ANNEX 4.5.1

SYSTEM EXPANSION PROGRAM

ON SIEM REAP WATER SUPPLY

THE STUDY ON WATER SUPPLY SYSTEM
FOR SIEM REAP REGION IN CAMBODIA

FINAL REPORT
Vol. III SUPPORTING REPORT

ANNEX 4.5.1 SYSTEM EXPANSION PROGRAM ON SIEM REAP WATER SUPPLY

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ANNEX 4.5.1 SYSTEM EXPANSION PROGRAM ON SIEM REAP WATER SUPPLY

1. Introduction

Four alternative water sources were examined and compared in Section 4.3, Main Report, and groundwater was selected as the most suitable water source for Siem Reap water supply to meet water demand in the target year 2010. Future water supply system using groundwater is discussed in this Annex.

2. Stagewised Development Policy

Service area, which is discussed in Section 4.1, Main Report, will be expanded in the end of year 2006 to cover new housing area located in southeastern area. Along with this service area expansion, water demand will increase. In this Master Plan, stagewised development policy is introduced to meet such expansion of service area and increase of water demand. To avoid idle capacity of the system, the stagewised development will be more economical. As shown on Figure 2.1, after the first implementation in year 2002 as Stage 1, system capacity will be increased again in year 2006 as Stage 2. The supply capacity of each stage was decided based on the maximum daily water demand.

Increase of water supply capacity is as shown on Table 2.1.

Table 2.1 Increase of Supply Capacity

Stage	Incremental Capacity (m^3/day)	Total Supply Capacity (m^3/day)
Existing		1,440
Stage 1	8,000	9,440
Stage 2	4,000	12,000

At the end of the Stage 1, the existing system of which capacity is 1,440 m^3/day will be abandoned because of its life time. The existing treatment plant was constructed in 1998 to solve water shortage problem as emergency project. The plant was designed for quick construction using steel tank filters and PVC piping. Therefore, the life time of the existing plant is judged until the end of the Stage 1. The total capacity of the Stage 2 will be 9,440 + 4,000 – 1,440 = 12,000 m^3/day.

