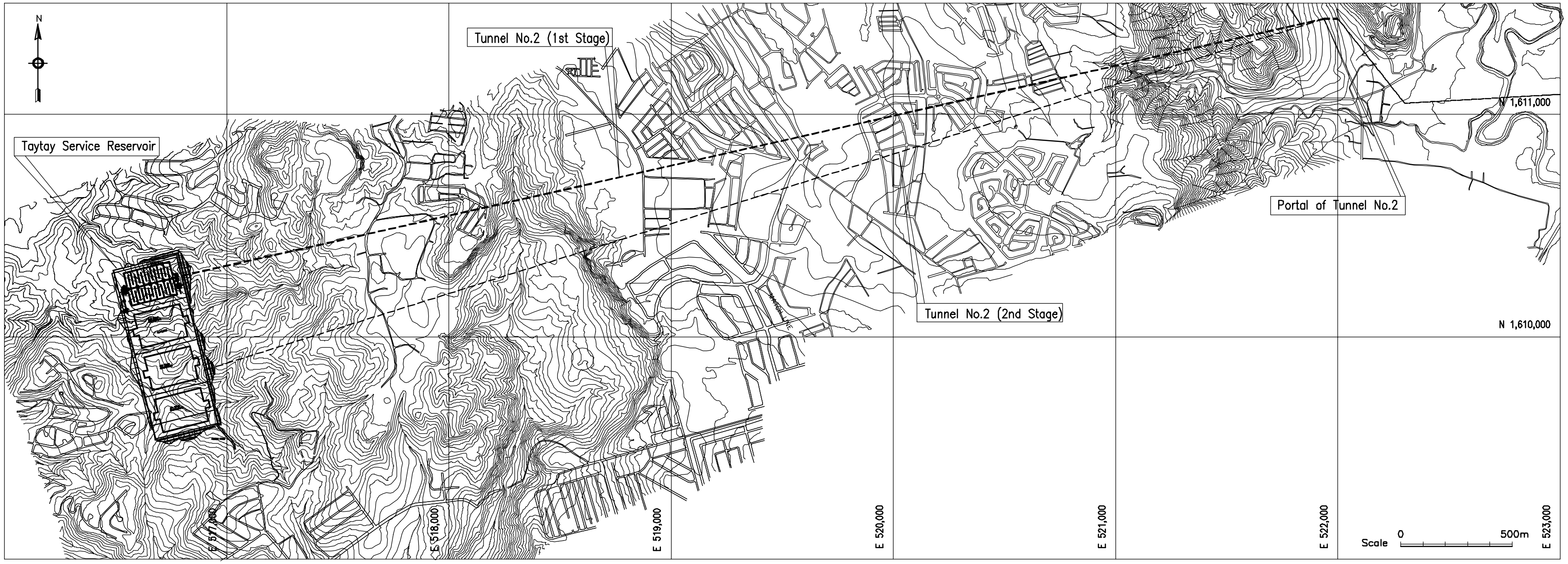
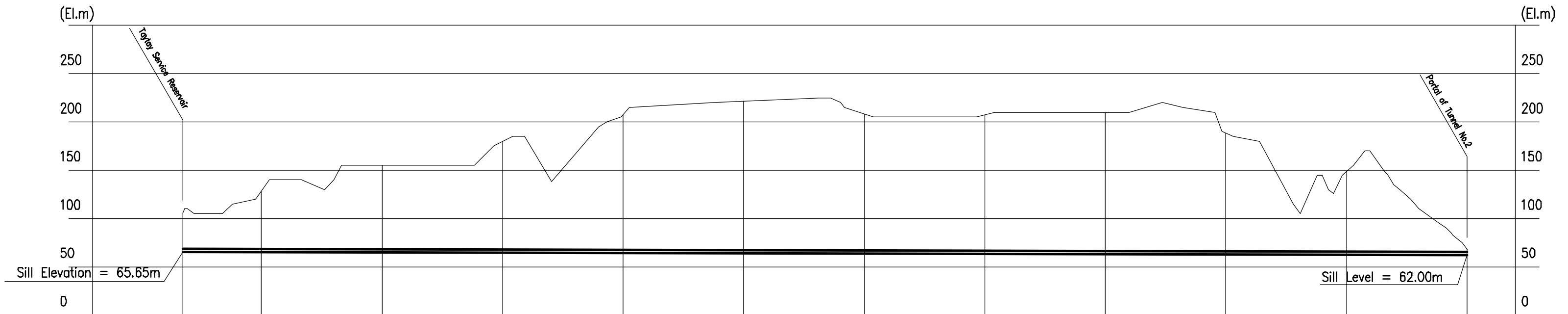


