Annex H

Power Development Plan

Annex H POWER DEVELOPMENT PLAN

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Annex H POWER DEVELOPMENT PLAN

H1 Power Supply

H1.1 Power Supply System

H1.1.1 General

This Study examines two hydropower schemes at a preliminary study level; Agos scheme and Lagundi scheme. The generated power is planned to supply to either the NPC Luzon interconnected system or Meralco distribution system.

Main features of the power supply systems are described in the Master Plan conducted in 2001 (Refer to Section E5 in Part E of Volume III). The Subsections below present the latest conditions revealed since that time.

H1.1.2 Luzon Interconnected System (NPC-TRANSCO)

National Transmission Corporation (TRANSCO) operates the nation-wide interconnected system. TRANSCO is a power transmission company established recently under the umbrella of NPC. TRANSCO is functioning mainly as a bulk power supplier to power distribution companies and major industrial customers. The national interconnected system consists of three main grids, namely Luzon, Visayas and Mindanao grids, of which the hydropower schemes under this Study will be connected to the Luzon grid..

Peak power demand of the Luzon grid was 5,557 MW in 2000 and is projected to increase to some 11,841 MW in 2010 (See Table E4.2 in Part E of Volume III), which is large enough to receive any scale of power from the proposed scheme. Energy sale of the Luzon grid was 32,593 GWh in 2000 and is foreseen to increase to 69,458 GWh in 2010.

The nearest substations are Malaya Gas Turbine Plant and Dolores Substation, both rated at 230 kV (See Figure H1.1 for the locations).

H1.1.3 Meralco Supply System

As a retail power distributor, Manila Electric Company (Meralco) distributes the power in its franchise area covering, from north to south, Bulacan Province, Metro Manila, Rizal Province, Cavite Province, southern part of Quezon Province and the area around Batang Gas City.

The operating statistics of the Meralco system from 1990 to 2001 are shown in Table E4.5 of Part E in Volume III. The peak power demand and energy sales were 4,318 MW and 22,689 GWh in 2001, respectively. As of 2001, Meralco purchases about 90 % of its power from NPC and the rest from the Meralco's IPPs. The Meralco system is also large enough to absorb the power from the planned hydropower schemes in this Study.

The nearest existing substation is the new Teresa Substation, rated at 115/34.5 kV (See Figure H1.1 for the location). Further, Meralco has a plan of building a new 115 kV substation near Tanay town within a 5-6 year period. Depending on the scale of the proposed hydropower plant, an alternative solution may be to transmit the power from the proposed plant directly to the Meralco supply system, if this Tanay new substation is built.

H1.1.4 Quezelco Supply Area

As a retail power distributor, Quezon Electric Company (Quezelco) is supplying the power to Infanta-General Nakar-Real area.

(1) Present Power Supply and Demand Conditions

A 69 kV transmission line from Kalayaan Power Station (P/S) supplies the power to a Quezelco's Substation (S/S) at Infanta. The substation, equipped with a 3.75 MVA, 69kV/13.2kV transformer, is a load end substation with an average load of 2.7 MW and a peak load of 2.9 MW (3.41 MVA @ 85% power factor). The peak load represents about 90% of Quezelco's total substation capacity.

At present, Quezelco is concerned that their present capacity of 3.75 MVA will exceed the demand within one year. For this reason, Quezelco was going to hold a Planning Workshop on October 9 to 11, 2002 to tackle their power development program in the next 5 years.

(2) Quezelco S/S Expansion Program

Quezelco has an average load growth rate of 22 % (about 0.366 MW per annum) with the highest load growth rate of 30.63% occurring in fiscal year 2001-2002. In this period, the loading to their 3.75 MVA transformer increased from 2.22 to 2.9 MW. Quezelco's present peak load of 2.9 MW is expected to grow to 7.83 MW within a five year period (2007) or more, if the average annual growth rate increases further due to the recently completed 42 km stretch of road from Famy, Quezon to Infanta town proper.

The proposed Agos hydropower plant is planned to supply its power also to the Quezelco system. This will contribute to improve the security of power supply in the area, since the area presently depends solely on supply from a single power source (Kalayaan P/S) delivered by a single-circuit 69 kV transmission line.

H1.2 Power Rates in NPC and Meralco Systems

The table below shows historical power rates in the NPC and Meralco systems:

Historical Power Rates in NPC and Meralco Systems

Year	NPC Luzon Grid	Meralco Franchise Area		Exchange Rate (Peso/US$)
	Power Tariff to Consumers	Power Tariff to Consumers	Purchased Power Cost (Purchase from NPC/IPPs)	
1995	1.85	-	-	25.7
1996	2.08	-	-	26.2
1997	2.29	-	-	26.5(29.5)
1998	2.77	-	-	40.9
1999	2.84	4.01	2.87	40.3(39.1)
2000	3.31 (Mar.-Dec.)	4.70	3.41	50.0(44.2)
2001	3.87 (Jan.-Mar.)	5.67	4.22	51.7
Increase Rate	16.7 % (1999-2001) 13.1 % (1995-2001)	18.9 % (1999-2001)	21.3 % (1999-2001)	

Sources: 1) NPC Annual Reports, 1999 and 2000, NPC
2) Effective Rates for Luzon Grid, March 2000-March 2001, NPC
3) Meralco Annual Reports, 2000 and 2001, Meralco

NPC has no clear-cut criteria for the price of power purchase from the IPPs, which would, according to NPC, be determined through negotiation on individual project basis (as of 2001). With the passage of RA9136-Electricity Industry Reform Act of 2001 and its IRR, NPC is bared from incurring obligations to purchase power from generation companies and other suppliers. Henceforward, TRANSCO is deemed to be the purchaser of power.

In the financial study for Laiban Dam project conducted in 1997, unit selling price was assumed as Peso 2.0/kWh (equivalent to US Cent 7.5/kWh in 1997). In the Master Plan Study in 2001, it was assumed as Peso 2.5/kWh (US Cent 4.8/kWh) by escalating the rate assumed in the Laiban Dam project at 5 % per annum.

The above table indicates that unit selling price has increased at a high rate during these 3 years. With the current prices in view, it may still be on a conservative side to assume that the selling price would not be less than Peso 3.5/kWh (US Cent 6.7/kWh) in the case of selling to NPC-TRANSCO system and Peso 4.0/kWh (US Cent 7.7/kWh) in the case of Meralco system, respectively, at 2002 price. The Study was carried out using these rates in assessing the financial viability of the proposed hydropower development schemes.

H2 Plan Formulation of Agos Hydropower Scheme

H2.1 Concept of Power Scheme

Construction of the Agos Dam will provide a potential of hydropower development, where a head of about 100 m is created. With an effective storage capacity of 409 million m^3, Agos Reservoir can yield 62.4 m^3/sec of water throughout a year, of which 34.7 m^3/sec (equivalent to 3,000 MLD) is conveyed to Metro Manila for water supply in the final stage. The remaining 27.7 m^3/sec (including 4.35 m^3/sec of river maintenance discharge) can be used for hydropower generation until such time when further water allocation for water supply purpose is required in the long future.

A basic principle to be assumed here is that, once hydropower scheme is included in the Agos Dam development plan, it should be afforded to have a concession period of at least 25 years for operation. The 25-year period is deemed to be a minimum period to make the power scheme economically and financially viable.

General plan and profile of the proposed Agos power scheme is shown in Figure H2.1. The plant will be built at the time of constructing the Agos Dam.

H2.2 Alternative Development Plans

The power supply system, whatever it is NPC-TRANSCO Luzon grid or Meralco system, can absorb any type of power generation from the proposed Agos scheme. From the aspect of load characteristics, the system may require the scheme to be preferably a peaking plant in order to use the merit of hydropower plant. With this in view, the following four (4) alternative plans were examined:

Formulation of Alternative Plans

Alternative	Maximum Plant Discharge/1 (m3/sec)	Need of Afterbay Weir for Flow Re-regulation	Remarks
A	110.8	With Afterbay Weir	Equivalent to 6-hour peaking operation
B	83.1	With Afterbay Weir	Equivalent to 8-hour peaking operation
C	55.4	Without Afterbay Weir	Equivalent to 12-hour semi-peaking operation
D	27.7/2	No need of Afterbay Weir	Principally, 24-hour base-load operation

Notes: /1; Maximum plant discharge at Rated Water Level (RWL)
/2; Selected through trial calculation so that average turbine flow would be 26.3 m^3/sec

Alternative Plans A and B require an afterbay pond for re-regulation of peaking discharges. An afterbay weir is proposed about 8 km downstream of the Agos Dam site. A preliminary plan of the afterbay weir is shown in Figure H2.2.

H2.3 Power Output Calculation

Using 31-year hydrological data, power outputs for the four alternative plans were calculated based on the following criteria:

(a) Power output calculation formula:

P= 9.8 x η x Q x He

where, η : Power generation efficiency, variable by Q and H

Q: Turbine discharge, variable by reservoir water level

He: Effective head, variable by Q

(b) Basic Operating Conditions:

- Full Supply Level (FSL): EL.159.0 m
- Rated Water Level (RWL): EL.152.5 m (Upper 1/4 of darwdown depth)
- Minimum Operating Level (MOL): EL.133.0 m
- Tailwater Level (TWL): EL.41.8m, EL.41.6m, EL.41.5m, EL. 41.2m in Alt. A, B, C, D, respectively

(c) Diameters of power waterway were determined for each alternative based on empirical formulae used in Japan.

(d) A unique aspect in the scheme is a relatively large variation of turbinable discharge, effective head and generation efficiency, all varying by reservoir water level. This aspect was taken into account in the calculation as stated above.

(e) Rated Water Level (RWL) was selected at a water level corresponding to the upper 1/4 level of the reservoir drawdown depth, i.e. EL. 152.5 m. Design head of turbine was determined at this hydraulic condition.

The results of calculation are summarized below and the details are given in Table H2.1:

Results of Power Output Calculation for alternative Development Plans

Alternative	Installed Capacity (MW)	90% Dependable Power Output (MW)	Annual Energy Generation (GWh)			Yearly Plant Factor
			Primary	Secondary	Total	
A	103.4	85.9	216.1	253.3	469.4	0.52
B	77.5	64.4	216.0	186.8	402.8	0.59
C	51.5	42.7	215.3	102.9	318.2	0.70
D	25.6	21.1	213.3	0.0	213.3	0.95

Notes: 1. Plant Factor = Total Energy/(Installed Capacity x 24 hrs x 365 days)
2. Dependable power used for economic evaluation is taken at 90 % guaranteed power.

H2.4 Comparison of Alternative Plans

Comparison of 4 alternative plans is primarily based on economic evaluation. Economic benefit was taken from alternative thermal power cost. The result is summarized below:

Comparison of Economic Viability of Alternative Development Plans

(Monetary Unit: US$ Million)

Alternative	Construction Cost /1	NPV of Cost/2 (C)	NPV of Benefit/3 (B)	Net Benefit (B-C)	EIRR (%)
A	159.0	120.9	120.0	-0.9	11.8
B	139.4	98.6	98.6	-7.3	10.3
C	81.2	68.8	68.8	6.3	14.6
D	58.5	40.1	40.1	-4.9	9.6

Notes:
/1 The above costs show economic costs based on 2002 market prices, covering the costs of intake, waterway, powerhouse, generating equipment, switchyard, afterbay weir (for Alternative A and B), transmission line and substation.
/2 Annual O&M cost at 0.5 % of civil works capital cost and 2.5 % of electrical/mechanical works capital cost
/3 As the alternative thermal costs, costs of combined-cycle plant are assumed as follows (See Section E5 in Part-E of Volume III):
- kW Value: Capital Cost = US$ 700/kW, Fixed O&M Cost = US$ 28.65/kW
- kWh Value: US$ 0.0217/kWh
- Adjustment Factor: 1.279 for kW value and 1.061 for kWh value
4) Economic costs and benefits are discounted at 12 % per annum.
5) Abbreviations NPV: Net Present Value
EIRR: Economic Internal Rate of Return

Since the Agos power scheme is proposed to be implemented under a BOT contract, the most important evaluation factor is the financial viability. Hence, the comparison was also made from financial aspect. The result is shown below:

Comparison of Financial Viability of Alternative Development Plans

Alternative	Construction Cost (US$ million)	FIRR (%)	ROE (%)	WACC (%)
A	239.7	22.6	32.8	15.8
B	210.2	21.4	30.7	15.1
C	121.9	25.6	38.5	17.9
D	87.8	19.5	28.3	14.3

Notes:
1) The above financial costs are based on 2002 market prices, covering costs of intake, waterway, powerhouse, switchyard, afterbay weir (for Alt. A and B), transmission line and substation. The costs are escalated at 2 % per annum for F/C portion and 3 % for L/C portion, respectively
2) Annual O&M cost at 0.5 % of civil works capital cost and 2.5 % of electrical/mechanical works capital cost
3) VAT of 10% is applied.
4) Unit power selling price is assumed to be Peso 3.5/kWh at 2002 price, which is escalated at 3 % per annum
4) Discounted at 12 %
5) Abbreviations FIRR : Financial Rate of Return
WACC : Weighted Average Cost of Capital
ROE : Return of Equity

As indicated in the tables above, the Alternative Development Plan C is found to be the most attractive from both economic and financial viewpoints. Therefore, the Alternative Development Plan C is selected as the most viable development scale for the Agos power scheme.

H2.5 Power Output in the Case of Implementation of Laiban Dam

MWSS contemplates the implementation of Laiban Dam either prior to or after the Agos Dam. In this case, a 1,830 MLD (21.2 m^3/sec) of water is conveyed to Metro

Manila being taken upstream of the Agos Dam. This implies the reduction of inflow to the Agos reservoir and accordingly the available discharges for power generation.

Power output of Alternative Plan C for the case after the completion of Laiban Dam was calculated as shown in the table below:

Power Output in the Case of Implementation of Laiban Dam

Phase	Water Supply from Laiban Dam (m^3/sec)	Water Supply from Agos Dam (m^3/sec)	Discharge Available for Power (m^3/sec)	Annual Energy production (GWh)		
				Primary	Secondary	Total
Case-1	21.2 (1,830MLD)	17.35 (1,500MLD)	24.0	192.03	96.17	288.20
Case-2	21.2 (1,830MLD)	34.7 (3,000MLD)	6.5	52.73	28.43	81.16

Note: Installed Capacity: 51.5 MW (Alternative Plan C)
Case-1: Water supply meeting the demand level of around Year 2025
Case-2: Additional water supply of 1,500 MLD at Agos (in the case of future expansion)

As shown above, energy production at the Agos power plant is much reduced, particularly in the case water supply from Agos Dam is expanded to 3,000 MLD. Nevertheless, even under this condition, the plant can be operated at a reduced capacity as a base-load plant (25.6 MW) or as a semi-peaking plant (51.5 MW peak) by using the residual discharges including the river maintenance flow of 4.35 m^3/sec.

