PART B : FEASIBILITY STUDY

Chapter 1. Stage I Priority Projects Introduction

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This Feasibility Study covers the Stage I Priority Projects identified under the Master Plan of the Greater Phnom Penh Water Supply (Phase 2). The Master Plan was presented in Part A of this Volume. Stage I of the Master Plan, the target period for this Feasibility Study, covers the years 2005 to 2010. All of the projects identified as Stage I projects in Chapter 10 (Implementation Plan) of the Master Plan are considered to be Priority Projects.

The Stage I Priority Projects identified in the Master Plan encompass the following: 1) water supply augmentation; 2) existing systems rehabilitation; 3) peri-urban water supply; and 4) institutional development. The Master Plan contains extensive background information, context and detail which are necessary to fully understand the necessity, priority and objectives of these projects. Therefore, the reader is advised to study both parts of this volume.

The Feasibility Study first presents a chapter for each of the four principal Priority Projects mentioned above. A subsequent chapter outlines the project costs and implementation plans. In the last chapter, an Evaluation of the Priority Projects is presented encompassing the technical, financial, economic, and environmental dimensions of the projects. In addition, a number of supporting documents are presented separately including a detailed Environmental Impact Assessment in accordance with JICA and RGC requirements.

Chapter 2. Water Supply Augmentation Project

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Expansion of the Chrouy Changva water treatment plant (WTP) with new intake station, raw water pipe and additional treatment and storage capacity is one of the most important projects in Stage I to meet the required water production capacity of 254,700 m^3/day. The plant will have proper treatment performance to secure safe and clean treated water meeting the national drinking water standard.

Distribution pipe consisting of main and branch pipes and meshed lines shall also be laid to serve water to consumers in newly expanded service areas. Since some parts of the Study Area cannot be covered by PPWSA's piped water supply service, well facilities will also be constructed. These are described in chapter 4, (Peri-Urban Water Supply Project).

The principal components of the Augmentation Projects are shown below.

(1) Water Treatment Plant (Chrouy Changva Stage II) Construction Project

- Intake Station and Chrouy Changva WTP of capacity 65,000m^3/d

(2) Transmission and Distribution System Augmentation Project

- One new water tank
- Booster pump stations for the existing towers if necessary
- Distribution pipe, diameter of 63 to 1350mm, total length of 450 km in Phnom Penh City and its suburbs

2-1 Water Treatment Plant Construction Project

In the Master Plan, it is identified that expansion of Chrouy Changva WTP with intake station and raw water pipe is one of the most important projects in Stage I to meet the required total water production capacity of 254,700 m^3/day by the year 2010.

The following are the conditions for Chrouy Changva WTP expansion:

- Production capacity to be added: 65,000 m^3/day
- Location: within the same premises of the existing plant
- Intake tower: new tower with intake capacity of 130,000 m^3/day
- Treatment process: same as the existing process

The existing Chrouy Changva WTP was originally planned to expand from its initial capacity of 65,000 m^3/day up to 130,000 m^3/day. Space was therefore reserved to accommodate a future

expansion of 65,000 m^3/day on the same premises. The major facilities to be constructed are flocculation /sedimentation tanks, filters and clear water reservoirs.

As for the existing intake tower, which was renovated in 2002 during the last construction, there is no more space to install additional intake pumps or change to larger pumps. Therefore, it is recommended to construct a new intake tower with the capacity to meet the total expanded production capacity of 130,000 m^3/day. The existing structure and pumping facility will be used as a stand-by unit.

The existing plant achieves proper treatment performance, securing safe and clean clear water meeting the national drinking water standards. The responsible engineers and operators are accustomed to operating the existing plant. It is therefore recommended to apply the same treatment process/ facility, except minor changes for improvement, if necessary.

The capacity of the clear water reservoir in Chrouy Changva WTP was reviewed and it was identified that the existing reservoir (5,760 m^3, equivalent to 2.1 hours at full production of 65,000 m^3/day) is far smaller than the requirement to cover water demand fluctuation in a day. Therefore, additional reservoirs should be provided with the expansion of the treatment facilities.

Also, some treatment facilities for sludge from sedimentation tanks and filter backwash water are required to meet the Cambodian National Sub-Decree, *Water Pollution Control*. It is recommended to construct the facilities, not in Stage I but at the earliest affordable stage thereafter.

2-1-1 Evaluation of the Existing Facility

An overall evaluation of the existing Chrouy Changva WTP is provided in the Supporting Report on Existing Water Treatment Plants. Further evaluation of the plant is presented in this section, prior to the preliminary design for the expansion.

2-1-1-1 Intake Pump

The following table shows major maintenance records after the commissioning in 2002.

Table 2.1 Maintenance Records after Commissioning

Facility/Equipment	Date	Problem/Trouble	Repair Works
Intake Tower			
Raw water pump			
- Pump No. 1 (1)	12/3/04	Vibration of vertical shaft	Replacement of bearing bush
- Pump No. 1 (2)	6/10/04	- ditto -	- ditto -
- Pump No. 1 (3)	1/9/05	- ditto -	- ditto -
- Pump No. 2 (1)	27/12/04	- ditto -	- ditto -
- Pump No. 2 (2)	28/4/05	- ditto -	- ditto -
- Pump No. 2 (3)	13/9/05	- ditto -	- ditto -
- Pump No. 3 (1)	29/4/04	- ditto -	- ditto -
- Pump No. 3 (2)	8/11/04	- ditto -	- ditto -
- Pump No. 3 (3)	28/9/05	- ditto -	- ditto -
- Pump No. 4 (1)	29/5/04	- ditto -	- ditto -
- Pump No. 4 (2)	20/11/04	- ditto -	- ditto -
Control panel	20/5/05	Break of electrical part	Replacement of part
Sedimentation Tank			
Flocculator Nos. 1, 4, 11	29/5/05	Break of control power system	Replacement of control power system
Stirrer	30/9/05	Noise of motor	Replacement of bearing
Scraper – No. 2	12/9/05	Cutting of driving wire	Replacement of wire
Scraper – No. 2	7/9/05	Over torque	Replacement of part
Clear Water Pump Station			
Chlorinator No. 2	5/9/05	Damage of pressure gauge	Replacement of gauge
Air Compressor	24/8/05	Improper operation	Replacement of water separator/drain
Air Blower	12/9/05	Noise of soft starter	Repair of cooling fan

Some equipment was repaired/replaced, and it seems all are initial breakdowns, except intake pumps. All four intake pumps have frequent problems with bearing bushes at the vertical shafts, which are made of synthetic rubber and wear out in a short period due to silt in the raw water. Comparatively, intake pumps for Phum Prek WTP have never experienced the same problem because the vertical bearings of Phum Prek are located in enclosed tubes which are filled with clear water so they never come in contact with raw water. It seems that adequate consideration was not given to this issue in the original selection of pumps for Chrouy Changva, a situation that should be rectified under the expansion project.

2-1-1-2 Inclined Tubes of Sedimentation Tank

The photo shows the present condition of the existing inclined tubes of the sedimentation tanks in the Chrouy Changva WTP. The top-ends of the tubes are deteriorated and broken. This is because the inclined tubes are not made of the proper material or with the proper thickness. The broken parts disturb the flow to the tube and replacement of the inclined tube will be required in the

near future. It is recommended to install inclined tubes of the proper material and thickness.

2-1-1-3 Filters

Filtration tests were conducted to confirm if the existing filters could withstand higher filtration speeds in order to minimize space required for the expansion works. This operation was done on the same six (6) filters for three days (72 hrs) with full production capacity (65,000 m^3/d or 2710 m^3/hr).

The designs of the filters are as follows:

Item	Existing	Expansion
Production capacity	65,000 m^3/d	130,000 m^3/d
Nos. of filters	8	12
Area of one filter	57.67 m^2	57.67 m^2
Area of all filter	461 m^2	692 m^2
Filtration speed per day	141 m^3/m^2/d	188 m^3/m^2/d
Filtration speed per hour	5.87 m^3/m^2/hr	7.83 m^3/m^2/hr

The detailed report on the test is given in the Supporting Report. The following table summarizes total filtration volume for each filter.

Table 2.2 Volume of Filtration for Each Filter

Filter	**No.1**	**No. 2**	**No. 4**	**No. 5**	**No. 6**	**No. 7**
Volume (m^3)	27,035	29,628	30,929	37,630	37,682	39,831
Ratio (%)	80 %	88 %	92 %	111 %	112 %	118 %
Volume (m^3)	87,592			115,143		
Ratio (%)	43 %			57 %		

Settled water is flowed through an 800 mm pipe, then divided into two channels. One channel is connected to filters numbered 1 to 4 and the other is connected to numbers 5 to 8. The results obviously show that filter nos. 1, 2 and 4 treat less water than the others. This is due to uneven division of the flow of settled water to the filter inflow channels. A design change should be made to prevent the uneven flow division of the channels.

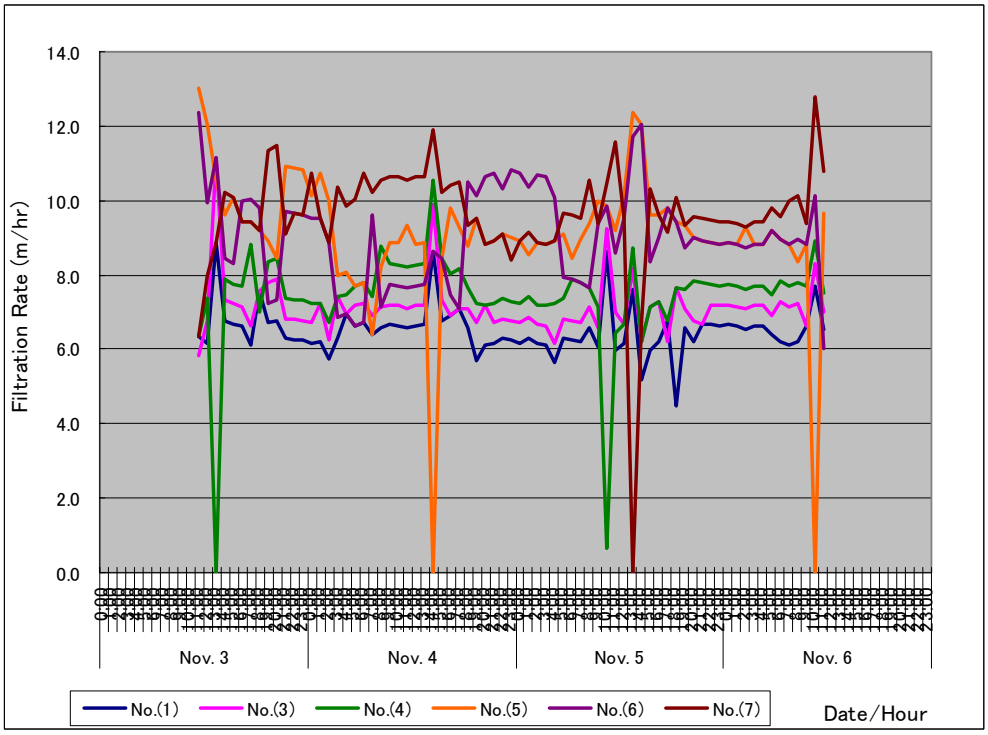


Figure 2-1 Flow Rate of Filters

Figure 2-1 shows the fluctuation in filtration rates of each filter. The rapid decrease of flow rate indicates filter washing (e.g., No. 5 Filter at 14:00 hours on Nov. 4) was done, and at the same hour the other two filters (Nos. 6 and 7) increased flow to accommodate settled water for No. 5 filter.

Except for the above rapid and irregular fluctuations, filters are operated within a range of 6 to 11 m/hr, while planned flow is 7.83 m/hr. The range is 76 percent to 140 percent of the planned rate. The original filter design had a filtration rate of 5.87 m/d 11 m/hr is 87 percent faster than the original rate.

It is therefore recommended to modify the existing filters by providing additional influent weirs to equalize the flow to each filter.

Figure 2-2 shows an example of an influent weir installed at the inflow of each filter. They are located at the same level and are of the same length in order to provide the same flow to each filter.

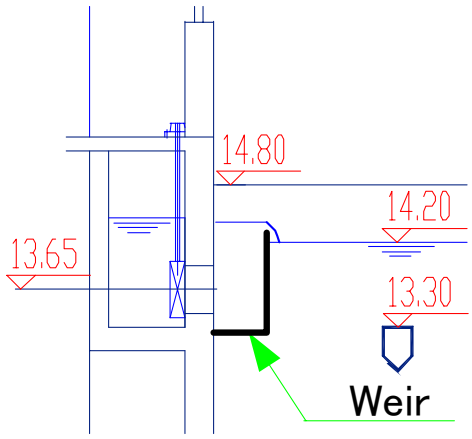


Figure 2-2 Inflow Weir

Based on the test, it is deemed acceptable to construct four more filters connecting to the existing filters, for the expansion of water production by 65,000 m^3/d to reach the total of 130,000 m^3/d, subject to the following points:

a. Re-design and improvement of hydraulic profile shall be considered.
b. Steady operation of sedimentation tanks shall be secured against high turbidity of raw water in rainy season.
c. If necessary, proper washing arrangement (washing/air scouring rate and period) and regular washing (once a day) shall be considered.

2-1-1-4 Clear Water Reservoir

The existing Chrouy Changva WTP can produce clear water up to its design capacity of 65,000 m^3/d. The following figure shows the inflow (2,708 m^3/hr or 65,000 m^3/day), distribution (1,056 to 4,417 m^3/hr, hourly peak of 1.63) and storage in the reservoir (-2,546 to 7,908 m^3).

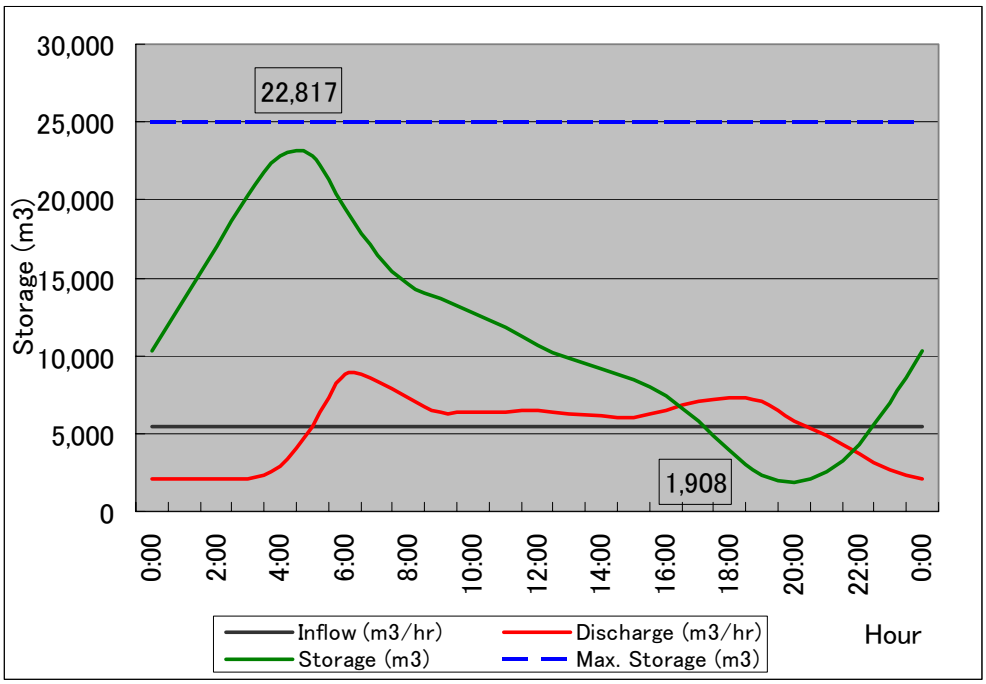


Figure 2-3 Actual Flow and Storage in Clear Water Reservoir

The existing clear water reservoir has storage capacity of 5,760 m^3 (retention time: 2.1 hrs), and it is obvious that the reservoirs cannot meet the daily fluctuation in water demand. Figure 2-3 indicates that the reservoir overflows early in the morning and lacks storage in the evening.

Therefore, additional clear water reservoirs should be constructed to meet the double production capacity and water demand fluctuation.

2-1-1-5 Backwash Water and Sludge Treatment

Some treatment facilities for the sludge from sedimentation tanks and filter backwash water are required to meet the Cambodian National Sub-Decree (*Water Pollution Control*).

Since the cost for the sludge treatment facility is rather high and the sludge or backwash water from the water treatment plant is not hazardous or harmful to human health, it is recommended to discuss with the concerned authority the possibility to obtain permission to discharge, or to construct the additional treatment facilities but not in Stage I, rather, at the earliest affordable stage.

2-1-1-6 Topographic Survey and Soil Investigation

A topographic survey was carried out at the existing plant before the preliminary design. The survey identified the total area of the existing plant as 3.44 ha. The result of the survey is used for the layout of the proposed new facilities.

Soil investigations were conducted at five locations on the existing plant premises. The following shows the results from one of the boreholes (No. 1), which is typical of the soil conditions at the plant.

Depth (m)	Soil Description	N-Value
0.0 – 1.6	Top soil, crushed stone, brick, reddish-brown, laterite, gravel, sand, silt and Medium stiff brown trace fine sandy silty lean CLAY	7
1.5 – 4.0	Soft brown trace fine sandy silty lean CLAY (ground water level: 1.9m)	4
4.0 – 5.0	Stiff light-brown mottled yellow trace fine sandy silty lean CLAY	15
5.0 – 6.0	Soft light-brown mottled yellow trace fine sandy silty lean CLAY	4
6.0 – 7.0	Medium stiff light-brown mottled yellow trace fine sandy silty lean CLAY	6
7.0 – 9.0	Soft light-brown mottled yellow trace fine sandy silty lean CLAY	3 – 4
9.0 – 11.0	Medium becoming stiff dark-gray some fine sandy silty lean CLAY	5 - 10
11.0 – 12.0	Loose dark-gray clayey fine SAND	4
12 – 20.45	Medium dense stiff dark-gray clayey fine to coarse SAND, a few fine gravel	12 - 22

In general, the soil is clay down to 10 meters and sand below that, which is not strong to support structures by single soil layer as N-values are low. Through this investigation and the experience of constructing the existing facilities, friction piles are to be applied for foundation of structures.

2-1-2 Facility Planning

2-1-2-1 Layout

Layout of the treatment plant facilities is arranged within the existing premises of Chrouy Changva WTP of 3.44 ha, as shown in the Supporting Report. The existing area has the level of +10.50 meters from MSL and the same level will be applied.

The existing facilities consist of an intake tower, a mixing-sedimentation tank, filters, clear water reservoirs, clear water pump station, chemical building and administration building.

The major facilities for the expansion are an intake tower, receiving well, a mixing-sedimentation tank, filters, and clear water reservoirs.

Treatment facilities for sludge from sedimentation tanks and backwash water from filters are also planned, but not on the same premises due to space constraints. The facilities are planned as shown in the Supporting Report, subject to the new adjacent location being provided.

2-1-2-2 Hydraulic Profile

The existing intake tower is designed considering high water level of +10.00 meters from MSL and low water level of +0.00 meters from MSL. The same high and low water levels are applied for the design.

Same hydraulic profile as the existing facilities is basically applied for new facilities except minor adjustments in several facilities.

2-1-2-3 Treatment Process

The existing treatment process consists of Flash Mixing, Coagulation & Flocculation, Settling, Filtration and Disinfection. The same process is applied for new facilities.

As evaluated in the Interim Report, the existing plant performs proper treatment to secure safe and clean clear water meeting the national drinking water standard even during periods of high turbidity of the raw water source.

The Process Flow Diagram for water treatment plant, Capacity Calculation and Major Equipment are summarized in the Supporting Report.

Land at the existing plant is very tight and insufficient for sludge treatment. Additional land could be acquired near the existing plant; however the adjacent area has been developed as a residential area and the land price has increased. A minimum area is required for sludge treatment, consisting of gravity thickening and mechanical dewatering.

Since the cost for the sludge treatment facility is rather high, and the sludge and backwash water from the water treatment plant are not hazardous or harmful to human health, being simply returned directly to from whence they were taken (the river). Therefore, it is recommended to discuss with the concerned authority the possibility to obtain permission to discharge with minimal treatment.

2-1-3 Major Facilities

Specifications of major facilities and equipment are preliminary. Exact specifications will be determined in the detailed design stage.

2-1-3-1 Intake Tower

Intake tower will be located 50 m south of the existing intake tower, and approx. 20 m from right bank of the Mekong River. The tower is a 12 m diameter and 24 m high cylindrical structure.

The tower is equipped with two inlet gates with inlet screens and five raw water pumps with a total intake capacity of 136,500 m^3/d, which is 5 percent larger than total plant production capacity.

The pumps will be vertical shaft, mixed flow type, with discharge flow of 1,422 m^3/hr and delivery head of 20 m. Special care should be taken in selecting the vertical shaft bearings to prevent the problem mentioned previously in Section 2-1-1.

Raw Water Pump	vertical shaft, mixed flow type 1,422 m^3/hr x 20 m x 110 kW x 5 sets

2-1-3-2 Water Treatment Plant

(1) Receiving Well

As mentioned above, same treatment will be applied. However, the expanded plant has two facilities and raw water will be divided into two equal flows at the receiving well.

The receiving well is located at the southwest end of the premises. Raw water delivered from the intake tower through a 1200 mm diameter and 100 m long raw water transmission pipe is led to this receiving well. The structure is a reinforced concrete rectangle with dimensions of 6.5 meters (W), 13 meters (L) and 8 meters (D).

Retention Time	4.5 min.

The hydraulic rapid mixing is located at the receiving well. The structure is reinforced concrete and consists of two inner split chambers, which are connected to the existing and new flocculation/ sedimentation tanks, respectively. This structure is also successively raised above the ground level to adjust water levels to deliver water to the two facilities.

At this receiving well, pre-chlorine and alum are dosed for oxidation of dissolved matters and coagulation.

(2) Flocculation Tank

Flocculation tank and sedimentation tank are integrated in one reinforced concrete structure, however, it is separated into two trains of tanks.

Each flocculation tank consists of six chambers with a mechanical flocculator each and the flocculators give gradually decreasing mixing strength. Width, length and depth of the flocculation tank are 15.1, 11.2 and 6 meters respectively. Six mechanical flocculators are

facilitated for each train of flocculation tank. The retention time is planned with more than 25 minutes.

Retention Time	25 min.
Flocculator	vertical shaft type 1.1 kW, 6 sets/train

(3) Sedimentation Tank

In order to have higher efficiency and smaller structure for sedimentation tanks, up-flow inclined tube-type sedimentation tank was selected in the existing plant. The same type is applied for the new facility. The structure of the tank is a reinforced concrete type with dimensions of 10 meters (W), 15.2 meters (L) and 5.5 meters (D).

Retention Time	1.7 hr
Up-flow Speed	3.0 m/hr
Inclined Tube	plastic honeycomb tube inclined angle 60 °
Sludge Collector	submersible, cable operated type, 0.75 kW, 6 sets/train
Desludge Valve	pneumatic valve 200 mm, 6 sets/train

In the sedimentation tank, inclined tubes cover the upper part of the tanks to accelerate sludge settlement at the tube, while clear water flows upward and settled sludge in the tubes drops to the bottom of the tanks.

For the removal of settled sludge, submerged rope-operated traveling sludge scrapers are provided to remove sludge effectively and to save manpower. The scraper is regularly operated several times a day with an automatic desludge valve in order to remove settled sludge at the bottom.

(4) **Rapid Sand Filters**

The existing eight filters are constant level, declining-rate with effluent flow control type. Four more of the same type of filters will be constructed. The dimensions of the expansion structure are 18.1 meters (L) by 22.1 meters (W). Each filter unit consists of a filter bed of 57.67 m^2.

There are two alternatives considered in this preliminary design. Alternative A is a design to construct an additional eight filters, while Alternative B is a design to expand the existing structure and add four filters. The following table compares these two alternatives. The most important difference is filtration speed. Alternative B is 33 percent faster than Alternative A (same as the existing filters). In order to confirm the feasibility of the faster filtration rate, a test using the existing filters was carried out at a filtration rate of 7.83 $m^3/m^2/hr$.

Table 2.3 Filter Alternatives

Item	Alternative A	Alternative B
Production capacity	130,000 m^3/d	
No. of filters	16	12
Area of one filter	57.67 m^2	57.67 m^2
Area of all filter	923 m^2	692 m^2
Filtration rate per day	141 $m^3/m^2/d$	188 $m^3/m^2/d$
Filtration rate per hour	5.87 $m^3/m^2/hr$	7.83 $m^3/m^2/hr$

As explained in the previous section, Alternative B is selected and an additional four filters will be constructed. Also, the influent weir should be provided at the inflow of each filter.

Type	constant level, declining-rate type with effluent control
Area of one filter	57.67 m^2
Filtration rate	7.83 $m^3/m^2/hr$
Washing	air scouring 54 $m^3/m^2/min$ backwashing 14.4 – 21.6 $m^3/m^2/min$
Gate & Valve (1set each/filter)	inflow gate: 500 mm x 500 mm effluent valve: 350 mm dia. backwash valve: 400 mm dia. air scouring valve: 200 mm dia. wash drain valve: 500 mm dia.

The existing backwash pumps or air scouring blowers will be utilized for washing the existing and new filters.

(5) Clear Water Reservoirs

Filtered water is introduced to three clear water reservoirs located downstream of the filters. The structures are reinforced concrete. The measurements of the two structures are 30.0 meters (W), 50.0 meters (L) and 5.0 meters (effective D) each and one structure is 20.0 meters (W), 45.0 meters (L) and 5.0 meters (effective D). The clear water reservoirs are connected with the existing pump house for clear water transmission to the storage reservoir, which lies apart from the treatment plant.

The following figure shows a simulation of constant water production of 5,417 m^3/hr (130,000 m^3/d), and typical daily water consumption and clear water storage in the reservoirs. It indicates that a total effective storage of 25,000 m^3 is the minimum requirement to secure constant production capacity.

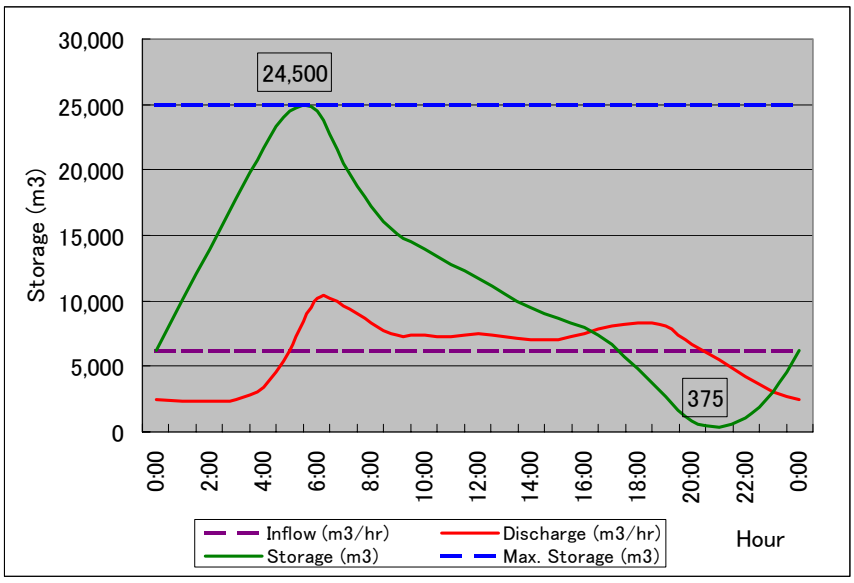


Figure 2-4 Future Flow and Storage in Clear Water Reservoir

(6) Clear Water Pump Station

Clear water pumps in the Clear Water Pump Station finally distribute the clear water. There are three existing pumps and they are proposed to be modified to the following specifications, taking into consideration the results of the *Energy Saving Study for Phnom Penh Water Supply Authority* dated August 2005.

Clear Water Pump A (Existing)	vertical shaft, centrifugal type 1,450 m^3/hr x 55 m x 315 kW 3 sets

The following pumps will be additionally installed to meet the expanded water production of the plant and water demand in the distribution network.

Clear Water Pump B	vertical shaft, centrifugal type 1,450 m^3/hr x 55 m x 300 kW 5 sets

(7) Other Facilities

The water treatment plant requires some other facilities such as chemical dosing facilities (alum, lime and chlorine), filter washing facilities (backwash pumps and air scouring blowers) and administration building (offices and laboratory). The existing common facilities will be used so no additional construction is required.

2-1-4 Operation and Maintenance

The existing plant, producing on average, 65,000 m^3/d, is operated on a 24-hour basis with a total of seventeen (17) staff, including the Plant Manager. The present staff formation is shown in the following Figure 2-5.

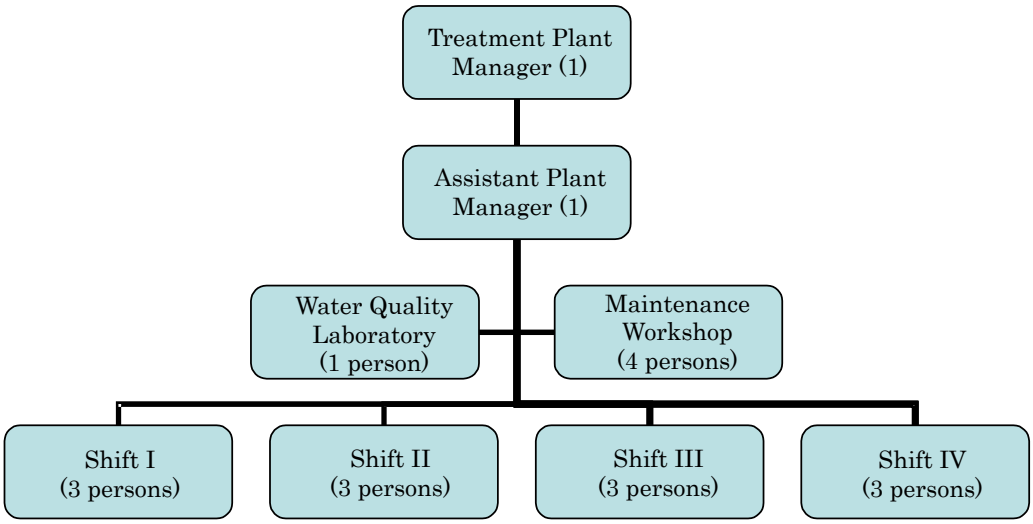


Figure 2-5 Current Staffing of Chrouy Changva WTP

The expanded water treatment plant, like the existing one, is composed of intake tower, water treatment, and distribution pumping facilities. All the activities can be managed by the existing technical personnel, plus some additional personnel as described in section 6-1-2 below, so that the plant is operated in good condition with proper operation and maintenance to maximize the functions of the equipment, extend its useful life and save on costly repairs in the future.

1) Raw Water Intake Facility

The proposed raw water intake facility consists of five intake pumps with appurtenances.

The production section should control the intake flow to supply raw water to meet daily demand. The laboratory section should monitor raw water quality to assure that the plant is operated to meet the national drinking water guidelines.

2) Water Treatment Facility

The production section will handle all of the production by the plant. The treatment process starts with pH adjustment and oxidization in the receiving tank, which is chemical dosing of the raw water, immediately followed by flocculation/sedimentation. These processes entail the conditioning of the raw water such that turbidity can be coagulated and allow the particles to grow to larger flocs in the flocculation tanks. Flocs are removed by settling in the sedimentation tanks, followed by the rapid sand filtration process.

The filtration flow rate is to be maintained and distributed hydraulically into each of the twelve filters by an influent weir installed at the inlet to each filter from the distribution channel. The highest filtration level at which washing will start will be controlled automatically by means of the water level in each filter and backwashing will then run for a pre-set time period. Thus the head loss of the filter sand will increase during the filtration cycle until washing is required.

Therefore, the production unit should firmly carry out the following key operations:

- Operate the plant at constant flow.
- Set the proper dosage of chemicals in the receiving well.
- Monitor the operation conditions of flocculation/sedimentation tanks and confirm regular desludging.
- Wash fitter units regularly to maintain good water quality.

Chemical feed pipelines and tanks should be flushed regularly to avoid clogging by impurities in the chemicals and retain the designed hydraulic performance. The equipment should be maintained periodically by the production unit to secure uninterrupted operation.

To achieve optimal water treatment, it is vital to analyze the quality of raw water and effluent from the filter units after chlorination with reference to the national drinking water guidelines. Typical water quality parameters to be analyzed daily are pH, temperature, turbidity, and residual chlorine. These water quality controls should be conducted by laboratory staff in cooperation with the production section.

3) Clear Water Pumping Facilities

The clear water pump station includes two clear water pumps to supply water to the distribution network. Each pump system comprises a suction valve, check valve and electrically operated discharge valve.

Energy or electricity consumption is the largest operating cost for the water treatment plant, so careful attention must be paid to operation of the clear water pumps, especially daily fluctuation of the delivery pressure. No excessive pressure should be given to the distribution network.

4) Wash Water and Sludge Treatment Facilities

In case wash water and sludge treatment facilities have to be introduced to the plant, the dewatering facility should be operated with special care. The facilities are very sophisticated and easily damaged compared with other treatment facilities in the plant.

Also sludge generation is a function of the turbidity of raw water. Operation hours of the facilities will vary seasonally; therefore, a flexible operation system is required for these facilities.

O&M items mainly focus on overhaul of mechanical/electrical facilities including electrical power receiving facilities. The operation and maintenance manuals for equipment and facilities should be fully understood by the engineering department.

The major issues involving operations and maintenance are centered in and around the maintenance of equipment/facilities, and logistics of maintenance resources such as materials, spare parts, tools and equipment. Thus planning and coordination among operations, maintenance,

material control, and procurement activities should be well coordinated by the manager of budget allocation, resulting in sufficient repair and maintenance works.

