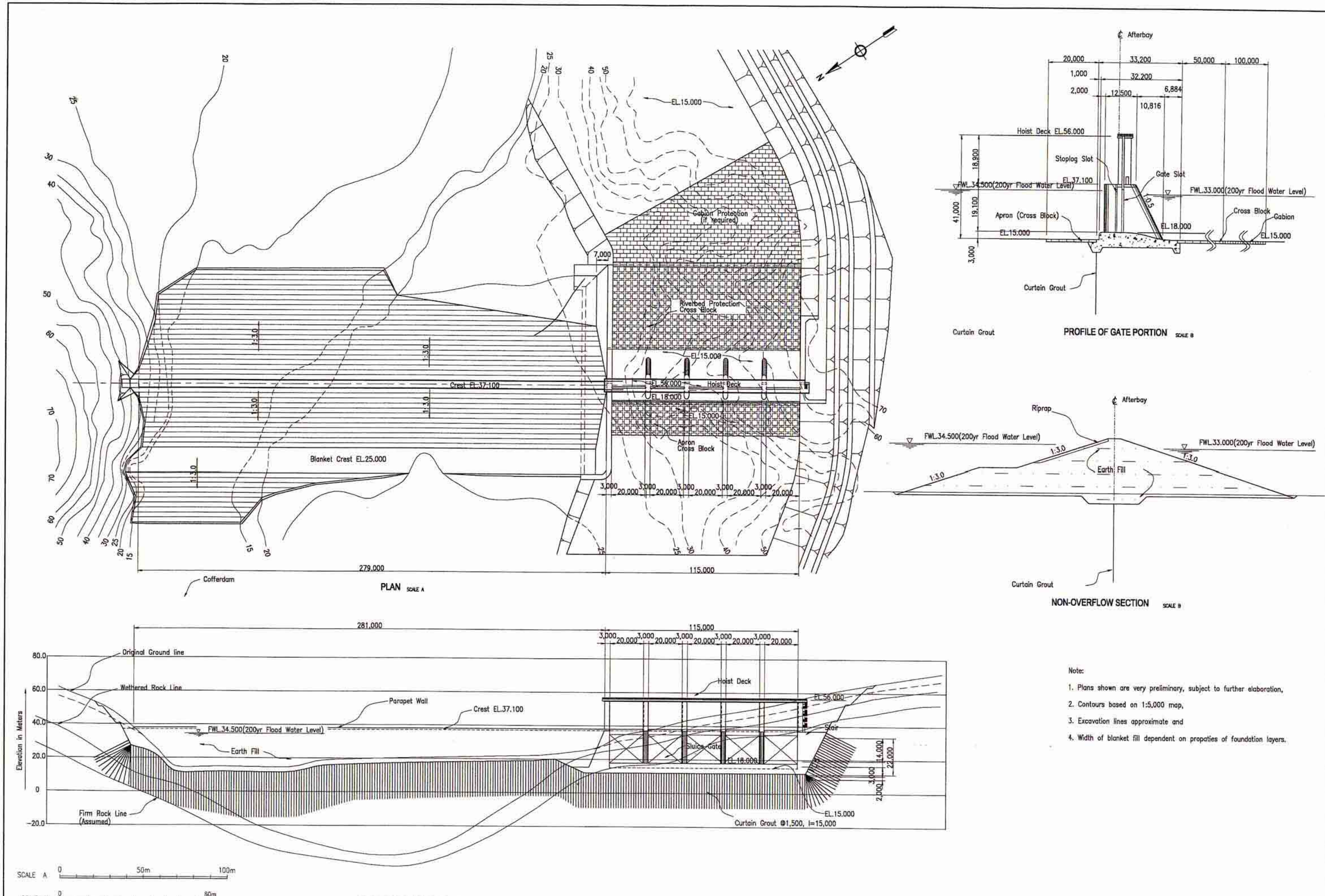
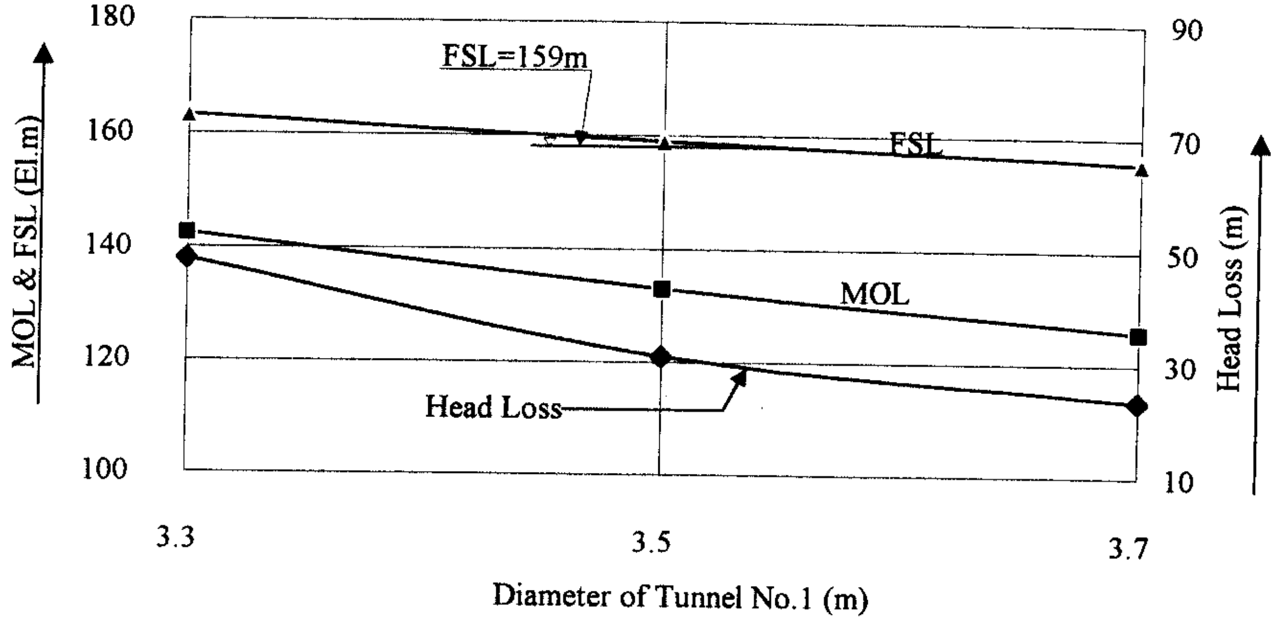
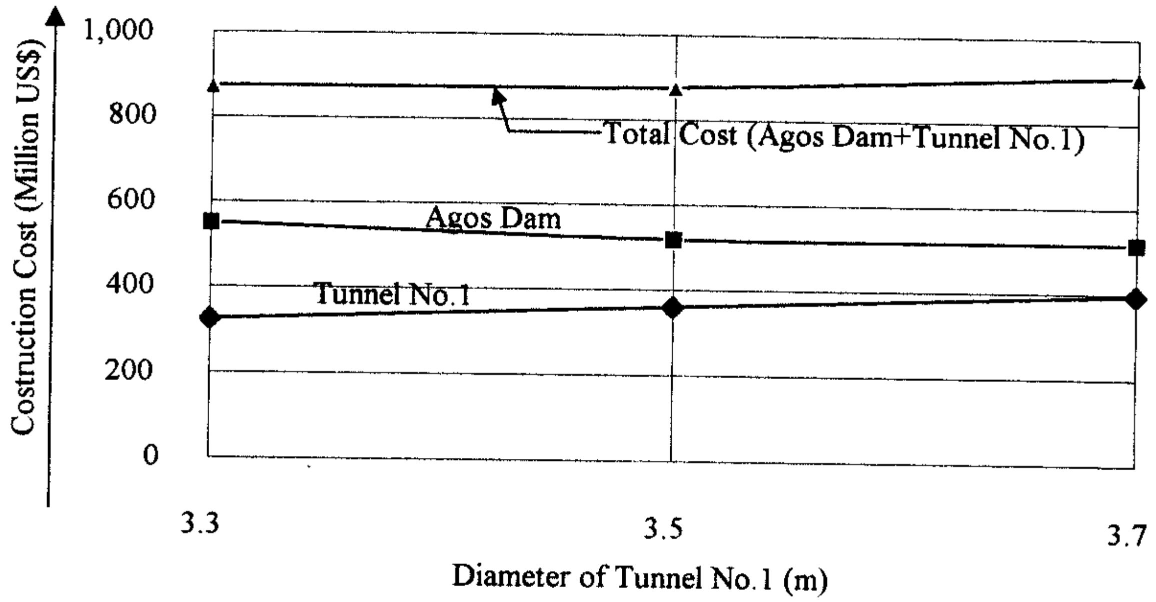