H3 Plan Formulation of Lagundi Hydropower Scheme

H3.1 Concept of Power Scheme

Construction of Lagundi power plant is conceivable at the downstream end of No.1 Tunnel to harness the head available between Agos Reservoir and the power plant. The proposed plan, however, has the following constraints due to the particular nature of the scheme:

(a) Power generation has to be made using the predetermined discharges delivered according to water supply demand. The discharge is supposed to fluctuate daily in a range of ±20 % of the daily average discharge. This means that the plant cannot yield a constant rate of power, though it is basically a 24-hour generation plant.

(b) No.1 Tunnel has a length of 27 km, where loss head is quite large in the order of 30 m at the maximum discharge. The effective head is almost nil under the conditions of MOL (minimum operating level) in the reservoir and the maximum discharge in the tunnel (42 m^3/sec by 2 tunnels). Moreover, power generation is not possible when the effective head is less than 65 % of the turbine design head due to the characteristics of the turbine. These imply that there would be interruption of power generation for certain periods in the dry season when the reservoir water level becomes low.

Owing to the above two constraints, the attractiveness of the Lagundi power scheme is supposed to be limited. Nevertheless, studies described below were made to examine any possibility of justifying the scheme.

General layout plan of the proposed Lagundi Power plant is shown in Figure H3.1. The plant will be constructed when the 2nd tunnel of Tunnel No.1 is built at the Stage 2-2 of the Project implementation.

H3.2 Proposed Development Plan

As shown in Figure G2.1, there are two (2) alternative plans with regard to the layout of the downstream part of Tunnel No.1. One is with the Lagundi power plant and the other without the plant.

In the case of the former plan, additional facilities specifically required for the construction of the power plant are the incremental lengths of Tunnels No.1 and No.2, surge tanks, penstocks, a powerhouse, a switchyard and a transmission line to a substation at the water treatment plant. The cost thereof should be born by the Lagundi power scheme. Provision of valve houses is common to both the alternative plans.

With regard to power generation, no alternative plan is conceivable since both the discharges and operating heads are the given conditions determined by water supply scheme. Basic features of the proposed plan are as follows:

- Daily average discharge: 34.7 m^3/sec (3,000 MLD for water supply), at the final stage of water supply project
- Maximum discharge: 42.1 m^3/sec (1.21 times the average discharge, corresponding to day peak discharge for water supply)
- Turbinable Head: 65-125 % of turbine design head (corresponding to EL.145.0-159.0 m in terms of the reservoir water level)

H3.3 Power Output Calculation

Using 31-year hydrological data, power outputs for the four alternative plans were calculated based on the following criteria:

(a) Power output calculation formula: See Subsection H2.3 above

(b) Basic Operating Conditions: as shown in the table below:

Item	Power Operating Condition
Full Supply Level (FSL)	EL.159.0 m (correspond to turbinable head 125 %)
Rated Water Level (RWL)	EL.153.2 m (correspond to turbinable head 100 %)
Operational Low Water Level	EL.145.0 m (correspond to turbinable head 65 %)
Minimum Reservoir Level (MOL)	EL.133.0 m (No power generation)
Tailwater Level (TWL)	EL.99.5 m

(c) A unique aspect in this scheme is that effective head, and accordingly power output varies greatly by discharge. A trial calculation revealed that larger power output is available under the flow condition at daily average discharge, rather than at the maximum discharge as shown in the table below:

Power Output by Daily Average Discharge to be Conveyed to Metro Manila

Discharge	Loss Head	Effective Head at RWL	Power Output
34.7 m^3/sec	22.0 m	31.7 m	9.3 MW
42.1 m^3/sec	31.9 m	21.8 m	6.4 MW

This suggests that installed capacity of the plant should better be determined at the daily average discharge for water supply (34.7 m^3/sec), which is regarded as the maximum plant discharge for the power scheme. In this case, discharges larger than 34.7 m^3/sec will be released through by-pass valves.

(d) At present stage, the exact features of daily fluctuation of discharges for water supply are not known. Hence, the power output calculation was made assuming the discharge to be constant at the rate of daily average discharge. Instead, energy production was assessed to be 80 % of the calculated figure in order to incorporate the loss of energy production due to by-passing of flow larger than 34.7 m^3/sec.

The result of power output calculation is shown below:

Calculated Power/Energy Production of Lagundi Power Plants

Item	Power/Energy Production
- Installed capacity	10.6 MW
- 90 % dependable power output	5.65 MW
- Annual Energy Production	78.0 GWh (regarded all as primary energy)
- Interruption of power generation	92 % of time

The details of the calculation are presented in Table H3.1.

H3.4 Assessment of the Proposed Plan

The viability of the scheme was assessed through financial analysis under the following conditions:

(a) Construction costs cover the incremental lengths of Tunnel No.1 and No.2, surge tanks, penstocks, powerhouse, generating equipment, a switchyard and transmission line, estimated at US$ 20.1 million equivalent

(b) Annual O&M costs at 0.5 % of civil works capital cost and 2.5 % of electrical and mechanical works capital cost

(c) Power revenue is Peso 3.5/kWh at 2002 price, which is escalated at 3 % per annum in the cash flow analysis.

The results of the financial analysis show that net return becomes negative value at U$ 29.4 million in the present worth and a FIRR of 5.3 %. Relatively low figures of the both items are due to high burden of costs for waterway and low energy production due to large head loss in the waterway.

The results suggest that the scheme is not justifiable from the financial viewpoint. Further, the relatively long interruption of power generation makes the attractiveness of the scheme lesser.

Hence, the Lagundi power scheme was ruled out from the plan formulation of the Project.

H4 Planning of Transmission Lines and Substations

H4.1 Existing Transmission Lines and Substations

(1) Malaya Substation

TRANSCO Malaya Substation (S/S) is situated in the complex of Malaya Gas-Turbine Power Station (P/S), which is now privatized and owned by Kephilco, a Korean firm. The location is shown in Figure H1.1.

Malaya S/S is a 230 kV switching facility, and it has no 69 kV bus. Malaya S/S is directly connected to Dolores S/S via the existing 230 kV double circuits, bundle of 4 x 795 ACSR conductors, with a total length of 39 km. There are now two 230 kV feeders available at Malaya S/S, as the Malaya Gas Turbine P/S is no longer allowed by the government to operate due to its high operating cost.

Malaya S/S can accommodate one additional bay to receive a 230 kV double circuit transmission line from the proposed Agos power plant. However, Figure H1.1 shows that Malaya S/S is not an ideal interconnecting point for the Agos power station as it is farther than Dolores S/S.

(2) Dolores S/S

Dolores S/S can accommodate one additional bay to introduce the 230 kV double circuit transmission line from the proposed Agos power plant, but like Malaya S/S, it has no 69 kV bus. Dolores S/S has an old substation site adjacent to the Dolores S/S. The old substation site has an enough area to accommodate a 2 to 3 bay 230 kV 1-1/2 breaker scheme substation. The additional feeder bay will be provided in the old substation area. Since the ground level of old substation site is a few meter higher than the present Dolores S/S area, the work will require the excavation of a part of the old substation site.

(3) TRANSCO Trunk Transmission Lines

Both the Malaya S/S and Dolores S/S could properly convey to Manila the additional power coming from the proposed Agos power plant through the existing transmission lines. In the area, the backup 500kV transmission lines to San Jose Del Monte, Bulacan, is now fully operational. This makes, in the section between Malaya and Dolores, the reduction of load for the existing 4 x 795 ACSR, 39 km double-circuit 230kV Malaya-Dolores transmission line. Based on recent load flow studies, the load of Malaya-Dolores line is now only 150 MW (about 175 MVA), which is far below its rated capacity of 1,320 MVA.

(4) Meralco New Teresa S/S

New Teresa S/S is a Meralco 115 kV switching station connected to 115 kV Malaya S/S by a double circuit transmission line and to 115 kV Dolores S/S by a single circuit transmission line. It has no 69 kV bus and the only available tapping point for the proposed Water Treatment Plant S/S is 34.5 kV bus. The 34.5 kV bus is connected by an 8.3 MVA 115/34.5/13.8 kV three winding transformer. The 8.3 MVA transformer is serving several municipalities around New Teresa S/S. This

S/S has no sufficient space for accommodating an additional double-circuit incoming line.

No attempt was made to determine the loading of the 115 kV transmission lines since Dolores S/S is a better alternative.

(5) Quezelco Substation

The existing 3.75 MVA 69 kV Quezelco S/S is a far contrast from its main property as it was erected in an area of only 450 m^2. It is not possible to expand this existing substation to accommodate an additional 69 kV feeder from the proposed Agos power plant because of the very limited space and further it is located in a residential area with all surrounding lots already occupied.

On one hand, Quezelco has its main office and stockyard of 2 ha area, situated about 8 km from the existing 69 kV substation. Quezelco agreed to relocate the existing substation to their 2 ha property, provided Agos power project (Stage 2-1 project) would fund the procurement and installation of all 69 kV equipment and accessories for the new switching facilities.

A 69 kV transmission line from Agos power plant must therefore consider the new site for Quezelco S/S.

H4.2 Power Transmission Plans

(1) Main Receiving Substation

Comparing the existing substations as stated above, this Study assumes that main receiving substation is Dolores Substation in consideration of the following:

- Dolores S/S presently functions as a key substation for the supply network in the area
- It is proximity to the Morong Water Treatment Plant (WTP), where a local substation for the distribution of power to various waterway facilities is proposed

As stated in the foregoing Section H1.1, Meralco has a plan of constructing a new substation near Tanay town in the Municipality of Tanay within 5-6 years. Taking a merit of proximity to the Agos site, this Tanay S/S may be an alternative tapping point for receiving the power from the Agos power plant. Nevertheless, this alternative plan is regarded as a plan to be further studied in the subsequent stage. In the present Study stage, the assumption of the Dolores S/S is more conservative in terms of estimating the project cost.

(2) Power Supply to Waterway Facilities

Water supply project envisages the construction of various waterway facilities needing the supply of power for operating the plant and equipment. The major facilities are (i) Kaliwa Low Dam and Intake, (ii) Morong Water treatment Plant (WTP), (iii) a Valve House at bifurcation of waterways to Antipolo and Tayatay, (iv) Antipolo Pump Station, (v) Antipolo Service Reservoirs and (vi) Taytay

Service Reservoirs. Power requirement at these facilities is roughly estimated as follows:

Power Requirement at Waterway Facilities

Facility	Power Required (kW)	
	Stage 1	Final Stage
Kaliwa Low Dam	20	30
Morong Water Treatment Plant	1,200	3,600
Valve House at Bifurcation Point	10	20
Antipolo Pump Station	2,500	13,500
Antipolo Service Reservoir	10	20
Taytay Service Reservoir	40	120
Total	3,780	17,290

Power transmission plan shown in (3) below will take into account the supply of power to these facilities.

(3) Power Transmission Plan

The proposed project envisages the implementation in three (3) stages.

- Stage 1: Construction of Kaliwa Low Dam and 1st Kaliwa-Taytay Waterway: At this stage, power for waterway facilities will be supplied from the existing Dolores S/S.
- Stage 2-1: Construction of Agos Dam with Agos power plant: Power from the Agos power plant will be interconnected to the Luzon Grid as well as to the power supply system for waterway facilities. Power will also be sent to Quezelco S/S in Infanta.
- Stage 2-2: Construction of 2nd Kaliwa-Taytay Waterway

Following the above overall schedule, the implementation of power transmission and distribution facilities is proposed as shown in Figure H4.1 in the form of main single line diagram. The Figure shows the proposed power transmission system at the respective stages of the implementation as described hereunder.

Stage 1:

The Stage 1 requires the construction of the following power transmission facilities for power supply to the water treatment plant, pump station and other water service facilities.

(a) Extension of the existing Dolores S/S for additional 230 kV bays to introduce a 230 kV double-circuit transmission line described in (b) below.

(b) Construction of a 15.6 km long 230 kV double-circuit transmission line between the existing Dolores S/S and a new 230 kV substation described in (c) below.

(c) Construction of a new 230 kV substation at the Morong Water Treatment Plant (hereinafter referred to as "Morong S/S").

The Morong S/S will be developed in stage-wise to meet expansion plan of the waterway facilities. In Stage 1, the following equipment will be installed in the Morong S/S:

- One 230/34.5/13.8 kV, 12.5/10/2.5 MVA step-down transformer
- One 13.8/0.48 kV station-service transformer
- 230 kV switchgear for a step-down transformer primary circuit and two transmission line circuits
- 34.5 kV switchgear for a step-down transformer secondary circuit and a distribution line circuit
- 13.8 kV switchgear for a step-down transformer tertiary circuit, three distribution line circuits and a station-service transformer circuit
- One lot of low voltage switchgear
- Control and protection equipment for the above equipment

The proposed step-down transformer will have a sufficient capacity to supply power to the various waterway facilities to be developed at the Stage 2-1.

(d) Construction of the following 34.5 kV distribution lines

- 34.5 kV distribution line of 5.8 km long between Morong S/S and Antipolo Pump Station
- 34.5 kV distribution line of 2.0 km long between Antipolo Pump Station and Antipolo Service Reservoirs

(e) Construction of the following 13.8 kV distribution lines

- 13.8 kV distribution line of 30.6 km long between Morong S/S and Kaliwa Low Dam
- 13.8 kV distribution line of 4.7 km long between Morong S/S and Valve House
- 13.8 kV distribution line of 6.5 km long between Valve House and Taytay Service Reservoir

<u>Stage 2-1</u>:

Agos Hydropower Plant will be developed in Stage 2-1.

The Agos P/S will be interconnected with the Luzon Grid at Morong S/S via 230 kV double-circuit transmission line as well as Quezelco Substation in Infanta via 69 kV single-circuit transmission line.

The development of the Agos P/S requires the construction of the following power transmission facilities.