2-2 Transmission and Distribution Systems

2-2-1 General

The Master Plan considers zoning and monitored distribution by blocks organized around a redundancy system as the definitive strategy offering an economic and sustainable solution. However, its impacts have not yet been evaluated. The purpose of this feasibility report is to assess the different alternatives based on their modeling results. For the purpose of this comparison, some key points were selected on the network. The impact of any envisioned system modification is observed and analyzed on each of these key points.

Tests are built so as to seek the most effective solutions from both hydraulic and energy standpoints. For accurate results with regard to the latter, the "energy cost" functionality of the WaterCAD software has been used. Though it does not claim to deliver exact results, this facility is useful to compare and evaluate the outputs of different scenarios.

The following criteria, based on the Master Plan, have been used to guide system development and establish the location of equipment:

1) Ensure that the agreed level of service be met for all consumers and increase supply security.
2) Use existing infrastructure efficiently.
3) Because lifetime of the Water Tank and Transmission Pipeline are over 50 years, the system should be planned reasonably flexible to adapt to city development variations and further longer term development after the designed system is commissioned.
4) System operation and optimization must be considered to ensure costs are acceptable to the community.

2-2-2 Evaluation of the Existing Conditions

(1) Water Production Management

The present state and use of the water treatment plants, as analyzed by the Study Team, is as follows:

1) The Chrouy Changva WTP presently delivers a very high (65 m) hydraulic grade, with a very low efficiency since it generates significant energy losses. Actual production volume of this WTP is much smaller than its nominal capacity (65,000 m^3/day). This WTP presently feeds water to the northern and western main branches of the system.

2) In contrast, the Phum Prek WTP produces 150,000 m^3/day with a 45 meter hydraulic grade and efficient use of energy, supplying the southern part of the network. This facility already works at its upper capacity limit.

3） The Chamkar Mon WTP, despite its high outlet hydraulic grade (75 m), is unable to satisfy the most southern demand (Ta Khmau) due to inadequate transmission lines.

Given this situation, it has been recommended that the Chrouy Changva WTP equipment be revised towards a less powerful and energy-demanding installation. Simulations clearly confirm that limiting the inlet head will considerably limit the losses along the transmission network.

When necessary to ensure adequate pressure toward the western end of the network, it would be of much more benefit to do so through the installation of a booster next to the Airport water tank.

(2) Water Transmission Balancing

The opportunity to open the valves and bind the Chrouy Changva and Phum Prek WTPs at the root point of the Airport and Pochentong western branches is a major issue.

Simulations show that in the present production situation, this opening would lead to a considerable increase of energy losses, with little result on the satisfaction of water demand. The reason is that pressure from the Chrouy Changva WTP causes reverse flow into the Phum Prek WTP.

However, if the Chrouy Changva WTP pumping power can be decreased to reduce this excessive head, the two treatment plants can be coupled with benefit for the balance of distribution across the whole area they serve.

The completion northwards of a closed loop around the Ruessei Kaev area, and the connection westwards of the Airport and Chaom Chao branches, will then naturally complete the transmission skeleton to improve pressure balance in normal use, and to increase PPWSA's capacity to offer a continuous service to most customers whenever any section of these lines must be temporarily disabled.

2-2-3 Applied Conditions

2-2-3-1 Water Demand

Table 2.4 shows the average daily water demand estimated in the Master Plan by the Study team for each zone and each target year.

The relative part of peripheral zones in the whole water demand will grow from about 8 percent today to almost 20 percent in 2020. These zones often concentrate both the highest poverty and the highest industrial potential.

Based on the Master Plan water demand projections per sub-district for each target year, average daily water demand, transmitted by three main water transmission loops, has been calculated. The results of this calculation are summarized in the table below. Average daily water demand for each transmission loop is divided by zones.

Table 2.4 Average Water Demand for each Transmission Loop Segmented by Zone

	Transmission Loop	Average Daily Water Demand for each Transmission Loop					Unit: m^3/day
		Central Zone	North Zone	West Zone	Airport Zone	South Zone	Loop Total
2010	Ruessei Kaev	6,184	4,299	0	0	0	10,483
	Prey Pring Cheung	56,662	0	4,324	3,474	0	64,460
	Ta Khmau-Dangkao	1,178	0	0	602	4,596	6,375
	Others	81,852	334	295	1,551	1,178	85,211
	Zone Total	145,877	4,632	4,619	5,627	5,773	166,529

2-2-3-2 Water Head and Hydraulic Grade

The intervals recommended for heads at WTP pumping station outlets for the first stage of the Master Plan are given in the table below.

Table 2.5 Planned Head of WTPs and Hydraulic Grade

Pump Heads and required pressures								
WTP	Chrouy Changva		Phum Prek		Chamkar Mon		Nirouth	
Year	Head at Outlet (m)	HG at C1 (m)	Head at Outlet (m)	HG at Outlet (m)	Head at Outlet (m)	HG at Outlet (m)	Head at Outlet (m)	HG at C2 (m)
2010	47<<55	45<<55	- ditto -	55	-	-	-	-

Note: HG = Hydraulic Grade, C1 = Chrouy Changva Bridge, C2 = Monivong Bridge

2-2-3-3 Water Tank

There are four water tanks in existence or under construction in the Study Area, as shown in the table below. In each area covered by a water tank, pressure is limited by the water tank height. This pressure control should enable maintenance of a good quality of distribution up to the year 2010, when underground reservoirs associated with pumping stations could be planned to take over the pressure control while the network develops and the water demand increases.

Table 2.6 Water Tanks

Water Tank	Service Zone	Loop	Status
T1: Olympic Stadium	Central	-	Existing
T2: Chom Chao	Airport	Prey Pring Cheung Loop	Under Construction
T3: Pochentong Airport	West	Prey Pring Cheung Loop	Under Construction
T4: Chrang Chamreh	North	Ruessei Kaev Loop	Under Construction

2-2-3-4 Simulation Criteria, Guidelines and Indicators

Simulation Criteria

According to the Master Plan, the main requirements for the 2010 system are:

1) a significant improvement of the water supply towards the southern part of the city, especially Ta Khmau, Mean Chey and Dangkao area;
2) the elimination of current low-pressure problems in Ta Khmau, Trapeang Krasang, Chaom Chau, Phnom Penh Thmei; and
3) the balancing of water pressures in the northern and western areas, thanks to the creation of loops.

The minimum supply head to be adopted is 20 meters at any supply outlet, the targeted value being 30 meters by 2015.

Table 2.7 System Requirements for Simulation in 2010

Hydraulic grade	In the main network Everywhere as result	< 55.0 m > 30.0 m	
	Distribution system	> 20.0 m	
Velocity	Diameter	Max.	Min.
	> 1000 mm > 500 mm < 500 mm	1.6 m/s 2.2 m/s 1.8 m/s	0.2 m/s 0.3 m/s 0.3 m/s
Water Demand	Hourly coefficient	1.63	0.37
Loss rate	Stable for 2005-2020	1.15	
Energy cost	Kw/h reference	US$ 0.13	
Pipe material	Transmission	Ductile Iron	
	Distribution	HDPE if < 225	
C value (Hazen & Williams)	Ductile Iron	130	
	HDPE	150	
	Smooth steel pipe	110	

Reference Indicators

Our analysis evaluates action results and compares alternatives based on data observed at a few key points. It must be strongly underlined that the Master Plan refers to a target reference state of the network which is supposed to be achieved in 2020.

At each implementation stage the positioning and sizing of facilities must be driven by the perspective of this final objective. As a result, some transmission line segments that are planned in the first (2010) implementation stage might appear oversized if the vision is limited to the 2010 (or 2015) demand forecast and supply planning. These elements are highlighted and explained in the Master Plan.

The reference indicators that have been selected and used are presented in the table below.

Table 2.8 Reference Indicators for Evaluation and Comparison of Alternatives

Indicator	Location	Parameter Unit	Comment
TFM (totalizing flow metered : m^3/d)	Outlets of all WTPs: - Chrouy Changvar (WTP1) - Phum Prek (WTP2) - Chamkar Mon (WTP3) - Nirouth (from 2014 on) Representative Pressure pipes: - A, B, C, D, E (Ref. Figure)	- Flow of Pressure Pipe (m^3/d),(l/s) - TFM (m^3/d) (totalizing flow metered) - Flow Velocity (m/s)	For a given water demand, the comparison of water quantities injected into the system at each WTP enables to evaluate the balancing level achieved between the different sectors. The flow repartition also highlights the head-related interactions which can restrain the efficiency of pumping and yield considerable energy losses.
Reference base pressure	Chrouy Changvar bridge - C1	- Pressure of junction: Hydraulic Grade (m)	This point is taken as a reference in various studies and especially the recent energy saving study by BCEOM.
Most remote pressure junction nodes	Svay Pak, Ta Khmau, Kien Svay, Preaek Lieb, Cheung Aek, Baek Chan, Samraong Kraom	- Pressure of Junction: Hydraulic Grade (m) Head (m)	These nodes are the remote ends of each branch. The stake is to supply them with regularity and within the bounds of the Master Plan criteria (especially regarding pressure).
Pipe and/or Junction in Downstream (D/S) of each water tank	Representative Pressure Pipe: - P284: D/S of T2 - P259: D/S of T3 - P276: D/S of T4 - P3579: D/S of Ta Khmau	- Flow of Pressure Pipe (m^3/d),(l/s)	The operation conditions of water tanks currently under construction of course are a good indicator but their global analysis cannot be run in the restricted framework of this feasibility study. We choose the observation pressure junction at the downstream proximity of each tank.
	Representative junctions: - J445: D/S of T2 - J446: D/S of T3 - J449: D/S of T4 - J230: D/S of Ta Khmau	- Pressure of Junction: Hydraulic Grade (m)	
Central nodes on each loop	Chosen for representatives - J-476: PPCL - J-495: RKL - J-550: PPCL	- Pressure of Junction: Hydraulic Grade (m) - Flow of Pressure Pipe (m^3/d),(l/s)	So as to check the operation of each loop.
KPI	Global	- KPI = TFM – TFS / WD	The whole of water injected in the network should be as close as possible to the actual customer supply.

Note: PPCL =Prey Pring Cheung Loop, RKL =Ruessei Kaev Loop
Water Tank: T2= Chom Chau, T3= Airport, T4= Chrang Chamreh

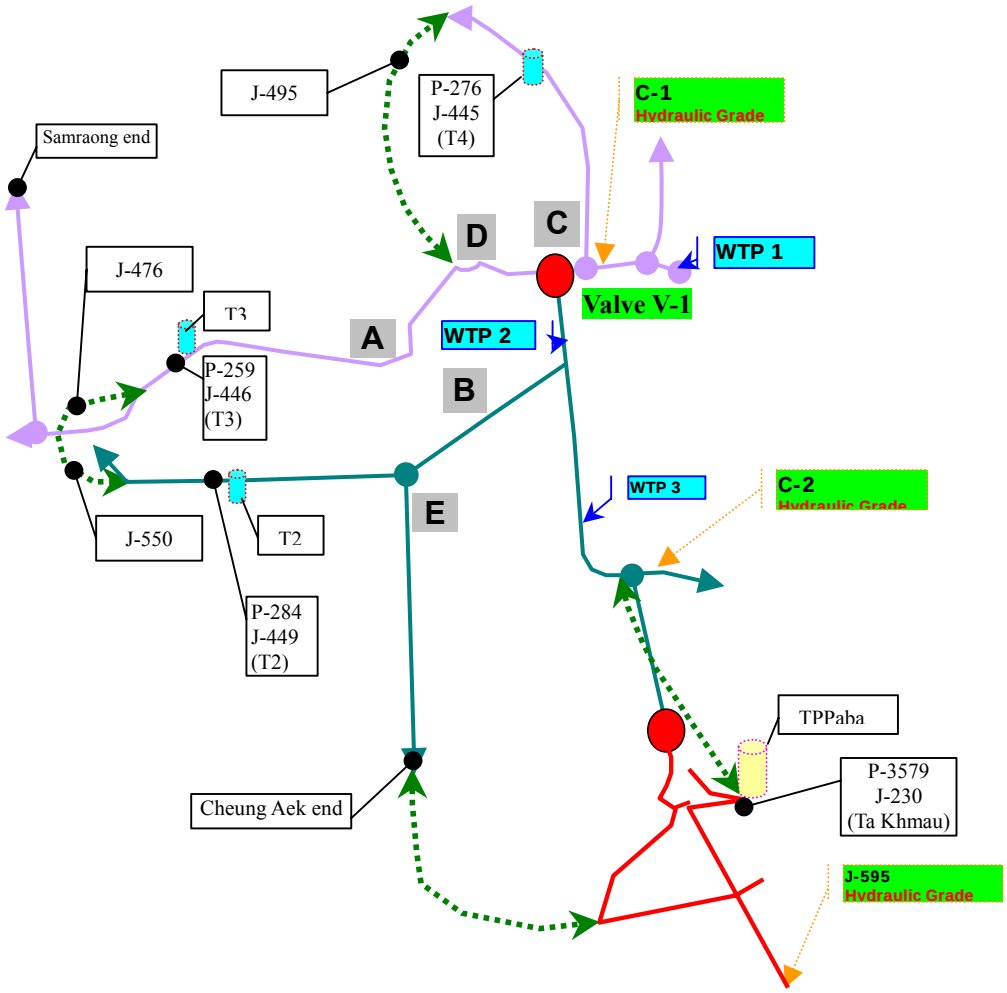


Figure 2-6 Location and Names of Reference Control Points

2-2-4 Recommendation for Zones and Loops

As described in the Master Plan, the service area can be divided into 5 zones as illustrated below.

Name of Zone	Description
Central zone	・ Spreading around the three existing WTPs ・ This area accounts for majority of water demand (92 percent today and 81 percent in 2020).
North zone	・ Supplied by the new Ruessei Kaev loop, supported by the Chrang Chamreh water tank
West zone	・ Supplied by the northern branch of the Prey Pring Choeung loop, supported by the Airport water tank
Airport zone	・ Supplied by the southern branch of the Prey Pring Choeung loop, supported by the Chaom Chao water tank
South zone	・ Supplied by the new transmission pipe ・ After installation of the Nirouth WTP, supplied by the Ta Khmau and Dangkao loop

Stage I of the Master Plan focuses on reinforcing or creating the two main transmission loops by connecting existing branches. Implementation of another main transmission loop, Ta Khmau and

Dangkao loop, is scheduled in Stage III. These three main transmission loops are summarized in the following table.

Table 2.9 Main Transmission Loops

Name of Loop	Description
Ruessei Kaev loop	・ Located in Ruessei Kaev district ・ This loop supplies water towards the north zone and central zone.
Prey Pring Cheung loop	・ Located around the Pochentong airport ・ This loop supplies water towards the west zone and airport zone.
Ta Khmau and Dangkao loop	・ This loop supplies water towards the south zone and central zone.

In each zone, distribution is organized along the main loop crossing the zone, originating from the associated WTP(s). The water tank(s) located in or close to the zone allow for pressure balancing.

The following two different types of loops can be distinguished, which perform slightly different functions:

1) The **reflexive loop**, offers the possibility to intercede on some part of the network without interrupting the distribution, though this distribution may be exclusive. In normal operation it enables an excellent flow control and a better distribution of pressures across the served areas. Two loops follow this principle: the Ta Khmau-Dangkao loop in the south and the Ruessei Kaev loop in the north.

2) The **interconnection loop**, which is fed by different sources and offers additional redundancy and flexibility of resources allocation. In addition it enables for pressure balance and thus increased security; and it allows avoiding interactions between close pumping groups. The Prey Pring Cheung Loop is an excellent example of such a loop. With the second stage of the Master Plan, the Mean Chey-Thmey loop will be another one.

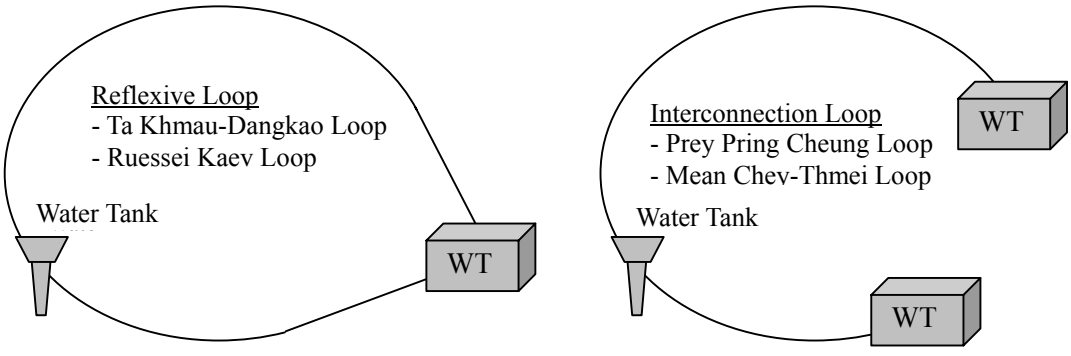


Figure 2-7 Reflexive Loop (left) and Interconnection Loop (right)

2-2-5 Recommendation for Independent Distribution Blocks

The major part of Phnom Penh water demand today is concentrated in the central zone. This zone offers sufficient pressure thanks to the proximity of the three WTPs. However as the network

extends towards the city's peripheral areas, pressure weakens and will be supplemented at peak hours through the means of water tanks.

Each autonomous transmission loop feeds different sub-areas through sub-networks or "blocks," which are disconnected from each other and connected to the main loop only at one entry point each, as shown on Figure 2-8.

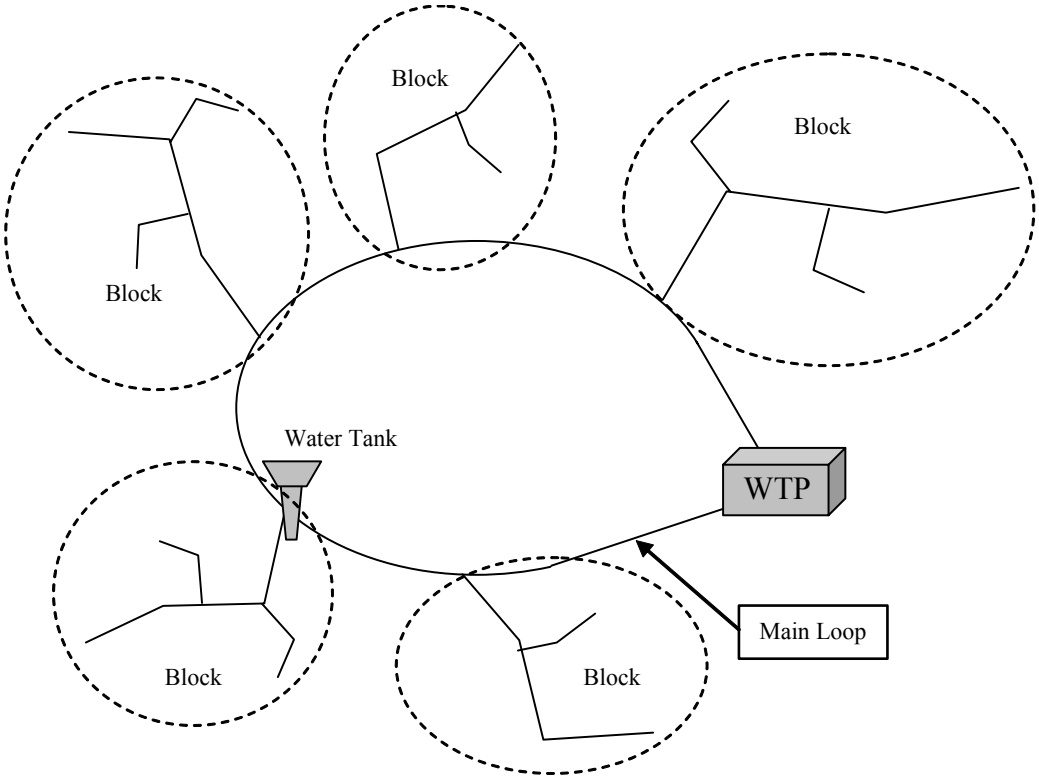


Figure 2-8 Principle of Independent Distribution Blocks Connected to Main Loop

From a security point of view, this structure offers the advantage to allow an intervention in any point of the transmission loop, with no interruption of the distribution on any blocks – provided valves are adequately installed on both sides of each connection point.

Similarly, an interruption in any block will have no impact on the ability to continue distribution to any other blocks connected to the same main loop.

2-2-6 Monitoring and Management Principles

The above structure will enable monitoring of the system on a per-block basis, provided measurement equipment is installed at each of these entry points.

If the loop depends on one sole WTP, the sum of consumption measured on these block entry points will be equal to the flow measured at the outlet of this WTP, minus transmission losses in the main loop. This is illustrated in Figure 2-9.

It is however desirable to arrange and enable connections among the main loops, and to secure the possibility for each one to be fed by other WTPs, as suggested by the "interconnection loop" model. Though this will slightly increase the complexity of the monitoring system, it will appreciably widen the range of management and regulation possibilities.

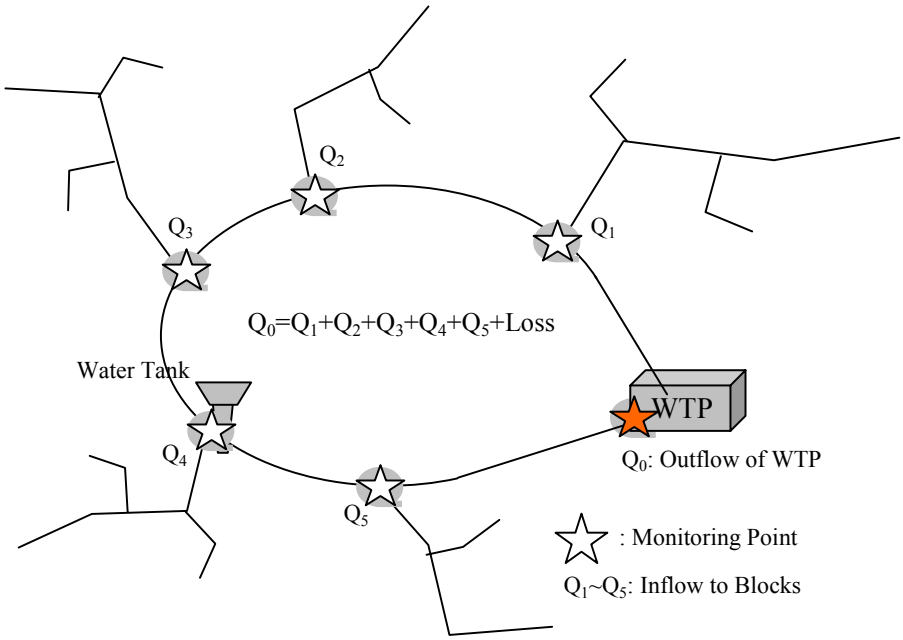


Figure 2-9 Monitoring Principle Based on Independent Blocks

To achieve this, more than 200 valves must be closed on the current network to isolate the distribution blocks. These blocks are normally fed through a unique point which is equipped with a telemeter. Such a system enables:

- control of each consumer zone
- easier identification of online losses, and
- better management of consumer satisfaction parameters.

On the other hand, it is difficult to regulate flows and pressures inside a block. A prerequisite and minimum requirement is therefore to control pressures at the block entry point. Multiplying the blocks will thus enable PPWSA to provide a better quality of service, to limit the risks of system failure and to better detect and isolate malfunctions. A close follow-up of the telemeter data enables adjustment of the service to accommodate consumer demand.

In the city core, the highly meshed network structure does not allow to alleviate every failure solely through the operation of valves. The new network with main loop and blocks has advantages over the existing system. Fitted with a telemeter at their base, these branches can hence be assimilated to large distribution zones. They also match the development axes along which the water demand is expected to increase most.

Along with the Master Plan principles, especially the loop-based reorganization of distribution, blocks shall be designed so each one covers a coherent part of the distribution area. This partition of the supplied area has been drafted for each stage of the Master Plan, based on the evolution of demand and expected final organization of the network. Telemeters are placed along the network so as to maximize the benefit of their exploitation at each development stage.

90 blocks with an average surface of 293 hectares and an approximate doubling of the current number of telemeters will be achieved by 2020. 59 telemeter locations are set for 2010, including the 42 existing ones.

2-2-7 Simulation Results and Sizing

Each of the planned actions was tested individually, since they induce different impacts. The detailed test results are presented in the Supporting Report.

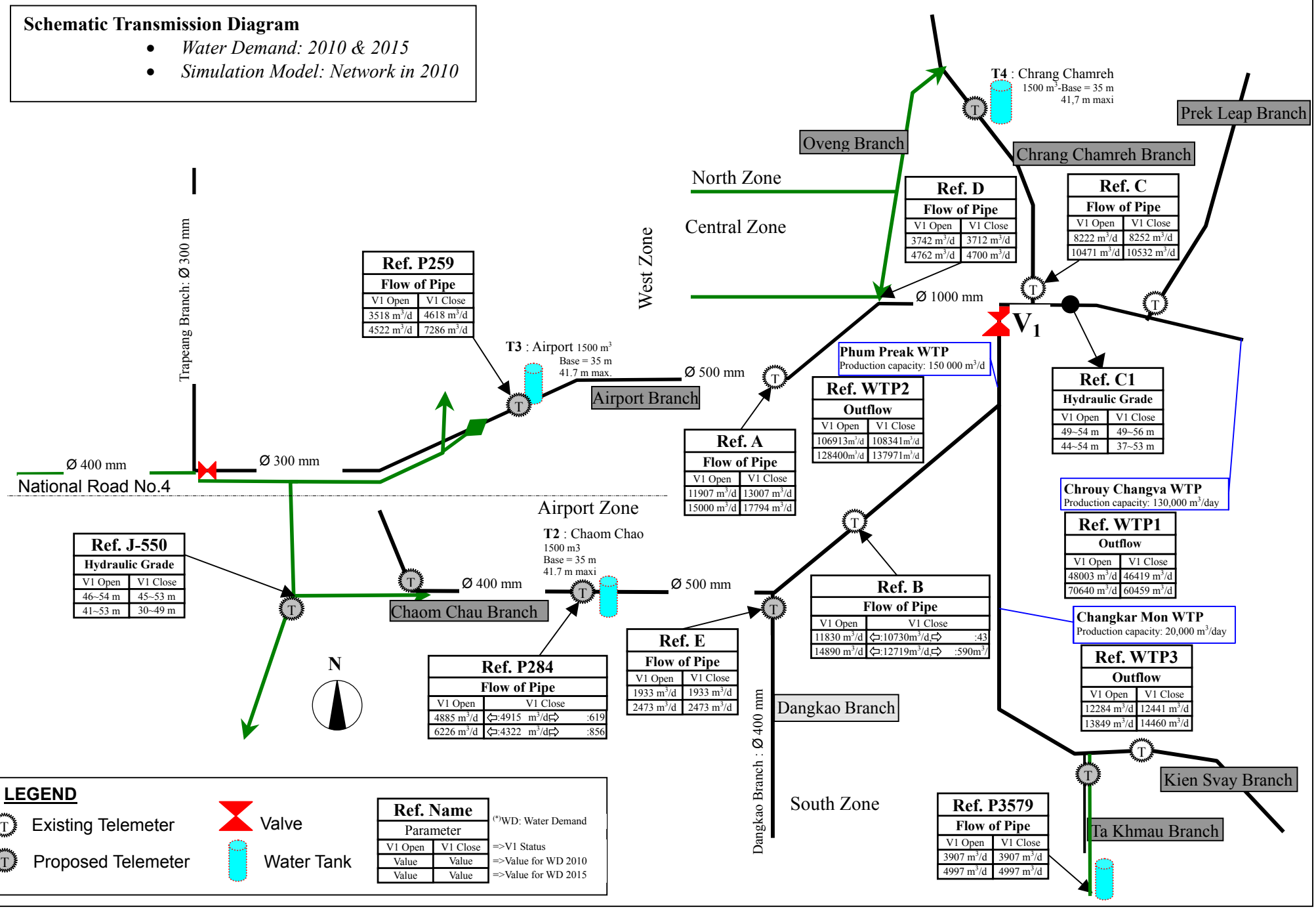
The main objective was to reach the best match between production and consumption. This assumes that the system operates properly and that the unaccounted losses do not invalidate the results.

The mutual compatibility of different possible actions must be taken into account prior to the design of each scenario. Scenarios were built to evaluate the impact of the following options:

1) **Present state**: straightforward hypothesis where no modification would be brought to the current network.
2) **Extensions as a tree network (V1 closed)**: layout of the main envisioned network extensions, though the intrinsic tree nature of the current network would be preserved.
3) **Extensions as a tree network (V1 open)**: based on the previous case, this scenario assesses the impact of re-opening this major junction between the Chrouy Changva and Phum Prek WTPs, and the main north and west transmission lines.
4) **Loops completed (V1 closed)**: addition to the second case of the planned connection between the two extremities of each loop's main branches.
5) **Loops completed (V1 open)**: re-opening V1 valve in the above situation.

Each scenario was tested against the current water demand condition, and then against the projected water demand for 2010. To evaluate the sustainability of each scenario, several configurations also have been tested against the projected 2015 and 2020 conditions.

As a comparison reference, we first ran simulations of the "no further action taken" hypothesis. These simulations cover the present situation, with the exception that the three water tanks currently under construction have been integrated into the model. In the first stage, valve V1 is supposed to remain closed.


Schematic Transmission Diagram
Water Demand: 2010 & 2015
Simulation Model: Network in 2010
T4 : Chrang Chamreh
1500 m3-Base = 35 m
41,7 m maxi
Prek Leap Branch
Oveng Branch
Chrang Chamreh Branch
North Zone
Central Zone
West Zone
Ref. D
Flow of Pipe
V1 Open V1 Close
3742 m3/d 3712 m3/d
4762 m3/d 4700 m3/d
Ref. C
Flow of Pipe
V1 Open V1 Close
8222 m3/d 8252 m3/d
10471 m3/d 10532 m3/d
Ø 1000 mm
V1
Ref. P259
Flow of Pipe
V1 Open V1 Close
3518 m3/d 4618 m3/d
4522 m3/d 7286 m3/d
T3 : Airport 1500 m3
Base = 35 m
41.7 m max.
Ø 500 mm
Airport Branch
Trapeang Branch: Ø 300 mm
Phum Preak WTP
Production capacity: 150 000 m3/d
Ref. WTP2
Outflow
V1 Open V1 Close
106913m3/d 108341m3/d
128400m3/d 137971m3/d
Ref. C1
Hydraulic Grade
V1 Open V1 Close
49~54 m 49~56 m
44~54 m 37~53 m
Ref. A
Flow of Pipe
V1 Open V1 Close
11907 m3/d 13007 m3/d
15000 m3/d 17794 m3/d
Ø 400 mm
National Road No.4
Ø 300 mm
Airport Zone
Chrouy Changva WTP
Production capacity: 130,000 m3/day
Ref. WTP1
Outflow
V1 Open V1 Close
48003 m3/d 46419 m3/d
70640 m3/d 60459 m3/d
Ref. J-550
Hydraulic Grade
V1 Open V1 Close
46~54 m 45~53 m
41~53 m 30~49 m
T2 : Chaom Chao
1500 m3
Base = 35 m
41.7 m maxi
Ø 400 mm
Ø 500 mm
Chaom Chau Branch
Ref. B
Flow of Pipe
V1 Open V1 Close
11830 m3/d ⇦:10730m3/d,⇨ :43
14890 m3/d ⇦:12719m3/d,⇨ :590m3/
Changkar Mon WTP
Production capacity: 20,000 m3/day
Ref. WTP3
Outflow
V1 Open V1 Close
12284 m3/d 12441 m3/d
13849 m3/d 14460 m3/d
N
Ref. P284
Flow of Pipe
V1 Open V1 Close
4885 m3/d ⇦:4915 m3/d⇨ :619
6226 m3/d ⇦:4322 m3/d⇨ :856
Ref. E
Flow of Pipe
V1 Open V1 Close
1933 m3/d 1933 m3/d
2473 m3/d 2473 m3/d
Dangkao Branch
Dangkao Branch : Ø 400 mm
Kien Svay Branch
South Zone
Ref. P3579
Flow of Pipe
V1 Open V1 Close
3907 m3/d 3907 m3/d
4997 m3/d 4997 m3/d
Ta Khmau Branch
LEGEND
Existing Telemeter
Proposed Telemeter
Valve
Water Tank
Ref. Name
Parameter
V1 Open V1 Close
Value Value
Value Value
(*)WD: Water Demand
=>V1 Status
=>Value for WD 2010
=>Value for WD 2015

2-2-8 Summary and Recommendations

In 2010 the system will have been upgraded with:

- network extension from 282 to 353 km of transmission pipes,
- upgraded capacity of Chrouy Changva WTP, from 65,000 to 130,000 m3/day,
- a new 900 mm pipe from this WTP to the Chrouy Changva bridge,
- a new water tank and transmission to supply Ta Khmau area,
- a new distribution security and sustainability policy with redundancy and energy saving incorporating:
  - loop systems;
  - independent pumping station and reservoirs; and
  - monitoring improvements.

Besides the five main projects, in order to make the installations reliable and improve services it appears important to further fit the water tanks with clear water reservoirs.

The ongoing projects (extension of the Chrouy Changva WTP with 2000 meters more transmission lines and the prolongation of some existing lines) will enable the piped water supply to reach some outlying areas with sufficient water demand.

This will require a prolongation of the network with about 70 km of new pipes dedicated to transmission in 2010. 52 km of them are planned in the Master Plan, as detailed in Table 2.10 below; the rest being already laid or under implementation.

Important transmission pipes are usually laid under the roadway, which facilitates the work by reducing possible interference with other infrastructure laid under the pavement.

The 2010 CDS mainly focuses on short-term development zones. Thus its implementation should be planned to these developments to respect the priorities and avoid redundant work to the extent possible.

