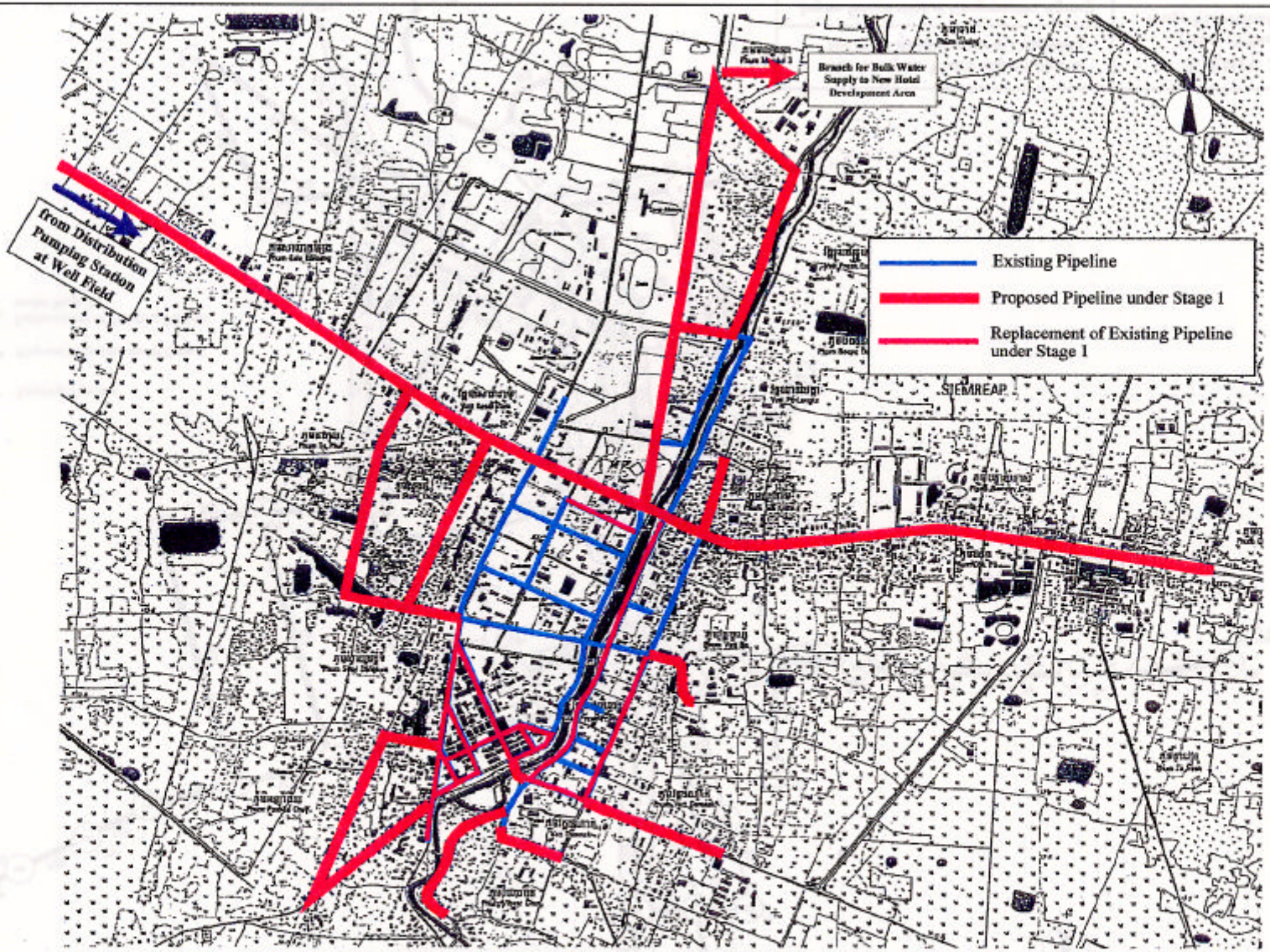

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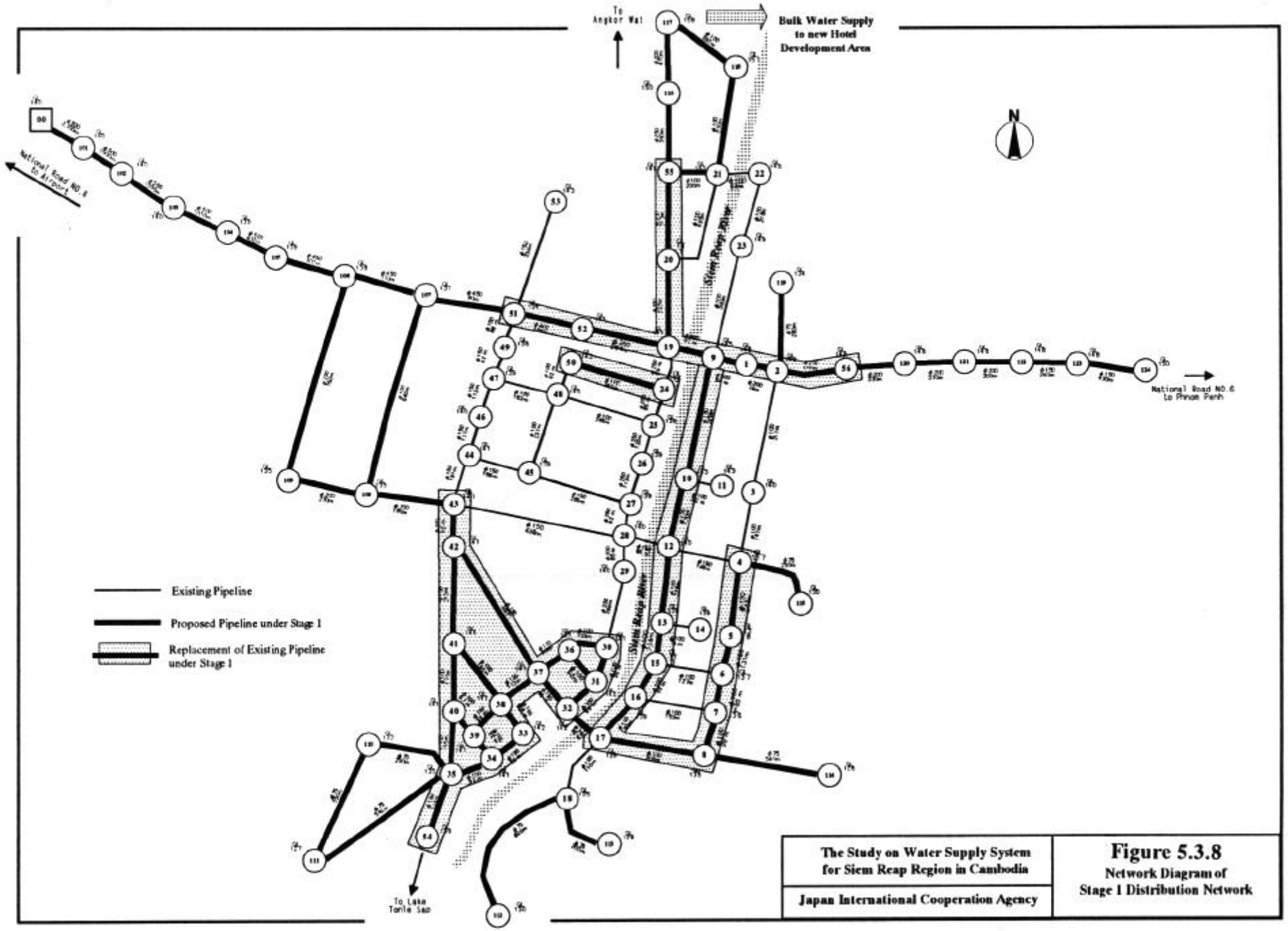
Figure 5.3.7
Stage 1 Distribution Network



The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 5.3.8** Network Diagram of Stage 1 Distribution Network
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2) Meter District