(a) Construction of Agos Switchyard to arrange the following equipment.

- 230 kV switchgear for two generator transformer circuits, a transformer primary circuit and two transmission line circuits

- One 230/69/13.8 kV, 12.5/10/2.5 MVA step-down transformer
- 69 kV switchgear for a step-down transformer secondary circuit
- 13.8 kV switchgear for a step-down transformer tertiary circuit

(b) Construction of a 230 kV double-circuit transmission line of 37.0 km long between Agos P/S and Morong S/S.

(c) Extension of the Morong S/S for additional 230 kV bays to introduce a 230 kV double-circuit transmission line described in (b) above.

(d) Construction of a 69 kV single-circuit transmission line of 14.0 km long between Agos P/S and Quezelco S/S in Infanta.

(e) Construction of the New Quezelco S/S to introduce a 69 kV single-circuit transmission line from the Agos P/S. After completion of the New Quezelco S/S, all functions of the existing Quezelco S/S are to be transferred to the New S/S.

<u>Stage 2-2</u>:

The Stage 2-2 requires extension of the Morong S/S to increase the power supply capacity to meet the expansion plan of the water treatment plant, pump station and other water service facilities.

The extension of the Morong S/S will be carried out for the following additional equipment.

(a) One 230/34.5/13.8 kV, 12.5/10/2.5 MVA step-down transformer

(b) 230 kV switchgear for the primary circuit of additional step-down transformer

(c) 34.5 kV switchgear for the secondary circuit of additional step-down transformer

(d) 13.8 kV switchgear for the tertiary circuit of additional step-down transformer

(e) Control and protection equipment for the above additional equipment

(4) Concepts of the Proposed Transmission Plan

Figure H4.1 shows the least cost solution for the interconnection of the proposed hydroelectric plants to the Luzon Grid. Aside from its lower cost, this scheme was selected because of its simplicity and reliability to provide continuous power supply to various facilities inside the waterway complex. The advantages derived from the scheme shown are summarized as follows:

(a) Two separate power sources are available for the power supply to the waterway facilities, i.e. from Dolores S/S and Agos power plant. Continuous supply to the waterway facilities is assured even when either one power source is out of service.

(b) The system is not dependent on New Teresa S/S, which is a switching station. At this station, only available interconnecting point is either to its 34.5 kV or 13.8 kV bus, which is supplied by a single 8.3 MVA 115/34.5/13.5 kV distribution transformer.

(c) Only three metering systems are required for simplifying tariff computation. They are between Agos power plant and Dolores S/S, and between Agos power plant and Infanta Quezelco S/S. Dolores S/S was selected as the tapping point for Agos 230 kV transmission lines, since it is nearer than Malaya S/S as shown in Figure H1.1, which depicts all the proposed transmission and distribution line routes.

(d) The 230 kV S/S at the Morong Water Treatment Plant is convenient not only for power distribution to the various water service facilities but also for interconnection between Agos P/S and Luzon Grid.

(e) Less costly as compared with the other alternative interconnection schemes examined earlier in this study.

H5 Preliminary Design of Power Facilities

H5.1 Agos Hydropower Station

H5.1.1 Civil Works

The general layout plan and profile of the proposed Agos powerhouse are shown in Figure F4.3 in Annex F of Volume V and Figure H5.1, respectively. This Subsection H5.1.1 summarizes the civil works required for constrcution of the Agos hydropower station, while Annex F of this Volume V discusses the comparison study of the alternative power waterway routes as well as the dimensions of the proposed structures for the Agos power station.

(1) Power Intake

Power intake and associated waterway are built on the left bank. The intake will feed the maximum plant discharge of 55.4 m^3/sec, which includes the minimum river maintenance discharge of 4.35 m^3/sec to be released to the downstream reach. The intake is of a lateral vermouth type with sill elevation at EL.120 m. The inlet openings are equipped with screens, but no raking devices are provided since it is deep from the reservoir operating levels. A closure gate is provided in a shaft built at some 148 m from the intake.

(2) Power Waterway

Water is to be fed into a power waterway of 755m in total length. It comprises intake structure, concrete-lined headrace tunnel of 5.9m in diameter and 535m long in the upstream part and a steel-lined penstock of 5.4m in diameter and 212m long. In view of a moderate length of the waterway, no surge tank is provided.

(3) Powerhouse

Powerhouse is of conventional type above-ground construction with dimensions of roughly 48m wide, 34m long and 47m high. It accommodates two units of turbines and generators with a total installed capacity of 51.5 MW. Two generator transformers are installed at the outside behind the powerhouse.

(4) Switchyard

A switchyard is built at the toe of dam at EL.55 m. The switchyard is of conventional, outdoor open type bus-and-switch arrangement for 230 kV switchgear, a 230/69/13.8 kV transformer, 69 kV switchgear and 13.8 kV switchgear. The switchyard has three outgoing feeders, that is, a 230 kV double-circuit transmission line to the Morong S/S, a 69 kV single-circuit transmission line to the New Quezelco S/S and a 13.8 kV distribution line to the After Bay. The required area of land is roughly 100 m by 150 m.

H5.1.2 Generating Equipment

(1) Operating Conditions

As described in the foregoing Section H2.3, the operating conditions for the generating equipment are summarized below:

(a)	Rated water level of Agos reservoir:	EL. 152.5 m
(b)	Maximum plant discharge:	55.4 m^3/sec
(c)	Tailrace water level at maximum plant discharge:	EL. 41.5 m
(d)	Rated head:	111.0 m

(2) Number of Units

Two units layout was selected to provide flexibility and redundancy in operation of the generating equipment in preparation for unit shutdown due to unforeseeable accident and periodical maintenance.

(3) Type of Turbine and Generator

Vertical-shaft Francis turbine is an optimum type of hydraulic turbine for rated head of 111.0 m and unit discharge of 27.2 m^3/s.

The generator is of vertical-shaft synchronous alternator with salient pole revolving field. Both semi-umbrella type and suspended type are applicable to the generator for rated output of 29.6 MVA and rated rotational speed of 400 rpm. As a result of comparative study, semi-umbrella type is selected because it is advantageous to plant civil work design due to smaller dimensions and lower lifting height.

(4) Principal Features of Generating Equipment

Principal features of the generating equipment are summarized as follows:

(a) Number of units : 2

(b) Hydraulic turbines

- Type : Vertical-shaft Francis turbine
- Rated unit discharge : 27.2 m^3/s
- Rated output : 27,400 kW
- Rated speed : 400 rpm

(c) Generators

- Type : Vertical-shaft, semi-umbrella type, synchronous alternator
- Rated output : 29,600 kVA
- Rated voltage : 11 kV
- Rated frequency : 60 Hz
- Rated power factor : 0.9 lagging

(d) Generator transformers

- Type : Three-phase, oil-immersed, ONAF, with off-circuit tap changer
- Rated power : 29,600 kVA
- Rated voltage ratio : 11/230 kV

H5.1.3 Switchyard Equipment

The switchyard is of conventional, outdoor open type bus-and-switch arrangement. Figure H5.2 shows a preliminary layout plan of the switchyard equipment.

(1) Main Bus Connections

The 230 kV main bus employs a breaker-and-a-half scheme (one and a half breakers per circuit) that is the same scheme as the existing 230 kV substations of the Luzon Grid. Meanwhile, the 69 kV and 13.8 kV buses employ a single-bus scheme.

(2) Principal Features of Switchyard Equipment

The principal features of the switchyard equipment are summarized below:

(a) Step-down Transformer

- Type	:	Three-phase, oil-immersed, ONAN, with on-load tap changer
- Rated power	:	12,500/10,000/2,500 kVA
- Rated voltage ratio	:	230/69/13.8 kV
- Rated frequency	:	60 Hz

(b) 230 kV Switchgear

- Type	:	Outdoor use, conventional type
- Highest system voltage	:	245 kV
- Rated insulation level		
Lightning impulse	:	950 kV
Power-frequency	:	395 kV
- Rated frequency	:	60 Hz

(c) 69 kV Switchgear

- Type	:	Outdoor use, conventional type
- Highest system voltage	:	72.5 kV
- Rated insulation level		
Lightning impulse	:	325 kV
Power-frequency	:	140 kV
- Rated frequency	:	60 Hz

(d) 13.8 kV Switchgear

- Type	:	Outdoor use, conventional type
- Highest system voltage	:	15 kV
- Rated insulation level		
Full-wave lightning impulse	:	110 kV
Power-frequency	:	50 kV
- Rated frequency	:	60 Hz

H5.2 Substations

H5.2.1 Extension of Dolores Substation

(1) Layout

The existing 230 kV Dolores S/S is of conventional, outdoor open type bus-and-switch arrangement and its 230 kV main bus employs a breaker-and-a-half scheme (one and a half breakers per circuit).

The Dolores S/S is extended for additional 230 kV bay with three circuit breakers, which is arranged for a breaker-and-a-half scheme, to introduce a 230 kV double-circuit transmission line coming from the Morong S/S.

(2) Principal Features of Equipment for Substation Extension

Principal features of the equipment for substation extension are summarized as follows:

(a) 230 kV Switchgear

- Type	:	Outdoor use, conventional type
- Highest system voltage	:	245 kV
- Rated insulation level		
Lightning impulse	:	950 kV
Power-frequency	:	395 kV
- Rated frequency	:	60 Hz

H5.2.2 Morong Substation

(1) Layout

The Morong S/S is designed for conventional, outdoor open type bus-and-switch arrangement and the required area of land is roughly 100 m by 150 m to arrange two 230/34.5/13.8 kV transformers, six 230 kV circuits, three 34.5 kV circuits, six 13.8 kV circuits and one 13.8/0.48 kV station-service transformer, as shown in Figure H4.1.

(2) Main Bus Connections

The 230 kV main bus employs a breaker-and-a-half scheme (one and a half breakers per circuit) that is the same scheme as the existing 230 kV substations of the Luzon Grid. Meanwhile, the 34.5 kV and 13.8 kV buses employ a single-bus scheme.

(3) Development Plan

The Morong S/S is developed in the following three stages.

(a) <u>In Stage 1</u>

- One 230/34.5/13.8 kV, 12.5/10/2.5 MVA step-down transformer
- One 13.8/0.48 kV station-service transformer

- 230 kV switchgear for a step-down transformer primary circuit and two transmission line circuits towards Dolores S/S
- 34.5 kV switchgear for a step-down transformer secondary circuit and a distribution line circuit
- 13.8 kV switchgear for a step-down transformer tertiary circuit, three distribution line circuits and a station-service transformer circuit
- One lot of low voltage switchgear
- Control and protection equipment for the above equipment

(b) In Stage 2-1

- Extension of 230 kV bay to arrange 230 kV switchgear for two transmission line circuits towards Agos P/S.

(c) In Stage 2-2

- Additional installation of one 230/34.5/13.8 kV, 12.5/10/2.5 MVA step-down transformer
- Additional installation of 230 kV switchgear for an additional step-down transformer primary circuit
- Additional installation of 34.5 kV switchgear for an additional step-down transformer secondary circuit
- Additional installation of 13.8 kV switchgear for an additional step-down transformer tertiary circuit
- Control and protection equipment for the above equipment

(3) Principal Features of Substation Equipment

Principal features of the substation equipment are summarized as follows:

(a) Step-down Transformer

- Type	:	Three-phase, oil-immersed, ONAN, with on-load tap changer
- Rated power	:	12,500/10,000/2,500 kVA
- Rated voltage ratio	:	230/34.5/13.8 kV
- Rated frequency	:	60 Hz

(b) 230 kV Switchgear

- Type	:	Outdoor use, conventional type
- Highest system voltage	:	245 kV
- Rated insulation level		
Lightning impulse	:	950 kV
Power-frequency	:	395 kV
- Rated frequency	:	60 Hz

(c) 34.5 kV Switchgear

- Type : Outdoor use, conventional type
- Highest system voltage : 38 kV
- Rated insulation level
  - Lightning impulse : 150 kV
  - Power-frequency : 70 kV
- Rated frequency : 60 Hz

(d) 13.8 kV Switchgear

- Type : Outdoor use, conventional type
- Highest system voltage : 15 kV
- Rated insulation level
  - Full-wave lightning impulse: 110 kV
  - Power-frequency : 50 kV
- Rated frequency : 60 Hz

H5.2.3 New Quezeloco Substation

(1) Layout

The New Quezelco S/S is designed for conventional, outdoor open type bus-and-switch arrangement and the area of land is about 2 hectare which is sufficient to arrange one 69/13.8 kV transformer, 69 kV switchgear and 13.8 kV switchgear. In addition to the existing 69 kV transmission line, another 69 kV transmission line coming from the Agos P/S is connected to this new substation.

(2) Main Bus Connections

The 69 kV and 13.8 kV buses employ a single-bus scheme.

(3) Principal Features of Substation Equipment

Principal features of the substation equipment are summarized as follows:

(a) Step-down Transformer

- Type : Three-phase, oil-immersed, ONAN, with on-load tap changer
- Rated power : 5,000 kVA
- Rated voltage ratio : 69/13.8 kV
- Rated frequency : 60 Hz

(b) 69 kV Switchgear

- Type : Outdoor use, conventional type
- Highest system voltage : 72.5 kV

- Rated insulation level
  - Lightning impulse : 325 kV
  - Power-frequency : 140 kV
- Rated frequency : 60 Hz

(c) 13.8 kV Switchgear

- Type : Outdoor use, conventional type
- Highest system voltage : 15 kV
- Rated insulation level
  - Full-wave lightning impulse: 110 kV
  - Power-frequency : 50 kV
- Rated frequency : 60 Hz

H5.3 Receiving Stations

Receiving Stations are required at the end of the 34.5 kV and 13.8 kV distribution lines to the various waterway facilities for power supply to the loads. Each receiving station is equipped with 34.5 kV or 13.8 kV switchgear, a step-down transformer and low voltage switchgear. 6.6 kV or 3.3 kV switchgear is also required at the Antipolo pump station for power supply to the pumps.

The step-down transformer is of three-phase, oil-immersed, outdoor-use type with off-circuit tap-changer. The 34.5 kV and 13.8 kV switchgear is of outdoor-use, metal-enclosed type.

