of equipment and wiring works.

7) Commissioning Test

The dry test for the first unit will start 52 month after start of construction works and the test will take a month. After the dry test, wet test will be conducted continuously and the test will take a month.

The commercial operation will commence after the completion of various kinds of wet test such as road rejection test.

(13) 400 kV Transmission Line

The construction works for the 400kV transmission line shall be completed before the power receiving from the power system and commissioning test of turbine and generator.

7.10.10 Construction Schedule

Based on the basic conditions and work quantities described in 7.10.8, the construction plan and schedule are prepared. The total construction period for 600MW is estimated at 66 months. The critical path of the construction works is the series of the access tunnel to the powerhouse – excavation in the powerhouse - concrete in the powerhouse – installation of electromechanical equipment – commissioning tests. The construction schedule for the Project is shown below.

However the construction schedule shall be reviewed in the next stage because it is closely related to the site topography, geology and environmental issues.

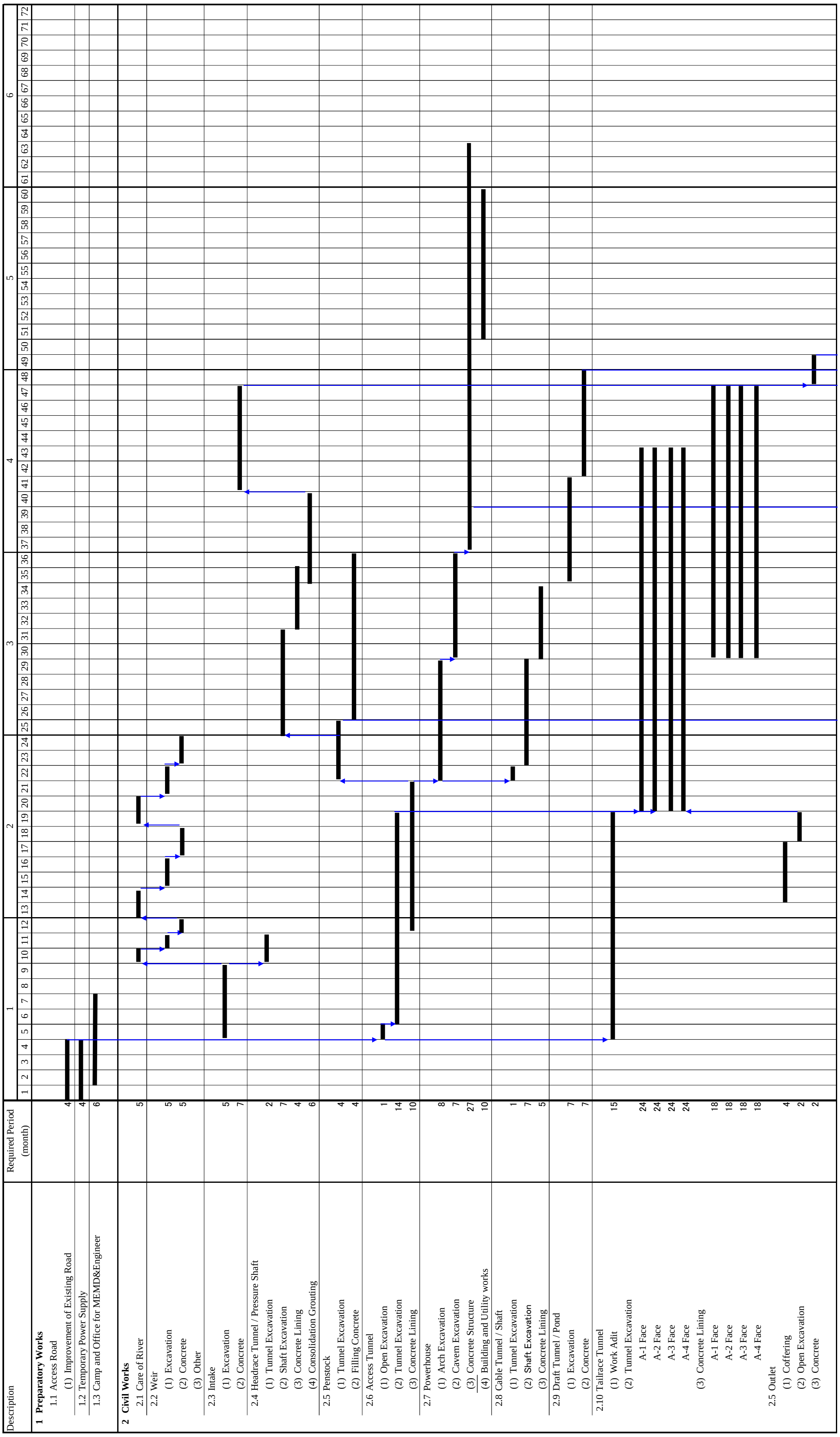


Figure 7.10.10-1 Construction Schedule

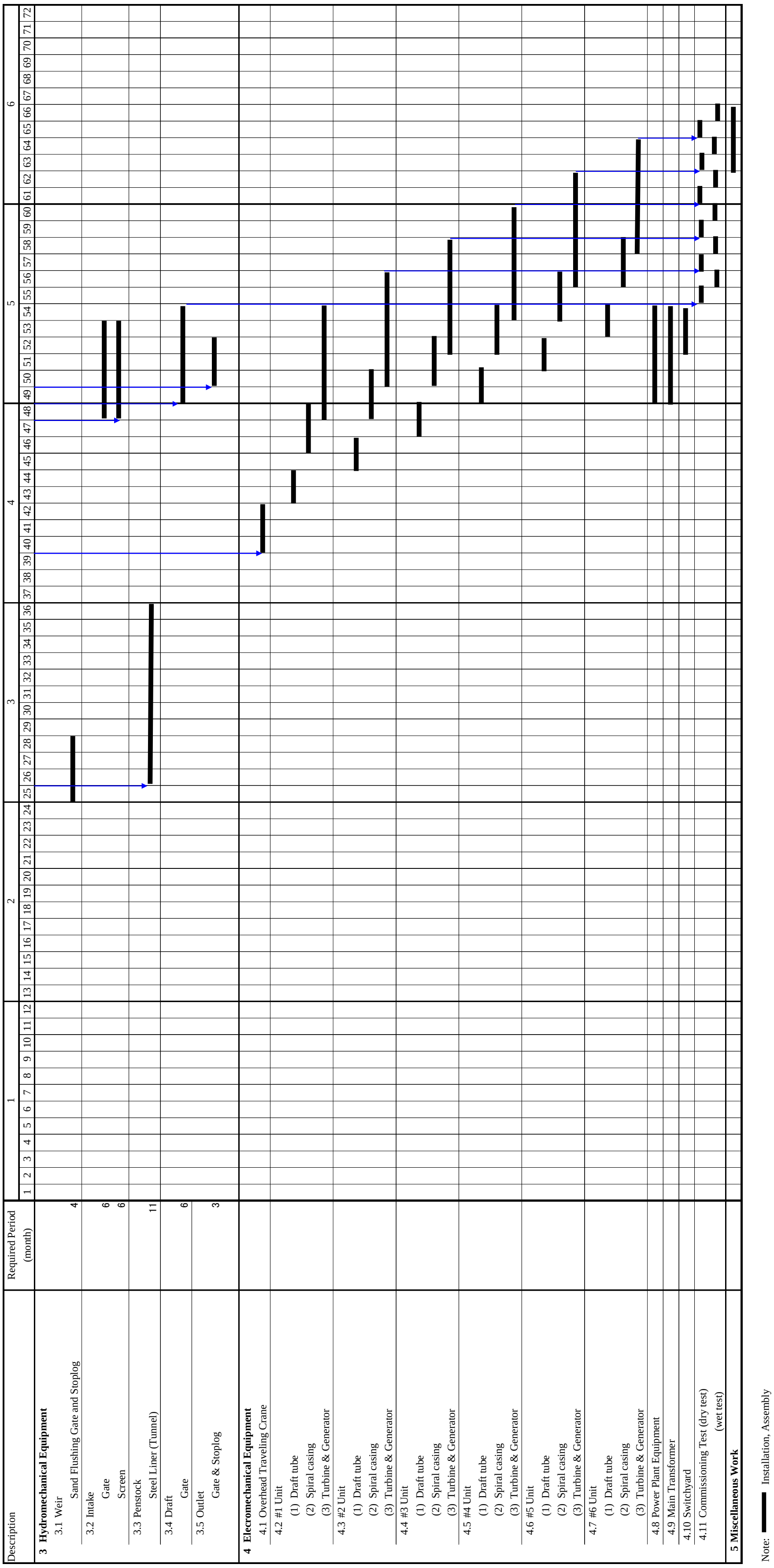


Figure 7.10.10-2 Construction Schedule

7.10.11 Construction Cost

The construction cost has been estimated at US$ basis as of 2010.

(1) There is no resident in the National Park however the compensation cost is estimated at 5MUS$ in consideration of the resettlement under the transmission line outside of park.

(2) Environmental cost accounts for 5 % of civil cost.

(3) The construction costs of civil work are basically calculated in manner of multiplying the unit price by the quantity of each work item. The unit prices of civil work items are estimated using international price of similar hydropower projects such as the existing Kiira powerhouse, the planned Karuma powerhouse, Sondu Miriu powerhouse in Kenya, allowing for cost escalation as of 2010.

(4) The construction costs for electromechanical equipment and hydro mechanical equipment are estimated in consideration of international market prices in 2010.

(5) Transmission cost consists of the line from the site to the planned switchyard in Karuma in consideration of international market prices in 2010.

(6) Administration and engineering fee is estimated at 15 % of the direct cost (total cost of preparatory works, environmental cost, civil works, hydro mechanical equipment, and electromechanical equipment and transmission facility).

(7) Contingency is estimated at 10% of the total cost of preparatory works, environmental cost, civil works, hydro mechanical equipment, electromechanical equipment and transmission facility.

(8) Price escalation and interest during the construction are not included in construction costs.

(9) VAT and customs duties for imported materials or equipment are not included in unit prices and construction costs.

The project cost, however, will not be the same as the cost to be borne by the executing agency for actual project implementation in the future. The estimated project cost may rise because the price escalation and interest during the construction will to be paid by the executing agency. Furthermore, local taxes and customs duties will have to be paid when the construction equipment and materials are imported by the contractor.

By the way the construction costs estimated shall be reviewed later because it is closely related to the site topography and geology which shall be investigated in the next stage.

7.10.12 Components of Construction Costs

The project cost consists of the following items.

(1) Preparatory Works	Land preparation, Compensation for resettlement, Existing road improvement, Access road, Temporary yards, Office and camp facilities for MEMD and Engineer
(2) Environmental Cost	Mitigation Cost, Monitoring Cost (5% of civil work cost)
(3) Civil Works	Weir : Weir body, Closure work Waterway : Intake, Headrace tunnel, Penstock, Draft pond, Tailrace tunnel, Outlet Powerhouse : Excavation, Concrete, Building work etc.
(4) Hydromechanical Equipment	Weir flushing gate, Steel Penstock, Draft gate, Inlet and Outlet gate
(5) Hydroelectric Equipment	Turbine, Generator, Main Transformer, Related auxiliary equipment, Traveling ceiling crane
(6) Transmission Line	Foundation, Steel tower, Electric wire
(7) Administration and Engineering Costs	Administration and engineering fee (15% of direct cost)
(8) Physical Contingency	Unforeseeable events (10% of direct cost)
(9) Interest during construction	Not considered
(10) Customs duties/tariffs	Not considered

7.10.13 Total Construction Cost

The construction cost for 600MW which is estimated on above conditions is described in Table 7.10.13-1.

Table 7.10.13-1 Project Construction Cost

Item	Cost (x10^{3}US$)	Note
1. Preparation and Land acquision	36,030	
(1) Access road	13,500	100x10^{3}US$/km × 135 km
(2) Compensation & Resettlment	5,000	
(3) Camp & Facilities	17,530	(3. Civil work)× 2%
2. Environmental mitigation cost	43,825	(3. Civil work)× 5%
3. Civil work	876,494	
(1) Weir	28,613	
(2) Intake	19,531	
(3) Headrace	21,053	
(4) Penstock	5,060	
(5) Access tunnel	13,018	
(6) Powerhouse	78,520	
(7) Draft Pond	23,712	
(8) Tailrace tunnel	601,861	
(9) Outlet	5,444	
(10) Miscellaneous	79,681	
4. Hydraulic euipment	38,886	
5. Electro-mechanical equipment	255,200	Installed Capacity 610 MW
6. Transmission line	29,000	Ayago-Karuma 58 km
Direct cost	1,279,434	
7. Administration and Engineering service	191,915	Direct cost × 15%
8. Contingency	127,943	Direct cost × 10%
Total cost	**1,599,293**	

7.10.14 Construction Cost for Stage Development

It is preferable that the project is developed step by step corresponding to the actual demand in consideration of financing efficiency. The approximate cost for every 100MW in case of stage construction is shown in Table 7.10.14-1.

The 1st stage for 100MW tends to be more expensive than after 2nd stage because it contains the common facilities such as access roads and tunnels, the weir and the transmission line.

Table 7.10.14-1 Project Construction Cost

(x 1,000US$)

Item	100 MW	200 MW	300 MW	400 MW	500 MW	600 MW
1. Preparation and Land acquision	23,046	25,391	27,736	31,121	33,579	36,030
(1) Access road	13,500	13,500	13,500	13,500	13,500	13,500
(2) Compensation & Resettlment	5,000	5,000	5,000	5,000	5,000	5,000
(3) Camp & Facilities	4,546	6,891	9,236	12,621	15,079	17,530
2. Environmental mitigation cost	11,365	17,227	23,091	31,553	37,697	43,825
3. Civil work	227,306	344,549	461,814	631,069	753,932	876,494
4. Hydraulic euipment	15,747	18,383	21,018	33,615	36,251	38,886
5. Electro-mechanical equipment	42,533	85,067	127,600	170,133	212,667	255,200
6. Transmission line	29,000	29,000	29,000	29,000	29,000	29,000
Direct cost	348,998	519,616	690,258	926,491	1,103,125	1,279,434
7. Administration and Engineering servi	52,350	77,942	103,539	138,974	165,469	191,915
8. Contingency	34,900	51,962	69,026	92,649	110,313	127,943
Total cost	**436,247**	**649,520**	**862,823**	**1,158,114**	**1,378,907**	**1,599,293**
Difference		213,273	213,303	295,291	220,792	220,386

7.10.15 Disbursement Schedule of Stage Development

The commercial operation year based on the power development plan described in Chapter 6 is shown in Table 7.10.15-1 and the annual required funding (disbursement schedule) is shown in Table 7.10.15-2.

In calculating the required funding, the construction period and disbursement schedule are assumed as below.

For 1st 100MW
Construction Term: 5 years
Disbursement Schedule: 1st year 10%, 2nd year 20%, 3rd year 30%, 4th year 30%, 5th year 10%

For 2nd 100MW, 3rd 100MW, 4th 100MW, 5th 100MW, 6th 100MW
Construction Term: 3 years
Disbursement Schedule: 1st year 30%, 2nd year 40%, 3rd year 30%

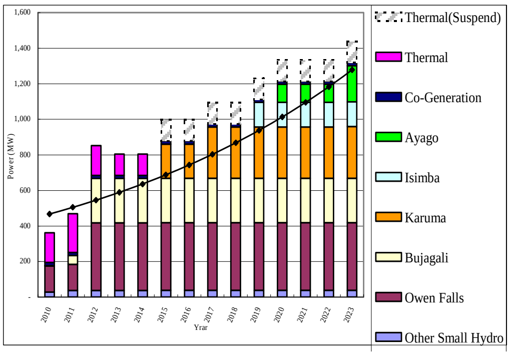
Table 7.10.15-1 Commercial Operation Year

	SCENARIO-Ⅰ (Medium Demand)	SCENARIO-Ⅱ (High Demand)	SCENARIO-Ⅲ (Low Demand)	SCENARIO-Ⅳ (Medium+Export)
1st 100MW	Year 2020	Year 2020	Year 2022	Year 2019
2nd 100MW	Year 2023	Year 2022	Year 2025	Year 2021
3rd 100MW	Year 2024	Year 2023	Year 2026	Year 2023

Table 7.10.15-2 Annual Required Funding (Disbursement Schedule)

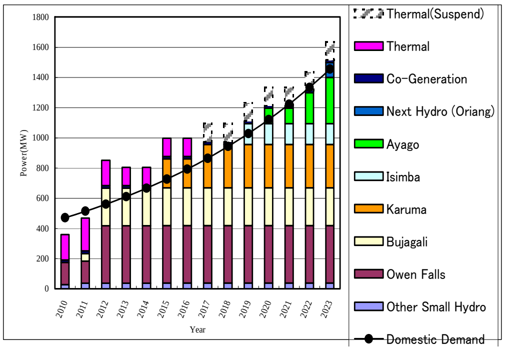
SCENARIO-Ⅰ : Medium Demand Case

year	Installed Capacity (MW)	Construction Cost (x1000US$) 100MW Progress	436,247	200MW Progress	213,273	300MW Progress	213,303	Total
2015		10%	43,625					43,625
2016		20%	87,249					87,249
2017		30%	130,874					130,874
2018		30%	130,874					130,874
2019		10%	43,625					43,625
2020	100			30%	63,982			63,982
2021	100			40%	85,309	30%	63,991	149,300
2022	100			30%	63,982	40%	85,321	149,303
2023	200					30%	63,991	63,991



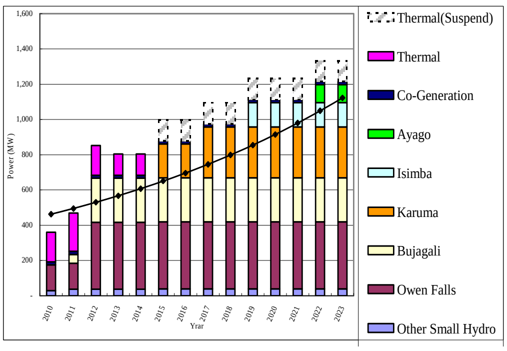
SCENARIO-Ⅱ : High Demand Case

year	Installed Capacity (MW)	Construction Cost (x1000US$) 100MW Progress	436,247	200MW Progress	213,273	300MW Progress	213,303	Total
2015		10%	43,625					43,625
2016		20%	87,249					87,249
2017		30%	130,874					130,874
2018		30%	130,874					130,874
2019		10%	43,625	30%	63,982			107,607
2020	100			40%	85,309	30%	63,991	149,300
2021	100			30%	63,982	40%	85,321	149,303
2022	200					30%	63,991	63,991
2023	300							



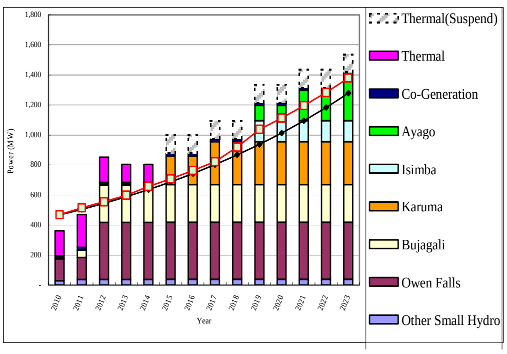
SCENARIO-Ⅲ : Low Demand Case

year	Installed Capacity (MW)	Construction Cost (x1000US$) 100MW Progress	436,247	200MW Progress	213,273	300MW Progress	213,303	Total
2015								
2016								
2017		10%	43,625					43,625
2018		20%	87,249					87,249
2019		30%	130,874					130,874
2020		30%	130,874					130,874
2021		10%	43,625					43,625
2022	100			30%	63,982			63,982
2023	100			40%	85,309	30%	63,991	149,300



SCENARIO-Ⅳ : Medium + Export to Kenya Demand Case

year	Installed Capacity (MW)	Construction Cost (x1000US$) 100MW Progress	436,247	200MW Progress	213,273	300MW Progress	213,303	Total
2014								
2015		10%	43,625					43,625
2016		25%	109,062					109,062
2017		30%	130,874					130,874
2018		30%	130,874	30%	63,982			194,856
2019	50	5%	21,812	40%	85,309			107,121
2020	100			30%	63,982	30%	63,991	127,973
2021	200					40%	85,321	85,321
2022	200					30%	63,991	63,991
2023	300							



7.11 Economic/Financial Evaluation

7.11.1 Economic Evaluation

(1) Methodology

This economic evaluation is to assess Ayago hydropower project from the standpoint of the national economy of Uganda in order to determine whether the Project is worthy of proceeding on to the next stage or feasibility study stage. For that purpose the usually adopted method was used - the comparative method with the alternative power plant with equal capability[4]. Under the supposition that if Ayago hydropower project would not be implemented, a thermal power with equivalent capability to Ayago project would be required, Ayago project will be evaluated with the cost stream of the thermal power as the benefit of Ayago hydropower.

The following evaluation criteria were adopted:

EIRR (economic internal rate of return) > discount rate

NPV (net present value) > 0

B/C (benefit-cost ratio) > 1

The evaluation was made in the time horizon from the start of construction up to the end of service life of civil structures of Ayago hydropower project -50 years. The evaluated scenarios were the following among the hydropower development scenarios discussed in Chapter 6.

Scenario I: Against the medium demand forecast, a total of installed capacity of 300 MW would be commissioned with 100 MW each in 2020, 2023 and 2024.

Scenario IV: Against the medium demand forecast plus power export to Kenya of 50% of firm energy, a total of installed capacity of 300 MW would be commissioned with 100 MW each in 2020, 2023 and 2024.

(2) Assumptions

The following key assumptions were agreed with MEMD to be adopted for the economic evaluation.

1) Alternative thermal power plant

An alternative thermal power plant was established with reference to the gas turbine power at Namanve of Jacobsen. The thermal efficiency was not clear but assumed to be 40%, conservatively higher than usual –which means less benefit– with 20 years of service life.

[4] There are various methods for project benefit evaluation including long-run marginal cost on the supply side and willingness to pay on the consumer’s side. Uganda does not have long-run power development plan or has not realized survey to grasp the willingness to pay. In such a case the usually adopted method is the comparative method with alternative project. It is to be noted that Uganda needs power supply by this project or equivalent others as a part of socio-economic development policy. In such a case, without Ayago project, another project with equivalent capability would be required. The comparative method with alternative adopts the cost of such alternative as benefit.

Table 7.11.1-1 Key Asumptions and for Economic Evaluation

	Station use	Planned outage	Forced outage	Transmission loss	Adjustment factor (kW)	Adjustment factor (kWh)
Ayago	1%	2%	0.5%	2%	-	-
Alternative thermal power	2%	5%	2%	-	1.16*	0.99

* Considering that 7 units of 8 MW gas turbine (56 MW) were installed to keep the guaranteed 50 MW to UETCL, the kW adjustment factor was determined by multiplying the calculated factor of 1.04 by 1.12 to get the adopted adjustment factor of 1.16.

The other assumptions were shown below:
The construction cost of the alternative thermal power: US$580/kW as base case.
The OM cost of the alternative thermal power: 3%/year of the construction cost as fixed cost
US$0.01/kWh as variable cost
The fuel cost of the alternative thermal power: US$0.5/liter of heavy fuel oil (Bunker C)
(equivalent to US$0.11/kWh with 40% of thermal efficiency)

The following assumptions were adopted for Ayago hydropower.
The OM cost: fixed cost only to be assumed at 0.7%/year of the construction cost.
The replacement cost of major equipment such as hydro mechanical and electrical equipment and transmission lines was counted in every 30 years.

2) Other assumptions

Discount rate: 10% as base case[5]

Standard Conversion Factor (SCF): SCF is a coefficient to correct distorted domestic prices. Ayago hydropower project would require most of the equipment and materials to be imported and the share of local currency portion would be small, so SCF was determined at 1, which means that SCF was not applied.

As for Scenario IV, it was assumed that 50% of firm energy would be exported to Kenya, leading to increase in foreign currency earnings, so the corresponding benefit was assessed with export power price. The power price was adopted at US$11.5 cents/kWh as base case considering ERA's electricity tariff regulation which does not allow power export at prices below the average power purchase cost of UETCL, which was US$11.357 cents in 2009 (figure provided by UETCL).

The remaining energy of 50%, which would be to cover the domestic demand, was assessed with the cost of the alternative thermal power as benefit.

[5] The discount rate on the base case was adopted from the average rate of Uganda's treasury bond of 3 months 8.2% and that of one year 12.7%.

(3) Evaluation

1) Scenario I

The following parameters were set as base case, bringing forth the results shown in the table below.

The construction cost of Ayago hydropower 100%= US$862million

The construction cost of the alternative thermal power 100％=US$202 million

The fuel price=US$50 cents

Discount rate=10%

Table 7.11.1-2 Economic Evaluation Result (Scenario I)

Cost Setting			
Ayago Hydropower			
Installed capacity		300	MW
Dependable capacity		300	MW
Firm energy		2,681	GWh
Secondary energy		0	GWh
Construction cost	(100%)	US$ 862,823	thousands
Discount Rate		10%	

Benefit Setting			
Alternative Thermal Power (Gas Turbine)			
Installed capacity		348	MW
Power generation			
for Ayago firm energy		2,654.2	GWh
for Ayago secondary energy		0.0	GWh
Construction cost	(100%)	US$ 201,840	thousands
Fuel price		US$ 0.50	
Export tariff for secondary energy		US$	/kWh

(Unit: US$ in thousands)

No. of years from Construction Start	No. of years from COD	YEAR	Ayago hydropower Construct. Cost	Ayago hydropower O & M Cost	(C) TOTAL COST	Alternative thermal power Firm Energy Constr. Cost	Firm Energy O & M Cost	Firm Energy Fuel Cost	Firm Energy Subtotal	Secondary Energy O & M Cost	Secondary Energy Fuel Cost	Secondary Energy Subtotal	(B) TOTAL BENEFIT	(B) - (C)
1		2015	43,625		43,625							0	0	-43,625
2		2016	87,249		87,249							0	0	-87,249
3		2017	130,874		130,874							0	0	-130,874
4		2018	130,874		130,874								0	-130,874
5		2019	43,625		43,625	40,368			40,368			0	40,368	-3,257
6	1	2020	63,982	1,527	65,509	26,912	5,464	48,869	81,245	0	0	0	81,245	15,736
7	2	2021	149,300	3,054	152,354	26,912	10,938	97,846	135,696	0	0	0	135,696	-16,658
8	3	2022	149,303	3,054	152,357	67,280	10,938	97,846	176,064	0	0	0	176,064	23,707
9	4	2023	63,991	4,547	68,538	40,368	21,867	195,583	257,818	0	0	0	257,818	189,280
10	5	2024		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
11	6	2025		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
12	7	2026		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
13	8	2027		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
14	9	2028		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
15	10	2029		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
16	11	2030		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
17	12	2031		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
18	13	2032		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
19	14	2033		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
20	15	2034		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
21	16	2035		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
22	17	2036		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
23	18	2037		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
24	19	2038		6,040	6,040	26,912	32,597	291,148	350,657	0	0	0	350,657	344,618
25	20	2039		6,040	6,040	40,368	32,597	291,148	364,113	0	0	0	364,113	358,074
26	21	2040		6,040	6,040	26,912	32,597	291,148	350,657	0	0	0	350,657	344,618
27	22	2041		6,040	6,040	67,280	32,597	291,148	391,025	0	0	0	391,025	384,986
28	23	2042		6,040	6,040	40,368	32,597	291,148	364,113	0	0	0	364,113	358,074
29	24	2043		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
30	25	2044		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
31	26	2045		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
32	27	2046		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
33	28	2047		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
34	29	2048	29,603	6,040	35,643		32,597	291,148	323,745	0	0	0	323,745	288,103
35	30	2049	29,603	6,040	35,643		32,597	291,148	323,745	0	0	0	323,745	288,103
36	31	2050		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
37	32	2051	29,603	6,040	35,643		32,597	291,148	323,745	0	0	0	323,745	288,103
38	33	2052	59,206	6,040	65,246		32,597	291,148	323,745	0	0	0	323,745	258,500
39	34	2053	29,603	6,040	35,643		32,597	291,148	323,745	0	0	0	323,745	288,103
40	35	2054		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
41	36	2055		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
42	37	2056		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
43	38	2057		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
44	39	2058		6,040	6,040	26,912	32,597	291,148	350,657	0	0	0	350,657	344,618
45	40	2059		6,040	6,040	40,368	32,597	291,148	364,113	0	0	0	364,113	358,074
46	41	2060		6,040	6,040	26,912	32,597	291,148	350,657	0	0	0	350,657	344,618
47	42	2061		6,040	6,040	67,280	32,597	291,148	391,025	0	0	0	391,025	384,986
48	43	2062		6,040	6,040	40,368	32,597	291,148	364,113	0	0	0	364,113	358,074
49	44	2063		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
50	45	2064		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
51	46	2065		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
52	47	2066		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
53	48	2067		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
54	49	2068		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
55	50	2069		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706
TOTAL			1,040,441	290,010	1,330,451	605,520	1,548,674	13,832,969	15,987,164	0	0	0	15,987,164	14,656,713
Present Value					572,552								1,707,029	
													EIRR	24.36%
													NPV	1,134,478
													B / C	2.98

The base case showed the following results.

Table 7.11.1-3 Economic Evaluation Result and Index (Scenario I, Base case)

Criteria	Evaluation	Index	Jugement
EIRR	24.36%	> 10%	Passed
NPV	US$ 1,134 million	> 0	Passed
B/C	2.98	>1	Passed

The above results led to determine Scenario I to be feasible; and, however, it was only for base case, so a stress test was made with the following parameters to verify the feasibility under severer conditions.

The construction cost of Ayago hydropower=150%

The construction cost of the alternative thermal power=50%

The fuel price=US$25 cents/liter

Discount rate=8%

Table 7.11.1-4 Economic Evaluation Result and Index (Scenario I, Stress Test)

Criteria	Evaluation	Index	Judgement
EIRR	10.65%	> 8%	Passed
NPV	US$ 323million	> 0	Passed
B/C	1.34	>1	Passed

The above results have revealed that Ayago hydropower project is feasible under severe conditions.

Sensitivity analysis was made by varying key parameters to see how the evaluation result changes as shown in the following pages.

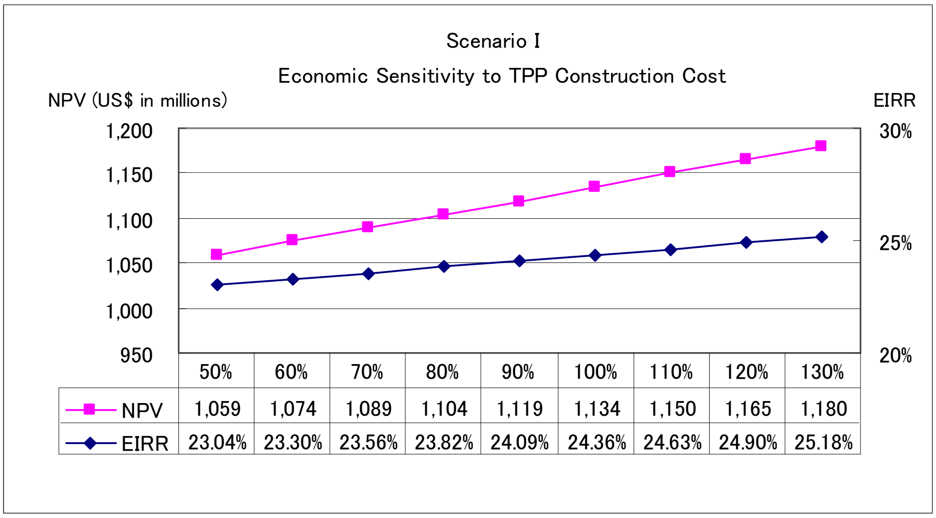
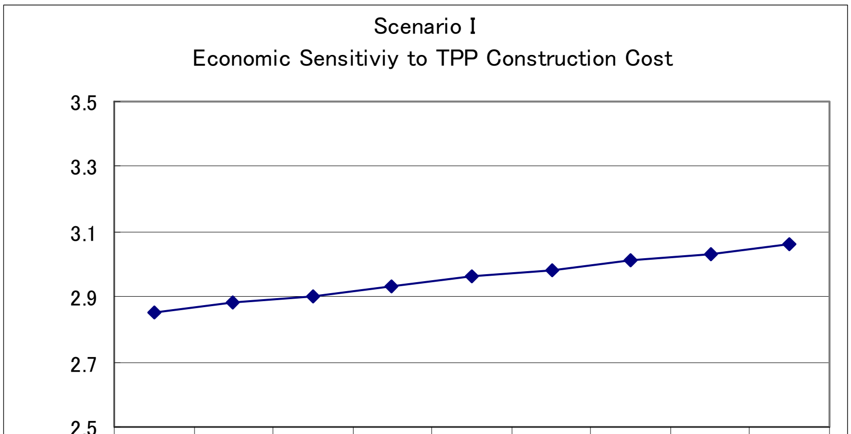
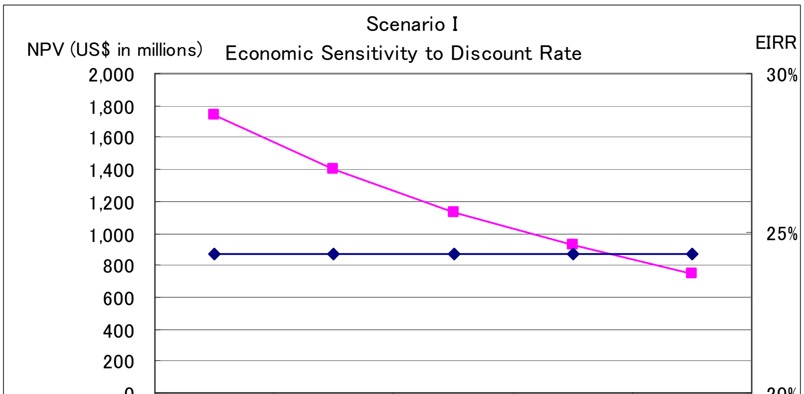


Figure 7.11.1-1 Scenario I Economic Sensitivity to TPP Construction Cost (1)



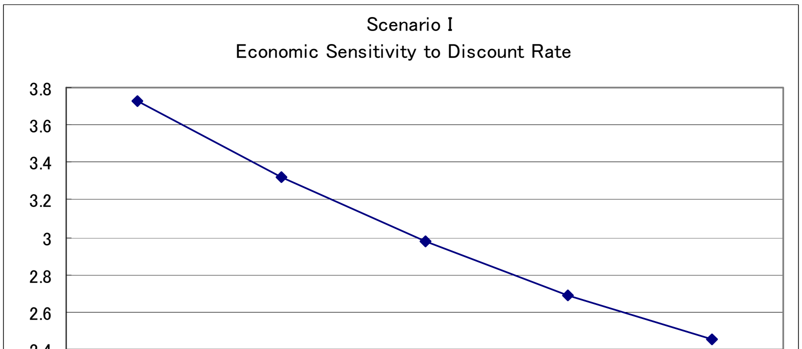
	50%	60%	70%	80%	90%	100%	110%	120%	130%
B/C	2.85	2.88	2.90	2.93	2.96	2.98	3.01	3.03	3.06

Figure 7.11.1-2 Scenario I Economic Sensitivity to TPP Construction Cost (2)



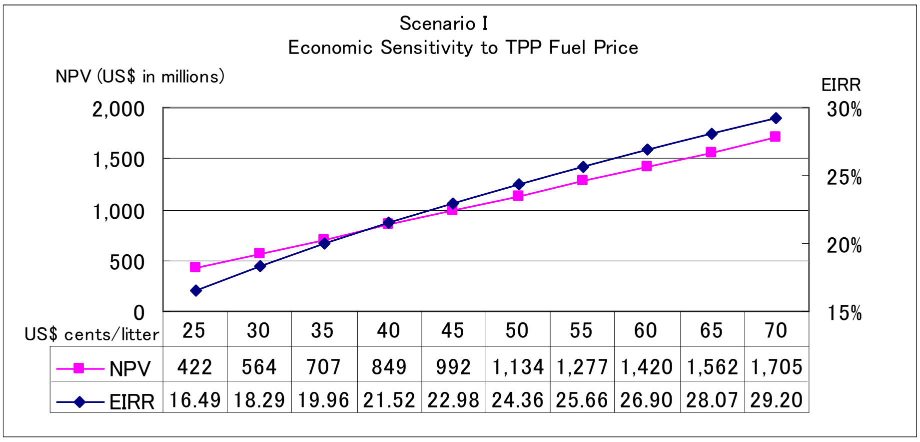
	8%	9%	10%	11%	12%
NPV	1,741	1,402	1,134	921	750
EIRR	24.36%	24.36%	24.36%	24.36%	24.36%

Figure 7.11.1-3 Scenario I Economic Sensitivity to Discount Rate (1)



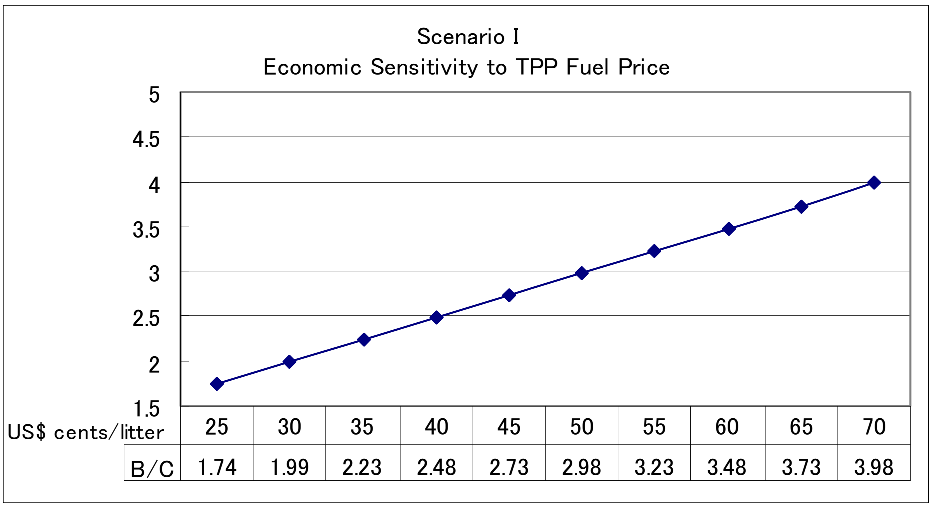
	8%	9%	10%	11%	12%
B/C	3.73	3.32	2.98	2.69	2.45

Figure 7.11.1-4 Scenario I Economic Sensitivity to Discount Rate (2)



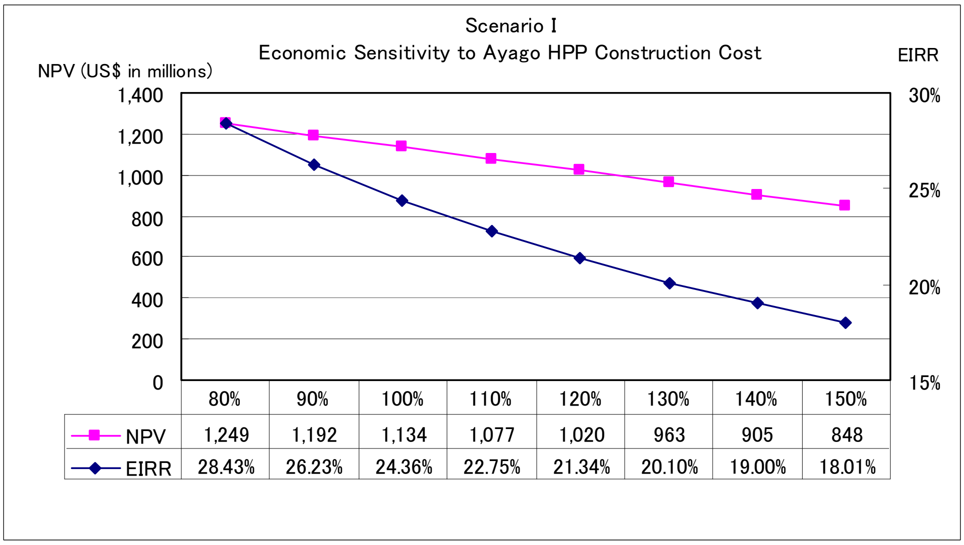
US$ cents/litter	25	30	35	40	45	50	55	60	65	70
NPV	422	564	707	849	992	1,134	1,277	1,420	1,562	1,705
EIRR	16.49	18.29	19.96	21.52	22.98	24.36	25.66	26.90	28.07	29.20

Figure 7.11.1-5 Scenario I Economic Sensitivity to TPP Fuel Price (1)



US$ cents/litter	25	30	35	40	45	50	55	60	65	70
B/C	1.74	1.99	2.23	2.48	2.73	2.98	3.23	3.48	3.73	3.98

Figure 7.11.1-6 Scenario I Economic Sensitivity to TPP Fuel Price (2)



	80%	90%	100%	110%	120%	130%	140%	150%
NPV	1,249	1,192	1,134	1,077	1,020	963	905	848
EIRR	28.43%	26.23%	24.36%	22.75%	21.34%	20.10%	19.00%	18.01%

Figure 7.11.1-7 Scenario I Economic Sensitivity to Ayago HPP Construction Cost (1)

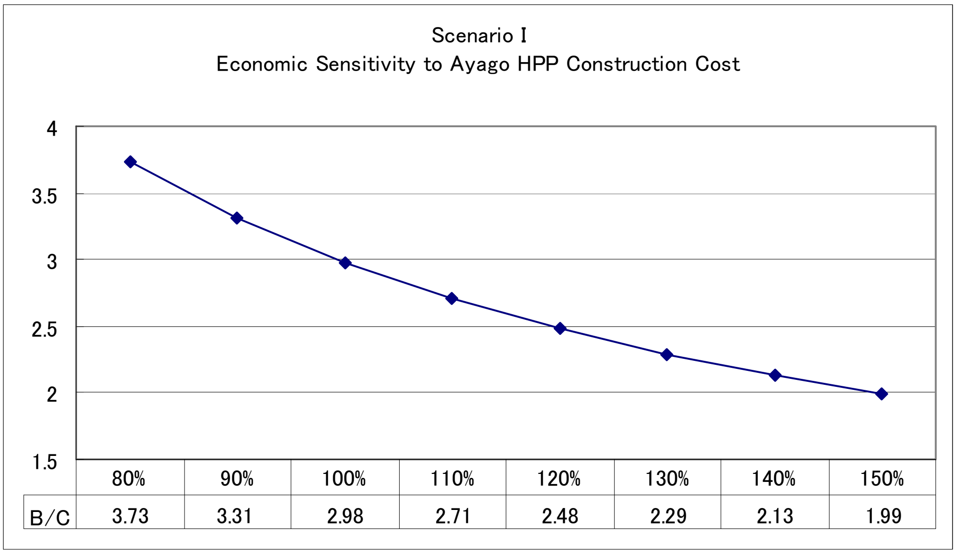


Figure 7.11.1-8 Scenario I Economic Sensitivity to Ayago HPP Construction Cost (2)

2) Scenario IV

The following parameters were set as base case, bringing forth the results shown in the table below.