Some additional infrastructure will need to be considered at the time of laying out the pipelines, as indicated in Table 2.11.

Table 2.10 CDS 2006-2010: Pipe sizes for the first stage of Master Plan.

Projects	**Ta Khmau Transmission**		**Prey Pring Cheung Loop**		**Ruessei Kaev Loop**		**WTP Chrouy Chanva-2**		**Transmission Extend**		Total
Diameter	Length (m)	Zone	Length (m)	Zone	Length (m)	Zone	Length (m)	Zone	Length (m)	Zone	Length (m)
1000											0.00
900							1,955	Center			1,955.00
800					967	Center					967.00
600					4,572	Center					4,572.00
500	5,313	South	5,962	West/Airport	5,397	Center/North					16,672.00
400	153	South	3,161	West/Airport	3,180	North			4,224	North	10,718.00
300			1,622	West					8,434	N,W,S	10,056.00
250									5,834	S,W,N	5,834.00
225									1,351	Central	1,351.00
Total	**5,466**		**10,745**		**14,116**		**1,955**		**19,843**		0.00
										Total CDS 2006-2010	**52,125.00**

Table 2.11 Infrastructure related to the main pipe layout, year 2010

Zone	**Pipe diameter (mm)**	**Name of infrastructures**	**Specific location**	**Length of structure**
Central	300	Concrete bridge #1, on NR#6A	PK 6+550 (Prek Leap Agricultural College)	19m
	300	Concrete bridge #2, on NR#6A	PK 7+700	32m
	300	Concrete bridge #3, on NR#6A	PK 8+550	19m
North	300	Concrete bridge, on NR#5	Prek Pnov Bridge	approx. 60m
	400	Box Culvert along the road to Km #9		
West	300	Railway to BB	At Samrong Kraom village	Crossing length approx. 20m

2-2-8-1 Pipe sizing

The choice of pressure pipe diameters is based on:

- Hydraulic parameters (flow, head losses, velocities) for gravity supplies,
- Optimum hydraulic and economic parameters (pumping costs and asset depreciation) for pump-assisted supplies.

There is a need to quantify the possible risks of water hammer, cavitation, and abrasion as a function of the operating conditions, and to install suitable protection against them. In this regard, Phnom Penh is relatively favored by a flat topography. This is both an advantage, since the low level variations minimize the risk of shock waves (hammer), and a constraint, since initial pumping must be powerful and may generate conflicting pressures that consume much energy. Optimum elevation (pressure head) must be provided; the WaterCAD system allows for the necessary estimations.

Head losses are hydraulic energy losses caused essentially by the water viscosity and its friction against the pipe walls. The effect is:

- an overall pressure drop at the lower end of a gravity system,

- an increase in energy consumption in a pumping main.

This is the main reason why the Master Plan limits velocity in the primary network, that is, in order to reduce as much as possible the head losses, which increase significantly beyond 2 m/s. System longevity is another compelling reason.

2-2-8-2 Pipe materials

All the main branches have been built since 1992. Only distribution pipes and pipes smaller than 225 mm use HDPE. Ductile Iron is the standard material for all larger pipes.

Table 2.12 Transmission Pipe requirements to 2010

CDS 2006-2010											
Pipe Material	**Ductile Iron**									**DHPD**	**Length (m)**
Diameter	**1,200**	**1,000**	**900**	**800**	**600**	**500**	**400**	**300**	**250**	**225**	**m**
Length by segment			1,955	967	4,572	5,313	4,224	8,434	5,834	1,351	32650
						5,962	153	1,622			7737
						5,397	3,161				8558
							3,180				3180
Total			1,955.00	967	4,572.00	16,672.00	10,718.00	10,056.00	5,834.00	1,351.00	**52,125.00**

2-2-9 Monitoring Method

According to the design principles, a partitioning of the network into distribution blocks will be achieved through implementation of the Master Plan. The average block characteristics are summarized in the following table.

Table 2.13 Main Characteristics of the Existing and Projected Distribution Blocks

Monitoring			By Block					
Telemeter zone name	2005 Zone Description	2010 Zone Description	Estimated Number of Blocks	Approx. 2010 Zone average Surface	Attached to station	Air distance from Phum Prek WTP	2005 average flow	2006 average flow
				(ha)		(m)	(m3/d)	(l/s)
7th January	Downtown	Downtown	5	39	Phum Prek	1270	2811	33
Chamkar Mon	Downtown	Downtown	11	79	Phum Prek	3105	3017	35
Doun Penh	Downtown	Downtown	6	69	Phum Prek	991	3678	43
Tuol Kouk	Downtown	Downtown	6	132	Phum Prek	2517	3036	35
Mean Chey	Suburb	Downtown	10	204	Phum Prek	4893	1352	16
Ruessei Kaev	Whole North zone	Suburb	18	397	Phum Prek	4817	2746	32
Dangkao	Suburb	Suburb	30	630	Phum Prek	7136	3843	44
Ta Khmau	Kandal province		4	626.5	Phum Prek	10600	_	_

The locations selected for the telemeters result both from the network layout and from a morphological analysis by interpretation of aerial and satellite photographs, which precisely renders the typology of sites. We first outline the 90 blocks to be set up by 2020, utilizing relevant information from the City Urban Master Plan (BAU). However, we recommend flexibility regarding these block definitions. Actual block management can be fully designed and implemented only when the land development plan is complete. Monitoring will remain complex

as long as such development is ongoing, all the more wherever development trends remain uncertain. Although key parameters can be followed up and yield strategic information, they will not give any relevant information regarding daily management.

Two types of controls are considered in the proposed monitoring system. Flows and pressure will be monitored by appropriate equipment located downstream from each water tank as well as at each representative node of the tree networks. Some blocks will be indirectly monitored through a combination of several telemeters. The following diagram shows a concrete example of this approach, which we tried to avoid but sometimes cannot circumvent.

Figure 2-10 Some blocks are controlled indirectly

The above structure will enable for the monitoring of the system on a per-block basis, provided measurement equipment is installed at each of these entry points. Management of each block will have no impact on the ability to supply any other block connected to the same main loop.

However, it is desirable to arrange and enable connections among the main loops, and to secure the possibility for each one to be fed by other WTPs, as suggested by the "interconnection loop" model. Though this will slightly increase the complexity of the monitoring system, it will appreciably widen the range of management and regulation possibilities.

More than 200 valves must be closed on the current network to isolate the distribution blocks. These blocks are normally fed through a unique point which is equipped with a telemeter. Such a system enables:

- control of each consumer zone and an easier identification of online losses, and
- better management of consumer satisfaction parameters.

A prerequisite requirement is to control pressures at the block entry point. Multiplying the blocks will enable provision of a better quality of service, to limit the risks of system failure and to better detect and isolate malfunctions. A close follow-up of the telemeter data enables adjustment of the service to accommodate consumer demand.

In the city core, the existing highly meshed network structure does not allow to alleviate failures only through the operation of valves. The new network with main loops and blocks has advantages over the existing system. Fitted with a telemeter at their base, these branches can be

assimilated to large distribution zones. They also match the development axes along which the water demand is expected to increase most.

The loop-based reorganization of distribution blocks is suitable for the whole distribution area. Telemeters are placed along the network so as to maximize the benefit of their exploitation at each development stage.

90 blocks with an average surface of 293 hectares and an approximate doubling of the current number of telemeters will be achieved by 2020. 59 telemeter locations are set for 2010, including the 42 existing ones.

2-2-10 Operating the system

Some criteria were selected as the most important for evaluating the performance of the possible management operations. These are:

- security of the water supply;
- appropriate pressure range (matching the Master Plan recommendations);
- minimal head losses;
- resistance to severe peaks of water demand;
- lowest energy cost.

We assume the following to be part of the 2010 Central Distribution System as described in the Master Plan.

- T1 water tank start-up planned in 2006
- T2 water tank service planned in 2006
- T3 water tank service planned in 2006
- T4 s water tank tart up planned in 2006
- Taba (Ta Khmau) water tank startup planned in 2008
- Ruessei Kaev Loop startup planned in 2007
- Prey Pring Choeung Loop start-up planned in 2008

Based on the above criteria and assumptions, we review the major alternatives that are available to manage the system as follows:

Ruessei Kaev Loop

This loop will be activated as soon as it is completed, since this brings an optimal pressure across the areas supplied. It must be noted that this operation does not affect other networks, such as Prey Pring Choeung Loop and the southern network.

Prey Pring Choeung Loop

This loop will also be activated as soon as it is completed. Simulation results show that this will ensure a better balance and stability of pressures across the loop.

However, this operation causes a potential problem with respect to filling the T2 and T3 water tanks at peak periods - when the loop is activated there is a possibility that one of these water tanks will become empty. If the loop is closed, both of them remain in the upper range of their capacity.

V1 alve Status

Based on the results of network analysis and ongoing observation of the actual operating conditions (pressure, flow, etc.), valve V1 should be kept closed until the completion of the new WTP in Stage II of the Master Plan, around 2010, in order to avoid reverse flow into Phum Prek WTP.

Ta Khmau Dangkao Loop (Ta Khmau Branch)

The whole Ta Khmau area is to be supplied through the water tank. A pumping station is planned to assist filling this water tank. The pumps operation is monitored as follows:

- pumping starts when the level in the tank is below 31.5 meters HG;
- pumping stops when the level is above 36 meters HG.

Until completion of the Dangkao-Ta Khmau loop that is planned in 2015-2020, the Ta Khmau network will remain isolated and its supply will rely only on one 5,300 meter (Dia.500 mm) transmission pipe.

The Ta Khmau area supply may face a security issue in 2010-2015. In case a problem should arise with this pipe there are the following temporary measures:

- the water tank, hopefully full, would still have a reserve corresponding to 30 percent to 40 percent of the average daily consumption:
- The existing 300 mm dia. and 250 mm dia pipes could be used again temporarily for transmission; but it must be underlined that these pipes are already highly used for distribution along their layout.

To enable this operation, the downstream end of these pipes should not be disconnected from the network, but only closed by a valve.

2-3 Remote Monitoring Systems

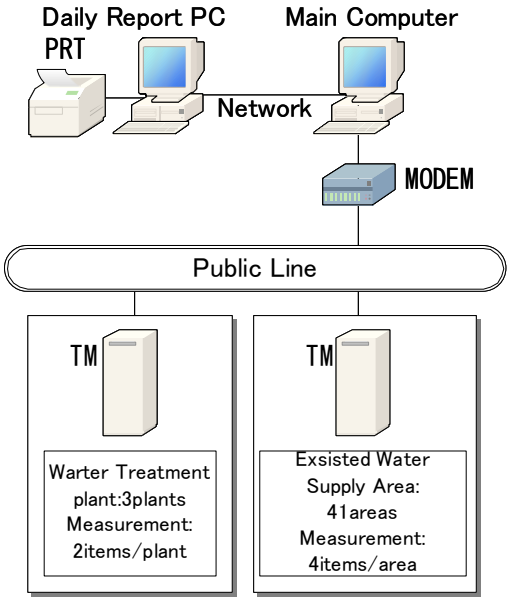
2-3-1 Outline of Existing Remote Monitoring System

There is a remote monitoring system covering the 42 existing remote stations (41 flow/pressure measuring points and 1 WTP) of the water supply system in Greater Phnom Penh. The central

station is located at the head office of PPWSA on the premises of the Phum Prek Water Treatment Plant. Remote stations are located at each remote monitoring point to collect field data and transmit them to the central station over the PSTN (Public Switched Telephone Network).

The system was established in 2002 with assistance from JICA to provide a centralized monitoring of the water distribution network. The central station consists of an operator station PC, a report PC, a modem device and a printer, while each remote station consists of a telemeter device equipped with input devices and a telecommunication module. The central station and the remote stations are connected automatically over the PSTN so that the data accumulated at the remote stations are transmitted to the central station 3 times a day in 8 hour intervals. It takes 1.5 hours to collect all the field data from the 42 remote stations to the central station by the polling method (central station calls each remote station). The data collected through the remote monitoring system has been utilized for analyzing water leakage on the water distribution networks, planning an effective and suitable rehabilitation schedule of the distribution network, etc.

Since the components of the central station have been transferred from the used system of a municipality in Japan, the version of operating system (OS) of the PC is not the latest and expected life time is short. It is preferable to upgrade the whole remote monitoring system to meet the improvement and the expansion of the water supply system in Phnom Penh under this Feasibility Study project. The existing system configuration is shown in the diagram at right.



2-3-2 Proposed Options for System Configuration

In addition to the existing 42 remote stations (flow/pressure measuring points and 1 WTP), 17 more remote stations are proposed to meet the improvement and the expansion of the water supply system in Greater Phnom Penh under this Feasibility Study.

Two mediums are mainly available as a data transmission channel, namely telephone lines and radio channels respectively. The two mediums are sub-divided into two mediums, a public switched telephone network and dedicated telephone lines from the telephone lines, and 150/400MHz band and GHz band channels from radio channels respectively.

2-3-2-1 Option A – PSTN

The public switched telephone network (Option A) is easily applied to the remote monitoring system, as it has been utilized in the existing monitoring system. It is feasible for the system to meet an expansion of the measuring points up to approximately 60, including the 42 existing points, because just 43 minutes (2.5 min X 17), in addition to 90 minutes for data collection from the 42 existing remote stations, are the estimated requirement to extend for data collection from the 17 proposed remote stations. However, it takes 2 to 3 days for the telephone lines to be fixed once they get malfunction because of bad weather or other causes. The physical conditions of the existing telephone lines are vulnerable to bad weathers, especially rainy situation and the maintenance staffs of telecommunication companies are not sufficient. The central station comprises an operator station PC, a data server (a connectivity server), a printer for event/alarm and report output, two modems, a UPS and an interface panel for the Phum Prek WTP, while each remote station comprises a telemeter device, an AC/DC converter, an uninterruptible power supply (UPS), etc.

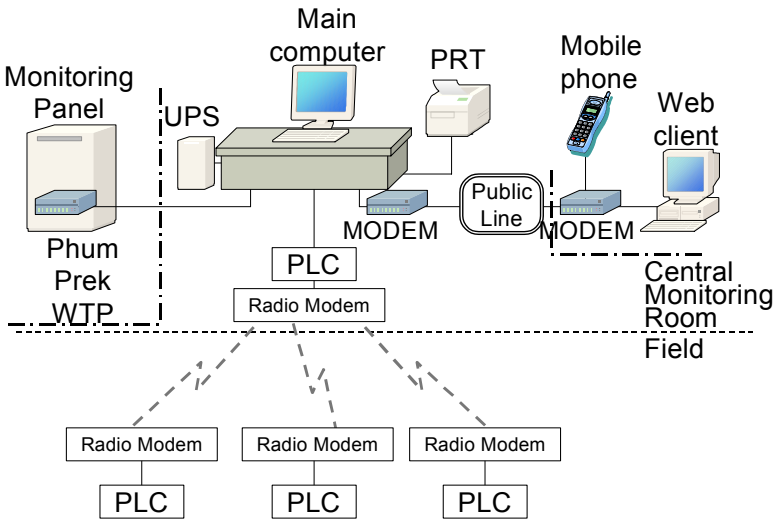
2-3-2-2 Option B – Dedicated Telephone Line

It is also possible to establish the remote monitoring system by linking up the central station with the remote stations over dedicated telephone lines. This option can provide continuous communication between the central station and each remote station enabling real time monitoring of the water distribution network. It is, however, more expensive than option A in terms of installation as well as operation and maintenance.

2-3-2-3 Option C – 150/400MHz Band Radio Network

Radio is also a good data transmission medium for linking up the central and remote stations scattered around the water distribution network of Phnom Penh because the Study Area is so flat that there is no obstacle to interrupt the radio waves. The 150/400MHz band is easily applied to the remote monitoring system taking simple system configuration into consideration. Since the 150/400MHz radio signal can travel 40 to 50 km, the radio network can easily cover both the existing and the proposed remote stations that are all within 12 km from the headquarters of PPWSA. The 150/400MHz band radio network (Option C) is the most recommendable transmission medium to achieve the remote monitoring system for the water supply system in Greater Phnom Penh from the viewpoint of reliability and economy. The radio network provides a reliable 24 hour per day data channel so that real time monitoring of the water distribution network can be achieved. Although the initial cost for this option is slightly higher than option A, this would become the most economical in five years because the annual operating cost is lower (than A or B). A radio device, a radio modem and an omni-directional antenna with a coaxial cable are all that is required to build the central station in addition to the system configuration of

option A. Each remote station comprises a PLC, a radio modem, radio device, a UPS and a directional antenna with a coaxial cable. The system configuration for option C is shown as follows:



2-3-2-4 Option D – GHz Band Radio Network

A GHz band radio network has been proposed for a PPWSA water tariff billing and collection system connecting the headquarters with three regional commercial offices that are currently being established under the new water towers. The frequency of 2.4 GHz will be utilized for data transmission. The GHz band could be utilized as a common data transmission channel for both the tariff collection system and the process monitoring system after consolidating the data at each water tower. The components making up the tariff collection system and the process monitoring system are provided separately at the headquarters of PPWSA and each water tower. In addition to the system configuration of the water tariff system, four multiplexers, three for the water towers and one for the headquarters of PPWSA, would be required to be installed before the radio devices in order for the process monitoring system to utilize the 2.4GHz band. The initial cost for this option (D) is slightly higher than option C, as the radio devices and radio modems are more expensive due to higher frequency. The system configuration for option D is the same as option C.

2-3-3 Recommendation

As described above, there are four practical ways available for data transmission of the remote monitoring system. The Project represents a good opportunity to replace the existing remote monitoring system for general improvement and to cope with the additional demands of managing the expanded water supply system in the future.

Option C, the 150/400MHz band radio network, is the most recommendable approach among the four options presented from the viewpoint of the following:

- economy
- reliability
- simplicity and ease of maintenance
- expandability and compatibility

Chapter 3. Rehabilitation Project

Chapter 3. Rehabilitation Project

Water treatment facilities, especially the mechanical and electrical equipment, will experience a lowering of efficiency over ten to fifteen years due to deterioration from wear and will become more easily damaged. Therefore, PPWSA needs to secure the budget for a long-term, regular replacement/rehabilitation project.

3-1 Rehabilitation Works

During 2006-2010, the following plants will pass more than ten years since their construction.

- Chamkar Mon WTP – 1 and 2 (total 20,000 m^3/d)
- Phum Prek WTP – 1 (100,000 m^3/d)

Rehabilitation works are recommended for these existing treatment plants.

The rehabilitation works consist of overhaul, repair, replacement and/or improvement of mechanical equipment, electrical equipment and, instrumentation that usually deteriorate after 10 to 20 years of use.

The actual contents of the works shall be determined by PPWSA considering the budgetary resources available and the seriousness of the deterioration of the equipment.

The followings are examples:

Chamkar Mon WTP

a. Replacement of old distribution pumps with high energy consumption

   (existing) 420 m^3/hr x 60 m / 320 m^3/hr x 70 m x total 3 sets

   (new) approx. 700 m^3/hr x 45 m x 3 sets

b. Modification of power supply system for intake pump station

   Direct power supply with low voltage of 400 V will be provided to the intake pump station.

Phum Prek WTP

a. Replacement of intake flow meter with improper operation

   Intake flow meter is not working properly; new flow meter (measures flow by measuring overflow level of intake weir) will be installed.

b. Replacement of deteriorated drive units of flocculators

   The existing drive units are old and should be replaced before any serious damage occurs.

c. Replacement of deteriorated inlet gates and modification of flow regulators of filters

The existing inlet gates cannot stop inflow properly; replacement with new motorized inlet gates will be required soon. Also, some modification of the flow regulators is recommended for reduced and easier maintenance.

d. Pressure monitoring system (SCADA) for less energy and proper operation

Water distribution pressures will be monitored at distribution mains of three water treatment plants and one major junction on the distribution network. These data are utilized for proper operation of the distribution network and energy-conserving management of distribution pumps at the plants.

e. Automatic water quality monitoring system needed for proper operation

For automatic monitoring of turbidity (raw/treated), alkalinity (raw/treated), pH (treated) and residual chlorine (treated).

f. Laboratory equipment for proper water quality control

Chrouy Changva WTP

a. Replacement of distribution pumps to save energy

(existing) 1350 m^3/hr x 65 m x 3 sets

(new) approx. 1600 m^3/hr x 43 m x 3 sets

Chapter 4. Peri-Urban Water Supply Project

Chapter 4. Peri-Urban Water Supply Project

4-1 Study Method

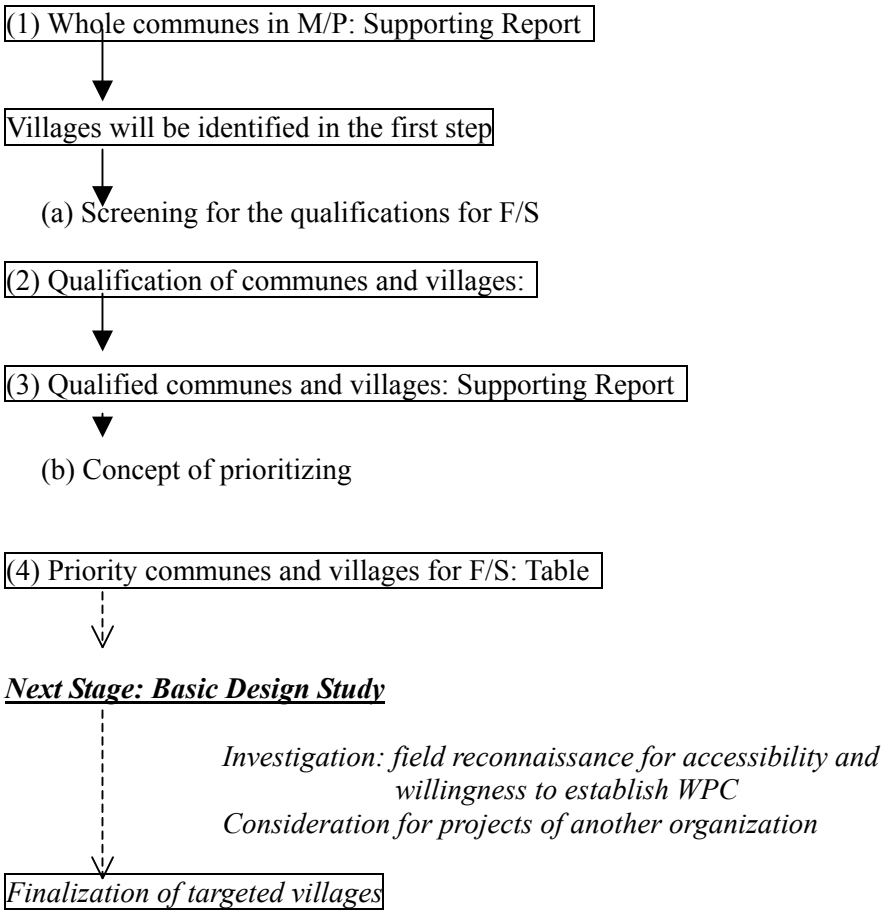
This feasibility study (F/S) was conducted on the basis of existing data. No new field investigations were conducted. Therefore, matters such as demand according to water supply condition, awareness of hygiene and willingness to establish WPC are not investigated. Accessibility to villages was judged by interpretation of satellite images. Accordingly, field investigation for these should be conducted in the future Basic Design Study (B/D).

4-2 Selection of the Priority Commune and Village

The target population of well water supply totals up to 182,070 in the M/P of 2020 shown in Supporting Report. In the F/S stage, communes and villages will be selected for attaining the target of safe water coverage of about 60 percent.

The flow chart of the selection procedure for priority communes and villages is as follows:

In this stage: F/S



(a) The Condition of Screening

The communes will be screened first for F/S as the following conditions:

- Communes with the safe water coverage will be set as about 60 percent in 2010,
- Communes with the safe water coverage of more than 60 percent in 2010 will be omitted,
- Communes with the pipeline installation in 2020 will be omitted,
- Villages will be sampled in each commune for the convenience to distinguish between inside and outside the Study Area, and
- Villages with no accessibility of car will be omitted by the interpretation of satellite image.

In the M/P stage, villages in communes were not identified, and they should be identified in the first step of screening. 55 villages of Dangkao District in MPP, and 94 villages in Kandal Province are identified in the Study Area.

After the result of screening, 7 communes/39 villages of Dangkao District in MPP, and 5 districts/20 communes/56 villages in Kandal Province in the Study Area are qualified for the F/S shown in Supporting Report on the basis of " (a) the condition of screening".

(b) Concept of Prioritizing

In the Peri-Urban Area, safe water supply should be established from the adjacent to urbanized area to remote area from the viewpoints of avoiding the disparity of water supply condition and easy operation and maintenance. Accordingly, 7 communes/39 villages in Dangkao District in MPP will be prioritized and next to Ta Khmau, Kien Svay, Kandal Stueng, and finally Angk Snuol districts in Kandal Province.

Qualified communes and villages are shown in Supporting Report. The following districts, communes, and villages are recommended for F/S with target safe water coverage of about 60 percent. The location of commune is shown in Supporting Report .

Table 4.1 Proposed Communes for the Well Construction in 2010

Province	District	Commune	Village*	Target population in 2010	Required well	Safe water coverage in commune
Phnom Penh	Dangkao	Phleung Chheh Roteh	8	2,359	11	60.0 %
		Pong Tuek	6	5,479	26	60.0 %
		Prey Veaeng	5	3,261	16	60.0 %
		Prey Sa	3	2,080	11	60.0 %
		Krang Pongro	4	1,194	6	60.0 %
		Prateah Lang	6	2,499	12	60.0 %
		Sak Sampov	1	422	2	60.0 %
	Sub-total		**33**	**17,294**	**84**	**-**
Kandal	Ta Khmau	Ta kdol	2	2,733	13	49.5 %
		Kampong Samnanh	2	2,981	14	32.9 %
	Kien Svay	Preaek Aeng	4	12,409	59	73.6 %
		Preaek Thmei	2	12,324	59	67.8 %
	Sub total		**10**	**30,447**	**145**	**-**
Grand total			**43**	**47,741**	**229**	**-**

*: Villages in communes are listed in Supporting Report.

4-3 Design Criteria

The Peri-Urban Water Supply Project should be started at an adjacent to urbanized areas of MPP and district towns of Ta khmau and Kien Svay to improve the disparity of water supply condition between them. Accordingly, Dangkao District in MPP and Takmau District and Kien Svay District in Kandal Province will be recommended to prioritize the implementation.

Basic concept for the Feasibility Study on "The Peri-Urban Water Supply Project" will be set as follows.

Target year:	2010
Coverage of safe water:	about 60% (70% in 2015, 80% in 2020) in peri-urban areas
Target population:	47,741 prioritized through screening & qualification
Omitting:	Commune where pipeline will be installed in 2020 and no accessibility
Priority Area:	Dangkao District: Phleung Chheh Roteh, Pong Tuek, Prey Veaeng, Prey Sa, Krang Pongro, Prateah Lang, and Sak Sampov communes in MPP Ta Khmau District: Ta Kdol, K.Amnanh communes Kien Svay District: P. Aeng, P. Thmei communes in Kandal Province
Unit Water Consumption:	40 liter/capita/day
Water supply facilities:	Deep well
Safe pumping yield of well:	20 liter/minute (=1.2 m^3/hour)
Coverage person per one well:	210 person/well
Design water supply amount:	8,400 liter/well

Required number of well: 229 wells

Water supply level: Level 1 Tube-well with hand pump
(because of low yield and recharging)

4-4 Groundwater Development Plan

The specification and the quantity of works to be implemented are summarized in Table 6.13.

Table 4.2 Specifications and Quantity for the Implementation

Item	Specifications	Quantity
Well construction	1. Drilling diameter: 0-30m; 10'5/8 inches; soil 30-60m; 10'5/8 inches; rock 2. Drilling depth: 60m 3. Casing length total: 60m 4. Screen opening ratio: 5% 5. Dry hole ratio: 30% (69 wells) Details are shown in Supporting Report.	1. 298 wells (229+69) 2. 8 inches PVC guide pipe: 30m /well 3. 4 inches PVC casing: 44m /well 4. Screen length: 16m /well 5. Packing / well 0-6m: mortar cement 6-15m: slime 15-60m: gravel 6. Geophysical logging: 229 wells 7. Pumping test: 229 8. Water quality test: 229 samples
Platform construction	Details are shown in Supporting Report.	229
Hand pump installation	Afridev (shown in Figure 6.4.)	229
Iron removal device installation	10% of well. Details are shown in Supporting Report.	23

(1) Well Construction

Drilling depth and target aquifer will be estimated as follows.

Table 4.3 Drilling Specifications

Province/ District	Commune	Bed rock depth	Target aquifer	Drilling depth	Nos. of well
		(GL-m)*		(GL-m)	(well)
Municipality of Phnom Penh					**84**
Dangkao	P.C. Roteh, Pong Tuek, Prey Veaeng, Prey Sa, Krang Pongro, Prateah Lang, Sak Sampov	30-50	Fissure	60	84
Kandal Province					**145**
Ta Khmau	Ta Kdol, Kampong Amnanh	30-40	Fissure	60	27
Kien Svay	Preaek Aeng, Preaek Thmei	30-40	Fissure	60	118
Total					**229**

*1: depth from ground level

The rotary drilling method will be recommended and down-the-hole (DTH) will be also adopted for the bedrocks. MRD has these equipment and sufficient experience in using them in the "Peri-Urban Project, 2005".

a) Test – geophysical logging, pumping test, water quality test

Geophysical loggings, pumping testing, and water quality test will be carried out for all wells after the completion of drilling. Outline of each specification is as follows.

- Geophysical logging: resistivity, spontaneous potential
- Pumping tests:
    1) Preliminary test
    2) Step drawdown test: 7 steps, 120 minutes / step
    3) Constant discharge test: 48 hours
    4) Recovery test: 24 hours
- Water quality test: parameter for domestic water will be conducted.

b) Validity for Well

If the following required specification and guidelines are not met, well will have to be re-drilled.

- Pumping yield: less than 1.0 m^3/hour and
- Water quality: exceeding the guideline of parameter for health; Arsenic and Fluoride.

If iron content exceeds the guideline of 0.3mg/l, the well can still be utilized with the installation of iron removal device.

c) Well Completion

PVC casing and screen pipe are recommended, as used in the "Peri-Urban Project, 2005" for sufficient strength and easy procurement by DRWS. Screen opening will be 5 percent and packed with 4 to 5mm gravel. The upper section of screen near the ground surface will be grouted with cement to prevent the infiltration of contaminated surface water. The screen location and the depth of pump location will be determined based on the result of geophysical logging and groundwater table.

d) Successful Rate of Drilling

Rate of unsuccessful wells totaled up to 29.5 percent (total drilling wells: 129, unsuccessful wells: 38) in phase 1 of "Peri-Urban Project, 2005" because of a few quantity or bad quality of groundwater. The deltaic geology will be difficult to investigate the distribution of aquifer. Accordingly, it is recommended the successful drilling rate may be applied the same rate of 70 percent for the Feasibility Study.

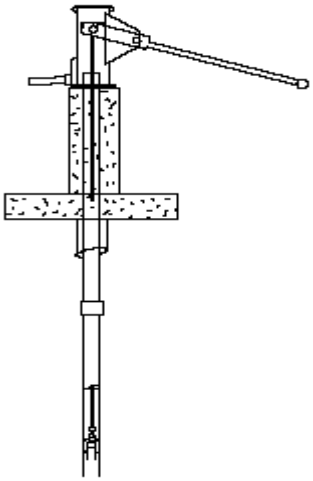
(2) Hand Pump Selection

The hand pump should have a discharge capacity of 20 to 30 l/minute and maximum pump head of 30 meters. They should be easy to use by women and children, easy to operate and maintain (O&M) by village level, and to be protected from rust and abrasion. The following hand pumps are commonly used in Cambodia.

Table 4.4 Major Hand Pump in Cambodia

Type	Pump head (m)	Price (US$)	Rust proof	Abrasion proof	O&M
Indian Mark III	15-45	300-400	unsuitable	suitable	Village level
Afridev	15-45	200-300	suitable	suitable	Village level
Tara	8-12	100-150	suitable	suitable	Village level
No.6	2- 6	<150	unsuitable	unsuitable	Village level

Only Afridev satisfies the required specifications. It is also the specified standard deep well hand pump by DRWS and same type used in the "Peri-Urban Project, 2005". Accordingly, Afridev will be the recommended hand pump for the project from viewpoints of specifications and hydrogeological similarity for "Peri-Urban Project, 2005", and easy for operation and maintenance by DRWS and WPC. The Afridev hand pump is outlined as follows.



Specification of Afridev:

Pump head: Maximum 45 meters

Pumping volume: xmaximum 22 liter/min

Riser pipe: diameter 63mm, PVC

These specifications can cope with required pumping volume of 8.4 m^3/day for the project.

Figure 4-1 Specification of Afridev

(3) Installation of Iron Removal Device

It is reported that iron content exceeds the WHO Guidelines (0.3mg/liter) in many wells in "Peri-Urban Project, 2005". So, Iron Removal Device was installed for some wells. Accordingly, this device will be also installed for some wells in the implementation stage. The details are shown in Supporting Report. DRWS has the experience to manage this device.

4-5 Implementation and O&M Plan

(1) Implementation Schedule

The tentative implementation schedule is shown in the following Table 6.16.

Stage	Year	2006	2010	2015
Study	Basic Design, Detailed Design			
Soft component	1. IEC (Information and Education Campaign): hygine education, establishment of WPC 2. Requesting the cooperation of well construction 3. Institutional strengthening of DRWS and PDRD 4. Monitoring of "Peri-Urban Project, 2005"			

Hard component		Well construction plan*1						
	Province	To be Served in 2010		Target aquifer	Well depth (m)	Implementation schedule		
	District	Target population	Reruired well			2006	2010	2015
	Phnom Penh City	**17,294**	**84**					
	Dangkao	17,294	84	Fissure	60			
	Kandal Province	**30,447**	**145**					
	Kien Svay	24,733	118	Fissure	60			
	Ta Khmau	5,714	27	Fissure	60			
	Grand Total	**47,741**	**229**					

Table 4.5 Implementation Schedule of Peri-Urban Water Supply Project

*1: Target population; to cover about 60 percent of commune population

The development plan and implementation schedule will be fully investigated in B/D and D/D stages.

