5.3 The Priority Project and Its Feasibility Study

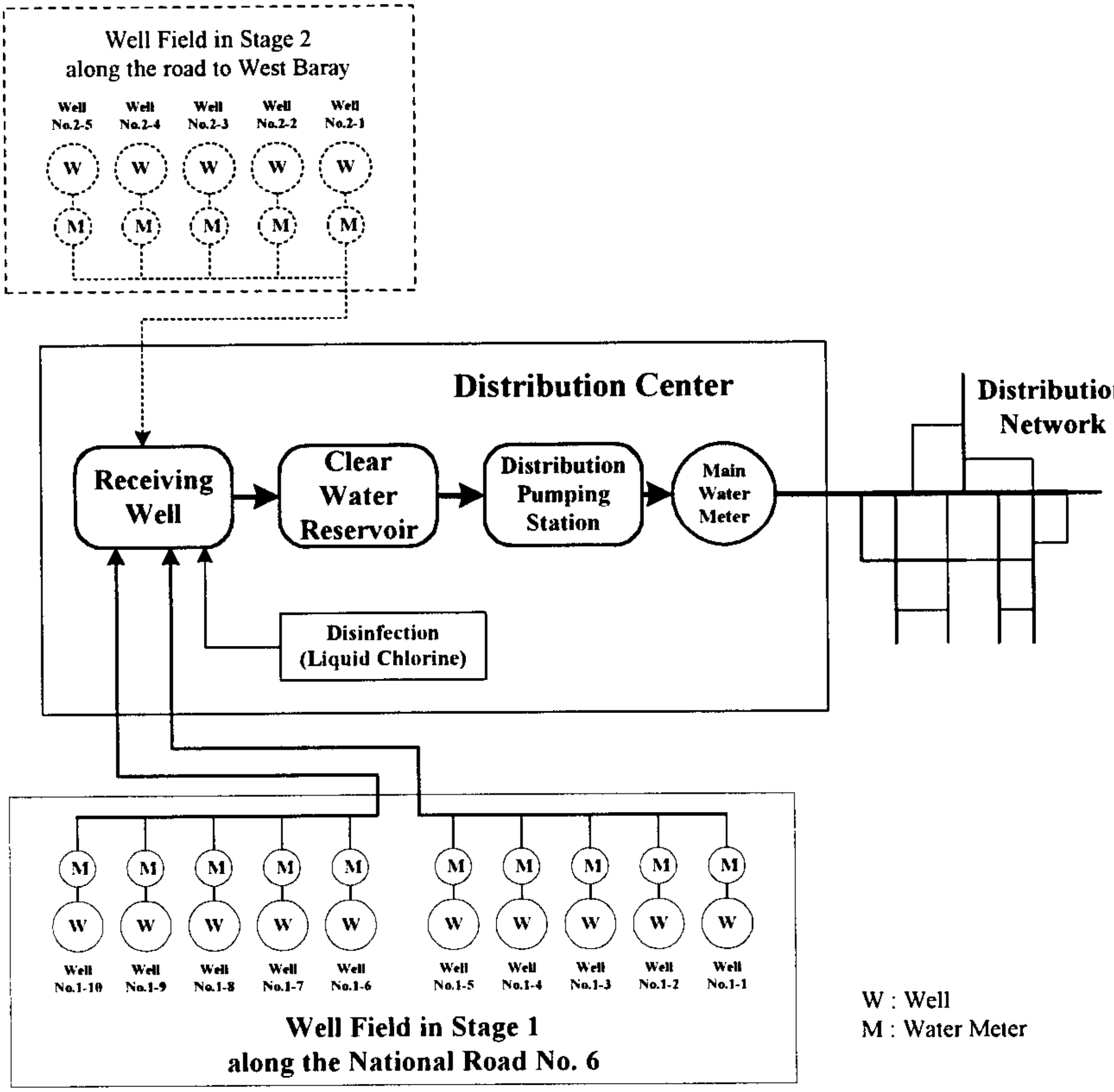
Water supply facilities and its operation and maintenance are discussed in this section. More detail information is available in Annex 5.3.1.

5.3.1 Future Water Supply Facilities

(1) System Flow

Future water supply system flow which will use groundwater is as shown in Figure 5.3.1. Groundwater abstracted from each well will be sent to receiving well through connecting pipeline. Each 5 wells connected by one connecting pipeline and these 5 wells will form one unit. The water meter equipped on each well will measure quantity of groundwater abstraction. Liquid chlorine will be dosed for disinfection in the receiving well. Disinfected groundwater will be stored in the clear water reservoir to buffer hourly peak water demand. Water will be pumped to distribution network, after measurement by the main water meter. Method of water distribution is direct pumping and new/additional elevated tank will not be constructed.