The construction cost of Ayago hydropower 100%= US$862million

The construction cost of the alternative thermal power 100%=US$202 million

The fuel price=US$50 cents

The export tariff=US$11.5 cents

Discount rate=10%

Table 7.11.1-5 Result of Economic Evaluation (Scenario IV)

Cost Setting		
Ayago Hydropower		
Installed capacity		300 MW
Dependable capacity		300 MW
Firm energy		2,681 GWh
Secondary energy		0 GWh
Construction cost	(100%)	US$ 862,823 thousands
Discount Rate		10%

Benefit Setting		
Alternative Thermal Power (Gas Turbine)		
Installed capacity		348 MW
Power generation		
for Ayago firm energy		2,654.2 GWh
for Ayago secondary energy		0.0 GWh
Construction cost	(100%)	US$ 201,840 thousands
Fuel price		US$ 0.50
Export tariff for firm energy	US$	11.5 cents /kWh

(Unit: US$ in thousands)

No. of years from Construction Start	COD	YEAR	Ayago hydropower Construct. Cost	O & M Cost	(C) TOTAL COST	Alternative thermal power Constr. Cost	Firm Energy O & M Cost	Fuel Cost	Subtotal (B1)	Secondary Energy O & M Cost	Fuel Cost	Subtotal	(B) TOTAL BENEFIT	(B) - (C)	In case of export of firm energy Exported power (GWh)	Export Revenue (B2)	(B) (B1 /2+B2)	(B) - (C)
1		2015	43,625		43,625							0	0	-43,625			0	-43,625
2		2016	109,062		109,062							0	0	-109,062			0	-109,062
3		2017	130,874		130,874							0	0	-130,874			0	-130,874
4		2018	194,856		194,856	40,368							0	-194,856			0	-194,856
5	1	2019	107,121	763	107,885	53,824	2,732	24,434	80,990			0	80,990	-26,894	109	12,552	53,047	-54,838
6	2	2020	127,973	3,054	131,026	40,368	10,938	97,846	149,152	0	0	0	149,152	18,126	437	50,264	124,840	-6,187
7	3	2021	85,321	4,547	89,868	40,368	21,867	195,583	257,818	0	0	0	257,818	167,950	874	100,471	229,380	139,513
8	4	2022	63,991	4,547	68,538	26,912	21,867	195,583	244,362	0	0	0	244,362	175,824	874	100,471	222,652	154,115
9	5	2023		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
10	6	2024		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
11	7	2025		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
12	8	2026		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
13	9	2027		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
14	10	2028		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
15	11	2029		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
16	12	2030		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
17	13	2031		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
18	14	2032		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
19	15	2033		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
20	16	2034		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
21	17	2035		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
22	18	2036		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
23	19	2037		6,040	6,040	40,368	32,597	291,148	364,113	0	0	0	364,113	358,074	1,301	149,564	331,620	325,581
24	20	2038		6,040	6,040	26,912	32,597	291,148	350,657	0	0	0	350,657	344,618	1,301	149,564	324,892	318,853
25	21	2039		6,040	6,040	40,368	32,597	291,148	364,113	0	0	0	364,113	358,074	1,301	149,564	331,620	325,581
26	22	2040		6,040	6,040	26,912	32,597	291,148	350,657	0	0	0	350,657	344,618	1,301	149,564	324,892	318,853
27	23	2041		6,040	6,040	40,368	32,597	291,148	364,113	0	0	0	364,113	358,074	1,301	149,564	331,620	325,581
28	24	2042		6,040	6,040	26,912	32,597	291,148	350,657	0	0	0	350,657	344,618	1,301	149,564	324,892	318,853
29	25	2043		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
30	26	2044		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
31	27	2045		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
32	28	2046		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
33	29	2047	29,603	6,040	35,643		32,597	291,148	323,745	0	0	0	323,745	288,103	1,301	149,564	311,436	275,794
34	30	2048	29,603	6,040	35,643		32,597	291,148	323,745	0	0	0	323,745	288,103	1,301	149,564	311,436	275,794
35	31	2049	29,603	6,040	35,643		32,597	291,148	323,745	0	0	0	323,745	288,103	1,301	149,564	311,436	275,794
36	32	2050	29,603	6,040	35,643		32,597	291,148	323,745	0	0	0	323,745	288,103	1,301	149,564	311,436	275,794
37	33	2051	29,603	6,040	35,643		32,597	291,148	323,745	0	0	0	323,745	288,103	1,301	149,564	311,436	275,794
38	34	2052	29,603	6,040	35,643		32,597	291,148	323,745	0	0	0	323,745	288,103	1,301	149,564	311,436	275,794
39	35	2053		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
40	36	2054		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
41	37	2055		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
42	38	2056		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
43	39	2057		6,040	6,040	40,368	32,597	291,148	364,113	0	0	0	364,113	358,074	1,301	149,564	331,620	325,581
44	40	2058		6,040	6,040	26,912	32,597	291,148	350,657	0	0	0	350,657	344,618	1,301	149,564	324,892	318,853
45	41	2059		6,040	6,040	40,368	32,597	291,148	364,113	0	0	0	364,113	358,074	1,301	149,564	331,620	325,581
46	42	2060		6,040	6,040	26,912	32,597	291,148	350,657	0	0	0	350,657	344,618	1,301	149,564	324,892	318,853
47	43	2061		6,040	6,040	40,368	32,597	291,148	364,113	0	0	0	364,113	358,074	1,301	149,564	331,620	325,581
48	44	2062		6,040	6,040	26,912	32,597	291,148	350,657	0	0	0	350,657	344,618	1,301	149,564	324,892	318,853
49	45	2063		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
50	46	2064		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
51	47	2065		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
52	48	2066		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
53	49	2067		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
54	50	2068		6,040	6,040		32,597	291,148	323,745	0	0	0	323,745	317,706	1,301	149,564	311,436	305,397
TOTAL			1,040,441	290,739	1,331,180	605,520	1,554,138	13,881,838	16,028,295	0	0	0	16,028,295	14,697,115	62,119	7,143,684	15,157,832	13,826,652
Present Value					614,179								1,893,110			1,205,859	1,770,173	
													EIRR	26.22%			**EIRR**	24.44%
													NPV	1,278,930			**NPV**	1,155,994
													B / C	3.08			**B / C**	2.88

The base case showed the following results.

Table 7.11.1-6 Economic Evaluation Result and Index (Scenario IV, Base case)

Criteria	Evaluation	Index	Jugement
EIRR	24.44%	> 10%	Passed
NPV	US$ 1,156 million	> 0	Passed
B/C	2.88	>1	Passed

The above results led to determine Scenario IV to be feasible; and, however, it was only for base case, so a stress test was made with the following parameters to verify the feasibility under severer conditions.

The construction cost of Ayago hydropower=150%

The construction cost of the alternative thermal power=50%

The fuel price=US$25 cents/liter

The export tariff=US%6 cents

Discount rate=10%

Table 7.11.1-7 Economic Evaluation Result and Index (Scenario IV, Stress Test)

Criteria	Evaluation	Index	Judgement
EIRR	10.19%	> 10%	Passed
NPV	US$ 18million	> 0	Passed
B/C	1.02	>1	Passed

The above results have revealed that Ayago hydropower project is feasible under severe conditions.

Sensitivity analysis was made by varying key parameters to see how the evaluation result changes as shown in the following pages.

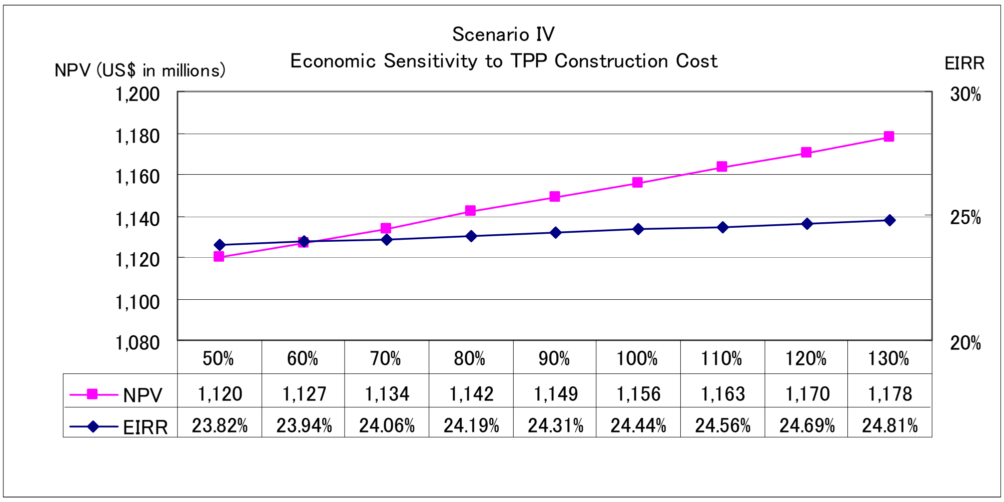


Figure 7.11.1-9 Scenario IV Economic Sensitivity to TPP Construction Cost (1)

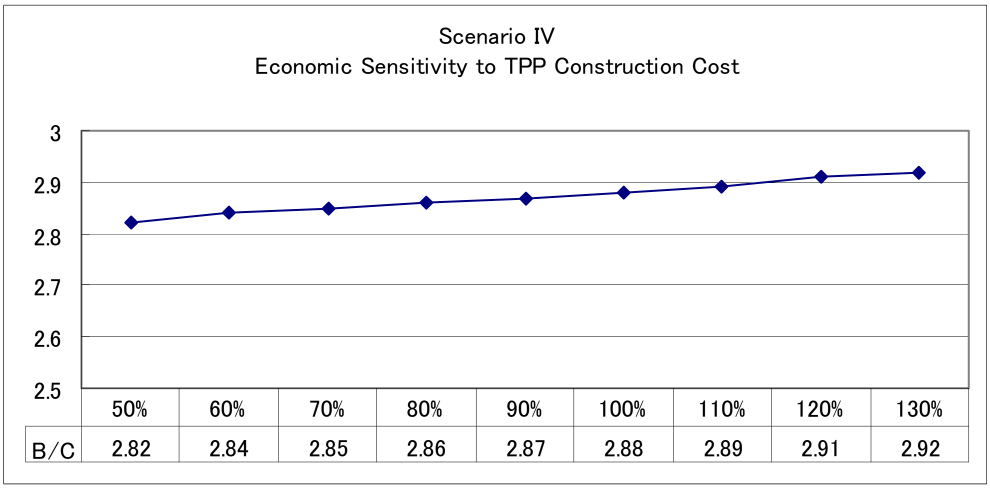


Figure 7.11.1-10 Scenario IV Economic Sensitivity to TPP Construction Cost (2)

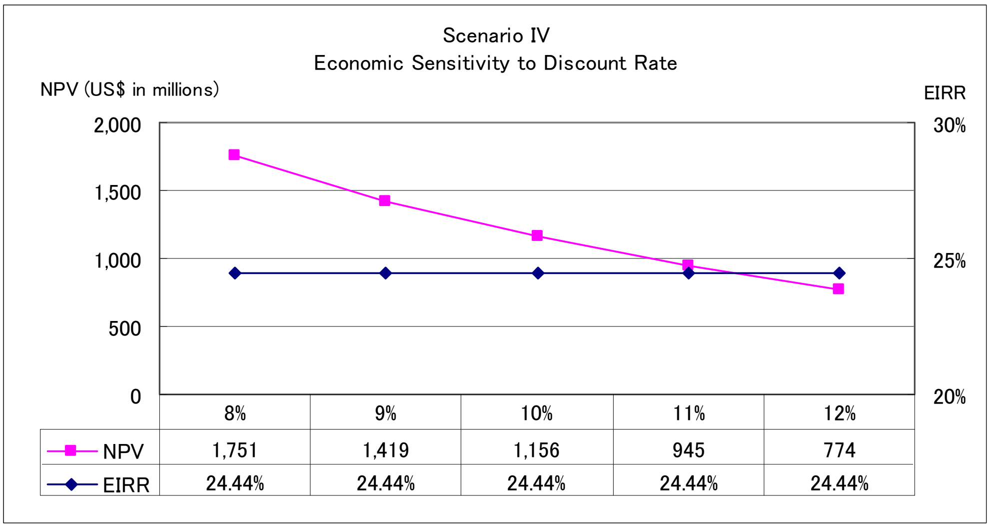


Figure 7.11.1-11 Scenario IV Economic Sensitivity to Discount Rate (1)

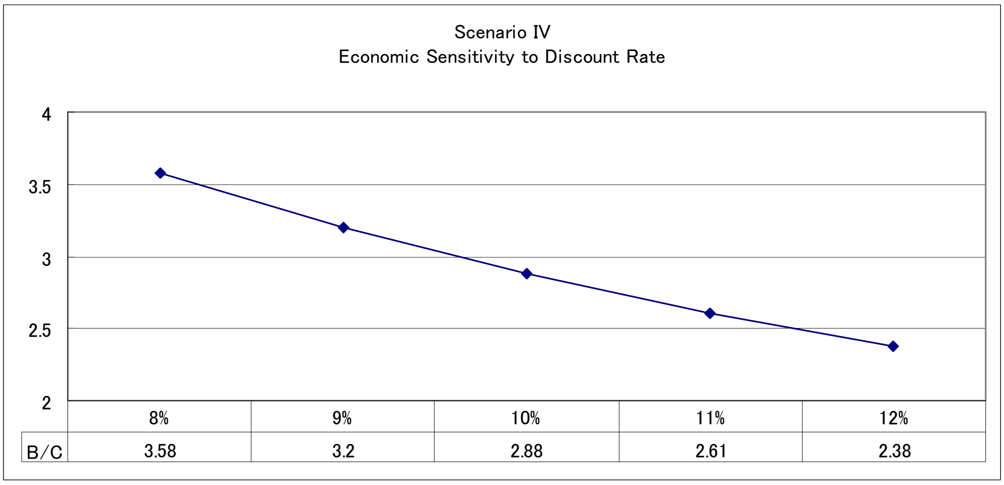


Figure 7.11.1-12 Scenario IV Economic Sensitivity to Discount Rate (2)

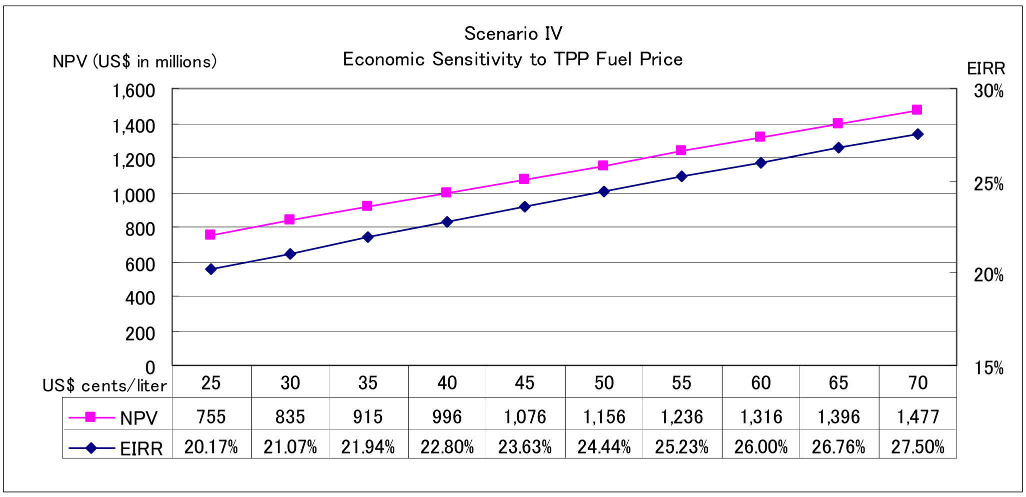
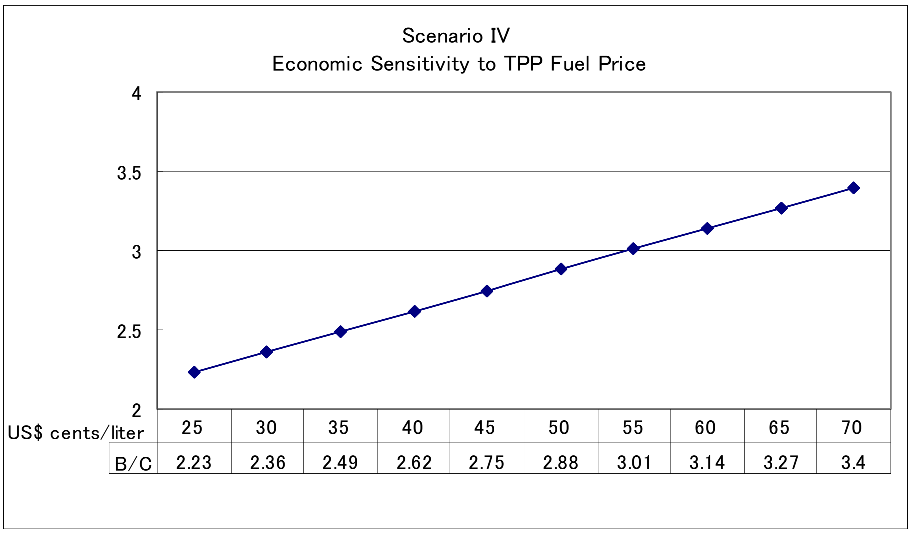
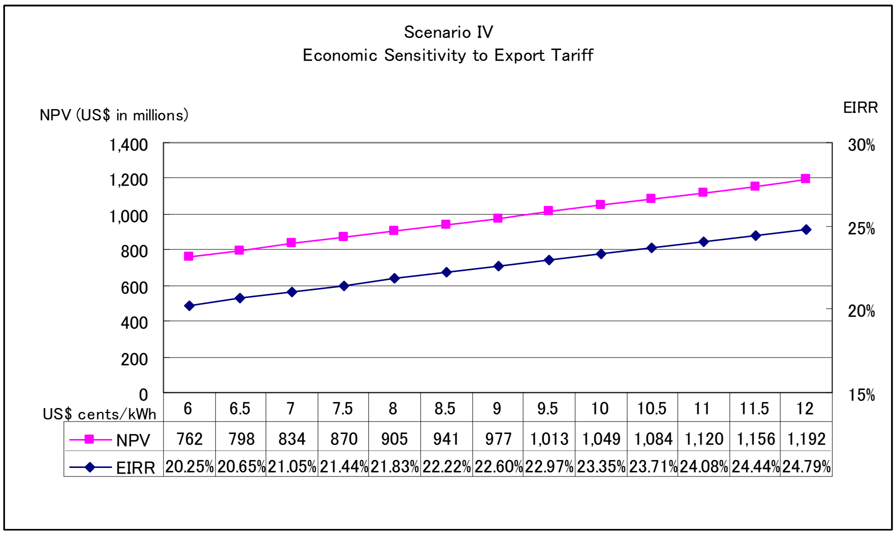


Figure 7.11.1-13 Scenario IV Economic Sensitivity to TPP Fuel Price (1)



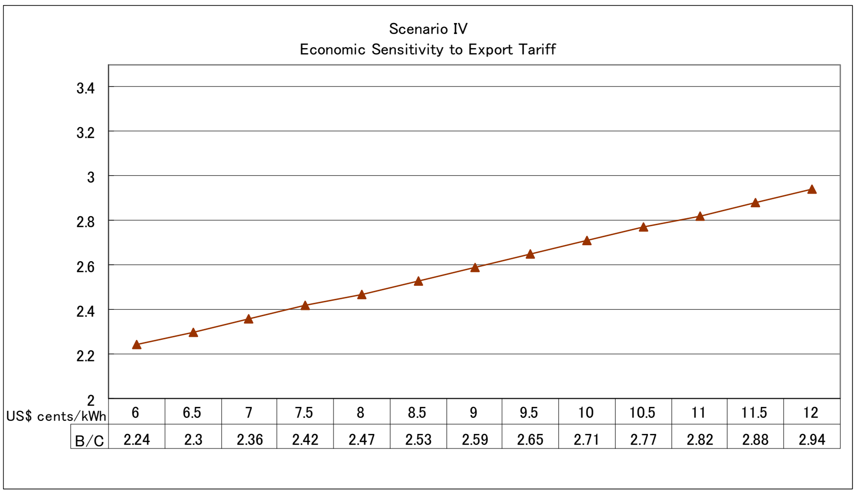
US$ cents/liter	25	30	35	40	45	50	55	60	65	70
B/C	2.23	2.36	2.49	2.62	2.75	2.88	3.01	3.14	3.27	3.4

Figure 7.11.1-14 Scenario IV Economic Sensitivity to TPP Fuel Price (2)



US$ cents/kWh	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
NPV	762	798	834	870	905	941	977	1,013	1,049	1,084	1,120	1,156	1,192
EIRR	20.25%	20.65%	21.05%	21.44%	21.83%	22.22%	22.60%	22.97%	23.35%	23.71%	24.08%	24.44%	24.79%

Figure 7.11.1-15 Scenario IV Economic Sensitivity to Export Tariff (1)



US$ cents/kWh	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
B/C	2.24	2.3	2.36	2.42	2.47	2.53	2.59	2.65	2.71	2.77	2.82	2.88	2.94

Figure 7.11.1-16 Scenario IV Economic Sensitivity to Export Tariff (2)

7.11.2 Financial Evaluation

(1) Methodology

This financial evaluation is aimed to evaluate the Ayago hydropower project financially for purposes of assessing the profitability of the project. The benefit was assumed to be power price to UETCL.

The following evaluation criteria were adopted:

FIRR (financial internal rate of return) > discount rate

NPV (net present value) > 0

B/C (benefit-cost ratio) > 1

The evaluation was made in the time horizon from the start of construction up to the end of service life of civil structures of Ayago hydropower project -50 years. The evaluated scenarios were the following among the hydropower development scenarios discussed in Chapter 6.

Scenario I: Against the medium demand forecast, a total of installed capacity of 300 MW would be commissioned with 100 MW each in 2020, 2023 and 2024.

Scenario IV: Against the medium demand forecast plus power export to Kenya of 50% of firm energy, a total of installed capacity of 300 MW would be commissioned with 100 MW each in 2020, 2023 and 2024.

(2) Assumptions

The following key assumptions were adopted for the financial evaluation.

Power price: US$6 cents/kWh

The OM cost of Ayago hydropower: fixed cost only to be assumed at 0.7%/year of the construction cost.

The replacement cost of major equipment such as hydromechanical and electrical equipment and transmission lines was counted in every 30 years.

Discount rate: 10% as base case

As for Scenario IV, it was assumed that 50% of firm energy would be exported to Kenya, leading to increase in foreign currency earnings, so the corresponding benefit was assessed with export power price. The power price was adopted at US$11.5 cents/kWh as base case considering ERA's electricity tariff regulation which does not allow power export at prices below the average power purchase cost of UETCL, which was US$11.357 cents in 2009 (figure provided by UETCL).

The remaining energy of 50%, which would be to cover the domestic demand, was assessed with the cost of the alternative thermal power as benefit.

(3) Evaluation

1) Scenario I

The following parameters were set as base case, bringing forth the results shown in the table below.

The construction cost of Ayago hydropower 100%= US$862million

The power price=US$6 cents/kWh

Discount rate=10%

Table 7.11.2-1 Financial Evaluation Result (Scenario I)

Cost Setting		
Ayago Hydropower		
Installed capacity		300 MW
Dependable capacity		300
Salable firm energy		2,601.1 GWh
Salable secondary energy		0.0 GWh
Construction cost	(100%)	US$ 862,823 thousands

Benefit Setting		
Power Tariff		
Firm energy	US$	60 /MWh
Firm export	US$	115 /MWh
Secondary energ	US$	0 /MWh

Discount Rate	10%

(Unit: US$ in thousands)

No. of years from Construction Start	No. of years from COD	YEAR	Cost: Construct. Cost	Cost: O & M Cost	Cost: (C) TOTAL COST	Sales: Firm Energy Salable Energy (GWh)	Sales: Firm Energy Sales Revenue	Sales: Secondary Energy Salable Energy (GWh)	Sales: Secondary Energy Sales Revenue	(B) TOTAL BENEFIT	(B) - (C)
1		2015	43,625		43,625					0	-43,625
2		2016	87,249		87,249					0	-87,249
3		2017	130,874		130,874					0	-130,874
4		2018	130,874		130,874					0	-130,874
5		2019	43,625		43,625					0	-43,625
6	1	2020	63,982	1,527	65,509	437	26,195			26,195	-39,313
7	2	2021	149,300	3,054	152,354	874	52,449			52,449	-99,905
8	3	2022	149,303	3,054	152,357	874	52,449			52,449	-99,908
9	4	2023	63,991	4,547	68,538	1,747	104,840			104,840	36,302
10	5	2024		6,040	6,040	2,601	156,066			156,066	150,027
11	6	2025		6,040	6,040	2,601	156,066			156,066	150,027
12	7	2026		6,040	6,040	2,601	156,066			156,066	150,027
13	8	2027		6,040	6,040	2,601	156,066			156,066	150,027
14	9	2028		6,040	6,040	2,601	156,066			156,066	150,027
15	10	2029		6,040	6,040	2,601	156,066			156,066	150,027
16	11	2030		6,040	6,040	2,601	156,066			156,066	150,027
17	12	2031		6,040	6,040	2,601	156,066			156,066	150,027
18	13	2032		6,040	6,040	2,601	156,066			156,066	150,027
19	14	2033		6,040	6,040	2,601	156,066			156,066	150,027
20	15	2034		6,040	6,040	2,601	156,066			156,066	150,027
21	16	2035		6,040	6,040	2,601	156,066			156,066	150,027
22	17	2036		6,040	6,040	2,601	156,066			156,066	150,027
23	18	2037		6,040	6,040	2,601	156,066			156,066	150,027
24	19	2038		6,040	6,040	2,601	156,066			156,066	150,027
25	20	2039		6,040	6,040	2,601	156,066			156,066	150,027
26	21	2040		6,040	6,040	2,601	156,066			156,066	150,027
27	22	2041		6,040	6,040	2,601	156,066			156,066	150,027
28	23	2042		6,040	6,040	2,601	156,066			156,066	150,027
29	24	2043		6,040	6,040	2,601	156,066			156,066	150,027
30	25	2044		6,040	6,040	2,601	156,066			156,066	150,027
31	26	2045		6,040	6,040	2,601	156,066			156,066	150,027
32	27	2046		6,040	6,040	2,601	156,066			156,066	150,027
33	28	2047		6,040	6,040	2,601	156,066			156,066	150,027
34	29	2048	29,603	6,040	35,643	2,601	156,066			156,066	120,424
35	30	2049	29,603	6,040	35,643	2,601	156,066			156,066	120,424
36	31	2050		6,040	6,040	2,601	156,066			156,066	150,027
37	32	2051	29,603	6,040	35,643	2,601	156,066			156,066	120,424
38	33	2052	59,206	6,040	65,246	2,601	156,066			156,066	90,821
39	34	2053	29,603	6,040	35,643	2,601	156,066			156,066	120,424
40	35	2054		6,040	6,040	2,601	156,066			156,066	150,027
41	36	2055		6,040	6,040	2,601	156,066			156,066	150,027
42	37	2056		6,040	6,040	2,601	156,066			156,066	150,027
43	38	2057		6,040	6,040	2,601	156,066			156,066	150,027
44	39	2058		6,040	6,040	2,601	156,066			156,066	150,027
45	40	2059		6,040	6,040	2,601	156,066			156,066	150,027
46	41	2060		6,040	6,040	2,601	156,066			156,066	150,027
47	42	2061		6,040	6,040	2,601	156,066			156,066	150,027
48	43	2062		6,040	6,040	2,601	156,066			156,066	150,027
49	44	2063		6,040	6,040	2,601	156,066			156,066	150,027
50	45	2064		6,040	6,040	2,601	156,066			156,066	150,027
51	46	2065		6,040	6,040	2,601	156,066			156,066	150,027
52	47	2066		6,040	6,040	2,601	156,066			156,066	150,027
53	48	2067		6,040	6,040	2,601	156,066			156,066	150,027
54	49	2068		6,040	6,040	2,601	156,066			156,066	150,027
55	50	2069		6,040	6,040	2,601	156,066			156,066	150,027
TOTAL			1,040,441	290,010	1,330,451	123,583	7,414,986	0	0	7,414,986	6,084,536
Present Value					572,552					764,250	
										FIRR	12.83%
										NPV	191,699
										B / C	1.33

The base case showed the following results.

Table 7.11.2-2 Financial Evaluation Result and Index (Scenario I, Base Case)

Criteria	Evaluation	Index	Jugement
FIRR	12.83%	> 10%	Passed
NPV	US$ 192 million	> 0	Passed
B/C	1.33	>1	Passed

The above results led to determine Scenario I to be financially sound; and, however, it was only for base case, so a stress test was made with the following parameters to verify the financial soundness under severer conditions.

The construction cost of Ayago hydropower=120%

The power price=US$5.5 cents/kWh

Discount rate=10%

Table 7.11.2-3 Financial Evaluation Result and Index (Scenario I, Stress Test)

Criteria	Evaluation	Index	Judgement
FIRR	10.18%	> 10%	Passed
NPV	US$ 14million	> 0	Passed
B/C	1.02	>1	Passed

The above results have revealed that Ayago hydropower project is financially sound under severe conditions. Severer conditions than the above would impair the financial soundness, so that some measures such as hike in power price would be necessary.

Sensitivity analysis was made by varying key parameters to see how the evaluation result changes as shown in the following pages.