After the completion of implementation, safe water coverage will increase from 44 percent in 2005 to 58.2 percent in 2010 in Peri-Urban Area shown in Supporting Report.

(2) IEC for Hygiene and O&M

The stage of B/D and D/D, Information and Education Campaign (IEC) will be planned and IEC will be conducted during the construction stage as follows:

- Investigation of peoples' awareness for water supply and hygiene, willingness to establish WPC,
- Information of the technical matter such as quantity and quality of groundwater, water supply cost to villagers,
- Education for the hygiene and importance of establishing WPC,
- Strengthening the WPC,
- Training of installation and repairing of hand pump, and
- Requesting the cooperation of well construction and machinery installation to villagers.

(3) Organization of Implementation and O&M

It is recommended that implementing agency for the study and project will be DRWS from the viewpoints of national plan and its sufficient experiences. It is also recommended the organization for the implementation and O&M as follows. This organization system has been already established and "Peri-Urban Project, 2005" adopted it.

Table 4.6 Organization for Implementation and O&M

Level	Agency	Implementation stage	O&M stage
Nation	DRWS of MRD	1. Managing & supervising for construction work 2. Organizing WPC	1. Major repair & well rehabilitation 2. Technical guidance for PDRD
Province	1. PDRD 2. Bureau of Rural Water Supply of PDRD	1.Organizing WPC 2. Training for villager	1. Major repair & well rehabilitation 2. Spare parts provision to WPC
Village	WPC (should be established in each village)	1. Assistance for construction work 2. Establishing WPC	1. Minor repair for hand pump 2. Spare parts request to PDRD 3. Collecting water tariff, cleaning, and inspection of facilities

Operation and maintenance will be the key responsibility of Water Point Committee (WPC)., DRWS has the duty to enhance the awareness of villagers for establishing and joining the WPC before and during the well construction stage.

A WPC should be established for each well facility and related group of households. The members of the WPC will be elected from among the users of the well. They have the duty to operate and maintain the well, collect the water tariff, clean the well site, and implement hygiene education.

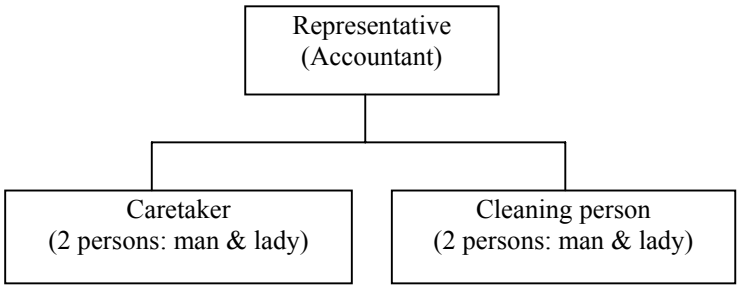


Figure 4-2 Recommended Organization of WPC

(4) Operation and Maintenance

There are 165 of existing JICA wells and it will come up to 394 wells in 2010 and 1032 wells in 2020. The present system cannot cope with the operation and maintenance near future. It is too much load for DRWS. DRWS has the responsibility to maintain small water supply facilities and wells in all provinces. But, "Pump Installation & Repair Section" of Drinking Water Department of DRWS consists of only 6 engineers. It is not enough capacity for O&M of all wells in their territory. Accordingly, the responsibility for well operation and maintenance should be changed.

PDRD in MPP and Kandal Province should have more responsibility shown in Table 4.7 in 2010 in the policy of decentralization.

Table 4.7 Responsibility for Operation and Maintenance at Present and Future

Item	DRWS		PDRD		WPC		Remarks
	2005	2010	2005	2010	2005	2010	
1. Dairy maintenance					O	@	Dairy
2. Minor repairing					O	@	Proper time
3. Water tariff collection					O	@	Every one month
4. Periodical inspection				@			Once in a year. WPC bears costs.
5. Well development	O			@			Once in 5 years. WPC bears costs.
6. Hand pump replacement	O			@			Once in 10 years. WPC bears costs.
7. Major repairing	O			@			Once in 5 years. WPC and DRWS bears costs.
8. Water quality monitoring	O	@					Twice in a year: dry and rainy seasons. WPC and DRWS bears costs.

O&M costs will be mainly borne by the WPC. The cost of major repairs and water quality monitoring should be subsidized by DRWS.

Table 4.8 Annual O&M cost for Well

Item	Unit cost (US$)	Quantity	Cost (US$)	Remarks
Renewal of spare parts	50.0	1.0	50.0	Every year
Patrol allowance of PDRD stuff	5.0	2.0	10.0	Every year, 2 stuffs
Car allowance	25.0	1.0	25.0	Every year, 1 car
Well development	160.0	0.2	32.0	Every 5 years
Allowance of PDRD stuff	15.0	0.4	6.0	2 stuffs
Car allowance	25.0	0.2	5.0	1 car
Renewal of hand pump	400.0	0.1	40.0	Every 10 years
Allowance of PDRD stuff	15.0	0.2	3.0	2 stuffs
Car allowance	25.0	0.1	2.5	1 car
Total			173.5	

Water tariff will be determined that each family has to share 4.3 US$ annually.

210 persons will use a well and family size will be 5.2 in the rural area. So, water tariff should be collected from 40 families.

(5) Institutional Strengthening

PDRD of MPP and Kandal Province consist of five (5) departments and "Bureau of Rural Water Supply" has the main responsibility of rural water supply. "Bureau of Rural Water Supply" consists of four (4) sections of Clean Water, Small Irrigation, Micro Energy, and Water Quality Experiment. These departments have not ability for well maintenance and repair.

PDRD of MPP has three district offices of Dankao, Mean Chey, and Russei Keo. Dankao and PDRD of Kandal Province have 11 district offices. Each district office consists of 6 staff, but they do not have the ability of well maintenance and repair.

Table 4.9 Organization of PDRD for O&M

	PDRD of MPP	PDRD of Kandal
Bureau / *Section*	Mnager:1 / Deputy: 2	Mnager:1 / Deputy: 2
Rural Water Supply	5 staffs	10 staffs
Administration, Finance, Planning	12 staffs	10 staffs
Primary Health Care	5 staffs	5 staffs
Community Development	5 staffs	8 staffs
Rural Economic Development	5 staffs	10 staffs
Section of Rural Road Development	*3 staffs*	*7 staffs*
Technician for well O&M	-	4 staffs
District Office	3 district offices	11 district offices
	Chief:1 / Assistant: 1	Chief:1 / Assistant: 1
Administrative stuff	1 staff	1 staff
Technical stuff (machinery)	3 staffs	3 staffs

Only technician of PDRD has the duty for the well maintenance and repair. But, they have been in charge of another job because of short budget at present. Accordingly, institutions of well maintenance and repair should be strengthened urgently both stuff number and budget.

Technology transfer to PDRD should be conducted by JICA Study Team and DRWS in the course of B/D, D/D, and implementation stages for the items of No.5,No.6, and No.7 in Table 6.18. It should be investigated in the B/D and D/D stages for suitable staff and budget of O&M organization for wells.

(6) Monitoring of "Peri-Urban Project, 2005"

DRWS and PDRD stuffs should monitor the production well that constructed by "Peri-Urban Project, 2005" for the training of coming "Peri-Urban Water Supply Project". The well in Prey Veaeng Commune have not been maintained and malfunctioned that the rubber packing of hand pump was not repaired. The well and iron removal device in Prey Thom Village of Kouk Roka Commune are functional but not cleaned, with rubbish and sewage in and around the platform. Some wells in Prey Sala Village in Dangkao District are functioned but villagers have not paid the water tariff. DRWS or PDRD should check and revitalize the activity of WPC for the sustainable development.

Chapter 5. Environmental Impact Assessment

Chapter 5. Environmental Impact Assessment

5-1 EIA Review Process for Proposed Projects

5-1-1 Objectives

The objectives of this EIA are;

(1) To assess possible impacts from the priority programs and projects. Impacts shall include positive and negative impacts, and impacts on environmental and social aspects.

(2) To propose mitigation measures, if any, to avoid or minimize the negative impacts.

5-1-2 Legislative and Regulatory Condition of EIA in Cambodia

In Cambodia, Sub-Decree No.72, 11/8/1999, Environmental Impact Assessment Process, defines the institutional arrangements and responsibilities, the EIA requirements, the examination criteria and procedures for existing and proposed projects, and the penalties for non-compliance. Additional guidance is provided in Declaration No.49, 9/3/2000, Guideline for Conducting Environmental Impact Assessment Reports.

The Sub-Decree applies to all public and private development projects. EIA's are required, among others, for water supply projects serving at least 10,000 users. All wastewater treatment plants; and all drainage systems serving an area above 5,000 hectares.

The project owner (in this case PPWSA) is required to conduct initial EIA (IEIA. Similar concept to IEE in JICA procedure.) and submit the IEIA with pre-feasibility study to MOE for review.

MOE will then order the project owner either to revise the IEIA or conduct EIA study.

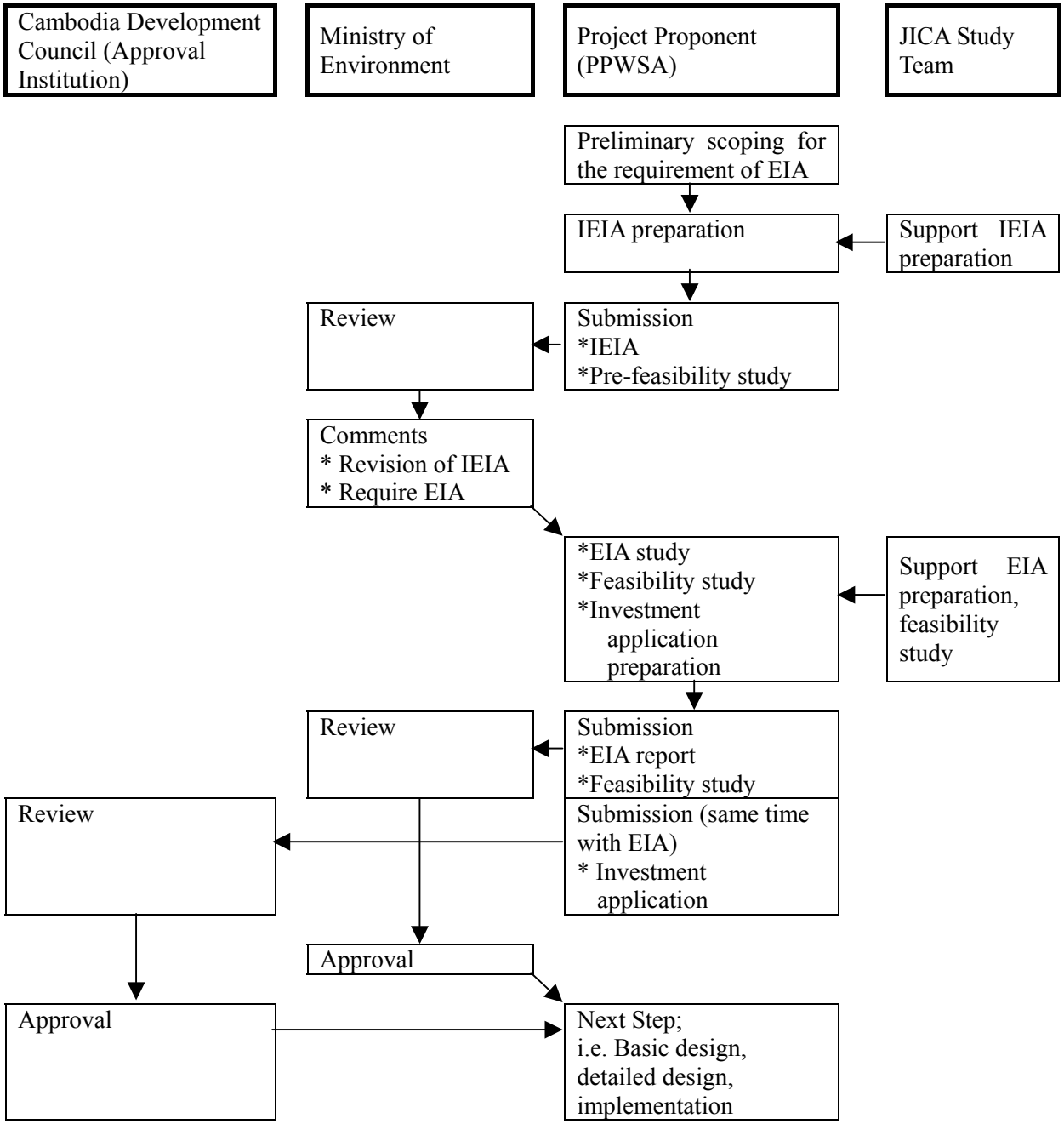
The review process is summarized in Figure 5-1. The project owner will submit the revised IEIA or EIA and feasibility study to the MOE, at the same time the owner submit an Investment Application to the funding institution (Council for the Development of Cambodia).

The Sub-Decree also enables public participation in the process.

MOE reviews all EIAs and monitors implementation of an approved Environmental Management Plan (EMP).

5-1-3 Assistance of the JICA Study Team

PPWSA is already equipped with skilled staff and experience with the EIA procedure in Cambodia. The Study Team worked with the responsible PPWSA staff in field study, scoping of potential impacts, assessing the degree of impacts, designing mitigation and monitoring measures.



Note:
IEIA: Initial environmental impact assessment, equivalent to IEE (Initial environmental examination)
Source: Article 14 to 20, Sub-Decree on Environmental Impact Assessment Process, No. 72.ANRK.BK, August 11, 1999

Figure 5-1 EIA Review Process for Proposed Projects in Cambodia

5-1-4 Environmental Evaluation Process of JICA

The Study Team has been following the Guidelines for Environmental and Social Considerations that JICA implemented in 2004. In the Guideline, water supply project is listed as project likely to have significant adverse impact on the environment and society. Also, large-scale involuntary resettlement and large-scale groundwater pumping are listed as sensitive characteristics.

Since the Cambodian Sub-Decree requires IEIA (IEE) and EIA for large scale water supply project, the Team is advised by JICA to follow the local procedure for environmental review.

In the Review of Scoping Report for the Master Plan Study, received by the Team on April 14, 2004, JICA categorized this Master Plan project as Category B according the JICA Guidelines.

Projects are classified as Category B if their potential adverse impacts on the environment and society are less adverse compared to those of Category A projects. Generally the adverse impacts are site-specific, few if any are irreversible. And in most cases, normal mitigation measures can be designed more readily against the impacts.

5-1-5 Next Step of the Proposed Projects

The PPWSA has obligation to submit EIA for this Feasibility Study to MOE. The comments from MOE to the EIA will be taken care of in the next phase of the projects.

The PPWSA, with assistance from the Government of France, is planning to hire a consultant for the basic design, feasibility study, and environmental study for the Chrouy Changva Water Treatment Plant Expansion Project.

The Terms of Reference for the study describes issues to be examined in the environmental study, including, but not limited to, the following items:

1) Impact of the expected additional abstraction of water in the local, national, and trans boundary context of the Mekong basin;
2) Water quality issues (water quality standards for potable water production, routine and emergency protection at the intake, water quality monitoring)
3) Resettlement action plan
4) Impact and management of any by-products of the treatment plant
5) Measures to optimize energy consumption
6) Screening of the measures envisaged for sanitation and waste water treatment
7) Impact on the construction of water transmission main
8) Impacts and mitigation measures during the construction period

The study is expected to start early 2006, and to end in June or July 2006. The study will determine detailed conditions of the project, such as issues of water rights, resettlement, by-product (sludge) management, impact from the construction of distribution pipes, and

mitigation measures during the construction period. Based on those conditions, PPWSA is expected to follow another round of EIA procedure with MOE.

The PPWSA is expected to conduct EIA study for other components of the Stage I project (i.e. construction of water tower and pumps, distribution pipes, wells) as it proceeds to engineering design of each project.

5-1-6 Recommendation of Environmental Study in the Following Phase

In the following phase of the implementation of the Master Plan, including the Stage I project, the scoping checklist of the IEE and EIA will be the starting point for PPWSA.

PPWSA, however, will need to be careful about the issue listed below in environmental study in the following phase.

- PPWSA must revise the scoping checklist for each project on site so that no environmental items are missed from the study.
- PPWSA must study the social and environmental condition around the project site to understand updated condition of the area.
- For the construction of distribution pipes, PPWSA must minimize relocation or modification of existing infrastructures and private structures. PPWSA also must count the number of structures, both public and private, that would be affected by the construction for the detailed planning of the project cost, as well as for the negotiation with the local businesses and residents.
- PPWSA must estimate the cost of environmental mitigation and monitoring measures with detailed information of project design and schedule.

PPWSA must start distribution of information and necessary negotiation with local communities regarding the design and schedule of construction of each project.

5-2 Description of the Project

5-2-1 Staged Implementation of the Master Plan

The Master Plan of Greater Phnom Penh Water Supply (Phase 2) proposes to implement a series of projects in three stages.

This EIA reviews the Stage I projects, that are planned to be completed by 2010, as shown in Table 5.1.

Table 5.1 Staging of the Project

Stage I (2005 to 2010) **Priority Activity** (Total Treatment Capacity :300,000 m^3/day)	2005 2005-2006 2006 2007-2009 2008-2010 2009-2010	Preparation of Project Detailed Design, Bidding Commencement of Construction & Procurement of Equipment Construction (Water Supply Facilities) Construction (Well Facilities) Commencement of Operation
Stage II (2009 to 2015) (Total Treatment Capacity 400,000 m^3/day)	2009-2010 2010-2011 2011 2012-2014 2011-2015 2014-2015	Preparation of Project Detailed Design, Bidding Commencement of Construction & Procurement of Equipment Construction (Water Supply Facilities) Construction (Well Facilities) Commencement of Operation
Stage III (2015 to 2020) (Total Treatment Capacity 500,000 m^3/day)	2015-2016 2016-2017 2017 2018-2020 2016-2020 2020	Preparation of Project Detailed Design, Bidding Commencement of Construction & Procurement of Equipment Construction (Water Supply Facilities) Construction (Well Facilities) Commencement of Operation

5-2-2 Summary of the Target Projects of EIA

The Stage I projects are summarized in Table 5.2. Details of the projects are described in Chapters 2, 3 and 4 of the Feasibility Study.

The Rehabilitation Project is not included in the environmental impact assessment. The project is to replace mechanical and electrical equipment at Phum Prek and Chamkar Mon WTP require replacement or rehabilitation since they are more than 10 years old, to the new one with same capacity. There will be no change of function, nor environmental impact by this rehabilitation, and recycle or disposal of old equipment. The Team, therefore, decided to exclude the Rehabilitation Project from the scope of the EIA study.

Table 5.2 Project List of the Stage I

Project and timing	Components, Facilities	Locations and details
Chrouy Changva Water Treatment Plant Construction Project Construction Period: 2007 – 08 Location: Nearby Existing Chrouy Changva WTP along the Mekong River (Present condition: Figure 5-4) (Proposed plan: Figure 5-2)	Intake Station (Image of existing intake station: Photo 1-1)	Capacity: 130,000m^3/day Facility: Intake Tower, Connection Bridge, Sub-Station/Electrical House The capacity of existing station is 65,000m3/day. The use of existing station will be stopped as reserve upon the completion of the new station.
	Raw Water Transmission Pipe	Diameter: Dia 1000mm x 2 Material: Ductile Cast Iron Pipe (DCIP) Total Pipe Length: Approx. 30m x 2 = 60m
	Additional Chrouy Changva WTP	Capacity: 65,000m^3/day Facility: Receiving Well, Sedimentation Tank, Filter, Distribution Reservoir The capacity of existing WTP is 65,000m^3/day.
	Additional Clear Water Reservoir	Capacity: 19,500m^3 Facility: Structure of reinforced concrete The capacity of existing clear water reservoir is 5,760 m^3.
Water Tower Augmentation Project	Booster pump stations for the existing towers	Airport Water Tower (1500m^3),
		Ponchengton (Chom Chao) Water Tower (1500m^3)
	Water Tower	Ta Khmau Water Treatment Plant (1500m^3)
Distribution Pipelines Augmentation Project Installation Period: 2007 - 09		Diameter of main pipeline: 225mm to 900mm Total Pipe Length of main pipeline: 52 km Location: Phnom Penh city and suburbs
Well Facility Construction Project Installation Period: 2008 - 10		Well Number:229 Equipment: Well, Hand Pump, deep well. Location: Phnom Penh City and its Suburbs
Rehabilitation Project (Excluded from EIA study)		Phum Prek WTP Replacement/Rehabilitation Work、 Chamkar Mon WTP Replacement/Rehabilitation Work

Note: WTP: water treatment plant

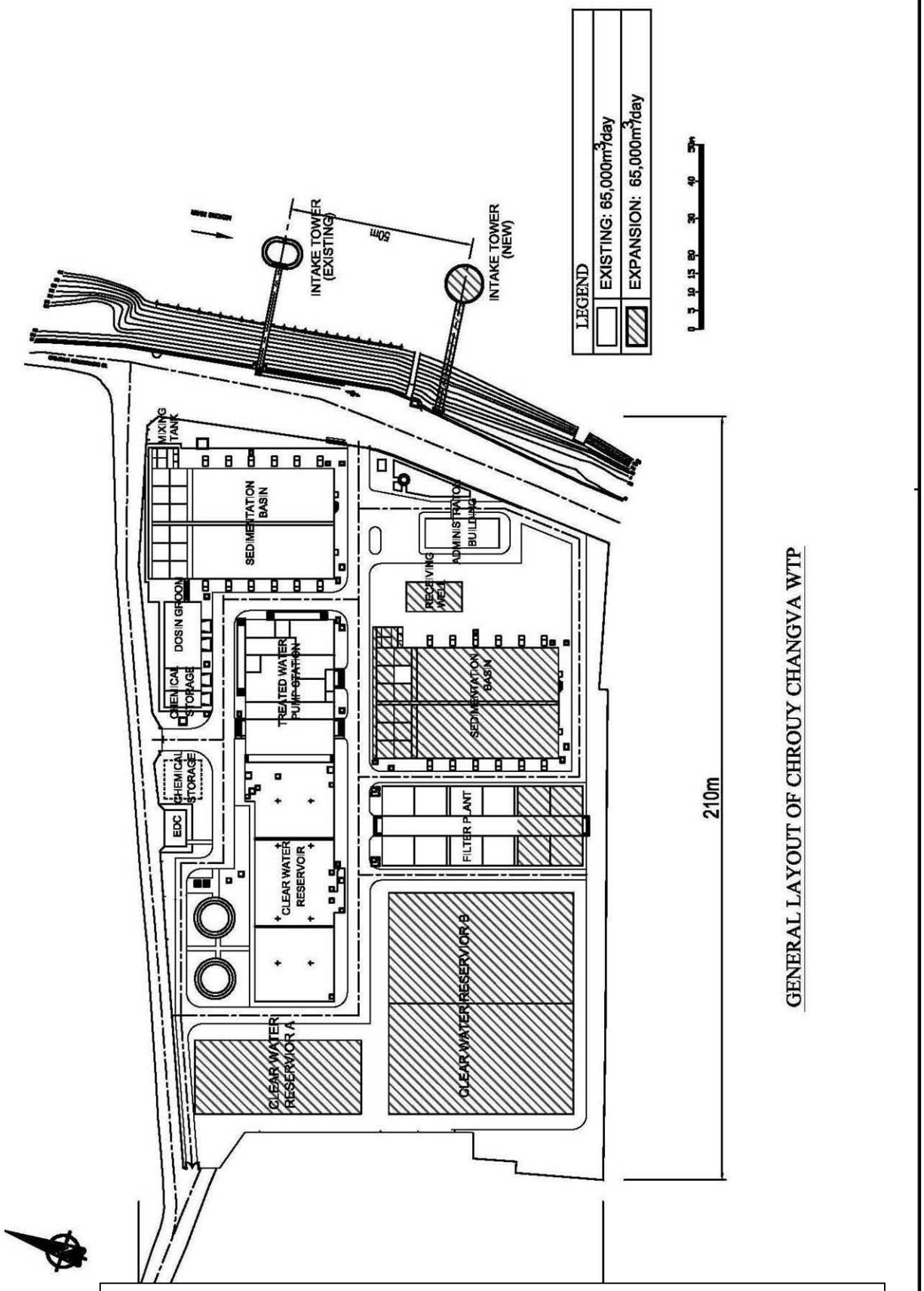


Figure 5-2 Existing and Proposed Facilities for Chrouy Changva WTP

Figure 5-3 Existing Intake and Water Treatment Plant

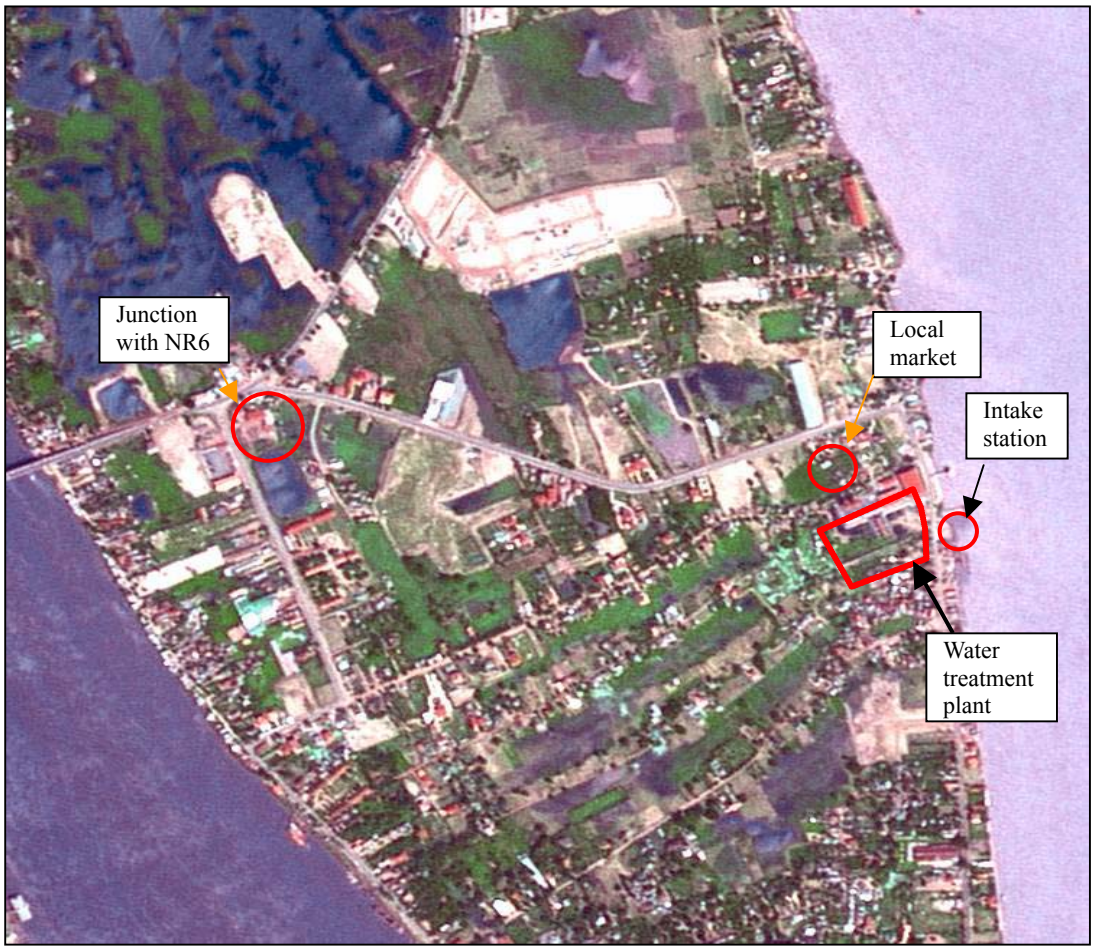


Figure 5-4 Chrouy Changva WTP and Surrounding Area

5-2-3 Water Tower at the Existing Ta Khmau Water Treatment Plant Site

A new water tower (1,500m^3) will be constructed within the site of the existing Ta Khmau Water Treatment Plant. Location of the tower is shown in Figure 5-7. Construction work will include boring study, demolition of existing buildings and facilities, construction of structures, pipe and equipment setting, and electrical setting.

5-2-4 Booster Pump Stations for the Existing Towers

The following two water towers are already under construction as of November 2005. Locations of the towers are shown in Figure 5-7.

*Airport Water Tower (1500m^3),
*Pochengton (Chom Chao) Water Tower (1500m^3)

This project provides underground booster pumps for those towers for additional water pressure. Construction work will include steps described in Table 5.3.

Table 5.3 Construction Procedures for Booster Pump Stations

1	Preparation	Bring equipments, a booster pump
2	Digging	Dig the hole to set the booster pump
3	Base construction	Prepare sturdy base to set the booster pump on
4	Pump setting	Set the pump on the base
5	Pipe coordination	Coordinate pipes around the pump
6	Filling	Fill the hole around the pump, compact the filling
7	Finishing	Prepare the ground surface

5-2-5 Transmission/Distribution Facilities (Water Pipes) Construction

Transmission/Distribution pipes of diameter 225mm to 900mm are proposed to be laid as extensions of the existing distribution network. Locations for the extension works are shown in Figure 5-7. Construction works at these locations will include steps described in Table 5.4. Photos for those steps are taken at construction site in Oct. 2005. The photos are shown in the Supporting Report.

Table 5.4 Construction Procedures for the Distribution Facilities (Water Pipes)

1	Set up	Bring equipments and pipes. Set notification boards and traffic barriers.
2	Marking	Mark the location of dig on the road surface.
3	Cutting	If the road surface is covered with asphalt, cut the layer at the marked line.
4	Digging	Dig the ditch.
5	Take out the soil	Take the dug-out soil out of the site for re-use.
6	Laying	Set the pipe in the ditch
7	Refill	Fill the ditch with sand
8	Tamping	Compress the refill
9	Finishing	Add another layer of refill, compress, and finish the surface.
10	Finish	Remove the equipments from the site.

5-2-6 Well Facility Construction Project

43 villages are chosen for well construction project to provide safe water in the Stage I of the Master Plan. The names of the villages are listed in

Table 5.5, and the locations of the villages are shown in Figure 5-5. Figure 5-6 shows the proposed well equipment that is already used in the Peri-Urban Water Supply Project.

In the project implementation schedule of the Peri-Urban Water Supply Project in this Feasibility Study, implementation schedule is proposed based on the expected urban development in each district. Dangkao District is the first target and well construction is planned to be implemented in the year 2008. Ta Khmau District is the second priority to be implemented in the year 2009. Kien Svay District comes last, and the well construction is planned to be implemented in 2009 and 2010.

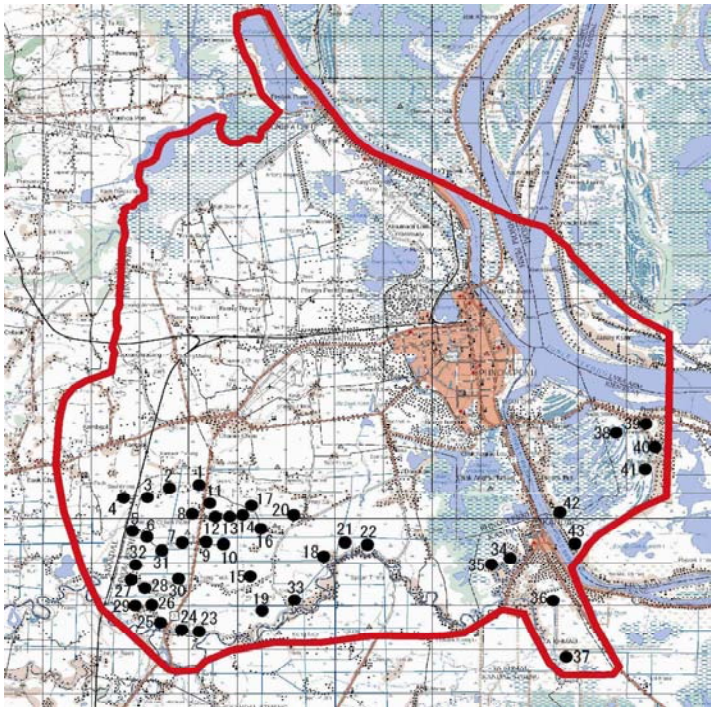


Figure 5-5 Locations of Target Villages for Well Facility Projects

Figure 5-6 Existing JICA Wells Similar to the Proposed Well Type

Table 5.5 Target Villages for Well Facility Projects

Province	District	Commune	Village		Census 2004	M/P population estimation	New well No. 2010*
					Popu-lation	2010	
Phnom Penh Municipality	**Dangkao**	Phleung Chheh Roteh	1	Toul Key	719	1,260	2
			2	Koppluk	304	533	1
			3	Prey Ro Ngeang	428	750	1
			4	Trainh Tabanh	136	238	0
			5	Phleung Chhea Roteh Lech	540	947	2
			6	Phleung Chhea Roteh Keut	438	768	1
			7	Kork Khasch	495	868	2
			8	Prey Key	580	1,017	2
		Pong Tuek	9	Sre Nhor	782	1,465	7
			10	Khleh Samday	618	1,158	6
			11	Prey Key A (Kor)	558	1,045	5
			12	Prey Key B (Kha)	337	631	3
			13	Tram Daok	219	410	2
			14	Trapaing Sala	411	770	4
		Prey Veaeng	15	Prey Veng Lech	524	914	3
			16	Kam Rieng	749	1,307	5
			17	Rol Chrouk	126	220	1
			18	Serey Day Dos	153	267	1
			19	Toul Sambour	904	1,577	6
		Prey Sa	20	Prey Sa Keut	396	675	4
			21	Anlong Kong	502	855	4
			22	Piem	323	550	3
		Krang Pongro	23	Kraing Svay	381	508	1
			24	Kraing Pong Ro	476	635	1
			25	Teuk Thla	861	1,149	2
			26	Prey Sampor	298	398	1
		Prateah Lang	27	Prateah Lang	1,285	2,113	4
			28	Phea	754	1,240	2
			29	Ang	646	1,062	2
			30	Taing Roneam	389	640	1
			31	Kok Khsach	331	544	1
			32	Kok Meas	189	316	1
		Sak Sampov	33	Kraing Tapho	248	543	2
Kandal Province	**Ta Khmau**	Ta Kdol	34	Preaek Kat	1,219	1,582	8
			35	Preaek Long	887	1,151	5
		Kampong Samnanh	36	Preaek Reang	2,240	2,910	12
			37	Krabau	495	643	2
	Kien Svay	Preaek Aeng	38	Mitakpheap	2,252	2,930	14
			39	Tuol Ta Chan	1,273	1,656	8
			40	Chong Preaek	2,568	3,341	16
			41	Roboah Angkanh	3,445	4,482	21
		Preaek Thmei	42	Campuh K'aek	4,932	6,376	30
			43	Kaoh Krabei	4,601	5,948	29
Total							229

*: Number of wells for each village is rounded. The sum does not match the total.