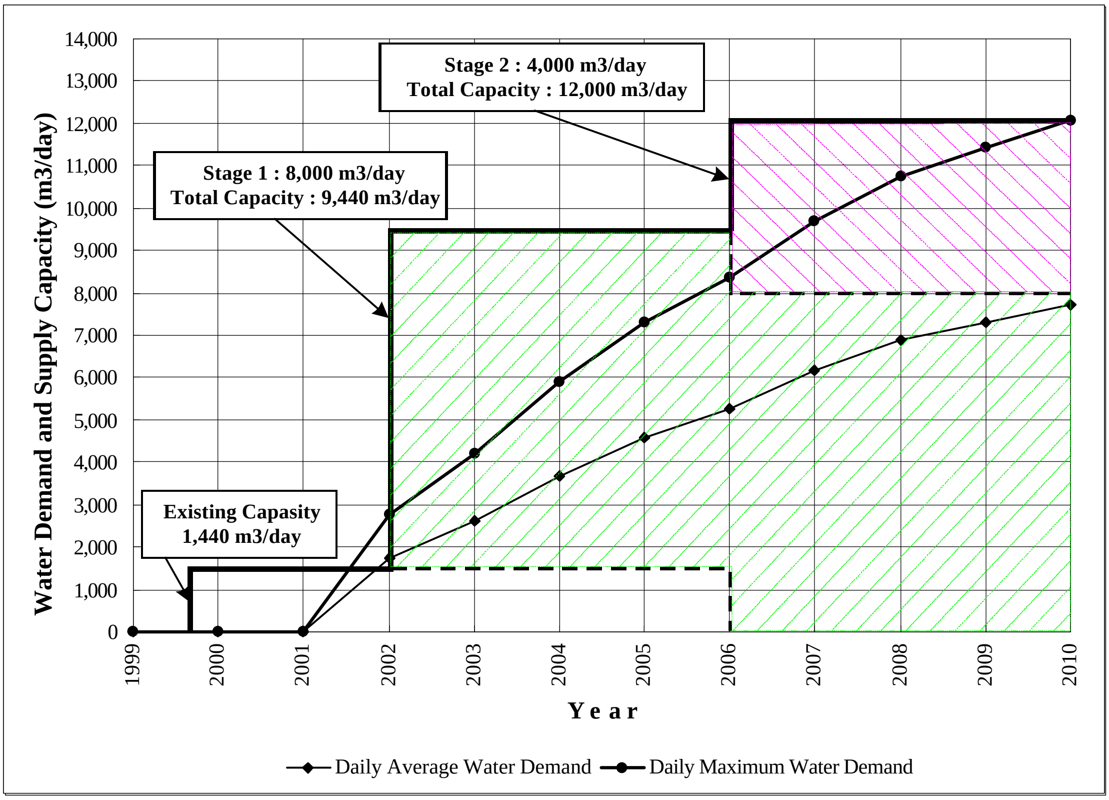


Figure 2.1 Stagewised Capacity Increase and Future Water Demand

3. Future Water Supply System

3.1 System Flow

Future water supply system flow that will take groundwater as its source is as shown on Figure 3.1.1.

Groundwater abstracted from each well will be sent to a receiving well through a connecting pipeline. 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.