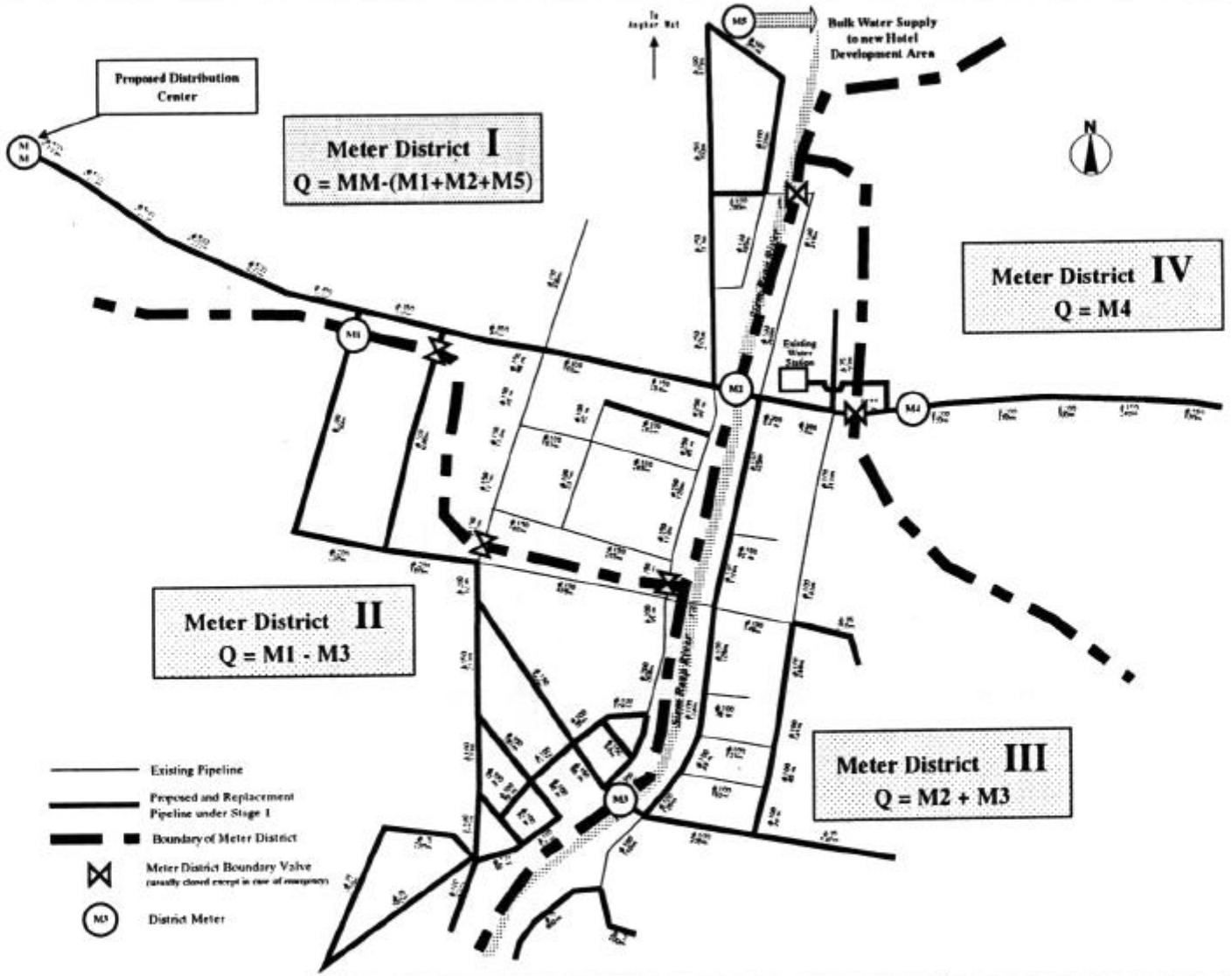
It is recommended to introduce a Meter District System (MDS) for the proposed distribution network. By introducing the MDS, the Waterworks can evaluate the effectiveness of water supply or level of UFW in each meter district. Each meter district will be isolated by closing boundary valves. If a pipeline crossing the boundary can not be closed, district meter will be installed. Total water inflow will be measured continuously by several district meters. The Waterworks can calculate total water consumption by accumulating water bills in the respective district and can compare total water inflow and total water consumption.