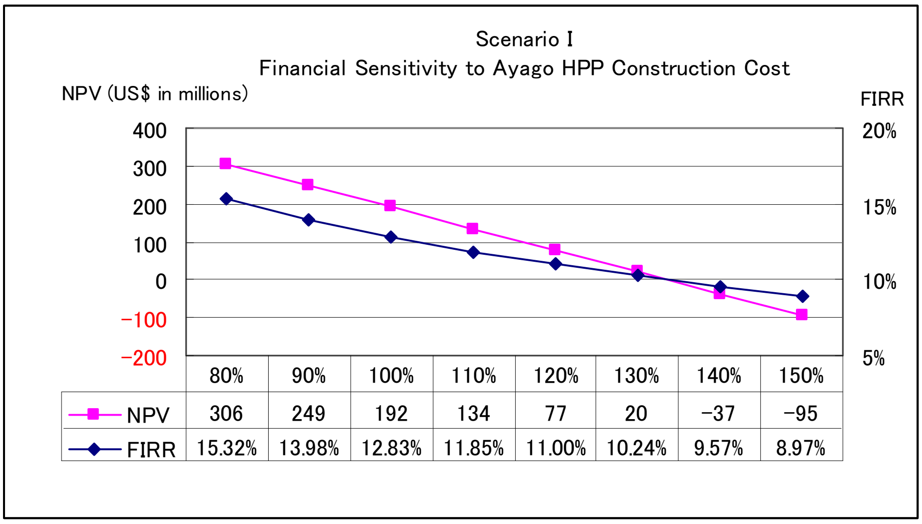


Figure 7.11.2-1 Scenario I Financial Sensitivity to Ayago HPP Construction Cost (1)

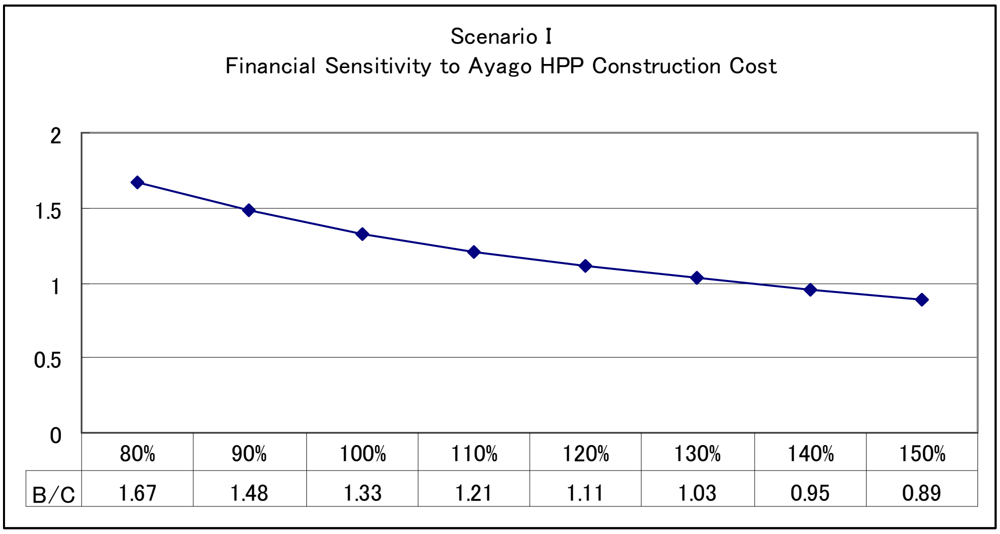


Figure 7.11.2-2 Scenario I Financial Sensitivity to Ayago HPP Construction Cost (2)

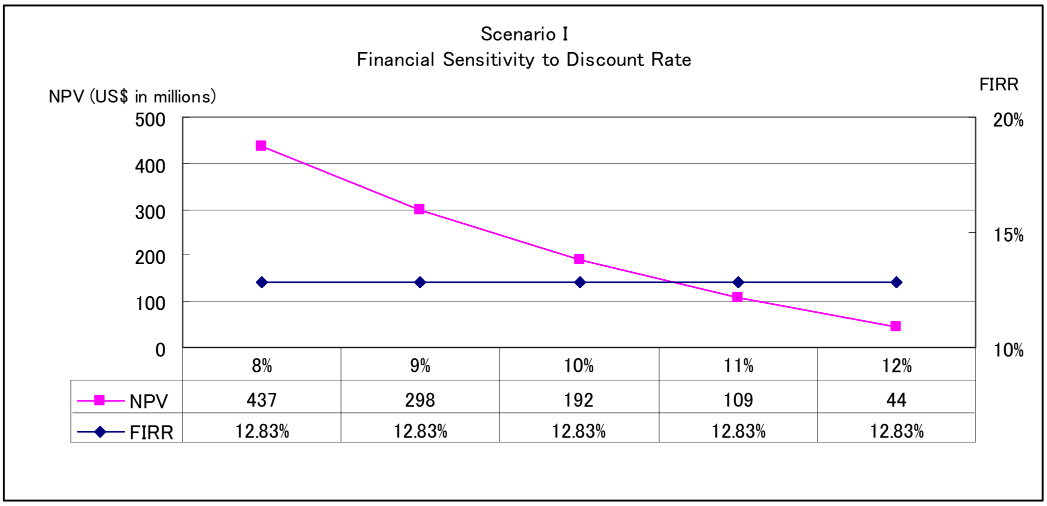


Figure 7.11.2-3 Scenario I Financial Sensitivity to Discount Rate (1)

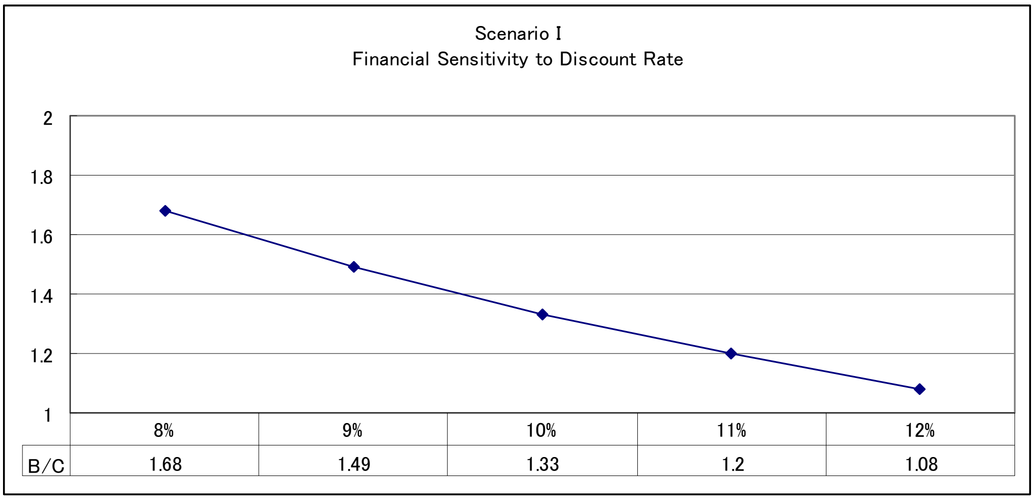
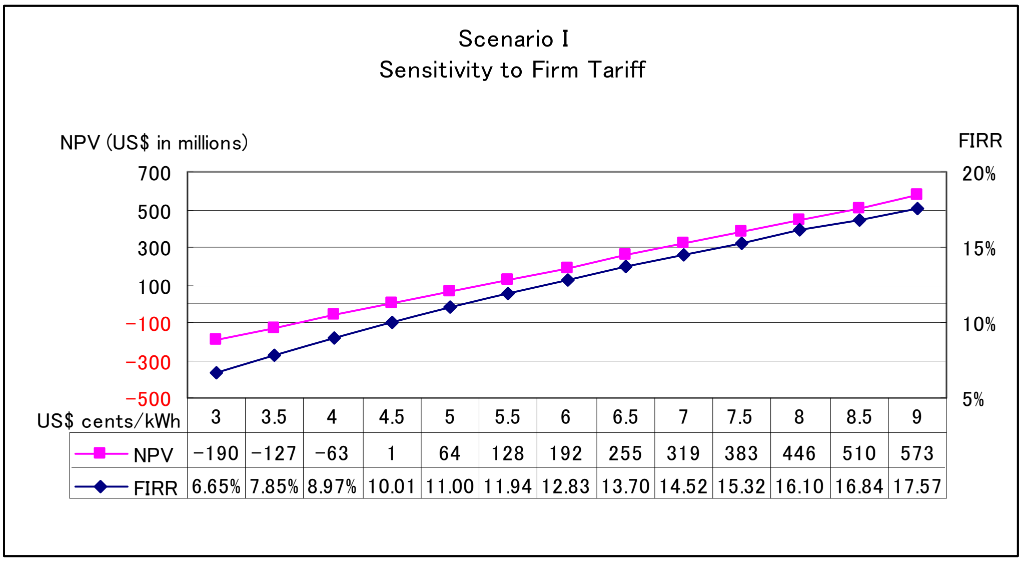
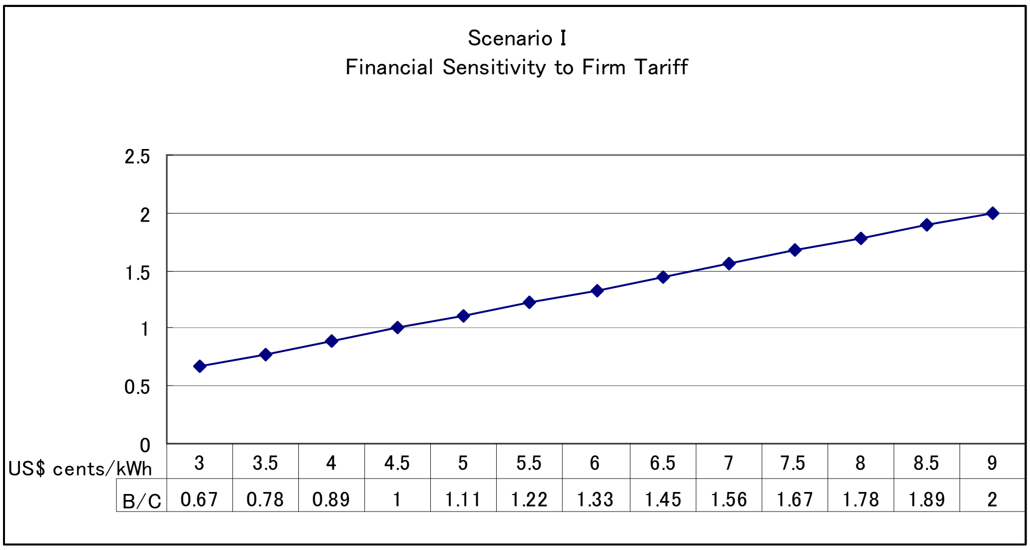


Figure 7.11.2-4 Scenario I Financial Sensitivity to Discount Rate (2)



US$ cents/kWh	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
NPV	−190	−127	−63	1	64	128	192	255	319	383	446	510	573
FIRR	6.65%	7.85%	8.97%	10.01	11.00	11.94	12.83	13.70	14.52	15.32	16.10	16.84	17.57

Figure 7.11.2-5 Scenario I Sensitivity to Firm Tariff (1)



US$ cents/kWh	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
B/C	0.67	0.78	0.89	1	1.11	1.22	1.33	1.45	1.56	1.67	1.78	1.89	2

Figure 7.11.2-6 Scenario I Sensitivity to Firm Tariff (2)

3) Scenario IV

The following parameters were set as base case, bringing forth the results shown in the table below.

The construction cost of Ayago hydropower 100%= US$862million

The power price=US$6 cents/kWh

The export price=US$11.5 cents

Discount rate=10%

Table 7.11.2-4 Financial Evaluation Result (Scenario IV)

Cost Setting			
Ayago Hydropower			
Installed capacity		300	MW
Dependable capacity		300	MW
Salable firm energy		2,601.1	GWh
Salable secondary energy		0.0	GWh
Construction cost	(100%)	US$ 862,823	thousands

Benefit Setting			
Power Tariff			
Firm energy	US$	60	/MWh
Firm export	US$	115	/MWh
Secondary energ	US$	0	/MWh

Discount Rate	10%

(Unit: US$ in thousands)

No. of years from			Cost			Sales					
					(C)	Firm energy for domestic demand		Firm energy for export		(B)	(B) - (C)
Construction Start	COD	YEAR	Construct. Cost	O & M Cost	TOTAL COST	Salable Energy (GWh)	Sales Revenue	Salable Energy (GWh)	Sales Revenue	TOTAL BENEFIT	
1		2015	43,625		43,625					0	-43,625
2		2016	109,062		109,062					0	-109,062
3		2017	130,874		130,874					0	-130,874
4		2018	194,856		194,856					0	-194,856
5	1	2019	107,121	763	107,885	109	6,549	109	12,552	19,101	-88,784
6	2	2020	127,973	3,054	131,026	437	26,225	437	50,264	76,488	-54,538
7	3	2021	85,321	4,547	89,868	874	52,420	874	100,471	152,891	63,024
8	4	2022	63,991	4,547	68,538	874	52,420	874	100,471	152,891	84,354
9	5	2023		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
10	6	2024		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
11	7	2025		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
12	8	2026		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
13	9	2027		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
14	10	2028		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
15	11	2029		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
16	12	2030		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
17	13	2031		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
18	14	2032		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
19	15	2033		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
20	16	2034		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
21	17	2035		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
22	18	2036		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
23	19	2037		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
24	20	2038		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
25	21	2039		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
26	22	2040		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
27	23	2041		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
28	24	2042		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
29	25	2043		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
30	26	2044		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
31	27	2045		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
32	28	2046		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
33	29	2047	29,603	6,040	35,643	1,301	78,033	1,301	149,564	227,597	191,954
34	30	2048	29,603	6,040	35,643	1,301	78,033	1,301	149,564	227,597	191,954
35	31	2049	29,603	6,040	35,643	1,301	78,033	1,301	149,564	227,597	191,954
36	32	2050	29,603	6,040	35,643	1,301	78,033	1,301	149,564	227,597	191,954
37	33	2051	29,603	6,040	35,643	1,301	78,033	1,301	149,564	227,597	191,954
38	34	2052	29,603	6,040	35,643	1,301	78,033	1,301	149,564	227,597	191,954
39	35	2053		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
40	36	2054		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
41	37	2055		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
42	38	2056		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
43	39	2057		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
44	40	2058		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
45	41	2059		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
46	42	2060		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
47	43	2061		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
48	44	2062		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
49	45	2063		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
50	46	2064		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
51	47	2065		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
52	48	2066		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
53	49	2067		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
54	50	2068		6,040	6,040	1,301	78,033	1,301	149,564	227,597	221,557
T O T A L			1,040,441	290,739	1,331,180	62,010	3,720,591	62,010	7,131,133	10,870,824	9,539,644
Present Value					614,179					1,253,332	
										FIRR	18.46%
										NPV	639,152
										B / C	2.04

The base case showed the following results.

Table 7.11.2-5 Financial Evaluation Result and Index (Scenario IV, Base Case)

Criteria	Evaluation	Index	Jugement
FIRR	18.46%	> 10%	Passed
NPV	US$ 639 million	> 0	Passed
B/C	2.04	>1	Passed

The above results led to determine Scenario IV to be financially sound; and, however, it was only for base case, so a stress test was made with the following parameters to verify the financial soundness under severer conditions.

The construction cost of Ayago hydropower=120%

The power price=US$4.5 cents/kWh

The export price=US$6 cents/kWh

Discount rate=10%

Table 7.11.2-6 Financial Evaluation Result and Index (Scenario IV, Stress Test)

Criteria	Evaluation	Index	Judgement
FIRR	10.19%	> 10%	Passed
NPV	US$ 15million	> 0	Passed
B/C	1.02	>1	Passed

The above results have revealed that Ayago hydropower project is financially sound under severe conditions. Severer conditions than the above would impair the financial soundness, so that some measures such as hike in power price or export price would be necessary.

Sensitivity analysis was made by varying key parameters to see how the evaluation result changes as shown in the following pages.

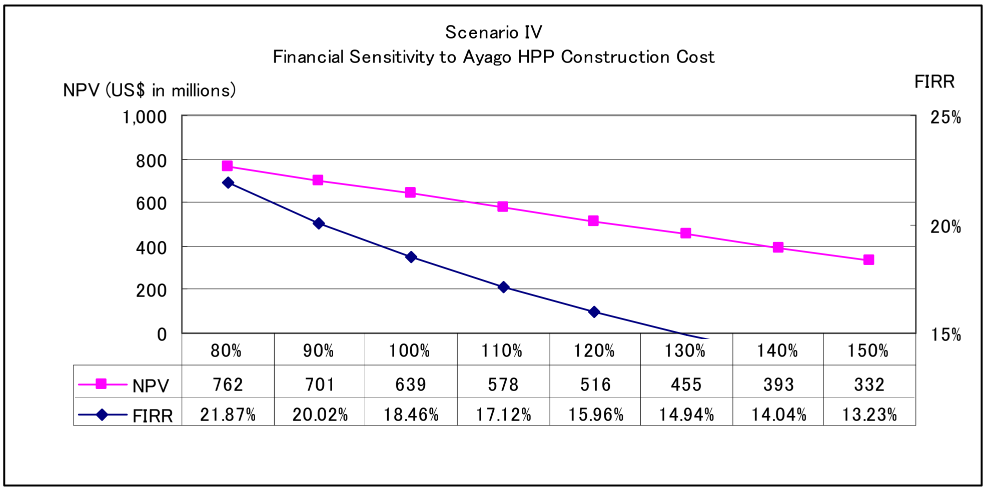


Figure 7.11.2-7 Scenario IV Financial Sensitivity to Ayago HPP Construction Cost (1)

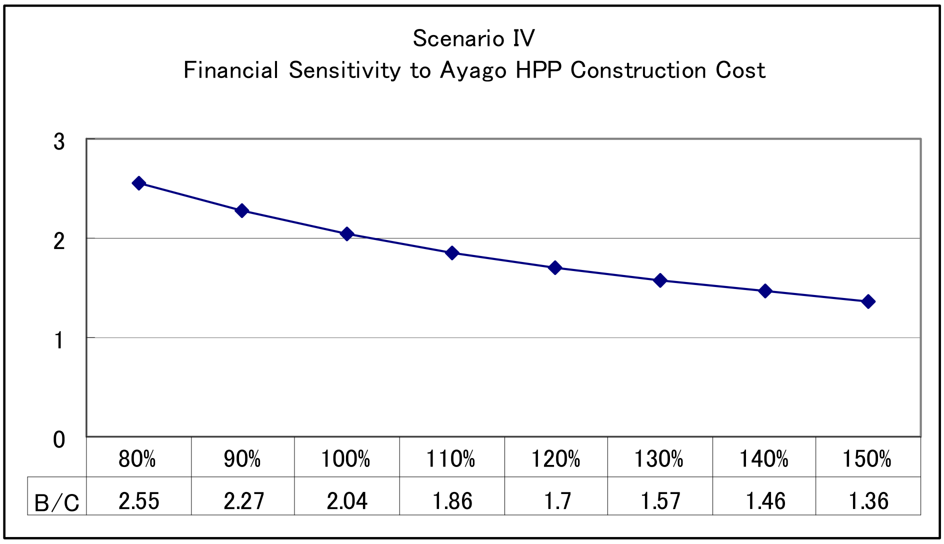


Figure 7.11.2-8 Scenario IV Financial Sensitivity to Ayago HPP Construction Cost (2)

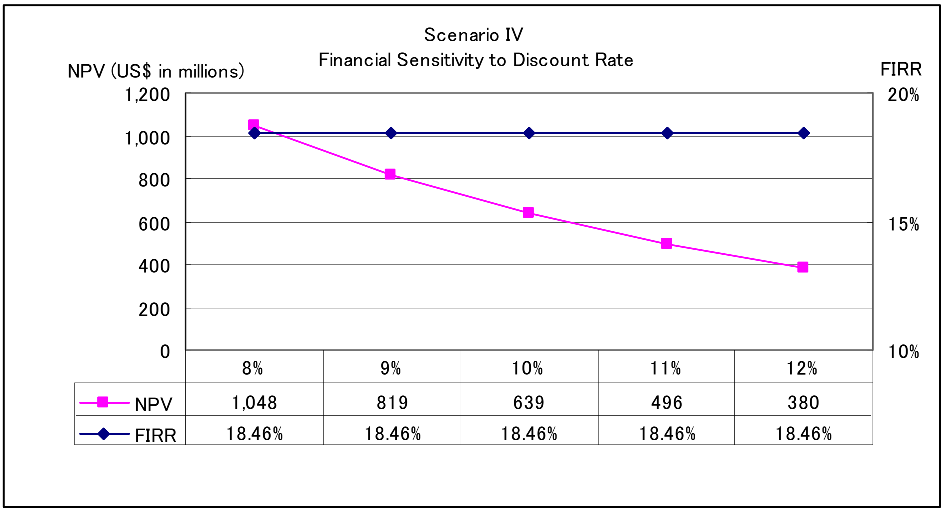
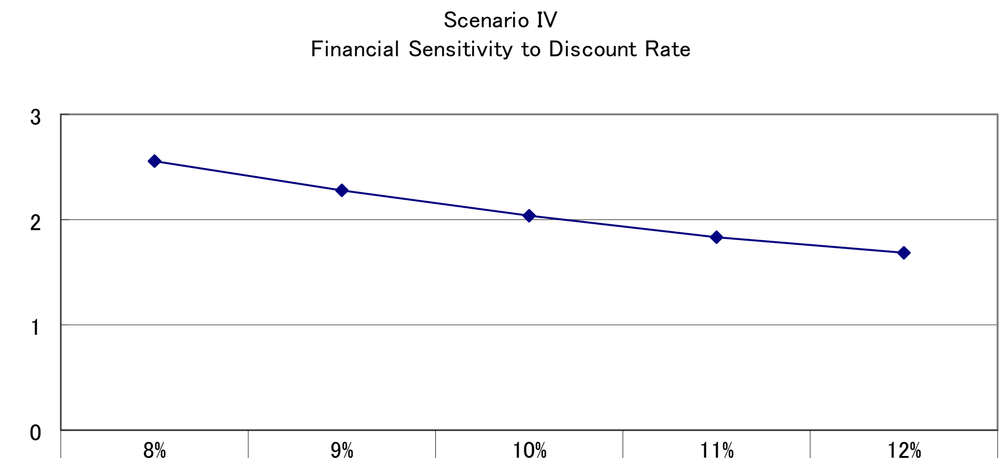
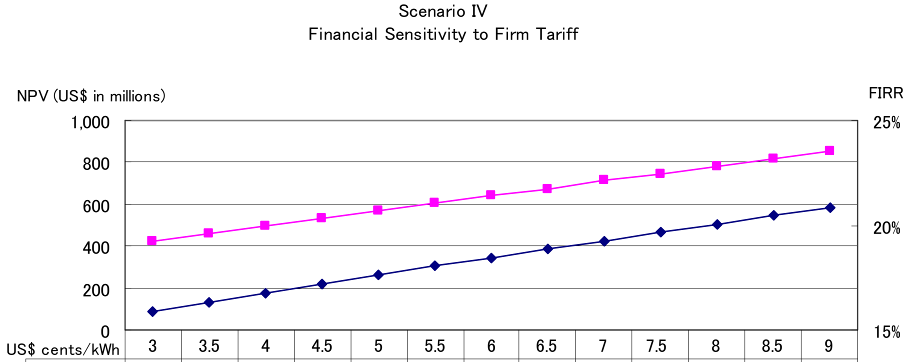


Figure 7.11.2-9 Scenario IV Financial Sensitivity to Discount Ratet (1)



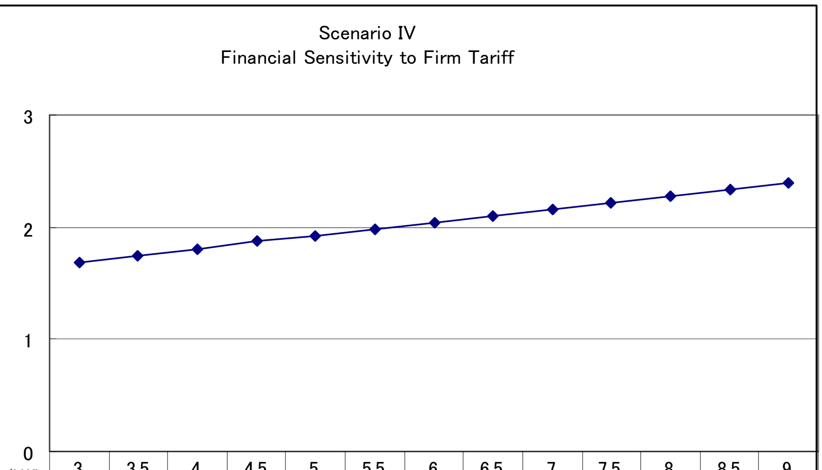
	8%	9%	10%	11%	12%
B/C	2.55	2.27	2.04	1.84	1.68

Figure 7.11.2-10 Scenario IV Financial Sensitivity to Discount Ratet (2)



US$ cents/kWh	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
NPV	424	460	496	532	568	603	639	675	712	747	782	818	854
FIRR	15.88%	16.33%	16.77%	17.20%	17.62%	18.04%	18.46%	18.87%	19.27%	19.67%	20.06%	20.45%	20.84%

Figure 7.11.2-11 Scenario IV Financial Sensitivity to Firm Tariff (1)



US$ cents/kWh	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
B/C	1.69	1.75	1.81	1.87	1.92	1.98	2.04	2.1	2.16	2.22	2.27	2.33	2.39

Figure 7.11.2-12 Scenario IV Financial Sensitivity to Firm Tariff (2)

7.11.3 Cashflow Analysis

(1) Methodology

This cashflow analysis is aimed to evaluate the Ayago hydropower project in terms of profitability and debt service capacity borrowing part of the required amount for project construction.

The following evaluation criteria were adopted:

IRR on Project[6] (internal rate of return on total employed assets) > interest rate of lending

IRR on Equity[7] (internal rate of return on own equity) > interest rate of lending (originally, interest rate for raising own equity)

LLCR [8](loan life coverage ratio > 1.5

DSCR[9] (debt service coverage ratio) > 1.5

The analysis was made in the time horizon from the start of construction up to the end of service life of civil structures of Ayago hydropower project -50 years. The evaluated scenarios were the following among the hydropower development scenarios discussed in Chapter 6.

Scenario I: Against the medium demand forecast, a total of installed capacity of 300 MW would be commissioned with 100 MW each in 2020, 2023 and 2024.

Scenario IV: Against the medium demand forecast plus power export to Kenya of 50% of firm energy, a total of installed capacity of 300 MW would be commissioned with 100 MW each in 2020, 2023 and 2024.

(2) Assumptions

The following key assumptions were adopted for the cashflow analysis.

Power price: US$6 cents/kWh

The OM cost of Ayago hydropower: fixed cost only to be assumed at 0.7%/year of the construction cost.

The replacement cost of major equipment such as hydromechanical and electrical equipment and transmission lines was counted in every 30 years.

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6 IRR on Project=Project profitability without regard to funding sources and tax of the country where the project is located.
7 IRR on Equity=Profitability for investor（Uganda government in this project）
8 LLCR=Total present value of net cashflow before debt service /Principal of borrowed amount
9 DSCR=Net cashflow before debt service in each year/Debt service amount in each year

Discount rate: 10% as base case

Loan conditions[10]: 50% of the construction cost was assumed to be borrowed with an interest rate of 7% and repayment period of 40 years (including 10 years of grace period)

Scenario IV assumed that 50% of firm energy would be exported to Kenya, so the export price was adopted at US$11.5 cents/kWh as base case considering ERA's electricity tariff regulation which does not allow power export at prices below the average power purchase cost of UETCL, which was US$11.357 cents in 2009 (figure provided by UETCL).

The remaining energy of 50%, which would be to cover the domestic demand, was assumed to be sold at domestic prices.

(3) Evaluation

1) Scenario I

The following parameters were set as base case, bringing forth the results shown in the table below.

The construction cost of Ayago hydropower 100%= US$862million

The power price=US$6 cents/kWh

Interest rate=7%

[10] 7% of interest rate was adopted as agreed with MEMD with reference to Japan's yen credit toward Uganda and considering the on-lend interest rate of about 7% to executing agency.

Table 7.11.3-1 Cashflow Analysis Result (Scenario I)

Assumptions							
Ayago HPP engineering assumptions			Finance structure			Tariff	
Installed capacity		300 MW	Government fund	Share	50%	Firm energy	US$ 6.0 cents
Dependable capacity		300 MW	Debt	Share	50%	Export energy	US$ 11.5 cents
Salable firm energy (net of station use 1% & TL loss 2%)		2,601 GWh/year		Interest rate	7%	Export share	50%
Construction cost	(100%)	US$ 862,823 thousands		Repayment period	40 years		
OM Cost (0.7% of construction cost)		US$ 6,040 thousands/year		Grace period	10 years	Tax rate	30%
						Escalation rate	0%

CASHFLOW STATEMENT Scenario I

No. of years from COD	No. of years from start of construction	Calendar year	Cash Inflow: Fund Injection	Cash Inflow: After-tax Profit	Cash Inflow: Depreciation	Cash Inflow: Total (A)	Cash Outflow: Disbursement	Cash Outflow: Debt Repayment	Cash Outflow: Total (B)	Cash Balance: Yearly (A)-(B)	Cash Balance: Accumulation	DSCR	LLCR Calculation, Cash available for debt service: Actual	Discounted	at 7.00%	IRR Calculation: on Project	on Equity
	1	2015	45,152	0	0	45,152	45,152	0	45,152	0	0					-45,152	-23,339
	2	2016	91,830	0	0	91,830	91,830	0	91,830	0	0					-91,830	-48,205
	3	2017	140,035	0	0	140,035	140,035	0	140,035	0	0					-140,035	-74,598
	4	2018	144,616	0	0	144,616	144,616	0	144,616	0	0					-144,616	-79,179
	5	2019	58,893	0	0	58,893	58,893	0	58,893	0	0					-58,893	-37,081
1	6	2020	81,490	9,079	2,944	93,513	81,490	0	81,490	12,023	12,023		20,777	19,418		-60,712	-19,968
2	7	2021	172,033	14,542	5,888	192,463	172,033	0	172,033	20,430	32,453		43,163	37,700		-128,870	-54,220
3	8	2022	177,262	10,884	5,888	194,034	177,262	0	177,262	16,772	49,225		44,731	36,514		-132,531	-57,880
4	9	2023	94,190	40,823	11,775	146,788	94,190	0	94,190	52,599	101,823		82,798	63,166		-11,392	20,603
5	10	2024		71,515	17,663	89,178		0	0	89,178	191,002		119,377	85,114		119,377	89,178
6	11	2025		71,515	17,663	89,178		14,380	14,380	74,798	265,800	2.68	119,377	79,546		119,377	74,798
7	12	2026		72,220	17,663	89,883		14,380	14,380	75,503	341,302	2.73	119,075	74,154		119,075	75,503
8	13	2027		72,924	17,663	90,588		14,380	14,380	76,207	417,510	2.79	118,773	69,127		118,773	76,207
9	14	2028		73,629	17,663	91,292		14,380	14,380	76,912	494,422	2.85	118,471	64,441		118,471	76,912
10	15	2029		74,334	17,663	91,997		14,380	14,380	77,617	572,038	2.91	118,169	60,071		118,169	77,617
11	16	2030		75,038	17,663	92,702		14,380	14,380	78,321	650,360	2.98	117,867	55,998		117,867	78,321
12	17	2031		75,743	17,663	93,406		14,380	14,380	79,026	729,385	3.05	117,565	52,200		117,565	79,026
13	18	2032		76,448	17,663	94,111		14,380	14,380	79,731	809,116	3.12	117,263	48,660		117,263	79,731
14	19	2033		77,152	17,663	94,816		14,380	14,380	80,435	889,551	3.20	116,961	45,360		116,961	80,435
15	20	2034		77,857	17,663	95,520		14,380	14,380	81,140	970,691	3.28	116,659	42,283		116,659	81,140
16	21	2035		78,562	17,663	96,225		14,380	14,380	81,844	1,052,535	3.37	116,357	39,414		116,357	81,844
17	22	2036		79,266	17,663	96,929		14,380	14,380	82,549	1,135,084	3.46	116,055	36,740		116,055	82,549
18	23	2037		79,971	17,663	97,634		14,380	14,380	83,254	1,218,338	3.56	115,753	34,247		115,753	83,254
19	24	2038		80,675	17,663	98,339		14,380	14,380	83,958	1,302,297	3.67	115,451	31,923		115,451	83,958
20	25	2039		81,380	17,663	99,043		14,380	14,380	84,663	1,386,960	3.78	115,149	29,757		115,149	84,663
21	26	2040		82,085	17,663	99,748		14,380	14,380	85,368	1,472,327	3.90	114,847	27,737		114,847	85,368
22	27	2041		82,789	17,663	100,453		14,380	14,380	86,072	1,558,399	4.02	114,545	25,854		114,545	86,072
23	28	2042		83,494	17,663	101,157		14,380	14,380	86,777	1,645,176	4.16	114,243	24,099		114,243	86,777
24	29	2043		84,199	17,663	101,862		14,380	14,380	87,482	1,732,658	4.31	113,941	22,463		113,941	87,482
25	30	2044		84,903	17,663	102,567		14,380	14,380	88,186	1,820,844	4.46	113,639	20,938		113,639	88,186
26	31	2045		85,608	17,663	103,271		14,380	14,380	88,891	1,909,735	4.64	113,337	19,516		113,337	88,891
27	32	2046		86,313	17,663	103,976		14,380	14,380	89,595	1,999,330	4.82	113,035	18,191		113,035	89,595
28	33	2047		87,017	17,663	104,680		14,380	14,380	90,300	2,089,630	5.03	112,734	16,955		112,734	90,300
29	34	2048		87,722	17,663	105,385	29,603	14,380	43,983	61,402	2,151,032	5.25	112,432	15,804		82,829	91,005
30	35	2049		88,427	17,663	106,090	29,603	14,380	43,983	62,106	2,213,139	5.49	112,130	14,730		82,527	91,709
31	36	2050		89,131	17,663	106,794		14,380	14,380	92,414	2,305,553	5.76	111,828	13,729		111,828	92,414
32	37	2051		89,836	17,663	107,499	29,603	14,380	43,983	63,516	2,369,068	6.06	111,526	12,797		81,923	93,119
33	38	2052		90,540	17,663	108,204	59,206	14,380	73,586	34,617	2,403,686	6.39	111,224	11,927		52,018	93,823
34	39	2053		91,245	17,663	108,908	29,603	14,380	43,983	64,925	2,468,611	6.77	110,922	11,116		81,319	94,528
35	40	2054		91,950	17,663	109,613		14,380	14,380	95,233	2,563,843	7.19	110,620	10,361		110,620	95,233
36	41	2055		92,654	17,663	110,318		0	0	110,318	2,674,161					110,318	110,318
37	42	2056		92,654	17,663	110,318		0	0	110,318	2,784,479					110,318	110,318
38	43	2057		92,654	17,663	110,318		0	0	110,318	2,894,796					110,318	110,318
39	44	2058		92,654	17,663	110,318		0	0	110,318	3,005,114					110,318	110,318
40	45	2059		92,654	17,663	110,318		0	0	110,318	3,115,431					110,318	110,318
41	46	2060		92,654	17,663	110,318		0	0	110,318	3,225,749					110,318	110,318
42	47	2061		92,654	17,663	110,318		0	0	110,318	3,336,067					110,318	110,318
43	48	2062		92,654	17,663	110,318		0	0	110,318	3,446,384					110,318	110,318
44	49	2063		92,654	17,663	110,318		0	0	110,318	3,556,702					110,318	110,318
45	50	2064		92,654	17,663	110,318		0	0	110,318	3,667,019					110,318	110,318
46	51	2065		92,654	17,663	110,318		0	0	110,318	3,777,337					110,318	110,318
47	52	2066		92,654	17,663	110,318		0	0	110,318	3,887,655					110,318	110,318
48	53	2067		92,654	17,663	110,318		0	0	110,318	3,997,972					110,318	110,318
49	54	2068		92,654	17,663	110,318		0	0	110,318	4,108,290					110,318	110,318
50	55	2069		92,654	17,663	110,318		0	0	110,318	4,218,607					110,318	110,318
														1,272,052			
			1,005,502	3,988,633	839,004	5,833,138	1,183,119	431,412	1,614,531	4,218,607				LLCR=	2.95	9.41%	12.32%
											Average DSCR=	4.19					
											Minimum DSCR=	2.68					

The base case showed the following results.

Table 7.11.3-2 Cashflow Analysis Result and Index (Scenario I, Base Case)

Criteria	Evaluation	Index	Jugement
IRR on Project	9.41%	> 7%	Passed
IRR on Equity	12.32%	> 7%	Passed
LLCR	2.95	> 1.5	Passed
DSCR Average	4.19	> 1.5	Passed
DSCR Minimum	2.68	> 1.0	Passed

The above results led to determine that Scenario IV is profitable and that there is no problem with debt service capacity; and, however, it was only for base case, so a stress test was made with the following parameters to verify the profitability and debt service capacity under severer conditions.

The construction cost of Ayago hydropower=120%

The power price=US$5.5 cents/kWh

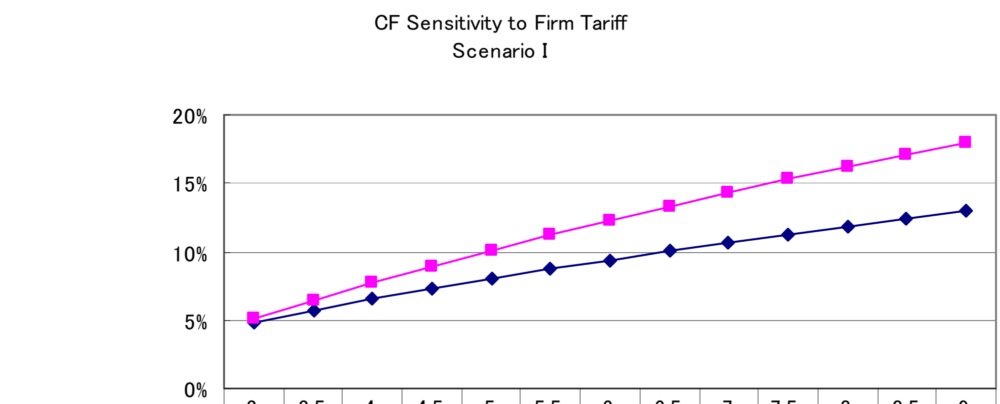
Discount rate=10%

Table 7.11.3-3 Cashflow Analysis Result and Index (Scenario I, Stress Test)

Criteria	Evaluation	Index	Jugement
IRR on Project	7.34%	> 7%	Passed
IRR on Equity	8.03%	> 7%	Passed
LLCR	1.72	> 1.5	Passed
DSCR Average	2.84	> 1.5	Passed
DSCR Minimum	1.71	> 1.0	Passed

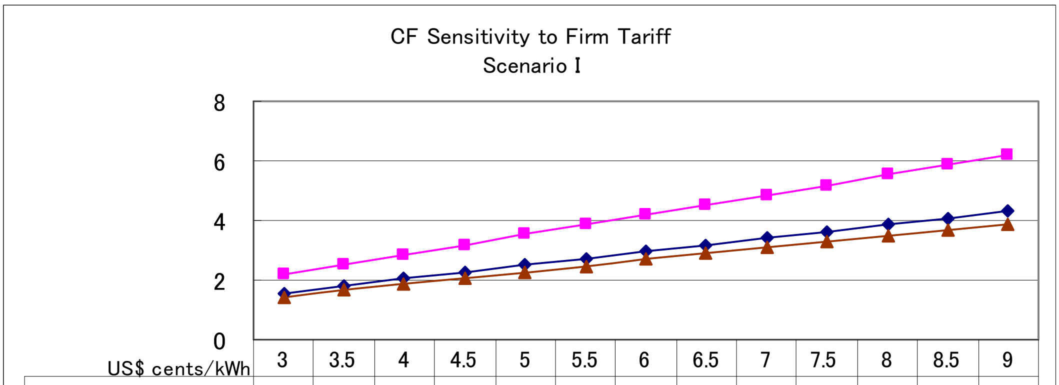
The above results have revealed that Ayago hydropower project would not lose profitability and debt service capacity under the above severe conditions. Severer conditions than the above would impair the profitability and debt service capacity, so that some measures such as hike in power price would be necessary.

