CHAPTER 5

WELL REHABILITATION SURVEY

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5.1 OPERATION AND MAINTENANCE OF MWSS WELLS

5.1.1 Organization and Activity

(1) Responsibility on Operation

The operation of MWSS-owned/supervised wells are all being handled by the Water Distribution and Maintenance Department (WDMD) through its Pumping Plants Division down to the Deepwell Pumping Plants Section (Figure 5.1.1). This department is responsible for the operation and monitoring of both operational and non-operational deep wells. The number of personnel assigned to each well station is on rotation basis. Water production of each well are recorded daily.

(2) Responsibility on Maintenance

The repair and maintenance of all wells owned by MWSS is the responsibility of the Central Maintenance Department (CMD) through the General Control and Repair Division (GCRD). This is shown in Figure 5.1.2. Under the GCRD, the Mechanical and Electrical Section implements the on-site repair and maintenance of pumps, motors, electrical controls and other accessories. For works that have to be done at the shop like some fabrication works, welding jobs, rewinding of motors, repair of pumps, etc., the General Workshop Section, also under the GCRD, takes charge.

Repairs and maintenance of these wells' other water supply and distribution facilities, such as piping systems and other appurtenances, are handled by GCRD's Treatment Plant Mechanical-Electrical Section.

The expenses incurred for small damages, repair and minor engine troubles are all borne by CMD as this office has the budget appropriated for such purpose.

(3) Responsibility on Rehabilitation/Construction

The Planning and Programming Department (PPD) through its Groundwater Monitoring Unit under the Hydrology and Research Division (HARD) studies and recommends feasible actions for the rehabilitation of deteriorated MWSS wells and those with very low water discharge. In some cases, the WDMD, or the CMD, or the customers of MWSS request for the rehabilitation of particular MWSS Wells. For the smooth implementation of well rehabilitation works, the support services of the Bidding, Documentation and Estimates Division (BDED) and Locally-Funded Projects Department (LFPD) are required, specifically for the preparation of bidding and contract documents and field supervision of the actual implementation works.

In drilling new wells, PPD does the feasibility studies and undertakes the construction of test wells through its different units and project offices. Such units include the Groundwater Monitoring Unit of HARD, and the offices of the Fringe Areas Water Supply Project (FAWSP), the Rizal Province Water Supply Improvement Project (RPWSIP), the Manila North-East Water Supply Project (MNEWSP), the Metro Manila Groundwater Development Project (MMGWDP) and the other future PPD projects which are groundwater-based.

Support services of the Design Department and BDED are also necessary for the preparation of design/plans and bidding/contract documents for the construction of deepwell pumping stations and their accessories--usually done when test wells are converted into production wells. The supervision of the actual construction of the pumphouse and all its facilities is carried out by the project office involved (FAWSP, RPWSIP, MNEWSP, MMGWDP). LFPD supervises only those projects initiated by HARD's Groundwater Monitoring Unit.

PPD oversees and monitors the implementation progress of the rehabilitation, drilling and pumping station construction works for MWSS deepwells.

(4) Daily Operation and Maintenance

The Deep Well Pumping Plant Section is engaged in the operation and maintenance of MWSS deepwells. Deepwell stations are clustered per area as follows:

1) Antipolo (town proper)
2) Cogeo, Antipolo, Rizal
3) Malabon, Metro Manila
4) Navotas, Metro Manila
5) Pasig, Cainta and Taytay, Rizal
6) Congress (IBP), Quezon City, Metro Manila
7) San Mateo-Montalban, Rizal
8) N.A.I.A.-Pasay City-Las Piñas-Parañaque, Metro Manila
9) Lagro, Quezon City, Metro Manila
10) Fairview, Quezon City, Metro Manila
11) Forbes Park-Valle Verde-Green Meadows, Metro Manila
12) Dasmariñas, Makati, Metro Manila
13) Cavite Area (Imus, Bacoor, Cavite City, Noveleta, Rosario, Kawit)
14) Muntinlupa, Metro Manila
15) Taguig (Signal Village 1 and 2, Upper Bicutan), Metro Manila
16) Escopa, Project 4 & Loyola Grand Villas, Q.C., Metro Manila
17) Valenzuela, Metro Manila

Deep well pumping stations are daily visited. Operating hours, power consumption, discharge rates, etc. are read and reported. Should a defect/trouble like damage to motor occur, a proposal for repair/maintenance is sent to the Central Maintenance Department and a corrective measure is undertaken.

Supervision of wells is not always by cluster. Some are supervised individually.

In the Antipolo area for example, the ten wells of MWSS are operated and maintained by a 19-person team. This manpower complement consists of an officer-in-charge, a pump operator/foreman (assistant of officer-in-charge), four (4) groups, (4 persons/group) and a roving operator. The detailed organization is shown in Fig. 5.1.3

Group 1 consists of two pump operators/foremen and two regular pump operators. It supervises Deepwell Pumping Station (DPS) Nos. 1, 2 and

7. Group 2, which is composed of one senior pump operator and three regular pump operators, supervises DPS Nos. 4 and 5. Group 3 consists of three regular pump operators and one casual pump operator. It supervises DPS Nos. 8, 9 and 10. Group 4, which is made up of one senior pump operator and one regular pump operator and two casual pump operators, supervises DPS Nos. 3 and 6. The relationship between the Groups and the respective wells under their supervision is shown in Fig. 5.1.4.

This group arrangement needs three personnel for operating each pump station. These personnel work five days a week, with pump operators working on eight-hour shifts. An extra operator is assigned to take over the other functions of one who is on rest day or off day. In addition, a roving operator is also assigned as alternate for absent operators. Total number and composition of personnel are shown below.

Table 5.1.1 PERSONNEL COMPLEMENT OF MWSS OPERATION IN ANTIPOLO AREA

Workers' Class	Number of workers
1. Supervising engineer (Officer-in-charge)	1
2. Pump operator foreman	3
3. Sr. pump operator	3
4. Regular pump operator	9
5. Casual pump operator	3
Total	19

5.1.2 Maintenance Capability and Equipment

Maintenance and repairs capability is different in each organization of MWSS. The Deepwell Pumping Station Operators can undertake minor maintenance works as follows:

WDMD DPS Operator's Maintenance Works

1) Replacement of pump head and diaphragm of chemical feeder
2) Replacement or repair of power and control fuses, burnt wires inside control panel, and other related repairs
3) Isolation of defective protective device (control panel)
4) Cleaning of chlorinators and chemical feeder
5) Repair of defective lighting fixtures
6) Maintenance and cleanliness of pump houses and surroundings and motor controls

All the other major maintenance works on deepwell pumping stations which cannot be undertaken by this WDMD DPS Operator are implemented by CMD. The CMD has the following equipment/tools and materials:

Equipment/Tools

a. Hydraulic crane
b. Chain hoist
c. Welding Machine
d. Megger Tester
e. Clamp Ammeter
f. Multi-Tester
g. Assorted hand tools (pliers, wrenches, screwdrivers, etc.)

Materials

a. Chlorine granules
b. Other materials (as per request)

5.1.3 Budget of the CMD

The 1990 Approved Budget of the MWSS for the maintenance of the water supply system is as follows:

Central Maintenance Department	₱170,152,100.00
General Control and Repair Division	60,544,900.00

The ratio of General Control and Repair Division (GCRD) to CMD in the MWSS budget is 35.6%.

5.1.4 Present Rehabilitation Procedure

The rehabilitation of a well is undertaken when the initial discharge rate is decreased by 50% or more. The decrease of the discharge rate may be caused by:

- Regional decline of water level;
- Trouble or superannuation of submersible pump; and,
- Encrustation or clogging of well screen or submersible pump screen.

Figure 5.1.5 shows MWSS's procedure for well rehabilitation. Investigation and analysis is conducted first, followed by detailed engineering work, and then the awarding of the rehabilitation work to contractors which carry them out.

Usual work items are:

- Mobilization and demobilization;
- Pulling out of existing pumping unit;
- Cleaning of well by brushing, bailing and developing by surging for 24 hours; and,
- Developing and pump testing of well for 48 hours.

The effect of rehabilitation work is verified by comparing yield of wells before and after rehabilitation. The static water level, before and after the rehabilitation work, is also measured to verify improvement of well productivity.

5.2 SURVEY AT WELL SITES

5.2.1 Survey Methodology

There are at present two hundred fifty-eight (258) MWSS wells in MSA, about half of which are inactive or abandoned. The total figure is based on the list of active, inactive and abandoned MWSS deep wells which the respective staffs of the MMGWDP and the Deep Well Pumping Plant Section of MWSS prepared (Table 5.2.1). Site survey of these wells was conducted, and the information and data obtained were used to establish a proper rehabilitation program. Investigation items were:

- Site visit of all active and some inactive MWSS deep wells;
- Questionnaire survey at each area-cluster of deep wells;
- Collection and analysis of construction and pumping records of each well;
- Detailed survey of selected wells including the measurements of water levels, discharge rates and water qualities by pumping tests; and
- Preparation of the experimental rehabilitation program.

5.2.2 Present Condition of MWSS Wells

Obtained during the site visits and the interviews with the operators are the data on the present condition of MWSS wells (Tables 5.2.1 and 5.2.2). The well conditions are classified into four: "Good", "Damaged", "Standby" and "Others".

"Good": wells being operated are in good condition.
"Damaged": wells are damaged as indicated by any of the following:

a) Salty water output
b) Dirty water
c) Well caved-in
d) Well is almost dry
e) Defective pump/motor unit

"Standby": wells are on standby, under rehabilitation, or provides adequate water supply.

"Others": wells are abandoned, inactive, have broken distribution pipeline, etc.

Tables 5.2.2 and 5.2.3 show that ninety-nine (99) out of one hundred thirty (131) "active" wells are in good condition. The rest of the wells are practically inactive. However, this number of active wells may increase since some of the "inactive" wells are under rehabilitation and may be activated in the future. In addition, a considerable number of wells have not been operated since turn-over. These wells however could be operated when needed.

Under the active and inactive categories are 28 damaged wells. The causes of damage by municipality are shown in Table 5.2.4.

5.2.3 Detailed Survey of Selected Wells

5.2.3.1 Scope and Specifications

Sixteen (16) out of twenty-eight (28) damaged wells were selected for detailed survey. This survey included pumping tests to obtain the data necessary for the well rehabilitation program. Those wells which were abandoned, or are very shallow, or have no original records were excluded. The scope and technical specifications of the rehabilitation are given as follows.

A. TWO WELLS

1) COGEO No.1, ANTIPOLO (3 days)

- Addition of 2 pieces of riser pipes and lowering of the pump setting by about 12 meters
- Short pumping test (30 minutes)
- Removal of existing pumping facilities
- Measurement of well depth and static water level
- Installation of a pump test unit (pump setting - 78 meters)
- Pumping test (2 hours)
- Water sampling
- Removal of pump test unit
- Re-installation of the existing pumping facilities

2) LAGRO No.5, QUEZON CITY (1 day)

- Measurement of pumping water level and discharge rate
- Addition of 3 pieces of riser pipes and lowering the pump setting by about 18 meters
- Pumping test (2 hours)
- Water sampling

B. TWELVE WELLS

- Removal of threaded-caps of sounding tube
- Measurement of static water level
- Pumping test (2 hours)
- Water sampling and measurement of pumping water level

C. TWO WELLS (Sumulong, Taytay and Forbes Park No. 12)

- Measurement of static water level

5.2.3.2 Results of the Survey

(1) Cogeo No.1, Antipolo

Due to low water output and frequent tripping of pump unit, this well has not been operated since July 1990.

The well and pumping unit have these following characteristics:

Existing pump setting	66m
Well depth	89.40m
Existing pump unit	Franklin Electric Model 2366016010 HP 7 1/2 230 V PH3 MAX A 24.6 3450 R.P.M. Insulation resistivity 1.5 megaohms (Low)

The new pump test unit which was used for the pump testing program has the following characteristics.