Proposed MDS is shown on Figure 5.3.9. As shown on the figure, the whole distribution network is recommended to be divided into 4 Meter Districts and totally 6 district meters will be required for establishment of the MDS. The boundary of the meter district is set from topographic condition, easy operation, characteristics of consumers, and current service block system of the Waterworks.

Estimated water consumption in each meter district during peak hour period in Year 2006 is shown on Table 5.3.5.

Table 5.3.5 Estimated Water Consumption in Each Meter District

Meter District	Water Consumption (Peak Hour) (l/sec)
I	28.1
II	19.0
III	28.4
IV	19.9
Bulk Supply for Hotel Zone	17.0



The Study on Water Supply System for Siem Reap Region in Cambodia	Figure 5.3.9 Proposed Meter District in Stage 1
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3) Service Main

It is recommended that tapping for connection is allowed from distribution pipe of which diameter is smaller than 150 mm. It will require parallel pipe installation along with larger diameter, more than 200 mm, to install connection. Required length of service main will be calculated from the length of distribution trunk main with diameter more than 200 mm.

Table 5.3.6 Length of Trunk Main Required Parallel Service Main

Diameter (mm)	Existing (m)	Stage 1 (m)	Total (m)
450		710	710
400		166	166
350		254	254
300		230	230
250	509	1,260	1,769
200	354	2,722	3,076
Total	**863**	**5,342**	**6,205**

Total length of service main will be about 6,200 m and diameter will be 50 mm and 75 mm. Length of each diameter is assumed to be same and the length will be 3,100 m each. PVC or PE is recommendable for the material of the service mains.

4) House Connection

Number of house connections will increase from the commencement of water supply service under Stage 1 Project as shown on Table 5.3.7.

Table 5.3.7 Number of Connections

Year	House Connection (Domestic)	Connection for Hotels	Connection for Guest Houses	Total Number of Connections	Incremental Connection
2002	1,640	21	83	1,744	1,354
2003	2,320	32	137	2,489	745
2004	3,067	43	204	3,314	826
2005	3,898	48	244	4,190	875
2006	4,475	50	272	4,797	607

5.3.2 Operation and Maintenance

(1) Wells and Submersible Motor Pump

In general, periodic maintenance is recommended for the wells constructed in the alluvial aquifers once in 5 years. The most frequent problem is an iron incrustation in the screen. The cause is the dissolved iron hydroxide in low pH groundwater. This may coat a scale or gel along the screen slot by its dissolution. In order to keep the wells in good condition for long life without scale, the pumping yield should be kept under the designed operation with the following records keeping.

- Description of well structure,
- Pumping test data in construction stage
- Operation records,
- Ground water level, and
- the result of periodic water quality test

First rehabilitation of the wells from deterioration and incrustation is recommended during the construction of further 5 wells in Stage 2. Rehabilitation should be done by air jetting or swabbing method. A scale in the screen slot should be removed by the method. Deposited fine sand should be removed from the bottom of the well by jetting method.

There is a slight possibility that the impellers of submersible motor pump may get corroded due to low pH value 5.5 or less. Therefore, the wells were planned to use the durable PVC pipes against corrosion. In order to keep the impellers in good condition the following records should be kept.

- Record of pump installation depth,
- Operation record (pumping time, static water and pumping water level)
- Periodic check of the impellers of submersible motor pumps, once every 5 years.

(2) Production Facilities

The most important thing in operation of the production facility is keeping record of water quantity produced every day. These records are indispensable to evaluate management of waterworks, especially for assessment of the unaccounted-for water. Quantity of groundwater abstraction from each well and quantity of distributed water from distribution pumping station should be recorded every day and these data is useful for water balance analysis. In addition to the water quantity record, operation hour of well pumps, distribution pumps and generators, fuel consumption, chlorine consumption, water quality, etc, should be recorded by operators.

Maintenance of the mechanical equipment such as pumps, chlorinators and generators is also important. Waterworks is recommended to prepare routine work schedule with checking lists.