Figure 6.8 Agos Afterbay Weir



Head Loss, MOL & FSL by Diameter of No.1 Tunnel



Costruction Cost of Nunnel No.1 and Agos Dam by Diameter of Tunnel No.1

Figure 6.9 Comaprison of Diameter of Tunnel No.1 in Kaliwa-Taytay Waterway

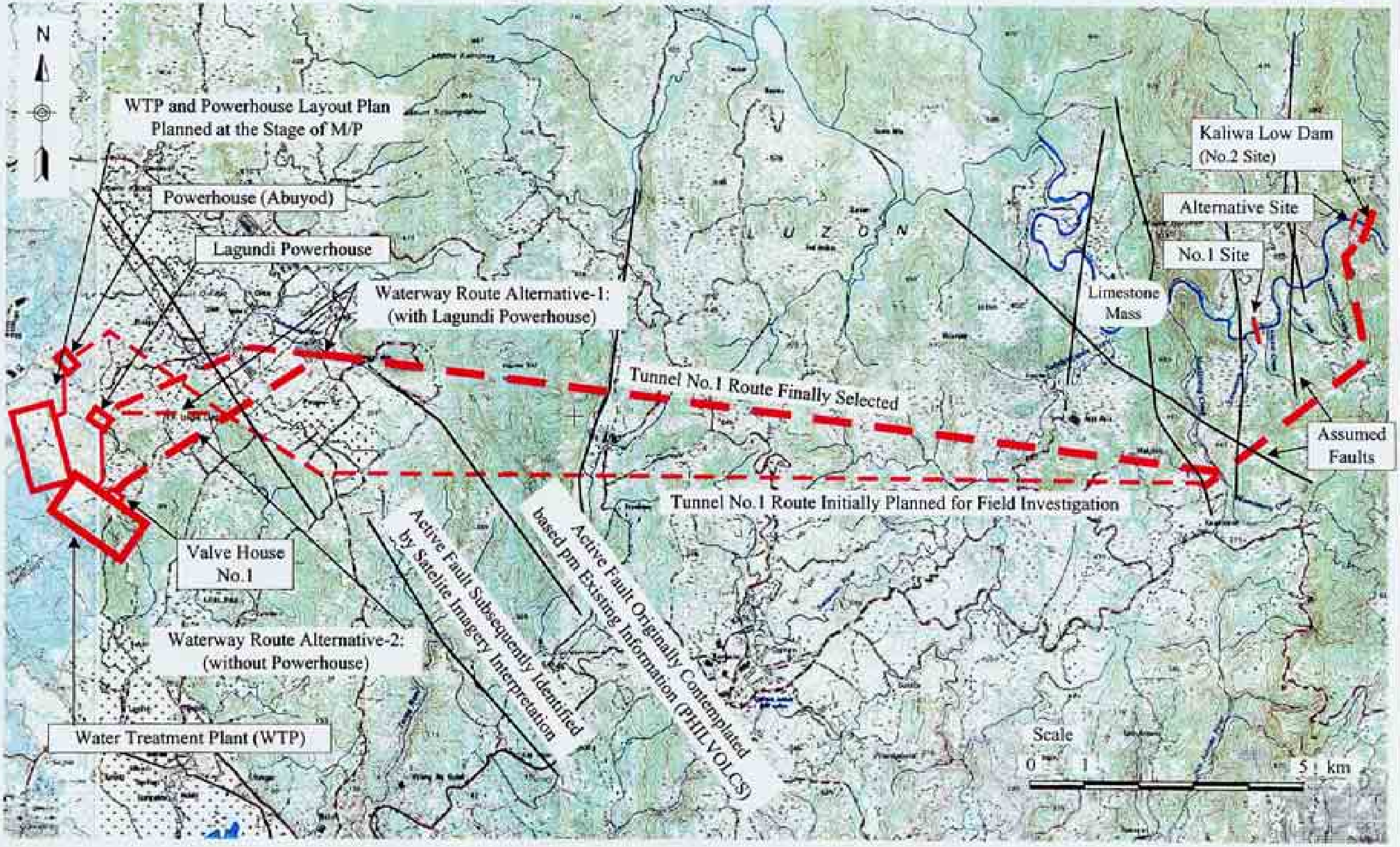


Figure 6.10 Alternative Routes of Tunnel No.1 in Kaliwa-Taytay Waterway

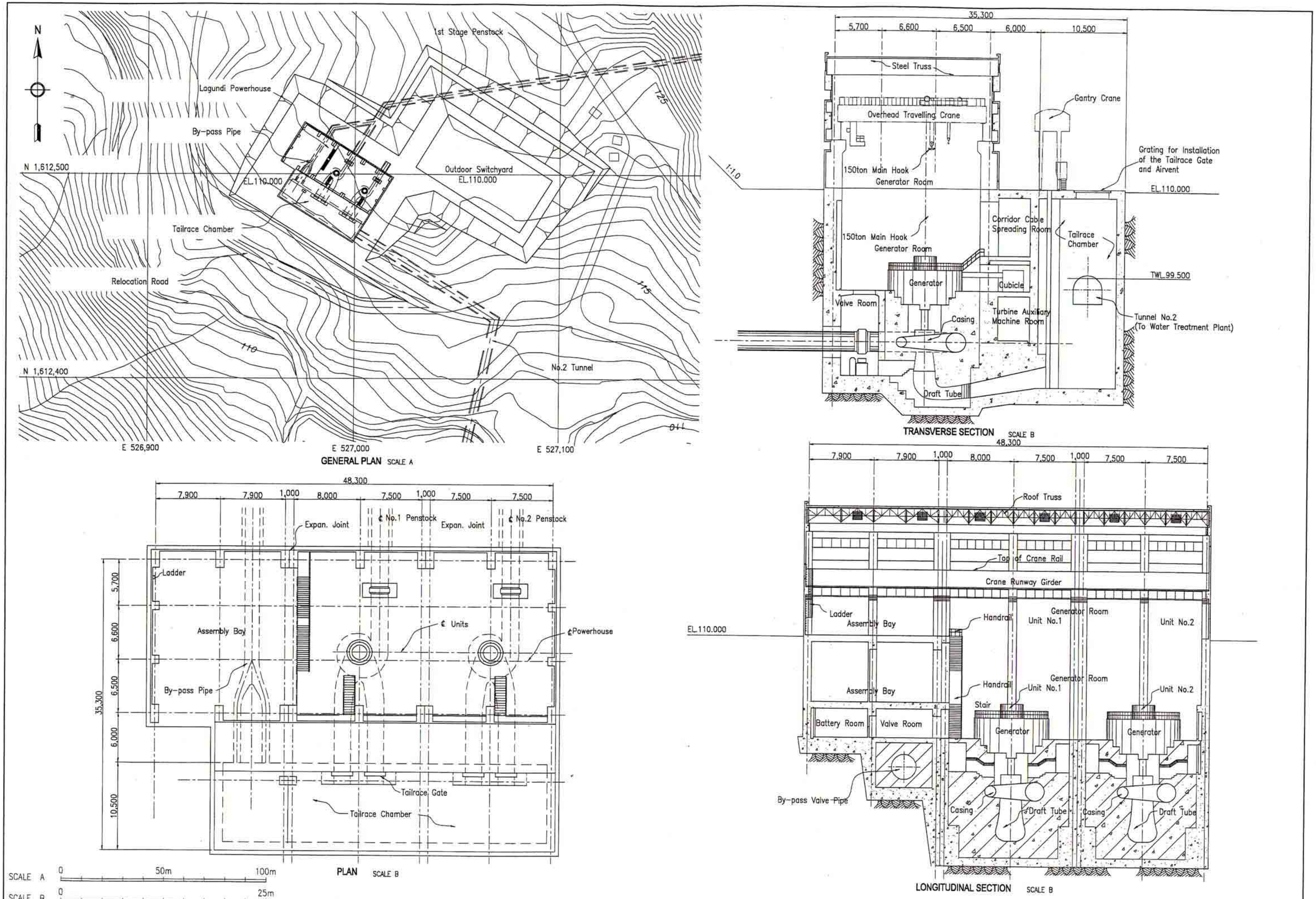


Figure 6.11 General Plan and Sections of Lagundi Powerhouse

CHAPTER VII FEASIBILITY-GRADE DESIGN OF MAJOR COMPONENTS FOR STAGE 1 DEVELOPMENT: KALIWA LOW DAM AND KALIWA-TAYTAY 1ST WATERWAY

7.1 Major Components

This Study contemplates to realize the proposed Project in two stages, namely Stage 1 Development and Stage 2 Development. The Stage 1 Development comprises construction of the Kaliwa Low dam and the 1st lane of the Kaliwa-Taytay Waterway (Kaliwa-Taytay 1st Waterway) connecting an intake structure at the Kaliwa Low Dam site and service reservoirs at Taytay and Antipolo. The general layout plan and profile of the Kaliwa-Taytay Waterway are shown in Figure 7.1.