Pump Test Unit	RED JACKE 2130 Serial No. DLE 6116 HP 15 230 V 44.5 A, 3450 R.P.M. Insulation resistivity 130 megaohms (Good)

At first, the pump setting was changed to 78 meters by adding twelve

(12) meters of riser pipes. Pumping started afterwards. During the pumping test, the discharge rate is 3.08 lps and the pumping water level (PWL) is more than 67.06 m.

Another pump test unit which was installed at the same depth was also ran. Results show 3.22 lps of discharge and more than 67.06m of PWL and 6.0m of static water level (SWL). Results are almost the same as those on using the existing pump unit.

It is therefore noted that the low output of the well was improved by having the pump setting changed. But even with an increased discharge rate, the existing pump unit must still be repaired because of the low insulation resistance. It is also recommended that the pump setting be lowered by about 12 meters.

(2) Cogeo No. 6, Antipolo

As observed, this well has a reduced discharge rate. Results of the pumping test at Cogeo No.6 are as follows:

Existing pump setting	100.5m
Well depth	107.4m
Discharge rate	2.50 lps
Submersible pump	25 HP
Pumping Water Level	38.0m

It is recommended that the existing pump unit be removed so that pump setting and conditions can be checked. It seems that the pump setting was wrong or the impeller has worn out. Adjustment of pump setting to a more suitable position is recommended.

(3) Lagro No.5, Quezon City

This well was rehabilitated once in July 1990. However, water comes up intermittently.

Present condition of the well is as follows:

Existing pump	30 HP

Existing pump setting	96m
Discharge rate	3.75 lps
Pumping water level	50.60m

The pump setting was changed by adding three (3) pieces of 4" diameter riser pipes. Results of the pumping test are as follows:

Discharge rate	6.50 lps
Pumping water level	54.80m
Static water level	42.00m

The well produced water after the rehabilitation. It seems the existing pump setting was recorded incorrectly.

(4) IBP (Congress) No. 3, Quezon City

The condition of the well is as follows:

Well depth	208.20m
Submersible pump	30 HP
Pump setting	108m
Static water level	39m

This well was inactive since April 1990 because of the presence of iron bacteria. The existing pump should be pulled up and checked. The iron scales adhering to the pump and the riser pipes should be removed.

(5) Alabang Junction, Muntinlupa

The condition of the well is as follows:

Well depth	246.0m
Submersible pump	30 HP
Pump setting	72m
Pumping water level	74.45m
Discharge rate	(Flow meter was broken)

During the site visit made prior to the test, it was learned that the water that comes out from the well is dirty and contains sand. During the pumping test, however, clean water came up without sand. This well seemed to be in good condition. Pump setting was possibly wrong.

(6) Malanday, San Mateo

MWSS rehabilitated this well in 1989, but the well output is low. Results of the pumping test done by the Study Team are as follows:

Submersible pump	30 HP
Pump setting	78m
Flow rate	6.67 lps
Pumping water level	30.50m

Many iron bacteria appear to be present in the groundwater. The iron scales may be inside the riser pipes and the pump unit.

(7) Dulong Bayan, San Mateo

It was reported that the well had caved-in. The pumping test conducted by the Study Team showed that it has not.

Submersible pump	15 HP
Pump setting	57m
Flow rate	10.0 lps
Pumping water level	19.0m

No sandy materials were observed in the groundwater during pumping. Pump operation is good. The groundwater flows directly into the distribution pipeline. Control of pumping rate is done by back pressure and thus could not be increased.

(8) Sumulong, Taytay

This well was inactive from September until the 3rd week of December 1990 due to defective electrical control. A 15-HP submersible pump was pulled out on December 27, 1990 and replaced by a 30-HP submersible pump the next day. The well condition is as follows:

Pump setting	75m
Static water level	58m

Submersible pump insulation resistance 0 ohm

The submersible pump needs repair because of zero (0) insulation resistance. Pump needs to be set deeper by adding three (3) pieces of 4" diameter riser pipes.

(9) Bangiad, Taytay

The well drilling was completed in March 1985. The pumping station was constructed in March 1987 and became operational in 1989.
Results of the pumping test:

Submersible pump	40 HP
Pump setting	90m
Flow rate	22.17 lps
Pumping water level	75.0m
40 HP submersible pump	Installed on Oct.3,1989.

The pump operation is good and groundwater is almost clean, except for some fine sand which sometimes comes out. The discharge rate should therefore be reduced.

(10) Zapote, Las Piñas

The pumping test results are as follows:

Submersible pump	25 HP
Flow rate	10.67 lps
Pumping water level	74.0m
Water quality	2,230 µS/cm; 30.9 deg. C; pH 7.95

Water coming from this well is salty. Considering the data obtained from the test wells drilled by the Study Team, the salty water may have originated from shallow aquifers in this area.

(11) Naga Road No.2, Las Piñas

The results of pumping test conducted by the Study Team are as follows:

Submersible pump	30 HP
Pump setting	132m
Flow rate	7.83 lps
Pumping water level	74.0m

The discharge rate was recorded at 23.03 lps in 1979. No rehabilitation work has been done during the last 12 years. It is therefore recommended that the existing pump unit be pulled out to check the setting and the pump's condition.

(12) Topacio Elementary School, Imus

The results are as follows:

Well depth	252m
Submersible pump	30 HP
Flow rate	14.5 lps
Pumping water level	81.0m

The report that the well had dried up was not true. This well seems to be in good condition. No sand came out during the test and the pump's operation was good.

(13) Dalahican, Cavite City

This well was also reported damaged. But the pumping test showed:

Well depth	189m
Submersible pump	15 HP
Pump setting	78m
Flow rate	6.67 lps
Pumping water level	52.45m

This well seems to be in good condition. No sand come out and the pump is still in good condition.

(14) Forbes Park No.12, Makati

The well characteristics are:

Well depth	304.80m
Static water level	48.50m

The pump unit was installed in September 1990.

(15) Forbes Park No.11, Makati

The well characteristics are:

Well depth	304.80m
Submersible pump	70 HP
Pump setting	210m
Pumping water level	139.0m

The discharge rate could not be measured because there was no flowmeter installed. Clean water came out from this well. The well is in good condition.

(16) Maricaban III, Pasay City

Results of pumping test show:

Well depth	237.74m
Submersible pump	30 HP
Pump setting	109m
Flow rate	11.22 lps
Pumping water level	110.40m
Water quality	1,421 µS/cm; 31.6 deg. C; pH 8.29

The well yields water that is a little salty. No sand came out. This well is still in good condition.

5.2.4 Summary of the Survey

(1) Recommended for well rehabilitation

Cogeo No.1, Antipolo
Cogeo No.6, Antipolo
IBP (Congress) No.3, Quezon City
Malanday, San Mateo
Sumulong, Taytay
Naga Road No.2, Las Piñas
Forbes Park No.12, Makati

(2) Well in good condition

Bangiad, Taytay

(3) Improvement in water quality could not be expected

Zapote, Las Piñas

(4) Increase the power rating of the pump or the total dynamic head

Dulong Bayan, San Mateo
Alabang Junction, Muntinlupa
Topacio Elementary School, Imus
Dalahican, Cavite City
Forbes Park No.11, Makati
Maricaban III, Pasay City

(5) Check and follow up the well condition

Lagro No.5, Quezon City

5.3 EXPERIMENTAL REHABILITATION WORK

5.3.1 Work Outline

The experimental work for rehabilitation was drawn up for five (5) MWSS deepwells in Metro Manila based on the survey results. The location and details of these wells are shown in Figures 5.3.1 to 5.3.6 and Table 5.3.1

The experimental work for rehabilitation involves the following activities:

1) Preparation and mobilization
2) Pulling out of existing pumping unit
3) Measuring of well depth and water level
4) Inspection of existing pumping unit
5) Installation of test pumping unit
6) First pumping test
7) Surging, bailing and airlifting
8) Second pumping test
9) Installation of existing pumping unit
10) Demobilization

After mobilization and preparatory work, the existing pumping unit well depth and static water level are then measured. The accumulation of sand, mud, rust and other materials at the bottom of the well are investigated throughout the measurement.

Electric conductivity and temperature logging are conducted just below the static water level down to the bottom of the well at one meter intervals.

The Study Team had the existing pumping units checked and the slight damages repaired. The scales adhering to the pumping units were removed and the units cleaned up.

A test pumping unit was installed in the well together with a micro-flow meter in order to carry out the following pumping tests.

1) Step-drawdown test
2) Constant discharge test
3) Recovery test
4) Flow measurement at screen sections

Flow measurement was not conducted at Sumulong, Taytay and Cogeo No.1, Antipolo because the diameter of the casings of these wells is 6 inches and the clearance between the test pump and casing was so narrow for the installation of micro-flow meter unit. The flow meter was also not used at Cogeo No.6, Antipolo because the well was cased without screens from the ground surface to the depth of 100m, but was uncased below this depth down to the bottom. Instead of measuring the micro-flow at three wells -- IBP No.3, Cogeo No.6, Antipolo and Naga Road No.2 -- a television camera was lowered inside the wells and photographs were taken.

First Pumping Test

Pumping rate and pumping water level were measured continuously and checked by using a triangle notch weir and electrical sounding wire. The electric conductivity, temperature and pH were measured by using water quality meters.

1) Step-drawdown Test

The step-drawdown test was conducted at five (5) steps with pumping duration of two (2) hours for each step. The pumping rate was decided at the site. The test was not completed at Cogeo No.1, Cogeo No.6, IBP No.3 and Naga Road No.2 wells because of large drawdowns or very low discharges.

2) Constant Discharge Test

This test was continued for forty eight (48) hours. The pumping rate was decided and was directed to the Contractor.

3) Recovery Test

After constant discharge test, the recovery of water level was measured for eight (8) hours.

4) Flow Measurement

The flow rate at each screen section of the well was measured. The depth of setting was at the uppermost part of each screen section.

Measurements were taken at one hour intervals during the conduct of the step drawdown.

Surging and Bailing

After the first pumping test, the wells were surged throughout the screen section. The wells are bailed when any accumulation are observed. Surging and bailing were performed for more than two (2) days, at eight (8) hours per day.

Airlifting

Upon completion of surging and bailing, the wells were discharged by airlifting for more than two (2) days, also at (8) hours per day. The compressor used for pumping by airlifting has a developing pressure of 8 kilograms per square centimeter (114 psi); the delivery rate was 17 cubic meter of air per minute. From time to time, the air flow was stopped to facilitate the loosening of trapped materials.

Airlifting was completed with the eductor pipes almost at the bottom of the well to ensure that all materials are cleaned out of the pipe.

Second Pumping Test

After airlifting, the second pumping test was conducted and flow measurements taken in the same manner as the first pumping test.

After completion of the second pumping test, the existing pumping unit was reinstalled in the well. Sounding tubes of 3/4-inch diameter were installed with the existing pumping unit to facilitate the measurement of water level.

Actually, the existing pumping unit is damaged and therefore was not reinstalled at Sumulong, Cogeo No.6 and IBP No.3. But the riser pipes and submersible pumps for replacement were not available. IBP No.3 is recommended to be abandoned because of its low water output and the presence of many iron bacteria.

5.3.2 Effect of Rehabilitation

The results of experimental works are summarized in Table 5.3.2.

(1) Sumulong, Taytay Deepwell

For the first pumping test, a 30-HP submersible pump was used. It was installed at a depth of 78m below ground level. For the second, a 10-HP submersible pump was used and installed at a depth of 120m below ground level. The diameters of casing are 8 inches from ground level to 80.77m, and 6 inches below 80.77m. The diameter of riser pipes is 3 inches. Static water level before pumping was 58.00m for the first pumping test and 58.50m for the second pumping test.