Sensitivity analysis was made by varying key parameters to see how the evaluation result changes as shown in the following pages.



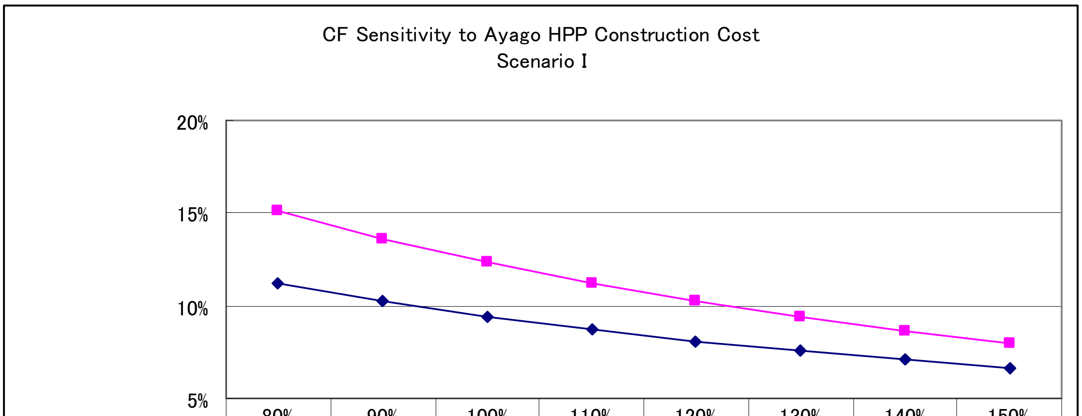
US$ cents/kWh	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
IRR on Project	4.8%	5.7%	6.5%	7.3%	8.0%	8.7%	9.4%	10.1%	10.7%	11.3%	11.9%	12.5%	13.0%
IRR on Equity	5.1%	6.5%	7.7%	9.0%	10.1%	11.2%	12.3%	13.3%	14.3%	15.3%	16.2%	17.1%	18.0%

Figure 7.11.3-1 CF Sensitivity to Firm Tariff Scenario I (1)



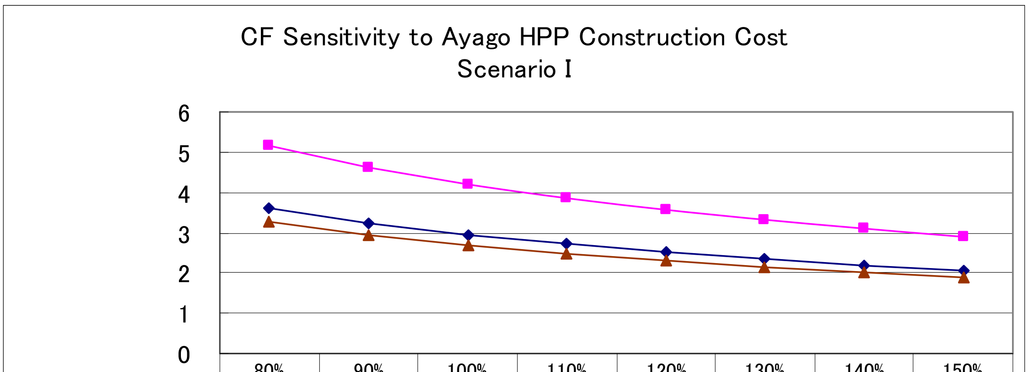
US$ cents/kWh	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
LLCR	1.6	1.8	2.0	2.3	2.5	2.7	3.0	3.2	3.4	3.6	3.9	4.1	4.3
DSCR Average	2.2	2.5	2.9	3.2	3.5	3.9	4.2	4.5	4.9	5.2	5.5	5.9	6.2
DSCR Minimum	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1	3.3	3.5	3.7	3.9

Figure 7.11.3-2 CF Sensitivity to Firm Tariff Scenario I (2)



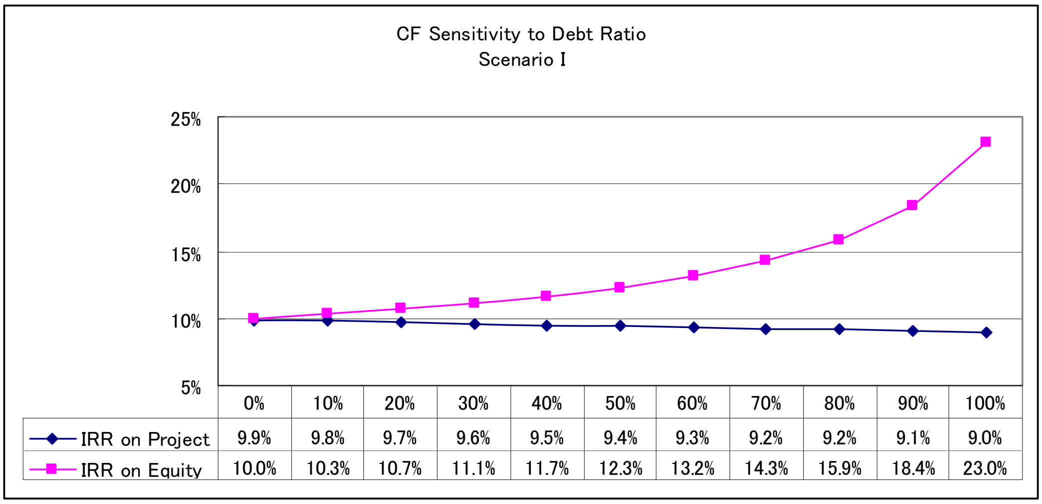
	80%	90%	100%	110%	120%	130%	140%	150%
IRR on Project	11.2%	10.2%	9.4%	8.7%	8.1%	7.5%	7.1%	6.6%
IRR on Equity	15.2%	13.6%	12.3%	11.2%	10.2%	9.4%	8.6%	7.9%

Figure 7.11.3-3 CF Sensitivity to Ayago HPP Construction Cost Scenario I (1)



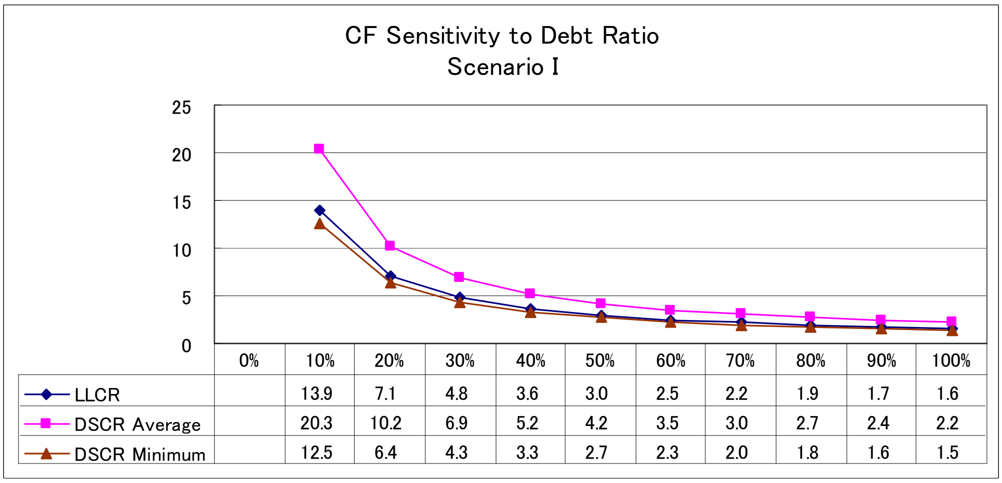
	80%	90%	100%	110%	120%	130%	140%	150%
LLCR	3.6	3.2	3.0	2.7	2.5	2.3	2.2	2.1
DSCR Average	5.2	4.6	4.2	3.8	3.6	3.3	3.1	2.9
DSCR Minimum	3.3	2.9	2.7	2.5	2.3	2.1	2.0	1.9

Figure 7.11.3-4 CF Sensitivity to Ayago HPP Construction Cost Scenario I (2)



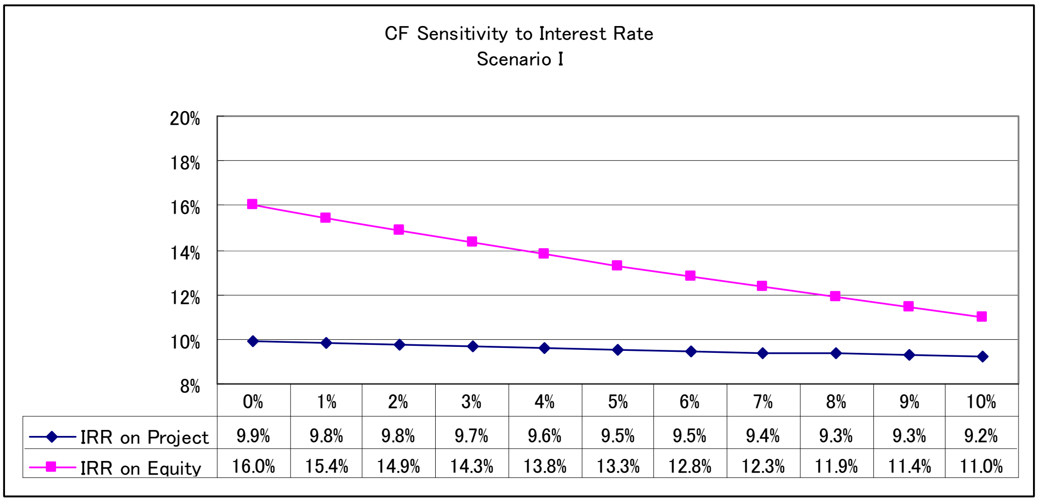
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
IRR on Project	9.9%	9.8%	9.7%	9.6%	9.5%	9.4%	9.3%	9.2%	9.2%	9.1%	9.0%
IRR on Equity	10.0%	10.3%	10.7%	11.1%	11.7%	12.3%	13.2%	14.3%	15.9%	18.4%	23.0%

Figure 7.11.3-5 CF Sensitivity to Debt Ratio Scenario I (1)



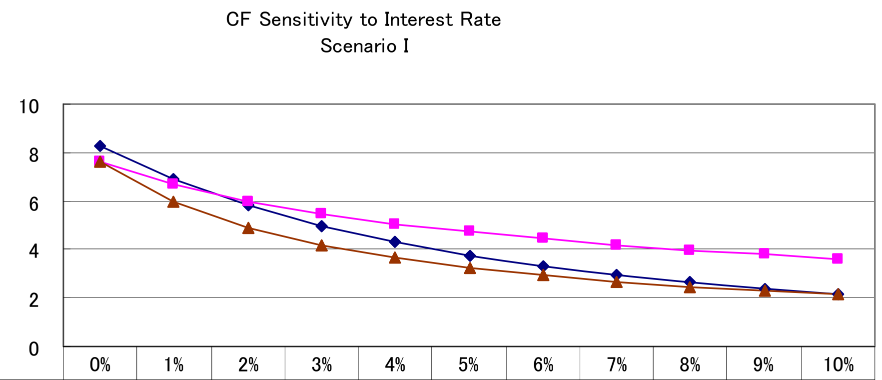
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
LLCR		13.9	7.1	4.8	3.6	3.0	2.5	2.2	1.9	1.7	1.6
DSCR Average		20.3	10.2	6.9	5.2	4.2	3.5	3.0	2.7	2.4	2.2
DSCR Minimum		12.5	6.4	4.3	3.3	2.7	2.3	2.0	1.8	1.6	1.5

Figure 7.11.3-6 CF Sensitivity to Debt Ratio Scenario I (2)



	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
IRR on Project	9.9%	9.8%	9.8%	9.7%	9.6%	9.5%	9.5%	9.4%	9.3%	9.3%	9.2%
IRR on Equity	16.0%	15.4%	14.9%	14.3%	13.8%	13.3%	12.8%	12.3%	11.9%	11.4%	11.0%

Figure 7.11.3-7 CF Sensitivity to Interest Rate Scenario I (1)



	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
LLCR	8.3	6.9	5.8	5.0	4.3	3.8	3.3	3.0	2.6	2.4	2.2
DSCR Average	7.6	6.7	6.0	5.5	5.1	4.7	4.4	4.2	4.0	3.8	3.6
DSCR Minimum	7.6	5.9	4.9	4.2	3.6	3.2	2.9	2.7	2.5	2.3	2.2

Figure 7.11.3-8 CF Sensitivity to Interest Rate Scenario I (2)

2) Scenario IV

The following parameters were set as base case, bringing forth the results shown in the table below.

The construction cost of Ayago hydropower 100%= US$862million

The power price=US$6 cents/kWh

The export price=US$11.5

Interest rate=7%

Table 7.11.3-4 Cashflow Analysis Result (Scenario IV)

Assumptions							
Ayago HPP engineering assumptions			Finance structure			Tariff	
Installed capacity	300	MW	Government fund Share		50%	Firm energy	US$ 6.0 cents
Dependable capacity	300	MW	Debt Share		50%	Export energy	US$ 11.5 cents
Salable firm energy (net of station use 1% & TL loss	2,601	GWh/year		Interest rate	7%	Export share	50%
Construction cost (100%)	US$ 862,823	thousands		Repayment period	40 years		
OM Cost (0.7% of construction cost)	US$ 6,040	thousands/year		Grace period	10 years	Tax rate	30%
						Escalation rate	0%

CASHFLOW STATEMENT Scenraio IV

No. of years from COD	No. of years from start of construction	Calendar year	Cash Inflow: Fund Injection	Cash Inflow: After-tax Profit	Cash Inflow: Depreciation	Cash Inflow: Total (A)	Cash Outflow: Disbursement	Cash Outflow: Debt Repayment	Cash Outflow: Total (B)	Cash Balance: Yearly (A)-(B)	Cash Balance: Accumulation	DSCR	LLCR Calculation (Cash available for debt service): Actual	LLCR Calculation (Cash available for debt service): Discounted	LLCR Calculation: at 7.00%	IRR Calculation: on Project	IRR Calculation: on Equity
	1	2015	45,152	0	0	45,152	45,152	0	45,152	0	0					-45,152	-23,339
	2	2016	114,406	0	0	114,406	114,406	0	114,406	0	0					-114,406	-59,875
	3	2017	140,799	0	0	140,799	140,799	0	140,799	0	0					-140,799	-75,362
	4	2018	211,601	0	0	211,601	211,601	0	211,601	0	0					-211,601	-114,173
1	5	2019	122,492	8,225	1,464	132,181	127,615	0	127,615	4,565	4,565					-112,803	-64,366
2	6	2020	152,946	27,687	5,855	186,488	152,946	0	152,946	33,542	38,108		58,515	51,109		-94,431	-30,444
3	7	2021	113,280	73,935	11,711	198,926	113,280	0	113,280	85,646	123,753		113,605	92,735		324	42,985
4	8	2022	94,190	72,367	11,711	178,268	94,190	0	94,190	84,078	207,831		114,277	87,181		20,087	52,082
5	9	2023		119,517	17,566	137,083	0	0	0	137,083	344,914		167,282	119,270		167,282	137,083
6	10	2024		119,517	17,566	137,083	0	0	0	137,083	481,997		167,282	111,467		167,282	137,083
7	11	2025		119,517	17,566	137,083		14,380	14,380	122,703	604,700	3.75	167,282	104,175		167,282	122,703
8	12	2026		120,221	17,566	137,788		14,380	14,380	123,407	728,107	3.83	166,980	97,184		166,980	123,407
9	13	2027		120,926	17,566	138,492		14,380	14,380	124,112	852,219	3.92	166,678	90,662		166,678	124,112
10	14	2028		121,631	17,566	139,197		14,380	14,380	124,817	977,036	4.00	166,376	84,577		166,376	124,817
11	15	2029		122,335	17,566	139,902		14,380	14,380	125,521	1,102,557	4.10	166,074	78,901		166,074	125,521
12	16	2030		123,040	17,566	140,606		14,380	14,380	126,226	1,228,783	4.19	165,772	73,605		165,772	126,226
13	17	2031		123,745	17,566	141,311		14,380	14,380	126,931	1,355,713	4.29	165,470	68,664		165,470	126,931
14	18	2032		124,449	17,566	142,016		14,380	14,380	127,635	1,483,348	4.40	165,168	64,055		165,168	127,635
15	19	2033		125,154	17,566	142,720		14,380	14,380	128,340	1,611,688	4.51	164,866	59,755		164,866	128,340
16	20	2034		125,858	17,566	143,425		14,380	14,380	129,044	1,740,733	4.63	164,564	55,744		164,564	129,044
17	21	2035		126,563	17,566	144,129		14,380	14,380	129,749	1,870,482	4.76	164,262	52,001		164,262	129,749
18	22	2036		127,268	17,566	144,834		14,380	14,380	130,454	2,000,935	4.89	163,960	48,510		163,960	130,454
19	23	2037		127,972	17,566	145,539		14,380	14,380	131,158	2,132,094	5.04	163,658	45,253		163,658	131,158
20	24	2038		128,677	17,566	146,243		14,380	14,380	131,863	2,263,957	5.19	163,356	42,214		163,356	131,863
21	25	2039		129,382	17,566	146,948		14,380	14,380	132,568	2,396,524	5.35	163,054	39,380		163,054	132,568
22	26	2040		130,086	17,566	147,653		14,380	14,380	133,272	2,529,797	5.52	162,752	36,735		162,752	133,272
23	27	2041		130,791	17,566	148,357		14,380	14,380	133,977	2,663,773	5.71	162,450	34,268		162,450	133,977
24	28	2042		131,496	17,566	149,062		14,380	14,380	134,682	2,798,455	5.90	162,148	31,967		162,148	134,682
25	29	2043		132,200	17,566	149,767		14,380	14,380	135,386	2,933,841	6.12	161,846	29,820		161,846	135,386
26	30	2044		132,905	17,566	150,471		14,380	14,380	136,091	3,069,932	6.35	161,544	27,817		161,544	136,091
27	31	2045		133,609	17,566	151,176		14,380	14,380	136,795	3,206,727	6.60	161,242	25,949		161,242	136,795
28	32	2046		134,314	17,566	151,880		14,380	14,380	137,500	3,344,228	6.87	160,940	24,206		160,940	137,500
29	33	2047		135,019	17,566	152,585	29,603	14,380	43,983	108,602	3,452,829	7.16	160,638	22,580		131,035	138,205
30	34	2048		135,723	17,566	153,290	29,603	14,380	43,983	109,306	3,562,136	7.48	160,336	21,063		130,733	138,909
31	35	2049		136,428	17,566	153,994	29,603	14,380	43,983	110,011	3,672,147	7.84	160,034	19,648		130,431	139,614
32	36	2050		137,133	17,566	154,699	29,603	14,380	43,983	110,716	3,782,862	8.23	159,732	18,328		130,129	140,319
33	37	2051		137,837	17,566	155,404	29,603	14,380	43,983	111,420	3,894,283	8.66	159,430	17,096		129,827	141,023
34	38	2052		138,542	17,566	156,108	29,603	14,380	43,983	112,125	4,006,408	9.15	159,128	15,948		129,525	141,728
35	39	2053		139,247	17,566	156,813		14,380	14,380	142,433	4,148,840	9.69	158,826	14,876		158,826	142,433
36	40	2054		139,951	17,566	157,518		14,380	14,380	143,137	4,291,978	10.30	158,524	13,876		158,524	143,137
37	41	2055		140,656	17,566	158,222		0	0	158,222	4,450,200					158,222	158,222
38	42	2056		140,656	17,566	158,222		0	0	158,222	4,608,422					158,222	158,222
39	43	2057		140,656	17,566	158,222		0	0	158,222	4,766,644					158,222	158,222
40	44	2058		140,656	17,566	158,222		0	0	158,222	4,924,866					158,222	158,222
41	45	2059		140,656	17,566	158,222		0	0	158,222	5,083,089					158,222	158,222
42	46	2060		140,656	17,566	158,222		0	0	158,222	5,241,311					158,222	158,222
43	47	2061		140,656	17,566	158,222		0	0	158,222	5,399,533					158,222	158,222
44	48	2062		140,656	17,566	158,222		0	0	158,222	5,557,755					158,222	158,222
45	49	2063		140,656	17,566	158,222		0	0	158,222	5,715,978					158,222	158,222
46	50	2064		140,656	17,566	158,222		0	0	158,222	5,874,200					158,222	158,222
47	51	2065		140,656	17,566	158,222		0	0	158,222	6,032,422					158,222	158,222
48	52	2066		140,656	17,566	158,222		0	0	158,222	6,190,644					158,222	158,222
49	53	2067		140,656	17,566	158,222		0	0	158,222	6,348,867					158,222	158,222
50	54	2068		140,656	17,566	158,222		0	0	158,222	6,507,089					158,222	158,222
														1,820,618			
			994,864	6,282,447	838,795	8,116,106	1,177,606	431,412	1,609,017	6,507,089				LLCR=	4.22	13.36%	18.64%
											Average DSCR=	5.95					
											Minimum DSCR=	3.75					

The base case showed the following results.

Table 7.11.3-5 Cashflow Analysis Result and Index (Scenario IV, Base Case)

Criteria	Evaluation	Index	Jugement
IRR on Project	13.36%	> 7%	Passed
IRR on Equity	18.64%	> 7%	Passed
LLCR	4.22	> 1.5	Passed
DSCR Average	5.95	> 1.5	Passed
DSCR Minimum	3.75	> 1.0	Passed

The above results led to determine that Scenario IV is profitable and that there is no problem with debt service capacity; and, however, it was only for base case, so a stress test was made with the following parameters to verify the profitability and debt service capacity under severer conditions.

The construction cost of Ayago hydropower=120%

The power price=US$4.5 cents/kWh

The export price=US$6 cents/kWh

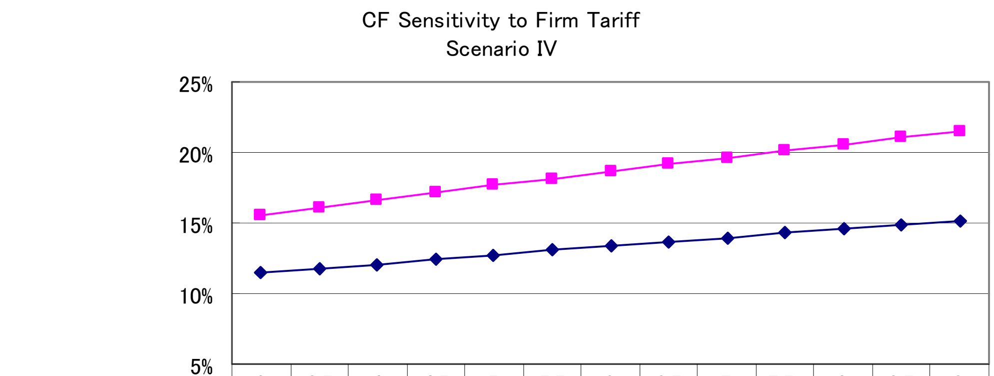
Interest rate=10%

Table 7.11.3-6 Cashflow Analysis Result and Index (Scenario IV, Stress Test)

Criteria	Evaluation	Index	Jugement
IRR on Project	7.19%	> 7%	Passed
IRR on Equity	7.50%	> 7%	Passed
LLCR	1.64	> 1.5	Passed
DSCR Average	2.67	> 1.5	Passed
DSCR Minimum	1.61	> 1.0	Passed

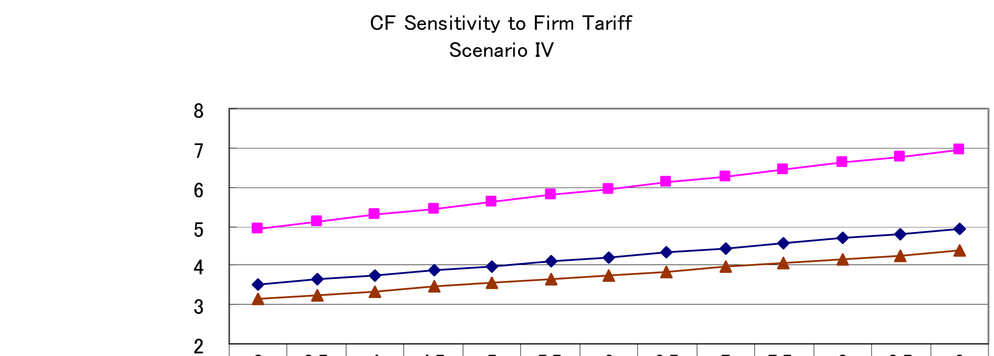
The above results have revealed that Ayago hydropower project would not lose profitability and debt service capacity under the above severe conditions. Severer conditions than the above would impair the profitability and debt service capacity, so that some measures such as hike in power price would be necessary.

Sensitivity analysis was made by varying key parameters to see how the evaluation result changes as shown in the following pages.



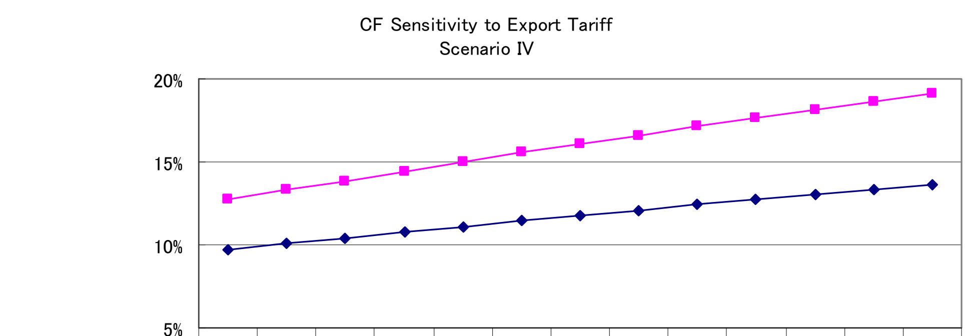
US$ cents/kWh	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
IRR on Project	11.4%	11.8%	12.1%	12.4%	12.7%	13.1%	13.4%	13.7%	14.0%	14.3%	14.6%	14.9%	15.2%
IRR on Equity	15.5%	16.1%	16.6%	17.1%	17.6%	18.1%	18.6%	19.1%	19.6%	20.1%	20.6%	21.0%	21.5%

Figure 7.11.3-9 CF Sensitivity to Firm Tariff Scenario IV (1)



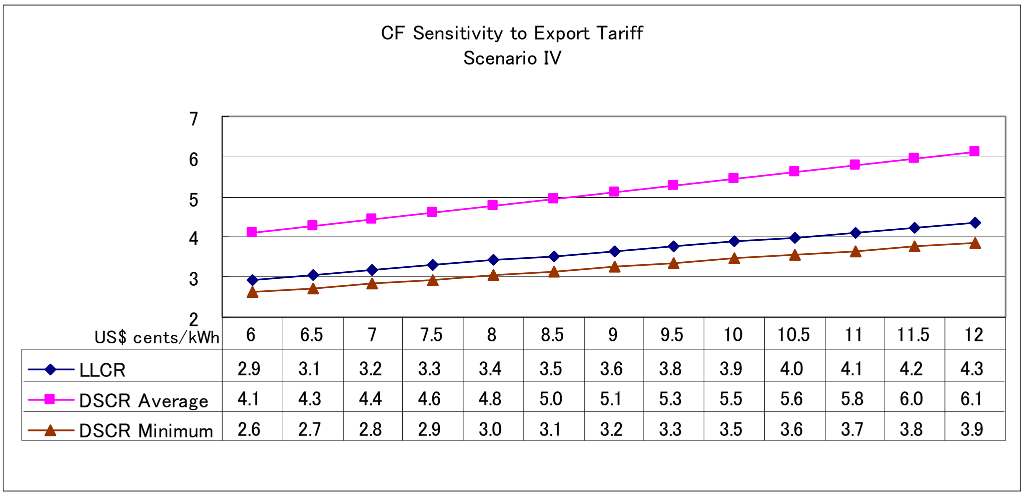
	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
LLCR	3.5	3.6	3.8	3.9	4.0	4.1	4.2	4.3	4.5	4.6	4.7	4.8	4.9
DSCR Average	5.0	5.1	5.3	5.5	5.6	5.8	6.0	6.1	6.3	6.5	6.6	6.8	7.0
DSCR Minimum	3.1	3.2	3.3	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4

Figure 7.11.3-10 CF Sensitivity to Firm Tariff Scenario IV (2)



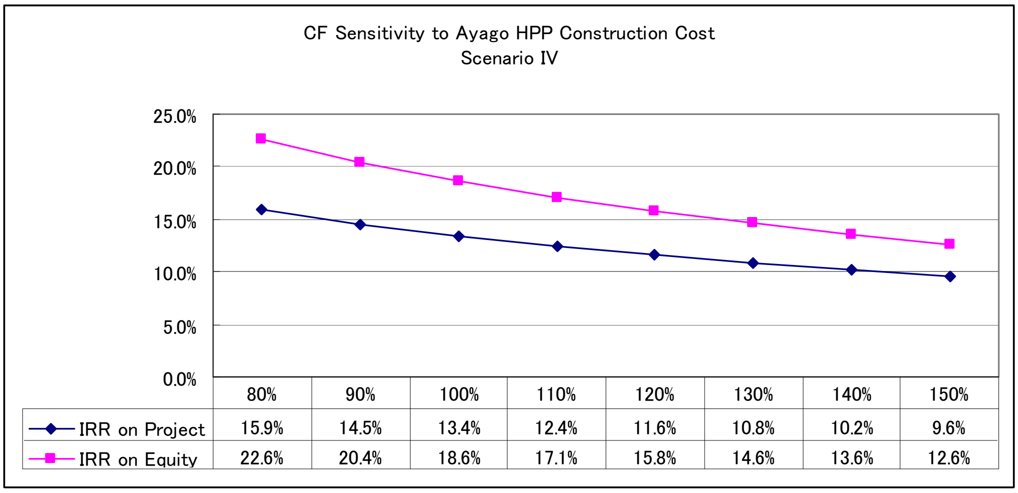
US$ cents/kWh	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
IRR on Project	9.7%	10.1%	10.4%	10.8%	11.1%	11.4%	11.8%	12.1%	12.4%	12.7%	13.1%	13.4%	13.7%
IRR on Equity	12.7%	13.3%	13.9%	14.4%	15.0%	15.5%	16.1%	16.6%	17.1%	17.6%	18.1%	18.6%	19.1%

Figure 7.11.3-11 CF Sensitivity to Export Tariff Scenario IV (1)



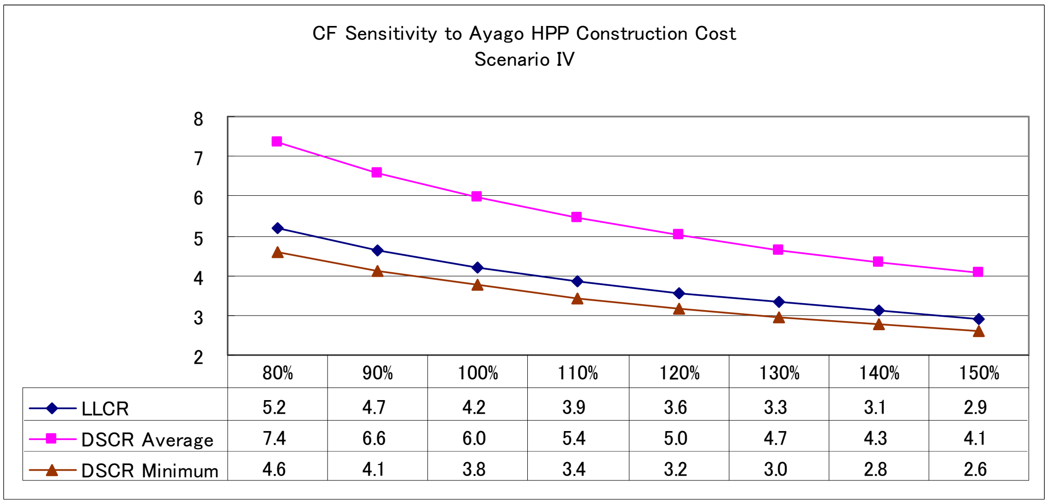
US$ cents/kWh	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
LLCR	2.9	3.1	3.2	3.3	3.4	3.5	3.6	3.8	3.9	4.0	4.1	4.2	4.3
DSCR Average	4.1	4.3	4.4	4.6	4.8	5.0	5.1	5.3	5.5	5.6	5.8	6.0	6.1
DSCR Minimum	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.5	3.6	3.7	3.8	3.9

Figure 7.11.3-12　CF Sensitivity to Export Tariff Scenario IV (2)



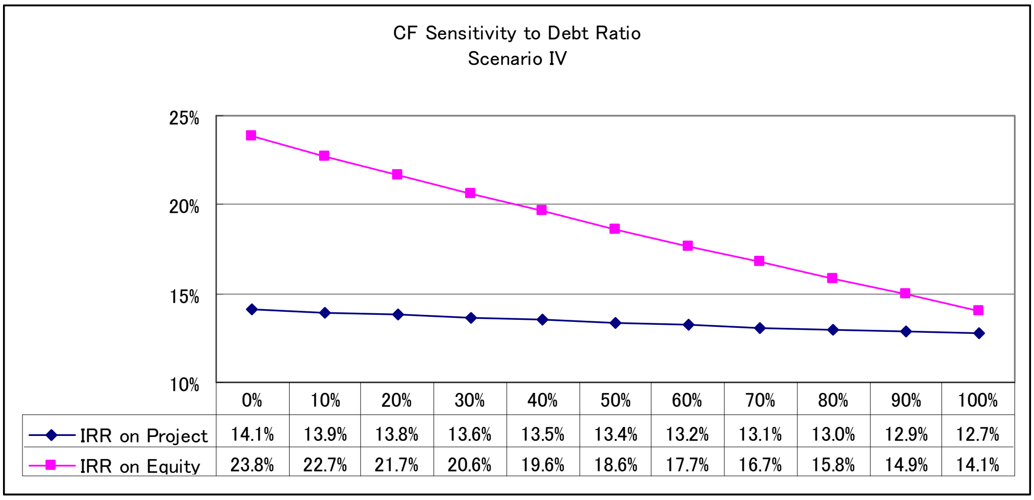
	80%	90%	100%	110%	120%	130%	140%	150%
IRR on Project	15.9%	14.5%	13.4%	12.4%	11.6%	10.8%	10.2%	9.6%
IRR on Equity	22.6%	20.4%	18.6%	17.1%	15.8%	14.6%	13.6%	12.6%

Figure 7.11.3-13　CF Sensitivity to Ayago HPP Construction Cost Scenario IV (1)



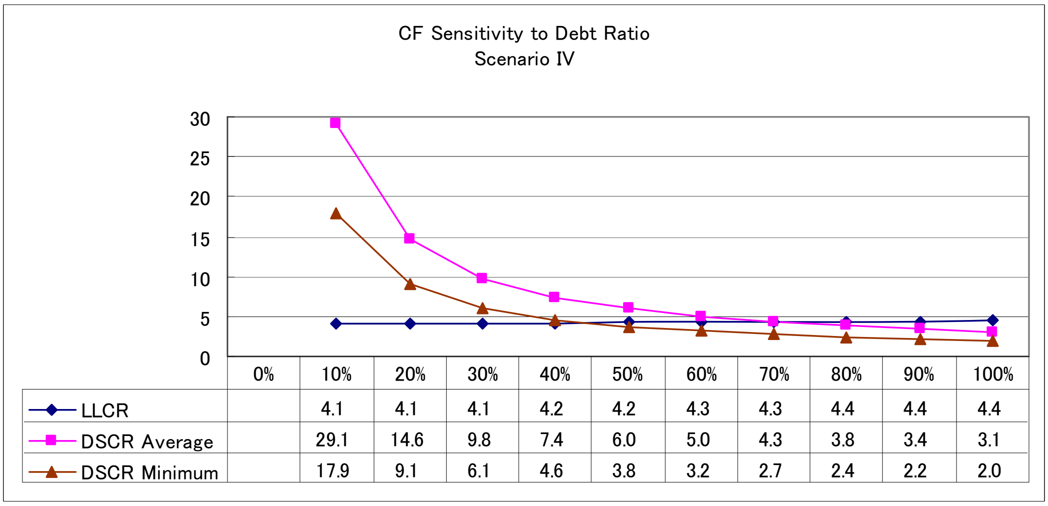
	80%	90%	100%	110%	120%	130%	140%	150%
LLCR	5.2	4.7	4.2	3.9	3.6	3.3	3.1	2.9
DSCR Average	7.4	6.6	6.0	5.4	5.0	4.7	4.3	4.1
DSCR Minimum	4.6	4.1	3.8	3.4	3.2	3.0	2.8	2.6

Figure 7.11.3-14　CF Sensitivity to Ayago HPP Construction Cost Scenario IV (2)



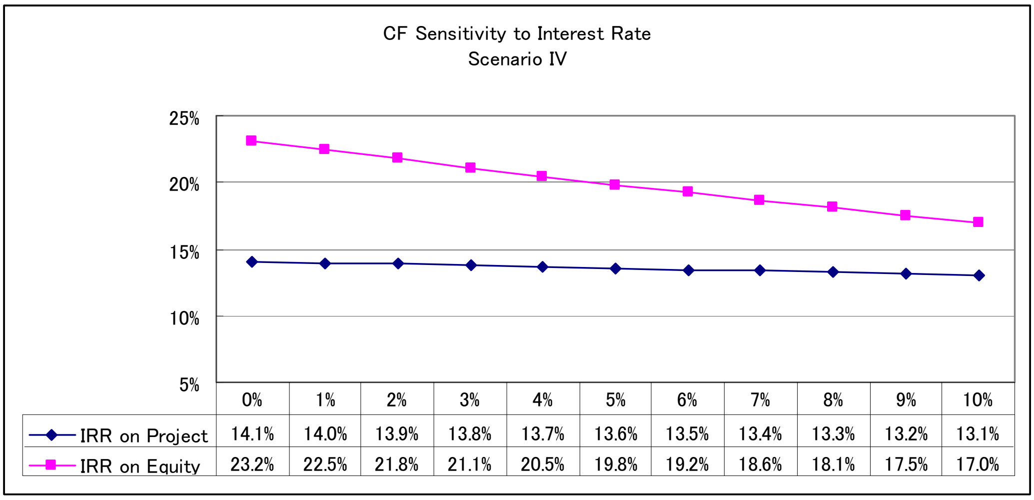
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
IRR on Project	14.1%	13.9%	13.8%	13.6%	13.5%	13.4%	13.2%	13.1%	13.0%	12.9%	12.7%
IRR on Equity	23.8%	22.7%	21.7%	20.6%	19.6%	18.6%	17.7%	16.7%	15.8%	14.9%	14.1%

Figure 7.11.3-15 CF Sensitivity to Debt Ratio Scenario IV (1)



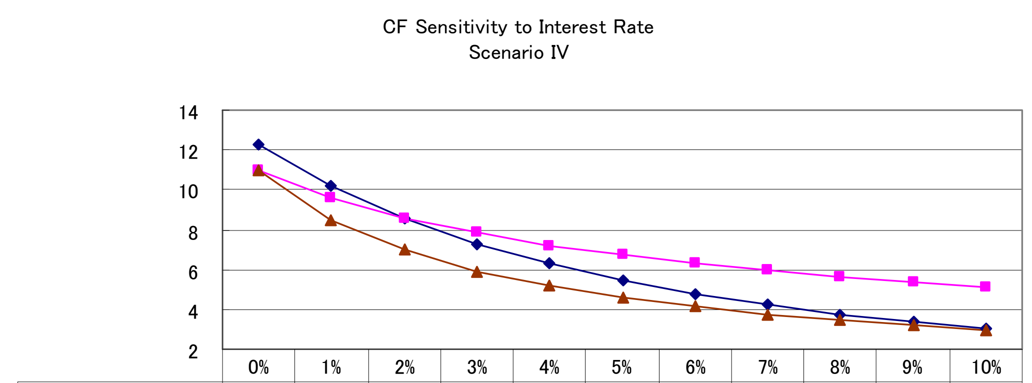
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
LLCR		4.1	4.1	4.1	4.2	4.2	4.3	4.3	4.4	4.4	4.4
DSCR Average		29.1	14.6	9.8	7.4	6.0	5.0	4.3	3.8	3.4	3.1
DSCR Minimum		17.9	9.1	6.1	4.6	3.8	3.2	2.7	2.4	2.2	2.0

Figure 7.11.3-16 CF Sensitivity to Debt Ratio Scenario IV (2)



	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
IRR on Project	14.1%	14.0%	13.9%	13.8%	13.7%	13.6%	13.5%	13.4%	13.3%	13.2%	13.1%
IRR on Equity	23.2%	22.5%	21.8%	21.1%	20.5%	19.8%	19.2%	18.6%	18.1%	17.5%	17.0%

Figure 7.11.3-17 CF Sensitivity to Interest Rate Scenario IV (1)



	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
LLCR	12.3	10.2	8.6	7.3	6.3	5.5	4.8	4.2	3.8	3.4	3.1
DSCR Average	11.0	9.6	8.6	7.8	7.2	6.7	6.3	6.0	5.6	5.4	5.1
DSCR Minimum	11.0	8.5	7.0	5.9	5.2	4.6	4.1	3.8	3.5	3.2	3.0

Figure 7.11.3-18 CF Sensitivity to Interest Rate Scenario IV (2)

Chapter 8

Environmental and Social Considerations

Chapter 8 Environmental and Social Considerations

8.1 Strategic Environmental Assessment

Three Strategic Environmental Assessments such as (1) Examination of alternative power source, (2) Examination of candidate projects, and (3) Examination of three layouts in Ayago site have been conducted under this study. Impact assessments for (1) and (2) have been conducted based on survey of literature. Impact assessment for (3) has been based on site survey. All the SEAs examine more than two alternatives from technical, economic, environmental and social points of view. The survey results and impact assessment are documented in the SEA report, attached as Appendix D. This study follows JICA guidelines for environmental and social considerations (2010, JICA).