In addition, attention should be paid on handling of chlorine gas. In case of leakage, chlorine gas using for disinfection is toxic to the operation staff. Therefore, when handling chlorine gas, all safety methods should be strictly adhered by the operation staff to prevent any accidental leakage.

(3) Distribution Facilities

For operation and maintenance of the distribution facility, Waterworks is recommended to put its effort on reduction of leakage.

Distribution network drawings are fundamental for routine maintenance work and reduction of leakage in the network. Network drawings should always be updated without delay when pipe installation work or pipe repair work was conducted. When this Project is implemented, as-built drawings for new pipeline will be provided by the Contractor, so it is great opportunity for the Waterworks to establish detail and accurate network drawings.

Valve locations should be also shown on the network drawings. Some valves, however, are not shown on the existing drawings. Waterworks is therefore recommended to review every drawing and also confirm the location in the field and operability of the valves shown on the drawings. Should there be any valves covered under road pavement, surface valve covers should be installed, and location of such valves should be marked on the drawings. Should there be any malfunctioning valves, they should be replaced with new ones, and the date of replacement should be added on the drawings.

Waterworks is recommended to measure the system pressure at as many points as possible throughout the entire service area. In areas where system pressure is found unnecessarily high, valves in and around such areas should be throttled to reduce pressure. This operation should be repeated until system pressure becomes reasonable level throughout the service area.

Records of leak repair should be kept at the Waterworks. Accumulation of these data will be invaluable when Waterworks prepare future pipe rehabilitation or replacement program. By analyzing such data, tendency of leakage may be perceived by Waterworks. Waterworks is, therefore, recommended to record the following data at each repair location:

- location (pipe route),
- pipe material, class, type of joint,
- pipe diameter (nominal and outside diameter), and
- year of installation.

When old pipes are to be replaced and abandoned, it is recommended that all house connections on the old pipes be removed and reconnected to the new one, and that the old pipes should be completely disconnected from the distribution system.

Waterworks is recommended to establish leakage detection team and the team should inspect ground surface above the distribution network pipeline. The team can find visible leakage on the ground surface and these leak points should be repaired as soon as possible. Waterworks also ask customers to report the leak point if they find it. Upon completion of the visible leakage survey and repair works of found visible leakage, execution of the leak sound detection by using detection devices for leak sound will be recommended in future.

Accuracy of water meter declines with time. A certain large portion of unaccounted-for water is resulted from metering loss by old meter. Periodical meter checking and its replacement is recommended. It is necessary to establish a policy that all meters in service more than 7 to 10 years should be replaced.

According to the Waterworks, damage to water pipes by other civil works has been increasing in recent years. To avoid damage by careless civil works, exchange of information on new construction works should be exercised between Waterworks and other agencies related to municipal infrastructures. It is also recommended that Waterworks ask agencies responsible for road maintenance not to overlay valve covers by road pavement.

5.3.3 Necessity of Monitoring

Eight groundwater monitoring and two land subsidence monitoring have been conducting since February 1998 by automatic observation instruments. Also, approximately 100 existing well such as dug well, open well and hand pump well are observing on a monthly basis since January 1998 with partly lack of the data due to various obstruction by social instable condition during absence of the JICA study team.