5-2-7 Project Components That Are Out of Scope

5-2-7-1 Rehabilitation Project

It is necessary every ten to fifteen years to replace or rehabilitate water treatment facilities, especially mechanical and electrical equipment, to achieve expected efficiency. Certain mechanical and electrical equipment at Phum Prek and Chamkar Mon WTP require replacement or rehabilitation since they are more than ten years old.

The project is to replace existing equipment with new ones of the same capacity. There will be no change of function or environmental impact from this rehabilitation or from recycling or disposal of old equipment. The Study Team therefore decided to exclude the Rehabilitation Project from the scope of the EIA study.

5-3 Social and Environmental Conditions in the Project Area

5-3-1 Social and Environmental Conditions Surrounding Chrouy Changva WTP

5-3-1-1 Target Area

The target area covers approximately 500 meters radius surrounding the location of planned construction work.

5-3-1-2 Social and Environmental Conditions

The proposed project area is located in the village 1, Sangkat Chrouy Changva, Khan Ruessei Kaev, Phnom Penh City.

Within the radius of 500 meters from the proposed location of the project there are:

1) The existing Chrouy Changva intake station in the Mekong River and WTP with the area of about 1 ha (100m x100m).
2) One Mosque located about 250 meters from the proposed site.
3) From the distance of about 200 meters onward there are occupied residential houses.
4) Two houses located close to the proposed intake site, about 50 meters along the Mekong river bank, are the office of a dredging business. Two ferries are tied there and a few heavy machines are set on the ferries to take the river sand from the boats to dump trucks.
5) Small market on the corner north from the site.
6) Small ferry station back of the market on the Mekong River.
7) Surrounding area is mainly rural atmosphere with large land lots prepared for future housing development.

5-3-2 Social and Environmental Conditions at Water Tower Projects

5-3-2-1 Target Area

The target area covers approximately 500 meters radius from the locations of the planned construction work site in Ta Khmau and three other existing water tower sites. See the Supporting Report for photos.

5-3-2-2 Social and Environmental Conditions

The social and environmental conditions surrounding the water tower/booster pump sites are summarized in Table 5.6.

No problematic condition was observed in the target areas regarding traffic conditions, public facilities or existing environmental resources.

Table 5.6 Summary of Social Environmental Conditions for Water Tower Projects

No.	Water Tower	Road and traffic condition	Social, cultural and religious facilities	Existing environmental resources and problems
1	Ta Khmau	Traffic condition in the project areas is not busy, as the road in front of the proposed site is one way road from Ta Khmau to Phnom Penh.	There are no main cultural or religious facilities in the project area.	Existing environmental resources in the project area is in good condition. At present there is no significant environmental problem in the project area.
2	Airport North	The proposed site is located off road No. 4. Traffic condition is not a problem for installation of booster pump in the existing perimeter of the water tower.	There are no main cultural or religious facilities in the project area.	Existing environmental resources in the project area is in good condition. At present there is no significant environmental problem in the project area.
3	Airport South (Pochengton)	The proposed site is located off Veng Sreng road. Traffic condition is not a problem for installation of booster pump in the existing perimeter of the water tower.	There are no main cultural or religious facilities in the project area.	Existing environmental resources in the project area is in good condition. At present there is no significant environmental problem in the project area.

5-3-3 Social and Environmental Conditions for Transmission/Distribution Project

5-3-3-1 Target Area

The target areas are the areas adjacent to the water tower site and the planned line for distribution pipe construction. Sections for proposed pipe construction are shown in Figure 5-7.

5-3-3-2 Social and Environmental Conditions

Social and environmental conditions along the proposed pipe construction routes are described below. Typical photos from each area are shown in the Supporting Report.

(1) Pipeline in Chrouy Changva

Planned route for pipeline in Chrouy Changva area does not show difficulties for pipe construction, as summarized in the following table.

Resettlement, The poor indigenous of ethnic people	There is no large permanent house or slum houses or infrastructure that need to relocate or remove during construction phase, but some place the right of way of the road are narrow (about 3m) may cause difficulty for heavy construction equipment to move during construction.
Existing social infrastructures and service, air pollution, noise and vibration	No large social infrastructure within the proposed location except house of normal residents.
Cultural Property	No important cultural heritage sites in the target area along this part of the proposed road side
Hazards (traffic accidents risk)	The traffic on the proposed road is not busy. The road is 5-6m wide with only few car and motorbike. This road can be considered as village road with laterite covered and mostly only local people are using this road.

(2) Pipeline in Praek Leab

Although the traffic on the National Road No. 6 is heavy, planned route for pipeline in Prek Leap area does not show difficulties for pipe construction because of wide right-of-way, as summarized in the following table.

Resettlement, The poor indigenous of ethnic people	There are no large permanent houses or slum houses or infrastructure that needs to be relocated or removed during construction phase. Right of way of the road proposed to lay the distribution pipe is wide enough (5m or more) for laying pipe, except 2-3 small shops close to the road about 3m.
Existing social infrastructures and service, air pollution, noise and vibration	There are 4 gas stations along this part of the road.
Cultural Property	There is one pagoda along this part of the road.
Hazards (traffic accidents risk)	The traffic on this part of the proposed road is very busy. The road is about 10m wide.

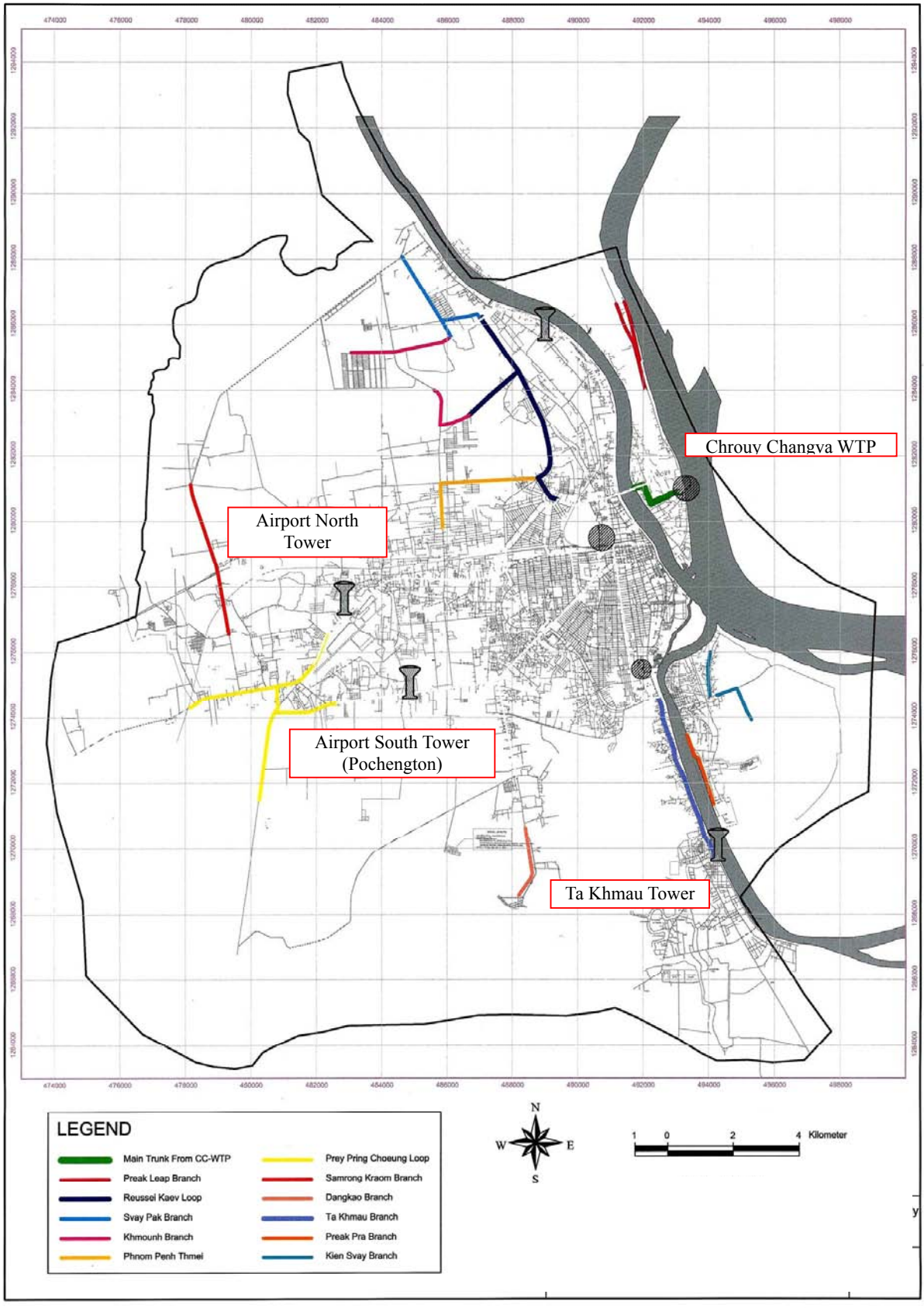


Figure 5-7 Locations of Transmission/Distribution Pipelines

(3) Pipeline in Ruessei Kaev

Planned route for pipeline in Ruessei Kaev area does not show difficulties for pipe construction, as summarized in the following table.

Resettlement, The poor indigenous of ethnic people	There are no large permanent house or slum houses or infrastructure that needs to be relocated or removed during construction phase. Right of way of the road proposed to lay the distribution pipe is wide enough (5m or more) for laying pipe. There is also no house in most parts along this road.
Existing social infrastructures and service, air pollution, noise and vibration	No large social infrastructure within the proposed location except house of normal residents.
Cultural Property	No important cultural heritage sites in the target area along this part of the proposed road side
Hazards (traffic accidents risk)	The traffic on the proposed road is not busy. The road is considered to be high way with wide of more than 10m.

(4) Pipeline in Svay Pak

Planned route for pipeline in Svay Pak area does not show difficulties for pipe construction, as summarized in the following table.

Resettlement, The poor indigenous of ethnic people	There are no large permanent house or slum houses or infrastructure that needs to be relocated or removed during construction phase. Right of way of the road proposed to lay the distribution pipe is wide enough (5m or more) for laying pipe. There is also no house in most parts along this road.
Existing social infrastructures and service, air pollution, noise and vibration	No large social infrastructure within the proposed location except house of normal residents.
Cultural Property	No important cultural heritage sites in the target area along this part of the proposed road side
Hazards (traffic accidents risk)	The traffic on the proposed road is not busy.

(5) Pipeline in Khmounh

Planned route for pipeline in Svay Pak area does not show difficulties for pipe construction, as summarized in the following table.

Resettlement, The poor indigenous of ethnic people	There are no large permanent houses or infrastructures that need to be relocated or removed during construction phase. Right of way of the road proposed to lay the distribution pipe is wide enough (5m or more) for laying pipe. There is also no house in most parts along this road.
Existing social infrastructures and service, air pollution, noise and vibration	No large social infrastructure within the proposed location except house of normal residents.
Cultural Property	No important cultural heritage sites in the target area along this part of the proposed road side
Hazards (traffic accidents risk)	The traffic on the proposed road is not busy. The road is about 6m wide.

(6) Pipeline in Phnom Penh Thmei

Planned route for pipeline in Svay Pak area passes close to a few shops and house fences. Special care and coordination/negotiation with local residents will be necessary prior to the commencement of the construction.

Resettlement, The poor indigenous of ethnic people	At the corner of the proposed road to north and the existing road to east, there are 4 shops located right close to the road. These shops need to be relocated temporary during construction of the distribution of pipeline. Further on this road to Phnom Penh Thmei about 300m there are houses fence close to the road make it difficult for heavy construction equipment to work in this area.
Existing social infrastructures and service, air pollution, noise and vibration	No large social infrastructure within the proposed location except house of normal residents.
Cultural Property	No important cultural heritage sites in the target area along this part of the proposed road side
Hazards (traffic accidents risk)	The traffic on the proposed road is not too busy. The road is about 6m wide.

(7) Pipeline in Prey Pring Choeung (Chaom Chau)

Planned route for pipeline in Prey Pring Choeung area includes cross sections of National Roads 3 and 4. Although the roads are wide, construction work must be carefully managed to avoid negative impacts on commercial and transport business in the area. Also, it will be necessary to communicate with military section before any underground work near their facilities.

Resettlement, The poor indigenous of ethnic people	There are no large permanent houses or slum houses or infrastructures that need to be relocated or removed during construction phase. Right of way of the road proposed to lay the distribution pipe is wide enough (5m or more) for laying pipe, except on the road No. 3 near the corner of road No. 4 there is mobile sellers of bread, cake and drinks for travelers and taxi stop to pick their passengers.
Existing social infrastructures and service, air pollution, noise and vibration	There is military center along this part of the road
Cultural Property	No important cultural heritage sites in the target area along this part of the proposed road side
Hazards (traffic accidents risk)	The traffic on the proposed road (No. 3) is not too busy. The road is about 8m wide. Traffic on road No. 4 is very busy.

(8) Pipeline in Samraong Kraom

Planned route for pipeline in Samraong Kraom area passes a few garment factories, military center, and a railway. Although the roads are wide, construction work must be carefully managed to avoid negative impacts on those facilities.

Resettlement, The poor indigenous of ethnic people	There are no large permanent houses or slum houses or infrastructures that need to be relocated or removed during construction phase. Right of way of the road proposed to lay the distribution pipe is wide enough (5m or more) for laying pipe, except some tree, flower tree will be damaged by the construction.

Existing social infrastructures and service, air pollution, noise and vibration	There few garment factories, military center along this part of the proposed road, and one railway across this road.
Cultural Property	No important cultural heritage sites in the target area along this part of the proposed road side
Hazards (traffic accidents risk)	The traffic on this part of the proposed road is not too busy. The road is about 7m wide.

(9) Pipeline in Dangkao

Planned route for pipeline in Dangkao area passes close to a market and a pagoda. Special care and coordination/negotiation with local residents will be necessary prior to the commencement of the construction.

Resettlement, The poor indigenous of ethnic people	There one commune market along the proposed road for laying pipeline. There are three shop which are very close to the road left right of way space one about 2m. These shops may need to be removed during construction of pipeline.
Existing social infrastructures and service, air pollution, noise and vibration	There is one school and one glass factory along this part of the road.
Cultural Property	There is one pagoda along this part of the road
Hazards (traffic accidents risk)	The traffic on the proposed road is not too busy. The road is about 8m wide.

(10) Transmission Pipeline to Ta Khmau

Planned route for pipeline in Ta Khmau area passes many factories. There are obvious commuting-hours with heavy traffic. Pedestrian traffic is also heavy during the work breaks. Notification to the factory owners, workers, and road-stalls about the schedule of construction work will be important. Also, it will be better to avoid the rush hours for the construction work.

Resettlement, The poor indigenous of ethnic people	There are no large permanent houses or slum houses or infrastructures that need to be relocated or removed during construction phase. Right of way of the road proposed to lay the distribution pipe is wide enough (5m or more) for laying pipe, but almost 100 percent of the road side or right of way of this road is covered with paving tile or pavement and some tree.
Existing social infrastructures and service, air pollution, noise and vibration	There many factories, shops and restaurants along this part of the road
Cultural Property	There are three pagoda along this part of the road
Hazards (traffic accidents risk)	The traffic on this part of the proposed road is very busy, especially during rush hour 7-8 AM in the morning, 11-12 AM at noon and 5-7 PM in late afternoon. The road is about 30m wide.

(11) Pipeline in Prek Pra

Planned route for pipeline in Prek Pra area is along a 5 m-wide road with houses built almost right on the road. Careful design will be necessary to minimize any relocation of the houses.

Resettlement, The poor indigenous of ethnic people	The houses in this part of the road are very close to the road for whole distance of the proposed pipeline length. Almost no right of way space available for laying pipelines.
Existing social infrastructures and service, air pollution, noise and vibration	There is one bridge with length of about 7m along this part of the road
Cultural Property	There is one pagoda along this part of the road
Hazards (traffic accidents risk)	The traffic on this part of the proposed road is very busy. The road is about 5m wide.

(12) Pipeline in Kien Svay (Chbar Ampov 1+2)

Planned route for pipeline in Kien Svay located along the village road in village Chbar Ampov 1 and 2 area does not show difficulties for pipe construction, as summarized in the following table.

Resettlement, The poor indigenous of ethnic people	There are no large permanent houses or slum houses or infrastructure that needs to be relocated or removed during construction phase. Right of way of the road proposed to lay the distribution pipe is wide enough (5m or more) for laying pipe.
Existing social infrastructures and service, air pollution, noise and vibration	There is one small bridge with length of about 4 m along this part of the road
Cultural Property	No important cultural heritage sites in the target area along this part of the proposed road side
Hazards (traffic accidents risk)	The traffic on this part of the proposed road is not busy. The road is about 5m wide

5-3-4 Social and Environmental Conditions for Well Facility Construction

5-3-4-1 Target Area

The target 43 villages are listed in

Table 5.5.

5-3-4-2 Social and Environmental Conditions

Target villages are mainly rural, except in the vicinity of national roads.

Main sources of water for household consumption, including drinking purpose, in this area are;

1） From small river, which is usually no water or very little water in the stream in dry season,
2） From pond near their houses,
3） From hand dug well with depth of about 10-15m,
4） From private hand pump wells with shallow water depth (20-30m), and,
5） From common hand pump wells with average depth about 100m provided by various organizations.

Where a well is constructed with the assistance of PRDWS-JCFC (the Project for Rural Drinking Water Supply in Peri-Urban of Phnom Penh, Grant Aid from the People of Japan as Token of Friendship and Cooperation between Japan and Kingdom of Cambodia), a committee

is established for each well to manage and take care of the well. Two persons for each well were trained to maintain and repair the well.

5-3-4-3 Groundwater Quality in the Greater Phnom Penh Area

The "Peri-Urban Project, 2005" conducted tests of ground water quality. Detailed results of the study are explained in Chapter 8 of the Master Plan.

From the viewpoint of water quality, it is recommended that the target water source will be deep alluvial and fissure aquifers.

(1) Well Water

Iron (Fe) exceeds the guideline (<0.3 mg/liter) in 8 of tested 15 communes. Chloride (Cl) also exceeds the guideline (250 mg/liter) in 3 districts.

Local residents dislike the taste and avoid drinking groundwater. Instead they buy drinking water from water vendors at a price of 2,500 to 6,000 Riels/m^3.

It is noted that arsenic is detected in Kouk Roka Commune and Fluoride is detected in 17 of 165 samples at Chaom Chau, Kakab, Kouk Roka, Phlueung Chheh Roteh, Prey Veaeng, Sak Sampov, and Samraong Kraom communes. The density is especially high in Kakab, Prey Veaeng, and Samraong Kraom communes. These chemicals are considered to be harmful to human health.

(2) Water in Aquifer

Total Dissolved Solids (TDS) exceed the WHO Guidelines (<1000 mg/liter) in half the samples from alluvial aquifers, and the concentration was even higher from fissure aquifers.

Fe content in fissure aquifers and combined alluvial and fissure aquifers (Al+F) is higher than that of alluvial aquifers (Al). It suggests that fissure aquifers exhibit less recharge with low permeability compared with alluvial aquifers.

Chloride (Cl) content shows the same tendency as TDS content in alluvial aquifers. Chloride exceeds the guideline (<250 mg/liter) in more than half the samples from alluvial aquifers and is comparatively higher than from fissure aquifers.

5-4 Analysis of Alternatives

5-4-1 Selection of Priority Projects

Among the projects proposed in the Master Plan, priority projects were selected so that PPWSA will be able to increase its production capacity by the target year 2010.

Therefore, expansion of capacity at the existing Chrouy Changva WTP, where extra space is still available, was chosen as the main project of Stage I.

The project is planned to be implemented over three stages based on the design target years of 2010 (Stage I) for the feasibility study, 2015 (Stage II) for the intermediate development plan and 2020 (Stage III) for the long term development plan. The stages have the following production capacity requirements, as shown in Table 5.7.

Table 5.7 Staging of the Project

Basic Parameter	Stage I	Stage II	Stage III
Target Year	2010	2015	2020
Total Treatment Capacity *)	300,000 m^3/day	400,000 m^3/day	500,000 m^3/day

*) Total Treatment Capacity includes existing WTP capacity.

5-4-2 Site Selection

5-4-2-1 Water Treatment Plant

Alternatives for the water treatment plant site are;

1) To use extra space in the Chrouy Changva WTP site, or
2) To acquire new land for a new water treatment plant.

For the Stage I project, the Chrouy Changva site was selected because the necessary procedures before commencement of the construction work will be the shortest.

5-4-2-2 Water Transmission/Distribution Pipelines

In the Master Plan, the Study Area was divided into 5 zones as shown in Chapter 7. To achieve efficient water distribution, a loop system was proposed.

The rationale of this first scenario is to join the existing main transmission pipes in order to form loops that will, with limited investment, enable:

- to distribute the water from the expanded/new (north and south) treatment plants,
- to cover a slightly extended area, particularly towards local areas where development is planned, and
- to ensure in covered areas the benefits of a meshed system to better balance system pressure and provide alternate routes to supply water when one branch or plant must be temporarily disabled.

The completion of the inner loops will be carried out in Stage I.

There could be various alternatives for detailed routes of the distribution pipes. To create the loops, the Team chose National Roads, branch roads connected to National Roads, and roads that run close to the water towers. Also, branch extension of distribution pipes are designed for roads that already have dead-end distribution pipes and population along the road.

5-4-2-3 Well Facility Construction Project

The target villages were selected according to the following considerations.

- Communes with the expected safe water coverage of more than 60 percent by piped water in 2010 were omitted,
- Communes with the pipeline installation by 2020 were omitted, and
- Villages without suitable accessibility by construction traffic will be omitted based on the interpretation of satellite images.

5-4-3 Technical Alternatives

5-4-3-1 Water Treatment Plant

Existing facilities are efficiently operated and have not caused any serious shortages. Therefore, the Team proposes to utilize similar technology and equipment for the expansion.

For the future improvement, the Team recommends PPWSA to equip sludge treatment facilities at each water treatment plant.

5-4-3-2 Well Facility Construction Project

The hand pump should have a discharge capacity of 20 to 30 liters/minute and maximum pump head of 30 meters. They should be easy to use by women and children, easy to operate and maintain (O&M) at village level, and be protected from rust and abrasion. Among the hand pumps commonly used in Cambodia, only Afridev satisfies the required specifications. It is also the specified standard deep well hand pump by DRWS and same type used in the Peri-Urban Project, 2005.

Accordingly, Afridev was recommended for the project.

5-4-4 Without Project Situation

Without the additional water treatment plant, the daily maximum water demand will surpass the water production capacity by year 2007 (Table 5.8).

In such case, the following difficulties may occur to the households in Phnom Penh:

Before 2007:

1） Water pressure or supply hours will decrease during high demand (dry) season.

2） Expansion of distribution pipes will be discouraged because of lower pressure.

3） Increase of per capita water demand will be unmet and inequity among the residents regarding water use will be wider.

After 2007:

4） It will be difficult for PPWSA to increase the number of connections because of the water shortage.

Table 5.8 Water Production and Water Demand Without Project

Year	2005	2010	2015	2020
Present Water Production Capacity (m^3/d)	235,000			
Daily Ave. per capita water demand (lpcd)	80	86	95	104
Peak Day per capita water demand	104	111	123	135
Daily Max. per capita demand (lpcd)	122	131	144	158
Total population	1,529,999	1,774,891	2,034,868	2,303,826
Served population	1,035,931	1,244,738	1,491,113	1,866,102
Coverage (%)	67.7	70.1	73.3	81.0
Daily Ave. water demand (m^3/d)	133,402	166,529	209,292	271,093
Daily Max. water demand (m^3/d)	204,027	**254,691**	**320,094**	**414,612**
Nos. of served households	105,870	136,540	180,736	247,712
Nos. of non-domestic connections	15,517	18,729	21,640	25,011
Total no. of connections	121,387	155,269	202,376	272,723

Without proper extension of the distribution pipe network, the increasing population of Greater Phnom Penh area will depend on unsafe water sources and expensive vendor water. In addition to that, ground water resources will be increasingly exploited by industrial facilities in the suburbs of Phnom Penh.

In rural areas without existing PPWSA service, residents will maintain their current condition of water supply, depending on deep wells, shallow wells, private water suppliers or water vendors.

Without proper provision of deep wells and water quality monitoring, hygiene condition of the residents will stay poor, and arsenic poisoning may remain unnoticed.

5-5 Scoping of Potential Impacts

5-5-1 Scoping Checklist

In the process of scoping of environmental impacts (Table 5.9), 12 environmental items are identified as possibly affected by the implementation of the Stage I projects.

Table 5.9 Scoping Checklist

		Projects			
	Environmental Items	**1**	**2**	**3**	**4**
1	Resettlement				
2	Local Economy such as employment and livelihood	X P	P	X P	P
3	Existing social infrastructures and services	X	X	X	X
4	Land use and utilization of local resources				
5	Social institutions such as social infrastructure and local decision-making institutions				
6	The poor, indigenous or ethnic people			X P	P
7	Misdistribution of benefit and damage			X P	P
8	Local conflict of interests				
9	Gender			P	P
10	Children's rights			P	P
11	Cultural Property			X	
12	Water Rights and Rights of Common	X			
13	Public Health Condition			P	P
14	Infectious diseases such as HIV/AIDS etc.				
15	Waste	X			
16	Hazards (Risk)(Traffic accidents)	X		X	
17	Topography and geology				
18	Soil erosion				

		Projects			
	Environmental Items	**1**	**2**	**3**	**4**
19	Groundwater				
20	Lake/River				
21	Sea/Coastal zone	N/A	N/A	N/A	N/A
22	Flora and Fauna				
23	Climate				
24	Landscape				
25	Air pollution			X	
26	Water contamination	X			
27	Soil contamination				
28	Noise and vibration	X	X	X	
29	Ground subsidence				
30	Offensive odor				

Reference: "Environmental Guidelines for Infrastructure Projects", JICA, 1992 (some modifications)
Note : Project 1: Chrouy Changva Water Treatment Plant, 2: Water Tower, 3: Distribution Pipes, 4: Well Construction, X: Target for field survey, P: Item that positive impact is expected, N/A: Not applicable

5-5-2 Summary of Positive Impacts

5-5-2-1 Chrouy Changva Water Treatment Plant Project

Local manufacturing, transportation, and construction businesses are expected to benefit from the construction phase of the project.

5-5-2-2 Water Tower Construction and Booster Pump Installation

Local manufacturing, transportation, and construction businesses are expected to benefit from the construction phase of the project.

5-5-2-3 Transmission/Distribution Pipes Construction Project

Construction works will be handled directly by the PPWSA. The project will support to keep sufficient number of workers in the organization.

Extension of areas provided by the piped water will benefit local businesses, will lessen the labor of housewives and children to fetch water, and will benefit greatly the public health conditions of the area.

Poorer rural populations on the outskirts of Phnom Penh city will benefit from the extension of distribution pipes since they can rely on piped water, especially in dry seasons, rather than relatively expensive vendor water. PPWSA has a few subsidiary measures, explained later in this chapter, to encourage poorer households to connect their house to the piped water. Using those measures, maldistribution of benefits from the piped water supply will be minimized.

5-5-2-4 Well Facility Construction Project

Construction works may benefit local construction businesses.

Increase of deep wells will benefit greatly the public health conditions of the area, will lessen the labor of housewives and children to fetch water, especially in dry seasons, and will help the households by reducing dependency on relatively expensive vendor water.

5-5-3 Project Phase and Key Impacts

Identified impacts for each project are expected in the phases described in the following tables. Degree of impacts on some environmental items that are expected to be affected by the same cause, such as construction vehicles, will be assessed together in the following sections.

Table 5.10 Identified Key Impacts for Chrouy Changva WTP Project

Cause of the Impacts / Affected Environmental Items	Planning Phase			Construction Phase		Operation Phase			
	Spatial Occupancy	Use of Resource	Distribution of Resource	Reclamation And Spatial Occupancy	Operation of Construction Equipment and Vehicles	Spatial Occupancy	Operation of Vehicles, Ships and Airplanes	Operation and Maintenance of Associated Facilities	Accumulation of people and Goods
Resettlement									
Local Economy such as employment and livelihood				Y					
Existing social infrastructures and services					**Y**				
Water Rights and Rights of Common		Y							
Waste								Y	
Hazards (Risk)(Traffic accidents)					**Y**		Y		
Water contamination								Y	
Noise and vibration					**Y**				

Table 5.11 Identified Key Impacts for Water Tower Project

Cause of the Impacts / Affected Environmental Items	Planning Phase			Construction Phase		Operation Phase			
	Spatial Occupancy	Use of Resource	Distribution of Resource	Reclamation And Spatial Occupancy	Operation of Construction Equipment and Vehicles	Spatial Occupancy	Operation of Vehicles, Ships and Airplanes	Operation and Maintenance of Associated Facilities	Accumulation of people and Goods
Existing social infrastructures and services					Y				
Noise and vibration					Y				

Table 5.12 Identified Key Impacts for Transmission/Distribution Pipe Construction Project

Cause of the Impacts / Affected Environmental Items	Planning Phase			Construction Phase		Operation Phase			
	Spatial Occupancy	Use of Resource	Distribution of Resource	Reclamation And Spatial Occupancy	Operation of Construction Equipment and Vehicles	Spatial Occupancy	Operation of Vehicles, Ships and Airplanes	Operation and Maintenance of Associated Facilities	Accumulation of people and Goods
Resettlement									
Local Economy such as employment and livelihood				Y					
Existing social infrastructures and services					Y				
The poor, indigenous or ethnic people			**Y**						
Misdistribution of benefit and damage			**Y**						
Cultural Property					Y				
Hazards (Risk)(Traffic accidents)					Y				
Air pollution					Y				
Noise and vibration					**Y**				

Table 5.13 Identified Key Impacts for Well Water Development Project

Cause of the Impacts / Affected Environmental Items	Planning Phase			Construction Phase		Operation Phase			
	Spatial Occupancy	Use of Resource	Distribution of Resource	Reclamation And Spatial Occupancy	Operation of Construction Equipment and Vehicles	Spatial Occupancy	Operation of Vehicles, Ships and Airplanes	Operation and Maintenance of Associated Facilities	Accumulation of people and Goods
Existing social infrastructures and services								Y	

5-5-4 Existing Environmental Standards

5-5-4-1 Drinking Water Quality

WHO guidelines for drinking water are widely used in Cambodia. There are no environmental standards for quality of underground water in Cambodia.

Table 5.14 WHO Guideline for Drinking Water (2004)

TDS	Fe	Mn	Cl	SO_4	F	Coliform bacteria
(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(c/ml)
1000	0.3	0.4	250	250	1.5	0

Source: WHO (2004)

5-5-4-2 Public Water Body and Waste Water

Sub-decree No. 27 (6 April 1999) Water Pollution Control defines environmental standards for public water body and waste water from manufacturing institutions. Those standards are listed in the Supporting Report.

5-5-4-3 Air Pollution and Noise

There are environmental standards for gas emission from mobile sources and immobile sources. For noise, there are standards for mobile sources. Those standards are listed in the Supporting Report.

There is no standard for vibration in Cambodia.

Although environmental standards are legalized, quantitative monitoring activity is not yet common in Cambodia, including Phnom Penh.

5-6 Assessment of the Environmental Impacts

5-6-1 Chrouy Changva Water Treatment Plant Area

5-6-1-1 Target Area

The target area covers approximately 500 meters radius around the locations of planned construction work.

5-6-1-2 Field Study and Evaluation

(1) Resettlement, the Poor, Indigenous of Ethnic People

No resettlement of residents is expected by the construction of the water treatment plant as the facilities will be constructed within the perimeter of the existing Chrouy Changva WTP.

Also, there will be no resettlement, temporary or permanent, from the construction of the intake tower and raw water transmission pipes.

(2) Local Economy such as Employment and Livelihood

There are ferries used by the existing dredging businesses about 30 meters downstream of the proposed intake tower. PPWSA, together with the local village chief, is under negotiation with the business owners for any necessary coordination during the construction and operation phase.

At this stage, there are three possible outcomes from the agreement:

1） The ferries will be relocated from the present site during and after the construction of the intake.
2） The ferries will be relocated from the present site only during the construction phase, and will be back for operation thereafter.
3） The ferries will stay at the present location during and after the construction, since the 30 meters distance from the intake site will be sufficient as a buffer for construction works.