8.2 Environmental Flow

8.2.1 Study Based on Hydrologic Statistics

The environmental flow is studied using the daily discharge data at Masindi Port which is based on the actual records from 1978. The missing data is assumed by the regression formula which is based on the relation between Masindi and Mbulamuti.

The daily discharge shown in the years below is prepared in accordance with the actual and assumed data.

－ 1957 to 1961, 1963 to 1968, 1971, 1974 to 1978, 1980, 1989 to 1993, 1995 to 2009.

(1) Duration Curve

The discharge-duration curves of Nile River presented by Masindi Port are shown in Figure 8.2.1-1.

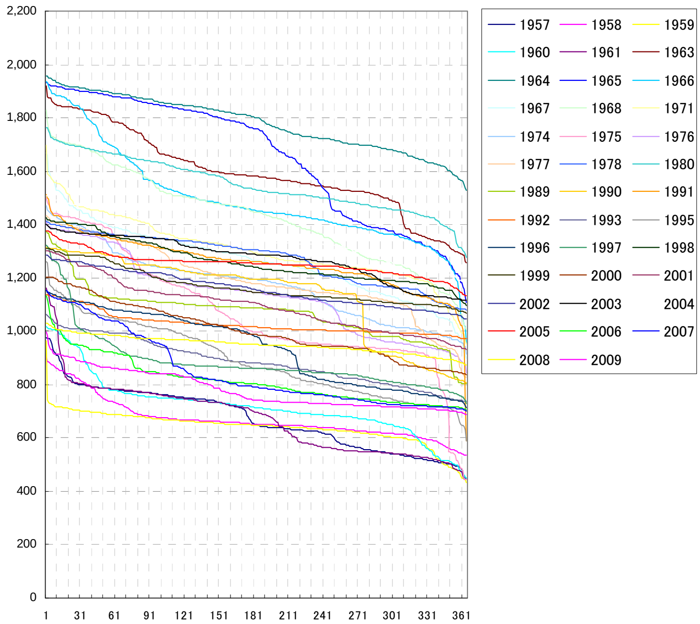


Figure 8.2.1-1　Duration Curve of Nile River

The river flow ranges from 600 m^3/s to 1,400 m^3/s except that the discharge in flood season in the 1960s exceeds 1,400 m^3/s. The annual fluctuations seem to be little as shown in Figure 8.2.1-1.

(2) Average and Minimum Discharge

The average and minimum discharge are shown below.

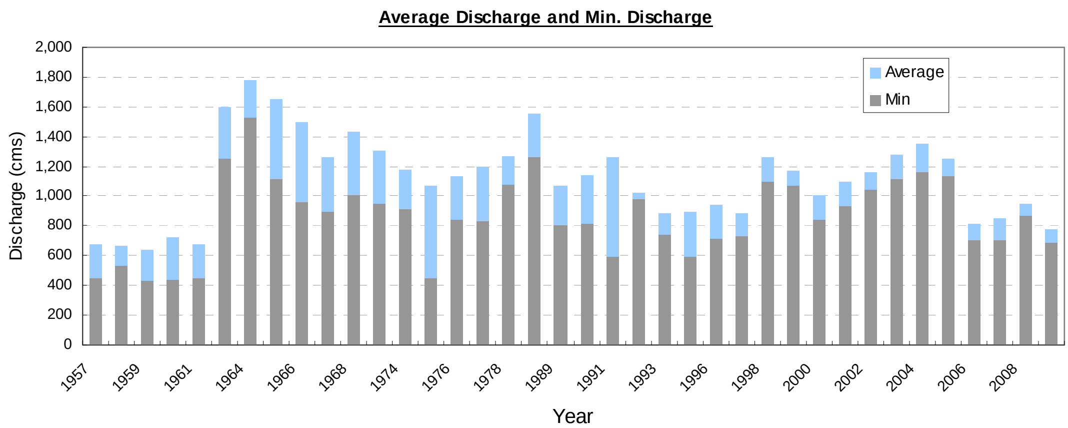


Figure 8.2.1-2　Average Discharge and Min Discharge

There is little difference between the average and the minimum discharge since the flow of the Nile is abundant and stable throughout the year.

The average and minimum flow per year are shown in Figure 8.2.1-2.

Average flow　= 1,114 m^3/s

Minimum flow= 859 m^3/s

On the other hand, the average water flow during draught, which occurs once in 10 years ranges from 450 m^3/s to 530m^3/s.

(3) Ayago Stage Development

Ayago Project will be developed in several stages. Therefore, along the way the discharge in the recession area might decrease while the maximum discharge will increase. To see the impact in the recession area, the number of days in which the discharge is over 450m^3/s (i.e. the draught water flow) is calculated as shown in Table 8.2.1-1.

As a result, the relationship between the maximum discharge corresponding to different MWs and the rate of days over 450m^3/s is shown in Figure 8.2.1-3.

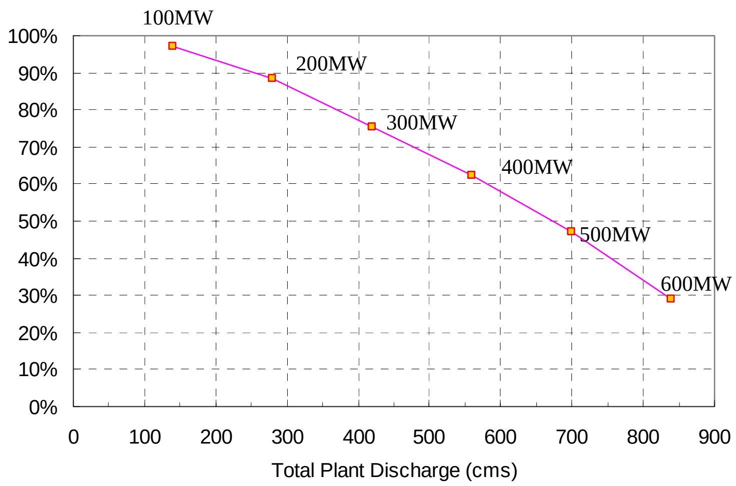


Figure 8.2.1-3 Maximum plant discharge and date of minimum water volume

Table 8.2.1-1 Development Stage and Water Discharge

Development Stage	100MW	200MW	300MW	400MW	500MW	600MW
Maximum Discharge (m^3/s)	140	280	420	560	700	840
No. of Day Under 450 m^3/s	400	1654	3490	5384	7510	10103
Total days	14245	14245	14245	14245	14245	14245
Rate of Day over 450 m^3/s	97%	88%	76%	62%	47%	29%

8.2.2 Reviewing Process of Environmental Flow

Water recession between intake and outlet might cause serious impact on Hippopotamus and Crocodiles. In addition, the vegetation change of riverine forests might indirectly affect the fauna which depend on riverine forests. Thus, the volume of environmental flow must be carefully reviewed. It is difficult to identify the volume of environmental flow now but the reviewing process is supposed to be in two stages as shown in following flowchart. (1) to (8) shall be conducted during the feasibility study and (9) to (15) shall be conducted during the first construction stage.

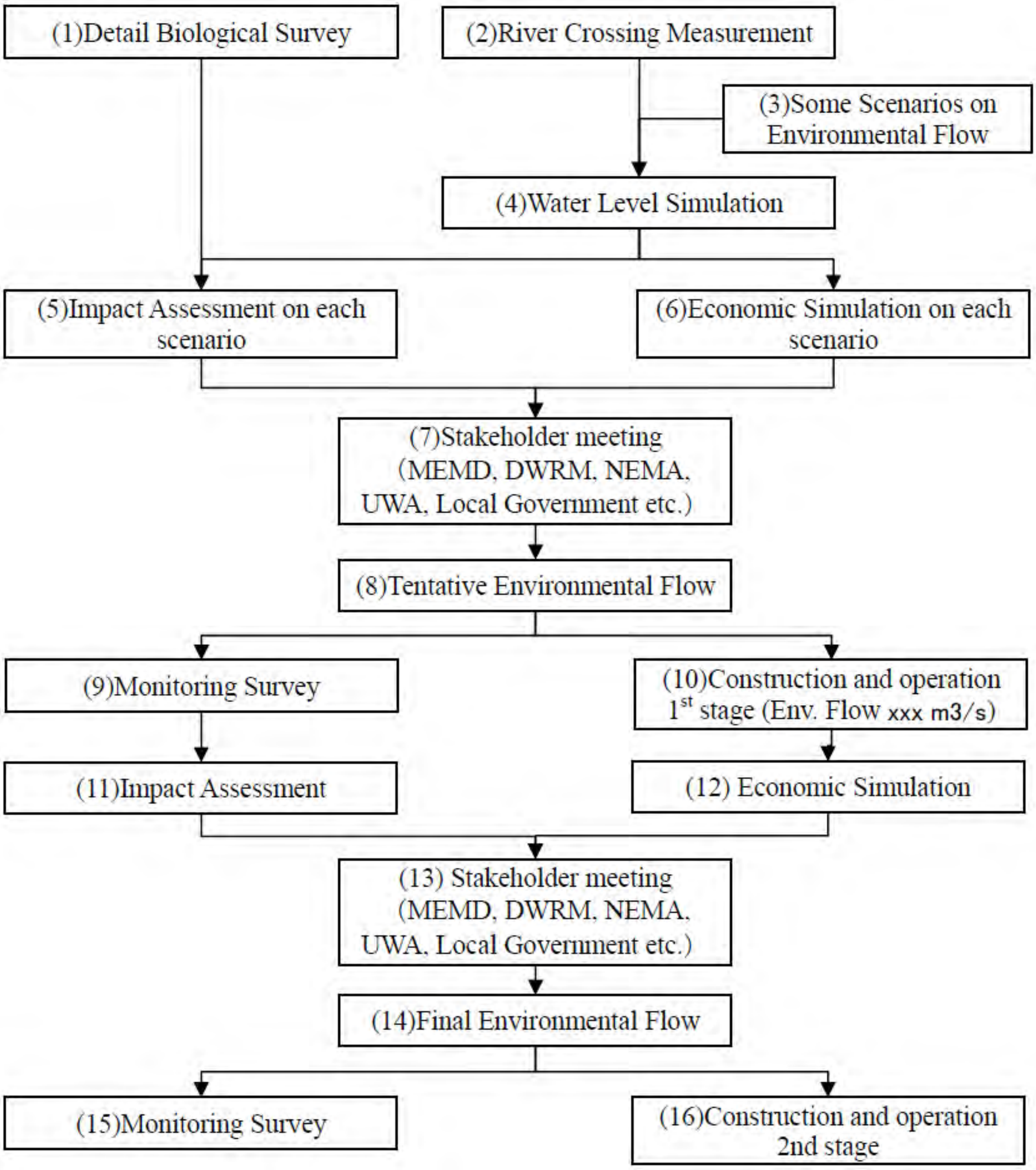


Figure 8.2.2-1 Sample procedure on determining the environmental flow

(1) Detailed Biological Survey

A Habitat survey of Hippopotamus, detailed distributional survey of Crocodiles, and detailed flora and fauna survey should be conducted. Although fauna and flora have already been briefly surveyed, it is still uncertain that the migration root of Hippopotamus, home range, preferred water depth, preferred velocity of water, resting area, feeding area and seasonal change of riverine vegetation and fauna have been exhaustively studied. A detailed survey lasting more than one year is recommended.

(2) River Crossing Measurement

More details on river crossing measurement are recommended. Although a brief river crossing measurement has been done in the pre-feasibility study, it is not accurate enough for simulation of water volumes. In order to conduct a detailed simulation, more intense distance measurement is required.

(3) Some Scenarios on Environmental Flow

Some environmental flow scenarios should be set with reference to the minimum flow of once in ten years.

(4） Water Level Simulation

Water level simulation should be done based on the scenarios. The simulation results should preferably be displayed using the lateral profile and plain view.

(5) Impact Assessment on each scenario

Impact Assessment should be conducted based on the detailed biological survey and water level simulation. If possible, estimation for a decreasing population should be done.

(6) Economic Simulation on each scenario

Economic evaluation of electric power business should be studied according to the set scenarios.

(7) Stakeholder meeting

After the biological impact assessment and economic study, a stakeholder meeting should be held to discuss the preferable environmental flow.

(8) Tentative Environmental Flow

After discussions in the stakeholder meeting, the environmental flow of the first stage shall be determined.

(9) Monitoring Survey of First stage（300MW）

A biological monitoring survey should be continued during construction and operations of the first stage.

(10） Construction and operations of 1st stage

Implement the construction of first stage and operate with of the tentative environmental flow of the first stage.

(11) Impact Assessment

Assess the impact of environmental flow based on the monitoring results for several scenarios.

(12) Economic Simulation

Study the economic evaluation of environmental flow for several scenarios.

(13) Stakeholder meeting

Hold a stakeholder meeting to review the results of the impact assessment and economic study and discuss the preferable environmental flow for the second stage.

(14) Determination of the Final Environmental Flow

Determine the final environmental flow for the second stage based on discussions ensuing from the stakeholder meeting.

(15) Monitoring survey second stage (600MW)

The monitoring survey, construction and operations should be kept to the second stage.

(16) Construction and operations of 2^{nd} stage

Implement for construction of second stage and operate along with the final environmental flow.

8.3 Cumulative Impact Assessment

In addition to the seven hydropower plants, some oil exploitation projects are being executed on the west side of the Murchison Falls National Park. Even if the impact of each of the projects is in the acceptable level, the total impact might cause serious challenges. The possibility of such a cumulative impact is reviewed as follows.

Table 8.3-1 Considered projects for cumulative impact assessment

Project Name	Project Type	Progress
Kalagala	Hydropower (330MW)	None (stopped by Kalagala offset)
Isimba	Hydropower (138MW)	Feasibility Study
Karuma	Hydropower (576MW)	Feasibility Study
Oriang	Hydropower (392MW)	None
Ayago	Hydropower (612MW)	Pre-feasibility study
Kiba	Hydropower (288MW)	None
Murchison	Hydropower (648MW)	None
(Oil drilling)	Oil Mining	Appraisal exploration

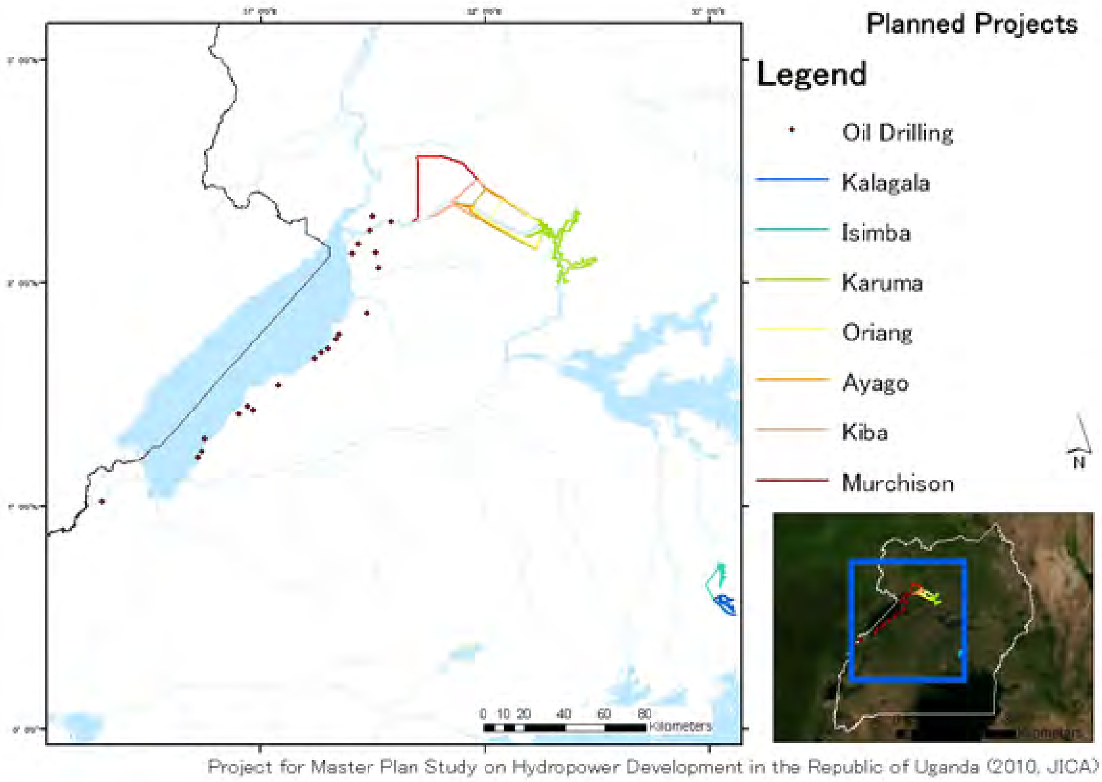


Figure 8.3-1 Considered projects for cumulative impact assessment

8.3.1 Physical Impact

The envisaged physical impacts include; increasing recession area, water pollution, and increase in traffic. Total recession area is 50.2 km (See Table 6.10.3-1). Estimated impact area is 1,075km^2. (suppose: estimated impact area is 1km from the project area.)

Table 8.3.1-1 Length of Recession

Project Name	MFNP	Outside	Total
Kalagala	0.0	0.0	0.0
Isimba	0.0	0.0	0.0
Karuma	11.3	2.4	13.7
Oriang	11.3	0.0	11.3
Ayago	8.6	0.0	8.6
Kiba	14.8	0.0	14.8
Murchison	1.8	0.0	1.8
Total	47.8	2.4	50.2

Table 8.3.1-2 Impact Area (1km buffer from the project site)

Project Name	Impact Area (km^2)
Isimba	117.2
Oriang	171.3
Kiba	258.9
Murchison	226.9
Kalagala	87.4
Karuma	337.0
Ayago	211.2
Oil	75.4
Overlap area	410.3
Total Impact Area	1,075.0

8.3.2 Cumulative Impact on protected area

In addition to estimated impact area and protected area, 432km^2 might be affected i.e. 6% of Murchison Falls National Park as well as 390km^2(10% of National Park might be affected)

Table 8.3.2-1 Cumulative impact on Protected Area

Protected Area	National (km^2)	Impact Area (km^2)	Percentage
Central Forest Reserve	2,396.9	8.3	0.3%
Wildlife Reserve	937.1	33.0	3.5%
Local Forest Reserve	10.4	0.6	5.5%
National Park	3,867.4	390.9	10.1%
Total	7,211.8	432.8	6.0%

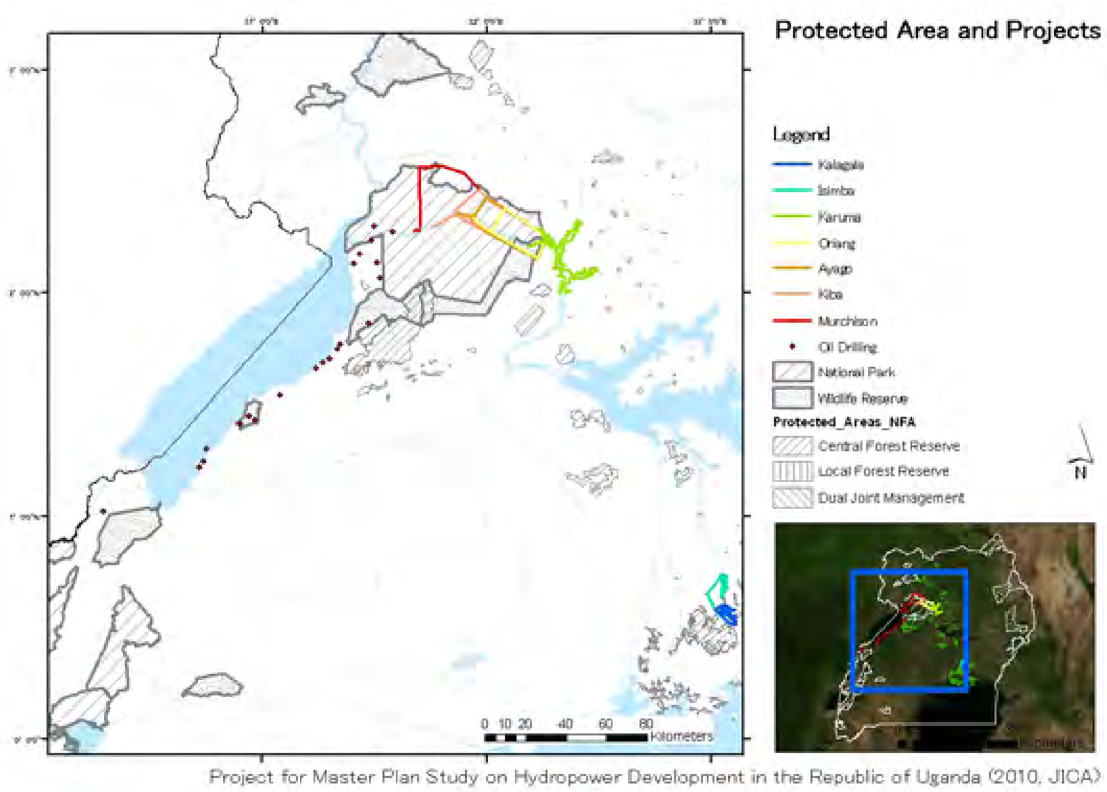


Figure 8.3.2-1 Cumulative Impact on protected area

8.3.3 Impact on Hippopotamus

According to UWA's survey (2005), approximately 2000 Hippopotamus are estimated to be living in the Murchison Falls National Park. If all the hydropower projects are constructed, 680 Hippopotamus, which is 34.2% of current population, are estimated to be effected.

Table 8.3.3-1 Estimated number of Hippopotamus Affected by Water Recession

Project Name	Length of Water Recession	Estimated number of Hippopotamus	Percentage of the Total in MFNP
Kalagala	0.0	0	0.0%
Isimba	0.0	0	0.0%
Karuma	11.3	162	8.1%
Oriang	11.3	162	8.1%
Ayago	8.6	123	6.1%
Kiba	14.8	212	10.6%
Murchison	1.8	26	1.3%
Total	47.8	684	34.2%

8.3.4 Impact on Encroachment and Poaching

Even though encroachment and poaching have already been confirmed as existent, they might increase because of improvement of access roads.

Particularly, poaching at south bank might increase because Oriang, Ayago and Kiba projects are planned at the same point.

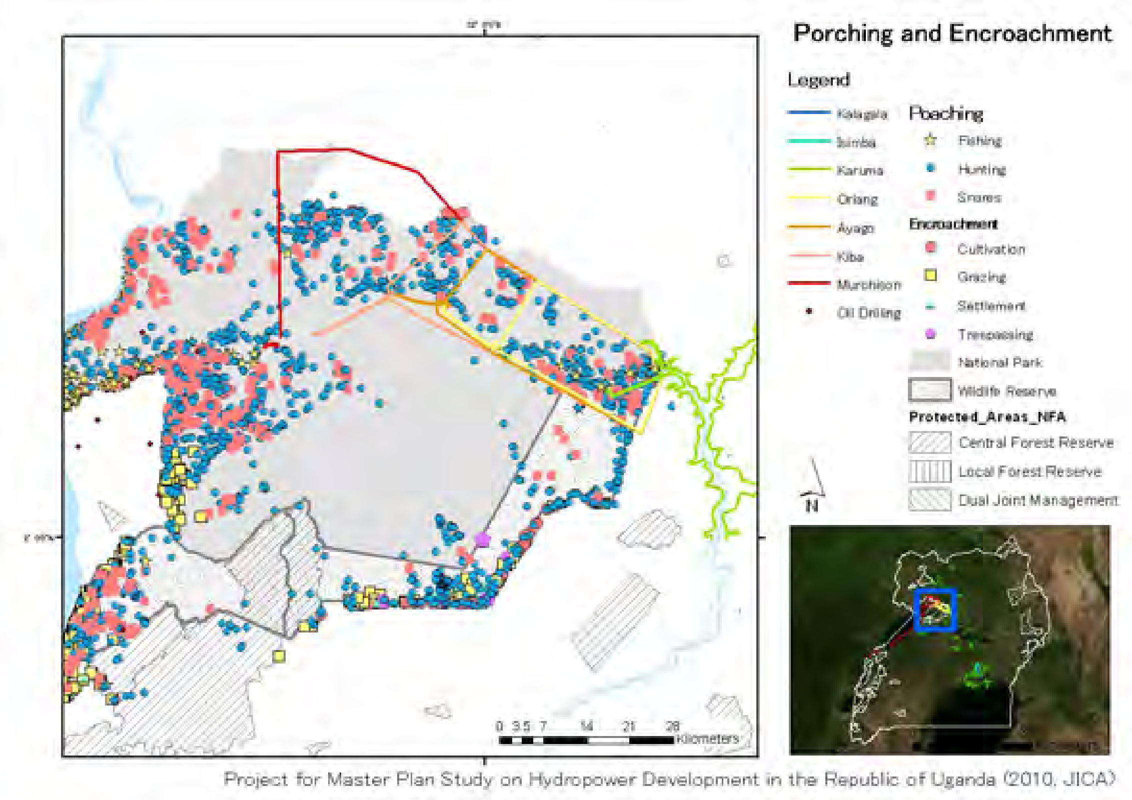


Figure 8.3.4-1 Illegal action and planned projects

8.3.5 Impact on Tourism within Murchison Falls National Park

The Construction period of the hydropower plant lasts between four and five years. If all the four projects in the national park start, the total construction period is thus 20 years. The Impact on Elephants, Giraffes and Lions might continue intermittently for a long period of time, because the constructed roads go through the densely populated area.

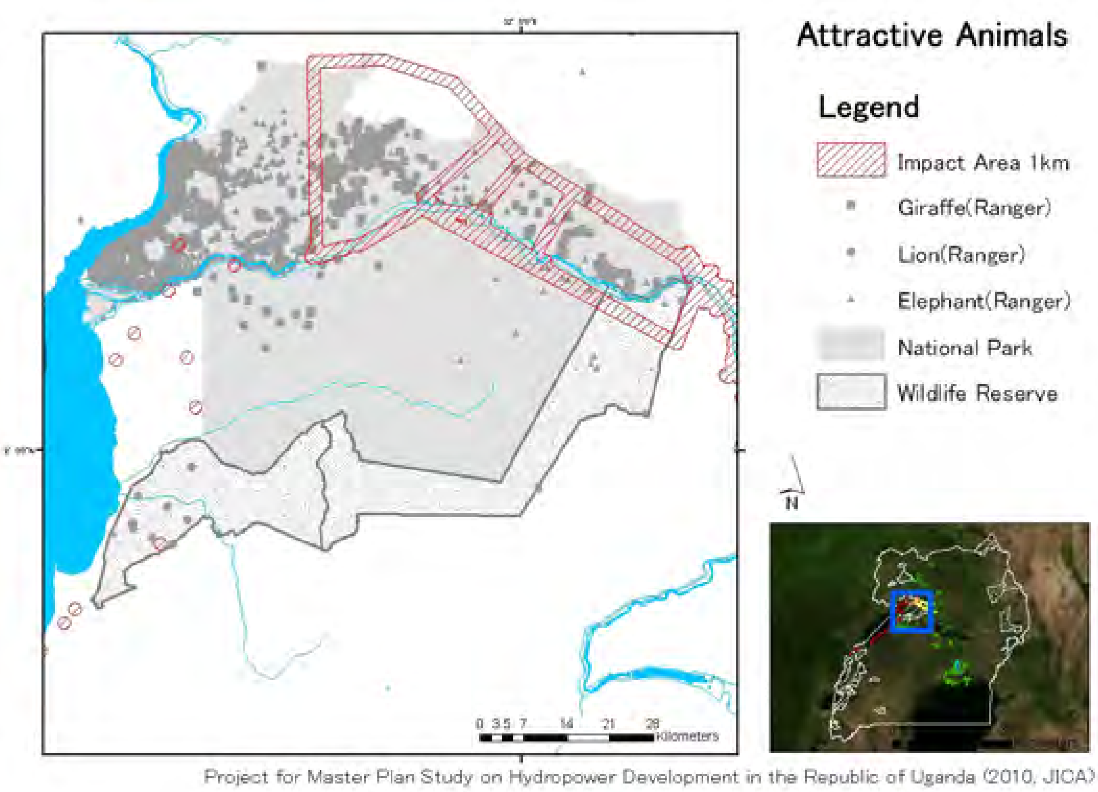


Figure 8.3.5-1 Attractive Animals and planned projects

8.3.6 General Evaluation of Cumulative Impact Assessment

If all the projects examined are put into operation, the length of recession will be 50.2 km in total and 34.2% of total habitat of hippopotamus might be lost. In the end the ecosystem, flora and fauna in the Murchison Falls National Park will be affected very much and the impact on tourism will be serious. When the hydropower project will be developed, it will be requested to decide the adequate environmental flow, study cumulative impact assessment and execute the measures for environment conservation.

Table 8.3.6-1 General Evaluation on Cumulative Impact

Items	Impacts	Significance
Length of Recession	50.2 km	Serious
Impact Area	1,075 km2	Middle
Impact on protected area	6.0 % of total protected area in the country	Serious
Impact on Hippopotamus	34.2 % of the total Hippopotamus population in the country	Serious
Poaching and Encroachment	Expansion of the poaching is anxious	Middle
Impact on tourism	Impact will be long and seriously.	Serious

8.4 Other Considerations

In addition to environmental and social considerations, the SEA study Stakeholder Meeting Guideline (Appendix E-1) Guidelines and Environment Database (Appendix E-2) as well as Environmental and Social checklist (Appendix F) are in place. These are attached in Appendices.

8.5 Information disclosure and Stakeholder meeting

Three stakeholder meetings were held in this Study. The first one focused on the overview of the Study and the consideration of the evaluation criteria in stage 1 and stage 2. The second one aimed to explain the results of stage 1 and 2 and to consider the study plan in stage 3. The objectives of the third one were to explain the results of stage 3 and to consider the Master Plan.

8.5.1 Summary of the First Stakeholder Meeting

- Date: 11th December 2009, 9:30-13:30
- Venue: Statistics House, Kampala, Uganda
- Participants: 47（Project Implementer: 12, Implementing Authority: 1, Relevant Ministry: 3, Relevant Authority/ Institution: 9, University: 0, NGOs: 4, Local Government (District): 0, Cultural leader/ Kingdom: 0, Media: 8, Donor: 5, Private sector: 5）
- Contents
  - Overview of the Master Plan Study
  - Explanation on Strategic Environmental Assessment (SEA)
  - Discussion on the evaluation criteria in stage 1 and stage 2 of SEA
- Major comments:
  - Nuclear power should be included in the comparative analyses as it produces clean and sustainable energy and produces much energy from little fuel. – The Study Team has included.
  - Evaluation Criteria in stage 2 should be expanded to include risk on human health. – The Study Team expanded the criteria to include it.
  - The environmental sensitivity of the project sites should be closely studied. Let's make an effort to make sure that the outline of the methodology is going to be fully implemented. – The Study Team planned the field survey during the third period of study in Uganda.
  - The Study should involve as many stakeholders as possible such as private sectors, NGO representatives, National Planning Authority, and National Investment Authority. – The Study Team invited the proposed stakeholders in the next meeting.
  - It is better to review District Development Plans of local governments along River Nile. – The Study Team agreed to review them.

- The Study Team should look at the Power Sector Investment Plan and see how best to synchronize the Hydropower Master Plan Study. – The Study Team will consider the Power Sector Investment Plan through the discussion with MEMD.
- The oil company is going to conduct field surveys in the Murchison Falls National Park since there is a possibility of oil production near Lake Albert. The company would like to exchange ideas with the Study Team. – The Study Team agreed on that.

8.5.2 Summary of the Second Stakeholder Meeting

- Date: 19th February 2010, 9:30-13:30
- Venue: Hotel Africana, Kampala, Uganda
- Participants: 67（Project Implementer: 12, Implementing Authority: 1, Relevant Ministry: 4, Relevant Authority/ Institution: 3,University: 1, NGOs: 5, Local Government (District): 5, Cultural leader/ Kingdom: 2, Media: 3, Donor: 5, Private sector: 14, JICA or Study team: 15）
- Contents:
  - Overview of the Master Plan Study
  - Discussion on the results of stage 1 and stage 2 of SEA
  - Explanation of TOR for Stage 3
- Comments:
  - Although the Government of Uganda has given the priority to the energy sector, this should not be at the expense or threat of choking other sectors of the national economy such as tourism which is a major revenue earner. UWA is very concerned that the Murchison Falls is being considered for hydropower development in the Master Plan. There is a need for the Ministry of Energy and Mineral Development (MEMD) and the Ministry of Tourism and Industry (MTTI) to discuss and come up with the best strategy for all the economic activities without putting at stake the wildlife. – MEMD will discuss with UWA.
  - Although it is concluded that hydro is the best energy source to meet the country's energy demands, did the study consider possible impacts of climate change on flows and that the possible reduction of flows might change the ranking of hydro? – The study team considered them based on the data of 100 years hydrology to come up with appropriate design discharges. Also, the Government of Uganda has come up with an energy mix strategy.
  - The current projections in oil development are that, heavy oil will be available for power generation by June 2010. Wouldn't this make heavy diesel oil power generation a cheaper option than Hydro sooner than later as projected in the Master Plan Studies? - The estimated quantities of production of heavy diesel oil for power productions do not

give the large capacities required by the load forecast. Hydro still remains on top.