The pumping tests were conducted at five steps with discharge rates of 60, 108, 144, 168 and 198 l/min for the first test; for the second, 78, 120, 162, 198 and 240 l/min. Each step has a duration of two hours.

From the results, well loss parameters were calculated using Jacob's equation. For the first pumping test, the values of B and C obtained from Q-s/Q graphs are 5.40×10^{-2} day/m^2 and 1.65×10^{-4} day^2/m^5, respectively; and for the second, 2.60×10^{-2} day/m^2 and 1.43×10^{-4} day^2/m^5, respectively. Well efficiencies were calculated as 51.3% when discharge rate is 198 l/min (285 m^3/day) at the first pumping test and as 34.0% when discharge rate is 240 l/min (328 m^3/day).

In order to determine the transmissivity T and storage coefficient S of the aquifer, the continuous pumping and recovery tests were carried out before and after rehabilitation work. The discharge rate determined from the step-drawdown test was 156 l/min at the first pumping test and 204 l/min at the second pumping test. Duration of pumping was 48 hours. The discharge rates were small because the diameter of the casing pipes was reduced from 8 to 6 inches at depth of 80.77m and only a smaller submersible pump could be installed. The residual drawdown before and after rehabilitation work was measured for 8 hours after pumping has stopped.

The specific capacity was noted to have improved from 9.50 m^2/day to 13.07 m^2/day. Aquifer loss coefficient and well loss coefficient have also improved. This may indicate that the clogging of the well screen and aquifer were removed by rehabilitation work. EC values during pumping tests also support this idea.

(2) Cogeo No. 1, Antipolo

A 10-HP submersible pump was installed at a depth of 78m below ground level. The diameter of casing and riser pipes were 6 and 3 inches, respectively. The static water level before pumping was 8.10m at the first pumping test and 6.55m at the second.

Step-drawdown tests were conducted at discharge rates of 42, 78, 120, 156 and 198 l/min before and after rehabilitation work. The duration of each step was two hours.

From the results, well loss parameters were calculated using Jacob's equation. For the first pumping test, the values of B and C obtained from Q-s/Q graphs are 8.00×10^{-3} day/m^2 and 2.55×10^{-4} day^2/m^5, respectively; and for the second, 2.00×10^{-3} day/m^2 and 2.10×10^{-4} day^2/m^5, respectively. Well efficiencies are calculated as 13.6% at the first pumping test and as 4.70% at the second pumping test. Discharge rate is 156 l/min (225 m^3/day).

The continuous pumping test was conducted at a discharge rate of 198 l/min. Duration of pumping at the first pumping test was 10 hours because the pumping water level declined to near the level of pump setting. Duration of the second pumping test was 48 hours. The discharge rate was small because the pumping water level declined rapidly to the level of pump setting.

The residual drawdown was measured for eight hours after the pumping has stopped.

The specific capacity was noted to have improved from 17.0 m^2/day. Aquifer loss coefficient and well loss coefficient have also improved.

This may indicate that the clogging of the well screen and aquifer were removed by rehabilitation work.

It was also observed that the pumping water level declined rapidly and did not become stable at the discharge rate of 198 l/min. This may indicate that the groundwater of this well come from the fissure of basalt and is unconfined. Storage coefficient S values and aquifer loss coefficient values B obtained from the pumping tests also support this idea.

(3) Cogeo No. 6, Antipolo

A 20-HP submersible pump was installed at a depth of 90m below ground level. The diameter of casing pipes and riser pipes were 8 and 3 inches, respectively. The 8" blank casing pipes were installed up to 91.44m below ground level and a 14" borehole was uncased from a depth of 91.44 to 117.35 meters. The static water level was 11.50m at the first pumping test and 10.49m at the second.

Step-drawdown test was performed at discharge rates of 49.2, 102, 150, 204 and 252 l/min. Although the planned duration of each step was two hours, the final step had only a duration of twenty (20) minutes, because the pumping water level had declined to the level of the pump setting.

For the first pumping test, the values of well loss parameters B and C obtained from Q-s/Q graphs are 0.00 day/m^2 and 8.00×10^{-4} day^2/m^5, respectively; and for the second, 0.00 day/m^2 and 7.35×10^{-4} day^2/m^5 respectively. Well efficiencies are calculated as 0.00% at the first pumping test and also as 0.00% at the second. Discharge rate was 204 l/min (294 m^3/day).

The continuous pumping test was conducted at a discharge rate of 150 l/min. Duration of pumping for the first pumping test was 22 hours. Although it was planned for forty eight (48) hours, pumping was aborted due to power failure (brown out). Duration of the second pumping test was 48 hours. The discharge rate was small because the pumping water level declined rapidly and reached the pump setting position.

The specific capacity was noted to have improved a little from 4.30 m^2/day to 4.58 m^2/day. Well loss coefficient has also improved a little. This may indicate that the clogging of the well screen and aquifer were originally small.
It was also noted that the pumping water level declined continuously and was unstable when the discharge was 252 l/min. This may indicate that the groundwater of this well come from the fissure of basalt rocks, like that in Cogeo Deepwell No.1.

(4) IBP (Congress) No.3

The discharge from IBP No.3 was so small that the pumping test could not be carried out.

According to the lithologic log that was obtained at the time the well was completed on 23 May 1978, the geologic formation mainly consists of clayey layers and the screen section was set at very thin gravel beds. EC values at 18 degrees range from 136 to 156 µS/cm. Considering such low conductivities, this may indicate that water directly enters the well from surface sources such as rain or perched water. Very small amounts of groundwater may flow into the well through the screen section.

(5) Naga Road No.2

A 30-HP submersible pump was installed at a depth of 102m below ground level. The diameters of casing and riser pipes were 10 and 4 inches respectively. The static water level before pumping was 55.84m at the first pumping test and 55.42m at the second.

The step-drawdown test was conducted at discharge rates of 102, 204, 300 and 360 l/min. Although planned for five steps, testing was stopped at the final step because of the small dynamic head.

For the first pumping test, the values of well loss parameters B and C obtained from Q-s/Q graphs were 3.20×10^{-2} day/m^2 and 6.20×10^{-6} day^{-2}/m^5, respectively; for the second, 2.95×10^{-2} day/m^{-2} and 6.20×10^{-6} day^{-2}/m^5, respectively. Well efficiencies were calculated at 92.3% at the first pumping test and at 90.2% at the second. Discharge rate was 300 l/min

(432 m^3/day).

The discharge rate determined from the step-drawdown test was 354 l/min. The continuous pumping test duration was 48 hours.

The discharge rate was not so high at the first pumping test because the existing 6-stage submersible pump that was used, after dismantling and removing the scales from the pump impeller, does not have high dynamic head. At the second pumping test, the discharge rate was also not so high because the existing pump was again used. A new 30-HP, 12-stage, submersible pump was then installed, but the motor conked out during the 20-minute test operation due to the intrusion of sand. Such being the case.

The residual drawdown was measured for eight hours after the pumping has stopped.

The specific capacity was noted to have improved from 28.9 m^2/day to 30.6 m^2/day at a discharge rate of 378 l/min. It was also noted that after rehabilitation the groundwater flowed into the well through lower screen sections. Well loss coefficient was the same. This may indicate that the clogging of the well screen and aquifer was very few.

5.3.3 Recommendation

Based on the result of the experimental work for rehabilitation of five (5) MWSS deepwells, the recommendation on the operation and maintenance of these wells are as follows.

(1) Sumulong, Taytay

The control panel of the submersible electric motor and all columns of riser pipes should be replaced. The submersible pump should have a smaller diameter and capacity than the existing one has. Pump should be set deeper because the diameter of the well casing pipes was reduced from 8" to 6" at a depth of 80.77m, and the pumping water level is below this depth when the well was pumped at a discharge rate of 240 l/min. Submersible cable should be replaced because its insulation resistance reading is only 10 megaohms.

The submersible pump that should be installed must be 10 HP, 133mm in diameter, and it should have 115 meters of total dynamic head at 216 l/min of discharge. Twenty (20) columns of 3" x 20' riser pipes should also be installed.

(2) Cogeo No.1, Antipolo

Submersible pump should be replaced because its insulation resistance reading is only 0.5 megaohms, despite Contractor's not finding of any damage during inspection of the dismantled pump assembly.

In the course of the rehabilitation work, the pump setting has been changed from 66m to 78m by using two additional columns of 3" riser pipes and 12m additional submersible cable. The pumping water level was not stable and was still declining when the discharge was 198 l/min.

It is therefore recommended that this well should be operated on a half-day basis, at about 150 l/min of discharge and stopped for the rest of the day.

The pumping water level should always be monitored. Pump condition, especially the bolts, should be carefully maintained.

(3) Cogeo No.6, Antipolo

Submersible pump should be replaced because its insulation resistance reading is only 8 kiloohms and it has a 1x1 cm-size hole at the pump bowl. Two (2) pieces of 3"x20' riser pipes are usable, but 14 pieces of 3"x20' riser pipes and one 1 piece of 3"x20' riser pipe should be re placed. One hundred and one (101) meters of submersible cable are still usable. The pumping water level was not stable and still declining when the discharge was 204 l/min.

Submersible pump which has a capacity of 7.5 HP and 97 meters of total dynamic head at 200 l/min discharge rate should be installed with 16 pieces of 3"x20' riser pipes.

This well should be operated on a half-day basis at a discharge rate of about 150 l/min and be similarly maintained as the Cogeo Antipolo Deepwell No.1.

(4) IBP (Congress) No.3

This well should be abandoned after it has been plugged with cement.This well produces very low water output and has many iron bacteria inside the well. In order to avoid the spread of iron bacteria, and obviate the possibility of infection of another active well through the aquifer, the well should be completely plugged.

(5) Naga Road No.2

Seventeen (17) pcs. of 3"x20' riser pipes formerly used at Tuazon deep-well were installed to replace those of Naga Road Deepwell No.2. It is recommended that the pumping unit be pulled out and checked within two to three years. The pumping water level and discharge rate should be monitored regularly. Pumping facilities should be properly maintained.

TABLE 5.2.1a LIST OF ACTIVE MWSS DEEP WELLS

(as of March 1991)

Well Name Municipality	Actual Condition	Group
ANTIPOLO		
1. M.L. Quezon (Pump £1)		
2. Sto. Nino (Pump £2)		
3. P. Burgos (Pump £3)		
4. Nursery (Pump £4)		
5. Circumferential Road (Pump £5)		
6. Road to Teresa (Pump £6)		
7. Sumulong Elementary School (Pump £7)		
8. San Isidro Elementary School (pump £8)		
9. Ang Tahanan (Pump £9)		
10. Saguinsin (Pump £10)		
11. Cogeo £ 1	Defective pump unit	D-Pump
12. Cogeo £ 2	Defective pump unit	D-Pump
13. Cogeo £ 4		
14. Cogeo £ 5	Defective pump unit	D-Pump
15. Cogeo £ 6	Defective pump unit	D-Pump
CAINTA		
16. San Juan		
17. Gloria-Marick		
18. San Fabian		
19. Mapandan	Abandoned	Others
20. Sto. Domingo	Defective pump unit	D-Pump
TAYTAY		
21. Sumulong	Defective pump unit	D-Pump
22. San Isidro		
23. Sta. Ana Elementary School		
24. Taytay Elementary School		
25. San Victores		
26. Rosario		
27. Bangiad		
SAN MATEO		
28. San Mateo Public Market		
29. Banaba, Ampid		
30. Malanday	Abandoned	Dirty
31. Maly		
32. Dulong Bayan 11	Well caved-in	Caved

TABLE 5.2.1a (CONTINUATION)