Plan



Tunnel Sill Elevation	65.65						S = 1/1500					62.00	Tunnel Sill Elevation
Ground Elevation	106	129	155	180	207	221	208	207	212	188	149	68	Ground Elevation
Total Distance	5327.00	5000.00	4500.00	4000.00	3500.00	3000.00	2500.00	2000.00	1500.00	1000.00	500.00	0.00	Total Distance
Distance	327.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	0.00	Distance
No. of Point	No.12	No.11	No.10	No.9	No.8	No.7	No.6	No.5	No.4	No.3	No.2	No.1	No. of Point

Profile

Scale V 0 100m

Scale H 0 500m

Figure 7.11 Plan and Profile of Tunnel No.2

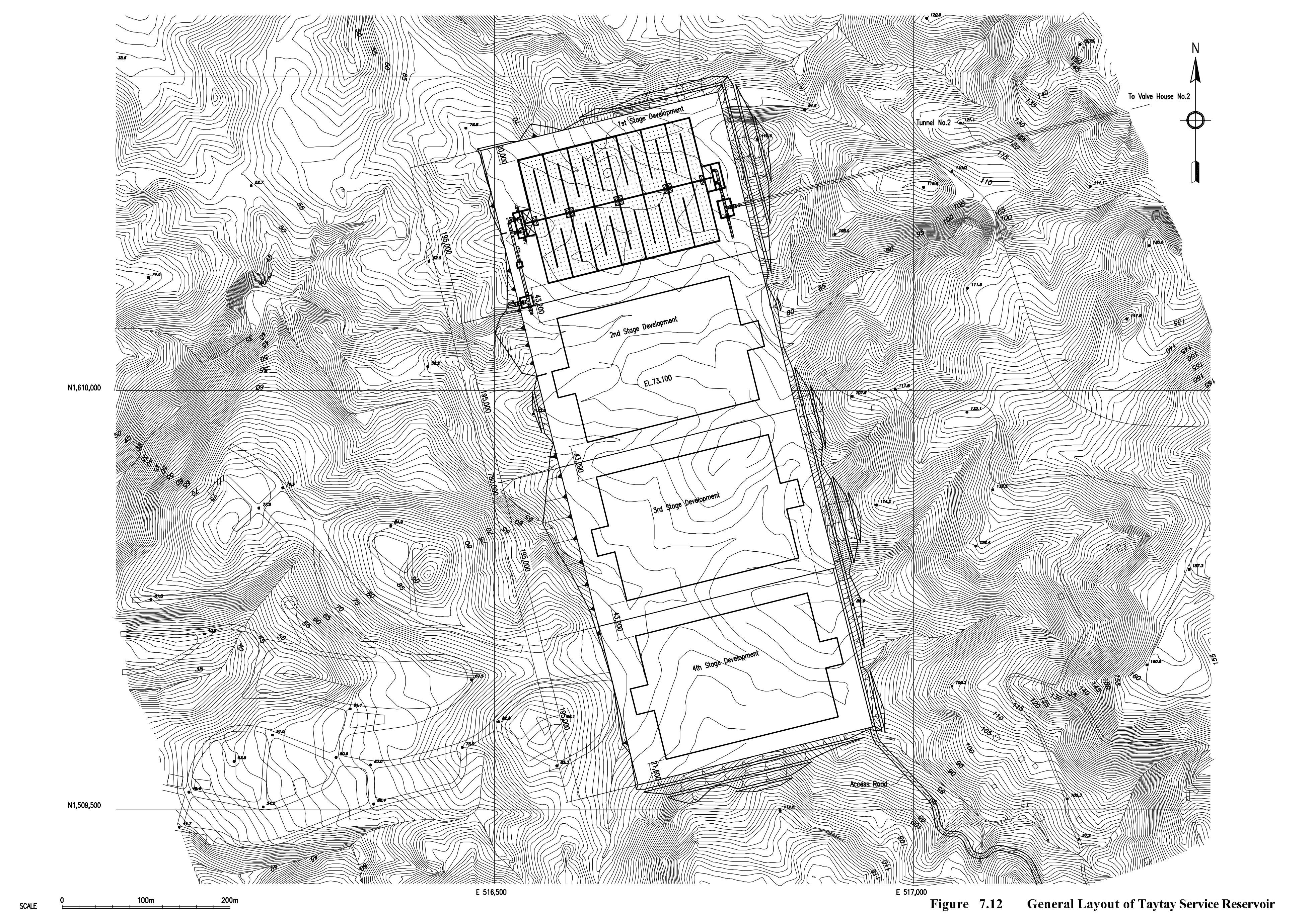


Figure 7.12 General Layout of Taytay Service Reservoir

CHAPTER VIII FEASIBILITY-GRADE DESIGN OF MAJOR COMPONENTS FOR STAGE 2 DEVELOPMENT: AGOS DAM AND KALIWA -TAYTAY 2ND WATERWAY

8.1 General

The major components to be provided in the Stage 2 Development involve the following:

1) Water resources facilities and its relevant hydropower station

   1-1) Agos dam and its appurtenant structures including river diversion works and spillway

   1-2) Agos power station consisting power waterway, Agos powerhouse, and power transmission facilities and substation

2) Kaliwa-Taytay 2nd Waterway

The 2nd Stage Development is further divided into the two stages, namely Stage 2-1 and Stage 2-2. In the Stage 2-1, the Agos Dam is to be constructed. Besides, the second unit (#2) of the Morong WTP will be installed to secure the water supply capacity of 1,830 MLD for Metro Manila. Likewise, the capacities of the Antipolo Pump Station and Taytay Service Reservoir will be expanded to cope with the projected water demands in the service areas. While, the Kaliwa 2nd Waterway will be provided in the Stage 2-2. The major facilities involved in the 2nd Stage Development are listed in the table below:

List of Major Components to be Built in Stage 2 Development