- Kalagala offset is a government obligation in return for World Bank funding of the Bujagali Project. Does the inclusion of Kalagala in the Hydro Master Plan mean that government is retracting on its obligation on the implementation of projects under the Kalagala Offset? – The government is still committed to implementing programs under the "Kalagala Offset" that is why although Kalagala is ranked top, it is not being progressed to the Feasibility stage. However, when conditions change in future, it will be looked at in light of the changed conditions.
- I am not satisfied with the explanation given that small hydro and wind energy were not considered in this study. There are big impacts by micro hydro and wind power on rural villages/communities. - Small hydro and wind power can indeed have impact on rural communities. However, looking at the national demand forecast, several small hydro projects will be required to have a significant impact on the energy demand, while one large hydro project provides exactly that big impact required by the demand forecast.
- It is necessary for us to consider that existing /completed dams are not performing to expectations. - Poor performance of existing dams cannot be used as standard for all dams as several issues including design criteria vary.
- There is a concern that the construction of a dam may cause deforestation. - The projects are all run of river type and if any with small daily poundage reservoirs that will not cause any inundation. On the other hand it could be hoped that availability of electric power to a larger population will reduce charcoal burning and relieve pressure on the forests.
- It appears that the weighting was done from environmental perspective. Did the weighting also consider monetary weights in terms of revenue lost from tourism? – Yes.
- It was mentioned by the Permanent Secretary in his remarks that the study needs to be taken through the Feasibility level up to design and Tendering. Who makes that decision? - MEMD
- The Nile goes through many countries. Will there be a conflict of interest with countries such as Egypt? - This will be solved through political negotiations.
- While looking at power import, the study should critically examine the potentials of respective countries before recommending imports. - This will be considered.
- Increase in population will increase pressure on water usage and consequently reduce yield of flows and power generation. Did the study consider such a scenario and impact on downstream water uses? - The study under "hydrological studies" considers that minimum flows taken into consideration in determining design discharges will take care of such variations.
- The zoning of the Park as availed to the study team by UWA was done several years ago when there were no human activities in the park. This might have to be

reconsidered in light of oil drilling activities taking place in the west part of the conservation area. UWA would want to rezone the park area to enable animals move to less activity areas. So what was demarcated as moderate tourist activity would become a zone of intense tourism. - This will need to be discussed with all stakeholders.

- The opinion of a participant was that Slide 13 of the presentation of the third session with pictures that were taken by the study team after bush fires gave a wrong impression that the conservation area was clear and easy to access. He suggested that the area was an impenetrable forest during most of the year. - The picture was indeed taken after a bush fire, however the trees were not destroyed and the picture well shows the distribution of trees which is well confirmed by the satellite image.

8.5.3 Summary of the Third Stakeholder Meeting

- Date: 20th January 2011, 9:30-15:30
- Venue: Imperial Royale, Kampala, Uganda
- Participants: 100（Project Implementer: 22, Implementing Authority: 1, Relevant Ministry: 2, Relevant Authority/ Institution: 12, University: 2, NGO: 9, Local government (District): 13, Cultural leader: 2, Media: 3, Donor: 6, Private sector: 15, JICA or Study team: 12, Other: 1）
- Contents:
  - Explanation on the draft final report (Hydropower Master Plan, Pre-F/S at Ayago site, results of stage 3 of Strategic Environmental Assessment)
  - Discussion on the draft final report
- Comments:
  - The summary of multi-criteria ranking with hydro scoring the highest is interesting. However, it should be noted that there are costs involved in the mitigation involved in hydropower development. - This was noted by both the Ministry and the study team as well.
  - Why are solar and wind power not well placed in the multi-criteria decision making? - The multi-criteria decision making is just a summary. When you look at the detailed evaluation they were weighted, there are very many considerations like environment and social aspects.
  - How is the demand forecast carried out? When developing the NDP it was agreed that energy is necessary to stimulate economic growth and not vice versa. The demand forecast that was carried out in the study does not seem to take this into account. - The fact that energy is necessary to stimulate economic growth is represented in scenario V of the demand forecast.
  - Where will the thermal energy come from in the vision 2035 scenario? - According to

the Vision 2035, thermal will remain part of the energy mix and it may be imported into the country.

- It appears that there are quite a number of studies going on, what is the actual strategy that the government of Uganda going to achieve them? Are the funds available to implement these studies? - Even if the funds are not available, it is important for the government to have the plans in place and how it is going to achieve them, that's why the government has put in place the Energy Fund as well as the PPP's. However, it is also important to have the documents in place so as to solicit for the funds from the donors.
- In order to have economic viability, the proposed transmission lines should have timelines attached. - Detailed designs and timelines will be prepared by UETCL.
- Suggested that most important parameter for power generation is the volume of water, did the study consider inflows from the catchment areas of the tributary rivers? - The Study Team includes hydrologists who have collected and analyzed all hydrological data including inflows from tributaries in order to come up with design flows.
- In slide 29, it is indicated that the 3rd 100MW at Ayago comes on line in 2024. Why are we waiting for that long? - This study tries to combine realistic demand and NDP aspirations. In this regard, the study shows the minimum that we must achieve.
- Why has the consultant recommended more drilling when so far there are no serious problems? - This investigation is not conclusive. Additional work has to be done even if so far no serious problems have been encountered.
- It has been noted that most of the TOR for EIAs are not well costed. Mitigation is not well catered for. How is MEMD going to handle the mitigation? - Mitigation measures will have to be carried out because there will be a monitoring team to ensure this. If necessary, additional resources will be obtained to carry out the mitigation.
- Are the cultural sites being protected so that they can attract more tourists? - There are some that are protected and others that still need some more studies to know their significance and this will be captured in the EIA.
- Looking at the seven candidate projects that were considered for the study, Karuma and Ayago are so close. Were other parts of the country considered? - Yes. Mini-hydros are being considered under the renewable energy in various parts of the country, but this particular study is mainly looking at big impact hydros of over 500MW like Ayago.
- What proportion of the water will be diverted into the pipes and will there be any environmental impact? - The proportion of water to be used will depend on the EIA as well as the capacity of the plant.
- Are there people expected to be displaced by the project? If so, who are they and how are they affected? - The whole idea of the study is partly to know whether there is any impact on the people around the project area. For Ayago in particular, there are no

people affected because of its location in the park.

The tables below show the list of organizations and NGOs which attended the stakeholder meetings.

Table 8.5.3-1 List of Organizations for Stakeholder Meetings (1st, 2nd and 3rd)

Category	Name of Organization
Project Implementer	Ministry of Energy and Mineral Development (MEMD)
Implementing Authority	National Environmental Management Agency (NEMA), Uganda Wildlife Authority (UWA), Directorate of Water Resource Management (DWRM)
Relevant Ministry	Ministry of Local Government (MOLG), Ministry of Tourism, Trade and Industry (MTTI), Ministry of Gender, Labor and Social Development (MGLSD)
Local Government (District)	Jinja, Kamuli, Mukono, Kayunga, Masindi, Kiryandongo, Buliisa, Apac, Nakasongola, Bundibugyo
Relevant Authority/ Institution	National Forest Authority (NFA), National Planning Authority (NPA), Electricity Regulatory Authority (ERA), Uganda Electricity Generation Company Ltd (UEGCL), Uganda Electricity Transmission Company Ltd (UETCL), National Water and Sewerage Corporation (NWSC), Rural Electrification Agency (REA), Uganda Industrial Research Institute, Nile Basin Initiative (NBI)
University	Makerere University, Kyambogo University
NGO	International Union for Conservation of Nature (IUCN), World Wildlife Fund (WWF), Nile Basin Discourse (NBD), Uganda Wildlife Society (UWS), National Association for Professional Environmentalists (NAPE), AFIEGO (African Institute for Energy Governance), Nature Uganda, Plan Team East Africa
Cultural leader	Busoga, Bunyoro, Lango
Donor	World Bank, African Development Bank, European Investment Bank,GTZ, KFW, Norwegian Embassy, French Department Agency, UNIDO, the Embassy of Japan, JICA
Media	Daily Monitor, New Vision, Vision Voice, Kampala FM, B/TV, UBL/TV, The Reporter, Redpaper
Private Sector	WSS Ltd., AZ Consultant, Energy Infratech Ltd., Bujagali Energy Limited, Oil companies (Tullow, Heritage), Pictures of Africa, Henley Infrastructure, SPL/PB Power, China CAMCE Engineers Co. Ltd., SMEC Consulting, Ultimate Consult

Table 8.5.3-2 List of NGOs for Stakeholder Meetings (1st, 2nd and 3rd)

Name	Main Activities
IUCN (International Union for Conservation of Nature)	IUCN is the world's oldest and largest global environmental network - a democratic membership union with more than 1,000 government and NGO member organizations, and almost 11,000 volunteer scientists in more than 160 countries. It has supported the World Commission on Dams (WCD). The government of Uganda has picked IUCN to provide technical input and provide the lead in the development of the sustainable management plan of Kalagala-Itanda Offset. (http://www.iucn.org/)
WWF (World Wide Fund for Nature)	WWF Uganda is part of the global network of WWF International. It has the Oil and Gas Project beside Lake Albert and monitors environment risk of the area. It also supports UWA through the International Gorilla Conservation Programme in Bwindi National Park under collaborative forest management schemes. (http://wwf.panda.org/esarpo)
NBD (Nile Basin Discourse)	NBD was officially launched in December 2003. It was founded primarily to strengthen the voice of civil society in development projects and programmes of the NBI and to ensure that NBI responded to the development needs of local communities. It is a network of the 10 countries of the Nile Basin; Burundi, DRC, Egypt, Eritrea, Ethiopia, Kenya, Sudan, Rwanda, Tanzania and Uganda. Currently, the NBD is working to a three-year programme with two-years funding from DFID, UK. (http://www.nilebasindiscourse.org/)
UWS (Uganda Wildlife Society)	It was founded in 1998 with members from academia, the public sector, the private sector and the general public, UWS is committed to promoting the conservation of wildlife and environment in Uganda. It is one of the largest and diverse membership-based conservation groups. It is supported by many donors such as DANIDA, USAID, FAO, UNEP and IUCN. (http://www.uws.or.ug/)
NAPE (National Association for Professional Environmentalists)	NAPE was formed in 1997 in Uganda. It works on many environmental issues with specific focus on undertaking lobbying and advocacy for sustainable use of natural resources in the areas of water and energy. It is a founder member of the African Rivers Network that brings together African civil society organizations and dam-affected communities. It is also a member of Friends of the Earth International. (http://www.nape.or.ug/)
AFIEGO (African Institute for Energy Governance)	AFIEGO was registered in 2004. The idea of establishing AFIEGO came in after realizing the gaps in the formulation and enforcement of policies and laws in the energy sector across the world. It is carrying out a number of activities to see that the Government of Uganda uses the country's resources for the benefit of its citizens. (http://www.afiego-ug.org/)

8.5.4 Consideration of Downstream and Neighboring Countries and International Watercourse

Around Lake Victoria, which is the source of Victoria (White) Nile, there are several countries such as Kenya, Tanzania, Rwanda, Burundi and Democratic Republic of Congo. Ethiopia and Eritrea are located at the source of Blue Nile. In addition, Sudan and Egypt are located in downstream of the River Nile.

Nile Basin Initiative (NBI) was established in February, 1999. It is a regional partnership among nine countries; Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda, working together to develop the resources of the Nile Basin for the benefit of all. NBI Secretariat is located in Entebbe in Uganda. It is a transitional mechanism to begin the implementation of the shared vision: "to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the common Nile Basin water resources". It has a strong support from a many bilateral and multilateral development partners coordinated by the World Bank.

To translate the shared vision into action, the NBI has launched a Strategic Action Program, which includes two complimentary programs and a Cooperative Framework Strategy.

(1) A basin wide Shared Vision Program (SVP) creating a basin wide enabling environment for sustainable development.

The SVPs includes the following projects:

- Nile Trans-boundary Environment Action Project (NTEAP)
- Nile Basin Regional Trade (RPT)
- Efficient Water Use for Agricultural Production (EWUAP)
- Water Resources Planning and Management (WRPM)
- Confidence Building and Stakeholder Involvement (CBSI)
- Applied Training Project(ATP)
- Socio-Economic Development and Benefit-Sharing (SDBS)

(2) Subsidiary Action Programs (SAPs).

The SVP is comprised of grant based activities to foster trust and cooperation and build an enabling environment for investment. The SAPs are the vehicle for the Nile Basin countries to engage in concrete activities for long term sustainable development, economic growth and regional integration. The SAPs includes the following programs:

- Eastern Nile Subsidiary Action Program (ENSAP)
- Nile Equatorial Lakes Subsidiary Action Program (NELSAP)

More information and the key achievement of the projects/programs can be found at the webpage (http://www.nilebasin.org/).

(3) The Nile Basin Cooperative Framework

The Nile Basin countries are also pursuing through an institutional dialogue process using negotiators and a panel of experts, the establishment of a Legal Cooperative Framework for the NBI to sustain cooperation in the Nile Basin.

In May 2010, five upstream countries such as Ethiopia, Kenya, Uganda, Rwanda and Tanzania signed a Cooperative Framework Agreement to seek more water from the River Nile. This was strongly opposed by Egypt and Sudan. An Egyptian government spokesman insisted that Egypt would not join or sign any agreement that affects its share. Representatives of upstream countries said they were tired of first getting permission from Egypt before using river Nile water for any development project like irrigation, as required by a treaty signed during the colonial era between Egypt and Britain in 1929. The new agreement, once effective, will transform the NBI into a permanent Nile River Basin Commission.

Therefore, in order to avoid international complication on the Nile, it is better to disclose information on hydropower development in Uganda to Nile Basin countries as much as possible. Since Egypt and Sudan are conscious on water use for irrigation by Uganda, it is necessary to take possible measures with appropriate timing such as inviting both countries for stakeholder meetings in Uganda, disclosing information on the webpage, and informing them of the progress.

For example, during the EIA stage, the hydropower development project at Bujagali sent a letter from Ministry of Foreign Affairs of Uganda to the governments of downstream and neighboring countries to inform them of the project summary (project area map, design and TOR). Then, the Ministry received a reply of "No objection letter" by Egypt. Similar procedure is advisable for the future hydropower project in Uganda.

8.6 Environmental Law and Regulations

8.6.1 Laws and Regulations of Uganda

(1) EIA Laws and regulations

In terms of Stage 1 and Stage 2, the Environmental and Social study followed Guidelines for Strategic Environment Assessment and the other environmental Act, Policy and constitution, because the stages have no site survey in the National Park.

- GUIDELINES FOR STRATEGIC ENVIRONMENT ASSESSMENT (SEA) (December 2006, NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY)
- The Constitution of Uganda (1995, article 39: Every Ugandan has a right to a clean and

healthy environment)

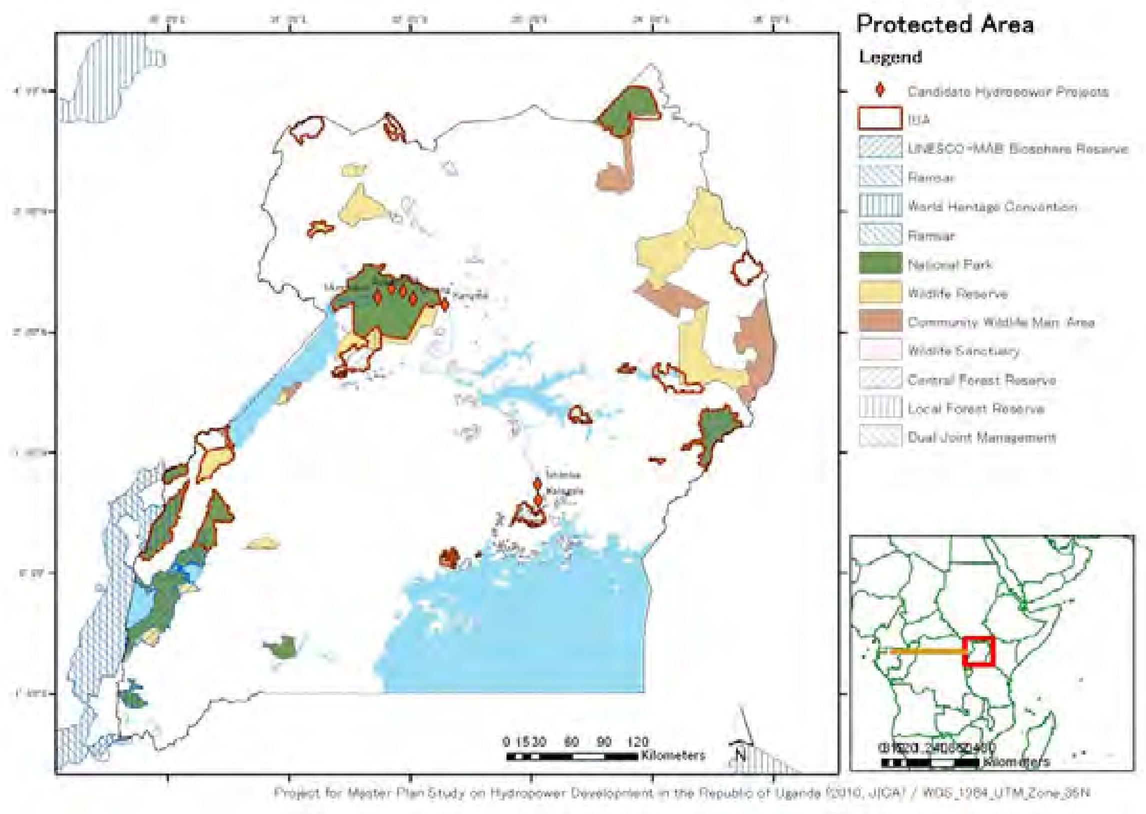
- The National Environment Policy, 1994, Energy Policy, Renewable energy policy and various sectoral policies
- National Environment Act CAP 153

In terms of stage 3, the study followed the EIA regulation too, because it includes site survey in the National Park. After the submission of the project brief, NEMA concluded NEMA approved the survey with the conditions (there is no need to conduct neither EIA nor IEE for the survey).

- NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY (June 2004) "ENVIRONMENTAL IMPACT ASSESSMENT GUIDELINES FOR THE ENERGY SECTOR"
- National Environment Management Authority (July 1997) "GUIDELINES FOR ENVIRONMENTAL IMPACT ASSESSMENT IN UGANDA"
- The Environmental Impact Assessment Regulations, 1998, UPPC

(2) Protected areas

Many kinds of protected areas, such as national parks, Wildlife Reserves, and Community Wildlife Management Areas, are in Uganda. The largest national park is Murchison Falls National Park, which is 3,867km^2, the same size as Saitama Prefecture (see Figure 8.6.1-1).



(Source: World Database on Protected Areas (http://www.wdpa.org)/ National Forest Authority Uganda/ Nature Uganda (JICA revised)

Figure 8.6.1-1 Protected Area in UGANDA (WGS_1984_UTM_Zone_36N)

Table 8.6.1-1 Protected area designated by Government of Uganda

Name of the protected area			Law	Management Organization	Definition / Purposes	Prohibited Action	Allowed Action
Wildlife Conservation Areas	Wildlife Protected Area	National Park	Uganda Wildlife Act 1996	Uganda Wildlife Authority (UWA)	(a) to preserve selected examples of the biotic communities of Uganda and their physical environments; (b) to protect areas of aesthetic beauty and of special interest; (c) to preserve populations of rare, endemic and endangered species of wild plants and animals; (d) to assist in water catchment conservation; (e) to generate economic benefits from wildlife conservation for the people of Uganda; (f) without prejudice to the purposes listed in paragraphs (a) to (d), of this subsection, and within any limitations imposed by them, to provide facilities for studying the phenomena in the wildlife conservation area for the advancement of science and understanding; and (g) without prejudice to the purposes listed in paragraphs (a) to (e), of this subsection, and within any limitations imposed by them, to provide facilities for public use and enjoyment of the resources in the wildlife conservation area.	(a) hunts, takes, kills, injures or disturbs any wild plant or animal or any domestic animal; (b) takes, destroys, damages or defaces any object of geomorphological, archaeological, historical, cultural or scientific interest, or any structure lawfully placed or constructed; (c) prepares land for cultivation, prospects for minerals or mines or attempts any of these operations; (d) drives, conveys or introduces any wild animal into a wildlife conservation area; (e) wilfully drives, conveys or introduces any domestic animal into a national park or negligently permits any domestic animal, of which he or she is for the time being in charge, to stray into a wildlife conservation area; (f) starts or maintains a fire without lawful authority, commits an offence.	(a) biodiversity conservation; (b) recreation; (c) scenic viewing; (d) scientific research; and (e) any other economic activity.
		Wildlife Reserve	Uganda Wildlife Act 1996	Uganda Wildlife Authority (UWA)			(a) conservation of biological diversity; (b) scenic viewing; (c) recreation; (d) scientific research; and (e) regulated extractive utilisation of natural resources.
	Wildlife Management Area	Wildlife Sanctuary	Uganda Wildlife Act 1996	Uganda Wildlife Authority (UWA)	(a) to so manage and control the uses of land by the persons and communities living in the area that it is possible for wildlife and those persons and communities to coexist and for wildlife to be protected; (b) to enable wildlife to have full protection in wildlife sanctuaries notwithstanding the continued use of the land in the area by people and communities ordinarily residing there; (c) to facilitate the sustainable exploitation of wildlife resources by and for the benefit of the people and communities living in the area; (d) to permit the sustainable exploitation of the natural resources of the area, by mining and other like methods in a manner which is compatible with the continued presence in the area of wildlife; (e) to carry out such of the purposes of a wildlife conservation area as are compatible with the continued residence of people and communities in the wildlife management area and the purposes under paragraphs (a) and (b) of this subsection.		Activities which are not going to be destructive to the protected species or its habitat
		Community Wildlife Area	Uganda Wildlife Act 1996	Uganda Wildlife Authority (UWA)			individuals who have property rights in land may carry out activities for the sustainable management and utilisation of wildlife if the activities do not adversely affect wildlife

Name of the protected area	Law	Management Organization	Definition / Purposes	Prohibited Action	Allowed Action
Central Forest Reserve	National Forestry Tree Planting and Tree Planting Act (2003)	National Forest Authority (NFA)	A site of Special Scientific Interest: (i) protecting nature and scenic areas of national or international importance; (ii) enhancing biological genetic resources in an undisturbed, dynamic and evolutionary state; (iii) maintaining animal and plant indicator species; or (iv) preserving rare, endangered or vulnerable species, or high biological diversity; A strict nature reserve; (i) protecting streams, rivers, lakes, lakeshores, riverbanks or wetlands; (ii) soil, slope and environment protection; or (iii) protecting the ecosystem; Recreation forest: Eco-tourism	No person shall, in a forest reserve, cut, disturb, damage, burn or destroy any forest produce, or remove or receive any forest produce except – (a) in accordance with regulations or guidelines made for the proper management of the forest reserve; (b) in the course of the management of the forest reserve by the responsible body; (c) in terms of the exercise of a right or interest in the forest reserve; or (d) in accordance with a license issued under this act.	Management Plan for each Forest Reserve will identify the actions.
Local Forest Reserve		National Forest Authority (NFA)			Management Plan for each Forest Reserve will identify the actions.

Table 8.6.1-2 Definition of International Conservation Area

Name of the protected area	Programme/ Convention	Related Organization	Definition
UNESCO-MAB Biosphere Reserve	Man and the Biosphere Programme	UNESCO/ UWA	* Sites of excellence where new and optimal practices to manage nature and human activities are tested and demonstrated; * Tools to help countries implement the results of the World Summit on Sustainable Development and, in particular, the Convention on Biological Diversity and its Ecosystem Approach; * Learning sites for the UN Decade on Education for Sustainable Development.
World Heritage Convention	-	UNESCO/ UWA	Natural Criteria (i) "contains superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance" (ii) "is an outstanding example representing major stages of Earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features" (iii) "is an outstanding example representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems, and communities of plants and animals" (iv) "contains the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation"
Ramsar	The Convention on Wetlands (Ramsar, Iran, 1971)	Wetlands Management Department (WMD)	A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
Important Bird Areas (IBA)	-	Bird Life International	IBAs are key sites for conservation – small enough to be conserved in their entirety and often already part of a protected-area network. They do one (or more) of three things: •Hold significant numbers of one or more globally threatened species •Are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species •Have exceptionally large numbers of migratory or congregatory species

If someone needs to do unlawful act in wildlife conservation area, EIA procedure will be needed. Following the citation of the Uganda Wildlife Act (1996).

Table 8.6.1-3 Procedure of unlawful act in a wildlife conservation area

24. Authority to carry out an otherwise unlawful act in a wildlife conservation area.
  (1) If the executive director is satisfied that an otherwise unlawful act specified by this Act should be carried out in any wildlife conservation area in the interests of better wildlife management, he or she shall require an environmental impact assessment to be carried out on the subject and shall submit the results of the environmental impact assessment to and request the opinion of the board.
  (2) If the board, having considered any matter submitted by the executive director under subsection (1), is of the opinion that an otherwise unlawful act should be carried out in the interest of better wildlife management, it shall issue written instructions to any officer or person authorising him or her to undertake the otherwise unlawful act.
  (3) The board may, at any time delegate, in writing, to the executive director, power to permit certain acts covered by this section which are determined by the board to be of a minor character.

(Source: Uganda Wildlife Act, 1996)

(3) Other permits for hydropower development

In order to proceed with the hydropower project following permits will be needed before construction. These permits are needed even if project is outside of the National Park.

Table 8.6.1-4 Needed Permits for Hydropower Project

Permits	Legal basis	Issuing Authority
Permit to enter or reside in a Wildlife Reserve, OR authority to carry out an otherwise illegal activity	The Wildlife Act CAP 200	UWA
Certificate of Approval of EIA	The National Environment Act CAP 153	NEMA
Wetlands, River Banks use permit	The National Environment (Wetlands, River Banks and Lakeshores Management) Regulations	NEMA
Pollution licenses including waste storage, transportation and disposal	The National Environment (Waste Management) Regulations, 1999	NEMA
Waivers on limits on use of lakes and rivers	The National Environment Act CAP 153	NEMA
Licence to dredge the Nile River	The Rivers Act	Ministry of Water and Environment
Construction permit	The Water Act CAP 152	Directorate of Water Resources Development
Surface Water Abstraction Permit	The Water Act CAP 152	Directorate of Water Resources Development

In terms of storage and dispensing facilities of Hydrocarbons the project proponent needs;

1. To carry out an EIA for approval of storage and dispensing facilities;
2. To apply for a construction permit from the commissioner of Petroleum Supply; and
3. To apply for an operating license from the commissioner of Petroleum Supply.

All this is provided for in the Petroleum Supply Act, 2003, and the Petroleum Supply (General) Regulations of 2009.

8.6.2 Compliance with JICA Guidelines for Environmental and Social Considerations

This study is a Preparatory Survey (Technical cooperation project) which is JICA's support for preparation of Master Plan Study on Hydropower Development in the Republic of Uganda. This study follows JICA GUIDELINES FOR ENVIRONMENTAL AND SOCIAL CONSIDERATIONS (April 2004). This project applies the policy of Strategic Environmental Assessment for all three stages in terms of Environmental and Social considerations, because the project stage is before feasibility study.

Table 8.6.2-1 JICA Guidelines for Environmental and Social considerations (April 2004)

III. Procedures of Environmental and Social Considerations

3.2 Development Study (Master Plan Study)

3.2.3 Full-scale Study Stage

1. JICA involves a member(s) for environmental and social considerations in study teams for Category A and B studies;
2. JICA collects relevant information and conducts field surveys covering a wider area than that of the preparatory study stage, holds consultations with the recipient governments, and prepares drafts of scoping;
3. For Category A studies, JICA consults with local stakeholders in collaboration with the recipient governments after disclosure of drafts of scoping, and incorporates results of consultation into TOR. The consultation widely covers the needs of projects and the analysis of alternatives. For Category B studies, JICA consults with local stakeholders in collaboration with the recipient governments after the disclosure of drafts of scoping when necessary;
4. The TOR includes an understanding of needs, the impacts to be assessed, study methods, an analysis of alternatives, a schedule and other matters. JICA endeavors to incorporate the concept of Strategic Environmental Assessment into such studies. JICA then obtains an agreement on the TOR with the recipient governments through consultations;
5. In accordance with the TOR and in collaboration with the recipient governments, JICA conducts IEE-level environmental and social considerations studies, and analyzes alternatives including a "without project" situation. During studies, JICA incorporates its results into related reports prepared in a process accordingly;

6. For Category A studies, when preparing a rough outline of environmental and social considerations, JICA holds a series of stakeholder consultations in collaboration with the recipient governments after information disclosure and incorporates the result of consultation into these studies. For Category B studies, JICA consults with local stakeholders after information disclosure in collaboration with the recipient governments, when necessary;
7. Based on the above-mentioned procedure, JICA prepares drafts of the final reports incorporating results of environmental and social considerations studies, and explains them to the recipient governments to obtain their comments. For Category A studies, JICA discloses the drafts to and consults with local stakeholders in collaboration with the recipient governments, and incorporates the results of that consultation into the final reports. For Category B studies, JICA consults with local stakeholders in collaboration with the recipient governments after disclosure of drafts of the final reports when necessary;
8. JICA prepares final reports incorporating results of study, and submits them to the recipient governments after confirming that the reports meet the requirements of the guidelines; and
9. JICA discloses final reports promptly after their completion, on its website and at the JICA library and a relevant overseas office.

If JICA carry on feasibility study, JICA GUIDELINES FOR ENVIRONMENTAL AND SOCIAL CONSIDERATIONS (April, 2010) will be applied. Appendix 1 of the guideline indicates the basic principle of the JICA projects. Fulfillment of the requirements must be confirmed when JICA decide whether JICA will support the project or not.

Table 8.6.2-2 JICA Guidelines for Environmental and Social considerations (April 2010)

Appendix 1. Environmental and Social Considerations Required for Intended Projects

4. Compliance with Laws, Standards, and Plans

1. Projects must comply with the laws, ordinances, and standards related to environmental and social considerations established by the governments that have jurisdiction over project sites (including both national and local governments). They must also conform to the environmental and social consideration policies and plans of the governments that have such jurisdiction.
2. Projects must, in principle, be undertaken outside of protected areas that are specifically designated by laws or ordinances for the conservation of nature or cultural heritage (excluding projects whose primary objectives are to promote the protection or restoration of such areas). Projects are also not to impose significant adverse impacts on designated conservation areas.

6. Ecosystem and Biota

1. Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests.
2. Illegal logging of forests must be avoided. Project proponents etc. are encouraged to obtain certification by forest certification systems as a way to ensure the prevention of illegal logging.

8.6.3 Requirement Environmental Considerations for feasibility study

Ayago is a Selected Prospective Hydropower Project in this study. The Ayago project is located in the middle of the National Park and some IUCN red list species are confirmed in the project area. Then it is not avoided to cause some impact on these protected areas and wildlife. If MEMD conducts Ayago Project using donors support, MEMD has to keep donors policies such as World Bank, African Development Bank, JICA and so on. Followings are the other donors' guidelines. Including JICA Guidelines all of the guidelines are requiring highly consideration on protected area. It means sufficient mitigation measures needed based on detail baseline survey and scientific impact assessment following Ugandan laws such as 21 and 24 of Wildlife Act (Table 8.6.2-2) etc. for the feasibility study stage.

Table 8.6.3-1 Operational Policies of World Bank

OP 4.04 - Natural Habitats

Project Design and Implementation

4. The Bank does not support projects that, in the Bank's opinion, involve the significant conversion or degradation3of critical natural habitats.

5. Wherever feasible, Bank-financed projects are sited on lands already converted (excluding any lands that in the Bank's opinion were converted in anticipation of the project). The Bank does not support projects involving the significant conversion of natural habitats unless there are no feasible alternatives for the project and its siting, and comprehensive analysis demonstrates that overall benefits from the project substantially outweigh the environmental costs. If the environmental assessment4indicates that a project would significantly convert or degrade natural habitats, the project includes mitigation measures acceptable to the Bank. Such mitigation measures include, as appropriate, minimizing habitat loss (e.g., strategic habitat retention and post-development restoration) and establishing and maintaining an ecologically similar protected area. The Bank accepts other forms of mitigation measures only when they are technically justified.

6. In deciding whether to support a project with potential adverse impacts on a natural habitat, the Bank takes into account the borrower's ability to implement the appropriate conservation and mitigation measures. If there are potential institutional capacity problems, the project includes components that develop the capacity of national and local institutions for effective environmental planning and management. The mitigation measures specified for the project may be used to enhance the practical field capacity of national and local institutions.

7. In projects with natural habitat components, project preparation, appraisal, and supervision arrangements include appropriate environmental expertise to ensure adequate design and implementation of mitigation measures.

Table 8.6.3-2 African Development Bank Group's Policy on the Environment

Protecting Global Public Goods

5.1.6 Coupled with the environmental problems facing Africa is its increasing marginalization by the process of globalization. To be able to share in the benefits and opportunities offered by globalisation, it is accepted that there will be a need to: (i) accelerate the economic growth rates by raising the levels and productivity of investment and attracting larger volumes of international capital; (ii) reorient economic policies, with major policy reforms and greater participation of the private sector; (iii) increase competitiveness of traditional exports, while diversifying them; and (iv) enhance regional integration and strengthen cooperation arrangements. Fortunately, Africa is endowed with a rich resource base consisting, among others, of minerals, oil and gas deposits which can provide a basis for mining and industrial development. Its rich flora and fauna, and wide expanses of natural habitats offer excellent opportunities for tapping into the potential of the global tourism industry, which remains the fastest growing industry in the world.

5.3.5 Global Public Goods represent a unique opportunity for Africa to reverse the downward trend in the flow of ODA. In fact, the continent is a large producer of goods that have international and global benefits. Their protection will, therefore, require global efforts and the Bank will, in the context of its normal lending programs, encourage RMCs to protect and manage natural parks and nature reserves, mangroves, reefs and lagoons, and encourage the inclusion of GPG concepts and practices in public sector operations. It will support the implementation of people-oriented programs that emphasize developing management systems and technological packages and incentives for expanding forest cover and tree integration with agricultural production systems. The Bank will, furthermore, promote the role of private sector in financing initiatives to combat climate change, particularly in the use of permit trading as a major mechanism to implement the Kyoto Protocol. It will specially emphasise the role of women in the conservation of biological diversity and the sustainable use of biological resources.

Chapter 9

Implementation Plan

Chapter 9 Implementation Plan

9.1 Funding Plan

The conceivable financial sources for Ayago hydropower project are Uganda government budget (Energy Fund), multi- and bilateral development aid and private-sector investment. In examining the funding plan for Ayago, it is necessary to take into account the fund requirements of the other 2 large hydropower plans: Karuma and Isimba hydropower projects planned to be developed in a not-too-distant future.

The largest of IPP cases by private investment in Uganda is Bujagali[1] hydropower project with an installed capacity of 250 MW. As shown in Box 1, there are a number of financial stakeholders and a complicated financial structure has been formed, requiring necessarily time-consuming coordination of interests among the stakeholders. At the same time, IPP would involve uncertainties in timely funding and, in most cases, may bring about unexpected delay in implementation; for example, Karuma[2] hydropower project was originally promoted as IPP by a Norwegian developer NORPAK, who withdrew from the project in 2009, and is now being promoted as a government project toward construction start in 2011.

Ayago hydropower project should be put in service from around 2020. In order to arrive at that target year, a relatively surer and steadier way of funding should be sought. One of such ways may be a combination of government funding and donors' aid. This section will discuss its possibility.

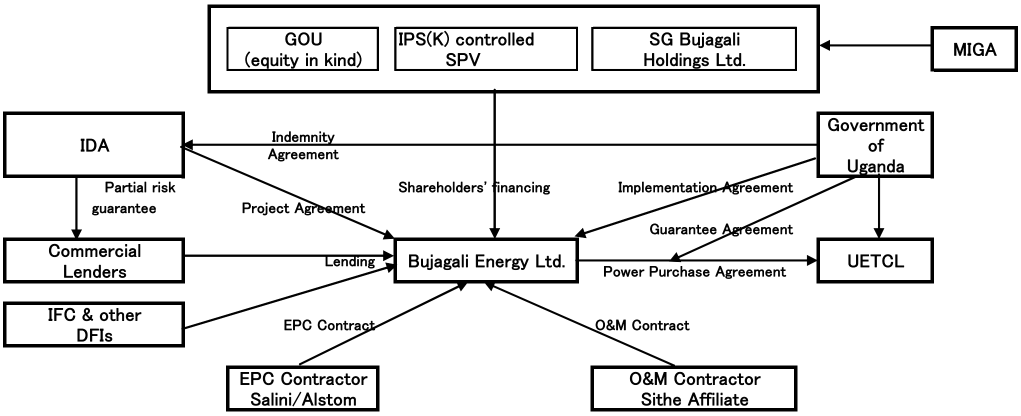
[1] Bujagali project was being developed toward commissioning in 2005 by AES Corporation, an American developer, who withdrew from the project in 2003 and then the actual sponsors of AFKED (Aga Khan Fund for Economic Development)and SITHE took over to start the construction in 2007 for commissioning in 2011.

[2] A Norwegian developer NORPAK obtained a developing right in 1995 and conducted a feasibility study and EIA, after which NORPAK withdrew from the project partly due to cancellation of WB's loan and Uganda government's decision to change the development scale from 250MW to 750MW.