The primary purpose of the Project is to convey a daily maximum discharge of 3,640 MLD (3,000 MLD x 1.21) or 42.0 m^3/sec with the two lanes of the Kaliwa-Taytay Waterway at the full development stage. Accordingly, the Kaliwa-Taytay Waterway to be provided in the Stage 1 Development is designed to have a capacity to convey a discharge of 1,820 MLD or 21.0 m^3/sec, a half of the design discharge at its full development stage, to Metro Manila.

The major facilities involved in the Stage 1 Development are listed in the table below:

List of Major Components to be Built in 1st Stage Development

Name of Facility	To be Installed in Sage 1 Development
1. Water Resources Facility in the Agos Basin	
1) Kaliwa Low Dam	Fully constructed.
2. Kaliwa-Taytay 1st Waterway Facility	
1) Kaliwa Intake Structure	1st intake structure and civil works for 2nd one
2) Tunnel No.1	1st lane and most upstream 30 m long section for the 2nd lane
3) Valve House No.1	3 main valves of 5 ones at ultimate stage
4) Morong Water Treatment Plant (WTP)	1st unit (#1) out of 4 units at ultimate stage
5) Pipeline No.1	1st lane
6) Valve House No.2	2 main valves out of 4 ones at ultimate stage
7) Pipeline No.2	1st lane
8) Antipolo Pump Station	2 pumps out of 10 pumps at ultimate stage
9) Antipolo Service Reservoir	1 unit out of 6 units at ultimate stage
10) Tunnel No.2	1st lane
11) Taytay Service Reservoir	1st unit out of 4 units

The following Sections describe the main features of the above components involved in the Stage 1 Development of the Project.

7.2 Kaliwa Low Dam

The layout plan and structural design of the Kaliwa Low Dam are shown in Figure 7.2. It is designed as a temporary structure and is to be submerged by the Agos Reservoir to be created in the Stage 2-1 Development of the Project.

The Kaliwa Low Dam is constructed with sand and gravel from riverbed and rock materials quarried and produced from excavation for the Kaliwa Low Dam and waterway tunnel. The upstream surface zone is covered with impervious fill to avoid seepage through the dam body. The downstream face is protected with cribs mixed with rocks to allow the overtopping of flood flow. The Kaliwa Low Dam is planned to function for three years, and then to be partially removed after the completion of the Agos Dam. Considering a relatively short-term operation period, a spillway is not provided. A sand flush gate is installed to periodically discharge sediments which will be accumulated in front of the intake structures on the right bank.

The Kaliwa Low Dam proposed in this Study is designed to be of temporary structure, since it is to be removed after the completion of the Agos Dam in the Stage 2-2 Development as explained above. On the other hand, the durable type of the Kaliwa Low Dam is explained in Annex F of Volume V.

7.3 Kaliwa-Taytay 1st Waterway

7.3.1 Hydraulic Condition and Physical Water Loss

(1) Hydraulic Condition

The hydraulic longitudinal profile of the Kaliwa-Taytay Waterway, including water levels at the proposed structures (e.g. water treatment plant, service reservoir), was determined based on the results of hydraulic head loss calculation. The head losses due to friction in the tunnel and pipeline are calculated by the William-Hazen formula. A value of 110 is adopted as the William-Hazen friction coefficient “C”. The design water level of the Taytay Service Reservoir is set at EL.72 m, which represents the required water level to ensure the distribution of water to the service areas in Metro Manila by gravity flow. Therefore, water level at Taytay Service Reservoir is set as the starting point for designing the hydraulic profile of the Kaliwa-Taytay Waterway. The hydraulic heads were calculated consecutively for each of the tunnel/pipeline sections by a general formula expressed as follows:

$$WL_u = WL_d + H_L$$

Where,
- WL_u : Water level at upstream structure (EL. m)
- WL_d : Water level at downstream structure (EL. m)
- H_L : Friction loss in pipeline or tunnel between the downstream and upstream structure and other losses (m)

In the calculation above, WLu is adopted to be a LWL required for the upstream structure, while WLd is a HWL designed for the downstream structure. The head loss due to friction and other losses in one lane of the waterway is calculated as follows:

Head Loss in Kaliwa-Taytay Waterway

Section of Waterway	Tunnel/Pipeline	Distance (km)	Head loss (m)
1) Taytay Service Reservoir and Morong WTP	1-1) Tunnel No.2 1-1) Pipeline No.1	10.4	12.1
2) Morong WTP and Intake Structure at Kaliwa Low Dam site	2-1) Tunnel No.1	27.6	31.8
Total		38.0	43.9

(2) Physical Water Loss

Physical water loss due to cracks of concrete lining and water leakage from joints of pipe may occur in the waterway facilities. Applying the standard loss rates of 150 l/day/cm/km for tunnel and 50 l/day/cm/km for pipeline as well as the water loss at the Morong WTP that is estimated at 3.04 MLD, the total water loss for one lane of the Kaliwa-Taytay Waterway is estimated at about 0.06 m^3/sec. Thus, the total physical water loss is calculated to be quite small as compared with the design discharge of 42 m^3/sec at the full development stage.

7.3.2 Kaliwa Intake Structure

In the First Stage Development, the two Kaliwa Intake structures, one for each of the two lanes of waterway, need to be constructed on the right bank of the Kaliwa Low Dam site on the Kaliwa River as shown in Figure 7.2. Each of the intake structures is composed of three inlets, inlet culverts and one gate shaft. The sill elevation of each inlet is set at EL. 121 m, 134 m and 147 m to allow the multi-level intake of water in the Agos Reservoir. Until the completion of the Agos Dam, only the lowest portion of inlet will be used. The discharge capacity of the intake structures is 6.4 m^3/sec at initial stage, 21.0 m^3/sec after the completion of Agos Dam, and is to be expanded to 42.0 m^3/sec at the ultimate stage. The discharge velocity of inlet will be kept to less than 1 m/sec.

7.3.3 Tunnel No.1

A 3.5 m diameter is selected for the 27.5 km long Tunnel No.1 based on the results of the economic comparison study on the diameter as described in the foregoing Chapter VI. Plan and profile of the Tunnel No.1 are shown in Figure 7.3. Typical cross sections of the waterway tunnels and pipelines are shown in Figure 7.4. The thickness of concrete lining of the Tunnel No.1 is determined to be 0.35 m in accordance with the standard design criteria in Japan, in which it is prescribed by the formula expressed as “D/10”, where “D” is the inner diameter of headrace tunnel”. As discussed in the succeeding Chapter IX, on the other hand, the Tunnel Boring Machine (TBM) and New Austrian Tunneling Method (NATM) are adopted as the construction method for each section of the tunnel in compliance with the geological conditions. The horizontal radius of curve in the TBM and NATM sections is adopted to be 1,000 m and 200 m, respectively.

The most downstream 50 m section of the Tunnel No.1 is designed to be steel-lined for inner surface and to be backfilled with concrete. The thickness of the penstock is determined to be 11 mm that is equivalent to the required minimum thickness.

7.3.4 Valve House No.1

The Valve House No.1 is installed at downstream end of the Tunnel No.1 to regulate water diverted from the Kaliwa Intake Structure to the Morong WTP. The Valve House No.1 is equipped with five motor corn-sleeve valves with diameter of 1,500 mm for main valve and six butterfly valves with diameter of 1,500 and 2,500 mm for sub-valve, pit and other valve house structures. Out of the five main valves, one main valve is planned to be installed as the standby valve. Diameters of main valves and sub-valves are determined to keep the flow velocity less than 6.0 m/sec. Two main valves and one main valve are accommodated for one lane of the waterway and by-pass way, respectively. Each waterway is designed to be bifurcated upstream of the Valve House No.1 to convey water to the waterway and by-pass way. Thus, the by-pass way connects 1st waterway and 2nd waterway to convey water in case one main valve in the waterway is closed for the purpose of maintenance and repair.