Name of Facility	To be Installed in Sage II Development	
	Stage 2-1	Stage 2-2
1. Water Resources Facility and Hydropower Facility in the Agos River Basin		
1) Agos Dam	Agos Dam	-
2) Agos Power station	Agos Power station	-
2. Kaliwa Taytay 1st Waterway Facility		
1) Tunnel No.1	-	2nd lane
2) Valve House No.1	-	2 main valves
3) Morong Water Treatment Plant (WTP)	2nd unit (#2)	3rd unit (#3) and 4th unit (#4)
4) Pipeline No.1	-	2nd lane
5) Valve House No.2	-	2 main valves
6) Pipeline No.2	-	2nd lane
7) Antipolo Pump Station	-	8 units of pumps
8) Antipolo Service Reservoir	-	2 units
9) Tunnel No.2	-	2nd lane
10) Taytay Service Reservoir	-	3rd and 4th units

The main features of the above components involved in the Stage 2 Development of the Project are described in the following Sections.

8.2 Agos Dam

8.2.1 Main Dam

The feasibility-grade design and comparison studies on the Agos Dam and its appurtenant structures are explained in Annex F of Volume V. The main structural features of the Agos Dam are summarized in the following Paragraphs.

(1) Surcharge Water Level of Agos Reservoir

As described in the succeeding Subsection 8.2.3, the combined type of gated weir and non-gated weir portions is adopted as the spillway type for the Agos Dam. To avoid occurrence of adverse effect on the downstream reach of Agos Dam due to improper operation of the spillway gates, the Study contemplates to set the reservoir surcharge water level for a 5-year probable flood as the surcharge water level. The usual floods of a 5-year probable flood and less than that are to be discharged downstream from the non-gated weir portion without opening the spillway gates.

(2) Required Freeboard and Crest Level

The Agos Dam to be constructed in the Stage 2-1 is to function as the water resources facility in the Agos River Basin instead of the Kaliwa Low Dam completed in the Stage 1.