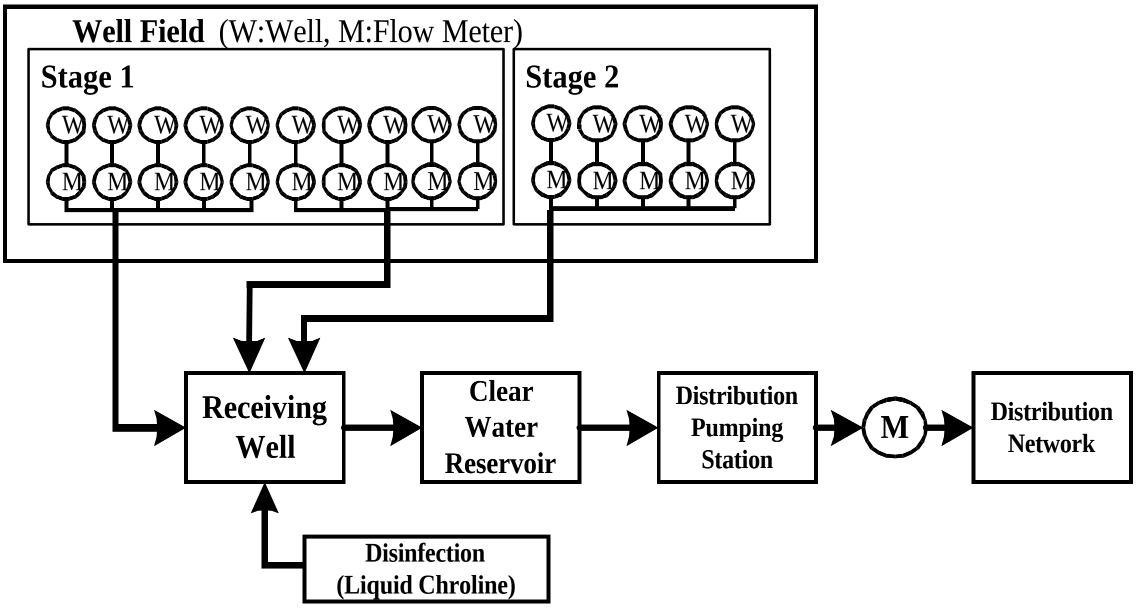


Figure 3.1.1 Water Supply System Flow

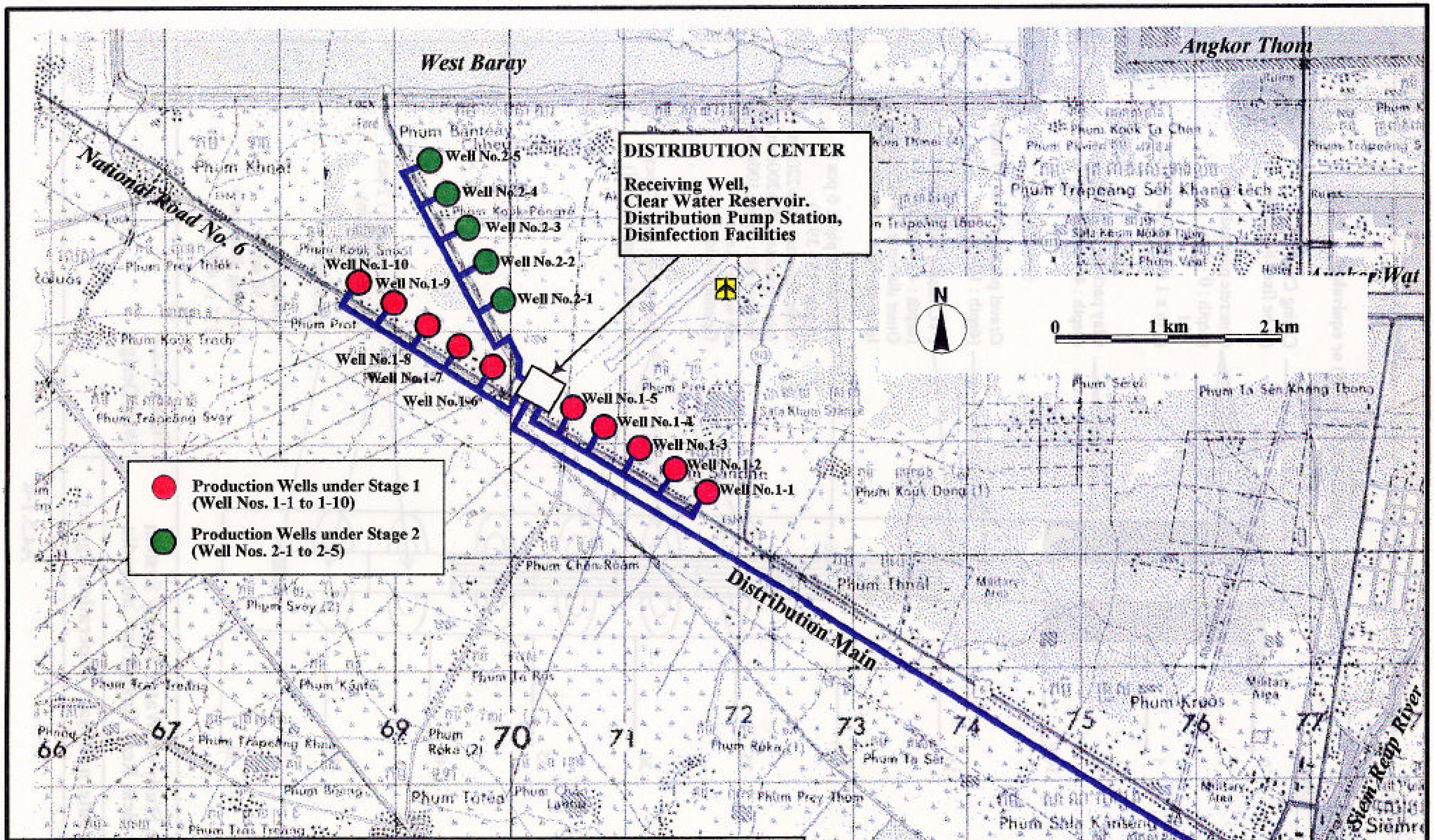
Water production facilities such as wells, receiving well, clear water reservoir, and disinfection facilities will be designed based on the Daily Maximum Water Demand. Distribution system such as distribution pumping station and distribution network will be designed based on the Hourly Maximum Water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

3.2 Production Facilities

3.2.1 Well Field

Plan of the well field is shown in Figure 3.2.1. As shown in the figure, 10 wells to be constructed under the Stage 1 will be located along the National Road No. 6. Additional 5 wells to be constructed under the Stage 2 will be located along the branch road from the National Road No. 6 to the West Baray Reservoir.