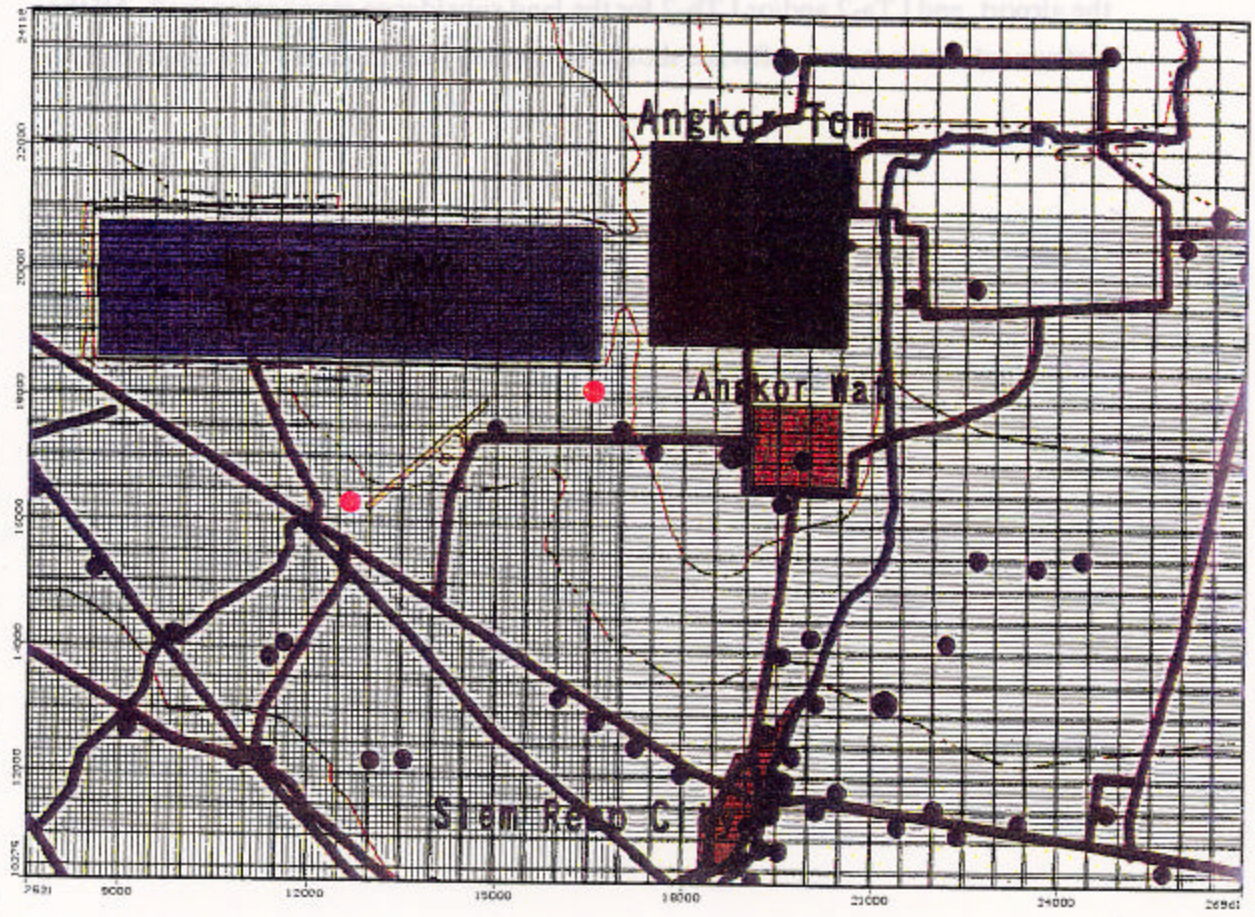
All data till February 2000 are compiled in Supporting Report, Annex 3.4.1 “Hydrogeology”. The data until November 1999 was used as the basic inputting to a model to calibrate for the computer simulation of groundwater.

It is important to continue the monitoring by the existing instruments to ensure no groundwater lowering over 4 m. It is also important to check whether a groundwater abstraction affect Angkor heritage by land subsidence. Besides them, an additional one more land subsidence monitoring at the army camp between the well field and Angkor heritage, and additional groundwater monitoring at the airport near the well field is recommended. Because these two existing land subsidence monitoring are located at Teachers’ Training School (LTa-1 and LTa-2) between the town and the heritage area, and in front of Angkor Wat (LTb1 and

LTb-2) apart from the Project site. Therefore, one more new monitoring is needed to directly check the influence on the Project by the installation at the suitable sites of the intermediate places of army camp and/or airport. Figure 5.3.10 shows the locations of proposed monitoring wells.

The specification for wells and instrument of the monitoring should be the same as this Study.

The design of the monitoring wells should be applied as the same as the constructed monitoring wells in this Study, i.e., WT 4 for the groundwater monitoring well at the airport, and LTa-2 and/or LTb-2 for the land subsidence monitoring well. All the instrument, devices and software should be applied also the same one in this Study.



● : Monitoring Wells

The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 5.3.10** Location of Proposed Monitoring Wells
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