The Agos Dam axis is selected to be AS-1, which is about 1 km downstream of the confluence of the Kanan and Kaliwa Rivers, taking into account the topographic and geological conditions as well as the potential land slide areas as discussed in the foregoing Chapter VI. Besides, the concrete face rockfill dam (CFRD) type with a FSL 159 m is selected as the optimum dam type for the Agos Dam in the same Chapter.

The general layout plan of the Agos Dam and its appurtenant structures including river diversion works and spillway is shown in Figure 8.1.

To determine the crest level of the Agos Dam, the required freeboards for the Agos Dam are estimated for the following four (4) cases:

(i) When the reservoir water level is at FSL,

(ii) When the reservoir water level is at the surcharge water level that is equivalent to the maximum reservoir water level for 5-year probable flood,

(iii) When the design flood (1.2 times of 200-year probable flood) passes though the spillway, and

(iv) When the probable maximum flood (PMF) passes through the spillway

For each of the above four cases, the required freeboard comprising rises of reservoir water level due to wave and earthquake and allowances for gate operation and fill type dam is calculated through adopting the design criteria in Japan for (i) to (iii) above, while the internationally accepted criteria is applied to estimate a freeboard for PMF in (iv) above. The required dam crest level is then calculated by adding the freeboard to the maximum reservoir water level as shown below:

Item	Case-1: RWL is at FSL	Case-2 : RWL is at SWL	Case-3: Design Flood	Case-4: PMF
a) Reservoir Water Level: RWL (m)	159.0	160.8	161.5	163.2
b) Required Freeboard : h_f (m)	5.1	4.4	3.7	1.1
c) Required Dam Crest Level (EL. m): (=RWL+ h_f)	164.1	165.2	165.2	164.3

From the above table, the crest level of Agos Dam is determined to be El. 165.2 m adopting the highest dam crest level among those required in the four cases. The crest length at El. 165.2 m is 790 m so that a ratio of dam height to dam crest length (V:H) comes to about 1:4.8.

(3) Typical Cross Section of Dam

The concrete face rockfill dam (CFRD) is selected as the dam type for the Agos Dam because of its economic advantage as compared with the earth core rockfill dam (ECRD) as discussed in the foregoing Chapter VI.

The outer slopes of the CFRD are determined based on the worldwide experiences in the CFRD design. A large number of worldwide designs on CFRD in a high seismic zone like the Agos River Basin show that 1V:1.5H for both upstream and downstream slopes to be satisfactorily stable. In fact, the same slopes are adopted in Laiban dam designed to be of CFRD type, which is planned to be constructed on the Kaliwa River. Therefore, it is determined to adopt 1V:1.5H as the outer slopes of Agos Dam.

The upstream surface of CFRD is covered with face concrete and its upstream toe is sealed off by curtain grout so as to avoid occurrence of seepage along dam foundation. The thickness of the concrete face slab is determined using the conventional formula (T=0.3 + 0.003H, where, T: thickness of concrete face slab (m) and H: vertical height from top of concrete face slab). Consequently, the thickness of the concrete face slab varies from 30cm at the top to 80cm at the bottom linked to its plinth.

Except for the concrete face slab, the CFRD embankment is composed of six (6) zones, i) fine filter (Zone 2A), coarse filter (Zone 2B), selected small rock (Zone 3A), rockfill zone (Zone 3B), random rockfill zone (Zone 3C) and riprap zone (Zone 3D) as show in Figure 8.2. Besides, the most upstream plinth zone is covered by the two (2) fill zones, i) impervious earthfill zone (Zone 1A) and ii) random fill zone (Zone 1B).

A 6m high vertical parapet wall will be provided at the upstream dam crest portion so as to reduce the total dam embankment volume. Its top elevation is set at El. 166.0 m, which is 0.8 m higher than the main dam crest level. The parapet wall will be placed on the top of the sloped face slab concrete.

8.2.2 River Diversion Works

A conventional river diversion method comprising two diversion tunnels, upstream cofferdam and downstream cofferdam is proposed to divert the river flow to make the construction areas of main dam, downstream part of spillway and powerhouse dry during their construction periods. A 20-year probable flood of 4,360 m^3/sec is adopted as the design flood for the river diversion works.