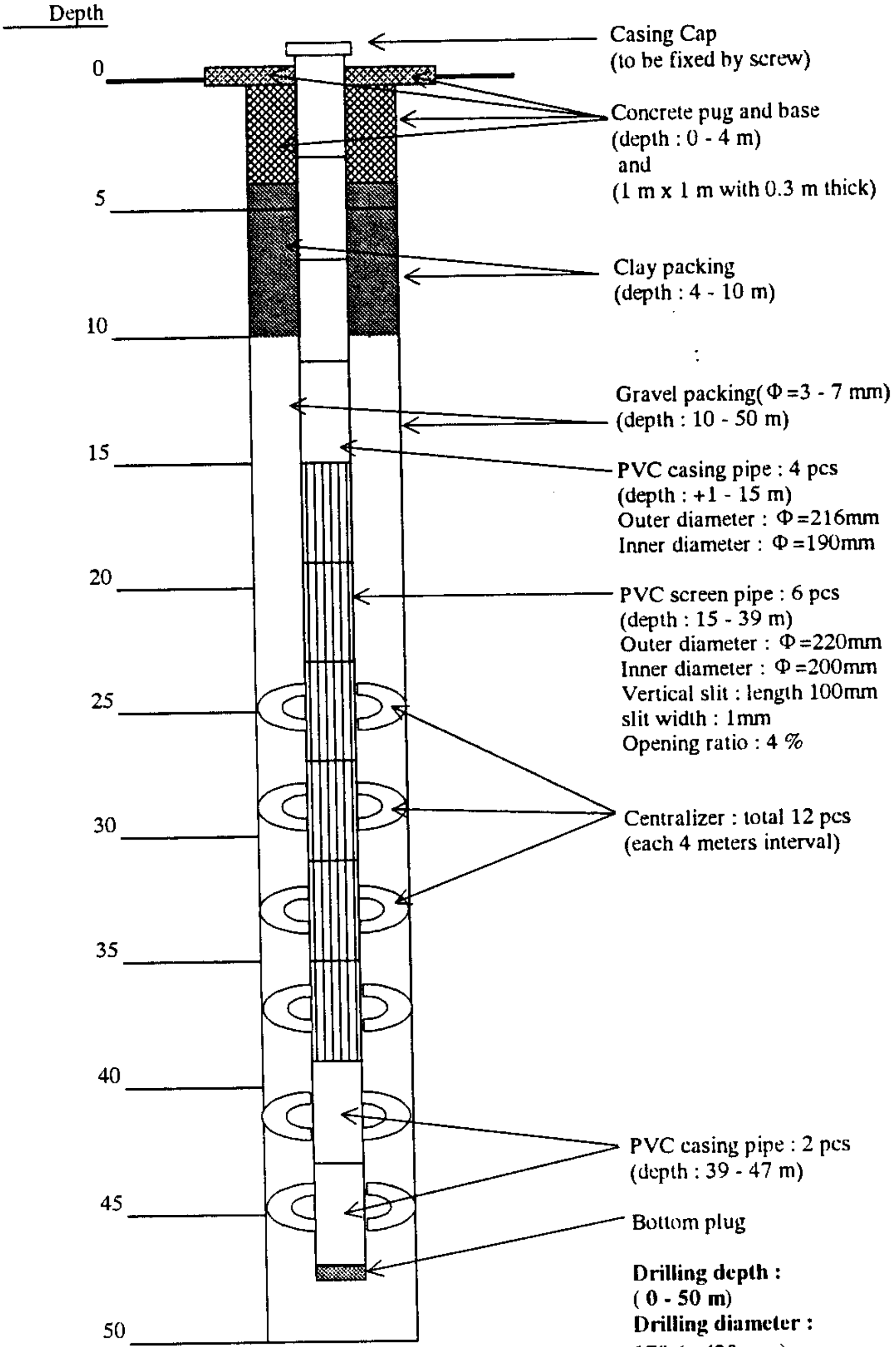
Each well will have a capacity of 800 m^3/day. Depth of each well will be 50 m. Drilling diameter will be 430 mm. Within the drilling bore, a pipe of smaller diameter (220 mm, outer) will be installed up to the depth of 47 m. The main portion of this pipe is the PVC screen pipe. Total length of the screen will be 25 m. This screen will have a 4% opening ratio with a slit width of 1 mm. Length of each vertical slit will be 100 mm. On both sides of this screen (top and bottom) PVC casing pipes will be placed. Casing pipe should follow VP200 (JIS K 6741) or equivalent standard to ensure required quality. On the top, this pipe will be closed by casing cap while it will be closed in the bottom by bottom plug. Provision will be kept for water flowing pipes in the casing cap. For structural strength, a concrete base will be constructed on the top. For smooth operation of the screen, a gravel pack of 40 m deep will be placed around the pipe within the drilling hole. The diameter of the gravel can vary between 3 and 7 mm. Provision will also be made to keep the well straight in the borehole by introducing centralizer. Details of the proposed well are shown in Figure 3.2.2.