Transformer ratings of the proposed receiving stations are summarized below:

Transformer ratings of the proposed receiving station

Receiving Station	Transformer Capacity	Voltage Ratio
Kaliwa Low Dam	50 kVA	13.8/0.48 kV
Valve House	31.5 kVA	13.8/0.48 kV
Antipolo Pump Station		
- In Stage 1	10,000 kVA	34.5/6.6 (3.3) kV
	100 kVA	6.6 (3.3)/0.48 kV
- In State 2-2	10,000 kVA	34.5/6.6 (3.3) kV
Antipolo Service Reservoirs	31.5 kVA	34.5/0.48 kV
Taytay Service Reservoirs	160 kVA	13.8/0.48 kV
After Bay	31.5 kVA	13.8/0.48 kV

H6 Construction Cost Estimate

H6.1 Civil Works and Generating Equipment

Cost of civil works and generating equipment is shown in Annex J.

H6.2 Transformers, Switchyard Equipment and Transmission Lines

Construction cost of transformers, switchyard equipment and transmission lines was estimated in consideration of current prices in NPC projects. Tables H6.1 and H6.2 show the unit construction costs of transmission lines and substation/ switchyard equipment, respectively. Table H6.3 summarizes the estimated construction cost of the staged implementations.

Tables

Table H2.1 Result of Power Output Calculation at Agos Power Station (1/2)

Peak Power Operation Hour : 6-hour

Year	Reservoir Water Level (El.m)			Plant Discharge (m^3/sec)		Power Output (MW)		Energy Generation (GWh)		
	Maximum	Minimum	Average	Maximum	Average	Maximum	Average	Primary	Secondary	Total
1950	159.0	146.0	154.3	110.8	107.7	103.4	101.2	221.6	318.6	540.2
1951	159.0	151.4	156.7	110.8	107.1	103.3	103.1	225.7	246.8	472.5
1952	159.0	145.2	155.5	110.8	107.2	103.3	101.8	223.6	285.9	509.5
1953	159.0	144.4	154.3	110.8	107.9	103.4	101.4	222.1	254.0	476.2
1954	159.0	133.0	147.9	110.8	99.7	103.3	88.7	193.9	197.7	391.5
1955	159.0	143.0	153.0	110.8	108.2	103.4	100.4	219.9	175.8	395.7
1956	159.0	159.0	159.0	105.3	105.3	103.3	103.3	226.8	489.7	716.5
1957	159.0	133.0	145.3	110.8	105.7	103.3	91.1	199.2	66.2	265.4
1958	159.0	159.0	159.0	105.3	105.3	103.3	103.3	226.2	192.9	419.1
1959	159.0	136.5	149.3	110.8	108.4	103.3	96.6	211.5	206.4	417.9
1960	159.0	154.9	158.2	108.8	105.9	103.4	103.3	226.8	403.3	630.1
1961	159.0	158.4	159.0	105.9	105.4	103.4	103.3	226.2	360.5	586.7
1962	159.0	149.9	157.4	110.8	106.4	103.4	103.0	225.7	325.3	551.0
1963	159.0	149.7	156.7	110.8	106.9	103.3	102.8	225.1	275.3	500.4
1964	159.0	156.0	158.5	107.8	105.7	103.3	103.3	226.8	402.1	628.9
1965	159.0	141.8	151.8	110.8	108.3	103.3	99.2	217.1	203.7	420.8
1966	159.0	133.0	149.5	110.8	106.8	103.3	95.7	209.6	145.9	355.5
1967	159.0	152.4	157.6	110.8	106.5	103.4	103.2	226.1	197.7	423.8
1968	159.0	146.3	155.5	110.8	107.4	103.3	102.1	224.3	275.2	499.5
1969	159.0	133.0	143.3	110.8	89.6	103.3	76.9	167.7	68.7	236.4
1970	159.0	133.0	148.0	110.8	90.1	103.4	81.8	178.6	195.4	374.0
1971	159.0	156.6	158.6	107.3	105.6	103.3	103.3	226.2	536.0	762.2
1972	159.0	158.4	158.9	105.9	105.4	103.4	103.3	226.9	376.8	603.6
1973	159.0	142.9	153.5	110.8	108.1	103.3	100.8	220.7	161.7	382.4
1977	159.0	147.9	156.6	110.8	107.0	103.3	102.8	225.2	303.4	528.6
1978	159.0	133.0	150.9	110.8	104.7	103.3	95.5	208.9	193.9	402.9
1984	159.0	138.5	151.2	110.8	108.3	103.4	98.6	216.6	191.6	408.2
1985	159.0	136.7	153.2	110.8	108.0	103.4	100.4	219.9	192.9	412.8
1986	159.0	137.1	153.1	110.8	107.7	103.3	99.9	218.8	226.4	445.2
1987	159.0	133.0	147.9	110.8	100.5	103.3	88.7	193.8	151.4	345.2
1988	159.0	137.8	151.7	110.8	108.1	103.4	98.9	217.2	231.5	448.7
	159.0	133.0	153.7	110.8	105.3	103.4	98.6	216.1	253.3	469.4

Peak Power Operation Hour : 8-hour

Year	Reservoir Water Level (El.m)			Plant Discharge (m^3/sec)		Power Output (MW)		Energy Generation (GWh)		
	Maximum	Minimum	Average	Maximum	Average	Maximum	Average	Primary	Secondary	Total
1950	159.0	146.0	154.3	83.1	80.8	77.5	75.8	221.5	225.0	446.5
1951	159.0	151.4	156.7	83.1	80.3	77.4	77.2	225.6	198.6	424.2
1952	159.0	145.2	155.5	83.1	80.4	77.4	76.3	223.5	218.1	441.6
1953	159.0	144.4	154.3	83.1	80.9	77.5	76.0	222.0	186.7	408.7
1954	159.0	133.0	147.9	83.1	74.7	77.4	66.5	193.7	139.9	333.6
1955	159.0	143.0	153.0	83.1	81.2	77.5	75.3	219.8	118.8	338.5
1956	159.0	159.0	159.0	79.0	79.0	77.4	77.4	226.7	359.3	586.0
1957	159.0	133.0	145.3	83.1	79.3	77.4	68.2	199.1	47.0	246.0
1958	159.0	159.0	159.0	79.0	79.0	77.4	77.4	226.1	155.2	381.2
1959	159.0	136.5	149.3	83.1	81.3	77.4	72.4	211.4	148.7	360.1
1960	159.0	154.9	158.2	81.6	79.5	77.5	77.4	226.7	271.2	497.9
1961	159.0	158.4	159.0	79.4	79.0	77.5	77.4	226.1	291.1	517.2
1962	159.0	149.9	157.4	83.1	79.8	77.5	77.2	225.5	238.4	464.0
1963	159.0	149.7	156.7	83.1	80.2	77.4	77.0	225.0	226.8	451.8
1964	159.0	156.0	158.5	80.9	79.3	77.4	77.4	226.7	318.7	545.4
1965	159.0	141.8	151.8	83.1	81.2	77.4	74.3	217.0	151.8	368.7
1966	159.0	133.0	149.5	83.1	80.1	77.5	71.8	209.4	108.1	317.5
1967	159.0	152.4	157.6	83.1	79.9	77.5	77.4	226.0	140.7	366.7
1968	159.0	146.3	155.5	83.1	80.5	77.4	76.5	224.1	200.2	424.2
1969	159.0	133.0	143.3	83.1	67.2	77.4	57.6	167.6	49.5	217.1
1970	159.0	133.0	148.0	83.1	67.6	77.5	61.3	178.4	138.3	316.7
1971	159.0	156.6	158.6	80.5	79.2	77.4	77.4	226.1	366.1	592.1
1972	159.0	158.4	158.9	79.4	79.1	77.5	77.4	226.8	262.6	489.3
1973	159.0	142.9	153.5	83.1	81.1	77.5	75.5	220.6	123.8	344.4
1977	159.0	147.9	156.6	83.1	80.2	77.4	77.1	225.1	231.6	456.7
1978	159.0	133.0	150.9	83.1	78.5	77.4	71.6	208.8	136.9	345.7
1984	159.0	138.5	151.2	83.1	81.3	77.5	73.9	216.4	134.6	351.0
1985	159.0	136.7	153.2	83.1	81.0	77.5	75.3	219.8	135.9	355.6
1986	159.0	137.1	153.1	83.1	80.8	77.4	74.9	218.6	177.4	396.0
1987	159.0	133.0	147.9	83.1	75.3	77.4	66.5	193.6	112.9	306.5
1988	159.0	137.8	151.7	83.1	81.1	77.5	74.1	217.0	178.0	395.0
	159.0	133.0	153.7	83.1	79.0	77.5	73.9	216.0	186.8	402.8

Table H2.1 Result of Power Output Calculation at Agos Power Station (2/2)

Peak Power Operation Hour : 12-hour

Year	Reservoir Water Level (El.m)			Plant Discharge (m^3/sec)		Power Output (MW)		Energy Generation (GWh)		
	Maximum	Minimum	Average	Maximum	Average	Maximum	Average	Primary	Secondary	Total
1950	159.0	146.0	154.3	55.4	53.8	51.5	50.4	220.8	112.1	332.9
1951	159.0	151.4	156.7	55.4	53.5	51.5	51.3	224.9	104.9	329.8
1952	159.0	145.2	155.5	55.4	53.6	51.5	50.7	222.8	114.2	337.0
1953	159.0	144.4	154.3	55.4	53.9	51.5	50.5	221.3	93.0	314.3
1954	159.0	133.0	147.9	55.4	49.8	51.5	44.2	193.1	74.5	267.6
1955	159.0	143.0	153.0	55.4	54.1	51.5	50.0	219.1	61.7	280.8
1956	159.0	159.0	159.0	52.6	52.6	51.5	51.5	226.0	201.4	427.3
1957	159.0	133.0	145.3	55.4	52.9	51.5	45.3	198.4	27.7	226.1
1958	159.0	159.0	159.0	52.6	52.6	51.5	51.5	225.4	116.8	342.2
1959	159.0	136.5	149.3	55.4	54.2	51.5	48.1	210.7	87.5	298.2
1960	159.0	154.9	158.2	54.4	53.0	51.5	51.5	226.0	139.1	365.1
1961	159.0	158.4	159.0	52.9	52.7	51.5	51.5	225.4	163.9	389.3
1962	159.0	149.9	157.4	55.4	53.2	51.5	51.3	224.8	126.2	351.0
1963	159.0	149.7	156.7	55.4	53.4	51.5	51.2	224.3	124.3	348.6
1964	159.0	156.0	158.5	53.9	52.8	51.5	51.5	226.0	167.3	393.3
1965	159.0	141.8	151.8	55.4	54.1	51.5	49.4	216.3	77.3	293.6
1966	159.0	133.0	149.5	55.4	53.4	51.5	47.7	208.7	65.9	274.6
1967	159.0	152.4	157.6	55.4	53.2	51.5	51.4	225.3	83.5	308.8
1968	159.0	146.3	155.5	55.4	53.7	51.5	50.9	223.4	121.2	344.5
1969	159.0	133.0	143.3	55.4	44.8	51.5	38.3	167.0	30.2	197.2
1970	159.0	133.0	148.0	55.4	45.1	51.5	40.8	177.8	75.8	253.6
1971	159.0	156.6	158.6	53.7	52.8	51.5	51.5	225.4	187.9	413.3
1972	159.0	158.4	158.9	53.0	52.7	51.5	51.5	226.1	138.5	364.5
1973	159.0	142.9	153.5	55.4	54.0	51.5	50.2	219.8	79.4	299.2
1977	159.0	147.9	156.7	55.4	53.5	51.5	51.2	224.4	130.6	355.0
1978	159.0	133.0	150.9	55.4	52.3	51.5	47.6	208.2	78.8	287.0
1984	159.0	138.6	151.2	55.4	54.2	51.5	49.1	215.7	75.8	291.5
1985	159.0	136.7	153.2	55.4	54.0	51.5	50.0	219.1	75.8	294.8
1986	159.0	137.1	153.1	55.4	53.8	51.5	49.8	217.9	94.7	312.6
1987	159.0	133.0	147.9	55.4	50.2	51.5	44.2	193.0	66.9	259.9
1988	159.0	137.8	151.7	55.4	54.0	51.5	49.2	216.3	93.7	310.0
	159.0	133.0	153.7	55.4	52.6	51.5	49.1	215.3	102.9	318.2

Peak Power Operation Hour : 24-hour

Year	Reservoir Water Level (El.m)			Plant Discharge (m^3/sec)		Power Output (MW)		Energy Generation (GWh)		
	Maximum	Minimum	Average	Maximum	Average	Maximum	Average	Primary	Secondary	Total
1950	159.0	146.0	154.3	27.7	26.9	25.5	25.0	218.8	0.0	218.8
1951	159.0	151.4	156.7	27.7	26.8	25.5	25.4	222.9	0.0	222.9
1952	159.0	145.2	155.5	27.7	26.8	25.5	25.1	220.8	0.0	220.8
1953	159.0	144.4	154.3	27.7	27.0	25.5	25.0	219.3	0.0	219.3
1954	159.0	133.0	147.9	27.7	24.9	25.5	21.9	191.2	0.0	191.2
1955	159.0	143.0	153.0	27.7	27.0	25.5	24.8	217.0	0.0	217.0
1956	159.0	159.0	159.0	26.3	26.3	25.5	25.5	224.0	0.0	224.0
1957	159.0	133.0	145.3	27.7	26.4	25.5	22.5	196.5	0.0	196.5
1958	159.0	159.0	159.0	26.3	26.3	25.5	25.5	223.4	0.0	223.4
1959	159.0	136.5	149.3	27.7	27.1	25.5	23.8	208.7	0.0	208.7
1960	159.0	154.9	158.2	27.2	26.5	25.5	25.5	224.0	0.0	224.0
1961	159.0	158.4	159.0	26.5	26.3	25.5	25.5	223.5	0.0	223.5
1962	159.0	149.9	157.4	27.7	26.6	25.5	25.4	222.9	0.0	222.9
1963	159.0	149.7	156.7	27.7	26.7	25.5	25.4	222.3	0.0	222.3
1964	159.0	156.0	158.5	26.9	26.4	25.5	25.5	224.0	0.0	224.0
1965	159.0	141.8	151.8	27.7	27.1	25.5	24.5	214.3	0.0	214.3
1966	159.0	133.0	149.5	27.7	26.7	25.5	23.6	206.8	0.0	206.8
1967	159.0	152.4	157.6	27.7	26.6	25.5	25.5	223.3	0.0	223.3
1968	159.0	146.3	155.5	27.7	26.8	25.5	25.2	221.4	0.0	221.4
1969	159.0	133.0	143.3	27.7	22.4	25.5	19.0	165.5	0.0	165.5
1970	159.0	133.0	148.0	27.7	22.5	25.5	20.2	176.2	0.0	176.2
1971	159.0	156.6	158.6	26.8	26.4	25.5	25.5	223.5	0.0	223.5
1972	159.0	158.4	158.9	26.5	26.3	25.5	25.5	224.2	0.0	224.2
1973	159.0	142.9	153.5	27.7	27.0	25.5	24.9	217.8	0.0	217.8
1977	159.0	147.9	156.7	27.7	26.7	25.5	25.4	222.4	0.0	222.4
1978	159.0	133.0	150.9	27.7	26.2	25.5	23.6	206.3	0.0	206.3
1984	159.0	138.6	151.2	27.7	27.1	25.5	24.3	213.7	0.0	213.7
1985	159.0	136.7	153.2	27.7	27.0	25.5	24.8	217.1	0.0	217.1
1986	159.0	137.1	153.1	27.7	26.9	25.5	24.7	215.9	0.0	215.9
1987	159.0	133.0	147.9	27.7	25.1	25.5	21.9	191.2	0.0	191.2
1988	159.0	137.8	151.7	27.7	27.0	25.5	24.4	214.3	0.0	214.3
	159.0	133.0	153.7	27.7	26.3	25.5	24.3	213.3	0.0	213.3