Well Name Municipality	Actual Condition	Group
MONTALBAN		
33. San Jose		
34. Manggahan		
35. Aranzazu		
VALENZUELA		
36. T. De Leon		
37. Pasolo Elementary School		
38. Arkong Bato	No operator	Others
MALABON		
39. Catmon	No operator	Others
40. Dampalit	No operation	Others
41. Dona Juana		
NAVOTAS		
42. Merville Subdivision		
43. Dagat Dagatan £ 1	No operation	Others
MUNTINLUPA		
44. Muntinlupa Bliss		
45. Poblacion	Defective Pump unit	D-Pump
46. Tunasan		
47. Putatan		
48. Cupang Elementary School		
49. Alabang Junction	Dirty water yields	Dirty
50. Sucat Elementary School		
PARANAQUE		
51. MIA £ 1		
52. mia £ 3		
53. MIA £ 4		
54. Sucat £ 2		
55. La Huerta		
TAGUIG		
56. Signal Village 11		
57. Upper Bicutan	No operation	Others
58. Signal Village 1	No operation	Others

TABLE 5.2.1a (CONTINUATION)

Well Name Municipality	Actual Condition	Group
LAS PINAS		
59. Naga £ 2	Defective Pump Unit	D-pump
60. Zapote, Las Pinas (under the supervision of Cavite pumping station)	Salty water yields	Salty
PASAY CITY		
61. Maricaban 1	Defective Pump Unit	D-pump
62. Maricaban 11		
63. Maricaban 111	Defective Pump Unit	D-pump
MAKATI		
64. Poblacion		
65. Ecology Village		
66. Ayala £ 1	No operation	Others
67. Forbes Park £ 2		
68. Forbes Park £ 6	Defective Pump Unit	D-pump
69. Forbes park £ 8		
70. Forbes Park £ 9		
71. Forbes Park £ 11	Defective Pump Unit	D-pump
72. Forbes Park £ 12	Defective Pump Unit	D-pump
73. Dasmarinas £ 39		
74. Dasmarinas £ 17	Not yet in operation	Others
PASIG		
75. Barrio Capitolyo		
76. Valle Verde Phase 5	Not yet in operation	Others
QUEZON CITY		
77. Greenmeadows £ 3		
78. Greenmeadows £ 4		
79. Fairview £ 1		
80. Fairview £ 2		
81. Fairview £ 3		
82. Fairview £ 4		
83. Fairview £ 5		
84. IBP Congress £ 2		
85. IBP Cognress £ 3	Recommended for abandon	Dirty
86. IBP Cognress £ 4		
87. Lagro £ 1		
88. Lagro £ 2		
89. Lagro £ 3		
90. Lagro £ 5		
91. Escopa, Project 4		
92. Loyola Grand Villas	No operation	Others

TABLE 5.2.1a (CONTINUATION)

Well Name Municipality	Actual Condition	Group
CAVITE CITY		
93. Samonte Park	Salty water yields	Salty
94. Garita		
95. San Roque		
96. Manalac		
97. Calle Marino		
98. San Nicolas		
99. Bagong Pook	No operator	Others
100. Garcia Extension	No operation	Others
101. Crescini		
102. Rivero		
103. Magcauas		
104. Ejercito		
105. Militar		
106. Antonio		
107. J. Felipe		
BACOOR		
108. Daang Bukid		
109. Poblacion		
110. Balsahan		
111. Combalay		
112. Talaba		
113. Niog		
114. Bacoor Central School		
115. Dulong Bayan		
IMUS		
116. Plaza Garcia		
117. Yengco		
KAWIT		
118. Malamok		
119. Aguinaldo		
120. Josephine Resort		
121. Putol-Sta. Isabel		
ROSARIO		
122. Poblacion		
NOVELETA		
123. Noveleta Elementary School		
124. Noveleta Well Field £ 1		
125. Noveleta Well Field £ 2		
126. Noveleta Well Field £ 3		
127. Noveleta Well Field £ 4		
128. Noveleta Well Field £ 5		
129. Noveleta Well Field £ 6		
130. Noveleta Well Field £ 7		
131. Noveleta Well Field £ 8		

Notes: Blank of actual condition is good condition.

TABLE 5.2.1b LIST OF INACTIVE MWSS DEEP WELLS

(as of March 1991)

Well Name Municipality	Actual Condition	Group
CAINTA		
1. Sumulong Highway	For rehab	Rehab
2. Poblacion	Frequent tripping of unit	D-pump
MARIKINA		
3. SSS Vill £ 1	Test tun	Stand-by
4. SSS Vill £ 2	Under rehabilitation program	Rehab
5. SSS Vill £ 3	Test run	Stand-by
6. SSS Vill £ 4	Test run	Stand-by
7. SSS Vill £ 5.	Test run	Stand-by
8. SSS Vill £ 6	Under rehabilitation program	Rehab
9. SSS Vill £ 7	Under rehabilitation program	Rehab
10. SSS Vill £ 8	Test run	Stand-by
11. SSS Vill £ 9	Test run	Stand-by
12. SSS Vill £ 10	Test run	Stand-by
13. East Drive, SSS Village	Test run	Stand-by
14. Industrial Valley	Insufficient water pressure	Adequate
15. Concepcion -	- do -	Adequate
MALABON		
16. Santolan	Adequate water supply	Adequate
17. Niogan	Stand-by	Stand-by
18. Panghulo	Stand-by	Stand-by
VALENZUELA		
19. Kadiwa Center	Sufficient surface water	Adequate
20. Tamaraw Hills	- do -	Adequate
21. Constantino	- do -	Adequate
22. Marulas Elem. School	- do -	Adequate
CALOOCAN CITY		
23. Banal St., Bagong Barrio	Stand-by	Stand-by
24. katarungan St., Bagong Barrio	Stand-by	Stand-by
NAVOTAS		
25. D. Dagatan £ 2	Sufficient surface water	Adequate
26. D. Dagatan £ 3	- do -	Adequate
27. D. Dagatan £ 4	- do -	Adequate
28. D. Dagatan £ 5	- do -	Adequate
29. D. Dagatan £ 6	- do -	Adequate
30. D. Dagatan £ 7	- do -	Adequate
31. D. Dagatan £ 8	- do -	Adequate

TABLE 5.2.1b (CONTINUATION)

Well Name Municipality	Actual Condition	Group
PARANAQUE		
32. San Dionisio	Sufficient water pressure	Adequate
33. Sucat £1	Sufficient water pressure	Adequate
TAGUIG		
34. Maharlika	operated by Muslim	Others
LAS PINAS		
35. Poblacion	defective pumping unit since 8/19/86	D-pump
36. Manuyo	For Rehab	Rehab
37. Ilaya	For Rehab	Rehab
PASAY CITY		
38. Henares Cpd.	Sufficient surface water	Adequate
MAKATI		
39. Ayala £ 8	defective unit	D-pump
40. Ayala £ 10A	Under rehabilitation program	Rehab
41. Ayala £ 11	Under rehabilitation program	Rehab
42. Ayala £ 19	Under rehabilitation program	Rehab
43. Ayala £ 20	Under rehabilitation program	Rehab
44. Ayala £ 22	Under rehabilitation program	Rehab
45. Ayala £ 25	Under rehabilitation program	Rehab
46. Ayala £ 28	Under rehabilitation program	Rehab
47. Ayala £ 29	Under rehabilitation program	Rehab
48. Ayala £ 31	Under rehabilitation program	Rehab
49. Ayala £ 33	Under rehabilitation program	Rehab
50. Ayala £ 35	Under rehabilitation program	Rehab
51. Magallanes £ 5	Under rehabilitation program	Rehab
52. Magallanes £ 15	Under rehabilitation program	Rehab
53. Magallanes £ 41	Under rehabilitation program	Rehab
54. Magallanes £ 42	Under rehabilitation program	Rehab
55. Dasmarinas £ 9	Under rehabilitation program	Rehab
56. Dasmarinas £ 14	Under rehabilitation program	Rehab
57. Dasmarinas £ 40	Under rehabilitation program	Rehab
58. Forbes Park £ 3	Defective unit & Sufficient water pressure	D-pump
59. Forbes Park £ 10	- do -	D-pump
60. Forbes Park £ 13	- do -	D-pump
61. Forbes Park £ 14	- do -	D-pump

TABLE 5.2.1b (CONTINUATION)

Well Name Municipality	Actual Condition	Group
PASIG		
62. Santolan	Sufficient surface water	Adequate
QUEZON CITY		
63. IBP £ 1	Defective motor	D-pump
64. Congressional Village £8	For Rehab	Rehab
65. D. Tuazon Pumping Station	Sufficient water	Adequate
66. D. Tuazon Elem. School	Sufficient water	Adequate
67. Lagro £4	Defective motor	D-pump
68. GSIS Village	Sufficient water pressure	Adequate
69. Bagbag, Novaliches	- do -	Adequate
70. Poblacion, Novaliches	- do -	Adequate
71. North Fairview £ 8		Others
KAWIT		
72. Binakayan, Kawit	Stand-by unit	Stand-by
73. Bo. Wawa	Stand-by unit	Stand-by
PASIG		
74. Wawa, Rosario, Cavite	Stand-by-unit	Stand-by
75. Bo. Sapa	- do -	Stand-by

TABLE 5.2.1c LIST OF ABANDONED MWSS DEEP WELLS

(as of March 1991)

Well Name Municipality	Actual Condition	Group
ANTIPOLO		
1. Cogeo £ 3	Well caved in	Caved-in
CAINTA		
2. Irma	Non potable water yields	Dirty
3. Felix	Non potable water yields	Dirty
TAYTAY		
4. Isagani	Very low water output	D-pump
MARIKINA		
5. San Roque	Adequate Water Supply	Adequate
6. Malanday	Availability of surface water	Adequate
SAN MATEO		
7. Ampid 1	Non potability water yields	Dirty
8. Sta. Ana	Now operational	Others
9. Ampid 11	Non potability water yields	Dirty
MONTALBAN		
10. Geronimo	Pumping unit was not installed	D-pump
11. Poblacion	Pumping unit was not installed	D-pump
VALENZUELA		
12. Malinta	No available data	Others
MALABON		
13. Bo. Hulong Duhat 1	No more existing well	Others
14. Bo. Hulong Duhat 11	No more existing well	Others
15. Dampalit, old well	Cemented, Salty	Salty
CALOOCAN CITY		
16. Pasmon Tala	Clogged	Caved-in
MANILA		
17. Baluto, Tondo	Salty water yields	Salty
18. Aduana, Intramuros	Old well/clogged	Caved-in
19. Muralla, Intramuros	Old well/clogged	Caved-in

TABLE 5.2.1c (CONTINUATION)

Well Name Municipality	Actual Condition	Group
PARANAQUE		
20. Sto. Nino	Salty water yields	Salty
21. Sukat £ 3	Salty water yields	Salty
22. MIA £ 2	Salty water yields	Salty
23. MIA £ 3	Salty water yields	Salty
24. MIA £ 4	Salty water yields	Salty
LAS PINAS		
25. Naga £ 1	Salty water yields	Salty
26. Las Pinas Elem. School	Salty water yields	Salty
27. Pulang Lupa £ 2	Salty water yields	Salty
PATEROS		
28. Fort Bonifacio	Salty water yields	Salty
29. San Pedro	Old well/cemented	Salty
TAGUIG		
30. Tipas	Salty water yields	Salty
31. Tuktukan	Salty water yields	Salty
32. Ususan	Salty water yields	Salty
PASAY CITY		
33. School of Deaf	Availability of surface water	Adequate
MAKATI		
34. Forbes Park £ 15	Non potable water yields	Dirty
PASIG		
35. Pasig Market	Clogged/cemented	Caved-in
36. dela Paz	Clogged	Caved-in
MANDALUYONG		
37. National Mental Hospital £ 1	Old well/ Availability of surface water	Adequate
38. National Mental Hospital £ 2	Old well/ Availability of surface water	Adequate
39. MWSS Bliss, Bgy. Hulo	Availability of surface water	Adequate
CAVITE CITY		
40. R. Palma	Well caved-in	Caved-in
41. M. Castro	Salty water yields	Salty
42. Dalahican	Well is almost dry	Dry
43. Del Trabajo	Well caved-in	Caved-in
44. Paterno St.	Well caved-in	Caved-in
45. Public Market	Well caved-in	Caved-in
46. Hermanos St.	Well caved-in	Caved-in