Water production facilities such as wells, receiving well, clear water reservoir, and disinfection facilities were planned based on the Daily Maximum Water Demand. Distribution system such as distribution pumping station and distribution network was planned based on the Hourly Maximum Water Demand.



The Study on Water Supply System for Siem Reap Region in Cambodia	Figure 5.3.1 Water Supply System Flow
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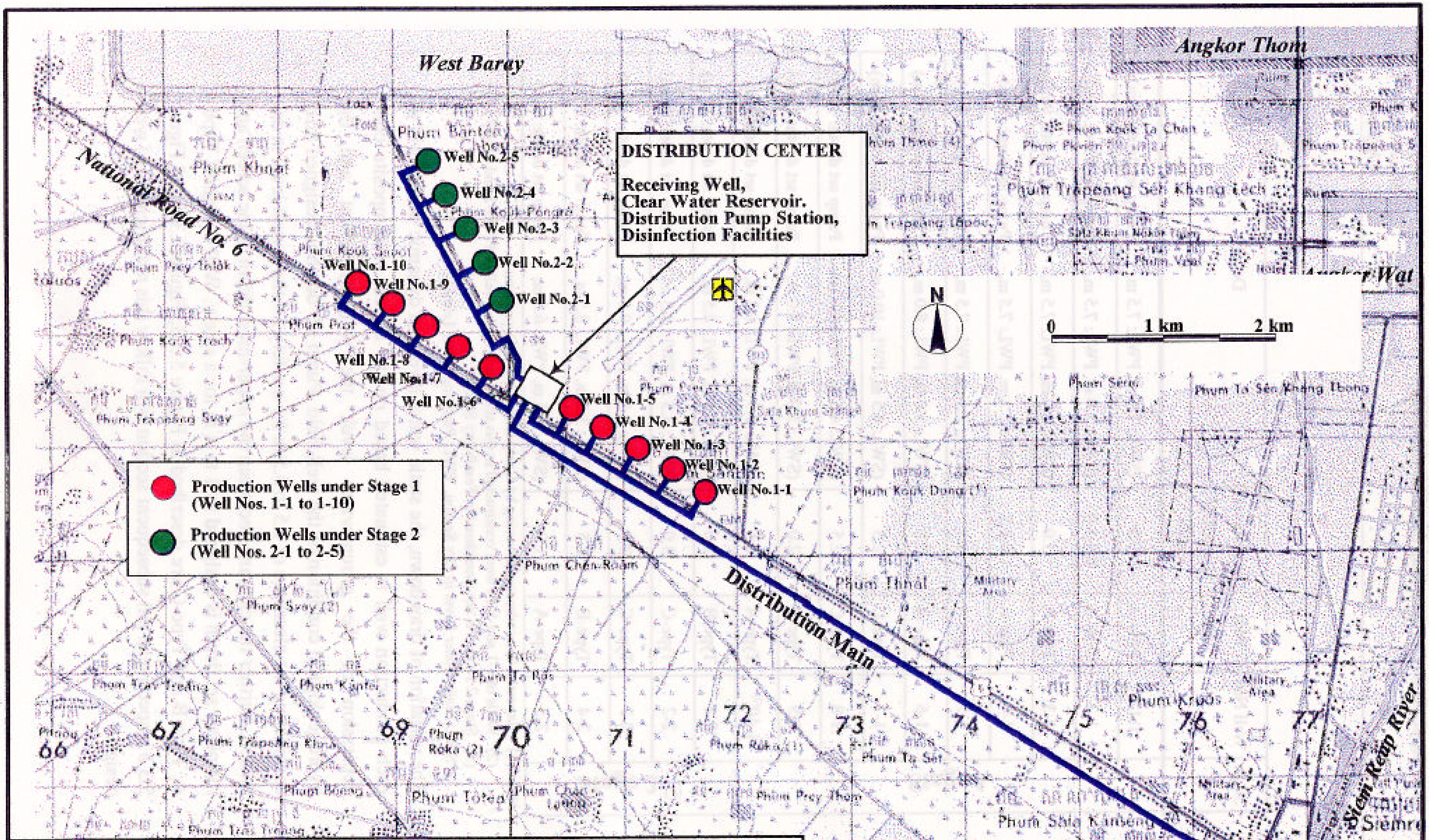
(2) Production Facilities

1) Well Field

10 wells to be constructed under Stage 1 will be located along the National Road No. 6 with 400 m intervals. Among 10 wells, the 2 pilot wells are constructed in this study and usable as production wells. Additional 5 wells to be constructed under Stage 2 will be located along the branch road from the National Road No. 6 to the West Baray with the same well interval of 400 m. Plan of the well field is shown on Figure 5.3.2.