Table H3.1 Result of Power Output Calculation at Lagundi Power Station

Year	Reservoir Water Level (El.m)			Plant Discharge (m^3/sec)		Power Output (MW)		Energy Generation (GWh)
	Maximum	Minimum	Average	Maximum	Average	Maximum	Average	
1950	159.0	146.0	154.3	34.7	30.9	10.6	9.4	82.6
1951	159.0	151.4	156.7	34.7	30.1	10.6	10.2	88.9
1952	159.0	145.2	155.5	34.7	30.3	10.6	9.8	85.7
1953	159.0	144.4	154.3	34.7	31.2	10.6	9.5	82.9
1954	159.0	133.0	147.9	34.7	32.2	10.6	6.7	58.3
1955	159.0	143.0	153.0	34.7	31.5	10.6	9.1	79.6
1956	159.0	159.0	159.0	28.2	28.2	10.6	10.6	93.1
1957	159.0	133.0	145.3	34.7	33.3	10.6	5.6	48.5
1958	159.0	159.0	159.0	28.2	28.2	10.6	10.6	92.8
1959	159.0	136.5	149.3	34.7	31.8	10.6	6.8	59.8
1960	159.0	154.9	158.2	31.5	28.8	10.6	10.5	92.1
1961	159.0	158.4	159.0	28.6	28.3	10.6	10.6	92.7
1962	159.0	149.9	157.4	34.7	29.4	10.6	10.3	90.2
1963	159.0	149.7	156.7	34.7	30.0	10.6	10.1	88.4
1964	159.0	156.0	158.5	30.5	28.6	10.6	10.5	92.6
1965	159.0	141.8	151.8	34.7	31.6	10.6	8.7	76.3
1966	159.0	133.0	149.5	34.7	31.9	10.6	7.0	61.3
1967	159.0	152.4	157.6	33.8	29.4	10.6	10.3	90.6
1968	159.0	146.3	155.5	34.7	30.5	10.6	9.8	85.9
1969	159.0	133.0	143.3	34.7	33.2	10.6	4.5	38.9
1970	159.0	133.0	148.0	34.7	32.0	10.6	6.8	59.3
1971	159.0	156.6	158.6	30.0	28.5	10.6	10.6	92.5
1972	159.0	158.4	158.9	28.6	28.3	10.6	10.6	93.1
1973	159.0	142.9	153.5	34.7	31.4	10.6	9.2	80.9
1977	159.0	147.9	156.6	34.7	29.9	10.6	10.1	88.5
1978	159.0	133.0	150.9	34.7	31.3	10.6	7.8	68.1
1984	159.0	138.5	151.2	34.7	31.7	10.6	8.1	71.4
1985	159.0	136.7	153.2	34.7	31.2	10.6	8.8	77.0
1986	159.0	137.1	153.1	34.7	30.9	10.6	8.7	76.3
1987	159.0	133.0	147.9	34.7	32.1	10.6	6.6	58.0
1988	159.0	137.8	151.7	34.7	31.4	10.6	8.3	72.7
	159.0	133.0	153.7	34.7	30.6	10.6	8.9	78.0

Table H6.1 Transmission Lines - Unit Construction Cost

Description	Forex (US$)	Local (PhP)	Total (Php)
Transmission Line Equipment			
- 230 kV, ST-DC, 1-795 MCM, ACSR Complete with Line Hardware	190,471	1,551,040	11,455,532
- 69 kV, WP-SC, 1-336.4 MCM, ACSR Complete with Line Hardware	23,723	270,707	1,504,303
- 13.8 kV, WP-SC, 1-336.4 MCM, ACSR Complete with Line Hardware	16,212	157,000	1,000,024
Transmission Line Right of Way Cost/Km			
230 kV, ST-DC T/L Route P85.00/sq. meter		1,190,000	1,190,000
230 kV T/L ST-DC Clearing Cost		59,500	59,500
		1,249,500	1,249,500
69 kV, WP-SC T/L Route P110.00/sq. meter		770,000	770,000
69 kV T/L WP-SC Clearing Cost		38,500	38,500
		808,500	808,500
13.8 kV, WP-SC T/L Route P110.00/sq. meter		550,000	550,000
13.8 kV T/L ST-DC Clearing Cost		27,500	27,500
		577,500	577,500

Transmission Line (T/L) Circuits:

Voltage	Transmission Line Type	Rating
230 kV	DC-ST, 1-795 MCM Conductor	358.6 MVA/Ckt.
69 kV	SC-WP, 336.4 MCM Conductor	53.9 MVA
13.8 kV	SC-WP, 336.4 MCM Conductor	10.4 MVA

Notes:

ST-SC - Steel Tower, Single Circuit Transmission Line
ST-SC - Steel Tower, Double Circuit Transmission Line
WP-SC - Wood Pole, Single Circuit Transmission Line
The indication 1-795 MCM, ACSR refers to the type of conductor
ACSR - Aluminum Cable Steel Reinforced

Table H6.2 Substation and Switchyard - Unit Construction Cost

Description	Forex ($)	Local (P)	Total Php
Substation & Switchyard Equipment			
(1) 230 kV			
- 230 kV PCB, Outdoor Type, 3000A, 40kA	71,150	129,493	3,829,293
- Spare Parts & Special Tools /Bay	36,430	0	1,894,360
- Disconnect Switches & Line Materials /Bay	17,500	31,850	941,850
- Complete 1-Bay 230 kV Substation (3PCB's)	267,380	486,632	14,390,392
- Complete 1-Bay 230 kV Substation (2PCB's)	196,230	357,139	10,561,099
- Complete 2-Bay 230 kV Substation (6PCB's)	321,310	584,784	17,292,904
- 50 MVA, 13.8kV/230kV Gen. Transformer	2,982,506	4,652,709	159,743,021
- 15 MVA, 230kV/69kV Transformer	894,751	1,395,812	47,922,864
- 7 MVA, 13.8kV/69kV Gen. Transformer	370,281	491,327	19,745,939
- 5 MVA, 69kV/13.8 transformer	253,512	1,581,920	14,764,544
- 2 MVA, 69kV/13.8 transformer	105,509	140,379	5,626,847
- 1.5 MVA, 13.8kV/4.16kV transformer	168,830	224,606	9,003,766
- 1 MVA, 13.8kV/4.16kV Sta. Transformer	50,703	316,384	2,952,940
- 750 KVA, 13.8kV/480 Volts Sta. Transformer	39,548	246,880	2,303,376
(2) 69 kV			
- 69 kV PCB, Outdoor Type, 1200A, 37kA	42,998	78,256	2,314,152
- Disconnect Switches & Line Materials /Feeder	3,200	16,640	183,040
- Complete 2 Feeder 69 kV Substation	92,396	240,230	5,044,822
- Complete 3 Feeder 69 kV Substation	138,594	266,655	7,473,543
- Complete 4 Feeder 69 kV Substation	184,792	336,321	9,945,505
- Complete 5 Feeder 69 kV Substation	230,990	420,402	12,431,882
(3) 13.8 kV			
- 13.8 kV PCB, Outdoor Type, 1200A, 37kA	18,700	34,034	1,006,434
- Disconnect Switches & Line Materials /Feeder	1,600	8,320	91,520
- Complete 2 Feeder 13.8 kV Substation	40,600	105,560	2,216,760
- Complete 3 Feeder 13.8 kV Substation	60,900	117,172	3,283,972
- Complete 4 Feeder 13.8 kV Substation	81,200	147,784	4,370,184

Note: Substation (S/S) and Swichyard (S/Y) Electrical Equipment:

Voltage	Specification and Rating
230 kV	PCB, Live Tank Outdoor Type, 300 Amps. Type, 40 kA
69 kV	PCB, Circuit Breaker, Outdoor Type, 37 kA
13.8 kV	Generator Circuit Breaker, 3000 Amps. Type, 40 kA
13.8/230 kV	50 MVA Generator Transformer
13.8/230 kV	7 MVA Generator Transformer

Table H6.3 Substation, Switchyards and Transmission Lines - Cost Estimate (1/3)

A. STAGE 1: POWER SUPPLY TO WATERWAY FACILITIES

1-A. Transmission Lines

Transmission Lines	Length	Forex ($)	Local (Php)	Total (PhP)
- Dolores S/S to WTP				
15.6 Kms, 69 kV, WP-SC	15.6	370,079	4,223,029	23,467,127
Right-of-Way and Clearing Cost			12,612,600	12,612,600
- WTP to Kaliwa Low Dam				
30.6 Kms, 69 kV, WP-SC	30.6	725,924	8,283,634	46,031,672
Right-of-Way and Clearing Cost			24,740,100	24,740,100
- WTP to Valve House				
6.7 Kms, 13.8 kV, WP-SC	6.7	108,620	1,051,900	6,700,161
Right-of-Way and Clearing Cost			3,869,250	3,869,250
- Valve House to Taytay S/R				
6.5 Kms, 13.8 kV, WP-SC	6.5	105,378	1,020,500	6,500,156
Right-of-Way and Clearing Cost			3,753,750	3,753,750
- WTP to Antipolo P/S				
7.5 Kms, 13.8 kV, WP-SC	7.5	121,590	1,177,500	7,500,180
Right-of-Way and Clearing Cost			4,331,250	4,331,250
- Antipolo P/S to Antipolo S/R				
2 Kms, 13.8 kV, WP-SC	6.5	105,378	1,020,500	6,500,156
Right-of-Way and Clearing Cost			3,753,750	3,753,750
- Antipolo S/R to Taytay S/R (Tie Line)				
6 Kms, 13.8 kV, WP-SC	6	97,272	942,000	6,000,144
Right-of-Way and Clearing Cost			3,465,000	3,465,000
Total Transmission Line Cost		1,634,241	74,244,763	159,225,295

1-B. Switching Facilities

Water Treatment Plant	Forex ($)	Local (Php)	TOTAL (PhP)
- 5 MVA, 69kV/13.8kV X'fmer	253,512	1,581,920	14,764,544
- Radial Substation with 3 x 69kV Feeders	138,594	266,655	7,473,543
- Radial Substation with 3 x 13.8kV Feeders	60,900	117,172	3,283,972
WTP Receiving Facilities Total	453,006	1,965,746	25,522,058

Kaliwa Low Dam/Water Intake	Forex ($)	Local (Php)	TOTAL (PhP)
- 1 x 2 MVA, 69kV/13.8kV X'fmer	105,509	140,379	5,626,847
- Radial Substation with 3 x 69kV Feeders	60,900	117,172	3,283,972
Kaliwa Low Dam Receiving Facilities Total	166,409	257,551	8,910,819

Dolores S/S	Forex ($)	Local (Php)	TOTAL (PhP)
- 1 Bay 230 Kv Substation (3PCB's)	267,380	486,632	14,390,392
- 1 x 15 MVA, 230kV/69kV X'fmer	894,751	1,395,812	47,922,864
Dolores S/S Equipment Cost	1,162,131	1,882,444	62,313,256

(to be continued)

Table H6.3 Substation, Switchyards and Transmission Lines - Cost Estimate (2/3)

Valve House	Forex ($)	Local (Php)	Total (PhP)
- Radial Substation with 3 x 13.8kV Feeders	60,900	117,172	3,283,972
Valve House Receiving Facilities Total	60,900	117,172	3,283,972
Taytay S/R	Forex ($)	Local (Php)	TOTAL (PhP)
- Radial Substation with 4 x 13.8kV Feeders	81,200	147,784	4,370,184
Taytay S/R Receiving Facilities Total	81,200	147,784	4,370,184
Antipolo P/S	Forex ($)	Local (Php)	TOTAL (PhP)
- Radial Substation with 3 x 13.8kV Feeders	60,900	117,172	3,283,972
Antipolo P/S Receiving Facilities Total	60,900	117,172	3,283,972
Antipolo S/R	Forex ($)	Local (Php)	TOTAL (PhP)
- Radial Substation with 4 x 13.8kV Feeders	81,200	147,784	4,370,184
Antipolo P/S Receiving Facilities Total	81,200	147,784	4,370,184

Stage 1 Total Project Cost	Forex ($)	Local (Php)	TOTAL (PhP)
1-A. Total Transmission Line Cost	1,634,241	74,244,763	159,225,295
1-B. Switching Facilities			
Water Treatment Plant	453,006	1,965,746	25,522,058
Kaliwa Low Dam	166,409	257,551	8,910,819
Dolores S/S Equipment Cost	1,162,131	1,882,444	62,313,256
Valve House	60,900	117,172	3,283,972
Taytay S/R	81,200	147,784	4,370,184
Antipolo P/S	60,900	117,172	3,283,972
Antipolo S/R	81,200	147,784	4,370,184
Total	3,699,987	78,880,415	271,279,739