TABLE 5.2.1c (CONTINUATION)

Well Name Municipality	Actual Condition	Group
BACOOR		
47. Banalo	Salty water yields	Salty
48. Wawa	Well is almost dry	Dry
IMUS		
49. Nueno	Well caved-in	Caved-in
50. Topacio Elem. School	Well is almost dry	Dry
51. Satorre St.	Clogged/Well caved-in	Caved-in
KAWIT		
52. Tirona	Well caved-in	Caved-in

TABLE 5.2.2 WELL CONDITIONS OF MWSS DEEP WELLS

(NUMBER OF WELLS)

WELL CONDITIONS	STATUS			
	ACTIVE	INACTIVE	ABANDONED	TOTAL
IN GOOD CONDITION	99	0	0	99
DAMAGED WELLS				
Defective unit	13	9	3	25
Yields salty water	2	0	17	19
Well caved-in	1	0	14	15
Yields dirty water	3	0	5	8
Well is almost dry	0	0	3	3
TOTAL	19	9	42	70
STAND BY				
Stand by	0	16	0	16
Under Rehabilitation Program	0	25	0	25
Adequate surface water supply	0	23	6	29
TOTAL	0	64	6	70
OTHERS	13	2	4	19
GRAND TOTAL	131	75	52	258

TABLE 5.2.3 PRESENT STATUS OF MWSS DEEPWELLS (31 MAY 1991)

(UNIT: NUMBER OF WELLS)

MUNICIPALITY	Pumping Rate (l.p.s.)	ACTIVE WELLS			Inactive Wells	Abandoned Wells	EXISTING WELLS		
		Good	Damaged	Total			Good	No Good	Total
ANTIPOLO	153.29	11	4	15	0	1	11	5	16
BACOOR	74.00	8	0	8	0	2	8	2	10
CALOOCAN	0.00	0	0	0	2	1	0	3	3
CAINTA	56.36	3	2	5	2	2	3	6	9
CAVITE	92.59	12	3	15	0	7	12	10	22
IMUS	24.33	2	0	2	0	3	2	3	5
KAWIT	51.62	4	0	4	2	1	4	3	7
LAS PINAS	18.08	0	2	2	3	3	0	8	8
MANDALUYONG	0.00	0	0	0	0	3	0	3	3
MAKATI	95.77	6	5	11	23	1	6	29	35
MALABON	8.67	1	2	3	3	3	1	8	9
MANILA	0.00	0	0	0	0	3	0	3	3
MARIKINA	0.00	0	0	0	13	2	0	15	15
MONTALBAN	48.75	3	0	3	0	2	3	2	5
MUNTINLUPA	72.84	5	2	7	0	0	5	2	7
NAVOTAS	5.05	1	1	2	7	0	1	8	9
NOVELETA	88.38	9	0	9	0	0	9	0	9
PARANAQUE	33.09	5	0	5	2	5	5	7	12
PASAY	39.75	1	2	3	1	1	1	4	5
PASIG	3.25	1	1	2	1	2	1	4	5
PATEROS	0.00	0	0	0	0	2	0	2	2
QUEZON	191.24	14	2	16	9	0	14	11	25
ROSARIO	12.67	1	0	1	2	0	1	2	3
SAN JUAN	0.00	0	0	0	0	0	0	0	0
SAN MATEO	54.33	3	2	5	0	3	3	5	8
TAGUIG	10.00	1	2	3	1	3	1	6	7
TAYTAY	65.19	6	1	7	0	1	6	2	8
VALENZUELA	11.59	2	1	3	4	1	2	6	8
TOTAL	1210.84	99	32	131	75	52	99	159	258

Note: NO GOOD - No operational or no good conditioned wells

TABLE 5.2.4 WELLS UNDER UNSATISFACTORY CONDITIONS

(UNIT: NUMBER OF WELLS)

MUNICIPALITY	TYPE OF CAUSE OF DAMAGE: D PUMP			SALTY			CAVED-IN			DIRTY			DRY			ANOTHER REASON: STAND	REHAB	ADEQUATE		OTHERS			TOTAL			GT
	A	I	Ab	A	I	Ab	A	I	Ab	A	I	Ab	A	I	Ab	I	I	I	Ab	A	I	Ab	A	I	Ab	
ANTIPOLO	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	1	5
BACOOR	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	2
CALOOCAN	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	1	3
CAINTA	1	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	1	0	0	2	2	2	6
CAVITE	0	0	0	1	0	1	0	0	5	0	0	0	0	0	1	0	0	0	0	2	0	0	3	0	7	10
IMUS	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	3
KAWIT	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	1	3
LAS PINAS	1	1	0	1	0	3	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	3	3	8
MANDALUYONG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	3
MAKATI	3	5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	18	0	0	2	0	0	5	23	1	29
MALABON	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	1	0	2	0	2	2	3	3	8
MANILA	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
MARIKINA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	3	2	2	0	0	0	0	13	2	15
MONTALBAN	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
MUNTINLUPA	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
NAVOTAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	1	0	0	1	7	0	8
NOVELETA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PARANAQUE	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	5	7
PASAY	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2	1	1	4
PASIG	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	2	4
PATEROS	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
QUEZON	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	5	0	1	1	0	2	9	0	11
ROSARIO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	2
SAN JUAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAN MATEO	0	0	0	0	0	0	1	0	0	1	0	2	0	0	0	0	0	0	0	0	0	1	2	0	3	5
TAGUIG	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	2	1	3	6
TAYTAY	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
VALENZUELA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	1	0	1	1	4	1	6
TOTAL	13	9	3	2	0	17	1	0	14	3	0	5	0	0	3	16	25	23	6	13	2	4	32	75	52	159
G.T.	25			19			15			8			3			16	25	29		19			159			159

Notes:

- D PUMP - Defective pump/ motor unit
- SALTY - Salty water yields
- CAVED-IN - Well caved-in
- DIRTY - Dirty Water yields
- DRY - Well is almost dry
- STAND - Stand-by
- REHAB - Recommended for rehabilitation
- ADEQUATE - Adequate water supply
- A - Active wells
- I - Inactive wells
- Ab- Abandoned wells

TABLE 5.3.1 WELLS FOR EXPERIMENTAL REHABILITATION WORK

Well Name	Municipality	Status	Total Depth	Casing Pipe Position Size	Well Screen Position	Exist. Pump		Test Pump		Pump After Rehab.	
						Set.	Cap.	Set.	Spec.	Set.	Spec.
Cogeo Antipolo No.1	Antipolo	In-active	91.44m	0m-9.75m 8" 9.75-91.44 6"	64m-87.78m	66m	7.5 Hp	78m	SP8-21 7.5HP OD 133	3" 78m	Existing Pump Installed
Sumulong	Taytay	In-active	202.69	0-80.77 8" 80.77-202.7 6"	Unknown	75	30	78m 120m	30 HP 10 HP OD 133mm	NO	No Pump Installed
Naga Road No.2	Las Pinas	Active	243.84	0-243.84 10"	103.63-121.91 128.01-158.49 164.59-170.68 182.88-213.36 219.45-237.74	78	30	120m 102m	SP45-12 30HP OD 150	3" 102m	Existing Pump Installed
IBP (Congress) No.3	Quezon City	In-Active	202.69	0-80 10" 80-202.69 8"	87-99 103-122 129-144 151-166 173-197	120	20	108	20 HP 9 stage OD 140	NO	No Pump Installed
Cogeo Antipolo No.6	Antipolo	In-Active	117.35	0-91.44 8"	91.44-177.35 bore hole	99	20	90	20 HP 9 stage OD 140	NO	No Pump installed

TABLE 5.3.2 RESULTS OF EXPERIMENTAL REHABILITATION WORK

	Sumulong Taytay	I B P No. 3	Cogeo ATP No.1	Cogeo ATP No.6	Naga Road No.2
Well Depth (m)	202.68	202.69	91.44	117.35	243.84
Accumulation (m)	5.68	32.69	4.44	11.35	0
Static Water Level (m)	58.00	39.30	7.25	11.50	55.40
EC-T Logging					
ECt (uS/cm)	684-961	92-144	335-390	316-342	517-9585
T (. C)	30.2-30.7	27.7-28.1	25.8-27.10	26.4-27.50	30.0-34.20
Micro Current	*	*	*	*	
1st Pumping Test					
Discharge Rate (m3/d)	285	(25.9)	285	294	544
Drawdown (m)	30.00	(70.7)	48.80	68.40	17.70
Specific Capacity (m2/d)	9.50	(0.37)	5.84	4.30	30.70
Transmissivity (m2/d)					
Continuous - Theis	14.6	-	2.83	1.33	36.9
Continuous - Jacob	15.2	-	5.27	7.19	31.1
Recovery - Jacob	11.4	-	32.6	19.8	29.2
Storage Coeff.	7.65x10-5	-	1.19	2.26	3.18x10-4
Aquifer Loss Coeff. (day/m2)	5.40x10-2	-	8.00x10-3	0.0	3.2x10-2
Well Loss Coeff (day2/m5)	1.65x10-4	-	2.55x10-4	8.0x10-4	6.2x10-6
2nd Pumping Test					
Discharge Rate (m3/d)	328	(54.4)	285	294	518
Drawdown (m)	25.10	(70.70)	19.50	64.20	17.07
Specific Capacity (m2/d)	13.07	(0.77)	14.60	4.58	31.9
Transmissivity (m2/d)					
Continuous - Theis	14.6	-	4.37	1.34	36.6
Continuous - Jacob	4.10	-	11.1	4.88	31.1
Recovery - Jacob	44.8	-	17.4	15.2	31.9
Storage Coeff.	1.03x10-4	-	2.05	3.32	3.90x10-4
Aquifer Loss Coeff. (day/m2)	2.6x10-2	-	2.0x10-3	0.0	2.95x10-2
Well Loss Coeff (day2/m5)	1.43x10-4	-	2.10x10-4	7.35x10-4	6.2x10-6

TABLE 5.3.3 MEASUREMENT OF MICRO-CURRENT AT NAGA ROAD NO. 2, LAS PIÑAS

step	screen position length	F1	F2	F3	F4	F5	Total
		103.63m -121.91m	128.01m -158.49m	164.59m -170.68m	182.88m -213.36m	219.45m -237.74m	
		18.28m	30.48m	6.09m	30.48m	18.29m	103.62m
1st step drawdown test							
	V cm/s	3.36	0.0	0.0	0.0	0.0	3.36
1	Q l/m	102	0	0	0	0	102
	%	100	0	0	0	0	100
	V cm/s	1.12	5.6	0.0	0.0	0.0	6.72
2	Q l/m	34.2	169.8	0	0	0	204
	%	16.7	83.3	0	0	0	100
	V cm/s	1.78	4.8	3.3	0.0	0.0	9.88
3	Q l/m	54	145.8	100.2	0	0	300
	%	18.0	48.6	33.4	0	0	100
	V cm/s	2.95	5.3	4.2	0.0	0.0	12.45
4	Q l/m	90	160.8	127.2	0	0	378
	%	23.7	42.6	33.7	0	0	100
2nd step drawdown test							
	V cm/s	0.56	2.80	0.0	0.0	0.0	3.36
1	Q l/m	17	85	0	0	0	102
	%	16.7	83.3	0	0	0	100
	V cm/s	1.42	2.3	0.9	2.1	0.0	6.72
2	Q l/m	43.1	69.8	27.3	63.8	0	204
	%	21.1	34.2	13.4	31.3	0	100
	V cm/s	0.98	6.0	1.1	1.8	0.0	9.88
3	Q l/m	29.8	182.3	33.4	54.6	0	300
	%	9.9	60.8	11.1	18.2	0	100
	V cm/s	2.15	6.3	3.4	0.0	0.0	11.85
4	Q l/m	65.3	191.4	103.3	0	0	360
	%	18.1	53.2	28.7	0	0	100