The specification of the wells is based on the results of groundwater simulation analysis and pumping test. The well is designed to meet the drawdown depth requirement with safety clearance, well interference, and diameter of the submersible pump to be installed. The material for the casing and screen pipes is PVC, which is durable against corrosion by low pH groundwater. Because of the different drawdown in different wells, some modification is done in the well design. The detail of the well design is summarized in the following table based on the simulation result of 800 m^3/day/well in Chapter 4.



The Study on Water Supply System for Siem Reap Region in Cambodia

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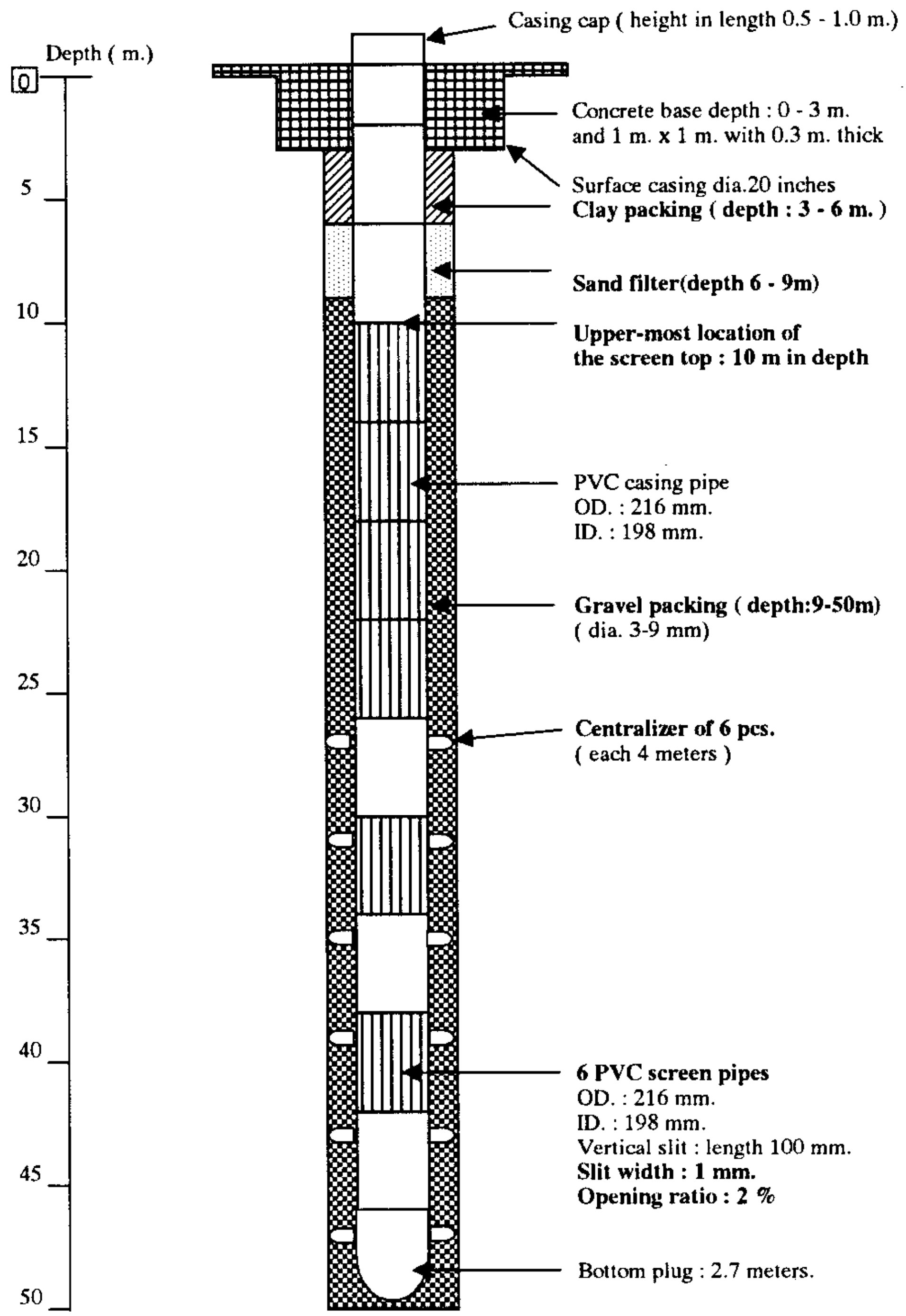
Figure 5.3.2