The discharge capacity for each main valve is 10.5 m^3/sec. The discharge measurement is planned to be carried out by an ultra-sonic type discharge meter, which is installed in the Tunnel No.1.

The Valve House No.1 is of beam type made of reinforced concrete with dimensions of 53.0 m in width, 31.0 m in length and 21.1 m in depth to accommodate various valves (See Annex G of Volume V). The main equipment to be installed in the Valve House No.1 is shown in Table 7.1.

7.3.5 Morong Water Treatment Plant

(1) Proposed Site

The Morong Water Treatment Plant (WTP) site is selected by examining 1:2,000 scale topographic maps and aerial photographs and conducting a field visit to the site. In selecting the site, the following factors are taken into consideration:

- Availability of required area for the construction of the Morong WTP,
- Topographical and geotechnical conditions, and
- Availability of river and creek, which can release excess water to be discharged from the plants.

The proposed site for the Morong WTP is situated in Barangay Lagundi of the Municipality of Morong, about 4 km east of Antipolo. The site is very close to a creek, which flows down to San Gabriel, Plenza and further to San Juan on the coast of the Laguna Lake. The air distance from the WTP site to the proposed Taytay Service Reservoir is approximately 9 km. The Morong WTP site consists of paddy field, farm land, uncultivated land and hilly areas, with about 25 households at scattered locations. It was confirmed through the site reconnaissance that most of the land is privately owned. This Study contemplates to acquire a total land of 95 ha required for the construction of the Morong WTP.

The ground elevation of the Morong WTP site ranges from EL. 85 m in the relatively flat areas to EL. 105 m on the hilltops, descending gently to the south. Construction of the plant yard will require several millions m^3 of earth works.

(2) Design Principles

The Morong WTP will be developed in 4 stages with 910 MLD each in accordance with the increase of water demand in Metro Manila. The preliminary computation and conceptual design are prepared for the 1st and 2nd stage developments of the proposed water treatment facilities (1,820 MLD in capacity out of 3,640 MLD at the full development stage that is equivalent to the daily peak water demand of Metro Manila in 2025).

For determination of design capacity of the treatment facilities, water loss within the yard of water treatment plant is planned to be as minimal as possible. Wash water from the filters is returned to receiving well, and sludge from sedimentation basin is thickened and supernatant water also returned to receiving well through backwash wastes returning tank. Water loss at plant is estimated at only 0.08% out of assumed intake water volume as explained in Annex G of Volume V. Thus, the design capacity of the Morong WTP is adopted to be same as the maximum daily water demand of 3,640 MLD of Metro Manila in 2025.

The treatment process units are selected and designed taking into consideration the raw water quality, economic construction and easiness of operation and maintenance. Simple structures will bring flexibility to the variation of raw water quality and unpredictable constraints of operation and maintenance works. As for coagulant, poly aluminum chloride (PAC) is recommended, since its performance shows many advantages in improving floc density and settling velocity through the worldwide experience. In addition, the application of PAC for water treatment does not require coagulant aid such as poly-electrolyte(s).

Lime will be used for pH adjustment in coagulation process. Pre-chlorination will be adopted for oxidation of ammonium, objectionable taste and odor, iron and /or manganese, while post-chlorine will be used for disinfectant. Intermediate chlorination aiming at manganese removal would not be necessary considering the actual operation status of the existing water treatment plants in Metro Manila. In case of adopting intermediate chlorination, further study will be needed regarding the type of manganese (soluble Mn^{2+}) and its concentration.

Referring to main constituents obtained for the Kaliwa and Kanan Rivers in the previous studies as well as water quality analyses conducted in the course of the Study (Refer to Subsection 4.6), dosage rates of the chemicals are anticipated as shown below:

Anticipated Dosage Rates

Chemicals to be used	Dosage Rate (mg/l)		
	Maximum	Average	Minimum
PAC	50.0	10.0	5.0
Lime	10.0	2.0	1.0
Chlorine			
Pre-chlorine	5.0	2.0	1.0
Post-chlorine	1.5	1.0	0.7

The design of unit process has been carried out in consideration of functionally appropriate layout, electricity saving and environmental aspects. Design criteria for unit process is determined with reference to the design standards of JWWA and/or AWWA as explained in Annex G of Volume V.

(3) Layout of major facilities

The treatment plant facilities are laid out within the proposed site of about 95 ha as shown in Figure 7.5. Sludge drying beds are planned so as to enable easy discharging of supernatant water to the nearby stream.

(4) Flow diagram of the system

The proposed water treatment system is planned for one unit water treatment plant with the design capacity of 910 MLD. Figure 7.6 gives the flow diagram required to compute and determine the capacity of each process unit in the system. Sludge in the sedimentation basin will be separated at the sludge thickeners and subsequent supernatant water is returned to the receiving well together with wash water generated in the filter.

(5) Major facilities

Receiving well

The structure is of a reinforced concrete and a stepped channel to secure rapid mixing energy using hydraulic jump. The structural dimensions are 6 m in width, 22 m in length and 6 m in depth. Four units of chamber are required for the 1st stage.

Flocculation basin

The flocculation basin consists of three reinforced concrete channels with baffle wall for hydraulic mixing to attain G-values of 60 sec^{-1} gradually down to 20 sec^{-1} for floc formation. Retention time is planned for 20 minutes. Width, length and depth of the flocculation basin are 1.8-3.2 m, 22 m and 3.5 m, respectively. Twelve units of the basin are required for the 1st stage.

Sedimentation basin

Due to the comparatively good conditions of raw water throughout the year with 10 NTU turbidity on average, horizontal flow sedimentation is selected. The structure of the basin is of a reinforced concrete type with dimensions of 22.0 m in width, 84.4 m in length and 4.0 m in depth. A flight chain type sludge collector will be equipped to remove sludge effectively and to save manpower. Twelve units of the basin are required for the 1st stage.

Rapid sand filter

The filter is of a constant rate and dual media type, having 44 filter units of 88 m^2 each. The filter basin is located immediately after the sedimentation basin connected by channels. The filter is planned to be operated at a filtration rate of 240 m/day. The filter media comprises anthracite (50 cm in thickness) and sand (25 cm in thickness). Backwashing and surface washing rates are set at 0.75 m/min and 0.15 m/min, respectively.

Clear water reservoir

Filtrated water is conveyed by two connection pipes of 2,800 mm diameter to the clear water basin located downstream of the filter basin. The structure is of flat slab type made of reinforced concrete. It has 2 compartments, each having the dimensions of 42.0 m in width, 84.0 m in length and 3.0 m in depth. The retention time is planned at 1.1 hour. Two units of the basin are required at the 1st stage.

Backwash wastes returning tank

The backwash wastes returning tank consists of 4 units of rectangular tank including 1 stand-by, each with dimension of 12.0 m in width, 36.0 m in length and 3.0 m in depth. The structure is of a reinforced concrete type equipped with the recycling pump system from the backwash wastes returning tank to the receiving well.

Sludge thickening tank

The sludge thickening tank consists of four units of 26.0 m x 3.5 m (D) circular tanks. The structure is of a reinforced concrete type provided with center driven type sludge collector. Retention time for thickening sludge is assumed to be 48 hours. The thickened sludge is pumped to the sludge drying bed. Likewise, supernatant water is transferred to the backwash wastes returning tank.

Sludge drying bed

The sludge drying beds are provided adjacent to small streams. On the basis of the computation of sludge volume, ten drying beds are provided in the 1st stage. The structure of drying beds is of a reinforced concrete type with dimensions of 25.0 m in width, 90.0 m in length and 1.0 m in depth.

The main equipment to be installed in the Morong WTP are listed in Table 7.2. Design criteria and dimensions of major facilities for the 1st stage (910 MLD) and 2nd stage (1,820 MLD in total) are summarized in Table 7.3. The preliminary design drawings of the major facilities are attached in Annex G of Volume V. However, further examination of each unit process including filter washing method as well as mechanical and electrical equipment needs to be made in the next detail design stage.