NOTE: WELL DEPTH : 243.84M
CASING SIZE : 10" (O.D. : 25.4 CM)

TABLE 5.3.4 EXISTING PUMPING FACILITIES AND STATUS:

WELL NAME	SUMULONG TAYTAY	IBP NO.3	COGEO ATP NO.1	COGEO ATP NO.6	NAGA ROAD NO.2
Control panel	Defective	Replaced some parts	Good	Good	Good
Submersible Cable	Low Resistance	good	Low Resistance	Good	Good
Riser Pipes	Rusted	Rusted	Good	2 pcs are good another 14.5 pcs were rusted	Rusted
Submersible Pump and	Good	Took out plastics from pump suction	Good	10x10 mm hole observed	Took out soft scales from pump impleller
Motor	Newly	Good	Low resistance	Low resistance	Good
Before Rehab.	Inactive	Inactive	Inactive	Inactive	Active
After Rehab.	No pump	No pump	Active	No pump	

Sumulong Taytay

Grundfos pump model - sp 25-20 (without 2 bowl assembly)
Century submiersible motor 30 Hp
11 pcs 3"0 riser pipes and 1.5 pcs 4"0 riser pipes

IBP NO.3

Gruppo Industriale Ercole pump
motor 20 Hp
20 pcs 3"0 riser pipes

Cogeo Antipolo No.1

Grundfos pump model - sp 16-10
Franklin Electric motor 7.5 Hp
11 pcs 3"0 riser pipes

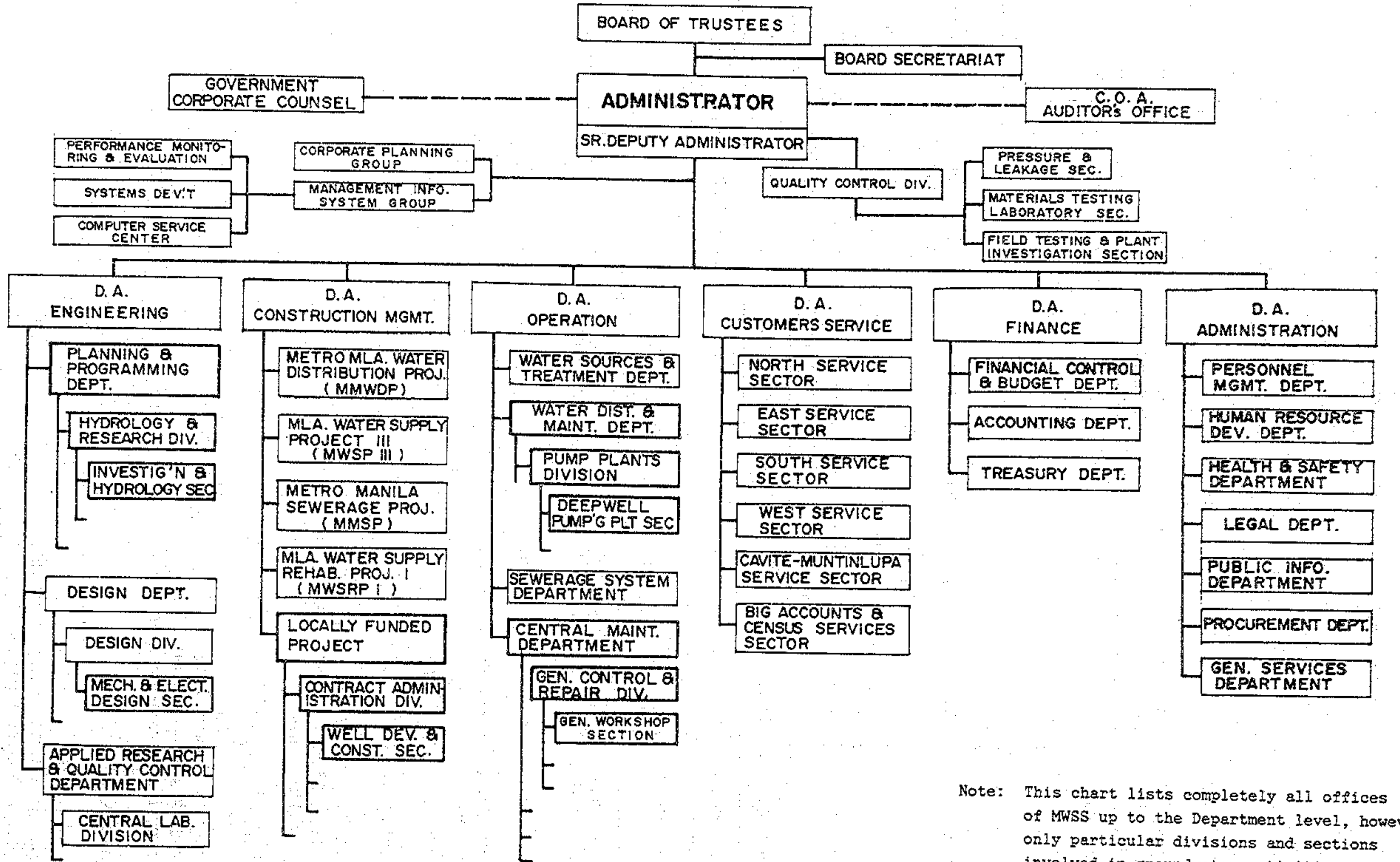
Cogeo Antipolo No.6

Fairbanks Morses Pumps
Colt Industries motor 20 Hp
16.5 pcs 3"0 riser pipes

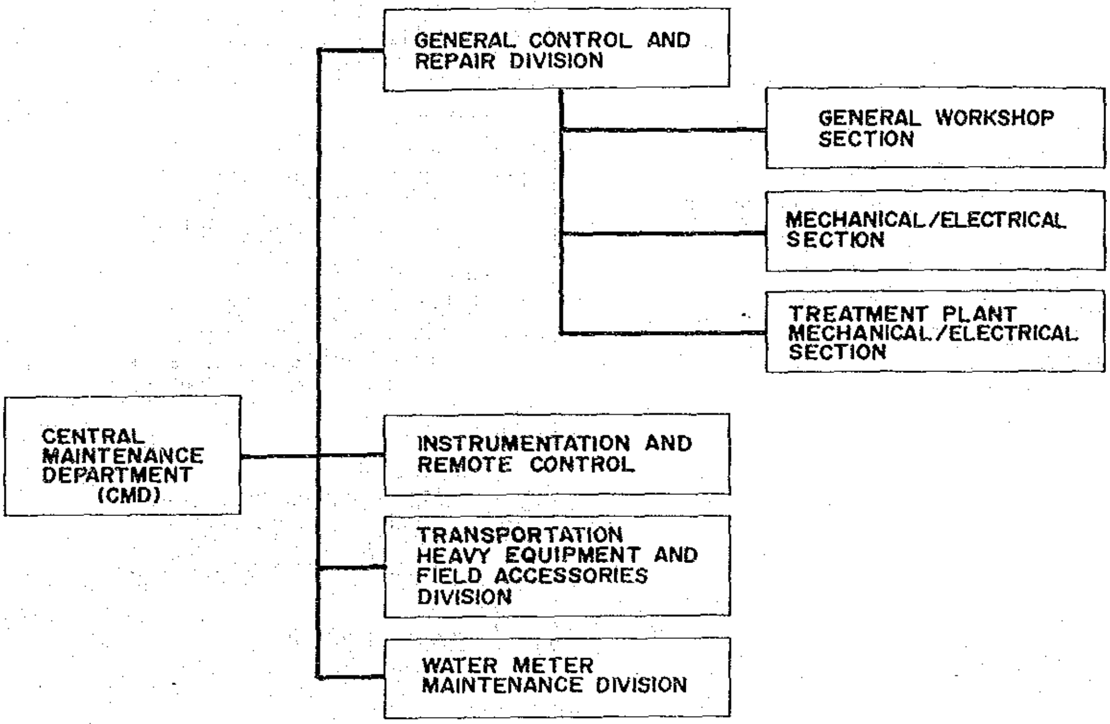
Naga Road No.2

Grundfos pump
Franklin Electric motro 30 Hp
13 pcs 4"0 riser pipes

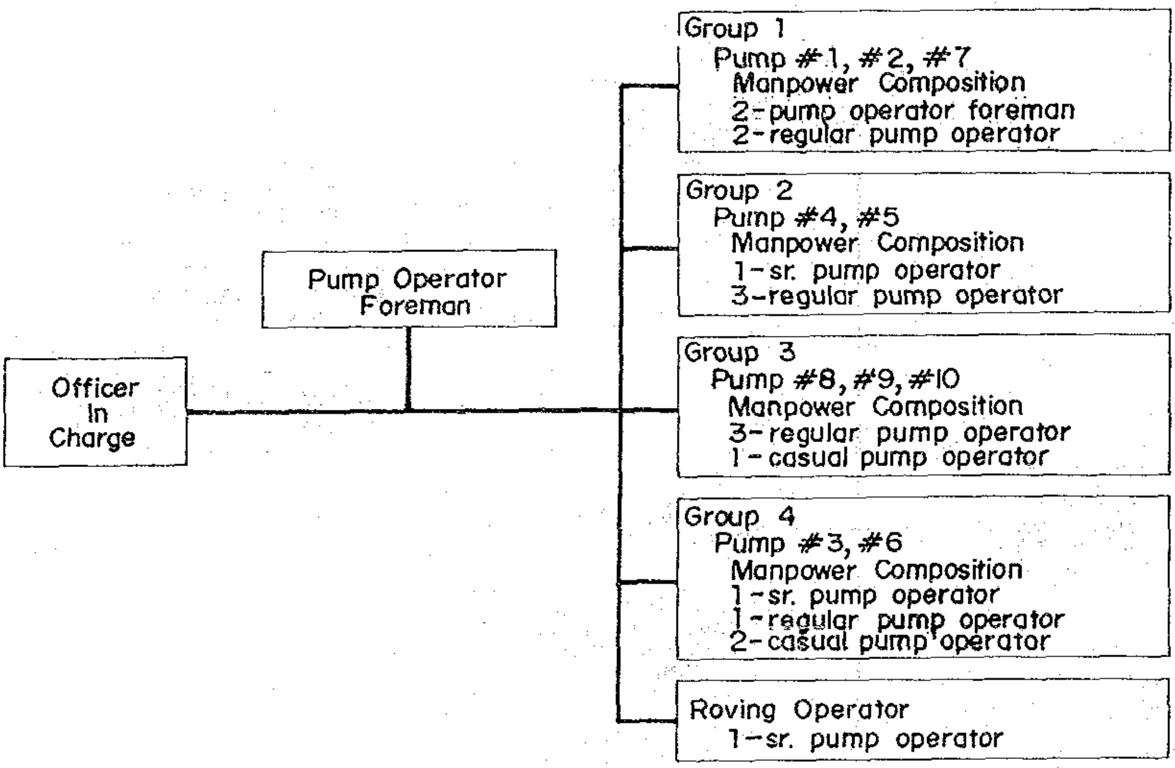
FIG. 5.1.1 MWSS ORGANIZATIONAL CHART



Note: This chart lists completely all offices of MWSS up to the Department level, however, only particular divisions and sections involved in groundwater activities are included in the chart



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 5.1.2 CENTRAL MAINTENANCE DEPARTMENT ORGANIZATION
JAPAN INTERNATIONAL COOPERATION AGENCY	



NOTE : The three (3) pump operator foremen were actually performing pump operational duties.