B. STAGE 2-1: AGOS HEP INTERCONNECTION SYSTEM

2.A. Agos Switchyard Equipment	Forex ($)	Local (Php)	Total (PhP)
- 2 x 50 MVA, 13.8kV/230kV Gen. X'former	5,965,012	9,305,419	319,486,043
- 15 MVA, 230kV/69kV X'former*	0	1,395,812	1,395,812
- Transport of 15 MVA 230/69 kV X'former from Dolores S/S to Agos HEP	0	75,000	75,000
- Installation Cost of 15 MVA 230/69 kV x'former at Dolores		930,540	930,540
- 2 x 1.5 MVA, 13.8kV/4.16kV Sta. X'former	337,660	449,212	18,007,532
- 3 Bay 230 Kv Substation (8PCB's)	517,540	941,923	27,854,003
- Radial Substation with 5 x 69kV Feeders	230,990	420,402	12,431,882
- Radial Substation with 3 x 13.8kV Feeders	60,900	117,172	3,283,972
Total Agos Switchyard Equipment Cost	7,112,102	13,635,479	383,464,783

2.B. Afterweir Bay Switching Facilities	Forex ($)	Local (Php)	TOTAL (PhP)
- Radial Substation with 3 x 13.8kV Feeders	60,900	117,172	3,283,972
Antipolo P/S Receiving Facilities Total	60,900	117,172	3,283,972

(to be continued)

Table H6.3 Substation, Switchyards and Transmission Lines - Cost Estimate (3/3)

2-C. Transmission Lines

Transmission Lines	Length	Forex ($)	Local (Php)	Total (PhP)
- Agos HEP to Dolores S/S				
50.6 Kms, 230 kV, ST-DC	50.6	9,637,833	78,482,624	579,649,919
Right-of-Way and Clearing Cost			63,224,700	63,224,700
- Agos HEP to Kaliwa Low Dam				
7.6 Kms, 69 kV, WP-SC	7.6	180,295	2,057,373	11,432,703
Right-of-Way and Clearing Cost			6,144,600	6,144,600
- Agos HEP to Afterweir Bay				
3.5 Kms, 13.8 kV, WP-SC	3.5	56,742	549,500	3,500,084
Right-of-Way and Clearing Cost			2,021,250	2,021,250
- Agos HEP to Quezelco S/S**				
7.6 Kms, 69 kV, WP-SC	7.6	0	2,057,373	2,057,373
Right-of-Way and Clearing Cost			6,144,600	6,144,600
- Cost of retiring 13.5 Kms of the 15.6 Kms, 69 kV, T/L, WPSC, Dolores S/S to WTP	13.5	0	1,388,727	1,388,727
Total Transmission Line Cost		9,874,869	162,070,747	675,563,956

**This 15 MVA transformer is initially installed at Dolores S/S*

***Installation cost only. Materials shall come from the 13.5 Kms part of 15.5 Kms Dolores S/S to WTP T/L*

Stage 2 Total Project Cost	Forex ($)	Local (Php)	Total (PhP)
2.A. Agos Switchyard Equipment	7,112,102	13,635,479	383,464,783
2.B. Afterweir Bay Switching Facilities	60,900	117,172	3,283,972
2-C. Transmission Lines	9,874,869	162,070,747	675,563,956
Total	17,047,871	175,823,398	1,062,312,711

C. STAGE 3: Lagundi Hydro-Electric

3.A. Lagundi Switchyard Equipment	Forex ($)	Local (Php)	Total (PhP)
- 2 x 7 MVA, 13.8kV/230kV Gen. X'former	740,562	982,654	39,491,878
- 2 x 750 KVA, 13.8kV/480 Volts Sta. X'former	79,096	493,760	4,606,752
- Radial Substation with 3 x 69kV Feeders	138,594	266,655	7,473,543
Total Agos Switchyard Equipment Cost	958,252	1,743,069	51,572,173

3-B. Transmission Lines

Transmission Lines	Length	Forex ($)	Local (Php)	Total (PhP)
- WTP to Lagundi HEP***				
2 Kms, 69 kV, WP-SC	2	0	541,414	541,414
Right-of-Way and Clearing Cost			1,617,000	1,617,000
Total Transmission Line Cost		0	2,158,414	2,158,414

***Note: Line Materials shall come from the retired 15.6 Kms of 69 kV Dolores S/S to WTP T/L

Stage 3 Total Project Cost	Forex ($)	Local (Php)	Total (PhP)
3.A. Lagundi Switchyard Equipment	958,252	1,743,069	51,572,173
3-B. Transmission Lines	0	2,158,414	2,158,414
Total	958,252	3,901,483	53,730,587

Cost of Entire Project	Forex ($)	Local (Php)	Total (PhP)
Stage 1 Total Project Cost	3,699,987	78,880,415	271,279,739
Stage 2-1 Total Project Cost	17,047,871	175,823,398	1,062,312,711
Stage -22 Total Project Cost	958,252	3,901,483	53,730,587
Grand Total	21,706,110	258,605,296	1,387,323,037

Figures

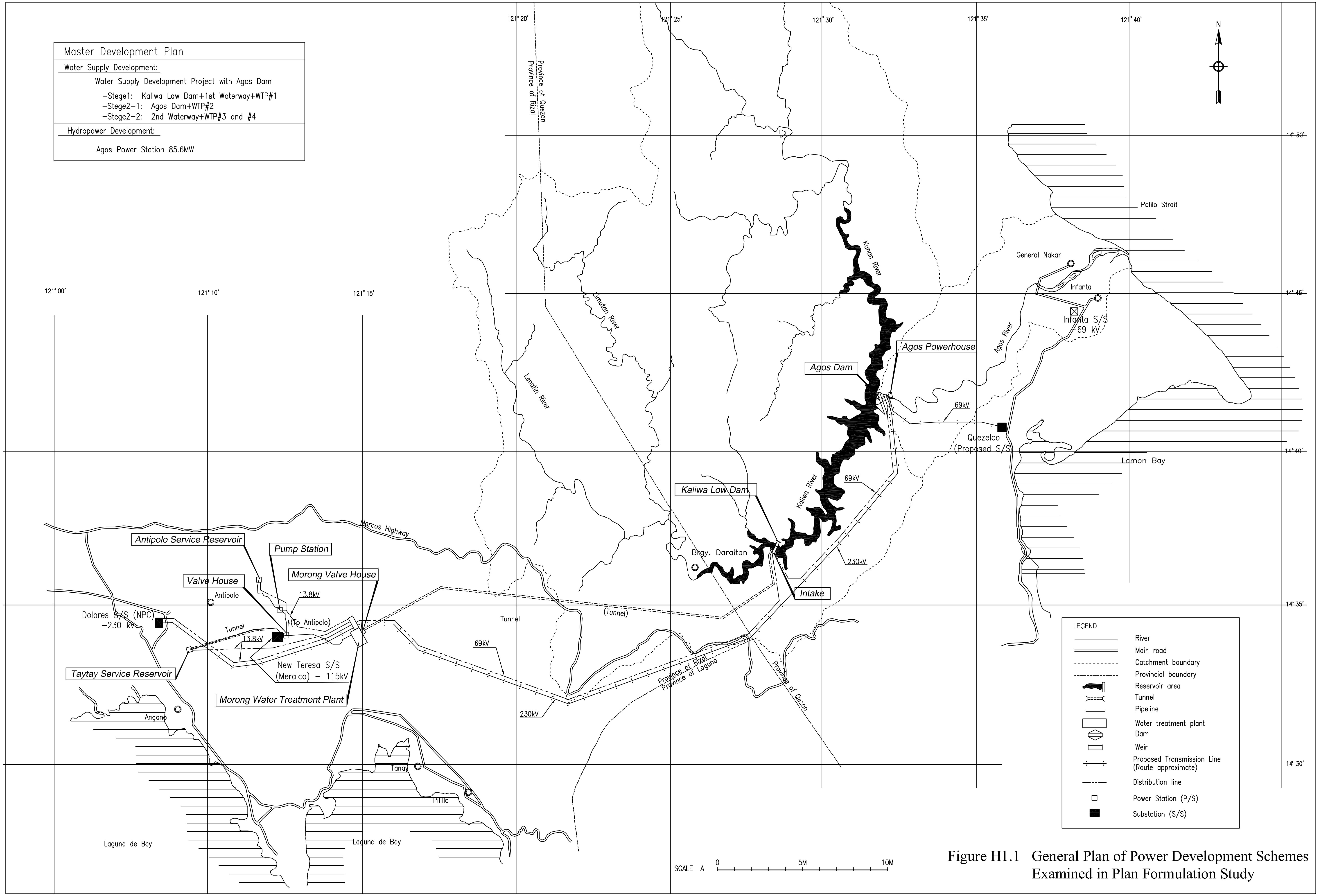
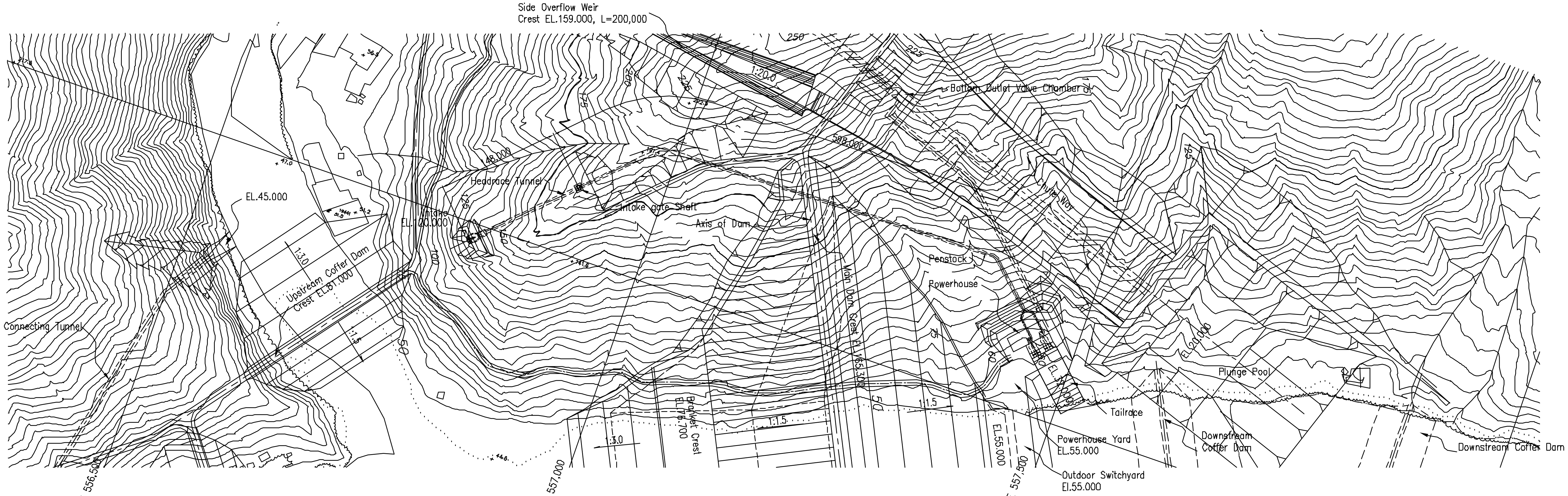
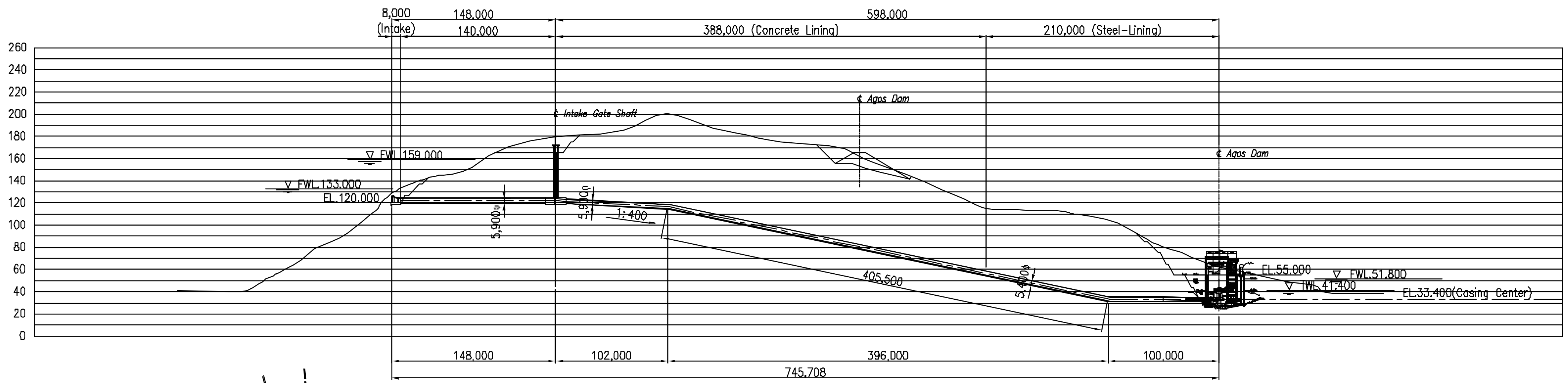


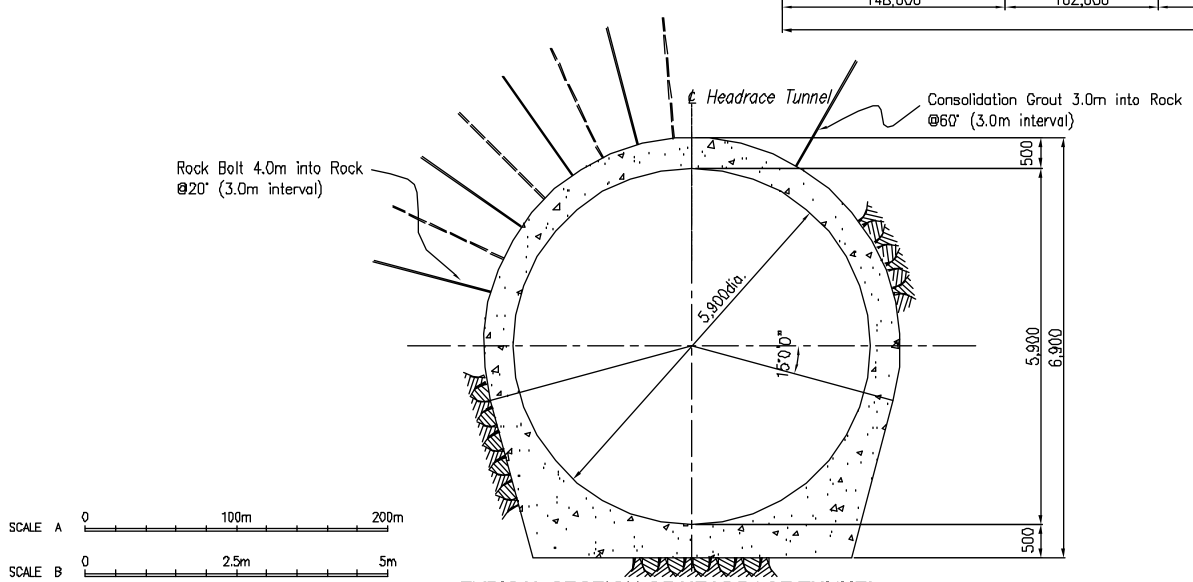
Figure H1.1 General Plan of Power Development Schemes Examined in Plan Formulation Study