(6) Main equipment

The main equipment to be installed in the Morong WTP are as follows:

1) Chemicals feeding equipment
2) Backwashing pump
3) Surface washing pump
4) Sludge collector
5) Flow meter
6) Standby generator
7) SCADA system

The above equipment for the Morong WTP are broken down in detail in Table 7.2 together with their dimensions, capacities and quantities.

7.3.6 Pipeline No.1

The Pipeline No.1 is composed of 4.0 km long pipeline of 3.4 m diameter (Pipeline No.1-1), and 0.9 km long pipeline of 3.3 m diameter (Pipeline No.1-2). Plan and profile of the Pipeline No.1 are shown in Figure 7.7. Water is diverted from the Valve House No.2 to the Antipolo Service Reservoir through 4.2 km long branch pipeline of 1.6 m diameter. The Pipeline No.1 is of steel pipe laid out in an excavated trench by the cut-and-cover method and sheetpiling.

The required thickness of steel pipe is determined based on the internal and external pressures. The internal pressure consists of static pressure and water hammer pressure. The water hammer pressure is set at 5.5 kg/cm^2 for the pipeline design. The external pressure is calculated both for the service stage and construction stage, taking into account of earth pressure and wheel load for service stage and wheel load of bulldozers used temporarily in the construction stage. As a result, the required thickness of steel pipe is determined to be 28 mm for Pipeline No.1-1 and 26 mm for Pipeline No.1-2.

At some places, there is a possibility that the buoyancy will act on submerged pipeline under the high groundwater level condition. In such a case, the pipeline has to be installed at the position to have a sufficient depth of earth coverage below the ground surface so as to prevent it from being lifted up. The required minimum depth of the earth coverage is estimated at 2.5 m for Pipeline No.1-1 and No.1-2. Accordingly, the pipes will be laid in the underground, at least 2.5 m below the ground surface after backfilling as mentioned above. The pipes need to be covered with backfill materials which are to be fully compacted.

To avoid differential settlement of installed pipes, they will be placed on sand bed. The required thickness of the sand bed material is determined to be 0.70 m for Pipeline No.1-1 and 0.67 m for Pipeline No.1-2 applying the formula, which is expressed as “0.2*D”, where “D” is an inner diameter of the pipe”.

The Pipeline No.1 crosses with creek and river at four (4) locations on its entire route. Three river crossing structures and one bridge for the Pipeline No.1 will have to be constructed to cross the creek and river at these places.

The various types of valves are provided at adequate points of the Pipeline No.1, such as air valves at beginning and end point of river crossing structures, an isolating valve with manhole structure for maintenance at the location 2 km downstream from the Morong WTP. In addition to them, blow-off valve chamber will be installed in the Valve House No.2 aiming to drain accumulated sand in Pipeline No.1-1, 1-2, 2 and Tunnel No.2 for maintenance.

7.3.7 Valve House No.2

The Valve House No.2 is provided at junction point of the Pipeline No.1 and No.2 for diverging water to the Antipolo area. A total of four sets of motor butterfly valves of 3,300 and 2,400 mm diameter will be installed for flow control and/or isolation. Blow-off valves are also installed aiming to drain accumulated sediment in the Pipeline No.1-1, 1-2, 2 and Tunnel No.3 for maintenance. Taking into account the difficulty of the future expansion, the entire structures are planned to be constructed in the 1st stage to cope with the full development stage.

(1) Proposed Site

The Valve House No.2 is planned to be constructed in the low flat area in the municipality of Teresa, about 4.0 km downstream from the Morong WTP (See Figure G2.23 in Annex G of Volume V). The land is formed by alluvial deposits such as soft clay, silt or sand materials. The piling works are recommended to be provided to support the Valve House No.2.

(2) Structure and Main Equipment

The Valve House No.2 is of beam type made of reinforced concrete with dimensions of 32.0 m in width, 26.0 m in length and 9.2 m in depth to accommodate various valves (See Figure G2.24 in Annex G of Volume V). The main equipment to be installed in the Valve House No.2 is shown in Table 7.4.

7.3.8 Antipolo Pump Station

A part of water conveyed to the Valve House No.2 through the Kaliwa-Taytay Waterway is diverged to the Antipolo area. With regard to distribution method, pumping system is a requisite due to the high altitude of the Antipolo service area with ground elevation of more than EL. 200 m. In addition, it is projected that a large volume of water will need to be pumped up due to the higher population growth rate as well as the high service coverage to be achieved under the Concession Agreement.

(1) Proposed Site

The Antipolo Pump Station is planned to provided in the area with ground elevations of about El. 65m that is surrounded by limestone hill, paddy field and relocation land in Barangay Talbog of Antipolo, 2 km north of the proposed Valve House No.2 site. Figure 7.8 presents a general layout of the Antipolo Pump Station at the full development stage (Stage 2 Development).

(2) Design Capacity

The water demand projection made in this Study reveals that the water demand of the Antipolo area will increase rapidly between year 2020 and 2025 so that the projected water demand in 2025 becomes almost double of that in 2020. To avoid the excessive initial investment for the Antipolo Pump station, the structure including sump and pump house is planned to be constructed in 2 stages to meet the ultimate water supply volume to. Besides, the required number of pump units are planned to be installed in 3 stages in accordance with water demand increase (See Annex G of Volume V). The following table presents staged development plan of the facilities including service reservoir for water supply to the Antipolo area.

Staged Development of Water Supply for Antipolo Area

Year	2010	2015	2020	2025
- Required Water Supply	43 MLD	87 MLD	320 MLD	680 MLD
- Construction of Pump Station w/Sump	340MLD	-	-	340MLD
- Installation of Pump Equipment	88MLD	-	260MLD	340MLD
- Storage Volume of Antipolo Service Reservoir	30,000 m^3	-	30,000 m^3 x 2	30,000 m^3 x 3

Notwithstanding the above, the actual installation program may need to be modified based on the actual growth of water demand in the Antipolo area. The water demand projection of the Antipolo area for the low population growth scenario is presented in the foregoing Section 3.3 for reference.

(3) Structure and Main Equipment

The sump is of flat slab type made of reinforced concrete with 2 compartments, each with the dimensions of 18.6 m in width, 32.7 m in length, and 4.0 m in effective depth. HWL and LWL of the reservoir are set at EL. 64.5 m and El. 60.5 m, respectively. The Antipolo Pump Station is of reinforced concrete beam type with a floor space of 840m^2. The preliminary design drawing of the pumping facilities for water supply to the Antipolo area in the Stage 1 Development is presented in Annex G of Volume V.

The one unit of pump has a capacity of 0.99 m^3/min x 205 m x 2,500 kW (Motor power) and required number of pump unit is two in year 2015, five in year 2020 and ten in year 2025, including one stand-by unit, respectively. During the period of lower water demand, the on-off operation will be practiced in accordance with water level of the proposed Antipolo Service Reservoir. The main equipment installed in the Antipolo Pump Station is shown in Table 7.5.

7.3.9 Pipeline No.2

The 4.2 km long Pipeline No.2 of 1.6m diameter is also of steel pipe buried in an excavated trench that will be provided by the cut-and-cover construction method, as well as provision of sheet-piling where necessary. Plan and profile of the Pipeline No.2 are shown in Figure 7.9. The water diverged at the Valve House No.2 for water supply to the Antipolo area is planned to be lifted up to the Antipolo Service Reservoir (see Subsection 7.3.10) by pumps installed in the Antipolo Pumping Station that is located 1.1 km distant from the Valve House No.2.

In the Pipeline No.2 section, which connects the pump station and Antipolo Service Reservoir, water hammer is foreseen to take place due to shut-down of the pumps and undulation of pipeline route. There is a possibility that high negative pressure will act thereon at the time of occurrence of such a water hammer. To protect the Pipeline No.2 from the high negative pressure, installation of air vessels, one-way surge tank, open surge tank are conceivable as the water hammer protection measures. The comparison study reveals that the combination of air vessel and surge tank is the best measure to protect it from the high negative pressure. The required capacity of air vessel is 25 m^3 and that of the one-way surge tank and open surge tank is 50m^3. In consideration of construction cost as well as the operation and maintenance cost, the open surge tank is selected as the surge tank system for the Pipeline No.2. The air vessel and the surge tank are planed to be installed at the two locations, namely at the Antipolo Pump Station and some 800 m downstream point from the Antipolo Pump Station.