The negotiation is expected to come to agreement during the detailed design phase, which is expected to end in 2006.

Construction of raw water transmission pipes across the road may affect the trucking of sand from the dredging facilities.

About 50 to 70 heavy dump trucks per day were counted during the field survey.

In case the businesses remain at the existing location or nearby during the construction of the pipes, PPWSA should negotiate with the business owners for mitigation measures. The measures could include shifting construction to night-hours, weekends, or any other agreed time-zone when the dump trucks are not in operation. Shifting the transportation route during the pipe construction would be an alternative mitigation measure.

(3) Existing Social Infrastructure and Services, Noise and Vibration

Within the radius of 500 meters, there is no main social infrastructure or services that could be affected by the noise and vibration from the construction or limitation of access.

(4) Water Right and Right of Common

Regarding the water right of the Mekong River, there are two documents to refer at this moment:

1） 1995 Mekong Agreement and Procedural Rules, and
2） Draft Law of the Ministry of Water Resources and Meteorology (MOWRAM).

According to the Mekong Agreement, the National Mekong Committee (NMC) is required to consult the international Mekong River Committee for intra-basin use of the main stream during the dry season (Procedures 5.1), as well as inter-basin diversion from mainstream during wet season. The Tonle Sap River is also covered by the Agreement.

The Agreement Annex provides a format for the notification for consultation. The format requires information about notifying ministry/agency, location of the project, purpose of the proposed project, expected date for the implementation, duration and timing for water use. The notification is required to have attached documents including feasibility study report, implementation plan, and project schedule (Procedures 4.2.1). The notification is required to be submitted to the Mekong River Committee from the NMC prior to implementation. The Agreement, however, does not state the procedure between project proponents and the NMC.

PPWSA, in the future phase, will need to consult with MIME and the Cambodian National Mekong Committee for the proper procedure according to the Agreement.

Article 18 of the draft law of the Ministry of Water Resources and Meteorology explains the concept of water use license and water use fees. Exemption from water use fees will be described in the sub-decree.

PPWSA will also need to closely monitor the process and statement of the law for future coordination of their business with other water users.

(5) Hazards (traffic accident risk)

During the construction phase, there will be additional traffic bringing equipment in and out of the project site.

With heavier traffic volume, there are two areas where special care will be necessary to avoid traffic accidents:

1) The junction between road No 6 and the road to the existing Chrouy Changva WTP. The junction is close to the Japan Friendship Bridge and traffic is heavy, especially in the morning from around 6.30 AM to 8.30 AM and in late afternoon from 4.00 PM to 6.00 PM. This junction is about 3 km from the WTP, but this is the only major access road to the site.
2) The road bends about 100 meters north of the project site. The width of the road narrows at the corner and there is a small ferry landing plus houses and small shops of local residents where children play. The target area is in the suburb where the traffic is not heavy. Traffic jams and accidents are rare. Besides trucks from the dredging business, there are only about 80 to 100 motorbikes and 10 to 15 cars between 6:00 AM to 6:00 PM.

During the construction phase, PPWSA should have the contractor provide special staff for traffic control at the above places. Present traffic speed is quite slow. With proper control of pedestrians, local vehicles and construction vehicles, the risk of traffic accident can be minimized.

During operation phase, the impacts of the project are considered to be minor. About 5-10 trucks per month will be added to the present traffic volume to carry chemicals (Alum and Chlorine) and other materials to the WTP.

5-6-2 Water Tower Augmentation Projects

5-6-2-1 Target Area

The target area is approximately 500 meters radius around the locations of the planned construction work site in Ta Khmau and two other existing water tower sites. Photos of the target area are shown in the Supporting Report.

5-6-2-2 Field Study and Evaluation

(1) Ta Khmau Water Tank

Since there are a few office buildings in the project area, there will be some impacts on those occupants from the noise and vibration during construction, but it will not be significant as they are not located too close to the project site.

(2) Installation of Booster Pumps at Airport and Chaom Chau Water Tanks.

Since the booster pumps will be installed within the perimeter of the existing water towers, installation work of the booster pumps will not produce much noise and vibration. There will be no impacts on surrounding houses and social infrastructure by the installation of these pumps.

5-6-3 Transmission/Distribution Facilities Augmentation Project

5-6-3-1 Target Area

The target areas are adjacent to the planned lines for distribution pipe construction. Typical image of each area is shown in the Supporting Report.

5-6-3-2 Field Study and Evaluation

(1) Chrouy Changva

No significant impact is expected on Resettlement, the poor indigenous or ethnic people, existing social infrastructure and services, air pollution, noise and vibration, cultural property, and hazards (traffic accident risk).

(2) Prek Leap

No significant impact is expected on Resettlement, the poor indigenous or ethnic people, existing social infrastructure and services, air pollution, noise and vibration, cultural property, and hazards (traffic accident risk).

(3) Ruessei Kaev

No significant impact is expected on Resettlement, the poor indigenous or ethnic people, existing social infrastructure and services, air pollution, noise and vibration, cultural property, and hazards (traffic accident risk).

(4) Svay Pak

No significant impact is expected on Resettlement, the poor indigenous or ethnic people, existing social infrastructure and services, air pollution, noise and vibration, cultural property, and hazards (traffic accident risk).

(5) Khmoun

No significant impact is expected on Resettlement, the poor indigenous or ethnic people, existing social infrastructure and services, air pollution, noise and vibration, cultural property, and hazards (traffic accident risk).

(6) Phnom Penh Thmei

No significant impact is expected on existing social infrastructure and services, air pollution, noise and vibration, and cultural property.

Planned route for pipeline in Svay Pak area passes close to a few shops and house fences. Special care and coordination/negotiation with local residents will be necessary prior to the commencement of construction to minimize the impact of temporary removal of related structures.

(7) Prey Pring Choeung (Chaom Chau)

No significant impact is expected on cultural property.

Planned route for pipeline in Prey Pring Choeung area include cross sections of National Roads 3 and 4. Although the roads are wide, construction work must be carefully managed to avoid or minimize traffic accidents and temporary relocation of commercial and transport activities in the area.

Also, it will be necessary to communicate with the military before any underground work near their facilities to avoid any impact to the function of their facilities.

(8) Samraong Krom

No significant impact is expected on resettlement, the poor indigenous or ethnic people, air pollution, noise and vibration, cultural property, and hazards (traffic accidents risk).

Planned route for pipeline in Samraong Kraom area passes a few garment factories, military center, and a railway. Although the roads are wide, construction work must be carefully managed to avoid negative impacts on those facilities.

(9) Dangkao

No significant impact is expected on existing social infrastructure and services, air pollution, noise and vibration, cultural property.

Planned route for pipeline in Dangkao area passes close to a market and a pagoda. Special care and coordination/negotiation with local shop owners will be necessary prior to the commencement of construction to minimize impact from temporary relocation or inconvenience. Also, proper arrangement of traffic control is important to avoid traffic accidents near the market.

(10) Ta Khmau

No significant impact is expected on resettlement, the poor indigenous or ethnic people, existing social infrastructure and services, air pollution, noise and vibration, and cultural property.

Planned route for pipeline in Ta Khmao area passes many factories. There are obvious commuting hours with heavy traffic. Pedestrian traffic is also heavy during the work breaks. It is important to control traffic to avoid accidents. Notification to the factory owners, workers, and road-stalls about the schedule of construction work will be important. Also, it will be better to avoid the rush hours for the construction work.

(11) Prek Pra

No significant impact is expected on existing social infrastructure and services, air pollution, noise and vibration, cultural property, and hazards (traffic accident risk).

Planned route for pipeline in Prek Pra area is along a 5 meter wide road with houses built almost right on the road. Careful design will be necessary to minimize any relocation of the houses.

(12) Kien Svay (Chbar Ampov 1+2)

No significant impact is expected on resettlement, the poor indigenous or ethnic people, existing social infrastructure and services, air pollution, noise and vibration, cultural property, and hazards (traffic accident risk).

5-6-3-3 Measures to Support Low Income Households

PPWSA has adopted the following two measures to encourage households with lower income to connect their house to the piped water:

1） Installment (10, 15, or 20 months) of connection fee payment, designed by PPWSA, and

2） Subsidized price (30, 50, or 70 percent) of connection fee, supported by World Bank (IDA) Grant No. H034-KH.

From 1999 to 2004, about 15 percent of new domestic connections used the installment payment program for their connection fee.

In the outskirts area of Phnom Penh, most households currently rely on water from river, rain, and communal well (average management fee 2,000 R/household/month). In dry seasons, however, many households avoid stagnant water for drinking and buy water from vendors at a cost of 2,500-6,000R/m^3. The average domestic price of PPWSA water is, on the other hand, 874R/m^3, or 20,000R/month.

From the above facts, it can be concluded that households with low income have support for connection and they will benefit from the connection in terms of health conditions with safe water as well as having a reliable, cheaper water source especially during dry seasons.

5-6-4 Well Facility Construction Project

5-6-4-1 Target Area

The target villages are listed in Table 5.5.

5-6-4-2 Field Study and Evaluation

Field survey was conducted on existence of well management organization, groundwater quality of existing wells, and significance of water shortage at the target villages. Survey method was direct interview with a few villagers randomly selected. Interviewer was staff of local consultant. Detailed results of the field study are shown in the Supporting Report.

Through the interviews in the target villages, it was found that even without an existing well management committee, most villages have already experienced some kind of collective activities or formed committees for other purposes and thus are willing to form a committee for managing the well.

Water quality from almost all deep hand pump wells with depth around 100 meters or more in all target villages are reported as good quality water, which can be used for both household consumption and drinking purposes. Water quality from other sources, except from rain, is usually used only for household consumption.

Among the 43 villages interviewed, residents from villages listed in Table 5.15 described the most significant water shortages. All these villages are located in Dangkao District, which is planned to be the first target for the well construction project.

Table 5.15 Villages With Possibly Significant Water Shortage

No.	Village
4	Phleung Chhea Roteh Lech
5	Phleung Chhea Roteh Keut
8	Sre Nhor
10	Prey Key A (Kor)
13	Trapaing Sala
14	Prey Veng Lech
15	Kam Rieng
28	Ang
31	Kok Meas

No.: Number corresponds with Table 5.5.

5-7 Environmental Impact Mitigation Measures

5-7-1-1 Chrouy Changva Water Treatment Plant Project

Table 5.16 Environmental Mitigation Plan for Chrouy Changva WTP Project summarizes the main environmental concerns, the necessary preparations and countermeasures to protect the environment, and the responsibilities of the different parties.

Table 5.16 Environmental Mitigation Plan for Chrouy Changva WTP Project

Phase	Issue	Required preperations and countermeasures	Responsibility	Cost
Pre-Construction	Resettlement	- Make sure that there are no families permitted to settle on the site before construction begins.	PPWSA, local village chief	1)
	Local Economy	- Arrange proper procedure to negotiate with owner of the dredging business about possibility to move the business location	PPWSA, local village chief, Phnom Penh Municipality	1)
	Water Rights	- PPWSA to consult with MIME and MOWRAM about water law and MRC agreement, and submit required information and documents.	PPWSA	2)
Construction	Existing social infrastructures and services, Noise and Vibration	- Inform people living nearby about the date of begin and completion of the construction work	PPWSA and its contractor, local village chief	1)
	Local Economy	- Arrange proper work schedule to avoid negative impacts on the transportation of river sand from the local business.	PPWSA and its contractor	1)
	Hazard (traffic accidents risk)	- Place proper sign and person to regulate the traffic flow during construction phase at the two important places; the junction with NR6 and the road bend north of the site. - Monitor the deployment of heavy plant, equipment and materials so that the road will not be blocked or narrowed. - Train and control their drivers to operate vehicles at low speed. - Place additional traffic police to provide awareness training to residents near the construction site.	PPWSA and its contractor, local village chief	3)

Note: 1) Cost for the activities is included in the Project cost as Government's administration expenses as described in "Chapter 13-3-1 Construction Cost" in the Main Report - Part A.
2) Cost and timing for the negotiation regarding water right will be studied in detail in the next step (basic design phase) of the project, that is expected to finish in 2006.
3) Cost for the traffic management will mainly be covered by the contract fee paid by PPWSA.

5-7-1-2 Water Tower Augmentation Projects

Table 5.17 summarizes the main environmental concerns, the necessary preparations and countermeasures to protect the environment, and the responsibilities of the different parties.

Table 5.17 Environmental Mitigation Plan for Water Tower and Booster Pumps

Phase	Issue	Required preperations and countermeasures	Responsibility	Cost
Construction	Existing social infrastructures and services, Noise and Vibration	- Inform people living nearby about the date to start and finish the construction work	PPWSA and its contractor, local village chief	1)

Note: 1) Cost for the PPWSA activities is included in the Project cost as Government's administration expenses as described in "Chapter 13-3-1 Construction Cost" in the Main Report - Part A.

5-7-1-3 Distribution Facilities Augmentation Project

Table 5.18 summarizes the main environmental concerns, the necessary preparations and countermeasures to protect the environment, and the responsibilities of the different parties.

Table 5.18 Environmental Mitigation Plan for Distribution Augmentation Project

Phase	Issue	Required preperations and countermeasures	Responsibility	Cost
Pre-Construction	Resettlement Local Economy	- Inform people and institutions in the project area about construction plan and detailed schedule. - Make proper negotiation and compensation.	PPWSA, local village chief	1) 2)
Construction	Existing social infrastructures and service, air pollution, noise and vibration Local Economy	- Inform people and institutions in the project area about construction plan and detailed construction schedule.	PPWSA and its contractor, local village chief	1)
	Hazard (traffic accidents risk)	- Place proper sign and person to regulate the traffic flow during construction phase at the two important places; the junction with RN6 and the road bend north of the site. - Monitor the deployment of heavy plant, equipment and materials so that the road will not be blocked or narrowed. - Train and control their drivers to operate vehicles at low speed. - Place additional traffic police to provide awareness training to residents near the construction site.	PPWSA and its contractor, local village chief	3)

Note:
1) Cost for the activities is included in the Project cost as Government's administration expenses as described in "Chapter 13-3-1 Construction Cost" in the Main Report - Part A.
2) Cost and timing for the negotiation regarding compensation fee will be studied in detail in the basic design phase of the project.
3) Cost for the traffic management will mainly be covered by the contract fee paid by PPWSA.

5-7-1-4 Well Facility Construction Project

Table 5.19 summarizes the main environmental concerns, the necessary preparations and countermeasures to protect the environment, and the responsibilities of the different parties.

Table 5.19 Environmental Mitigation Plan for Well Facility Construction Project

Phase	Issue	Required preperations and countermeasures	Responsibility	Cost
Pre-Construction	Existing social infrastructures and services	- Start formation of well-management groups to make the project most effective.	Ministry of Rural Development	1)
Construction	Existing social infrastructures and services	- Continue training of the well-management groups so that they acquire sufficient knowledge and skill to manage the wells.	Ministry of Rural Development	1)
Operation	Existing social infrastructures and services	- Let the well-management groups to function as the leader of local community regarding the water and well management. - Support the well-management groups to educate other local residents about the proper use and management of the wells.	Ministry of Rural Development	1)

Note: 1) Cost and timing for the activities will be studied in detail in the basic design phase of the project.

5-8 Public Participation

5-8-1 First Seminar on the Master Plan with Local Communities Related to Alternative Sites

5-8-1-1 Date and Time

2005.6.10 8:00 - 12:30

5-8-1-2 Venue

Phnom Penh Hotel

5-8-1-3 Objectives

To present the approach, methodology and techniques adopted in the preparation of the Water Supply Master Plan.

5-8-1-4 Attendants

All departments of PPWSA and key government agencies concerned, including local offices, were represented, as well as some external (donor) agencies and consultants, per the attached attendance list (see Supporting Report).

5-8-1-5 Presentation

The agenda of the seminar is shown in Table 5.20.

The seminar opened with remarks delivered by PPWSA General Director Ek Sonn Chan.

In accordance with the above-mentioned agenda, the Study Team made a series of presentations summarizing the draft Interim Report and focusing on the approaches, methodology and assumptions used in arriving at the recommendations. The presentations are described in the attached Workshop Handout, which includes an executive summary and copies of the PowerPoint Slides used for the presentations. At the end of each presentation, questions were taken from the attendants and the Team answered them.

Table 5.20 Agenda at Seminar June 10

Time	Topic/Activity	Lead
8:00 – 8:20	**Opening Remarks** by Mr. Ek Sonn Chan (10 min)	
	Workshop objectives and structure (10 min)	Y Sato
8:20 – 10:00	**Technical Assessments and Planning** (100 mins) • Demand projections and Customers • Development and analysis of alternative demand-capacity scenarios • Design considerations • Bases for project estimates	Y Sato S Osaka G Stetten I Mizuno
10:00 – 10:20	Coffee/Tea Break	
10:20 – 10:40	**Financial Analysis & Tariff Projections** (20 mins) • Financial Projections • Tariff Projections	C Sun
11:40 – 12:00	**Institutional Assessment and Planning** • Capacity Building (20mins)	W Barreiro P Ide
12:10 – 12:30	**Drainage/Sewerage Survey Results** (20 mins)	T Matsushita
	Closing Remarks by JICA	

5-8-1-6 Summary of Discussion

Questions and answers are summarized in Table 5.21. Topic 1 is about the well development project. Topics 2 to 4 are about the issue of the poor. In Topic 5, Phnom Penh Municipality recognizes the consistency between the Master Plan and the City Plan. Topics 6 to 9 are raised by MOE and Phnom Penh Municipality regarding sewage treatment.

Table 5.21 Questions and Answers at Seminar June 10

	Topic/Question	Study Team Response
1	MRD Dr. Mao Saray: What is role of handpump shallow wells in rural expansion plan? M/P mentions 250 meter criteria (as maximum distance from house to well), but Ministry has policy of 150 meters. Also, how to get JICA's assistance?	Mr. Sato: Shallow well is not recognized as safe water source due to unstable and usually low quality. We will investigate the matter of maximum distance to well as well as availability of financial source.

	Topic/Question	**Study Team Response**
2	BAU Planner: What is PPWSA criteria for bringing service? It seems that without at least 30 households they won't connect.	Mr. Sato: Basic criteria to expand service area is based on demand and full cost recovery. Mr. E.S.Chan: We cannot supply if no demand and no request, no reason to extend to empty place. We focus priority on the crowded areas and poor communities. But small settlements along the pipeline can also be served even if no request. Demand for connections still exceeds our capacity. I just want to emphasize that we cannot something if nothing there and no demand, but we are ready to provide if needed.
3	MRD Dr. Mao Saray It's well known that poor pay higher price for water.	Mr. E.S.Chan: We have the a progressive tariff structure and Social Fund for Connection. Poor can't help poor, rich can help poor, we must not go bankrupt.
4	MIME staff: Please be careful regarding the ingredient for setting the tariff.	The Team takes notes.
5	BAU Planner: Regarding the selection of Nirouth site, we considered same way in City Plan.	
6	BAU Planner: Did you consider the waste water issue? MOE: MOE expects it is essential that a implementation of development plan for drainage and sewerage.	Mr. Sato: This MP study is focused on the development plan for water supply aspects. Team will suggest only urgent issues on the current drainage and sewerage systems.
7	Municupality of Phnom Penh (Drainage and Sewerage section): What is pond surface area we need to reserve for natural treatment, or if not enough, then what to do and how much cost?	Mr. Matsushita: At present, the south lake/marsh surface areas is not enough even if fully preserved. North lake is also not enough in future. Therefore, additional treatment facilities will be required. Mr. Sato: Study is not yet finished regarding technical solution and the cost to treat the wastewater.
8	MPWT: How much land should be we keep?	Mr. Matsushita: All existing should be kept.
9	BAU: In City Plan we already reserved, about 400 hectares in north and 1200 hectares in south. Since Tonle Sap flows in both directions during the year, we should put any sewage effluent there. We should consider 2 systems: one would drain the rainwater to the north and the other would transfer sewage to the south and dispose at Bassac..	
10	JICA Mr. Ono: We need to see the financial results, not just methodology.	Mr. Sun: These were presented at the stakeholders meeting earlier this week, but in summary, the conclusions we reached were the following... (some additional Powerpoint slides presented, see record of stakeholder's meeting for details)
11	BAU: Need to aggregate data from different institutions to build GIS	Mr. Barreiro: Agreed that it would be useful if the City coordinated a GIS-based data management system so that all city services can be easily coordinated and planned.

BAU: Department of Planning, Phnom Penh Municipality (Bureau des Affaires Urbaines)

5-8-2 Second Seminar on the Master Plan with Local Communities Related to Alternative Sites

5-8-2-1 Date and Time

2005.11.21 9:00 - 12:00

5-8-2-2 Venue

PPWSA Conference Room

5-8-2-3 Objectives

To update stakeholders on the progress of the work undertaken on the JICA Study for the Master Plan of Greater Phnom Penh Water Supply (Phase 2) and to discuss the key findings and conclusions which will be included in implementation of the priority projects proposed by the Master Plan.

5-8-2-4 Attendants

All departments of PPWSA and key government agencies concerned, including local offices, were represented, as well as some external (donor) agencies and consultants are invited. (See Supporting Report).

5-8-2-5 Agenda

Tentative agenda, as of November 2, is shown in Table 5.22.

Table 5.22 Tentative Agenda for Seminar November 21

Topic / Activity	Lead Presenter/Discussant
Registration	
Introductory Remarks	PPWSA General Director Mr. Ek Son Chan
Introduction of Project and Consultants	PPWSA Deputy General Director Mr. Long Naro (in Khmer language)
Presentation of Objectives of the Meeting and the Agenda. Introduction of Participants	Deputy Director Mr. L. Naro Planning and Technical Department, PPWSA
1. Overview of Feasibility Study on Priority Projects for Stage I	Mr. Y Sato, Team Leader, JICA Study Team
2. Expansion of Chrouy Changva	Mr. S Osaka, Water Supply Engineer, JICA Study Team
3. Extension of Transmission & Distribution System	Mr. Guillaume Stetten, Transmission and distribution pipelines planning, JICA Study Team
4. Peri-Urban Water Supply Project	Mr. Y Sato, Team Leader, JICA Study Team
5. Financial Analysis	Mr. C Sun Financial Analyst, JICA Study Team
6. Institutional Development Plan	Mr. W Barreiro, Capacity Building Specialist, JICA Study Team

5-8-2-6 Summary of Discussion

Questions and answers are summarized in Table 5.23.

Table 5.23 Questions and Answers at Seminar June 10

	Topic/Question	Study Team Response
1	(Mr. Ek Son Chan) How can production be doubled by adding only 4 filters to existing 8?	(Mr. Osaka) Testing proves feasibility of increasing filtration rate of existing (and new) filters to 8m/hr. Still safe and still provides sufficient capacity for backwashing.
2	(Mr. Long Naro) Hypothetically, what will be the effect if the project is delayed (e.g., if financing cannot be arranged according to proposed schedule)?	(Mr. Sato) Short delay will be okay, but eventually there will be the problem of empty clear water reservoir.
3	(Mr. Long Naro) Does the financial evaluation of PPWSA assume a project cost of $67m or $75m (i.e., does it include the Peri-Urban portion which belongs to MRD)?	(Mr. Sun) Actually, $75m. So if change to $67m then result of financial evaluation becomes even more positive for PPWSA. Either way, there will be no problem since financial evaluation is already positive.
4	(Safege Team Leader) Is the figure of 15% NRW used for both economic and technical analysis?	(Mr. Sato) Basically yes, NRW figure is not broken down further. So it is safe to assume 15% for purposes of technical calculation of facility capacity requirements, plus usual 30% margin.
5	(Dr. Chea Visoth, PPWSA Senior Advisor) Is it possible to say what is the optimal level of NRW based on cost versus investment trade-off?	(Mr. Ek Son Chan) Accurate answer requires another study.

5-8-3 Communication with Local Communities and Future Customers

PPWSA already has regular work procedure regarding the design and construction of their facilities. In the procedure, PPWSA pays great care to follow the local process of decision making, starting with talks to the village chiefs. Without the agreement of the chiefs, PPWSA will not start any action for the construction works. Information about the PPWSA projects is distributed by the village chief to the local community. Residents in the community are free to express their concern to the chief, who is one of the residents of the village.

PPWSA also has Customer Service Department for any complaints or requests from the customers or those who is willing to connect and need information.

To improve the connection rate among the households in existing service area, and to advertise its good water quality and 24-hour service, PPWSA sponsored a TV commercial in 2004.

The Study Team did not directly support such communication by PPWSA, but observed its regular work-style and evaluated the communication style as very effective.

5-9 Environmental Monitoring and Management Plan

5-9-1 Chrouy Changva Water Treatment Plant Project

In Table 5.24, recommended environmental monitoring plan is summarized.

During pre-construction and construction phase, monitoring of the mitigation procedures and effectiveness of mitigation measures is important to avoid or minimize any negative impact from the project. Monitoring in the operation phase will be covered by regular operation and management staff and budget, but it is also important for proper production and distribution of safe water for the Greater Phnom Penh.

Table 5.24 Environmental Mitigation Plan for Chrouy Changva WTP Project

Phase	Issue	Required preperations and countermeasures	Responsibility	Cost
Pre-Construction	Resettlement	- Monitor that there are no involuntary resettlement.	PPWSA, local village chief	1)
	Local Economy	- Monitor that proper procedure and arrangements are made and documented with the local businesses near the site.	PPWSA, local village chief, Phnom Penh Municipality	1)
	Water Rights	- Monitor that proper procedure and arrangements are made and documented with MIME, MOWRAM and Cambodian MRC.	PPWSA	2)
Construction	Existing social infrastructures and services, Noise and Vibration, Local Economy, Hazard (traffic accidents risk)	- Conduct on-site inspections to monitor the compliance to the mitigation plan, and the level of impact from the construction work. - If necessary, take sufficient countermeasures and educate the contractor to reduce any negative impact from the construction work on the daily life and economic activities of local residents.	PPWSA and its contractor	1)

Note: 1) Cost for the activities is included in the Project cost as Government's administration expenses as described in "Chapter 13-3-1 Construction Cost" in the Main Report - Part A.
2) Cost and timing for the negotiation regarding water right will be studied in detail in the next step (basic design phase) of the project, that is expected to finish in 2006.

5-9-2 Water Tower Augmentation and Booster Pumb Installation Projects

In Table 5.25, recommended environmental monitoring plan is summarized.

During construction phase, monitoring of the effectiveness of mitigation measures is important to avoid or minimize any negative impact from the project.

Table 5.25 Environmental Mitigation Plan for Water Tower and Booster Pump Projects

Phase	Issue	Required preperations and countermeasures	Responsibility	Cost
Construction	Existing social infrastructures and services, Noise and Vibration	- Conduct on-site inspections to monitor the compliance to the mitigation plan, and the level of impact from the construction work. - If necessary, take sufficient countermeasures and educate the contractor to reduce any negative impact from the construction work on the daily life and economic activities of local residents.	PPWSA and its contractor	1)

Note: 1) Cost for the activities is included in the Project cost as Government's administration expenses as described in "Chapter 13-3-1 Construction Cost" in the Main Report - Part A.

5-9-3 Distribution Facilities Augmentation Project

In Table 5.26, recommended environmental monitoring plan is summarized.

During pre-construction and construction phase, monitoring of the mitigation procedures and effectiveness of mitigation measures is important to avoid or minimize any negative impact from the project.

Table 5.26 Environmental Mitigation Plan for Distribution Augmentation Project

Phase	Issue	Required preperations and countermeasures	Responsibility	Cost
Pre-Construction	Resettlement Local Economy	- Monitor that there are no involuntary resettlement. - Monitor that proper procedure and arrangements are made and documented with the local businesses near the site.	PPWSA, local village chief	1)
Construction	Existing social infrastructures and service, air pollution, noise and vibration Local Economy	- Monitor that the construction work is on schedule. - If necessary, modify the schedule to the realistic plan and widely notify the new construction schedule.	PPWSA and its contractor	1)
	Hazard (traffic accidents risk)	- Conduct on-site inspections to monitor the compliance to the mitigation plan, and the level of impact from the construction work. - If necessary, take sufficient countermeasures and educate the contractor to reduce any negative impact from the construction work on the daily life and economic activities of local residents.	PPWSA and its contractor	2)

Note: 1) Cost for the activities is included in the Project cost as Government's administration expenses as described in "Chapter 13-3-1 Construction Cost" in the Main Report - Part A.
2) Cost for the on-site inspection will mainly be covered by the PPWSA project cost.

5-9-4 Well Facility Construction Project

Table 5.27 summarizes the main environmental concerns, the necessary preparations and countermeasures to protect the environment, and the responsibilities of the different parties.

Table 5.27 Environmental Mitigation Plan for Well Facility Construction Project

Phase	Issue	Required preperations and countermeasures	Responsibility	Cost
Pre-Construction Construction Operation	Existing social infrastructures and services	- Monitor the process of institutional development of the well-management groups. - If any specific arrangement is necessary depending on the local condition, involve relevant parties to decide on the necessary change, and record the process of discussion.	Ministry of Rural Development	1)
	Well validity	- The Team recommends that if the well fails to achieve following conditions, another well has to be re-drilled for efficiency and safety reasons: 1) Pumping yield exceeds 1.0 m3/hour, 2) Arsenic and Fluoride concentration is below the threshold of health guideline.	Ministry of Rural Development, Ministry of Environment	1)

Note: 1) Cost and timing for the activities will be studied in detail in the basic design phase of the project.

5-9-5 Institutional Strengthening and Training

The Environmental Monitoring Program (EMP) will be carried out throughout the period of the project: Pre-construction, Construction, and Operation & Maintenance.

The Social and Environmental Unit (SEU) of the Project Management Office (PMO) of the PPWSA will be responsible for monitoring the project and will also prepare a project performance report to the Project Manager (PM) and responsible Ministry as well as to the project donor.

Monthly monitoring progress reports will be completed and submitted to the PM during the construction phase of the project.

The SEU of the PMO will prepare the report on:

1） monitoring and evaluation of social and environmental situation that happened at construction stage every day or every week as urgently required by PM, and,
2） monitoring of the system operation every week or month.

In terms of providing information about the project, PPWSA (Household Connection Office of the Commercial Department and Pipe Distribution Office of the Department of Water Production and Supply) will inform officially to local authorities then they can convey the information to people or institutions in the project areas.

In case of distribution pipeline needing to cross a bridge or culvert, the Planning and Technical Department of PPWSA will write an official letter to both the Ministry of Public Works and Transport and to the local authorities to inform them about the pipeline construction (including detailed schedule of construction work) and also technical specifications of the pipeline, including expected water pressure during operation.

Chapter 6. Institutional Development Plan & Capacity Building Plan for Stage I (2006-2010)

Chapter 6. Institutional Development Plan & Capacity Building Plan for Stage I (2006-2010)

The broad themes for the institutional development and capacity building plan during Stage I are on sharpening of organizational **directions**, strengthening of management **systems** and promoting more **delegation** of duties and responsibilities. Many of the current systems will have to be formalized and standardized as the PPWSA expands. Skill specialization and defining and refining of roles and responsibilities of the working teams will be pursued.

This Chapter presents the activities and interventions to achieve the institutional development objectives for this stage. There are the immediate capacity concerns directly related to Stage I improvements, as well the ongoing concerns to maintain and enhance the performance of PPWSA as a water company.

6-1 Institutional development plan for Stage I project implementation

The section describes the recommendations on how the project (for both the urban and the peri-urban) components will be planned, implemented and monitored. This function will clearly have to be led by project management units (PMU's), under PPWSA and, possibly, another under MRD.

6-1-1 Project management arrangements

In the proposed structure for PPWSA, a Project Management & Construction Section is proposed under the Technical Planning Department, to serve as permanent PMU for both externally and internally-funded projects. One of the initial responsibilities of this Section is envisaged to be the coordination of Stage I implementation. This is not a major departure from the existing arrangements and the existing staff of this section may be augmented with specialized expertise from other departments in the company, as needed. At present, the unit (currently called Tech & Projects Unit under Planning and Technical Department) is staffed by nine (9) persons. With respect to Stage I improvement, the principal task of this Section will be to coordinate and supervise implementation of Stage I improvements as soon as capital funding can be arranged.

The Project Management & Construction Section, at the minimum, should have the following composition:

Section Chief (1)	Engineer with project management experience, particularly procurement procedures, contract administration, prequalification, bidding and award procedures. Knowledge of project management and monitoring tools.
Construction Engineer (Civil Works)	Civil Engineer, with experience in installation of pipelines, construction of civil works (hydraulic structures). Knowledge of project management and monitoring tools.
Construction Engineer (Electro-Mechanical	Electrical or mechanical engineer, with experience in installation of electro mechanical equipment and machineries. Knowledge of project management and monitoring tools.
Project Field Inspectors	Technical graduates, with knowledge of construction and equipment standards, construction methods and field inspection procedures.
Support staff	With knowledge of records keeping and reporting requirements for project management. Able to provide administrative and financial management support to the Section.