Box 1: Bujagali Financial Scheme

Source: extracted from Project Appraisal Document of WB

Bujagali hydropower project has been developed by BEL, a special purpose company incorporated under the laws of Uganda by the project sponsors, which will be responsible for financing, building and operating the proposed project on a Build-Own-Operate-Transfer basis. BEL will sell electricity to UETCL under a 30 year PPA. The project sponsors are: (a) Industrial Promotion Services (Kenya), the Kenya subsidiary of IPS, the industrial development arm of the Aga Khan Fund for Economic Development (AKFED); and (b) Sithe Global Power LLC (US) (Sithe Global), an international development company formed in 2004 to develop, construct, acquire and operate strategic assets around the world.



(1) Investment Plan

As discussed above, to examine financial sources for Ayago project, the other major hydropower development projects – Karuma and Isimba projects - should be considered because of their proximity in timing of implementation.

Table 9.1-1 shows annual investment plan for construction of Karuma, Isimba and Ayago hydropower projects.

Table 9.1-1 Investment Plan

Unit: US$ in millions

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Karuma														
Generation	60	380	370	250	240									1,300
T/L		200	200											400
Total	60	580	570	250	240									1,700
Isimba														
Generation		10	110	70	90	60	50							390
T/L														n/a
Total		10	110	70	90	60	50							390
Ayago														
Generation						44	87	131	131	108	149	140	44	834
T/L												9	20	29
Total						44	87	131	131	108	149	149	64	863
Total	60	590	680	320	330	104	137	131	131	108				2,953

(Source: MEMD & JICA Study Team)

*Note: the amounts shown in the table are indicative only.

**Note: for Ayago hydropower project, the investment costs are for Scenario I, 300MW in 3-phased development.

(2) Possible Financial Sources

1) Uganda government budget (Energy Fund)

Energy Fund was started in 2005 and is appropriated from Uganda government budget for purposes of power development. The table below shows the current status of Energy Fund.

Table 9.1-2 Energy Fund Status (Unit: U.Shillings in billions)

Fiscal year	2009/2010	2010/2011
Budget appropriation	191.28 (US$ 85million)	0
Use	-	115.1* (US$51million)
Balance	657.2 (US$293million)	542.1(US$242million)

(Source: MEMD)

*Note: This amount is destined mainly for Karuma hydropower project.

** Exchange rate: US$2,244/U.Shilling

The government of Uganda establishes 2 special funds to promote electrification: Energy Fund and Rural Electrification Fund. Box 2 shows a summary of Energy Fund and Rural Electrification Fund.

Box 2: Government Funds for Power Sector

	Source	Administered by	Use
Energy Fund	Government budget, partly from tax on oil products	MEMD	Advance payment to BEL for Bujagali Construction (refunded to Energy Fund) Feasibility study for Karuma (15 billion shillings ≒US$6.7million)
Rural Electrification Fund	Government budget, partly from tax on electricity bill IDA Norway	REA through MEMD	US$50million for construction of 20 electrification projects

2) Multi-and bilateral development aid

The donors consider the energy sector to be a priority sector for their aid and show an interest in Ayago hydropower as one of large hydropower developments. The donors are expected to cover the shortfall of Energy Fund and, however, not a single donor could afford to cover such shortfall. A cofinance of some donors would be necessary.

For Uganda, being categorized as low-income country of least developed countries (LDC), concessionary loans with very soft loan conditions can be expected. Various donors have been providing grants and loans for Uganda power sector: included among others are AfDB, EIB and WB/IDA as multilateral aid and JICA, KfW and NORAD as bilateral aid. Box 3 shows the result of the hearings from some donors in Uganda made by JICA Study Team and Box 4 shows activities under way of some donors.

Box 3 Hearings from various donors

The followings are major findings from hearings made by JICA Study Team from various donors including AfDB and WB, AFD, KfW, and NORAD.

Policy for assistance	➢ Formulated according to the priorities given by GOU. ➢ See Box 4 for activities of some donors.
Possibility of loan to Ayago project	➢ Energy sector is given one of top priorities by GOU so that the donors are concerned with Ayago project as one of hydropower development schemes. ➢ The donors expect early completion of a feasibility study to consider Ayago project as a candidate for loan.
Precondition for project loan	➢ Cofinance is not necessarily a precondition to provide a project loan. ➢ WB requires that a feasibility study and an EIA should be conducted by separate consultants.
Upper limit to a project loan	➢ No predetermined upper limit to a project loan except for KfW (up to 30% of construction cost) ➢ The amount of a loan is flexibly determined according to funding necessity of each particular project.
Loan conditions	➢ For a public sector project, the softest conditions are those of AfDB such as no interest rate with 50 years of repayment period and 10 years of grace period and with 0.75 % of service charge and 0.5 % of commitment charge.
Others	➢ Some donors show concern over GOU's funding capacity and managing capacity for construction of large hydropower projects.

Box 4 Development Aid under way in Uganda Power Sector

Donor	Master plan or feasibility study	Generation	Transmission	Distribution or rural electrification
IDA (WB)		Thermal power (for Power Sector Development Operation) (UGX164.73 billion) Bujagali		Energy for rural transformation (UGX135.936billion)
AfDB		Bujagali	Bujagali interconnection (UGX27.49billion) Mbarra/Nkenda T-line (UGX135.817billion) NELSAP (UGX19.733billion)	
JICA	Ayago hydropower		Bujagali interconnection (UGX17.63billion)	
NORAD	Feasibility study for Isimba hydropower (UGX2.563billion)		Karuma interconnection (UGX0.926billion) Mputa interconnection (UGX48.654billion) Transmission Hoima-Kafu (UGX0.949billion)	Rural electrification (UGX67.686billion)
KFW		Small hydropower projects Bujagali		Rehabilitation of Maziba power station (Euro 1.9million) Completion of Nyagak I(US$6.9million & Euro 1.3million) Construction of Nyagak III(Euro 4.7million) Grid extension in West Nile region(Euro 9.9million), Feasibility study of Maziba.(Euro 0.22million)

(3) Funding Plan

The government of Uganda gives a top priority to the energy sector to boost the economic growth. Large sums of budget appropriation can be expected to be injected into Energy Fund and, at the same time, the government fiscal situation and debt capacity must be considered.

On the other hand, project loans from donors would be a cofinance of a number of donors to cover the shortfall of Energy Fund.

Table 9.1-3 shows the expected funding plan. It is to be noted that the amounts shown in the table are only indicative and roughly expected amounts on Uganda side.

Table 9.1-3 Funding Plan

Unit: US$ in millions

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Karuma															
	Fund requirement	60	580	570	250	240									1,700
	Funding	60	580	570	250	240									1,700
	Energy Fund (70% as Equity)	42	406	399	175	168									1,190
	National Social Security Fund (15% as Equity)	9	87	85.5	37.5	36									255
	Borrowings from private bunks (15%)	9	87	85.5	37.5	36									255
Isimba															
	Fund requirement		10	110	70	90	60	50							390
	Funding		10	110	70	90	60	50							390
	Private investimant & lending (95%)		9.5	104.5	66.5	85.5	57	47.5							370.5
	Government's equity participation for PPP (5%)		0.5	5.5	3.5	4.5	3	2.5							19.5
Ayago															
	Fund requirement						44	87	131	131	108	149	149	64	863
	Funding						44	87	131	131	108	149	149	64	863
	Energy Fund (50%)						22	43.5	65.5	65.5	54	74.5	74.5	32	431.5
	Donor's aid (50%)						22	43.5	65.5	65.5	54	74.5	74.5	32	431.5
Total Funding		60	590	680	320	330	104	137	131	131	108	149	149	64	2,953
	Energy Fund	42	406	399	175	168	22	43.5	65.5	65.5	54	74.5	74.5	32	1,622
	Government's equity participation for PPP		0.5	5.5	3.5	4.5	3	2.5							19.5
	National Social Security Fund	9	87	85.5	37.5	36									255
	Donor's aid						22	43.5	65.5	65.5	54	74.5	74.5	32	432
	Private investimant & lending		9.5	104.5	66.5	85.5	57	47.5							370.5
	Borrowings from private bunks	9	87	85.5	37.5	36									255

(Source: MEMD & JICA Study Team)

*Note: For Ayago hydropower project, the investment costs are for 3-phased development of 300MW.

In the case that the government (represented by the Minister of Finance and Planning of Economic Development) borrows the required funds from donors, debt service takes the flow described in Box 5.

Box 5: Debt Service Flow

The Minister of FPED on behalf of the government concludes a loan agreement with a donor and on-lends the borrowed money at about 7% of interest rate to an executing agency, UEGCL for example, who is obligated to make repayment of principal and interest to the Ministry of FPED for eventual debt service to the donor.

If the executing agency is UEGCL, it will recover the amount necessary for debt service by including such amount in concession fee, a component of Generation Tariff charged to UETCL, a transmission state company. Then UETCL will include such amount in Bulk Supply Tariff charged to UMEME, a private distribution company. Finally, UMEME will include it in its revenue requirement to be reflected in Retail Tariff.

With the end users paying their Retail Tariff to UMEME, the debt service will track back in the above flow.

9.2 Execution Plan

As discussed in the previous section, the conceivable financial resources are three sources from Uganda government budget (Energy Fund), multi- and bilateral development aid and private sector. The type of project execution will be governed by the combination of such financial sources. It is to be noted that government investment used here includes development aid.

9.2.1 Type of project execution by funding scheme

(1) Government project (public works)

In this type, the government will construct and operate a hydropower project with its own fund and borrowings of ODA or other sources. The power plant will be operated by a government agency such as UEGCL.

(2) PPP (Public-Private Partnership)

【Type A: Joint capital investment】

The government and the private sector will jointly establish a power company (SPC: Special Purpose Company) to construct and operate a hydropower project. This type is categorized as a variation of IPP because of private sector participation.

【Type B: Owned by the government and operated by the private sector】

Type B will construct a hydropower project only with the government's fund and the government will keep its ownership, while operation will be conducted under concession.

This type is similar to the type adopted when a government agency managed a vertically integrated power utility. At that time, the operation was conducted by the government agency (public power corporation). In Uganda, the operation sector was cut off from the government by power sector reform, from which arose the necessity of entrust the operation of hydropower plant to the private sector. In that sense, this type can be categorized as PPP, joint undertaking by the government for ownership and the private sector for operation. This type is the same as that of Nalubalee-Kiira hydropower plants.

【Type C: Joint operation of the facilities constructed separately by the government and the private sector】

The government will construct roads, transmission liens, weirs and other infrastructure facilities, while the private sector will construct power generation facilities. The management will be jointly conducted. There is a case such as Phu My thermal power plant in Vietnam, where the government constructed the common works and the power generation facilities of Unit No.1 and the private sector constructed the remaining units.

(3) IPP (Independent Power Producer)

【Type A: BOT】

Only with private investment a power company will be established, who will construct and operate the hydropower plant and, after 20 or 30 years, will transfer the ownership to the government.

【Type B: BOO】

This type is basically the same as Type A except that there is no obligation to transfer the ownership, so this BOO type is categorized as pure IPP.

Table 9.2.1-1 shows the advantages and disadvantages of the above types of project execution. The rating was given by whether Ayago hydropower project will be able to be commissioned in the expected timing as the first criterion (1), followed by the second criterion (2) of whether Uganda side will be able to accumulate project management capability from investigation/study stage to construction/operation stage. In the table, merits related with (1) and (2) are expressed by ✔

Table 9.2.1-1 Comparison of type of execution

Type of execution		Advantage	Disadvantage	Rating
Government project		Easy to control by the government Possible shortening of development period Possible to accumulate experience in project management and operation[3]Management transparency enhanced and increased possibility to fulfill accountability to the public	Vulnerable to intervention in autonomy as power utility Full funding responsibility on the government Necessary to secure project management staff Necessary to secure operation staff	(1)✔✔ (2)✔✔
PPP	【Type A】 Joint enterprise	Possible to utilize funds and know-how of the private sector Possible to reduce financial burden on the government Possible to participate in management according to equity share Management transparency enhanced and increased possibility to fulfill accountability to the public Possible to reduce input of human resources of the government	Time consuming for financial arrangements between a numerous investors, which may lead to delay in development Necessary to secure funds for government equity, which brings risk of losing the government equity in the case of failure of the project. Required to provide government guarantees as conditions for private sector participation, which brings contingent liabilities on the	(2)✔

[3] The government is obliged to disclose information and so are the government agencies. In that regard, management transparency can be expected to be enhanced, while there is a concern that the management of public utility by governmental agency might be interfered as government's political tool –tariff, profit distribution and personnel assignment.

Type of execution		Advantage	Disadvantage	Rating
			government Less likely to accumulate project management capability	
	【Type B】 Operation concession	Possible shortening of development period Possible to accumulate experience in project management No necessity for securing operation staff Possible to burden OM costs based on long-term OM plans including overhaul on OM contractor	Full funding responsibility on the government Necessary to secure project management staff Not possible to accumulate operation experience	(1)✔✔ (2)✔✔
	【Type C】 Separate construction	Possible to utilize funds and knowhow of the private sector Possible to reduce financial burden on the government Easier for the private sector to participate because of the government developing the higher risk works for the first stage Possible to accumulate project management experience	・Longer development period than as government project but more advantageous than joint enterprise of IPP Necessary to work out on how to co-manage the facilities separately constructed Required to provide government guarantees as conditions for private sector participation, which brings contingent liabilities on the government [4]Less transparent on the part of private participation	(1)✔ (2)✔
IPP	【Type A】 BOT	Possible to utilize funds and know-how of the private sector Possible to reduce financial burden on the government Possible to reduce input of human resources of the government	Time consuming for financial arrangements between a numerous investors, which may lead to delay in development Not easy for the private sector to participate because of the large size of required fund Required to provide government guarantees as conditions for private sector participation, which brings contingent liabilities on the government Less likely to accumulate project management capability Less transparent on	

[4] *Regarding a contract by the private sector, it is not required to disclose information as long as it does not conflict with laws and interference of public authority in private management is not allowed, so that management transparency may be reduced for the public as third party.

Type of execution		Advantage	Disadvantage	Rating
			management	
	【Type B】 BOO	Possible to utilize funds and know-how of the private sector Possible to reduce financial burden on the government Possible to reduce input of human resources of the government	Time consuming for financial arrangements between a numerous investors, which may lead to delay in development Not easy for the private sector to participate because of the large size of required fund Required to provide government guarantees as conditions for private sector participation, which brings contingent liabilities on the government Less likely to accumulate project management capability *Less transparent on management	

As discussed above, IPP type of project execution, including its variation of PPP Type A, will require a long time for funding and will involve uncertainties on the timing of financial close. Discussions here, therefore, will be centered on the type of government project or PPP Type B. At the same time, if there should be difficulties with single funding by the government, PPP C Type – joint management of the facilities separately constructed by the government and the private sector- would be expected as effective type for project execution.

9.2.2 Type of project execution by construction contract

In the case of government project or PPP Type B, the government of Uganda or its executing agency (hereinafter called ‘Owner’) will construct a hydropower project with government budget and development aid as ODA and then the power plant will be operated directly by the government or entrusted to the private sector under concession.

The next stages of Ayago hydropower project are F/S, detail design, preparation of tender documents, tendering, construction, commissioning tests, trial operation and start of commercial operation. The implementation schedule up to the construction start will differ by how those tasks will be conducted and the required capability of project management and executing organization of the owner will also differ. The current situation shows deficiency of in-house engineers in the owner’s organization, so that it is vital to conduct institutional building for project execution including employment of consultants to strengthen project management capability. Examinations here will be made into EPC type and CM type. For concrete measures see Chapter 11 “Development Issues and Suggestions”

(1) EPC(Engineering, Procurement, Construction)

EPC is a type whereby EPC contractor selected by tender will conduct detail design, procurement and construction (hence the name of EPC). EPC contractor will make detail design, so that EPC type of contract is adopted to shorten the construction period from detail design to completion of construction thus called fast-track way of execution. The full responsibility for detail design and construction will rest on EPC contractor and, in the sense of less involvement by the owner. It seems to be convenient for the owner if the owner lacks project management capability. On the contrary to that, the owner's lack of project management will bring about risks of having no other choice but obey the contractor's thought.

In the case of thermal power projects, uncertain factors of geology governing the foundation do not occupy smaller share in the total construction cost. That is why thermal power projects will be implemented by EPC tender on a lump-sum basis and the construction cost will become definite at the time of contract award.

Meanwhile, hydropower projects involving a lot of uncertain factors such as geology are considered to be high risk in tendering for tenderers. They will have to add high markup to the tender price according to uncertain factors of design and geological risks, which may raise tender prices in general. There are some cases where the unit-price method is adopted for those parts governed by geological conditions. If the actual conditions encountered at the time of detail design or construction differ from the assumed conditions of geology and bedrock at the time of basic design, additional costs will be claimed as design change or variation order. The final amount of finished construction is very likely to differ considerable from cost estimate at the time of basic design or tender price of a successful tenderer. Those matters may heighten risks in contract dispute and litigation.

It is, therefore, necessary for the owner to sufficiently conduct investigations of topography and geology before concluding a construction contract with EPC. In executing a project under EPC scheme, the following abilities will be required:

Preparation of tender documents eliminating ambiguities as much as possible (scope of works, tender drawings, specifications, payment conditions and other contract conditions)

Risk identification and assessment regarding payment conditions, lump sum or unit price

Review of detail design prepared by EPC contractor

Construction supervision

(2) CM(Construction Management)

CM type is an execution type whereby CM consultant will manage construction in terms of quality, cost and delivery, on behalf of the owner or jointly with the owner. The construction contractor will perform construction works under the supervision of CM consultant by unit-price type of contract (also called 'measurement type or BOQ type'). There are variations of CM contract type depending on the degree of responsibility on the consultant for the key management points of construction. Choice should be made among such variations ranging from CM at risk guaranteeing construction quality, cost and delivery –coming near EPC concept- to supervision consultant based on FIDIC conditions of contract (measurement type), who will not guarantee construction quality, cost and delivery but will make engineering judgment about allocation of cost burden standing between the owner and the construction contractor. The larger the responsibility (riskier) on the consultant, the higher the consultant’s fee.

The uncertain factors of geology mentioned above for EPC type will continue to exist for CM type. CM type will, however, not leave detail design to EPC contractor but the owner will have CM consultant do detail design, based on which the tender for construction and equipment supply will be put giving to prospective tenderers more accurate information on design and cost estimate. Thus, the tendering will be at such a level that uncertain factors will be reduced as compared with EPC tendering based on basic design level, enabling tenderers to bring down risk margin. CM consultant will take measurements of works performed, valuing such works in terms of quality and quantity, which will provide a basis for payment.

The Study Team considers it to be advisable to take supervision consultant type under FIDIC conditions of contract (measurement type), thus minimizing consultant’s fee and enabling appropriate risk allocation between the owner and the contractor based on genuinely engineering judgment by an experienced consultant hired by the owner.

That type will take longer time to construction start as compared with EPC type, where the contractor will do detail design, but it will enable the tenderers to reduce markup for risks by taking enough time in detail design to provide more accurate design and cost estimate and by adopting measurement type of contract on a unit-price basis. Employment of an experienced consultant will enable appropriate risk allocation between the owner and the contractor in terms of construction quality, cost and delivery based on neutral, technical judgment, thus reducing litigation risks.

(3) Joint S/V type

This type is the same as CM type as regards construction supervision by consulting firm. But the joint S/V type is to supervise construction forming a joint team of the consulting firm and the owner’s side. Such a formation will provide capacity building opportunities for project management capability and engineering expertise. The consulting firm will not guarantee the quality, cost and delivery of the project but it will make impartial judgment of cost allocation based on engineering judgment between the owner and the contractor.

Table 9.2.2-1 shows the advantages and disadvantages of the above types of project execution. The rating was given by the degree of securing construction quality, cost and delivery as the first criterion(1), followed by the second criterion(2) whether Uganda side will be able to accumulate project management capability and the third criterion(3) of the expected size of the consultant's fee. In the table, merits related with (1), (2) and (3) are expressed by ✔

Table 9.2.2-1 Comparison of type of execution

Type of execution		Advantage	Disadvantage	Rating
EPC		Being called as fast track, possible to reduce the period of detail design and construction Responsibility for design and construction solely on EPC contractor and no direct involvement of the owner in design and construction Possible to reduce input of human resources of the owner Lump-sum contract makes the construction cost definite at the time of contract	Necessary for the owner to have the ability to prepare EPC tender documents and to assess the submitted tenders by tenderers Fast track may not be kept if differing geological or other site conditions from tender conditions set at the level of F/S are encountered If the owner does not have ability, the quality of design and construction will not be adequately checked In the case of a lump-sum contract, tenderers are likely to add high markup on their tender price for risk hedge Even if a lump-sum contract is adopted, differing geological and other site conditions from tender conditions encountered may cause the contractor to claim additional costs as design change or variation order, against which the owner is required to have the ability to assess such claims In the case of a unit-price contract (measurement type), necessary for the owner to have the ability to valuate the works performed Very likely to cause contractual disputes and litigation with EPC contractor	(3)✔
CM	CM at Risk	Construction quality, cost and delivery guaranteed by CM consultant Possible to reduce input of human resources of the owner Design responsibility on CM consultant if they make detail	Consultant's fee raised to include high markup for risk hedge against guarantee of construction quality, cost and delivery, similar to EPC Less likely to able to accumulate experience in	(1)✔ ✔

Type of execution		Advantage	Disadvantage	Rating
		design	project management of the owner because of less involvement of the owner Very likely to cause contractual disputes and litigation between the construction contractor and CM consultant and between the owner and CM consultant	
	Joint S/V	Possible to make impartial judgment of allocation of responsibility from the engineering point of view regarding construction quality, cost and delivery Possible to reduce likeliness of contractual disputes and litigation with the construction contractor because of opportune neutral judgment by S/V consultant Reasonable consultant fee Possible to accumulate project management capability by forming a joint project management team of the owner and S/V consultant Design responsibility on S/V consultant if they make detail design	Construction quality, cost and delivery not guaranteed by S/V consultant	(1) ✔✔ (2) ✔ ✔✔ (3) ✔

9.2.3 Implementation schedule

Shown below is the general flow to construction after this Master Plan Study.

This implementation schedule was prepared assuming the execution type to be a government project under joint S/V considering the discussions made in the previous sections 9.2.1 and 9.2.2

Table 9.2.3-1 Flow of Implementation Plan after this Study

(1) Feasibility Study

1) Basic Investigation
2) Site Investigation (Geological Survey, Topographical Survey, River Survey)
3) Environmental Investigation (EIA)
4) Basic Design (Design Drawing)

↓

(2) EIA Procedure

1) EIA Report
2) Related Ministry and Agency and Public inspection
3) Review
4) Approval Procedure

↓

(3) Detailed Design and preparation of Bidding

1) Selection of Consultant
2) Work Adit and Insitu Test
3) Detailed Design
4) Preparation of Bidding Document

(4) Negotiation and Loan Agreement

1) Donor Meeting
2) Exchange of Note
3) Loan Agreement

↓

(4) Construction

1) Bidding, Evaluation and Approval
2) Contract
3) Preparatory Work
4) Main Construction

(1) Feasibility Study

Conduct a feasibility study specifically on Ayago project site after the Master Plan Study. In order to raise the accuracy of the results of the site investigation works (geology and topography) performed at the time of the Pre F/S, perform additional surveys such as land and river surveys, drilling-hole surveys and tests. Perform an EIA study to raise the level of SEA study conducted at the time of the Pre F/S to prepare an EIA report. Prepare basic designs and more accurate project cost estimate based on the results of the above investigations.

Those tasks were assumed to take 15 months.

(2) EIA procedure

Prepare an EIA report on the part of MEMD based on the results of the above F/S and in accordance with the guidelines of environmental and social impact assessment of ODA organizations. Thereafter, submit the EIA report to ministerial and public inspection, review and revise it reflecting the comments from the stakeholders for government approval.

Those tasks were assumed to be 11 months provided that part of the above procedure overlaps the works of F/S.

(3) Detail design and tender documents

Excavate exploratory adits into the planned site for underground power station and conduct in-situ tests to establish detailed conditions of geology and foundation for design basics. Perform detail design works and prepare tender documents based on the results of those works.

Those tasks were assumed to take 20 months, provided that the costs of the tasks are financed by MEMD's own funds to reduce the required time for the tasks although MEMD may be able to apply for engineering service loan to a donor.

(4) Negotiation with financial institutions and loan agreement

Conclude exchange of notes and loan agreements after loan negotiations with donors.

That task was assumed to take 10 months, provided that the negotiations will be commenced only when the required amount for construction has been determined by detail design.

(5) Construction

Prior to the start of construction, the tendering was assumed to take 5 months, tender evaluation 3 months and approval for contract award 2 months. It is desirable that preparatory works such as access roads and construction offices should be completed with MEMD's own funds before the start of main construction works to shorten the construction period.

Figure 9.2-3-1 shows a standard schedule from the end of the Master Plan Study to the construction start based on the above.

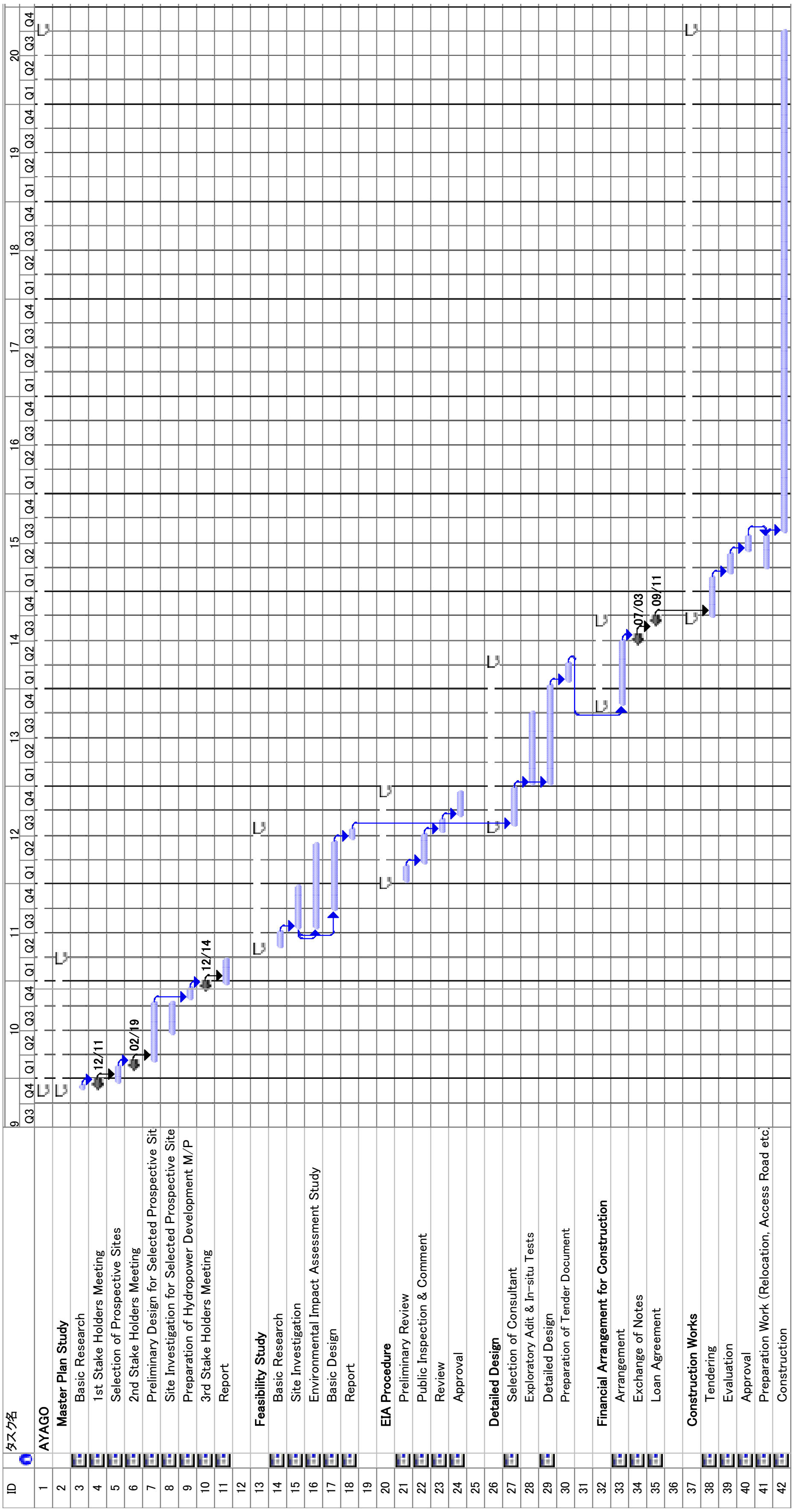


Figure 9.2-3-1 Implementation Plan

Chapter 10

Technical Transfer and Capacity Building

Chapter 10 Technical Transfer and Capacity Building

10.1 Technical Transfer

10.1.1 Hydrologic Analysis

Technical transfer for the hydrologic analysis was carried out in the form of seminar at MEMD office. The contents of the seminar are shown below. See Appendix I-1for further details.

Title	Contents
Introduction of Hydrology	Explanation of contents of hydrological study which includes; data collection and verification, statistical analysis, time series data analysis, low flow analysis, flood analysis.
Introduction of Reservoir Operation for a small scale reservoir	Introduction of developing the reservoir operation rule and procedure.
Introduction of Dynamic Programming for Optimum Reservoir Operation	Introduction of dynamic programming for a tool to obtain the optimum reservoir operation, with a simple example.

Photo; Seminar at MEMD in Kampala

10.1.2 Hydropower Planning Method

Technical transfer for the hydropower planning method was carried out by OJT and counterpart training in Japan.

(1) OJT in Uganda

Major items of OJT in Uganda were as follows

1) Grasp Hydropower Potential in Nile River

Selection of prospective development site, determination of development type and estimation of development scale were carried out utilizing 1:50,000 maps by joint work. Selection of 2 sites of the Oriang and Kiba hydropower which have not ever been found was one of the results of the work.

2) Calculation of Firm Power and Energy

The firm power and energy of the existing Nalubaale and Kiira hydropower plant was calculated in the joint work based on the actual operation data.

3) Installed Capacity Determination Method

The suitability of the installed capacity of the existing Nalubaale and Kiira hydropower was discussed based on the current load pattern and operation data. In this study the concept of the optimum development scale was explained to the counterpart, which is a key for determination of the installed capacity of hydropower.

(2) Technical Transfer in Counterpart Training in Japan

In the counterpart training in Japan, six Ugandan counterparts of JICA Study Team participated from 20th August 2010 to 3rd September 2010. Training on the planning of hydropower development and site survey was provided as described below. Detailed description of the technical transfer is shown in Appendix J-2.

1) 20th August (Fri)

Lecture: History of Hydropower Development in Japan

2) 25th August (Wed)

Lecture: Method of hydropower planning and best mix of several generation types

3) 26th August (Thu)

Lecture: Inflow analysis, operation and maintenance of regulating pond and reservoir

4) 27th August (Fri)

Site Study in Tenryu river cascade hydropower

- Understanding and acquisition on operation of integrated river development and cascade development
- Understanding on design of layout and structure of waterway type
- Understanding on facility of amenity flow discharge and operation method
- Understanding on utilization of amenity flow section for fishing and tourism
- Understanding on tourism development in regulating pond
- Understanding on structure and operation method of fish ladder in dam
- Understanding on dam spillway operation

10.1.3 Construction Plan and Cost Estimation

Technical transfer for construction plan and cost estimation was provided in the form of seminar at the time of the counterpart training in Japan. Shown below is the outline of the lectures given at the seminar and see Appendix J-3 for further detail.

(1) Preparatory Works and Temporary Facility Plan

The lectures were given for the access road and camp facility etc. which shall be prepared prior to the main works.

(2) Construction Planning of Main Structures

The lectures were given especially for the tunnel construction method because there is no power plant of waterway type in Uganda. Actual examples and pictures regarding the construction works were shown in the presentation.

(3) Construction works in Okukiyotsu II

Construction works in Okukiyotsu II which is one of the largest pumped storage power plants in Japan were introduced by videos to deepen the understanding.

(4) Design and Salient Features of Ayago Project

Design and salient features of Ayago project were explained.

(5) Cost Estimation of Ayago Project

The formula of approximate quantities was given so that trainees could calculate by themselves to deepen the understanding.

(6) Construction Plan for Environmental and Social Considerations

Actual examples for the construction method considering environmental impact were introduced because Ayago project is located in the national park.

(7) Construction Schedule of Ayago Project

The construction schedule for Ayago project was explained.

10.1.4 Risk Management for Project Implementation

Technical transfer for project risk management was provided in the form of seminar at the time of the counterpart training in Japan. The lectures were given at the introductory level and the intermediate level. As for the advanced level, the lecturer stated that it can only be learned on the site of a particular project and that, beside the matters learned in the lectures, it is necessary to learn the method of thinking by the employed consultants and how they cope with technical and contractual problems or difficulties encountered daily and also how the contractors reacts.

Shown below is the outline of the lectures given at the seminar and for detail see Appendix J-4.

(1) Introductory level

Explanation was given regarding the basic concepts of risk management.

1) The purposes or significance of government investment, which is a theme not touched in general risk management lecture, were explained and the lecturer stated that it is necessary to constantly hark back to those basics. Then, the advantages and disadvantages of implementation schemes, that is, IPP by private sector and public works by the government, were explained. It was also explained that risk perception of the interested parties can be different depending on investment type.

2) The risk categories were explained: force majeure, natural and political –the latter is country risk-, sponsor risk and commercial risk. Then general risk management was explained: aversion, acceptance, mitigation and transfer. Those measures can be different by the position of investors, IPP or government project.

(2) Intermediate level

At this level, lectures were centered on commercial risks such as completion risk, operation risk and market risk. To understand those risks, it is necessary to have some knowledge on construction contract, so some information was given for that from time to time.

1) Completion risk was explained in such that contract type differs by risk allocation between the owner and the contractor regarding the key points of construction management: quality, delivery and cost. Specifically, EPC is a full turn-key contract with design responsibility and design-build contract covers only design and construction with separate contracts for equipment supply and erection, while construction contract covers only construction with separate contracts for design and equipment supply and erection.

   Various types of payment of contract amount were explained: lump-sum, unit price and cost plus. It was explained that risk identification and management will differ by those different contract types. In addition, risks inherent in construction contract were explained from different points of view of the owner and the contractor on risk perception and management.

2) Employment of consultant was explained as a measure for risk mitigation. It was explained that the burden of responsibility and the cost of consultant will be proportional in construction management as discussed in Chapter 9 “Implementation Plan”. Advice was given to consider employment of consultant in a form suitable to Ugandan needs. It was also explained that the contract type will differ by the method of payment of consultant fee.

An introduction was made of internationally prevailing standard conditions of contract such as FIDIC.

3) As for operation risk, whether IPP or government project with operation concession to private sector, the importance of the capability of an operation company and the skill level of their operation staff was explained.

   Advice was given in such that, in the case of EPC for government project, it is desirable to make EPC contractor participate in operation for several years as quality assurance.

4) As for market risk, it was explained that PPA essentially takes take-or-pay method and that UETCL as off-taker cannot avoid such risk. Advice was given not to accept a contract which allows pass cost overrun of EPC through to tariff setting.

   A market risk was pointed out: incompletion of transmission liens at the time of power plant commissioning, cases found in some countries. It was explained that power evacuation lines are a means of access to market, so that it is necessary to make due arrangement in terms of engineering and operation.

10.1.5 Environmental Impact Assessment

Lecture style training was conducted for the Technical transfer of Environmental Impact Assessment during counterpart training in Japan. The training items include 5 topics. The detail of the training is shown in Appendix J-5.

(1) Environment

Showing the natural resources in the world and natural resources in Uganda discuss the way to the sustainable development.

(2) Environmental Impact

Environmental impact caused by hydropower projects were explained by introducing the cases in Japan and the other countries. The impacts include physical impacts, biological impacts, and social impacts.

(3) Environmental Impact Assessment

Basic concept of the Environmental Impact Assessment was introduced. The topics include Purpose of Environmental Impact Assessment, History of Environmental Impact Assessment, Tired approach, No Net Loss, and Mitigation.

(4) Strategic Environmental Assessment

Basic concept of Strategic Environmental Assessment was introduced. Some types of Strategic Environmental Assessment and some methods used for Strategic Environmental Assessment were explained.

(5) Project Environmental Impact Assessment

Basic procedure of project environmental impact assessment was lectured. The purposes and principles of screening, scoping, survey, impact assessment, mitigation, monitoring plan, and information to be disclosed and public participation are explained.

10.2 Human Resource Development

10.2.1 Present Situation and Issue

The national target of Uganda to promote hydropower development and stable electricity supply is currently being pursued with support from companies of developed countries. At the same time, viewing on a longer term, much needed is development of Ugandan human resources necessary for survey and investigation, planning, design, construction supervision and operation and maintenance of long-run hydropower developments. In that regard, important is not only the number required of engineers and technicians and other personnel but also the expertise and skills which they are required to have as discussed below.

(1) Number required of the personnel

There are various processes in hydropower development, ranging from policy determination and survey, planning and design to construction supervision and operation and maintenance as shown in Figure 10.2.1-1. Each process involves a numerous tasks, requiring a lot of human resources.

In October 2010, in the power sector in Uganda, construction of the Bujagali hydropower (250 MW) and feasibility studies of the Karuma (600 MW) hydropower and the Isimba (138 MW) hydropower were going on by mobilizing foreign contractors and consultants, while a hydropower master plan and pre feasibility study of the Ayago (600 MW) hydropower was under way jointly with Japanese consultants under technical cooperation with JICA.