Plan of Well Field

Stage	Well Nos	Well Type	Groundwater Lowering (m)(1)	Detail
Stage 1	1-1(2)	Type-A	0.5	(SWL: 1.5 m, PWL: 7.5 m, Pump set depth: 9 m)
	1-2	Type-A	0.5-1.0	(SWL: 2.0 m, PWL: 7.5 m, Pump set depth: 9 m)
	1-3	Type-A	1.0	(SWL: 2.0 m, PWL: 7.5 m, Pump set depth: 9 m)
	1-4	Type-A	1.0-1.5	(SWL: 2.5 m, PWL: 7.5 m, Pump set depth: 9 m)
	1-5	Type-A	1.5	(SWL: 2.5 m, PWL: 7.5 m, Pump set depth: 9 m)
	1-6	Type-B	2.0	(SWL: 3.0 m, PWL: 8.0 m, Pump set depth: 10 m)
	1-7	Type-C	2.5	(SWL: 4.5 m, PWL: 10.0 m, Pump set depth: 12 m)
	1-8	Type-C	2.5	(SWL: 4.5 m, PWL: 10.0 m, Pump set depth: 12 m)
	1-9	Type-B	2.0	(SWL: 3.0 m, PWL: 8.0 m, Pump set depth: 10 m)
	1-10(2)	Type-A	0.5	(SWL: 1.5 m, PWL: 6.5 m, Pump set depth: 9 m)
Stage 2 (3)	2-1	Type-B	2.0	(SWL: 3.5 m, PWL: 8.5 m, Pump set depth: 11 m)
	2-2	Type-C	3.0	(SWL: 4.5 m, PWL: 9.5 m, Pump set depth: 13 m)
	2-3	Type-C	3.0	(SWL: 4.5 m, PWL: 9.5 m, Pump set depth: 13 m)
	2-4	Type-B	2.5	(SWL: 3.5 m, PWL: 8.5 m, Pump set depth: 10 m)
	2-5	Type-A	1.0	(SWL: 1.5 m, PWL: 6.5 m, Pump set depth: 9 m)

Note: (1) Expected Groundwater Lowering by Composite Cone of Depression
(2) Wells of 1-1 and 1-10 were constructed in this study as the pilot well of PP-99-2 and PP-99-1.
(3) Stage 2 Project is not considered in Feasibility Study.
SWL: Static Water Level in Dry Season, PWL: Pumping Water Level

The variation of drawdown, the static water level and dynamic water level of each production well is estimated based on the effects of composite cone depression of the groundwater level, the well alignment and the hydrogeological condition of the well field. Pump set depth is designed after considering the clearance of 1.5 to 3.5 m for a safety for the lowest level in dry season. Further the clearance between the upper-most depth of the screen and the pump set depth is designed as 1 to 4 m for a safety. Well design of Type-A, Type-B and Type-C are described in Figure 5.3.3, Figure 5.3.4 and Figure 5.3.5 respectively. All subsequent section will follow this modification of well design.