The other aspects to be taken into account in determining the alignments of diversion tunnels and cofferdams are the following topographic and geological conditions specific to the Agos Dam site:

a) The river deposits at the Agos Dam site are as deep as 35 to 40m. The present design contemplates to remove the river deposits so that the plinth of CFRD is founded on the fresh rock below the river deposits. Consequently, there is a possibility that the seepage of river water stored by the upstream cofferdam will reach to the deeply excavated portion to provide the plinth during construction of the Agos main dam, hampering the smooth construction thereof.

b) The distance from the Agos Dam axis to the confluence of the Kanan and Kaliwa Rivers is very short at about 550m. Hence, the upstream cofferdam will have to be constructed adjacent to the Ago Dam in case the upstream cofferdam is aligned on the Agos mainstream. This may cause the seepage problem in the foundation of the Agos Dam.

To cope with the seepage problem in the main dam foundation during the construction, the two river diversion methods are worked out. These are; i) two cofferdams plan, one cofferdam on each of the Kanan and Kaliwa Rivers, ii) one cofferdam on the Agos mainstream. The latter diversion method requires to construct temporary bridges to access to the quarry site that is enclosed by the both tributaries upstream of the confluence, since a large flood takes place on the Kanan River even in the dry season. While, the cofferdam crests can be utilized as the access roads to the quarry site in the former plan. As discussed in Annex F of Volume V, the cost comparison study shows that there is no large difference between the construction costs of the two diversion methods. Besides, it is considered that the former diversion method enables to proceed the construction works at the foundation of the Agos Dam with more safety as compared with the latter diversion method. Hence, the two cofferdams plan is adopted as the river diversion method for the Agos Dam.

Besides, a slurry wall is planned to be provided at the upstream toe of the upstream cofferdams to further ensure the safety during the construction of the Agos Dam as shown in Figure 8.2.

In consideration of the embankment volume of the two cofferdams that can be completed in the one dry season in the Agos River Basin, the crest level of the upstream cofferdams is set at EL. 81m. Consequently, the required diameter of the two diversion tunnels is derived to be 10m through the hydraulic analysis. The one diversion tunnel is planned to be provided on each of right and left banks, considering the following conditions:

(i) It is preferable to align one of the two diversion tunnels in order to utilize it for the river diversion works during impounding of the Agos Dam and after the completion of the Agos Dam, since the spillway plunge pool on the left bank can also be utilized as the energy dissipater for the river diversion works.

(ii) The left bank side of the Agos Dam is much congested with spillway and Agos power waterway so that there is no sufficient space to economically provide the two diversion tunnels on the left bank.

The lengths of diversion tunnels on right and left banks are 1,589 m and 772 m, respectively. The diversion tunnel on the left bank is aligned to reach a plunge pool of spillway. It will be equipped with the river outlet works, which will be used to release the reservoir water to the downstream reach.

The downstream cofferdam is aligned just downstream of the main dam. In addition thereto, a temporary cofferdam needs to be provided to construct the plunge pool and powerhouse. Figure 8.1 shows the general layout plan of the diversion tunnels. Figure 8.3 shows the profile of the right bank diversion tunnel as well as the typical cross sections of the diversion tunnels, while Figure 8.5 shows the profile of the left bank diversion tunnel which will be used as the river diversion works.

8.2.3 Spillway

The spillway is aligned on the left bank from the topographic and geological viewpoints. The spillway is designed to have a capacity to discharge the design flood of 9,600 m^3/sec that is equivalent to 1.2 times 200-year probable flood at the Agos Damsite, except for the energy dissipater provided at the downstream end of the spillway that is designed for 100-year probable flood. Besides, it is designed to safely pass a probable maximum flood (PMF) of about 17,100 m^3/sec without endangering the Agos dam.