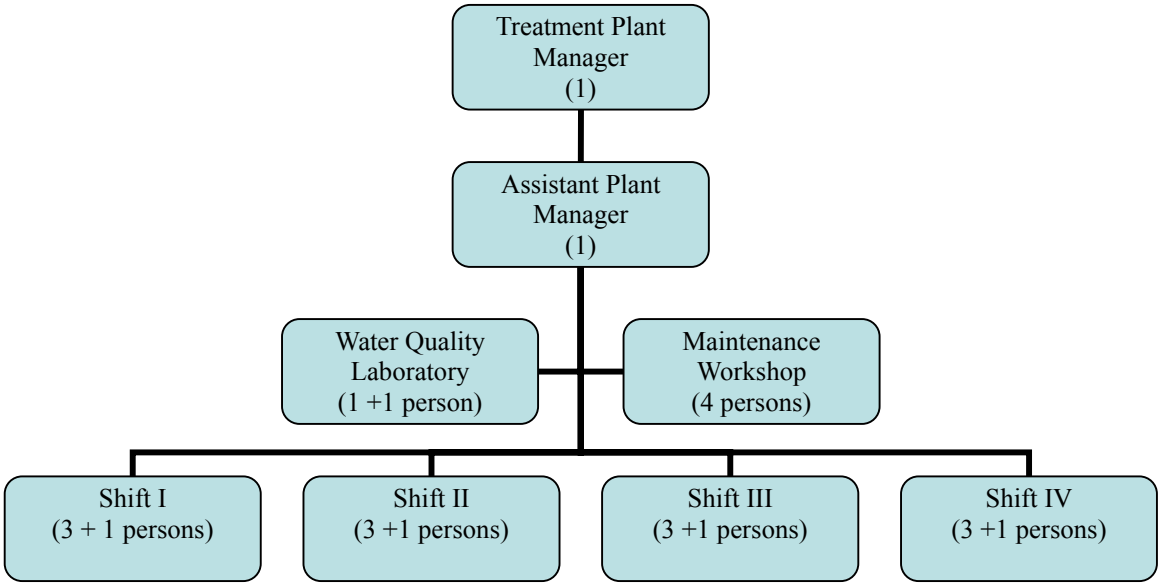
6-1-2 Preparing for effective operation and maintenance of new Stage I facilities

This section focuses on some of the changes that PPWSA will have to institute to operate and maintain the new facilities.

(1) Expanded operations at the Chruoy Changva Water Treatment Plant

This section gives a brief assessment of the current operations and management of the CC-WTP which is proposed for expansion in Stage I. The current management systems in the treatment plant are, by and large, satisfactory. Only a slight increase in the size of the work crew shift size will likely be needed. The control panels for the new facilities will be located in the same room as the controls for the existing facilities. The additional staff for each of the four (4) shifts will be needed to physically maintain the order and cleanliness in the facilities since the new systems are automated. The important skill which must be learned by the shift crew is in being able to identify and anticipate possible operational problems. Operator staff skills will have to be raised since the filtration rate will be increased. Laboratory staff (for routine testing) may be increased since the number of samples will increase. An additional laboratory staff is expected to assist the existing Chemist in taking additional samples and performing the chemical analyses. Some scheduling adjustments will also be needed in the delivery of chemicals and supplies since there in limited space for storing additional supplies. Additional samples for bacteriological testing will be tested at the central laboratory facility. The cleaning of the filter media and other major maintenance functions should be organized through the central maintenance services.

These additional staffing requirements are reflected in the consolidated staffing projections in the succeeding sections. Proposed staffing plan for CC-WTP operations are in the following Figure. (Additional staff is indicated with + sign.)



O&M Manuals for all the Chruoy Changva facilities (and other WTP's) are still not readily available. The development of these manuals are included in the capacity building plan. (As confirmed with the JICA Human Resources Development Project, the maintenance manuals which under preparation focuses on distribution facilities, mechanical and electrical equipment and water quality.)

(2) Expansion of Water Distribution

Improvements in the management of distribution operations and maintenance will include the following: additional water tank with booster (Takhmao); over 100 kms of HDPE and DCI pipeline; and installation of system monitoring facilities. Generally, the specific requirements raised by the Stage I distribution system improvements should be viewed within the broader context of improved operation and maintenance monitoring, response and asset management. Staffing projections in the succeeding section reflects the needs. The strategy will be towards streamlining maintenance management with higher use of the new technologies, the MIS and better system monitoring systems.

(3) Expansion of Water Quality Surveillance

For improving the water quality monitoring system in the short term, the Study proposes the followings:

a) PPWSA should also continue with its water quality surveillance program. The Study suggests that PPWSA consider having tests done progressively for <u>all</u> the parameters, including toxic

pollutants and heavy metals, at least once every five (5) years. These tests may be done through certified and capable partner institutions, such as the Ministry of Environment. It is neither practical nor feasible for PPWSA alone to develop internal capacity to conduct all the tests.

b) Currently, PPWSA conducts E. coli testing of water in the distribution system, once a month. In the table below, the new WHO Guidelines recommend that for piped supplies serving over 0.5 M population, the total number for samples (for fecal indicator testing) should be 12 samples annually per 100,000 head of population, plus an additional 180 samples. With a present served population of about 1.0 M, therefore, PPWSA should try to have 300 samples per year (or 25 samples per month) in the distribution system for fecal coliform testing to meet the new standards. The Study suggests however that this may be too sharp of an increase. Depending on the capacity and resources available, PPWSA should however try to progressively increase the number of samples tested for E. coli.

c) PPWSA should take steps to formulate and adopt a water safety plan following the 2004 WHO Guidelines which include the following key elements:

- Hazard assessment and risk characterization (to identify how hazards can enter the water system and the severity of its impact on services).
- Control measures or policies (or means by which risks may be controlled, including monitoring procedures.
- Measures to verify that the water safety plan is working effectively and will meet health-based targets.
- Contingency procedures (corrective actions for normal and emergency conditions)

d) The JICA Capacity Building Project had earlier proposed an internal structure for a Water Quality Management Center which this Study fully supports. Requisite training should be provided to the laboratory staff and technicians as well as other key field staff involved in water quality control. If the need arises, the PPWSA Water Quality Management Center may be able to offer training, advice and routine testing services for other water companies in Cambodia, as well (but this will require additional resources).

For the proposed expansion at Chrouy Changvar in Stage 1, only minor increases in the number of samples to be taken along the production line will be needed for routine testing. Additional staff have been included in the manpower projections.

6-1-3 Implementation of the peri-urban project

The principal tasks in the early stages of this component involve the organization and training of the local user groups, provision of training and information about the policies, obligations and

rules for participating in the project, and mobilizing the community to support construction activities. It is vital to enhance the awareness and willingness of villagers, particularly in low safe water coverage areas. Two options are presented and assessed in this section for implementation of the peri-urban project.

(1) Option 1: Continue previous arrangements under MRD

The previous phase of the "Peri-Urban Project" was implemented by the Department of Rural Water Supply (DRWS) of MRD. 165 production wells were constructed in rural area of the Study Area. DRWS has also cooperated with UNICEF and other external organizations to implement "The Second Five-Year Rural Water Supply Plan 2001-2005 (RWSP-II)". DRWS has sufficient experience of the implementation of rural water supply.

Assessment of this option:

Advantages:
- Consistency with broader national sector plans
- Sufficient experience in previous similar projects

Disadvantages:
- Limited manpower resources because of larger national responsibility of MRD.

(2) Option 2: Implementation under responsibility of PPWSA

This option transfers all responsibilities for implementation of the peri-urban well project under PPWSA as well since these are all within the Greater Phnom Penh service area. Activities will continue to be coordinated with the MRD.

Assessment of this option:

Advantages:
- Single group becomes responsible for implementation of all Stage I improvements.
- Better able to finance, organize and manage support and monitoring services.

Disadvantages:
- Not as much experience in rural water services and mobilizing rural communities. No track record with the rural villages.

(3) Operation & maintenance of community-managed water supply

Operation and maintenance of the peri-urban systems is clearly the responsibility of Water Point Committee (WPC). It shall be established for every well facility by the households who are benefiting from it. A member of WPC shall be elected from among the users to operate and maintain the well, collect the water tariff, clean the well site, implement hygiene education and coordinate with and submit reports to the service center. As needed, caretakers and grounds keeper will be appointed.

While operation and maintenance will be through the Water Point Committee (WPC's), a more robust technical support and monitoring program is needed. Mechanisms and policies for a Monitoring and Technical Support service center needs to be organized. A program to procure spare parts to be "re-sold" to the WPC needs to be organized, funded and implemented, possibly through the PPWSA since the areas served are within the Greater Phnom Penh service area. This new support service of PPWSA should provide Water Point Committees with technical and management advice and training, spare parts procurement support. It will regularly monitor the physical, institutional and financial condition of these systems.

(4) Recommendation

The following arrangements are deemed feasible and are recommended to ensure effective implementation of the project during construction and to ensure sustainability of the improved services.

Table 6.1 Summary of responsibilities during construction and O&M

Level	Institution	Construction Phase	Operation & Maintenance Phase
Central level	PPWSA and/or MRD	Managing and super-vision of construction Organizing and training WPC	Major repair & well rehabilitation Technical/management guidance for WPC Spare parts support to WPC Monitoring of condition of systems and status of WPC
Village level	Water Point Committee	Assistance in construction work Establishing WPC	Minor repairs of hand pump. Collecting water tariff, cleaning, and inspection of facilities Reports

6-2 Institutional development plan for PPWSA operations

As PPWSA is, at present, a well-functioning organization, the interventions to be introduced into the current arrangements have to be approached with extreme care and planning. In the Master Plan, a broad framework for organizational growth was explained. Building on that framework, the priority strategy at this stage of growth has to focus on enhancing the stability of the organization – so that its present high performance is sustained in spite of whatever events or changes may occur beyond its control. Stage I institutional development will be done by **organizational restructuring** (to help build a broader team of managers and supervisors with clear roles and responsibilities and set the stage for even higher levels of coordination among the management team and delegation of authority and responsibility); **intensified training programs** for all staff on all aspects of utility management and operations (not just technical

aspects) and **strengthening of existing management information system** (based on the existing Navision Financials software).

This is the basic concept behind this institutional development plan. While it seeks to address some current issues, its bases also lie in taking advantage of opportunities to prepare and organize for its future. These are presented in the succeeding section. The institutional development is presented in modules following the institutional assessment framework in the Master Plan.

6-2-1 Organizational Restructuring

(1) Management levels

As an initial step to organizational restructuring, it is useful to define the various management categories and their detailed responsibilities. This management framework is useful for addressing several problems and opportunities.

- promote delegation of authority and responsibility
- balance the current responsibilities and job descriptions of managerial positions;
- build a broader team of managers and supervisors with clear roles and responsibilities;
- set the stage for even higher levels of coordination among the management team;
- develop the performance indicators for the various managerial and supervisory positions in the company. The performance measurement indicators for management level within the company needs to be strengthened..

In this Study, **senior management level** includes: the General Director, Deputy General Directors, Department Managers; **middle management level** includes: Section Managers, Plant Managers and other similar positions; and **operational management level** includes: Shift Supervisors, Unit Supervisors, Team Leaders and other positions with supervisory responsibilities.

The various managerial and supervisory responsibilities and functions stratified and made to correspond with the three management levels. There management responsibilities are also classified with respect to their bearing on:

- Achievement of PPWSA objectives
- The formulation of PPWSA strategies
- PPWSA strategic program
- PPWSA strategic and operational budget

The management functions and responsibilities are laid out in the following table.

Table 6.2 Management Functions and Responsibilities

Management levels	Management function related to:			
	PPWSA objectives	**Formulation of PPWSA strategies**	**PPWSA strategic program**	**PPWSA strategic and operational budget**
Senior management	• Objectives for provision of services • Types of services to be provided • Efficiency in personnel administration • Targets for quality, quantity, continuity, cost and price • Interaction with external agencies.	• Situation diagnosis • Ensuring best use of equipment and installations • Improving availability of services • Design and construction criteria, appropriate technology Improving quality control • Selection of tenders for procurement of goods and services • Improving productivity of personnel • Ensuring safety procedures for workers • Management of water resources • Consolidation of programs formulated by middle and operational management • Feasibility studies • Long-term operation and maintenance plan	• Approval of long-term program • Allocation of resources • Monitoring, evaluation, adjustments	• Approval of annual budget for each program and its projects Encouragement of research, innovative approaches, special projects
Middle management	• Objectives by type of service provided • Definition of increase in output in terms of capacity for treatment, storage and distribution of water.	• Formulation, evaluation and supervision of medium-term programs • Expansion of coverage • Best use of resources • Improvement of quality of services • Reduction of water loss • Rehabilitation • Improvement of cost-productivity ratio • Control of production and quality • Control of pollution of water sources and receiving bodies • Education of customers	• Evaluation of long-term plan for operation and maintenance Determining priorities • Establishing methodology for implementing the long-term plan	• Setting targets for programs • Calculating need for financial resources and proposing budget allocation

Management levels	Management function related to:			
	PPWSA objectives	**Formulation of PPWSA strategies**	**PPWSA strategic program**	**PPWSA strategic and operational budget**
Operational management		• Proposal of medium-term programs	• Evaluation of feasibility of medium-term investment and operational programs	Studies, designs for expansion • Construction of new works • Rehabilitation • Macro-metering • Network survey • Leakage control • Technical mapping • Improvement of house connections • Inventory of technical information • Improvement of processes for production, quality control • Revision of procedures for maintenance • Definition of short-term objectives, targets, programs, projects • Definition of responsibilities regarding formulation, implementation, follow-up, monitoring and evaluation of projects • Improvement of raw water quality, pollution control • Improvement of efficiency, reduction of costs, increase in productivity.

The objective of restructuring is to streamline the structure into 3 levels: Department level, Section level and Unit Level. The proposed new structure, presented in Figure 6-1, is envisaged to be implemented gradually during the Stage I period. These proposed changes are summarized below:

Existing arrangement (Oct 2005)	**Proposed in new structure**
Adviser, concurrently managing the Training Center and matters related to the PPWSA Board of Directors.	No change (however, in the future, a Training Manager to head the PPWSA Training Center and A Board Secretary, to deal with all matters related to the Board of Directors, should be considered).
Inspection Office	No change
	Public Information Unit (new) to handle all media related matters of PPWSA.
	Corporate Planning and MIS Office (new) to coordinate all IT (information technology and MIS) and corporate planning (and monitoring) activities of PPWSA.
Technical, Projects, Production & Distribution Department becomes	**Engineering Office** to be headed by a Senior Deputy General Director.
Planning and Technical becomes	**Technical Planning Department** with the following Sections:
Procurement Management Office becomes	• **Procurement Management Section**
Statistics & Plan becomes	• **System Monitoring Section**
Tech & Project becomes	• **Project Management and Construction Section**
Production and Distribution becomes	Rename to **Operation and Maintenance Department** with the following Sections:
Production becomes	• **Water Production Section** with o Production Maintenance Unit o Phum Prek Water Treatment Plant o Chamcar Mon Water Treatment Plant o Chruoy Chang Var Water Treatment Plant The Water Quality Control Unit now reports directly to the O&M Department Manager.

Existing arrangement (Oct 2005)	Proposed in new structure
Distribution becomes….	• **Water Distribution Section** o Distribution Maintenance Unit o Distribution Operations Unit o Distribution Expansion Unit
Operation Man. Distribution Network becomes	• **Water Loss Control Section** o Various water loss control teams
Commercial Department	No change. Office of the Department Manager will be maintained, as currently defined.
House Connection becomes	• **Service Connection Section**
District offices (7) will remain the same	• No change
Customer Relation becomes	• **Customer Service Section**
Computer Center becomes	• **Billing Section**
Finance Department	No change
Accounting becomes	• **Accounting Section**, with three Units o General Accounting Unit o Stores Unit o Cash Unit
Finance becomes	• **Finance Section**, with two units o Budget Unit o Treasury Unit
Administration & Human Resources Management Department becomes	**Administrative Department**, with three (3) operating sections, as follows • Human Resources Management Section • Protocol Section • General Services Section

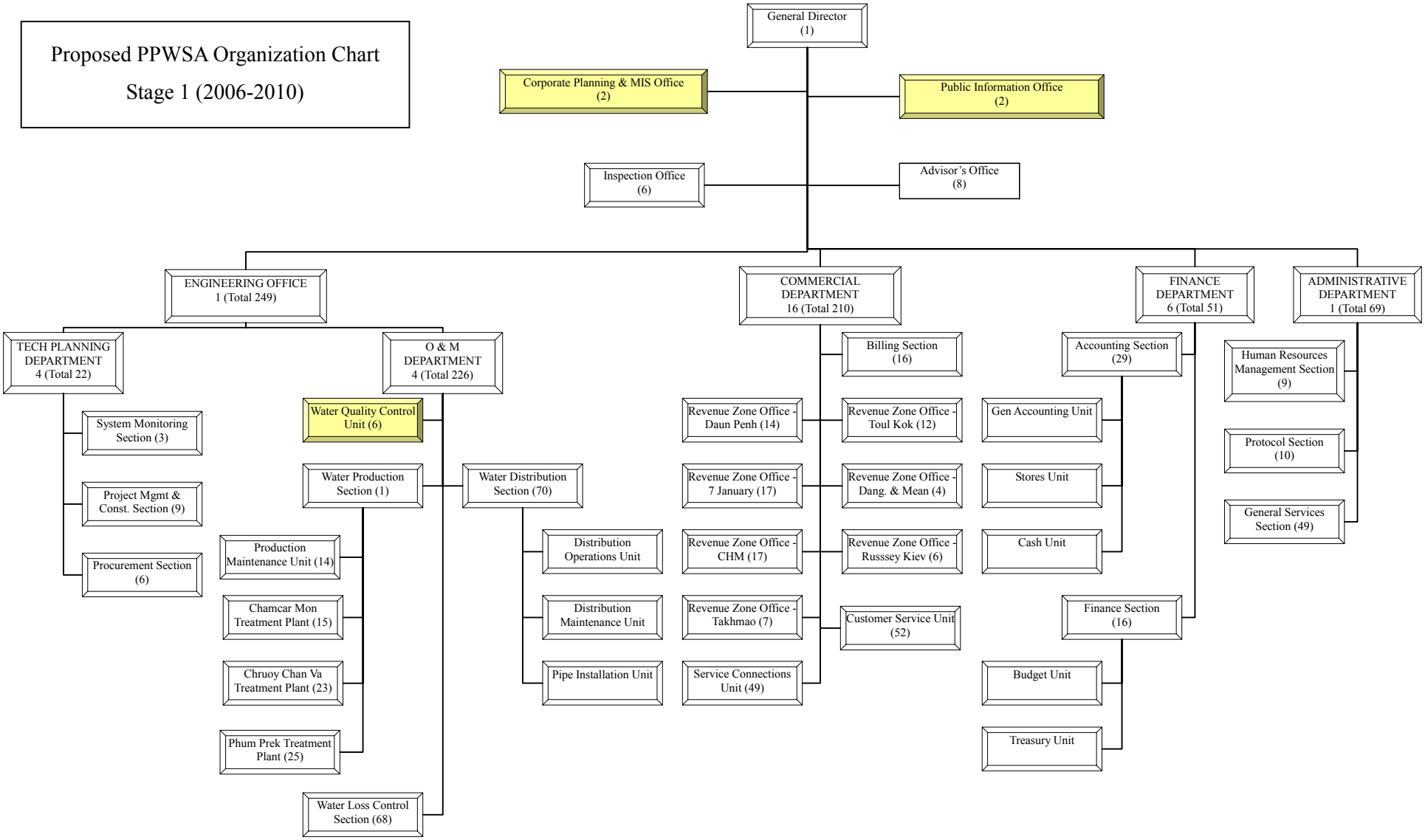


Figure 6-1 Proposed Structure for PPWSA 2010

6-2-2 Staffing Projections

Based on the anticipated growth of customer base and the need to operate and maintain additional assets, the following staffing projections have been developed. The current staffing ratio of 4.66 staff per thousand connection (as of October 2005) will gradually be raised up to about 3.7. This is envisaged to be feasible inasmuch as much of the new facilities will be automated and there will be wider use of computers and other labor-saving equipment .

The current staffing as of October 2005 is in the following table:

Customer Base	124,902
Total Staff Size	559
Staffing Ratio (staff/1,000 connections)	4.48

No	Department	Permanent	Contract	Trainee	Total
I	**General director**	1			1
II	**Deputy general director**	3			3
III	**Assistant to general director**	1			1
IV	**Secretariat**	6	2		8
V	**Inspection**	6			6
VI	**Human Resources and Administration Dept**				0
1	Administration section	19	10		29
2	Human Resource section	5			5
3	Protocol section	7	2	1	10
VII	**Finance and Accounting Dept**	2			2
1	Administration unit	3			3
2	Finance section	14		2	16
3	Accounting section	25	4		29
VIII	**Commercial Dept**	1			1
	Assistant of department head	1			1
1	Administration unit	3	1		4
2	Disconnection unit	9	1		10
3	House connection section	38	10	1	49
4	Customer relation section	28	17	7	52
5	Doun Penh revenue section	12		2	14
6	7 Makara revenue section	15	2		17
7	Chamkarmorn revenue section	16		1	17
8	Toulkork revenue section	10	2		12
9	Reusey keo revenue section	3	2	1	6
10	Meanchey-Dankor revenue section	3	1		4
11	Takhmao branch section	6	1		7
12	Computer center section	13	3		16
IX	**Production Dept**	1			1
1	Administration unit	3			3
2	Production section	2			2
a	Laboratory unit	4	1	1	6
b	Electric unit	5			5
c	Mechanics unit	8			8
d	Phum Prak treatment plant	23	1	1	25
e	Chamkarmorn treatment plant	13	1	1	15
f	Choychanvar treatment plant	10	4	3	17
3	Main pipe line section	51	11	2	64
4	Distribution section	56	7	5	68

X	**Statistic-Technical Dept**	1			1
1	Administration unit	3			3
2	Statistics section	3			3
3	Acquisition section	6			6
4	Technical Projects section	9			9
	Total	**448**	**83**	**28**	**559**

(Source: PPWSA Human Resources Management Office)

The projected staffing requirements to year 2010 are presented in the following table.

Year	2005	2006	2007	2008	2009	**2010**
Projected customer base	124,902	131,874	138,842	145,809	152,774	**159,760**
Total Staff Size	559	561	562	570	589	597
Staffing ratio (staff/1,000 connections)	4.48	4.25	4.05	3.91	3.86	3.74
OFFICE OF THE GENERAL DIRECTOR	1	1	1	1	1	1
Deputy General Director	3	3	3	3	3	3
Adviser's Office & Secretariat	9	9	9	9	9	9
Inspectors' Office	6	6	6	6	6	6
Public Information Office	Not ex.	Not ex.	1	1	2	2
Corporate Planning & MIS Office	Not ex.	2	2	2	2	2
SubTotal	19	21	22	22	23	**23**
OPERATIONS DEPARTMENT						
Engineering Section	22	22	22	22	22	**22**
Office of the Section Manager	*4*	*4*	*4*	*4*	*4*	*4*
Procurement Management Unit	*6*	*6*	*6*	*6*	*6*	*6*
Project Management Unit	*9*	*9*	*9*	*9*	*9*	*9*
Statistics & Planning Unit	*3*	*3*	*3*	*3*	*3*	*3*
Production & Distribution	214	214	214	222	226	**234**
Ofc of the Manager	*1*	*1*	*1*	*1*	*1*	*1*
Production	*24*	*24*	*24*	*24*	*24*	*24*
Phum Phrek WTP	*25*	*25*	*25*	*25*	*25*	*25*
Chamcar Mon WTP	*15*	*15*	*15*	*15*	*15*	*15*
Chruoy Chan Var WTP	*17*	*17*	*17*	*23*	*23*	*23*
Distribution Section	*64*	*64*	*64*	*66*	*68*	*74*
Operation Maintenance Dist Net	*68*	*68*	*68*	*68*	*70*	*72*
SubTotal	236	236	236	244	248	**256**
COMMERCIAL DEPARTMENT						
Ofc of Dept Manager	2	2	2	2	2	2
Administration Unit	4	4	4	4	4	4
Disconnection Unit	10	10	10	10	10	10
House Connection	49	49	49	49	49	49
Daun Penh District	14	14	14	14	16	16
7 January District	17	17	17	17	19	19
CHM District	17	17	17	17	19	19
Toul Kok District	12	12	12	12	14	14
Dang & Mean District	4	4	4	4	6	6
Russey Kiev District	6	6	6	6	8	8
Takhmao District	7	7	7	7	9	9
Customer Relations	52	52	52	52	52	52
Computer Center	16	16	16	16	16	16
SubTotal	210	210	210	210	224	**224**

ADMINISTRATIVE DEPARTMENT						
Ofc of the Department Manger	0	0	0	0	0	0
Administration	29	29	29	29	29	29
Human Resources	5	5	5	5	5	5
Protocol	10	10	10	10	10	10
SubTotal	44	44	44	44	44	**44**
FINANCE DEPARTMENT						
Office of the Department Manager	2	2	2	2	2	2
Administion Unit	3	3	3	3	3	3
Finance	16	16	16	16	16	16
Accounting	29	29	29	29	29	29
SubTotal	50	50	50	50	50	50
TOTAL STAFF PROJECTED	**559**	**561**	**562**	**570**	**589**	**597**

6-3 Organizational sub-system improvements

This section describes the various interventions to be implemented to improve the performance of PPWSA. These are institutional improvements which PPWSA will continue to implement on its own. Other improvements specifically requiring external technical assistance are identified for inclusion in an Institutional Capacity Building Project Proposal.

The succeeding Table refocuses the Assessment of Strengths and Weaknesses and the new opportunities for preparing PPWSA for the future following the organizational framework model presented in the action plan. The last column defines the expected outcome of the institutional development plan during Stage I.

Table 6.3 Expected Outcomes of the Institutional Development Plan

Current weakness and opportunities to be addressed	Recommended Activities	Expected 2010 Outcome
Physical (operating) system		
▪ Not all O&M procedures and standards written and documented. ▪ Limited operation skills. ▪ Untested maintenance systems and skills. ▪ O&M procedures and standards under preparation ▪ Data management and analysis can be improved. ▪ Untested maintenance systems and skills ▪ Data monitoring and telemetry system is new (for NRW)	A1. Review of existing technical standards used (construction, materials, inspection standards, etc) including comparison with local mandated standards, if any. A2. Adoption and approval of the new PPWSA standards (including construction standards, materials standards, inspection and testing procedures). A3. Review of existing policies, systems and procedures used (procurement, project planning and monitoring, project supervision, etc.) A4. Adoption and approval of a PPWSA Project Management Manual and Standards. A5. Agree on overall scope, content and structure of the PPWSA Operation and Maintenance Guidelines. Organize and assign work groups to draft (or update) various parts of guidelines. A6. Gather and review all existing O&M documents, Draft/update OMGs. A7. Detailed technical review of the OMG drafts. A8. Design & implement a system for regular internal review, upgrading and formal adoption of the OMG by PPWSA. A9. Review of existing asset management system. A10. Introduction of an upgraded asset maintenance management program to integrate a preventive maintenance program for all electro-mechanical assets of PPWSA. A11. Implementation of the Resources Module of the Navision Financials for planning and monitoring of all capital investment activities.	PPWSA will be able to: ▪ Manage capital investment and project management effectively through formally adopted technical & operating standards and procedures and formally established standard project management systems and procedures. ▪ Operate and monitor properly water supply production, treatment and distribution facilities through expanded operation and maintenance standards & guidelines. ▪ Maintain all water supply facilities properly through expanded preventive maintenance programs.
Organization planning system		
▪ Development of next line of managers. ▪ Participation of more managers and supervisors in the company planning process	B1. Update of the formal 5-year and annual business planning process, structure and tools. Identification of information required from the MIS. B2. Facilitate a series of discussion meetings with participation down to section heads and supervisors. B3. Assess and develop the process for due consideration of consumers' views (through a "consumers forum") in the planning. B4. Introduce a system for annual review of organization structure and staff competency mix in each of the working groups.	PPWSA will be able to: ▪ Prepare, update and monitor annual and 5-year plans through more input and participation from more managers and staff; and customer inputs in the process. ▪ Establish a flexible and responsive organization by implementing a policy & system for regular review and updating of departmental and section responsibilities, functions and restructuring.

Commercial system		
▪ Human errors in meter reading. ▪ Some low-income residents still cannot afford to connect (min of $112; equivalent to about 2-3 months salary)	C1. Assess, plan and implement a program to improve accuracy in meter reading.	PPWSA will be able to ▪ Serve customers at their convenience by streamlined procedures and more responsiveness to customer service requests. ▪ Get timely feedback from customers by implementing a systematic customer feedback system and promoting more dialogue with the public.
	C2. Introduce a system for regular reviewing of customer policies, services, standards and practices.	
	C3. Design and implement a more pro-active customer feedback system (Go out and get feedback; do not just wait for it to come; engage in dialogue with customers and customer groups).	
	C4. Assess, formulate and implement an expanded and continuous public relations program for current and prospective customers.	
Financial management system		
▪ Financial analysis skills limited. ▪ Improved affordability of low-income groups to water services	D1. Formulate a simulation model to regularly examine the impact of adjusting tariff structure on consumption patterns of customer groups to forecast revenues.	PPWSA will be able to: ▪ Determine, on an objective and continuing basis, the most appropriate tariff structure (including blocking) with due consideration for access of the low-income groups.
Administrative support system		
▪ Navision module for inventory management not fully utilized	E1. Examine the current inventory planning and control policies and practices in PPWSA.	PPWSA will be able to: ▪ Efficiently manage level of supplies and materials inventories.
	E2. Recommend and implement policy and system management improvements to inventory and property management systems.	

Human resources management system		
▪ Absence of a "back-up" (or understudy) system. ▪ Lack of long-term human resources development plan. ▪ Training plans still under preparation. ▪ Financial analysis skills limited ▪ Navision module for human resources management not fully utilized	F1. Identify and define practical (more job-specific) staffing indicators to be introduced.	PPWSA will be able to: ▪ Implement new methods for planning, recruitment, evaluation of staff, including manpower projection methods; review of job descriptions for all positions; set up practical qualification requirements for each job; establishing a clearer outsourcing policy and implementing a pro-active recruitment program and introduction of additional performance-based incentives. ▪ Provide high quality training opportunities for all staff by expansion of in-company training systems and capacity.
	F2. Conduct simple observation, work load analysis to propose a reasonable initial staffing criteria or target to apply.	
	F3. Propose a system for regular annual updating of manpower needs based on type of skills and competency needs (not only number of staff needed).	
	F4. Review and update existing job descriptions.	
	F5. Propose practical qualification requirements and productivity standards and indicators for each job title.	
	F6. Identify and assess all possible areas of current operations which may be outsourced or provided through service contracts and assess the advantages/benefits.	
	F7. Draft a policy note adopting principles to use in deciding when to outsource: how to outsource, including sample agreements.	
	F8. Formulate and implement a pro-active recruitment program to go out and seek "the best and the brightest" coming out of the country's education system.	
	F9. Develop a systematic applicant screening (testing?) program.	
	F10. Review and adoption of the overall framework for technical and managerial training proposed; Develop and implement training plan following the framework.	
	F11. Adopt a training management system (planning & monitoring) which provides for an annual program of training activities organized and implemented by PPWSA Training Center.	
	F12. Establishment of more linkages with other training and development centers in the country and Asia.	
	F13. Intensify trainer training and materials development.	
	F14. Establish a staff library (for information and research) at a central location with hi-speed Internet access as part of the Training Center for use of all staff.	
Management information system		
▪ Limited familiarity with information systems and information technology. (Navision not fully utilized)	G1. Review and if viable, expand application of existing Navision MIS software – focus on linked applications for the operations department (or replace with new software).	▪ Share and exchange information across departments on a regular and continuing basis for sound decision making.
	G2. Propose an MIS enhancement plan (addressing the information needs for the other system)	

6-4 Proposal for external technical assistance for institutional capacity building

This proposal for external technical assistance has been put together to support PPWSA in implementing the capacity building activities during Stage I.

The Study recognizes that PPWSA has, on its own, been implementing its internal development programs. PPWSA has been financing much of the institutional development activities and the needed manpower time and other resources and will likely continue to do so, having recognized the benefits. It is currently considering extension of the technical service contract with the company which provided the MIS software (and even considering upgrading to a higher version).

JICA has also been supporting PPWSA with the Capacity Building Project to strengthen skills and systems for operation and maintenance of its facilities, principally through training and development of operation and maintenance guidelines. Phase 1 of this project is expected to be completed by 2006. Discussions are ongoing for a second phase with will target mainly other water companies using the expertise which has been developed at PPWSA.

6-4-1 Project objectives

The objective of this institutional development assistance project is to ensure that PPWSA can sustainably manage the newly-expanded, as well as, the existing facilities. Specific outcomes have been presented in the preceding table.

6-4-2 Project inputs

The project envisages that starting 2007 until the end of Stage I, external technical support for institutional development will be built into future investment programs. This external assistance will augment PPWSA's own efforts in selected areas of need. This assistance comes in the form of management (and technical) systems review and development, training and advisory services.

It is anticipated that an annual external support budget in the order of 3 percent of the projected capital investment cost or about US$ 2.05 million during Stage I. A more detailed project formulation note can be found in the Supporting Reports.

The implementation of this external technical assistance is envisaged to begin by 2007 since some time may be needed to arrange for financing and selection of consultants to assist PPWSA.

	2006	2007	2008	2009	2010
Preparatory activities (arrange financing, selection of consultants)	▬				
Implementation of external Institutional Development Project		▬	▬	▬	▬

Chapter 7. Project Cost and Implementation

Chapter 7. Project Cost and Implementation

This chapter describes the proposed Implementation Plan and Procurement Plan for carrying out the Stage I Priority Projects.

7-1 Project Cost

7-1-1 Composition of Project Cost

The project financial cost comprises the following cost items.

1) Construction Cost
2) Equipment Procurement Cost
3) Engineering Services Expenses
4) Government's Administration Expenses
5) Institutional Development
6) Physical Contingency
7) Price Contingency

7-1-2 Foreign and Local Currency Portions

The project cost estimates are divided into the foreign currency portion (FC) and local currency portion (LC). The unit construction costs are divided into foreign and local currency portions according to certain ratios that take account of market conditions in Cambodia and other water supply projects currently being implemented, as detailed in the Support Report.

The division of foreign and local portions for each project component is shown in Table 7.1 below.