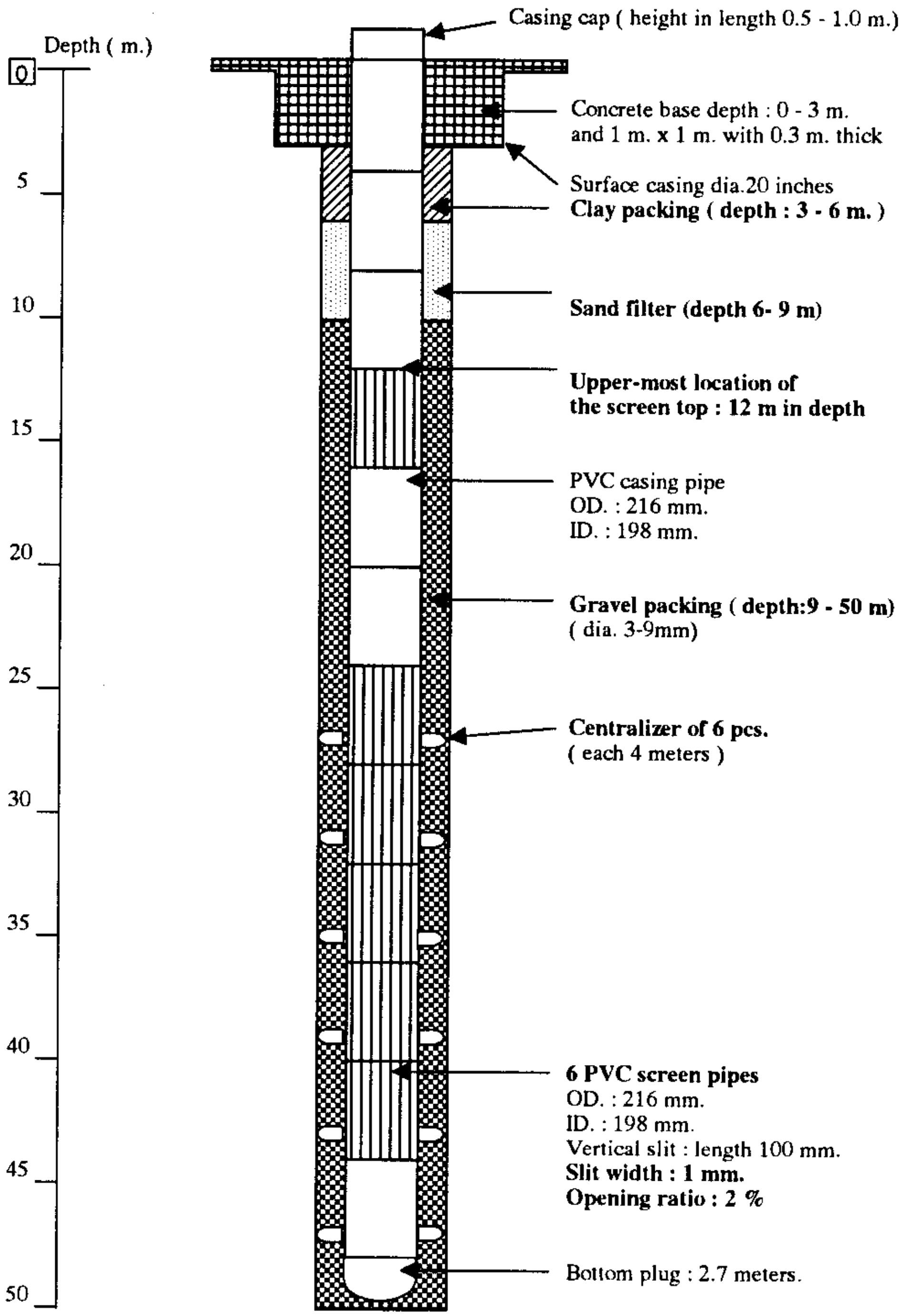
Note 1: **Opening ratio of the Screen shall be approximately 2 %.**
The size of slit in screen is 1.0 mm wide and 100 mm in length.

2: **Gravel packing quantity is around 5.3 m^3 (200 bags).**

3: **Sand filter by using medium river sand for 7-9 m shall be put to purify shallow groundwater**

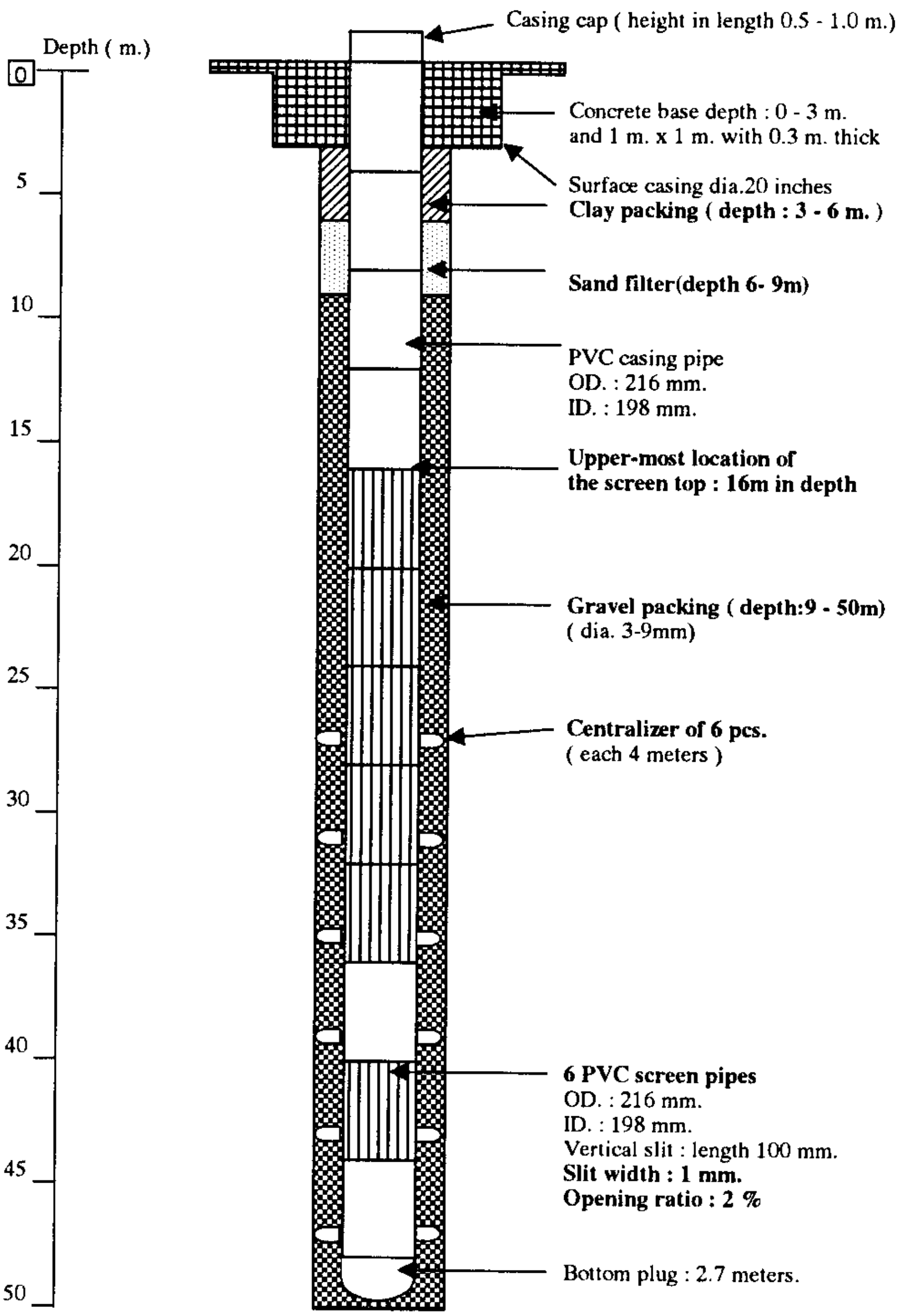
4: **This design shall be applied for the 6 wells in the stage-1(No.1-1, N0.1-2, N0.1-3 N0.1-4, N0.1-5 and N0.1-10), and the 1 well in the stage-2(N0.2-5)**