The pipeline No.2 is designed applying the same criteria and procedures as those on the Pipeline No.1 that are described in the foregoing Subsection 7.3.6. The main features of the pipeline No.2 are summarized below:

Main Features of Pipeline No.2

Item	Dimension and Quantity
i) Thickness of steel pipe	: 19 mm
ii) Minimum earth coverage on pipe below ground surface	: 1.2 m
iii) Thickness of sand bed materials	: 0.3 m
iv) Facilities to cross river/creek - River crossing structure with air valves - Pipe bridge	 : 1 place : 1 place

7.3.10 Antipolo Service Reservoir

(1) Proposed Site

The Antipolo Service Reservoir is planned to be constructed at relatively flat area of EL. 260 m in ground elevation in Barangay San Isidro in the Antipolo plateau. Figure 7.10 shows a general layout plan of the Antipolo Service Reservoir at the full development stage.

(2) Storage Capacity

In this Study, the required storage capacity of service reservoir is determined to be a water volume equivalent to 6 hours' supply of maximum daily discharge as explained in the succeeding Subsection 7.3.12. Hence, the required storage capacity per one unit for the Antipolo Service Reservoir is calculated at 30,000 m^3 that can suffice the water demand of the service area until year 2015. The additional two units (30,000 m^3 x 2) and other three units (30,000 m^3 x 3) are planned to be installed in year 2020 and 2025, respectively, in order to meet the rapidly increasing water demand therein.

(3) Structure and Main Equipment

The Antipolo Service Reservoir is of flat slab type made of reinforced concrete with 2 compartments, each having the dimensions of 37.6 m in width, 65.3 m in length and 6.0 m in effective depth. Its high water level (HWL) and low water level (LWL) are set at EL. 259.75 m and 253.75 m, respectively. The structural design drawings of the Antipolo Service Reservoir are attached in Annex G of Volume V. The main equipment installed in the Antipolo Service Reservoir is shown in Table 7.6.

7.3.11 Tunnel No.2

The 5.3 km long Tunnel No.2 of 3.3 m internal diameter is aligned to connect the Pipeline No.1-2 and Taytay Service Reservoir. The plan and profile of the Tunnel No.2 are shown in Figure 7.11. It partly passes through the Antipolo plateau where high groundwater level may exist. Hence, the inside surface of the tunnel is designed to be steel-lined in order to avoid intrusion of groundwater into the tunnel.

A thickness of the steel pipe is determined based on the external pressure acting on the pipe, since it is estimated to be much larger than the internal pressure due to the high groundwater level assessed based on the geological conditions. The portion between the steel liner and excavated surface of the tunnel is designed to be backfilled with concrete after installation of the steel pipe.

7.3.12 Taytay Service Reservoir

The majority of treated water conveyed from the Morong WTP is conveyed to the Taytay Service Reservoir which is a base facility to distribute water to the main service areas of Metro Manila such as the southwestern part (Cavite area), southern part (Muntinlupa area) and southeastern part (Rizal area). Accordingly, this Study defines that the Taytay Service Reservoir is an off-take point for delivering water to the two Concessionaires.

(1) Proposed Site

Considering that the altitudes of the site selected for the Taytay Service Reservoir range generally between EL.5 and 50 m, HWL and LWL of the service reservoir are set at EL. 72 m and 66 m, respectively. In addition, a large area of about 20 ha is required to construct the Taytay Service Reservoir to store and regulate the water conveyed from the Morong WTP through the Pipelines No.1-1 and No.1-2. Taking a full account of such conditions, the location of the Taytay Service Reservoir is selected at the hilly area in Taytay, about 2 km northeast of the town proper. Figure 7.12 shows a general layout of the Taytay Service Reservoir at the full stage development. With regard to water level, however, it is noted that the elevation of benchmark used by the MWSS is 10 m higher than that of the NAMRIA which is utilized in this Study. This means that the HWL and LWL mentioned above correspond to EL.82 m and 76 m, respectively, in the MWSS datum.

(2) Storage Capacity

In determining the storage capacity of the service reservoir, the following were taken into consideration:

(i) Total storage capacity of the existing service reservoirs in Metro Manila is 740,000 m^3, which is roughly estimated to be equivalent to 4.4-hour supply volume of the current water demand of 4,000 MLD in Metro Manila

(ii) The “MWSS design standards for Water Supply” specifies the reservoir capacity to be preferably a half-day supply volume, and

(iii) a simulation analysis conducted in this Study revealed that the storage capacity equivalent to 6-hour supply volume would suffice the daily fluctuation of water supply.

Considering the above comprehensively, the effective storage volume equivalent to 6-hour supply volume, i.e. 720,000 m^3 at the ultimate stage, is adopted as the required storage capacity of the Taytay Service Reservoir. The Taytay Service Reservoir will be developed in four stages with 180,000 m^3 each in accordance with the expansion of the Morong WTP. The above examination results are described in detail in Annex G of Volume V.

(3) Structure and Main Equipment

The Taytay Service Reservoir is of flat slab type made of reinforced concrete with 2 compartments, each with the dimensions of 75.0 m in width, 210.0 m in length and 6.0 m in effective depth. The plan and section of the Taytay Service Reservoir are presented in Annex G of Volume V. The main equipment installed in the Taytay Service Reservoir is shown in Table 7.7.

7.4 Access Road and Adit

The Project Area is located east of Metro Manila, and the Kaliwa-Taytay Waterway from Kaliwa Low Dam to the service reservoirs at Antipolo and Taytay is about 40 km long in total.

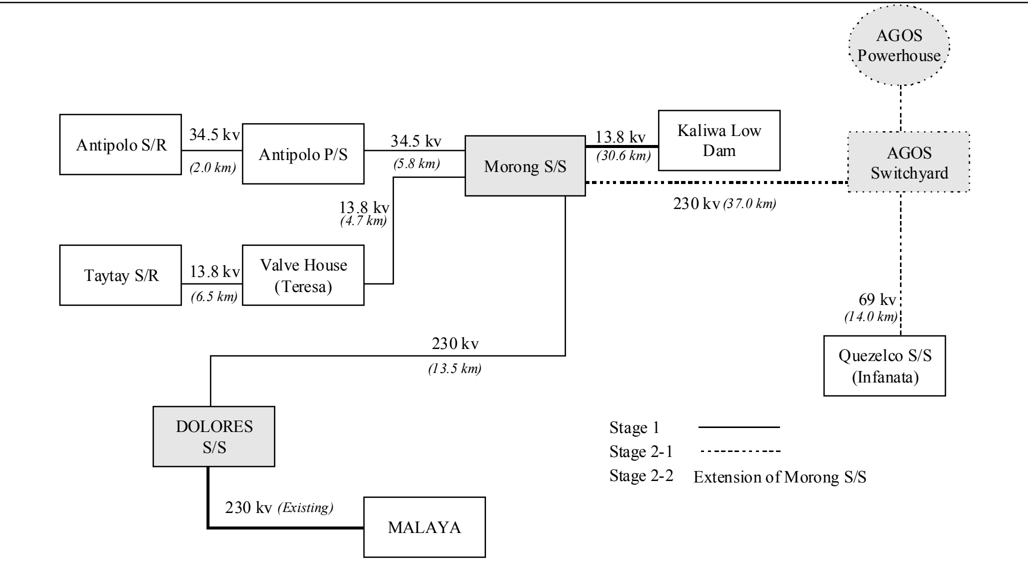
Since it is not accessible from the existing major and city roads to the respective site and tunnel adits at present, new access roads construction and existing road improvement are needed in the construction stage. It is estimated that construction of some12 km long new access roads and improvement of some 17 km long existing road in total need to be done.

Imported goods including construction machinery, TBM machines, generating equipment and steel materials for metal works will be landed at the port of Manila and transported to the respective sites overland without any difficulties upon the completion of new access roads and existing road improvement. The road distance from the port of Manila to the Kaliwa Low Dam is approximately 50 km.

7.5 Power Supply to Waterway Facilities

7.5.1 General

Waterway facilities require the power for operation of various plant and equipment installed at each facility. The transmission lines and power supply system to the respective facilities in the entire development stages of the Project, namely the Stage 1, Stage 2-1 and Stage 2-2, are summarized in the following schematic diagram:



Schematic Diagram for the Proposed Overall Transmission Line for the Project

The basic concept of the proposed power supply program in the Stage 1 is that power is supplied from the existing Dolores Substation (S/S) to the Morong Substation to be newly built under the Project when the Kaliwa Tayatay 1st Waterway system is built. Distribution lines therefrom to each waterway facility is built at this stage.