The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 3.2.1**
Japan International Cooperation Agency	**Plan of Well Field**

Well Design

Casing pipe : VP200(JIS K 6741) or equivalent



The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 3.2.2** **Well Design**
Japan International Cooperation Agency	

3.2.2 Well Connecting Pipe

Schematic plan of well connecting pipes is shown on Figure 3.2.3. 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 specially in the rainy season.

The results of hydraulic analysis of the well connecting pipe is shown on Table 3.2.1. Based on the results of the analysis, specifications of submergible pump in respective wells are decided.

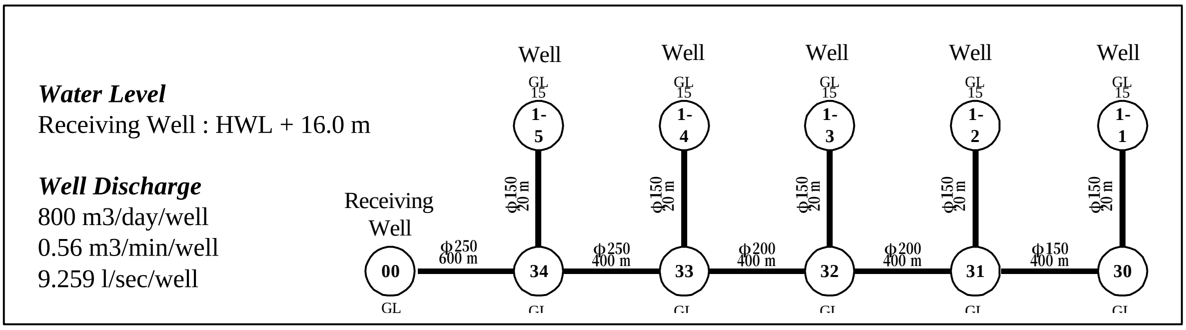


Figure 3.2.3 Schematic Plan of Well Connecting Pipe

Table 3.2.1 Results of Hydraulic Analysis on Well Connecting Pipe

NODE NO	Type	Q l/sec	WL m	GL m	EH m
0	1	46.295	16.00	14.00	2.00
11	0	-9.259	25.26	15.00	10.26
12	0	-9.259	23.91	15.00	8.91
13	0	-9.259	22.71	15.00	7.71
14	0	-9.259	20.16	15.00	5.16
15	0	-9.259	18.70	15.00	3.70
30	0		25.20	14.00	11.20
31	0		23.85	14.00	9.85
32	0		22.65	14.00	8.65
33	0		20.11	14.00	6.11
34	0		18.65	14.00	4.65

PIPE NO(u)	NO(d)	Dia mm	Length m	C	Q l/sec	V m/sec	I o/oo
11	30	150	20	120	9.26	0.52	2.70
12	31	150	20	120	9.26	0.52	2.70
13	32	150	20	120	9.26	0.52	2.70
14	33	150	20	120	9.26	0.52	2.70
15	34	150	20	120	9.26	0.52	2.70
30	31	150	500	120	9.26	0.52	2.70
31	32	200	500	120	18.52	0.59	2.40
32	33	200	500	120	27.78	0.88	5.09
33	34	250	500	120	37.04	0.75	2.92
34	0	250	600	120	46.30	0.94	4.41

3.2.3 Receiving Well

From three units of wells, each unit consisting of four wells, water 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, 12,000 m^3/day. The receiving well which has capacity of the Stage 2 will be constructed under the Stage 1. Structure will be RC made and high water level of the receiving well will be +16.0 m.

3.2.4 Disinfection Facilities

The disinfection of water supply system is almost universally accomplished by the use of chlorine gas or chlorine compounds (hypochlorites). The decision to use either chlorine gas or hypochlorites should be based on several factors.

In the existing New French System, Siem Reap Waterworks use chlorine gas as a disinfectant. Therefore, staff of the waterworks is familiar with using the chlorine gas. In Phnom Pen Water Supply Authority (PPWSA), they also use chlorine gas and alum are supplied by Malaysian supplier. The cost of the gas is 700 US$/ton. According to the results of discussion with PPWSA, it will be possible that PPWSA orders the chlorine gas including the quantity required in the Siem Reap Waterworks if the Siem Reap Waterworks is responsible for the payment for their share and for the transportation from Phnom Penh to Siem Reap Town.