The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 5.3.3 Well Design Type-A**
Japan International Cooperation Agency	



Note 1: Opening ratio of the Screen shall be approximately 2 %.
The size of slit in screen is 1.0mm wide and 100mm in length.
2: Gravel packing quantity is around 5.3 m^3 (200 bags).
3: Sand filter by using medium river sand for 7 - 9m shall be put to purify shallow groundwater
4: This design shall be applied for the 2 wells in the stage-1(No.1-6 and No.1-9), and the 2 wells in the stage-2(No.2-1 and No.2-4)

The Study on Water Supply System for Siem Reap Region in Cambodia	Figure 5.3.4 Well Design Type-B
Japan International Cooperation Agency	



Note 1: Opening ratio of the Screen shall be approximately 2 %.
The size of slit in screen is 1.0mm wide and 100 mm in length.
2: Gravel packing quantity is around 5.3 m^3 (200 bags).
3: Sand filter by using medium river sand for 7 - 9m shall be put to purify shallow groundwater
4: This design shall be applied for the 2 wells in the stage-1(No.1-7 and No.1-8),
and the 2 wells in the stage-2(No.2-2 and No.2-3)

The Study on Water Supply System for Siem Reap Region in Cambodia	Figure 5.3.5 Well Design Type-C
Japan International Cooperation Agency	

2) Well Connecting Pipe

Every five wells are connected by one connecting pipe of which diameter is 150 mm to 250 mm. Ductile Cast Iron Pipe (DIP) will be recommended for the material of the connecting pipe because of its reliability and easy installation work, especially in rainy season.

3) Well Submergible Pump

Specifications of well submergible pumps are designed from the head loss in the well connecting pipes and level of groundwater. From the calculated total head required, submergible pumps required is summarized in Table 5.3.1.

Table 5.3.1 Summary of Submergible Pumps Required under Stage 1

Submergible Pumps	Number of Pumps Required
Q 0.56 m^3/min x H11.2-12.2 x 2.2kW	3 units
Q 0.56 m^3/min x H14.7-17.8 x 3.7kW	7 units

(3) Distribution Center

1) Location and Plan of Distribution Center

Distribution Center will consist of receiving well, clear water reservoir, disinfection facilities, distribution pumping station and generators. The center will require about 1 ha land space to accommodate these facilities. Proposed location of the center was selected after consultation with local government and PDIME. Location will be at the side of the branch road to the West Baray from the National Road No. 6. Distance from the center to the Road No. 6 is about 200 m. The center will be located at the intermediate of the proposed well field.

Figure 5.3.6 shows the layout of the Distribution Center. As shown in the figure, reserved space will be required for the expansion of clear water reservoir for Stage 2.

According to the results of the water quality analysis of groundwater adjacent to the well field, no iron removal facilities will be required. However, in case that high iron concentration in future by changing quality from groundwater flowing, it is recommended to remove iron by slow sand filtration. Iron will be oxidized and removed by the iron bacteria layer developed on the surface of the slow sand filters. To accommodate required slow sand filtration system, additional 0.5 ha land space may be required if iron concentration becomes high in future. Furthermore, replacement of submergible pumps in wells with higher pump head and reconstruction of the receiving well will be required.