7.5.2 Power Supply System at Stage 1

The above schematic diagram shows the proposed system for power transmission from the Agos power plant and also power supply lines to the waterway facilities by stage. The power supply facilities built at the Stage 1 are as follows:

(a) Construction of a new 230 kV substation at the Morong water treatment plant (Morong S/S)

(b) Extension of the existing Dolores S/S for additional 230 kV bays to introduce a 230 kV double-circuit transmission line to the new Morong S/S

(c) Construction of a 230 kV double-circuit transmission line of 15.6 km long between the existing Dolores S/S and Morong S/S

(d) Construction of a 34.5 kV distribution line to the Antipolo Pump Station and further to the Antipolo Service Reservoir

(e) Construction of 13.8 kV distribution lines to the Kaliwa Low Dam and Taytay Service Reservoir via the Valve House No.2at Teresa

Main features of the power supply lines to each waterway facility are as follows:

Section	kV	Circuits	Length
Morong S/S-Kaliwa Low Dam	13.8	Double*	30.6
Morong S/S -Teresa Valve House	13.8	Double*	4.7
Valve House No.2 -Taytay S/R	13.8	Double*	6.5
Morong S/S -Antipolo Pump/S	34.5	Double*	5.8
Antipolo Pump/S- Antipolo S/R	34.5	Double*	2.0

Note: * Single circuit at the Stage 1 and double circuit at the Stage 2-2

Table 7.1 Main Equipment for Valve House No.1

Main Equipment	Dimensions and Quantity
1. Valve	・Motor corn-sleeve valve, 1,500mm diameter x 1.5kW x 4 sets (for main valve, waterway) ・Motor butterfly valve, 1,500mm diameter x 3.7kW x 4 sets (for sub valve, waterway) ・Motor corn-sleeve valve, 1,500mm diameter x 1.5kW x 1 (for main valve, by-pass way) ・Motor butterfly valve, 2,500mm diameter x 5.5kW x 2 sets (for sub valve, by-pass way)
2. Others	・Ventilation

Table 7.2 Main Equipment for Morong WTP

Main Equipment	Dimensions, Capacity and Quantity
1.Chemicals feeding equipment	
i) PAC feeding equipment	・ PAC receiving tank: 6.0m (W) x 10.0m (L)x 3.0m(H) x 2 sets ・ PAC dosing pump: 28 l/min x 0.5 MPa x 2.2 kW x 6 sets
ii) Lime feeding equipment	・Lime receiving tank: Cylindrical, 3.5 m diameter x 12.6 m ・Lime transfer pump: Progressive Cavity Pump, 796 kg/hr x 0.2MPa x 2.2 kW x 3 sets ・Lime dilution tank: Rectangular, Mild steel, 6.0 m x 6.0 m x 6.9 m (H) x 4 sets ・Lime dosing pump: 1.1 m^3/min x 0.3 Mpa x 11 kW x 5 units (incl. 1 stand-by)
iii) Chlorine feeding equipment	・Chlorinator: Vacuum Solution Type with vaporizer, 900mm (W) x 700 mm (D) x H 2,000mm, Pre-chlorine (200 kh/hour) x 4 sets, Post-chlorine (100 kg/hr) x 4 sets ・Water supply booster pump: Centrifugal type (Pre-chlorine) 60 m3/hr x 0.3 Mpa x 7.5kW x 2 units (Post-chlorine) 30 m3/hr x 0.3 Mpa x 15kW x 2 units ・Chlorine neutralization tower: FRP, Circulated pump (Magnet type, 500 l/min x 10 m x 3.7 kW), 1 set
2.Backwashing pump	・ Type: Double suction volute pump ・ Capacity: 66 m^3/min x 10 m x 175 kW x 4 units (including 2 stand by)
3. Surface washing pump	・ Type: Double suction volute pump ・ Capacity: 13.2 m^3/min x 10 m x 37kW x 4 units (including 2 stand by)
4. Sludge collector	
i) Flight chain type sludge collector	・ Dimension: 22.0 m (W) x 80.0 m (L) x 3.8 m (water depth) x 12 sets ・ Scraping speed: 0.6 m/min, Motor output: 0.75 kW
ii) Center drive type sludge collector	・ Dimension: 26.0m diameter x water depth of 3.5m x 4 sets ・ Scraping speed: 2-3 m/min, Motor output: 0.75 kW
5. Flow meter	・ Type: Ultrasonic flow meter, applicable diameter of 50-3,000 mm x 3 sets
6. Standby generator	・ Capacity: 1,250 kVA, 415V Diesel engine radiator cooling, 1 set
7. SCADA system	・ Personal computer 4 sets, Data server work station 2 sets, UPS 10 kVA, etc.

Table 7.3 (1/2) Design Criteria and Dimension of Water Treatment Plant 1,820 MLD and 910 MLD

Item	Second Stage (1,820 MLD)	First Stage (920 MLD)
Planned Flow	Q = 1,820,000 cu.m/day	Q = 910,000 cu.m/day
	Treatment / Nominal Capacity	Treatment / Nominal Capacity
Plant Capacity	Q = 1,820,000 cu.m/day / 1,820,000 cu.m/day	Q = 910,000 cu.m/day / 910,000 cu.m/day
(Daily Max)	= 75,833 cu.m/hour / 75,833 cu.m/hour	= 37,917 cu.m/hour / 37,917 cu.m/hour
	= 1,263.9 cu.m/min / 1,263.9 cu.m/min	= 631.9 cu.m/min / 631.9 cu.m/min
	= 21.06 cu.m/sec / 21.06 cu.m/sec	= 10.53 cu.m/sec / 10.53 cu.m/sec
(1) Receiving Well		
Criteria	Retention Time T = 1.5 min	Retention Time T = 1.5 min
Dimension	Rectangular 2 units	Rectangular 1 unit
	W m x L m x D m x compartment	W m x L m x D m x compartment
	6.0 6.0 6.0 8	6.0 6.0 6.0 4
(3) Mixing Chamber		
Criteria	Retention Time T= 1 - 5 min	Retention Time T= 1 - 5 min
Dimension	Rectangular 2 units	Rectangular 1 unit
	W m x L m x D m x units	W m x L m x D m x compartment
	6.0 10.0 6.0 8	6.0 10.0 6.0 4
Unit Volume	UV = 360 cu.m/unit	UV = 360 cu.m/unit
Total Volume	V = 2,880 cu.m	V = 1,440 cu.m
Retention Time	t = 2.3 min	t = 2.3 min
Mixing	Hydraulic Mixing	Hydraulic Mixing
(4) Flocculation Basin		Baffled channel
Criteria	Retention Time T = 20 - 40 min	Retention Time T = 20 - 40 min
	Required Volume V = 25,278 cu.m to 50,556 cu.m	Required Volume V = 12,639 cu.m to 25,278 cu.m
Dimension	24 units	12 units
Step 1	W m x L m x D m x No. of Channel	W m x L m x D m x No. of Channel
	1.8 22.0 3.5 2	1.8 22.0 3.5 2
Step 2	W m x L m x D m x No. of Channel	W m x L m x D m x No. of Channel
	2.4 22.0 3.5 2	2.4 22.0 3.5 2
Step 3	W m x L m x D m x No. of Channel	W m x L m x D m x No. of Channel
	3.2 22.0 3.5 2	3.2 22.0 3.5 2
Volume	Step 1 277 cu.m/unit	Step 1 277 cu.m/unit
	Step 2 370 cu.m/unit	Step 2 370 cu.m/unit
	Step 3 493 cu.m/unit	Step 3 493 cu.m/unit
	Volume / Unit 1,140 cu.m/unit	Volume / Unit 1,140 cu.m/unit
Total Volume	V = 27,350 cu.m	V = 13,675 cu.m
Retention Time	22 minutes	22 minutes
Mixing	Hydraulic Mixing	Hydraulic Mixing
(5) Sedimentation Basin		
Type	Rectangular, Horizontal Flow	Rectangular, Horizontal Flow
Unit Flow	q = 3,160 cu.m/hr/basin	q = 3,160 cu.m/hr/basin
Criteria	Retention Time T1 > 1.0 hours	Retention Time T1 > 1.0 hours
	Surface Load a = 4 - 9 mm/min	Surface Load a = 4 - 9 mm/min
	Hori. Flow Velocity v < 0.6 m/min	Hori.. Flow Velocity v < 0.6 m/min
	L/W Ratio L/W = 3 - 8 times	L/W Ratio L/W = 3 - 8 times
	Effective Depth D = 3 - 4 m	Effective Depth D = 3 - 4 m
	Depth of 30 cm or more is provided for sludge settlement.	Depth of 30 cm or more is provided for sludge settlement.
	Retention Time in Plate Settler T 20～40 min	Retention Time in Plate Settler T 20～40 min
Dimension	No. 24 basins	No. 12 basins
	W m x L m x D m x channels x basins	W m x L m x D m x channels x basins
	22 84.4 4.0 1 24	22 84.4 4.0 1 12
Volume	V = 7,427 cu.m/basin	V = 7,427 cu.m/basin
Retention Time	T1 = 2.4 hours	T1 = 2.4 hours
Hori. Flow Velocity	v = 0.60 m/min	v = 0.60 m/min
Overflow Weir	Load = 350 m3/m/day	Load = 350 m3/m/day
Sludge Removal	Flight chain type sludge collector	Flight chain type sludge collector
	Water Contents of Drained Sludge	Water Contents of Drained Sludge
	(with wash-out water)	(with wash-out water)