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

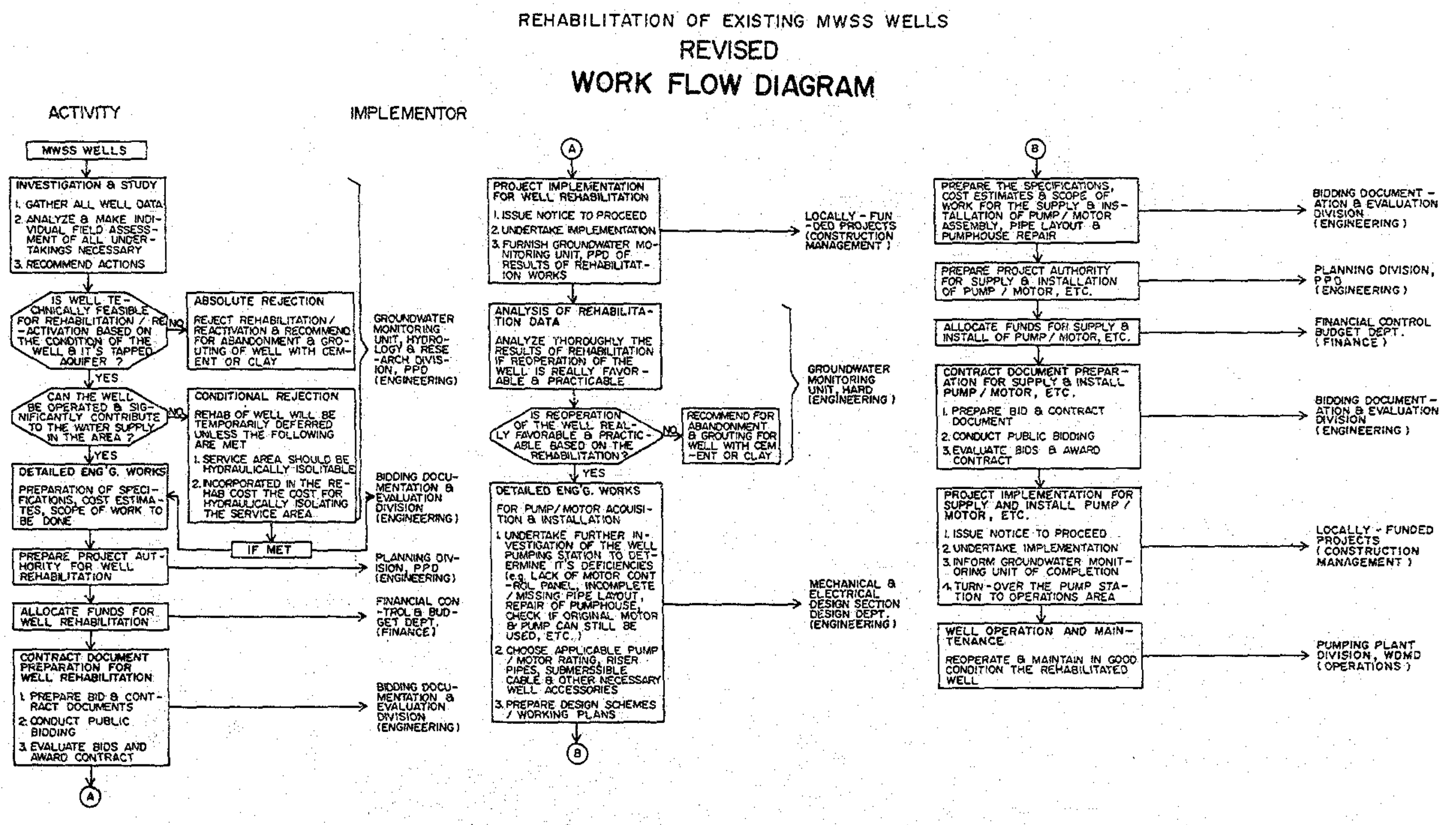
FIGURE 5.1.3

OPERATION AND MAINTENANCE ORGANIZATION FOR ANTIPOLO EXISTING WELLS

FIGURE 5.1.4 RELATIONSHIP BETWEEN MWSS OPERATORS' GROUP AND SUPERVISED WELLS

● : MWSS Existing Deep Well Pumping Stations

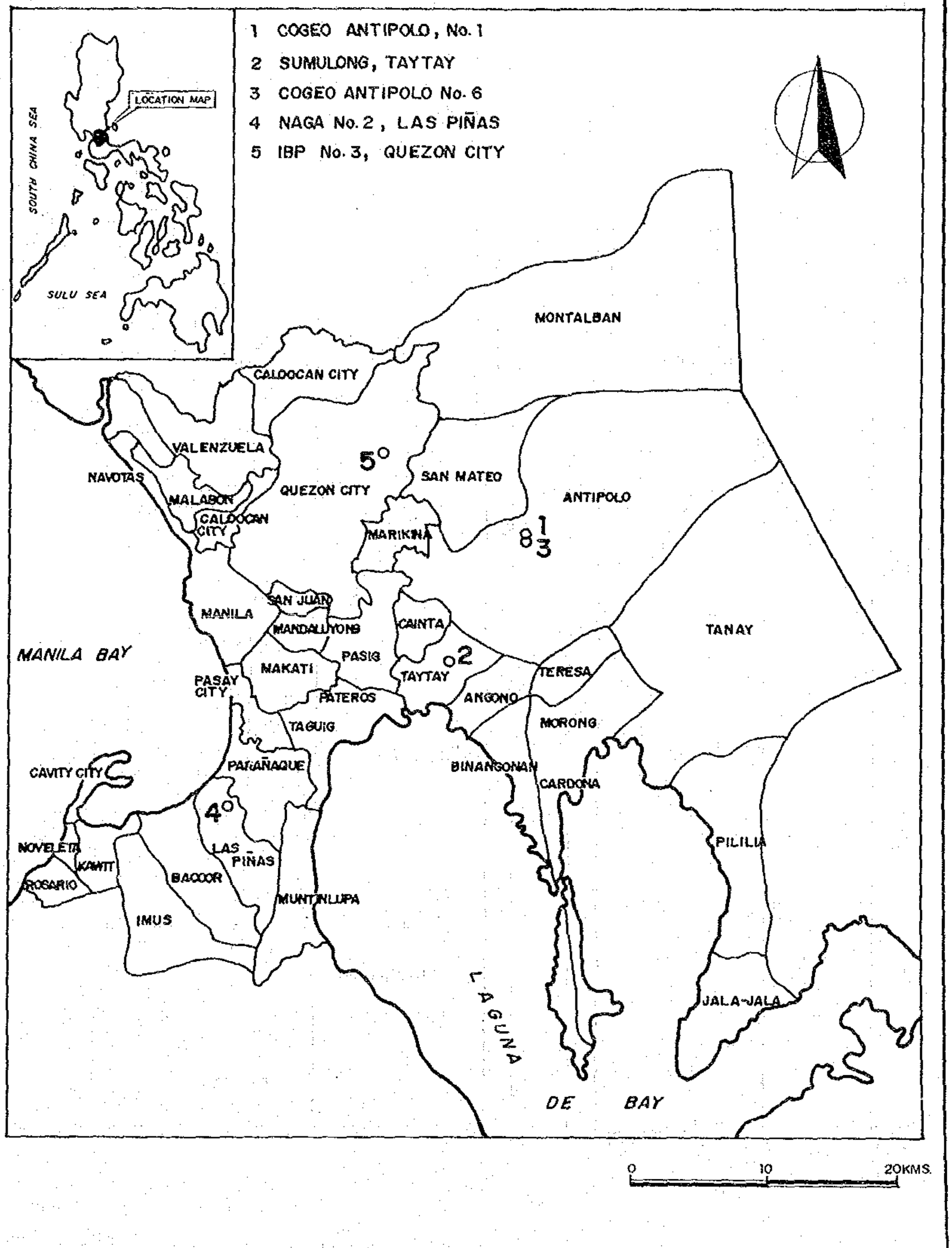
(∴) : Supervising Wells by MWSS Operators' Groups



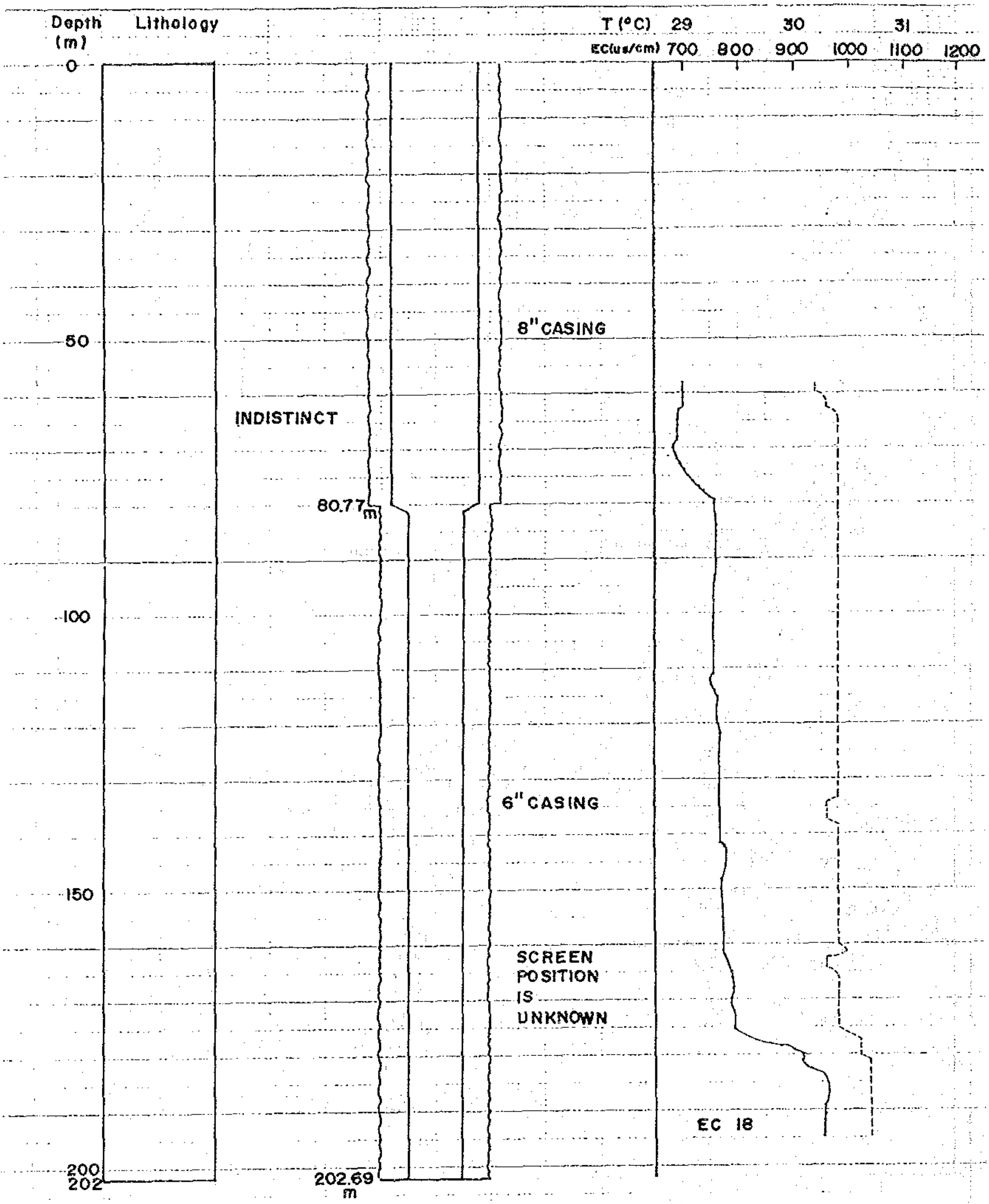
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