Considering this situation, chlorine gas is recommended as a disinfectant for the new system. Chlorine gas will be fed 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 under the Stage 1 and another one set will be added under the Stage 2. Chlorinators will be installed in the Chlorinator House and the house will also have a space for storage of the gas cilliynder.

3.2.5 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 continuance of the supply should there be any breakdown at the source or on the main trunk distribution pipelines.

Detention time of the reservoir is recommended to be about 8 hours. Reservoir volume is calculated from the detention time. The clear water reservoir will consist from three basins and two of them will be constructed under the Stage 1 and the other will be constructed under the 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 3.5 m. In the reservoir, buffer walls will be installed to avoid dead water space and pump suction well will be constructed as part of the reservoir.

Land space required for the distribution center which will accommodate the receiving well, disinfection facilities, clear water reservoir, and distribution pumping station will be about 1 ha.

3.2.6 Power Source

Own generator system is proposed to supply electricity for well pumps, distribution pumps, which are discussed below, and lighting etc. of new water supply system, considering 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. List of generators required for the new system is as shown on Table 3.2.2.

Table 3.2.2 List of Generators Required

Generator	Number Required for Stage 1	Number Required for Stage 2	Total Number of Generators
For Submergible Pumps (3P75kVA w/Fuel Tank)	4	2	6
For Distribution Pumps (3P150kVA w/Fuel Tank)	4	1	5

3.3 Distribution Facilities

3.3.1 Distribution Pumping Station

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

Flow of transmitting water will be controlled by a number of operating pumps. Therefore, capacity of each pump will be planned rather small. Power of these distribution pumps will be supplied by in-plant generators. Current situation of public electric supply is not stable and reliable and capacity of the public supply will not be enough for the future power requirement.

List of distribution pumps is shown on Table 3.3.1.

Table 3.3.1 List of Distribution Pumps

Distribution Pumps	Number Required for Stage 1	Number Required for Stage 2	Total Number of Generators
1.0 m^3/min x H35 m, 11kW	3	0	3
1.82 m^3/min x H35 m, 18.5kW	4	1	5

3.3.2 Proposed Distribution Network

From the distribution pumping station, water will be transmitted to the Siem Reap Town through distribution trunk main which will be installed along the National Road No. 6. Hotels which are located 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 the new hotel development area will be a separated system from the town water supply. Water for the 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. Transmission pipeline from this branch to the new hotel area will be installed by hotel developers.

Water transmitted by the trunk main will be distributed to entire service area. Major flow direction in the service area is as shown on Figure 3.3.1.

Future distribution network is established taking account of,

- future land use plan,
- future service area,
- future water demand, and
- topographic condition.

Planned future distribution network is checked by computer network analysis. Network analysis is conducted based on the following condition.

- C-value for new pipe is 120 and 110 for existing pipeline.
- Hourly peak factor is 1.2. (The peak factor is not applied for bulk water supply for the new hotel development area)
- Minimum residual pressure should be more than 15 m.
- In the case that existing pipe is not enough for future distribution, the existing pipe will be replaced by the new pipe and the existing pipe will be abandoned.

In addition to these conditions, existing pipe replacement is also taken into account. Existing pipelines to be replaced are discussed and selected in ANNEX 4.4.2 and those selected pipelines to be replaced are included in the network analysis and required pipe diameter is confirmed.

As the first step of the hydraulic network analysis, distribution network model was established as shown on Figure 3.3.3. As the second step, water demand in the service area is allocated to each node. Table 3.3.2 shows domestic water demand in 2010 for each village included in the service area by daily average and daily maximum basis. Table 3.3.3 shows domestic water demand in 2010 for each village by hourly maximum basis. This hourly maximum water demand is used for the analysis. Number of nodes which included in respective village are calculated and ratio of demand is allocated as shown on Table 3.3.4. From hourly maximum water demand in each village and ratio allocated to each node, domestic water discharge from each node is calculated as shown on Table 3.3.5.

For non domestic water demand, basic water demands, daily average, daily maximum, and hourly maximum are as shown on Table 3.3.6. Non domestic water discharge is calculated from the allocated ratio which is shown on Table 3.3.7 and water demand in each category and node discharge is calculated as shown on Table 3.3.8.

From the domestic water and non domestic water discharge, total water discharge at each node is calculated as shown on Table 3.3.9.