A combined type of non-gated and gated portions is selected to ensure the safer release of flood discharge. Concerning the length of the non-gated overflow sections, the two alternative plans of i) provision of 200 m long non-gated spillway on the left bank side of the spillway forebay, ii) provision of 200 m long non-gated spillway on the both sides of the forebay are compared from the economic viewpoint. As explained in Annex F of Volume V, the cost comparison study reveals that the latter plan is more economical than the former plan. Therefore, this Study adopts to construct the 200 m long side channel spillway with non-gated overflow crest on both sides of the forebay portion. In the gated portions, 4 radial gates, each having a dimension of 14.0 m and 11.0 m in height and width, respectively, are planned to be provided. The outflow hydrographs for the 5-year flood, design flood (1.2 times of 200-year probable flood) and PMF are estimated with the spillway dimensions as shown in Figure 8.4.

To avoid occurrence of sudden flooding in the downstream reach due to improper gate operation for usual magnitudes of floods, the spillway is designed to discharge downstream the 5-year probable flood or less than that through the side channels without opening the spillway gates as mentioned in the foregoing Subsection 8.2.1. The reservoir water level is estimated to rise to the surcharge water level of 160.8

m, 0.7 m below from the top elevation of closed spillway gate, on the condition that a 5-year probable flood is discharged downstream only from the non-gated side channels. This will not have adverse effects on the downstream reach due to the improper spillway gate operation under the usual condition.

After passing the gated portion, the flood water is to pass through a chuteway whose longitudinal slope is 1 in vertical distance to 4.3 in horizontal distance except for the upper horizontal short section. The chuteway width is designed to gradually reduce from 120 m in uppermost portion to 90 m at the lower end just upstream of the flip bucket.

As the alternative plans for the spillway energy dissipater, the two (2) alternative types are usually conceivable. These are plunge pool type and stilling basin type. As discussed in Annex F of Volume V, the cost comparison study clarifies that the plunge pool type is much more economical than the stilling basin type, since the latter type requires a considerably large concrete volume because of very deep top soil and river deposit at the site. Hence, the flip bucket with a plunge pool is selected as the energy dissipater because of its economical advantage as compared with the stilling basin type.

The general plan of the spillway is shown in Figure 8.1, while Figure 8.5 depicts the profile and section thereof.

8.2.4 Facility to Remove Log and Sediment in Agos Reservoir and Clearing of the Reservoir Area

It is prerequisite to install the log booms in the Agos Reservoir, each on the Kanan and Kaliwa Rivers, to trap and remove the logs flowing down from the upstream reaches towards the Agos Dam.

As discussed in the foregoing Subsection 4.3.4, the Agos Reservoir is planned to have the enough dead capacity to store the sediment transports at the Agos Dam site for 100 years. On the other hand, the sediment yield in the Agos River Basin may significantly increase in case the intensive deforestation will take place therein after the creation of the Agos Reservoir which will facilitate the people to encroach to the upstream area, especially to the Kanan River Basin. In the event of occurrence of such a situation, it is recommended to install the sediment removal system including the provision of weirs above the upstream edges of the Agos Reservoir so as to trap and remove sediment as much as possible before flowing into the Agos Reservoir. It is recommended to examine the sediment removal system in the next detailed design stage.

As discussed in the foregoing Subsection 5.3.4, this Study contemplates to completely clear the Agos Reservoir area so as to cope with the issue on emission of greenhouse gasses therefrom.

8.3 Agos Power Facilities

8.3.1 Power Waterway Facilities

The Agos power station is planned as a power station bearing the peak load for 12 hours a day in the power system in the dry season by harnessing effectively a head created by the Agos Dam and discharge in excess of water supply to Metro Manila out of the discharge to be regulated by the Agos Dam.

As the power waterway routes, two (2) alternative waterways of the left-bank and right-bank waterways are compared in Annex F of Volume V. From the topographic and geological conditions, the total length of the right-bank power waterway is about 350m longer than the left-bank one so that the latter is more economical than the former. Hence, it is determined that the Agos power waterway including the Agos powerhouse is aligned on the left bank.

The waterway for the Agos power station comprises power intake, headrace tunnel, intake gate shaft, shaft, penstock line, powerhouse and tailrace. Its total length from power intake to powerhouse is 755 m which comprises intake structure, 535 m long headrace tunnel of 5.9 m diameter and 212m long penstock tunnel of 5.4 m diameter. The Agos power waterway is illustrated in Figure 8.6.