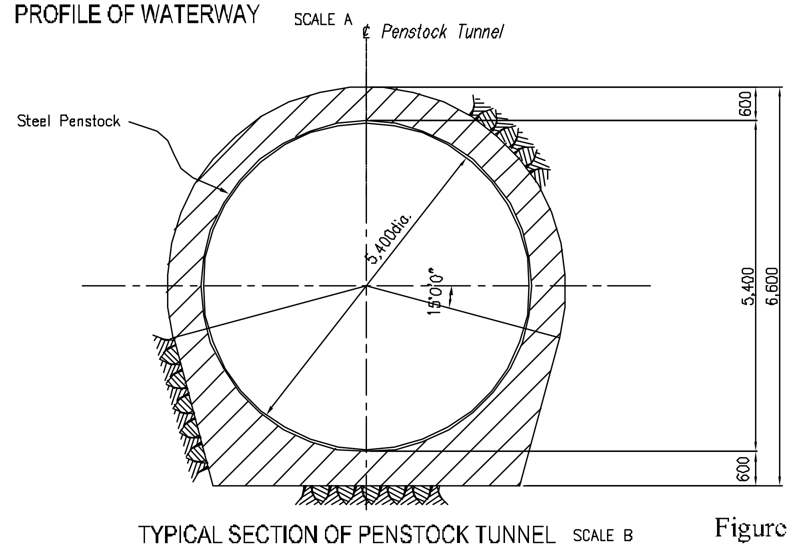
PLAN OF WATERWAY SCALE A



PROFILE OF WATERWAY SCALE A

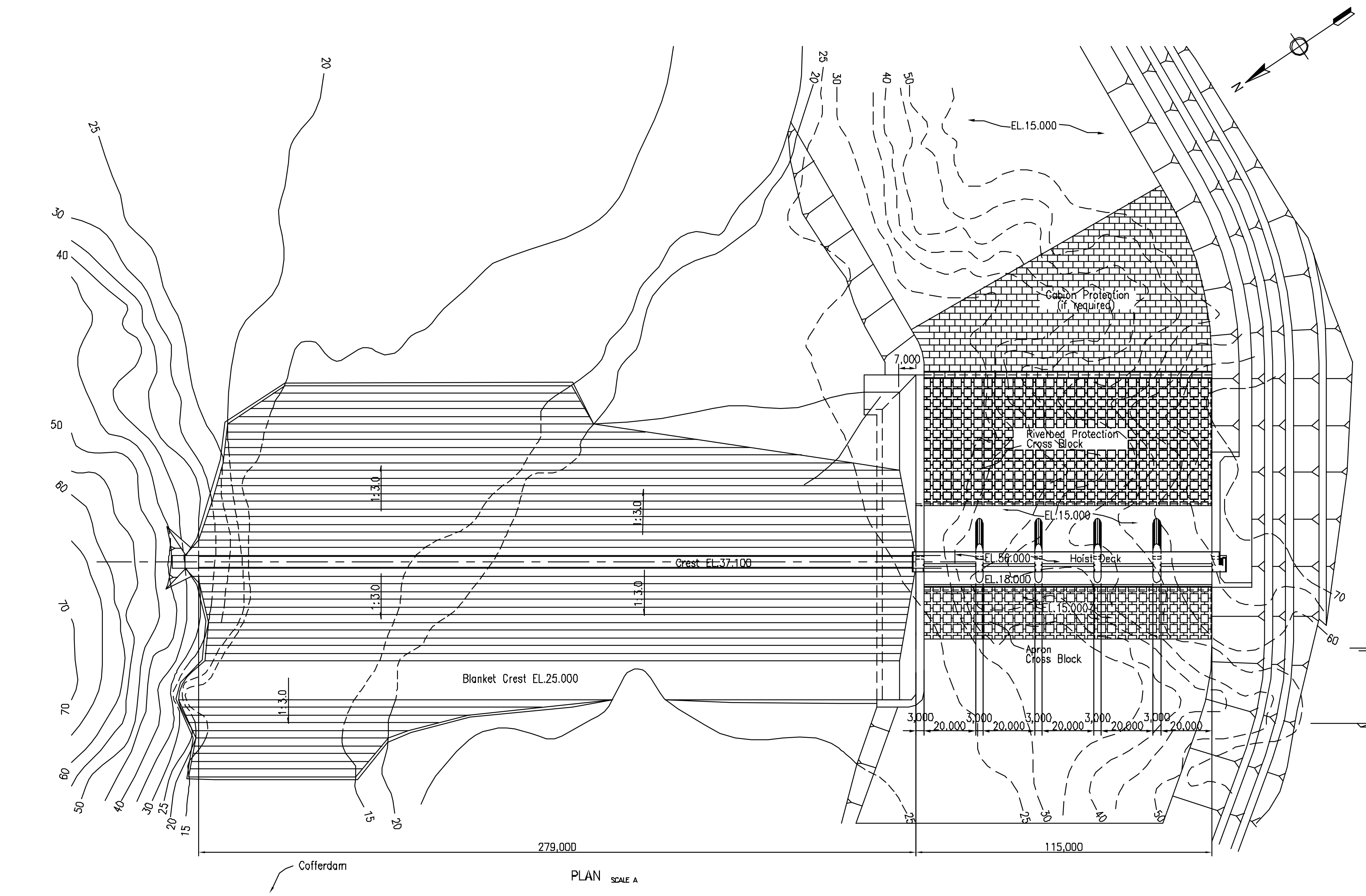


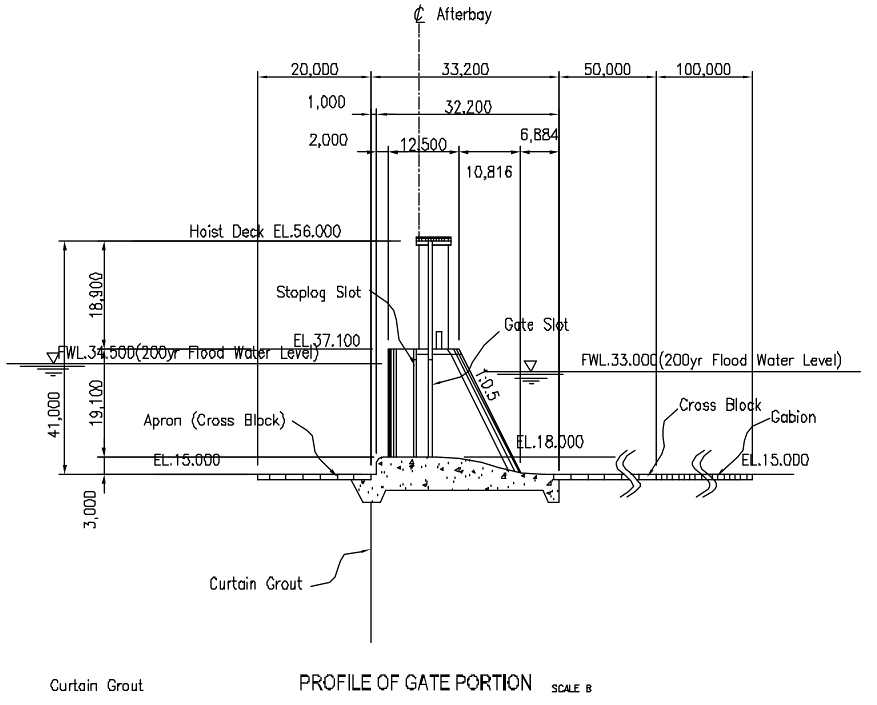
TYPICAL SECTION OF HEADRACE TUNNEL SCALE B

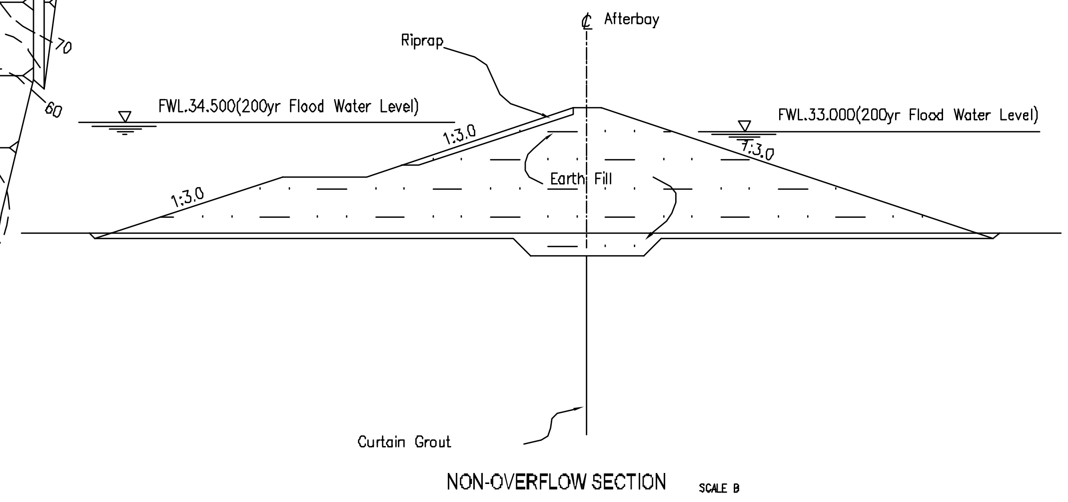


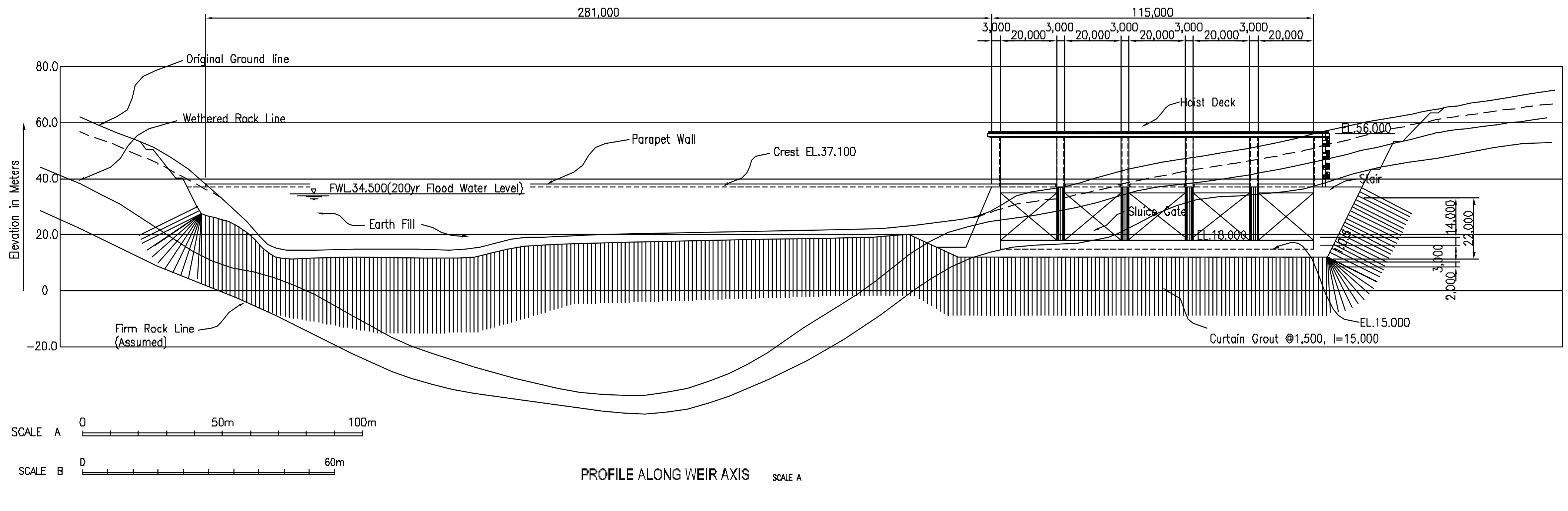
TYPICAL SECTION OF PENSTOCK TUNNEL SCALE B

Figure H2.1 General Layout Plan and Profile of Agos Hydropower Scheme









Note:

1. Plans shown are very preliminary, subject to further elaboration,
2. Contours based on 1:5,000 map,
3. Excavation lines approximate and
4. Width of blanket fill dependent on propaties of foundation layers.