Table 7.1 Component Division of Foreign and Local Portion

Item	Material	Foreign Portion	Local Portion
(1) Civil Works	Labor		O
	Sand, Gravel		O
	Concrete		O
	Form	O	
	Reinforcement Bar	O	
	Pile		O
(2) Pipe and Fittings	DCIP	O	
	HDPE	O	
(3) Mechanical/Electrical Equipment	Pump	O	
	Sludge Collector	O	
	Valve	O	
	Control Panel	O	
	Transformer	O	
(4) Construction Machinery			O
(5) Building Works	Brick		O
	Indoor Materials	O	O

Local currency is denominated in US dollars, which are widely circulated and commonly used for daily transactions in Cambodia.

7-1-3 Project Cost for Stage I Priority Projects

The total project costs of Stage I Priority Projects are as follows:

- Urban Water Supply Projects: US$ 72,405,000
- Peri-Urban Water Supply Projects: US$ 8,893,000

Project costs for Urban Water Supply Projects and Peri-Urban Water Supply Projects have been worked out as summarized in Table 7.2 and Table 7.3.

Table 7.2 Cost Estimates for Urban Water Supply Projects

(Thousand US$)

Code	Item	FC Portion	LC Portion	Total
100	**<Construction Cost>**			
110	**Chrouy Changva WTP -2nd Stage**	**17,225**	**5,405**	**22,630**
111	Intake Tower (for Chrouy Changva WTP)	3,385	577	3,962
112	Raw Water Transmission Facilities	176	43	219
113	Chrouy Changva WTP -2nd Stage (Q=65,000m^3/d)	13,664	4,785	18,449
120	**Water Tank**	**1,867**	**688**	**2,555**
121	Ta Khmau Water Tank	1,025	642	1,667
122	Booster Pump for Existing Water Tank	842	46	888
130	**Transmission/Distribution Pipe**	**8,753**	**3,127**	**11,880**
131	Transmission/Distribution Pipe (Dia 63 to 600) *1	6,620	2,506	9,126
132	Transmission/Distribution Pipe (Dia 700 to 1200)	2,133	621	2,754
135	**Monitoring Facility**	**4,800**	**200**	**5,000**
140	**Rehabilitation of M&E Equipment** *1	**9,300**	**500**	**9,800**
	Total Construction Cost	**41,945**	**9,920**	**51,865**
500	Equipment Procurement Cost	419	99	519
600	Engineering Service	4,688	519	5,187
700	Government's Administration*2	0	2,593	2,593
710	Institutional Development	0	2,062	2,062
800	Physical Contingency	4,703	1,519	6,223
900	Price Contingency	2,849	1,108	3,957
	Total Project Cost	**54,584**	**17,821**	**72,405**

Notes

*1: Distribution Pipe (Dia 63 to 600) and Rehabilitation of M&E Equipment are estimated to be implemented by PPWSA's own budget.

*2: Government administration expenses include mitigation costs for social and environmental impacts, such as resettlement, water rights.

Table 7.3 Cost Estimate for Peri-Urban Water Supply Projects

(Thousand US$)

Code	Item	FC Portion	LC Portion	Total
	<Construction Cost>			
150	**Well Facilities**	**1,212**	**5,093**	**6,305**
500	Equipment Procurement Cost	12	51	63
600	Engineering Service	567	63	631
700	Government's Administration	0	315	315
800	Physical Contingency	179	552	731
900	Price Contingency	186	662	848
	Total Project Cost	**2,157**	**6,736**	**8,893**

7-1-4 Disbursement Schedule

Disbursement schedules for the Urban Water Supply Projects and the Peri-Urban Water Supply Projects are provided as tabulated in Table 7.6 and Table 7.7, and summarized in Table 7.4 and Table 7.5 below, as the basis of the proposed implementation schedule described in the next section of this chapter.

Table 7.4 Summary of Disbursement Schedule for Urban Water Supply Projects

	FC Portion (Thousand US$)	LC Portion (Thousand US$)	Total (Thousand US$)
2005	0	0	0
2006	11,012	1,179	12,190
2007	17,933	6,422	24,356
2008	22,780	7,787	30,567
2009	2,859	1,795	4,654
2010	0	638	638
Total	54,584	17,821	72,405

Table 7.5 Summary of Disbursement Schedule for Peri-Urban Water Supply Projects

	FC Portion (Thousand US$)	LC Portion (Thousand US$)	Total (Thousand US$)
2005	0	0	0
2006	317	35	352
2007	0	0	0
2008	595	2,168	2,763
2009	613	2,233	2,846
2010	632	2,300	2,932
Total	2,157	6,736	8,893

Table 7.6 Disbursement Schedule for Urban Water Supply Projects

Year		Total (1000US$)			2005		2006		2007		2008		2009		2010	
Disbursement Schedule		FC	LC	Total	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC
100-	Construction Cost	41,945	9,920	51,865	0	0	7,120	380	14,610	4,003	18,026	4,755	2,188	782	0	0
500	Equipment Procurement Cost	419	99	519	0	0	71	4	146	40	180	48	22	8	0	0
600	Engineering Service	4,668	519	5,187	0	0	2,671	297	838	93	1,025	114	134	15	0	0
700	Government's Administration	0	2,593	2,593	0	0	0	375	0	931	0	1,139	0	149	0	0
710	Institutional Development	0	2,062	2,062	0	0	0	0	0	518	0	518	0	518	0	508
800	Physical Contingency	4,703	1,519	6,223	0	0	986	106	1,559	558	1,923	657	234	147	0	51
900	Price Contingency	2,849	1,108	3,957	0	0	163	17	780	279	1,625	555	281	177	0	80
Total of Annual Disbursement (Urban Water Supply Projects)		54,584	17,821	**72,405**	0	0	11,012	1,179	17,933	6,422	22,780	7,787	2,859	1,795	0	638

Table 7.7 Disbursement Schedule for Peri-Urban Water Supply Projects

Year		Total (1000US$)			2005		2006		2007		2008		2009		2010	
Disbursement Schedule		FC	LC	Total	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC
100-	Construction Cost	1,212	5,093	6,305	0	0	0	0	0	0	404	1,698	404	1,698	404	1,698
500	Equipment Procurement Cost	12	51	63	0	0	0	0	0	0	4	17	4	17	4	17
600	Engineering Service	567	63	631	0	0	284	32	0	0	95	11	95	11	95	11
700	Government's Administration	0	315	315	0	0	0	0	0	0	0	105	0	105	0	105
800	Physical Contingency	179	552	731	0	0	28	3	0	0	50	183	50	183	50	183
900	Price Contingency	186	662	848	0	0	5	1	0	0	42	155	60	220	79	287
Total of Annual Disbursement (Peri-Urban Water Supply Projects)		2,157	6,736	**8,893**	0	0	317	35	0	0	595	2,168	613	2,233	632	2,300

7-2 Implementation Plan

7-2-1 Implementation Schedule

In connection with the target years for this Study, Stage I priority projects are expected to be completed by the end of 2010.

Stage I Priority Project

Pre-construction Stage

010:	2005-2006	Preparation of Project
020:	2005-2006	Pre-Construction (Detailed Design, Bidding)
	2006	Commencement of Construction & Procurement of Equipment

Construction Stage

110-140:	2007-2009	Construction (Urban Water Supply Projects)
710:	2007-2010	Institutional Development (Urban Water Supply Projects)
150:	2008-2010	Construction (Peri-Urban Water Supply Projects)
	2009-2010	Commencement of Operation

The project implementation schedule is presented in Figure 7.1.

7-2-2 Components of the Project

Project components of Stage I Priority Projects consist of Chrouy Changva WTP-2nd Stage expansion, construction of water tank, transmission/distribution pipes, rehabilitation of mechanical & electrical equipment and well facility development shown in Table 7.8.

Table 7.8 Project Components for Stage I Priority Project

Stage	Code	Component	Reference
100: Stage I		**<Urban Water Supply Projects>**	
	110	Chrouy Changva WTP -2nd Stage	
	111	Intake Tower (for Chrouy Changva WTP)	For Q=130,000m^3/d
	112	Raw Water Transmission Pipe	For Q=65,000m^3/d
	113	Chrouy Changva WTP -2nd Stage	
	120	Water Tank	
	121	Ta Khmau Water Tank	V=1,500m^3
	122	Booster Pump for Existing Water Tank	
	130	Distribution Pipe	
	131	Distribution Pipe (Dia 63 to 600)	
	132	Transmission/Distribution Pipe (Dia 700 to 1200)	
	140	Rehabilitation of Mechanical & Electrical Equipment	
	710	Institution Development	
		<Peri-Urban Water Supply Projects>	
	150	Well Facility	

7-2-3 Condition for Construction Execution

(1) Topography, Meteorology, Hydrology and Geology

The site for major works is located on a relatively flat alluvial plain. The highest elevation is 11 meters above sea level. The ground elevation adjacent to the Mekong River is generally more than 10 meters above sea level, which decreases progressively to about 5 meters towards the southwest of the city.

The wet season occurs from May till November. The dry season occurs from December to April. Construction work, especially earthwork, should be executed in the dry season, otherwise some auxiliary work will increase the construction cost and extend the construction period.

Since the construction site is surrounded by the Tonle Sap River, the Tonle Bassac River and the Mekong River, the ground water level is relatively high, about 2 meters below GL (Ground Level). Dewatering will be necessary for some excavation work, especially during the wet season.

Soil conditions on the construction site are coarse clay to a depth of 11 to 13 meters below GL. Below this depth they are almost semi-stiff. Pile foundation shall be required for all structures and buildings up to 11 to 13 meters below GL.

(2) Infrastructure

The ports of Phnom Penh and Sihanoukville are the available ports to unload equipment from Japan and other countries. The port of Phnom Penh is located on the Mekong River, close to the construction site.

(3) Labor Force

Skilled and semi-skilled laborers can be recruited in the Phnom Penh area. However, sufficient numbers of engineers for the construction will not be obtained in Cambodia. It will be necessary to employ additional engineers from Laos or Thailand.

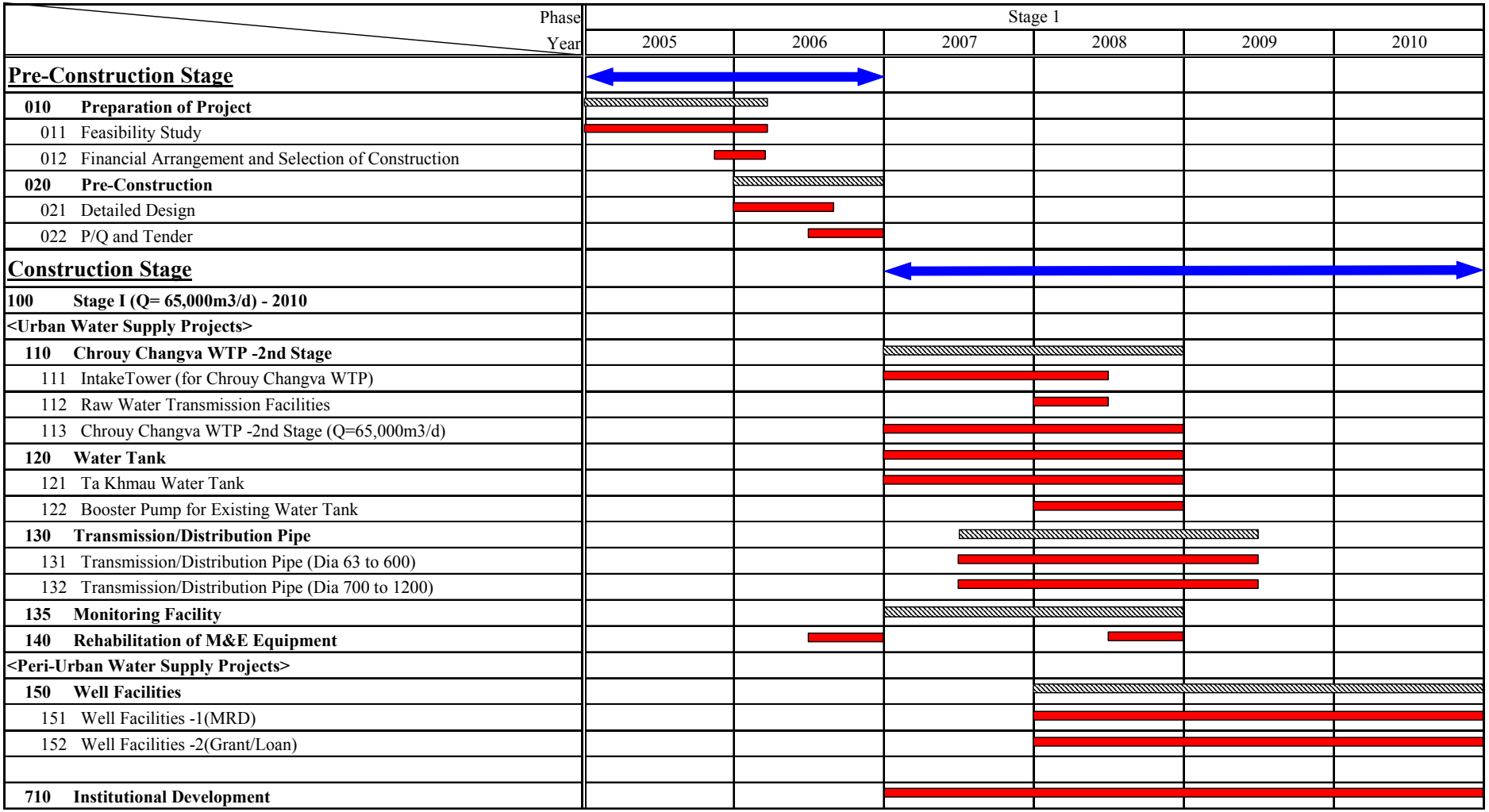


Figure 7-1 Implementation Schedule for Stage I Priority Projects

7-3 Procurement Plan

The construction materials necessary for the Project shall be procured in Cambodia to the greatest extent possible. However, construction materials that are not available in the country, cannot meet the quality or specifications of the design requirements, or cannot be reliably procured with regard to distribution volume or cost, shall be procured from other countries. The following summarizes a procurement plan for the project.

(1) Concrete, Pile, Sand, Gravel, Brick

These materials are easily procured in Phnom Penh since they are manufactured in the city.

(2) Reinforcement Bar, Sheet Pile, Form

These materials are not produced in Cambodia. However, they can be obtained from local agencies in Phnom Penh without difficulty. While a brand new sheet pile can be purchased from the agencies, it cannot be obtained as a leased material.

(3) Pipe

High Density Polyethylene (HDPE) pipe and Ductile Cast Iron (DCI) pipe, which will be used in this project, are not produced in Cambodia. HDPE pipe can be obtained from local agencies in Phnom Penh without difficulty. DCI pipe must be imported form other countries.

(4) Mechanical and Electrical Equipment

Major mechanical and electrical equipment such as pumps, sludge collectors, chemical equipment, valves, control panels and power receiving/transforming equipment are not produced in Cambodia. This equipment must be imported form other countries.

(5) Construction Machinery

Construction machinery, such as backhoes, dump trucks and pile drivers, can be leased in Phnom Penh.

Chapter 8. Evaluation of the Priority Projects

Chapter 8. Evaluation of the Priority Projects

8-1 Technical Evaluation

The jurisdiction of PPWSA water supply is expanded to over 500 km2 in the Phase 2 Master Plan, approximately five times the area compared to the Phase 1 Master Plan area. By the augmentation project for the Chrouy Changva water treatment plant, a total production capacity of 300,000 m^3/d will be achieved by the year 2010, which will secure the production capacity to meet the water demand up to the year 2013. Water tank and distribution pipelines will be extended towards the outskirts of the central city zone and enforced to ensure a reliable 24-hour supply. Peri-urban water supply will be improved by construction of over 200 wells in outlying areas. The total population with access to a safe and clean water supply will be expanded from the present 1.07 million to 1.32 million people in 2010. The coverage will be increased from the present 70.0 to 74.5 percent in 2010, targeting over 90 percent in 2020. The number of service connections will reach approximately 155,000 connections, from 121,000 at present.

It is noteworthy that the coverage will be achieved with continued efforts to control NRW at the level of 15 percent through well organized operation and maintenance efforts on the transmission/distribution pipelines, including optimization of supplied pressure and making use of the proposed supplied water monitoring system. Preservation of raw water quality is another important issue for both drinking water quality control and minimization of production cost.

8-2 Socio-Economic Evaluation

The Cambodia Millennium Development Goals (CMDGs) establish the key underlying coverage targets for the development of the Master Plan, including the phasing of its implementation and the selection of the Stage I Priority Projects. For the urban center of Phnom Penh, the CMDGs for urban coverage are already met and will continue to be met through PPWSA's safe water supply. For the peri-urban and rural areas, the staging of progress toward attaining average clean water coverage in excess of 80 percent is more problematic because implementation will proceed commune by commune. However, the coverage target will be applied for each of the selected communes to be served during each Stage.

Although difficult to measure, the benefits of improved water supply will be significant in both quantitative and qualitative terms. The economic evaluation presented later in this chapter provides a limited quantification of the benefits of executing the Priority Projects, but this must be considered an underestimation in relation to the many unquantifiable benefits to the health and quality of life of the beneficiaries.

The expected benefits from achieving the CMDG clean water coverage targets include improved public health overall and reduction of infant and maternal mortality associated with water-born disease. Improved water supply in rural areas also reduces the burden of fetching water that typically falls on women and children, which may contribute indirectly to greater rural labor force productivity and improved school attendance and educational achievement of children.

In urban and peri-urban areas, improved water supply from the Central Distribution System (CDS) is an aid to industrial development. Water supply is among the critical infrastructure requirements for the types of labor-intensive, light manufacturing industries that the RGC has targeted for promotion in its industrial policy, and such infrastructure expansion is among the specific RGC objectives for supporting the industrial sector.

On the negative side, it must be mentioned that expanded water supply inevitably results in greater production of wastewater. Preparation and implementation of a parallel Master Plan for drainage and sewerage in the Study Area is urgently necessary, in particular to ensure that the health benefits from improved water supply are not lost on account of deterioration in sanitary and environmental conditions. Chapter 7 of the Master Plan (Part A of this Volume) documented the dramatic loss of lake and marsh areas, especially in the northern area, that have traditionally provided a certain level of natural treatment of wastewater flowing from the City through the lake/marsh areas to the Tonle Sap and Tonle Bassac rivers, which surround the City. The treatment capacity of these natural bodies is already on the verge of exhaustion. Combined with steady growth in population and probable continued loss of these critical habitats, the quality of the water bodies themselves, as well as the effluent flowing from them into the afore-mentioned rivers, can be expected to deteriorate very significantly during the coming years. Planning and preparation of counter-measures, in addition to those already undertaken previously with JICA's assistance, should begin as soon as possible.

8-3 Financial and Economic Evaluation

The financial and economic evaluation in this section refers specifically to the Priority Project, which is Stage I in the proposed Master Plan.

8-3-1 Urban Water Supply

In undertaking the financial evaluation of the Priority Project, the assumptions and approach used are similar and consistent with those used in the Master Plan.

8-3-1-1 Financial Evaluation

The WACC of the priority project is 3.84 percent (real terms). The calculation of the WACC is shown in the table that follows.

Table 8.1 Weighted Average Cost of Capital

Particulars	Loan	Grant	Equity	Total
Weight (%)	60.00%	0.00%	40.00%	100.00%
Nominal Cost (%)	8.50%		9.00%	
Tax Rate (%)	20.00%		20.00%	
Tax Adjusted Nominal Cost (%)	6.80%		7.20%	
Inflation Rate (%)	3.00%	3.00%	3.00%	
Real Cost (%)	3.69%	0.00%	4.08%	
Weighted Component of WACC (%)	2.21%	0.00%	1.63%	
Weighted Average Cost of Capital (Real)				3.84%

The details of the FIRR calculation and sensitivity analyses are shown in the Supporting Report. The results of the calculation and analyses are summarized in the table below.

Table 8.2 FIRR and Sensitivity Analysis

Particulars	NPV @ WACC Million Riels	FIRR (%)	SI *	% Change
Base Case	108,337	6.73%		-
10% Increase in Project Costs	86,848	6.03%	1.16	10%
10% Increase in O&M Costs	83,162	6.13%	0.99	10%
10% Decrease in Revenue	50,839	5.31%	2.68	10%

* SI – Sensitivity Indicator

Under the base case scenario, the project's FIRR is higher than its WACC. With its FIRR higher than its WACC, the project is considered financially viable.

The results of the sensitivity analysis show that under the 3 adverse changes (increase in capital and O&M costs and decrease in revenues), the project's financial viability is not greatly affected as the project's FIRR is still higher than the project's WACC. Among the adverse changes, the project's financial viability is most sensitive to decrease in revenues.

The results of the financial projection as described later in this chapter shows that the proposed Priority Project can be implemented, together with PPWSA's existing assets and on going projects, on a sustainable basis. Throughout the economic life of the proposed project, PPWSA can generate sufficient revenues to cover the costs of operating and maintaining the proposed project, together with the existing assets and on going projects, and repay all its debt service obligations as they fall due.

8-3-1-2 Economic Evaluation

The economic benefits and costs under the Priority Project are the same in nature as in the Master Plan. They differ only in magnitude. In undertaking the economic evaluation of the Priority Project, the assumptions and approach used are similar and consistent with those used in the Master Plan.

The details of the EIRR calculation and sensitivity analyses are shown in the Supporting Report. The results of the calculation and analyses are summarized in the table below.

Table 8.3 EIRR and Sensitivity Analysis – Urban Water Supply

Particulars	NPV @ EOCC Million Riels	EIRR (%)	SI *	% Change
Base Case	178,359	17.55%		-
10% Increase in Investment Costs	163,140	16.52%	0.63	10%
10% Increase in O&M Costs	169,323	17.24%	0.18	10%
10% Decrease in Benefits	136,268	16.08%	0.92	10%

* SI – Sensitivity Indicator

Under the base case scenario, the project's EIRR is higher than the Economic Opportunity Cost of Capital (EOCC) of 10 percent. With its EIRR higher than the EOCC, the project is considered economically viable.

The results of the sensitivity analyses show that under the 3 adverse changes (increase in capital and O&M costs and decrease in benefits), the project's economic viability is not greatly affected as the project's EIRR is still higher than the project's EOCC. Among the adverse changes, the project's economic viability is most sensitive to decrease in benefits.

8-3-1-3 Financial Implications for PPWSA

This portion of the financial analysis will determine how the implementation of the Priority Project will impact financially the condition of PPWSA.

Financing Scheme

The sources of financing for the Priority Project are not definite yet. For financial analysis purpose, however, it is assumed that the total project cost would be financed by 60 percent loan and 40 percent equity. The loan is assumed to carry an interest rate of 8.5 percent per annum with a repayment period of 20 years plus a 5-year grace period.

Table 8.4 Financing Scheme – Urban Water Supply (in Millions)

Item	Riels	US$	%
Project Cost	293,240	72.40	100
Financed by:			
Loan	175,944	43.44	60
Equity	117,296	28.96	40
Total Sources	293,240	72.40	100

Tariff and Affordability

The projected average tariffs for each customer category and the overall that will prevail up to 2035 at 5-year interval are presented below.

Table 8.5 Proposed Average Tariff (Riels/m^3)

Customer Category	2005	2010	2015	2020	2025	2030	2035
Domestic	875	1,014	1,176	1,363	1,580	1,832	2,124
Commercial	1,159	1,344	1,558	1,806	2,093	2,427	2,813
ADM	1,030	1,194	1,384	1,605	1,860	2,157	2,500
Overall	972	1,122	1,290	1,484	1,721	1,995	2,313

Source: Consultant's Financial Projections

There are no increases in real terms in the projected average tariffs. The tariff increases used in the financial projection during the period are merely keeping up with inflation.

With the implementation of the proposed Priority Project, the average domestic water consumption is envisaged to increase from the current level of 80 lpcd to 96 lpcd in 2020 and thereafter. As a result of higher water consumption, the monthly household water charges will naturally rise. An analysis has therefore been undertaken to determine if the beneficiaries, in particular the low-income families, could afford to pay their estimated monthly water bills in 2020. The generally accepted guideline is that the charges for water supply should not exceed 4 percent of household income.

The data on water consumption and average household income for each income group used in the affordability analysis are similar and consistent with those used in the Master Plan.

The result of the affordability test is shown in Table 8.6.

Table 8.6 Household Affordability Test

Income Group	Average HH Income Riels/mo.	Water Used in 2020 (m^3/mo.)	Water Bill in 2020 at Constant 2005 Price	
			Riels/mo.	% to HH Income
Lowest 20%	425,295	17	14,742	3.5%
Second Quintile	651,284	20	17,690	2.7%
Third Quintile	832,545	25	22,112	2.7%
Fourth Quintile	1,115,767	29	25,798	2.3%
Highest Quintile	2,669,104	33	29,483	1.1%
All Groups	1,139,553	23	20,229	1.8%

The above affordability test shows that the projected tariffs during the implementation of the Priority Project are within the 4 percent affordability limit and would still be affordable to the beneficiaries, including the low-income families.

In addition to an affordable proposed tariff, the current connection fee is proposed to remain at the same level during the implementation period, as reflected in the financial projection, to make it affordable to the low-income families and encourage the shift to the PPWSA piped system. Apart from not increasing the connection fee, PPWSA is encouraged to continue and expand the system of installment payment of the connection fee by low-income families.

Results of Financial Projections

The results of the financial projection containing the Income Statement, Balance Sheet, Funds Flow Statement, Summary of Key Financial Indicators, Investment Program, Borrowings Summary, Water Demand and Production and Operating Costs from 2005-2035 are presented in detail in the Supporting Report. Table 8.7 below is a summary of the results at 5-year interval from 2005-2035.

The following are the key observations on the results of the financial projection:

- During the projection period (2005-2035), PPWSA would have net profit each year. This indicates that PPWSA's tariff level during the projection period is a full cost recovery tariff. PPWSA's projected tariff could recover the full cost of its operations plus depreciation and financing charges as long as the tariff keeps pace with inflation.
- PPWSA's financial condition during the projection period is healthy and it is able to repay its debts as they fall due. Should PPWSA be able to secure financing schemes with better conditions in terms of lower interest rate and longer repayment period that those assumed in the financial projection, PPWSA would have a much healthier financial condition. With lower interest rate, financing charges are reduced. With longer repayment period, the annual amount of loan principal repayment is reduced.

PPWSA can implement on a sustainable basis the proposed Priority Project, together with its existing assets and on-going projects, with no negative impact on its financial condition even without the benefit of a tariff increase in real terms.

Table 8.7 Summary of Key Financial Performance Indicators

	2005	2010	2015	2020	2025	2030	2035
OPERATING RESULTS							
Operating Revenues	47,338	68,203	98,532	138,158	160,163	185,673	215,246
Operating Expenses	15,407	25,097	37,244	52,853	61,124	70,929	82,051
Net Income	10,127	7,114	23,427	51,428	81,773	117,414	167,005
Cash from Operations	31,411	40,893	58,402	82,296	108,902	141,527	191,117
Operating Ratio	60%	60%	59%	51%	44%	39%	33%
Total Assets	529,093	748,574	738,798	890,138	1,192,540	1,665,295	2,403,684
Working Capital	45,491	8,038	46,575	280,266	593,147	1,163,746	1,962,808
Working Capital (Days)	1,063	115	450	1,909	3,493	5,907	8,612
OPERATING EFFICIENCY							
Service Connections	124,902	159,760	208,218	261,188	261,188	261,188	261,188
Average Tariff (Riels/m^3)	972	1,122	1,290	1,484	1,721	1,995	2,313
Growth in Connections (%)	2.9%	4.6%	4.9%	0.0%	0.0%	0.0%	0.0%
Water Sold ('000 m^3)	48,692	60,783	76,392	93,075	93,075	93,075	93,075
Non-Revenue Water (%)	15%	15%	15%	15%	15%	15%	15%
Capacity Utilization (%)	67%	65%	82%	100%	100%	100%	100%
FINANCIAL PERFORMANCE RATIOS							
Acc. Receivable (Days)	40	40	40	40	40	40	40
Current Ratio	3.59	1.28	2.36	7.35	13.76	24.39	36.07
Debt/Equity Ratio	0.21	0.44	0.22	0.10	0.03	0.00	0.00
Debt Service Coverage	1.98	1.18	1.98	5.18	8.95	0.00	0.00
Self Financing Ratio	0.94	4.79	0.80		1.4		
Return on Revenues	21.4%	10.4%	23.8%	37.2%	51.1%	63.2%	77.6%
Return on Assets	2.4%	1.6%	3.9%	9.3%	17.7%	26.8%	45.1%
Return on Equity	2.4%	1.4%	4.2%	6.7%	7.4%	7.3%	7.1%

Source: Consultant's Financial Projections

8-3-2 Peri-Urban Water Supply

8-3-2-1 Financial Evaluation

In undertaking the financial evaluation of the Priority Project, the assumptions and approach used are similar and consistent with those used in the Master Plan.

Consistent with the policy of the government for the RWSS sector, the following are the assumptions used in the financial projections:

- The WSUG shall be responsible for arranging the counterpart contribution from the community for the capital investment, operation and management of the facilities, the collection of water charges from the beneficiaries and the management of finances.
- The estimated capital investment shall be financed through grant (about 88.47 percent of capital investment) from the government and about 11.53 percent equity from the beneficiaries in the form of labor and local materials. It is assumed that the government will secure financing for the grant portion of the investment either in the form also of a grant from bilateral or multilateral institutions or a soft loan having a long repayment period (35 to 40 years) and low interest rate (1 percent or less).

Table 8.8 Financing Scheme – Peri-Urban Water Supply (in Millions)

Item	Riels	US$	%
Project Cost	36,016	8.893	100.00
Financed by:			
Grant	31,865	7.868	88.47
Equity	4,151	1.025	11.53
Total Sources	36,016	8.893	100.00

- Based on the affordability limit of 4 percent of monthly household income of Riels 170,447 (average monthly income of poorest 20 percent of rural households), the proposed monthly water charge is Riels 6,500 per household, about 3.8 percent of household income. This is projected to increase at the inflation rate of 3 percent annually.
- The average annual operation and maintenance (O&M) cost per well is estimated at about Riels 1.8 million. This is projected to increase at the inflation rate of 3 percent annually.

Based on the above assumptions, the proposed water charge can recover 100 percent of the O&M cost and about 20 percent of the annual depreciation charges. The amount collected from the partial recovery of depreciation charges shall be deposited and accumulated for future use in the rehabilitation of the well facility to ensure sustainability of operations.

8-3-2-2 Economic Evaluation

The economic benefits and costs under the Priority Project are the same in nature as in the Master Plan. They differ only in magnitude. In undertaking the economic evaluation of the Priority Project, the assumptions and approach used are similar and consistent with those used in the Master Plan.

The details of the EIRR calculation and sensitivity analyses are shown in the Supporting Report. The results of the calculation and analyses are summarized in the table below.

Table 8.9 EIRR and Sensitivity Analysis – Peri-Urban Water Supply

Particulars	NPV @ EOCC Million Riels	EIRR (%)	SI *	% Change
Base Case	9,781,074	18.37%		-
10% Increase in Investment Costs	7,909,029	16.18%	1.36	10%
10% Increase in O&M Costs	9,540,884	18.17%	0.11	10%
10% Decrease in Benefits	6,690,733	15.76%	1.66	10%

* SI – Sensitivity Indicator

Under the base case scenario, the project's EIRR is higher than the Economic Opportunity Cost of Capital (EOCC) of 10%. With its EIRR higher than the EOCC, the project is considered economically viable.

The results of the sensitivity analyses show that under the 3 adverse changes (increase in capital and O&M costs and decrease in benefits), the project's economic viability is not greatly affected as the project's EIRR is still higher than the project's EOCC. Among the adverse changes, the project's economic viability is most sensitive to decrease in benefits.

8-4 Environmental Impact Assessment

The proposed Stage I Priority Projects will have mostly beneficial impacts. Although some adverse impacts will occur during the construction and operation stage of the projects, minimization of environmental disturbances such as noise and dust during construction will be considered in the detailed design, and appropriate environmental management requirements will be incorporated in the specifications of construction contracts. All contractors will be required to reinstate affected areas to their original or better condition. Adequately planned preventive maintenance programs will be developed for all facilities constructed under the Project, and safe working practices at international standards will be adopted in both the construction and operational phases. Monitoring of the environment and the effectiveness of the mitigation measures is also the responsibility of PPWSA.

For the Priority Projects, possible impacts are expected on the items listed in the following table.

Priority Project	**Environmental Items Possible Impacts Are Expected**
Chrouy Changva WTP Project	Local Economy such as employment and livelihood Existing social infrastructures and services Water Rights and Rights of Common Waste Hazards (Risk)(Traffic accidents) Water contamination Noise and vibration
Water Tank/Booster Pump Project	Existing social infrastructures and services Noise and vibration
Transmission/Distribution Pipe Construction Project	Local Economy such as employment and livelihood Existing social infrastructures and services The poor, indigenous or ethnic people Misdistribution of benefit and damage Cultural Property Hazards (Risk)(Traffic accidents) Air pollution Noise and vibration
Well Water Development Project	Existing social infrastructures and services

PPWSA will need to be careful about the following issues in the implementation of Stage I Priority Projects, if necessary.

- PPWSA must revise the scoping checklist for each project on site so that no environmental items are missed from the study.
- PPWSA must update the social and environmental condition around the project site.
- For the construction of distribution pipes, PPWSA must minimize relocation or modification of existing infrastructures and private structures.
- PPWSA must prepare a required cost for environmental mitigation and monitoring measures based on the detailed information of project design and schedule if necessary.
- PPWSA must continue their efforts to distribute information and to negotiate with local communities regarding the design and schedule of construction of each project.

  In case that PPWSA cause forced relocation of settlement or legal businesses, PPWSA must faithfully participate negotiation procedure and consider proper compensation according to the local common sense as well as the international guidelines if necessary.