Table 7.3 (2/2) Design Criteria and Dimension of Water Treatment Plant 1,820 MLD and 910 MLD

Item	Second Stage (1,820 MLD)	First Stage (920 MLD)
Water contents	w = 99.8 %	w = 99.8 %
	Frequency of Cleaning Continuous	Frequency of Cleaning Continuous
(6) Rapid Sand Filter		
Type	Down Flow, Single Media	Down Flow, Dual Media (Anthracite 50cm, sand 25cm
No.	88 units (wash 8 units)	44 units (wash 4 unit)
Unit Flow	q = 20,682 cu.m/day/unit	q = 20,682 cu.m/day/unit
Criteria	Filtration Rate Fr = 200 - 240 m/day	Filtration Rate Fr = 200 - 240 m/day
	= 8.3 - 10.0 m/hour	= 8.3 - 10.0 m/hour
	Filter Area per Unit A ≦ 150 sq m	Filter Area per Unit A ≦ 150 sq m
Dimension	W m x L m x units	W m x L m x units
	6.0 14.6 88	6.0 14.6 44
	A = 88 sq m/unit	A = 88 sq m/unit
Filtration Rate	Fr = 236 m/day	Fr = 236 m/day
Filtration Rate	Fr'= 260 m/day	Fr'= 260 m/day
during washing	8 units out of 88 are washing	4 unit out of 44 is washing
Filters for Backwashing	1 filters/group	1 filters/group
Frequency	Once a day for each filter	Once a day for each filter
Rate	Surface Washing rate = 0.15 m3/m2/min	Surface Washing rate = 0.15 m3/m2/min
	duration = 6.0 min	duration = 6.0 min
	Backwashing rate = 0.75 m3/m2/min	Backwashing rate = 0.75 m3/m2/min
	duration = 8.0 min	duration = 8.0 min
(7) Chlorination Channel		
Location	at the Inlet of the Clear Water Reservoir	at the Inlet of the Clear Water Reservoir
Criteria	Contact Time T > 5 minutes	Contact Time T > 2 minutes
Required Volume	V = 6,319 cu.m	V = 1,264 cu.m
Dimension	No. 4 units	No. 2 units
	W m x L m x D m x units	W m x L m x D m x compartment
	6.0 36.0 3.0 2	6.0 36.0 3.0 2
Total Volume	v = 5,184 cu.m	v = 2,592 cu.m
(8) Clear Water Reservoir		
Criteria	Retention Time T > 1 hours	Retention Time T > 1 hours
Dimension	No. 4 units	No. 2 units
	W m x L m x D m x conpart. x units	W m x L m x D m x compart. x units
	42.0 84.0 3.0 2 4	42.0 84.0 3.0 2 2
Total Volume	V = 84,672 cu.m	V = 42,336 cu.m
Retention Time	T = 1.1 hours	T = 1.1 hours
(9) Backwash Wastewater Storage Tank		
Retention Time	2 hours	2 hours
Backwash Water	Vs + Vb = 604 cu.m/filter unit	Vs + Vb = 604 cu.m/filter unit
Frequency of Wash	Once a day 88 filters/day	One a day 44 filters/day
Required Volume	V = 4,433 cu.m	V = 2,216 cu.m
No.	N = 5 units +1 stanby	N = 3 units +1 stanby
Dimension	Dia. m x D m x units	D m x L m x D m
	36.0 12.0 5	36.0 12.0 3
Total Volume	v = 61,073 cu.m	v = 3,888 cu.m
(10) Sludge Thickening Tank		
Req'd Retention Time	Tr = 48 hours (24-48)	Tr = 48 hours (24-48)
No.	Cercular N = 8 units	Circular N = 4 units
Dimension	Dia. m x D m x units	Dia. m x D m x units
	26.0 3.5 8	26.0 3.5 4
Total W. Surface A.	A = 4,247 sq.m	A = 2,124 sq.m
Total Volume	v = 14,866 cu.m	v = 7,433 cu.m
(11) Sludge Drying Bed		
Water Contents of Thickened Sludge	w = 96.0 %	w = 96.0 %
Dimension	Rectangular 18 units + 2 unit	Rectangular 9 units + 1 unit
	W m x L m x D m x units	W m x L m x D m x units
	25 90 1.0 20	25 90 1.0 10
Area on duty	v = 40,500 m2	A = 20,250 m2

Table 7.4 Main Equipment for Valve House No.2

Main Equipment	Dimensions, Capacity and Quantity
1. Valve	・Motor butterfly valve, 3,300mm diameter x 7.5 kW x 2 sets (for flow control/isolating) ・Motor butterfly valve, 2,400mm diameter x 5.5 kW x 2 sets (flow control/isolating) ・Motor butterfly valve, 600mm diameter x 0.35 kW x 6 sets (for bypass valve) ・Motor butterfly valve, 600mm diameter x 0.35 kW x 2 sets (for blow-off valve)
2. Drain Pump	・ Type: Submersible pump, 0.5m^3/minute x 20m x 2.7kW x 2 sets
3. Others	・ Lighting: 2.0 kW ・ Ventilation

Table 7.5 Main Equipment for Antipolo Pump Station

Main Equipment	Dimensions, Capacity and Quantity
1. Booster pump	・ Type: Double suction volute pump ・ Capacity: 0.99 m^3/sec x 205 m x 2,500 kW x 2 sets (1 standby) ・ Motor: 2,500 kW x 4P, 60 Hz, 6,000 kVA
2. Power receiving and step down system	・ 33 kV incoming panel, 36 kV VCB ・ Transformer: 33 kV/ 6.6 kV 3,000 kVA ・ 6.6 kV VCB panel ・ Transformer panel: 6.6 kV/ 415-240 V, 100 kVA
3. Starter panel, control center and local control panel	・ Programmable logic controller ・ Instrumentation panel ・ Power control panel
4. Valves	・Motor butterfly valve, 1,600 mm diameter x 15 kW x 2 sets (for inlet/outlet)
5. Flow meter	・Type: Ultrasonic flow meter, 50-3,000 mm (applicable diameter) x 2 sets

Table 7.6 Main Equipment for Antipolo Service Reservoir

Main Equipment	Dimensions, Capacity and Quantity
1. Valves	・Motor butterfly valve, 1,800/ 1,400 mm diameter x 1.5 kW x 1 set each (for expansion of service reservoir) ・Motor butterfly valve, 1,100/ 1,200mm diameter x 0.75 kW x 2 sets each (inlet/outlet flow)
2. Flow meter	・Type: Ultrasonic flow meter, applicable diameter of 50-3,000 mm x 2 sets
3. Others	・ Water level indicator: 2 sets ・ Remote monitoring system

Table 7.7 Main Equipment for Taytay Service Reservoir

Main Equipment	Dimensions, Capacity and Quantity
1. Valves	・Flow control valve: Motor butterfly type, 3,300 mm diameter x 5.5 kW (for inlet flow from WTP) x 1 set ・Flow control valve: Motor butterfly type, 4,000 mm diameter x 7.5 kW (for off-take) x 1 set ・Inlet/Outlet valve: Motor butterfly type, 2,600/2,800 mm diameter x 3.7 kW x 2 sets each
2. Flow meter	・Type: Ultrasonic flow meter, applicable diameter of 50-3,000 mm x 2 sets
3. Others	・Water level indicator: 2 sets ・Remote monitoring system