The powerhouse and tailrace are planned to be provided at the space between the spillway and downstream cofferdam. The powerhouse accommodates two units of generating equipment comprising turbines, generators and transformers. The total installed capacity is 51.5 MW and maximum power discharge is 55.4 m^3/sec.

The Agos powerhouse is shown in Figure 8.7.

8.3.2 Switchyard

A switchyard is built at the toe of dam at EL.55 m as shown in Figure 8.1. The switchyard is of conventional outdoor open type of 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 Substation (S/S). The required area of land is roughly 100 m by 150 m.

8.3.3 Generating Equipment

(1) Operating Conditions

The operating conditions of generating equipment for the Agos power station 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

(2) Number of Units

For the Agos powerhouse, the two units layout plan 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 for the 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
(e) Generator transformers		
- Type	:	Three-phase, oil-immersed, ONAF, with off-circuit tap changer
- Rated power	:	29,600 kVA
- Rated voltage ratio	:	11/230 kV

8.4 Kaliwa-Taytay 2nd Waterway

In the Stage 2-1, the second unit (#2) of water treatment plant will be installed in the Morong WTP on the Kaliwa-Taytay 1st Waterway constructed in the 1st Stage so as to enhance the water treatment capacity thereof up to 1,820 MLD or 21.0 m^3/sec to meet the water demand of Metro Manila.

In the Stage 2-2, the Kaliwa-Taytay 2nd Waterway will be constructed almost along the Kaliwa-Taytay 1st Waterway as shown in the corresponding Figures of the foregoing Chapter VII. The dimensions of the tunnels, pipelines and units of the Morong WTP, Valve House No.1 and No.2, Antipolo Pump Station, and Antipolo and Taytay Service Reservoirs which will be provided in the Stage 2-2 are the same as those in the Stage 1. The dimensions and structural features of those facilities involved in the Stage 1 Development are explained in the foregoing Chapter VII.

With the completion of the construction works in the Stage 2-2, the Project has the ultimate water conveyance capacity of 3,640 MLD or 42.0 m^3/sec for Metro Manila.

8.5 Access Road

The Agos damsite is located at the eastern side of Metro Manila, within the Municipalities of General Nakar and Infanta, the Province of Quezon. The proposed Agos Dam lies across the Agos River and Barangay Pagsangahan.

The site can be reached via Infanta, Quezon through Marcos Highway. From Infanta, there is an existing unpaved rough road going to the site and only a four-wheel drive car can pass through at present.

Since a considerable amount of construction materials and equipment as well as the power plant equipment will have to be delivered to the site, the adequately paved access road needs to be newly constructed.

With regard to the Kaliwa-Taytay 2nd Waterway Facilities, their construction works will be carried out using the access roads and tunnel adits provided in the Stage 1.

8.6 Power Supply to Agos Dam and Waterway Facilities

8.6.1 General

In the Stage 2, the power supply system for the Agos damsite and the waterway facilities will be installed in accordance with the basic concept shown in the "Schematic Diagram for the Proposed Overall Transmission Line" in the foregoing Subsection 7.5.1. The basic concept of the proposed power supply program in the Stage 2 is as follows:

Stage 2-1: After the completion of Agos Power Station (P/S), the facilities can receive power from the Agos P/S. At this stage, the waterway facilities will have two (2) power supply sources: Dolores S/S and Agos P/S. This will ensure the security of power supply for the waterway facilities.

Stage 2-2: After the completion of the 2^{nd} Waterway, the power requirement of the facilities will increase due to the increase of water production. This requires the extension of the Morong Substation facilities, such as additional transformer and switchgear equipment.

8.6.2 Power Supply System at 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 following power transmission facilities.

(a) Construction of Agos Switchyard

(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 from Agos P/S

(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) Installation of transformer and switching equipment at New Quezelco S/S to introduce a 69 kV single-circuit transmission line from the Agos P/S

8.6.3 Power Supply System at Stage 2-2

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

The extension of Morong S/S will include the installation of the following additional equipment:

(a) An additional 230/34.5/13.8 kV step-down transformer

(b) Additional 230 kV, 34.5 kV and 13.8 kV switchgear equipment for secondary circuit lines