Figure H2.2 General Plan of Agos Afterbay Weir

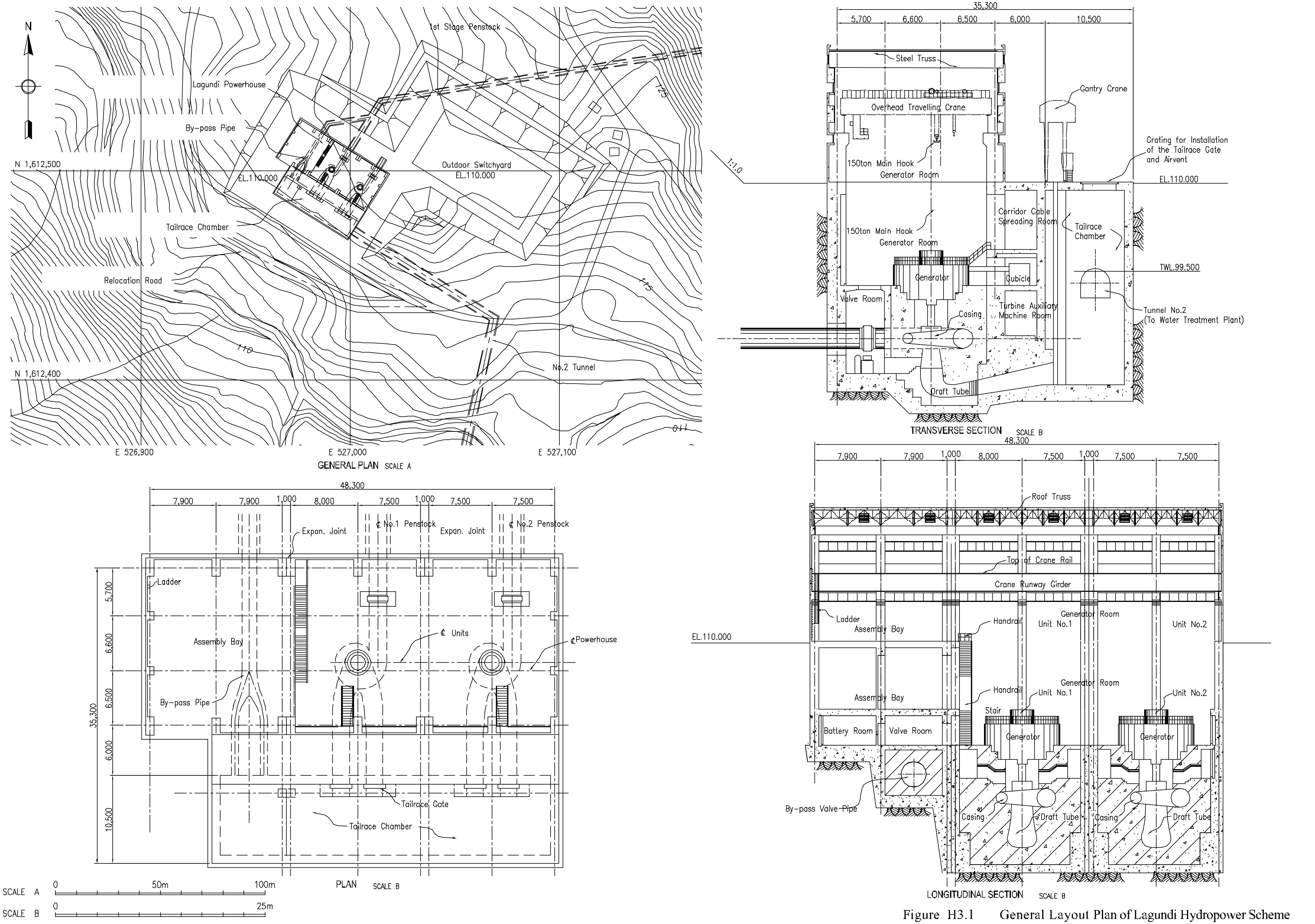


Figure H3.1 General Layout Plan of Lagundi Hydropower Scheme

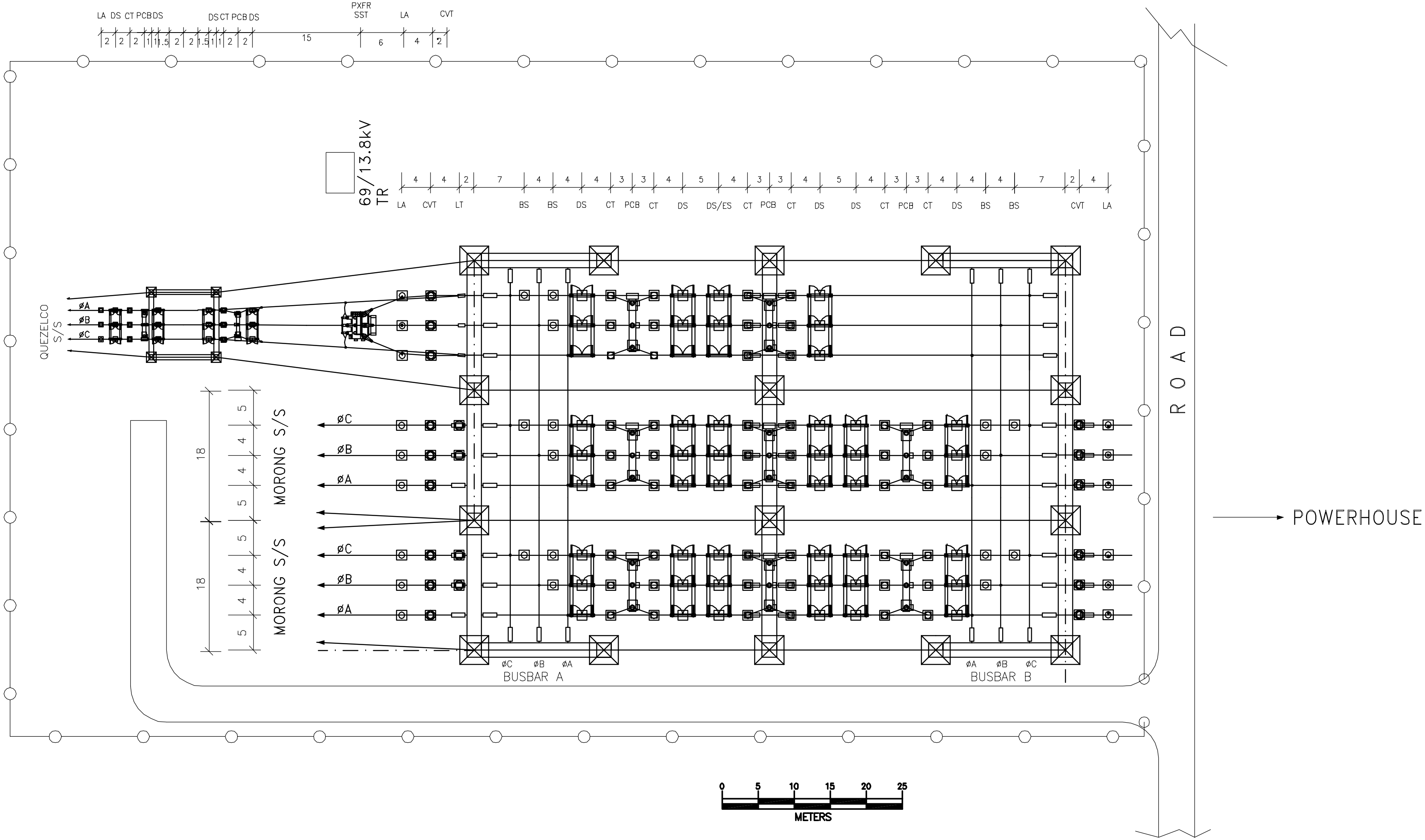


Figure H4.1 Power Transmission and Distribution Plan for the Project

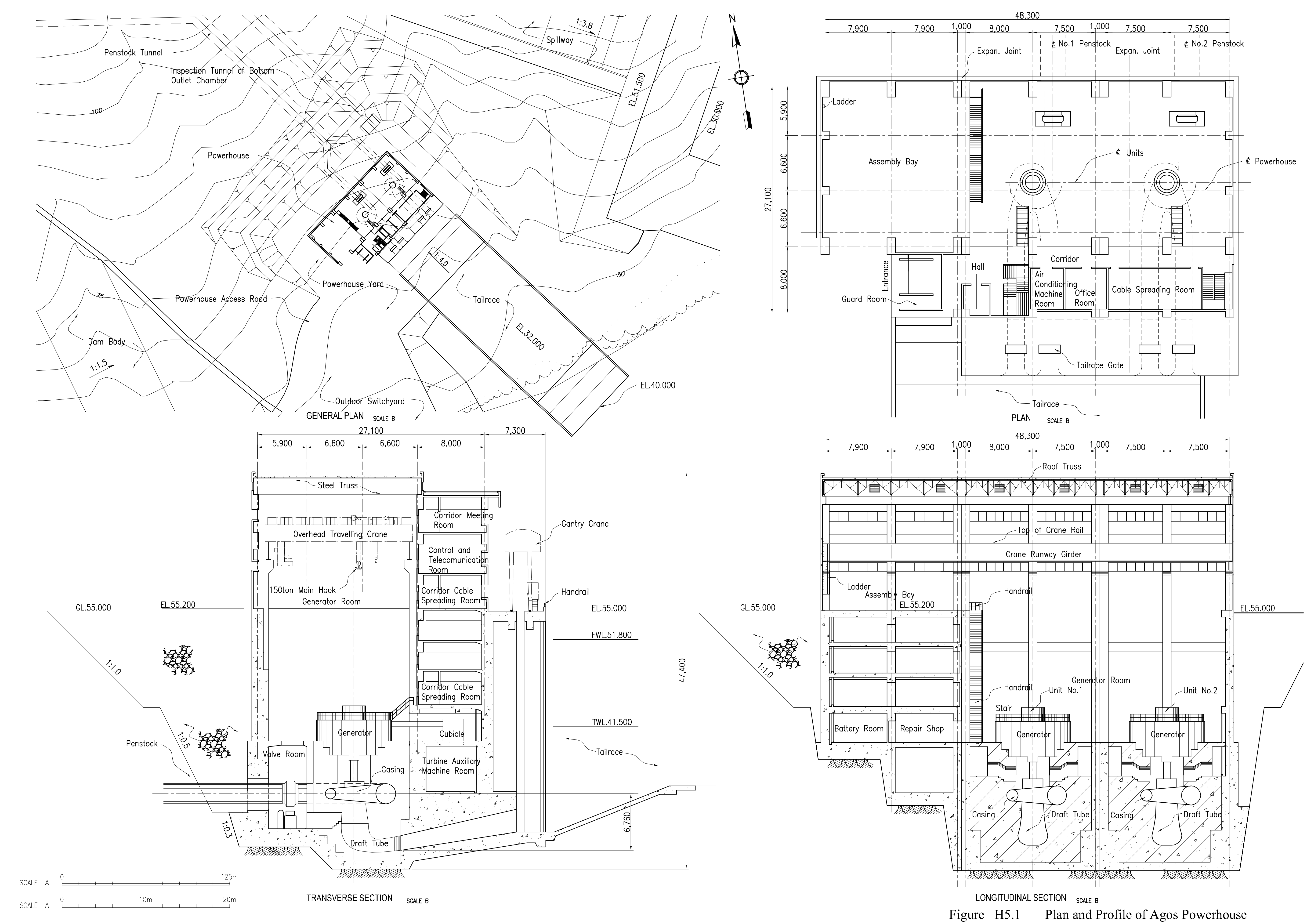


Figure H5.1 Plan and Profile of Agos Powerhouse

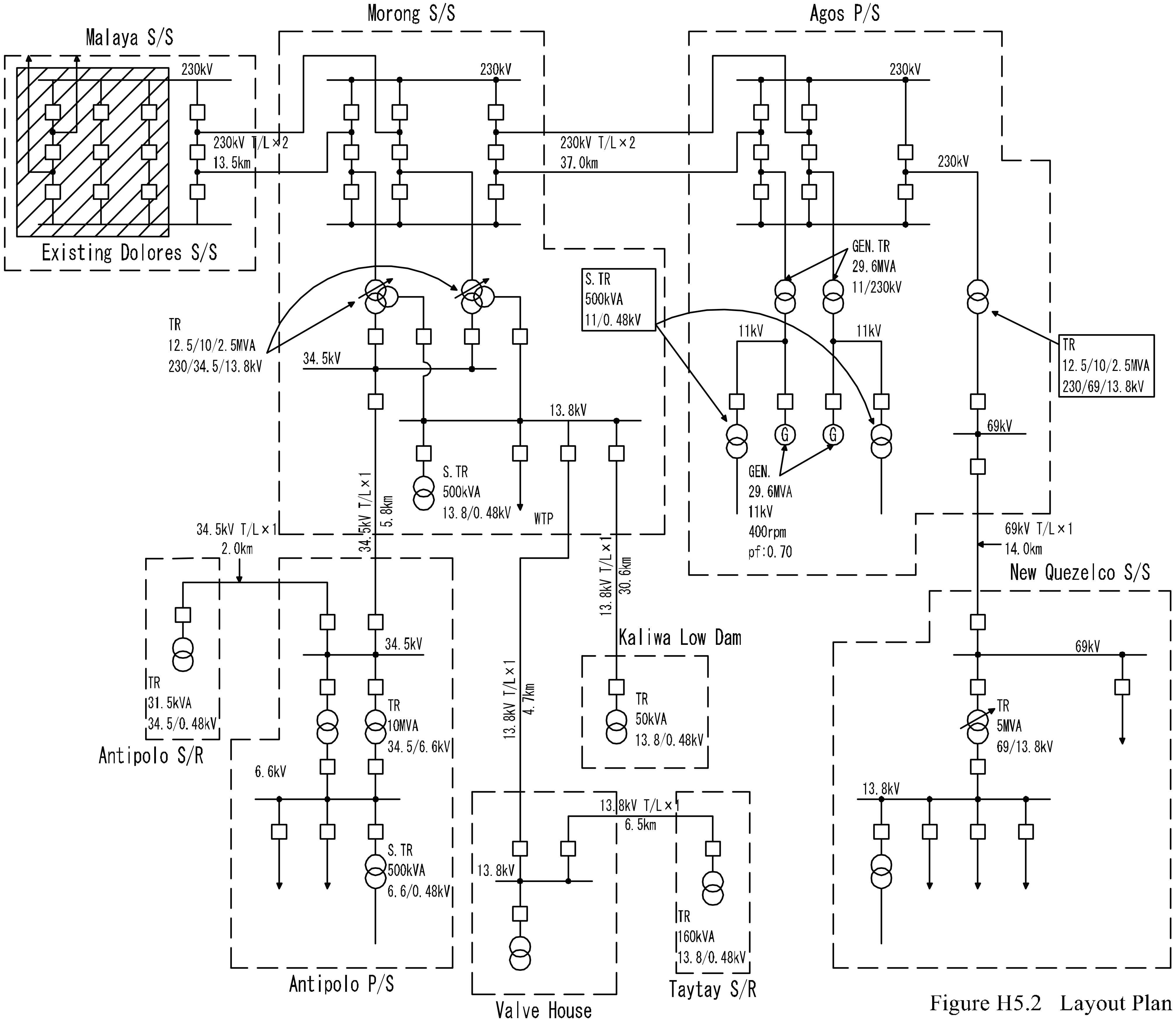


Figure H5.2 Layout Plan of Switchyard Equipment