To carry out a master plan study and a pre feasibility study for a large scale hydropower like Ayago project, personnel is required in various disciplines such as civil, geology, architecture, electrical, mechanical, telecommunications and so on. In Uganda, except for demand forecast and transmission system expansion plan carried out by UETCL, less than 10 officials of MEMD and HPDU (UEGCL) are involved in all tasks. Those 10 officials also take charge of power sector policy and preparation of power development plan, which leads to consider the current situation as overloading them.

If the above situation remains unchanged in the future when the above-mentioned hydropower projects proceed to design and construction stages, there is concern that smooth implementation should be difficult by the current number of personnel and the current system of organizations. Therefore, it is advisable that restructuring of the pertinent organizations as well as transfer and increase of personnel should be carried out.

The current situation of human resources of the power sector in Uganda is shown in Table 10.2.1-1. As shown in the table, there are extremely few civil engineers, and there is only 1 geological engineer, who prepares plans for basic investigation works and evaluates the investigation results for dam, waterway tunnel and power station. On the other hand, there are more than 100 electrical and mechanical engineers/technicians, accounting for 95% of the total personnel, of which about 60% of the electrical and mechanical engineers/technicians are difficult to participate in new hydropower development projects because they are working for operation and maintenance of The Nalubaale and Kiira hydropower station.

Bujagali hydropower is now under construction by IPP under EPC contract with foreign contractors in such that foreign contractors carry out design and construction by themselves. It is quite unlikely that only 3 Ugandan engineers/technicians working for Bujagali will remain in Uganda after its completion. After all, only less than 50 engineers are expected to participate in policy making, survey and investigation planning, design and construction supervision for the present.

In Japan during 1950s and 1970s, electric power companies, who were owners of large scale hydropower projects, kept necessary engineers within their organizations to assign a total of about 80 engineers, civil 50 and electrical 30 for 1 hydropower project as shown in Table 10.2.1-2. From the commencement of hydropower operation, operation and maintenance works was carried out by around 10 to 20 civil engineers and around 10 to 30 electrical engineers as shown in Table 10.2.1-3.

In Uganda, in the near future, 3 large scale hydropower developments -Karuma (600 MW), Ayago (600 MW) and Isimba (138 MW)- will be developed in tandem. For development of those hydropower projects, even considering the current advanced hydropower engineering and IT techniques, 30 civil engineers and 30 electrical engineers for 1 hydropower and 180 engineers for the 3 hydropower projects will be needed. Considering overlapping of construction period of those 3 hydropower projects it is desirable that at least about 60 civil engineers and about 60 electrical engineers, totaling 120, engineers will be needed. Hence, of the most urgency is to satisfy the required number of engineers.

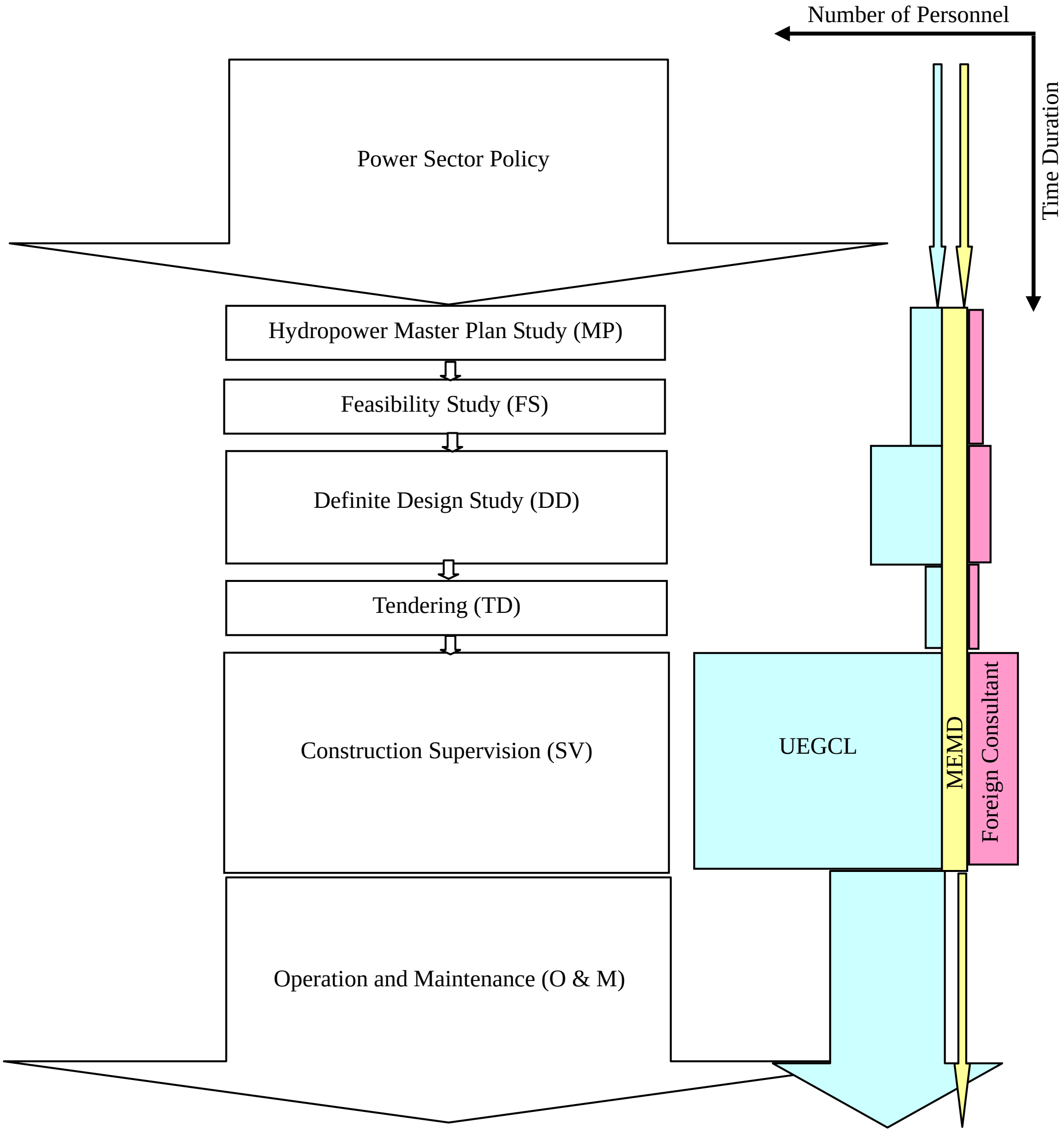


Figure 10.2.1-1 Procedure and Necessary Personnel for Hydropower Development in Uganda by Conventional Contract for Construction

Table 10.2.1-1 Human Resources in Uganda Power Sector

	Civil	Geological	Electrical	Administrative & Financial	Environmental	Total
MEMD			4	1		5
UETCL			30			30
UEGCL	1		4			5
HPDU (UEGCL)	1		2	1	1	5
Eskom	3		60	60		123
Bujagali Energy Ltd	1	1	1	1	1	5
Total	6	1	101	63	2	173

Table 10.2.1-2 Human Resources for Construction of Hydropower Project in Japanese

Project	Installed Capacity (MW)	Construction Period	Technical		Administrative & Financial	Environmental	Total
			Civil	Electrical & Mechanical			
Sakuma	350	1953-1956	50	34	87		171
Okutadami	360	1954-1961	140		36		176
Tagokura	380	1955-1961	109		64		173
Kuzuryuu	220	1965-1968	75	17	20	14	126
Shintoyone	1,125	1969-1973	47	21	41	11	120
Numappara	675	1969-1973	59	17	46		122
Okukiyotsu	1,000	1972-1982	56	24	37		117
Head Quarter		1960	50	50			

Table 10.2.1-3 Human Resources in Japanese for Operation and Maintenance Hydropower Project

Project	Numbers of Power Station	Total Capacity (MW)	Year	Maintenance		Operation	Admini-strative	Total
				Civil	Electrical			
Sakuma	1	350	1959	10	15	10	3	38
Akiba	2	80	1959	6	10	10	2	28
Okutadami	5	591.5	1999	20	25	15	20	80
Sakuma	5	1,568.2	1999	20	35	15	20	90

(2) Expertise and Skills Required

Past hydropower developments in Uganda are shown in Table 10.2.1-4. The Bujagali hydropower, which is now under way by IPP scheme, is being constructed by EPC contract in which design of the hydropower is carried out by the contractor, thus it is hard to say that enough engineering buildup can be expected on Ugandan side. The last proactive participation of Ugandan engineers in hydropower development was for the Kiira hydropower in 2005. Nevertheless, operation commencement of the first unit of the Kiira was in 2000, which means that civil works were completed before 2000. Furthermore, the Kiira hydropower utilizes the existing Owen Falls dam with new construction of open channel but no construction of underground structure such as tunnel and underground powerhouse. Therefore, it can be said that until now there has been no opportunity for Ugandan engineers to acquire experiences in design, construction supervision and maintenance of large-scale underground structures like the Karuma hydropower and Ayago hydropower.

Table 10.2.1-4 Development of Hydropower Projects in Uganda

Name of Project	Nalubaale	Kiira	Bujagali
Start of Construction	1949	1993	2007
First Unit Commissioning	1954	2000	2011
Completion of Project	1968	2005	2012

After completion of the Kiira hydropower, most of those Ugandan engineers/technicians who participated in erection of turbines and generators of Kiira hydropower were transferred to then UEB to become operation and maintenance staff of the Kiira and Nalubaale hydropower. Part of them was transferred to other sections of UEB. After unbundling of UEB into UETCL, UEGCL and UEDCL, operation and maintenance of the Nalubaale and the Kiira hydropower was consigned to Eskom and those O&M staff were accordingly transferred to Eskom.

In fact, very few are available engineers experienced in design, construction supervision and maintenance necessary for the Karuma and Ayago hydropower.

10.2.2 Method of Human Resource Development

To make up for deficiency of experience in hydropower development of Ugandan engineers, especially absolute deficiency of civil engineers, it is necessary to employ consulting engineers from advanced countries for hydropower development and to jointly work through OJT in the processes of master plan study, feasibility study, detailed design, preparation of tender document and construction supervision. In that respect, EPC contract by IPP scheme is not wise from the standpoint of capacity building since design and construction supervision is carried out by foreign consultants.

For mobilization of consulting engineers, one of the effective ways is to apply for technical cooperation to aid organization such as JICA at stages of master plan study and feasibility study and, in stages of detailed design, preparation of tender document and construction supervision, to apply for low -interest engineering service loan. Another way, in the case of Japanese ODA scheme, is to apply for dispatch of JICA experts, who would work as a member of Ugandan government or it executing agency.

Meanwhile, from a long range standpoint, Ugandan human resources development must be considered. A numerous universities in Uganda provide engineering courses and supply quite a few engineers to the social world, while very few universities such as the Makerere University and the Kyambogo University provide civil engineering courses and most of the graduates go into the field of road and bridge but very few into the power sector. It is desirable to establish hydropower engineering course in a number of universities and give education specialized in hydropower development not only to university students but also to those engineers who are already working in the world for human resource development to foster hydropower civil engineers and operation and maintenance engineers.

Human resources development methods for each stage of design, tendering, construction supervision and operation are described below in concrete terms.

1) Design Method

From the standpoint of human resources development, it is not wise to develop all hydropower projects by IPP scheme; for large scale hydropower projects like the Karuma and the Ayago hydropower projects, it is desirable to develop them as public work scheme with proactive participation of Ugandan engineers. In that regard, it is not wise to consign detailed design works to EPC contractor, so it is better to foment human resources development through OJT by mobilization of engineering consultants from advanced countries of hydropower development. Besides, it is worth to learn Japanese practice of hydropower development in that design engineering is developed taking into account the convenience of operation and maintenance after completion of the hydropower construction.

2) Tender Evaluation

The same thing can be said for tender evaluation starting from prequalification stage to contract award through OJT on a public work scheme by mobilization of engineering consultants from advanced countries of hydropower development.

3) Construction Supervision

It is important that proactive participation in construction supervision of Ugandan engineers is not only to acquire expertise in construction supervision but also for operation and maintenance after completion of the hydropower construction. Assignment of candidate personnel for operation and maintenance for a hydropower project to construction supervision enable them to understand the structures and characteristics of the facilities and to grasp such problems as deterioration, displacement, water leakage of the structures and their foundations.

4) Operation Techniques

Education and training of operation staff for the Bujagali hydropower, expected to commence commercial operation in 2011, is conducted by dispatching such staff to the training center at the Café Gorge hydropower station. The Karuma, Isimba and Ayago hydropower projects should follow the same way and it is desirable that operation staff for those hydropower projects should be selected mainly from the personnel participating in construction, erection and adjustment of those hydropower projects. As for the candidate staff of the Karuma hydropower operation and maintenance, expected to start operation after completion of the Bujagali hydropower, OJT training at the Bujagali hydropower station would be effective.

Chapter 11

Subjects and Suggestions

Chapter 11 Subjects and Suggestions

At this moment, F/S of Karuma Hydropower Project and Isimba Hydropower Project and Pre F/S of Ayago Hydropower Project are in operation. Development subjects and suggestions for these projects are stated below.

11.1 Issues and Suggestions for Overall Hydropower Development in Uganda

Issues and suggestions for overall hydropower development are discussed below from view points of technical, financial and framework aspect.

11.1.1 Technical Aspect

(1) Establishment of Hydro Power Technical Standards and Guideline

Technical standards for Hydropower are necessary to implement the Hydropower projects to secure quality, but there are no specialized standards in Uganda at this moment.

Under this circumstance, it is expected to establish technical standards and guideline including planning, investigation, design, construction, and operation maintenance as quickly as possible. Technical standards should be established by GoU in principle; however there are few engineers for Hydropower projects in Uganda. In addition, the experience for Hydropower projects is not so much because of few projects. Taking the above situation into consideration, it is necessary to introduce the overseas knowledge and experience to make practical technical standards.

(2) Maintenance of Basic Data

The actual situation of basic data for planning and design of Hydropower projects is listed below.

1) The format of river flow data, especially flooding data, and measuring method of river flow is not suitable for the study of Hydropower development projects.

2) The rainfall gauging stations in Nile River basin are not located suitable positions.

3) The data related to demand forecast has inconsequence, and accumulation of past data is not enough.

We suggest the data relating to Hydropower projects is managed by one implement agency in order to maintain data properly. The Master Plan Database in this study can be used as a tool of these data maintenance.

(3) Management Capacity of Implement Organization

The followings are proposed to make up for the lack of experience for Hydropower projects as practical measures.

- Dispatching of foreign official specialists to transfer technical knowledge
- Employment of foreign consultants
- Capacity building projects in ODA Scheme

(4) Enacting the Law related to Hydropower Projects

The necessary river law related to the hydropower development is not enacted at this moment. The law should be enacted using examples from overseas experiences of regulation contents and approvals as quickly as possible.

(5) Replacing Technology

The existing main power plant, Nalubaale Hydropower Plant, has operated for over fifty years and is required to investigate and study for replacement. Once other power plants will be constructed, its replacement can be done. It is also recommended that the necessary technology for the replacement should be introduced from foreign countries in ODA scheme.

11.1.2 Funding

(1) Funding Aspects

One of the major issues in implementing Ayago hydropower project is funding. Funding possibilities should be explored for 3 large hydropower developments planned for a short interval of time including Karuma and Isimba projects as well, taking due consideration of the economy and fiscal situation of Uganda to determine the optimum magnitude of development and commissioning year of each project.

It is difficult to implement all the projects only with government funds, so donors' aid will be indispensable. It is necessary to obtain understanding and cooperation of the donors regarding each of the large hydropower developments by utilizing Energy Sector Working Group.

The PPP scheme as advocated by Uganda government intends co-funding by the government and private sector. In that case, it is necessary to approach companies interested in private investment and private banks in an early stage. If such PPP scheme includes donors' financial assistance or guarantee, the government may be required to provide some forms of guarantee not only to private sponsors but also to the donors. In that regard as well, it is necessary to obtain understanding and cooperation from each donor at the table of Energy Sector Working Group. With the above considerations, issues in funding and suggestions will be discussed below.

(2) Issues in funding

1) Government investment

Given the large size of the project budget as compared with the government fiscal size, it is necessary to give due consideration to the economy and fiscal situation of Uganda.

2) Donors' aid

The government funding would not be able to cover the whole project cost, so donors' aid would be necessary.

3) Utilization of private money

Uganda government advocates PPP scheme utilizing financial participation of private sector. Private participation would require some forms of government guarantee and it is expected to take long time in negotiations.

(3) Suggestions in funding

1) Government Funding in Energy Fund and Preparation of Funding Plans

The funding plans discussed in Chapter were based on the indicative amounts for the present indicated by Uganda side. It is necessary to develop yearly amounts of possible funding into Energy Fund, based on the country's economic and fiscal prospects. Based on that, it is necessary to determine the implementation period and scheme of each project, together with the required funding from development aid and/or private sector.

As discussed in Chapter 9, the development of Ayago hydropower project was suggested with funding of Energy Fund and development aid. It is to be noted that development aid would take a form of loan, so that it is necessary to make examination into possible amounts of loan with due consideration of the government's fiscal situation and the balance of payments and foreign reserves.

2) Securing Understanding and Cooperation of Donors

If the above examination determines the necessity of development aid, prompt action should be taken to secure understanding and cooperation of donors. As for Ayago hydropower project, although the results of Pre F/S have been shown in this Master Plan Study, it is desirable to approach the interested donors with prior consent of the Ministry of Finance upon the completion of F/S based on more detailed investigations for geology and topology in order to make earlier request, understanding and cooperation from the donors.

In order to secure donors' cooperation, it is vital to consolidate an implementation system to strengthen the project management capability. Therefore, it is necessary to take prompt actions to build the suggested implementation system.

3) Approach to private sector

Isimba project is now conceived as PPP with government equity participation, so that it is necessary to approach private investors in an early stage. Together with private investors, it is necessary to examine financial scheme for project implementation and approach private banks and donors to learn what guarantee schemes would be require. It would take considerable time to reach financial close, so that it is necessary to install a task force for PPP promotion in MEMD. Making use of the lessons learned from Bujagali project, that task force should make examinations into the following points and then approach prospective investors.

- Method of selection of private investors as project sponsors (international competitive tender) and criteria for selection
- Qualifications and conditions for EPC contractor and OM contractor to be contracted with SPC to be established in Uganda by project sponsors
- Whether to require the fixed price of the power supply plans proposed by SPC.
- In connection with the above points, whether cost overrun of EPC would be allowed to pass through to Power Purchase Agreement
- Items to be guaranteed by the government

11.1.3 Problem of Project Implementation Structure and Suggestion

(1) Project Management Scheme

There is a concern with systematic management capability due to lack of large scale hydropower development experience and lack of authority.

Therefore, in case of execution of hydropower development project, creation of management scheme in accordance with development method is important issue.

Firstly, considering the current situation of implementation structure of MEMD and inadequate experiences of development and management of large scale hydropower development, a recommendable development scheme is PPP B type (owned by Government and operated by private sector) scheme utilizing engineering consultants to form a joint S/V team with staff from the government or its executing agency. Details for the employment of consultant and project implementation structure of MEMD are described as follows.

1) Employment of Consultant

Because a prefeasibility study of Ayago hydropower project has completed by this master plan study, it is necessary to employ consultants who will carry out feasibility study, detailed design and preparation of tender documents and construction supervision at an early stage. The consultant is expected to be employed through technical cooperation of development assistance, so that it is desirable to approach to donors concerned and request for cooperation at an early stage.

2) Establishment of Project Implementation Structure(MEMD)

For implementation of Ayago hydropower project, it is possible to entrust everything to the consultant instead of the owner side. However, in such a case, the owner side only makes payment for pieces of construction work performed, assessed and approved by the consultant so that acquisition of knowledge and experience necessary for hydropower development of second stage and further stages for phased development tend to be insufficient. To solve this issue, it is desirable to adopt joint project management method by forming a joint project team consisting of the owner and the consultant. More concretely, the owner side dispatches their personnel to the S/V team of the consultant.

(2) Power Sector Policy Making Organization and Development Implementation Agency

Under the current power sector structure in Uganda, functions of policy making and project implementation are not separated as shown in Figure 11.1.3-1. The function for national policy making and that of development of individual hydropower projects are on different levels and both functions are assigned to one organization. It may lead to a possibility that management will not be conducted appropriately or effectively.

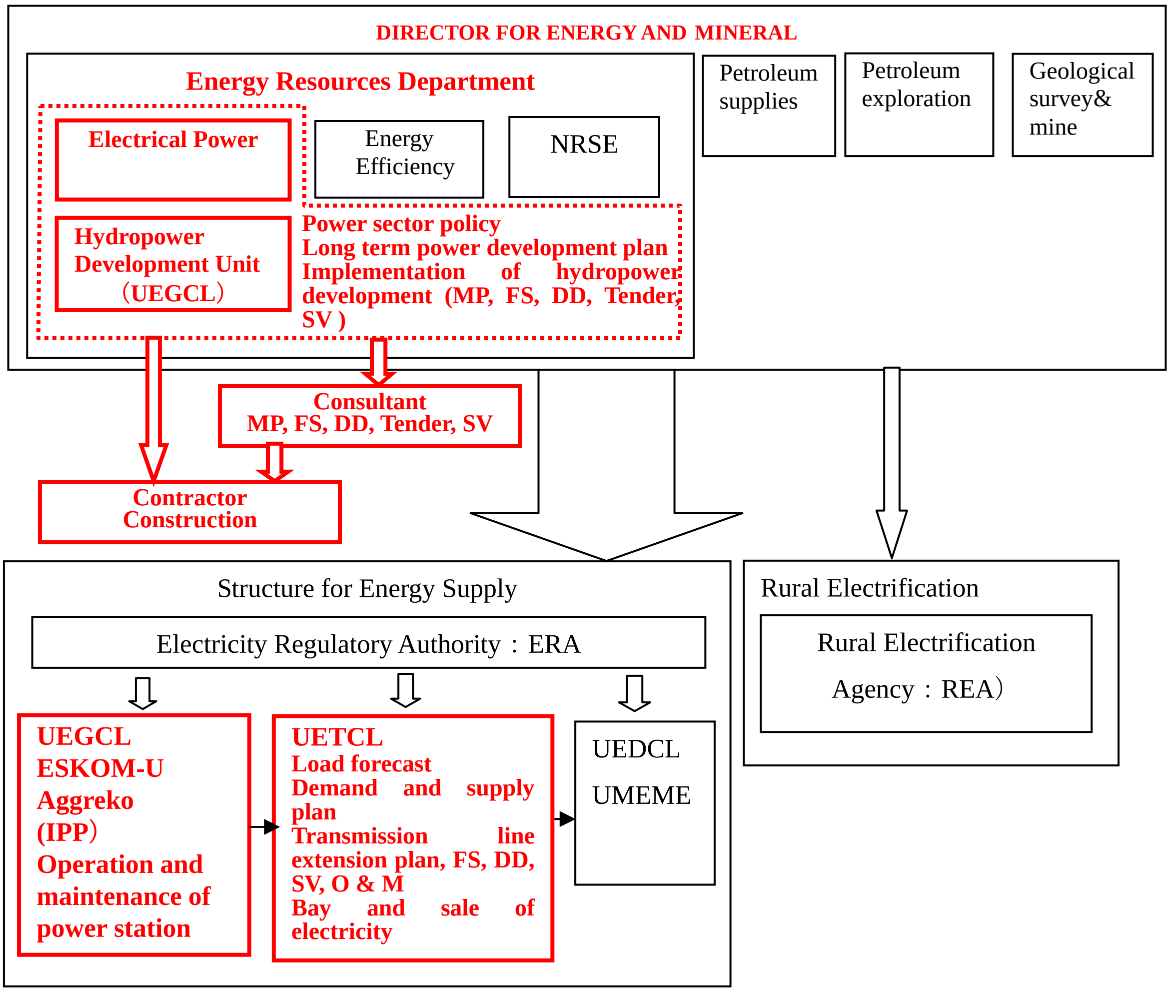


Figure 11.1.3-1 Current Organization for Implementation of Hydropower Development

In order to solve problem, it is recommended that development implementation agency shall be separated from policy making organization. As a solution to that issue, there are two methods: one is new establishment of electric power development authority and another is to give function of implementation of hydropower development to UEGCL. A suggested organizational structure in the case of giving function of implementation of hydropower development to UEGCL is shown in Figure 11.1.3-2. In accordance with this suggested organization, a well-planned appropriate distribution of personnel (engineers) is necessary.

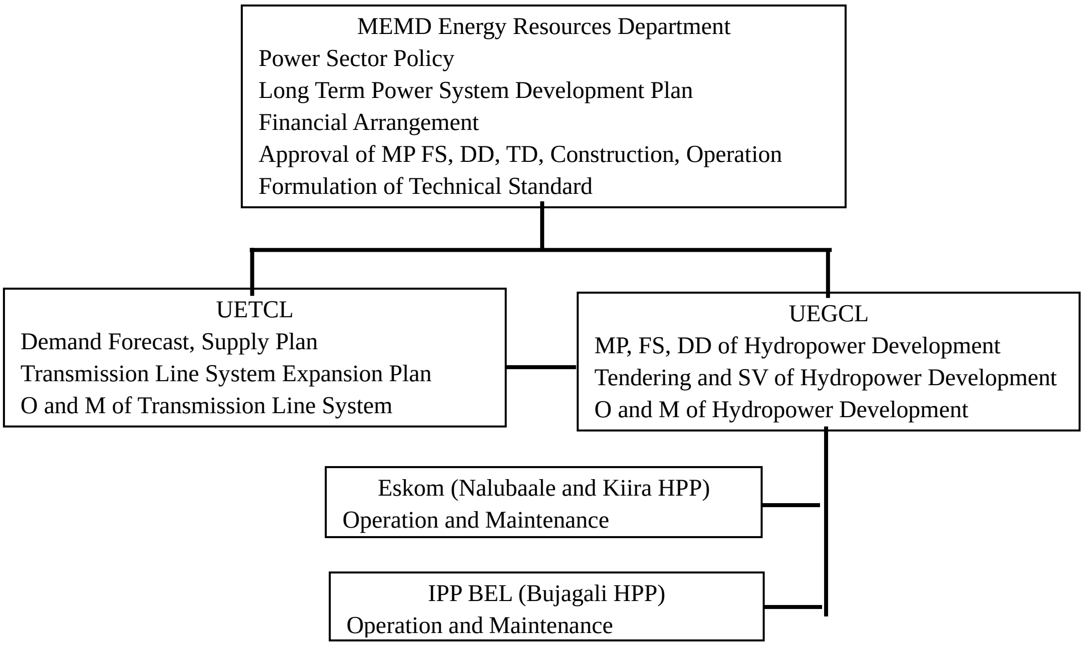


Figure 11.1.3-2 Suggested Organization for Implementation of Hydropower Development

(3) Reinforcement for Policy Making Organization and Implementation Agency

At present, tasks for policy making and implementation of hydropower development are carried out only 10 personnel of MEMD and HPDU. Such a situation is not adequate to implement development of large scales hydropower projects smoothly. Therefore, reinforcement for policy making organization and implementation agency is recommended as follows.

1) Power Sector Policy Making Organization

It is suggested to establish Power Sector Policy Making Organization in MEMD as special department (example: Energy Resources Department) to be in charge of Uganda power sector policy making and financing necessary for hydropower development as a major assignment. Concretely, Main assignments of the organization are as follows.

- Review and approval of demand forecast and supply plan formulated by UETCL
- Formulation of long term power development plan

- Preparation of implementation plan
- Review and approval of M/P, F/S and D/D
- Review and approval of tender
- Coordination of MFPED, donor countries and donor organizations for financing.

The suggested organization composed of personnel including civil engineers, electrical engineers and environmental experts as shown in Figure 11.1.3-3.

MEMD Energy Resources Department
Policy planner 10
Civil Engineer 8
Electrical Engineer 8
Environmental Expert 4
Financial and Procurement 10

Figure 11.1.3-3 Personnel Composition of Suggested Department

2) Organization of Hydropower Development Implementation

A suggested organization for promotion and implementation of hydropower development is shown in Figure 11.1.3-4. The organization should have the authority to manage from planning and design to construction and take charge of materializing those duties. Since commercial operation starts, operation and maintenance works can be carried out by existing organizations.

UEGCL
Hydropower Development Department

Financial and Procure Dept	Planning & Design Dept	Environmental Dept
Financer 5	Civil 15 (incl. Contract Engineer.)	Environmental Expert
Procurement 5	Geological 2	Natural Environment 5
Costing 5	Electrical 15	Social Environment 5

Figure 11.1.3-4 Suggested Organization Chart of Hydropower development Department

11.1.4 Issues and Recommendation on Environmental Aspects

Although hydropower development is relatively superior to the other power sources such as thermal power plant, some environmental issues are still pending. If some impacts especially on terrestrial and aquatic ecosystem or farmland acquisition and resettlement are not avoided, the damage might be serious. Thus in order to avoid total net loss, careful and sufficient mitigation measures based on a well conducted impact assessment are needed.

11.2 Issues and Suggestions for Ayago Hydropower Project

Issues and suggestions related to the development of Ayago Hydropower Project and concerning points for next Feasibility Study of Ayago Hydropower Project are described below.

11.2.1 Environmental and Social Considerations

(1) Compliance with JICA GUIDELINES

The project supported by JICA should be compliant with JICA GUIDELINES FOR ENVIRONMENTAL AND SOCIAL CONSIDERATIONS (March, 2010). Ayago project site is located in the middle of a protected area designated by Uganda Government laws to preserve natural resources and the project will cause impact on IUCN red list species and wildlife for tourism. But the total area used by the project is only 0.6 sq km, which is 0.016 % of the national park, and only management cars will access the site during operations. One cannot say that the project shall t cause serious impact on flora and fauna in the National Park, because the selected left side option lies on southern bank where population density of mammals is not so high. In addition, the project might be able to promote the protection of the National Park if the project implements not only mitigations for minimization of impacts but also supporting activities such as wild life habitat management, counter measures for poaching and encroachment as well as wild life monitoring as offset activities. It is important to seek for maximum mitigations in the Feasibility Study Stage to be compliant with JICA guidelines.

(2) Mitigation Strategy at Ayago Project site

The following are the mitigation strategies in the feasibility study stage. The mitigations cannot completely eradicate negative impacts but will definitely alleviate some of them.

1) Minimizing the waste rock disposal area

Area of the waste rock disposal site should be minimized when the layout designing is considered in Feasibility Study stage.

The brief minimization for the layouts has already been considered during pre-feasibility study. At first, the location for rock disposal site was sought outside the National Park. But 1,000,000 ten ton trucks will be needed for hauling the waste rock. The environmental impact of trucks moving 40 kilometric one way in form of noise, vibration, dust on surrounding flora and fauna and volume of carbon dioxide will be much. Thus, the disposal site within the National park seems to be better than outside the Park. All the disposal sites of the examined three layouts are located in the National Park. For the selection of the valley, the valleys with smaller watershed are sought.

When designing disposal sites in feasibility stage, more environmentally sound structures, locations and disposal measures should be considered.

2) Environmentally sound access roads

The access roads should be determined on the basis of their minimum impact on the ecosystem during feasibility study stage.

The access roads briefly examined at the pre-feasibility stage. At first, most short cut routes were examined. But it was later realized that the routes need much cut and fill earth volumes and one part needs a massive bridge. As a result the same route as the existing one was selected and although it is longer, it doesn't need a bridge and there is minimum vegetation cutting.

The selected access road might conflict with tourism use, local people's wood collection route, or animal migrations. Then considering tourism use and maintenance road for transmission line, the most environmentally sound route should be re-examined at the feasibility stage.

3) Mitigation for road kill

Road design and operation plan which aims to minimize road kill should be examined at the feasibility stage. The risk of road kill at the access roads would be high, because the roads go through the habitat of wild life. Coming across elephants might cause accidents. Then it is recommended to take suitable mitigation measures in the high risk areas and high risk seasons/time which is identified based on the surveyed migration routes, population density, and migration season/time. If some high risk areas are identified, crossing structures especially for wildlife, some structures which prevent invasion of animals into roads, operation plans to minimize road kill, and warning systems for drivers should be examined at the feasibility stage.

4) Layout to minimize cutting vegetation

When design and location of the facilities for hydropower plant are examined, minimizing the vegetation cut should be considered. Disturbance of riparian forest should especially be minimized because it provides habitat for many species. Most of the permanent facilities except maintenance roads, waste rock disposal sites, barrages, inlets and outlets such as penstock, powerhouse, surge tank and transformer are planned underground. On the other hand, most of the temporally facilities such as stock yard, crasher plant, batcher plant and temporally roads are above the ground. If this is the case, temporally vegetation loss will not be avoided. Careful designing for temporally facilities to minimize vegetation loss and vegetation recovery plans is needed.

5) Ensuring environmental flow

In order to minimize the impact on aquatic wildlife, environmental flow at the recession area must be ensured. It is difficult to suggest the ideal volume of environmental flow during pre-feasibility study. After the survey on population of Hippopotamus and Crocodiles, population home range, water quality, water temperature, water velocity, water depth, riverbed topography, topography of landing points, and migration routes, estimation for water volume, water quality, water temperature and water depth during operations should be done. Then environmental flow should be carefully examined based on the impacts by some water flow scenarios.

6) Minimize impact on landscape

The impact on the landscape should be minimized, because landscape in the National Park is a big natural resource for tourism in Uganda. Barrages and transmissions line might be landscape disturbance structures. Although a barrage is not normally seen by overflowed water, the shape can be customized to make the flow natural. The route of transmission line should be selected to minimize the disturbance of natural landscape, based on the several landscape simulations from some view points and tour courses using measured topographic map. The shape, color, and airway beacon of the transmission line tower should also befit the landscape. A visibility study for the other above ground facilities should be examined and screen planting can be designed for some cases.

7) Ensure the migration route for aquatic wildlife

The division of habitat of aquatic fauna should be minimized. Possibility of the special pass for Hippopotamus, Crocodile and/or fishes should be examined on the basis of the survey for movable water velocity, bump and slope.

8) Supporting UWA's activities

There are many National Park management activities which should be enhanced by UWA such as controlling fire, poaching patrol, encroachment patrol, park boundary management, park gate control, and wildlife monitoring. The possibility of supporting these activities might be examined as a part of the mitigations.

(3) Environmental monitoring

Environmental monitoring is recommended after EIA study, because the data is useful for mitigations before construction. Environmental monitoring at same points, by same methods before construction, under construction and in operations makes it possible to enable adequate mitigations in line with the biological changes.

(4) Survey on Bujagali Hydropower Project

Actual impact survey on Bujagali Hydropower project might have a lot to tell. The study team has already visited the project site several times, confirmed the implementation of the mitigations and reflected on the lessons on the scoping checklist during Pre-F/S stage. In addition to the design of feasibility study, the lessons of Bujagali Hydropower Project should be reflected upon.

(5) Development type of Karuma Hydropower Project

As for development type of Ayago Hydropower Project, run of river type, which has no storage capacity, is selected from the view point of minimization of environmental impacts. However, in case Karuma Hydropower Project has reservoir or regulating Pond, river flow may fluctuate widely due to the peak discharge. As a consequence there is concern that ecology of plants, animals and tourism surrounding river would be affected. In addition, it will be difficult to execute integrated operation with Ayago Hydropower Project.

11.2.2 Design

(1) Additional Topographical Survey

Although the rough topographical maps based on the aerial survey is prepared in the Pre-FS, the detailed topographical maps based on the location survey will be required in the F/S stage. In terms of river section survey, larger area shall be investigated to design structures and the study for the environmental flow.

(2) Additional Geological Investigation

Although in the Pre-FS stage the borings are mainly conducted at the weir, the intake, the upstream powerhouse and the outlet, in the F/S stage the additional borings shall be conducted at the downstream powerhouse and waterway. It is also recommended that the elastic wave exploration to see the characteristic of wide ranging water ways and the initial rock stress and borehole TV to design the underground powerhouse will be conducted.

(3) Hydraulic Model Experiment

The maximum intake discharge is so much (840m3/s) that the hydraulic model experiment is recommended to see the impact on the animals in the river.

(4) Network Stability Analysis and Reviewing Unit Capacity

In this study, stability analysis is not undertaken because the study is master plan stage. Therefore it is necessary to carry out stability analysis in the F/S because it might be critical for the network. Besides the unit capacity of 50MW might be reviewed based on the result of stability analysis.

11.2.3 Construction Plan and Cost Estimation

(1) Construction Planning

In the Pre F/S stage, the temporary facility yard and the disposal area are planned by using temporary map mainly. In the F/S stage the most appropriate area and scale shall be determined based on the topographic survey in consideration of environmental impact.

(2) Cost Estimation

In the Pre F/S stage, construction costs are estimated based on approximate quantities and market unit price. In the F/S stage the accuracy of quantities shall be improved according to drawings. Especially unit prices of work items shall be examined carefully with reference to the actual examples in the neighboring countries and contractor's quotation because there are few similar projects in Uganda.

11.2.4 Framework for Implementation of F/S

Necessary framework for implementation of F/S is described bellow.

1) Basic Design: including topographic survey and geological survey
2) Planning and Design: including

   /civil design (hydraulic structure, underground structure and environment-conscious including amenity flow and so on)

   /architecture (Building and landscape assessment)

   /electromechanical

   /steel structure

   /transmission line (selection of route and landscape assessment)
3) Construction Planning and Cost estimation
4) Power system planning (power supply and demand, verification of stability)
5) Economic and finance
6) Natural and Social Environment

For framework of counter part, the arrangements of responsible staffs for Civil and Geological work are expected at the F/S work.