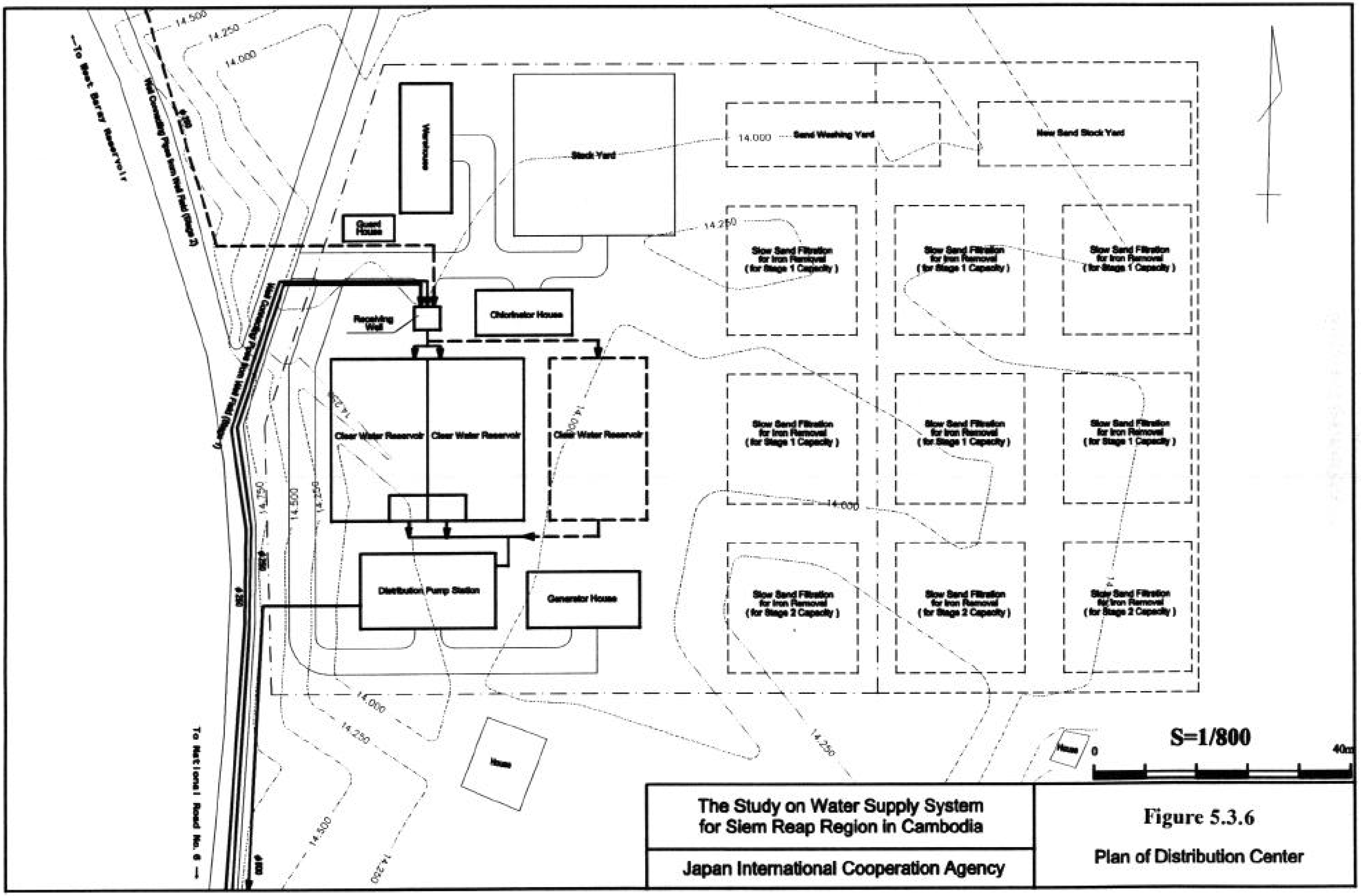


Figure 5.3.6
Plan of Distribution Center

It should be noted that these iron removal facilities and modification of the system flow are not included in Stage 1 Project.

2) Receiving Well

From the two units of wells under Stage 1, each unit consisting of five wells, groundwater will be conveyed to the receiving well. Purpose of the receiving well is to regulate the water flow and to dose and mix chlorine solution for disinfection.

Capacity of the receiving well is 42 m^3 (effective depth 3 m, area 14 m^2) and this is equivalent to 5 minutes of Stage 2 production capacity of 12,000 m^3/day. The receiving well with the capacity of Stage 2 will be constructed under Stage 1 because the size of the well is small and can not be constructed separately for each stage. Structures will be RC made and high water level of the receiving well will be +16.0 m.

Lime solution feeder will also be equipped at the receiving well for pH control. Value of pH will be checked daily basis and if pH value is too low, lime solution will be dosed.

3) Disinfection Facilities

Chlorine gas will be fed to the water by solution-feed chlorinators. Solution-feed chlorinators take gaseous chlorine evaporated in the container, measure it, and mix it with water to form a strong chlorine solution. The chlorine solution will be fed in the receiving well mentioned above.

Two sets of chlorinators will be installed in the Chlorinator House under Stage 1. The Chlorinator House will also have a space for storage of the container.

4) Clear Water Reservoir

Clear water reservoir will be constructed to balance the fluctuating demand from the distribution system against the output from the wells, and to act as a safeguard for the continuation of the supply should there be any breakdown at the source or on the main trunk distribution pipelines.

Detention time of the reservoir is about 8 hours. The clear water reservoir will consist of three basins. 2 of them will be constructed under Stage 1 and the other will be constructed under Stage 2. Structure of the reservoir will be RC made and dimension of the each basin will be W 15 m x L 25 m x Depth 3.5m.

5) Distribution Pumping Station

Distribution pumping station will be constructed to store distribution pumps that will transmit water to distribution system in the Town area through distribution trunk main.

Flow of transmitting water will be controlled by number of operating pumps. Therefore, capacity of each pump will be planned rather small. List of distribution pumps is shown on Table 5.3.2.

Table 5.3.2 List of Distribution Pumps

Distribution Pumps	Number Required for Stage 1
1.0 m^3/min x H35 m, 11kW	3
1.82 m^3/min x H35 m, 18.5kW	4

6) Power Source

Considering that the current situation that public electric supply in Siem Reap is not stable and reliable, and the capacity of the public supply will not be guaranteed for future power requirement. Own generator system is proposed to supply electricity to well pumps, distribution pumps and lighting etc. for new water supply system. List of generators required for the new system is as shown on Table 5.3.3.

Table 5.3.3 List of Generators Required

Generator	Number Required for Stage 1
For Submergible Pumps (3P75kVA w/Fuel Tank)	4
For Distribution Pumps (3P150kVA w/Fuel Tank)	4

(4) Distribution System

1) Hydraulic Network Analysis

From the distribution pumping station, water will be transmitted to the city through distribution trunk main, which will be installed along the National Road No. 6. Hotels locating along the National Road No. 6 will be supplied from branches on the trunk main.

According to the future land use plan, new hotel development project will take place in the northeast part of the town. Water supply system for new hotel development area will be a separated system from the water supply. Water for new hotel development area will be available at the branch on the northern end of the distribution network and water will be supplied by bulk. Hotel developers will construct transmission pipeline from this branch to the new hotel area by themselves.

Water transmitted by the trunk main will be distributed to entire service area. Future distribution network model for Stage 1 is established from the results of the hydraulic network analysis conducted in the Master Plan. Stage 1 distribution network is checked by computer network analysis and proposed Stage 1 distribution network which was confirmed by its capacity and rationality is shown on Figure 5.3.7 and network diagram which shows pipe diameter and length is shown on Figure 5.3.8. Length of the proposed distribution network is as shown in Table 5.3.4.

Table 5.3.4 Length of Distribution Pipeline by Diameter

Diameter (mm)	Stage 1		Remaining	Total
	New Installation(m)	Replacement(m)	Existing pipe(m)	(m)
500	7,450	-	-	7
450	710	-	-	
400	-	166	-	
350	-	254	-	
300	-	230	-	
250	360	900	509	1
200	2,630	92	354	3
150	765	1,169	1,964	3
100	1,860	3,499	3,005	8
75	3,250	-	-	3
Total	**17,025**	**6,310**	**5,832**	**29**

Pipe material should be considered separately for the trunk main of which diameter is more than 200 mm and secondary main of which diameter is less than 150 mm.

For the trunk main, DIP is recommended from the following advantages.

- Easy installation work comparing with Steel Pipe (SP) under rainy weather condition and high groundwater level
- Quick and easier installation by unskilled labor using push-on or mechanical joint.
- Easier maintenance and repair comparing with SP.
- High resistance against corrosion comparing with SP.

Even though DIP has disadvantages such as its weight, heavier than SP, DIP is a recommendable pipe material because of its high reliability.

For the secondary main, PVC or PE is recommendable. Siem Reap Waterworks started to use PVC to repair ACP line. In Phnom Penh, PE is prevailing as a material for secondary main. Comparison of PVC and PE is in Annex 5.3.1.