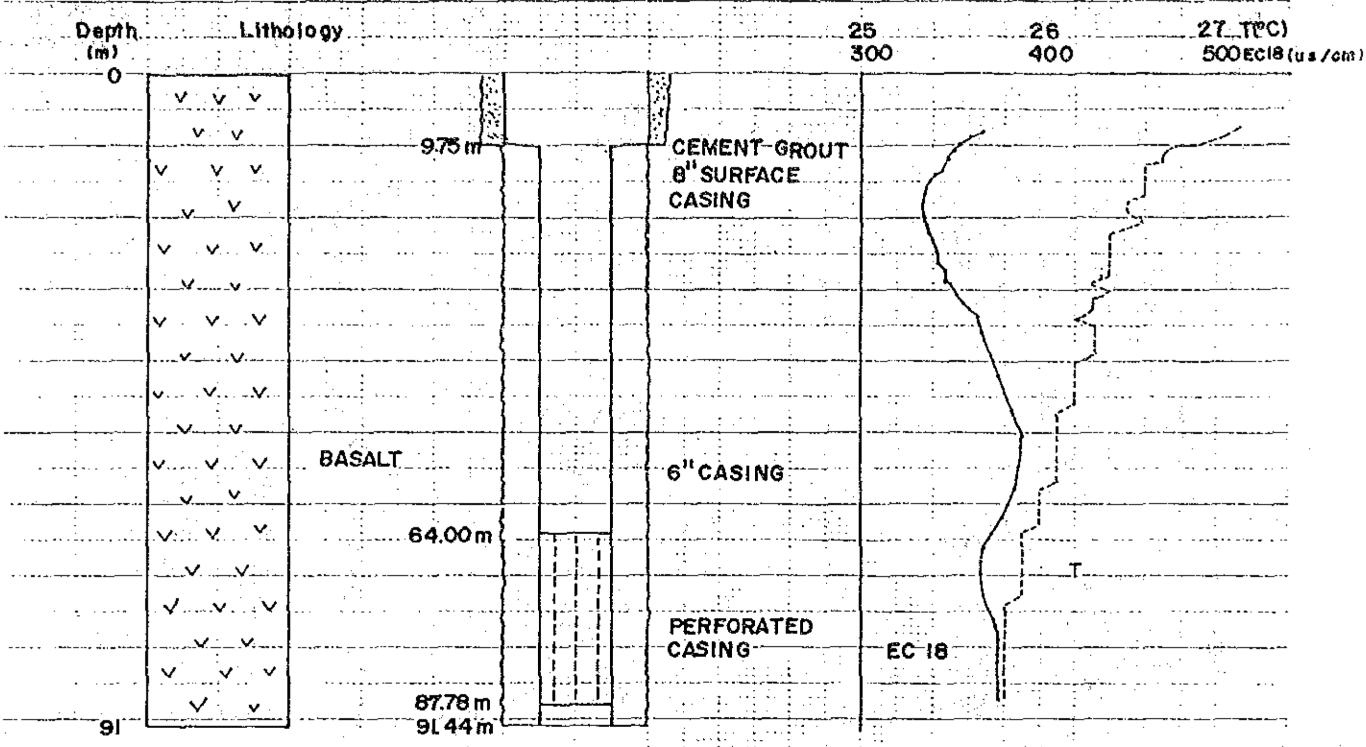
FIGURE 5.1.5
WORK FLOW DIAGRAM



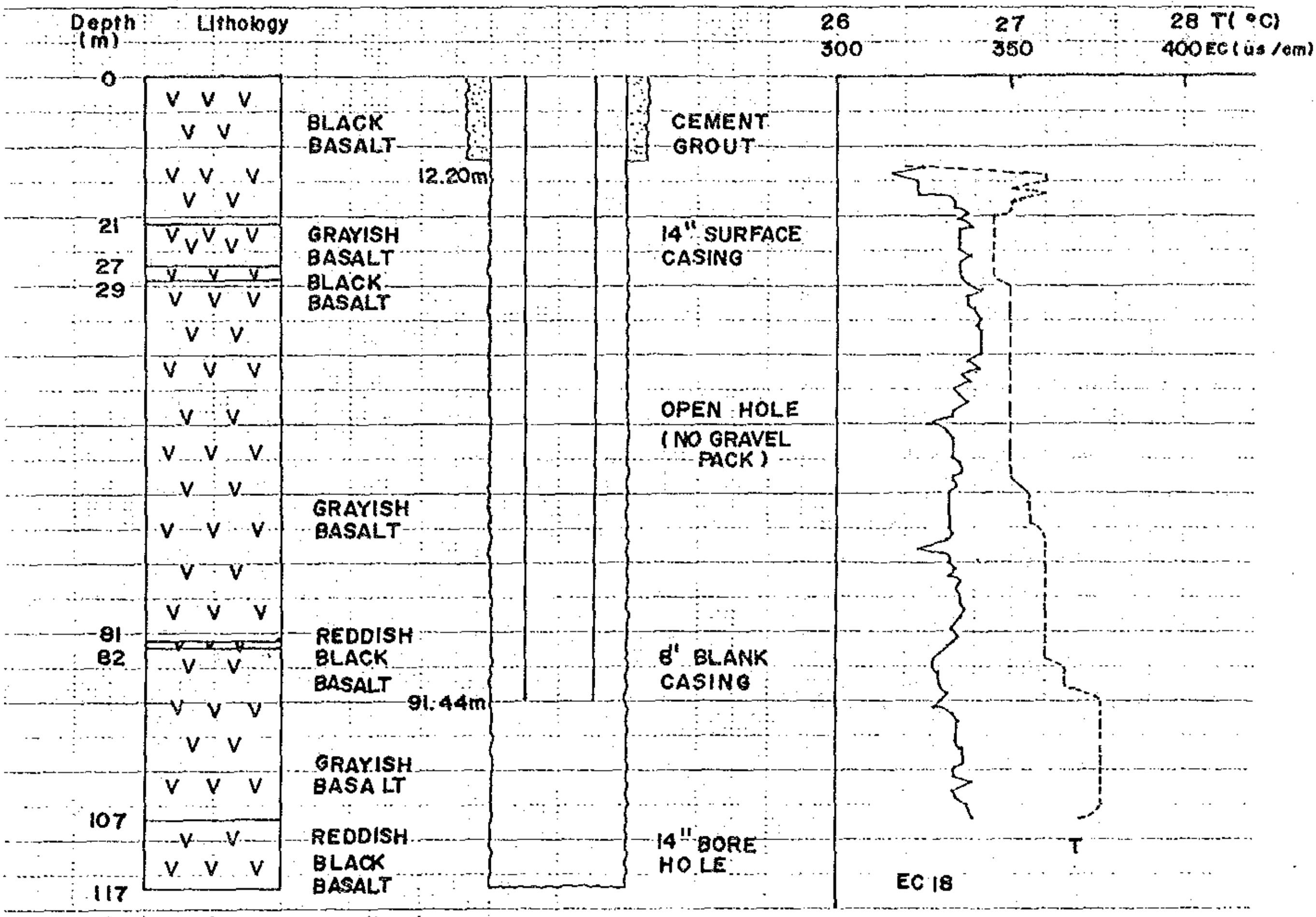
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 5.3.1 LOCATION MAP OF MWSS WELLS FOR REHABILITATION



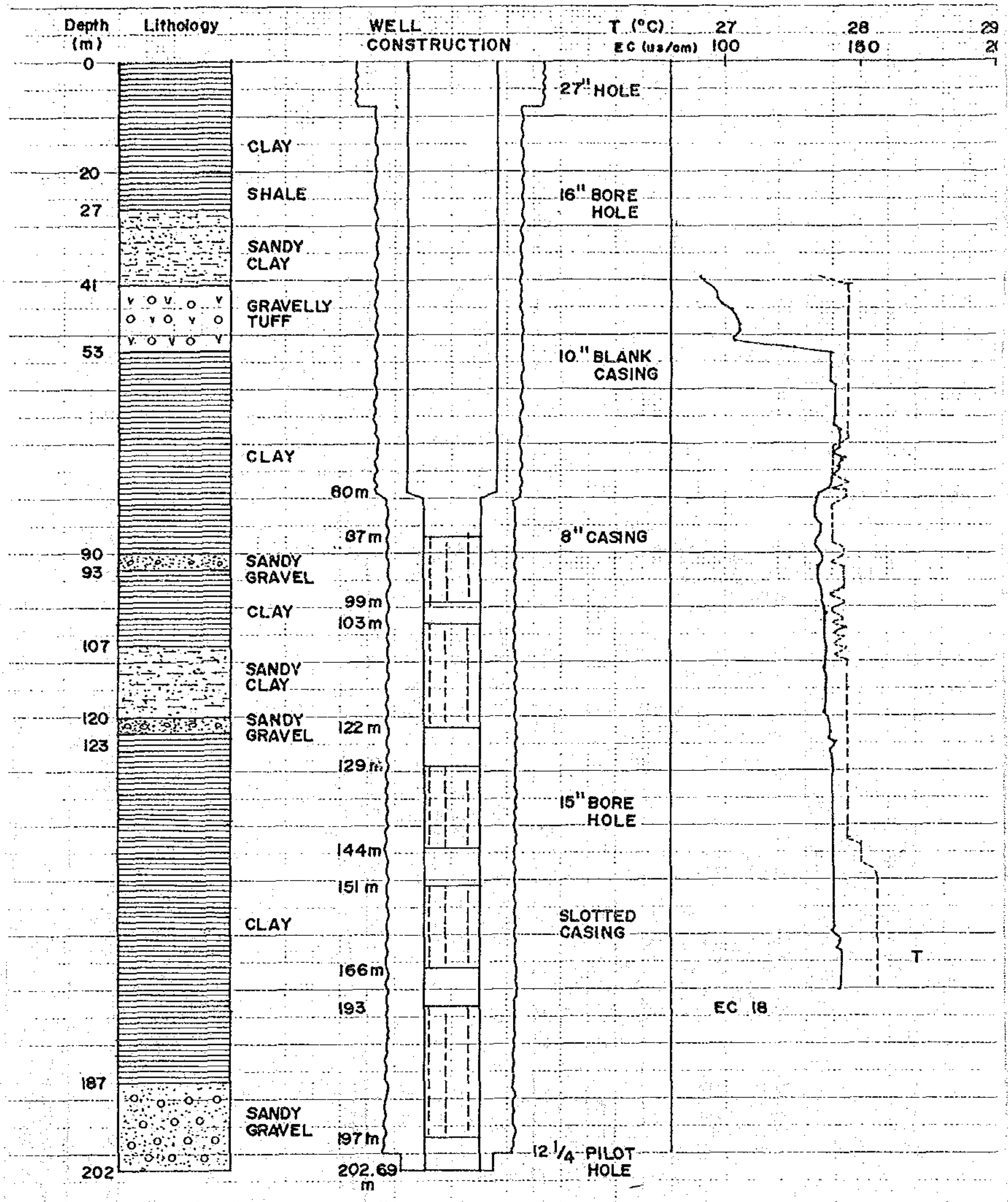
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 5.3.2 DETAILS OF MWSS WELLS FOR REHABILITATION (SUMULONG, TAYTAY)
JAPAN INTERNATIONAL COOPERATION AGENCY	



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 5.3.3
JAPAN INTERNATIONAL COOPERATION AGENCY	DETAILS OF MWSS WELLS FOR REHABILITATION (COGEO, ANTIPOLO NO. 1)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 5.3.4
JAPAN INTERNATIONAL COOPERATION AGENCY	DETAILS OF MWSS WELLS FOR REHABILITATION (COGEO, ANTIPOLO NO. 6)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 5.3.5
JAPAN INTERNATIONAL COOPERATION AGENCY	DETAILS OF MWSS WELLS FOR REHABILITATION (IBP NO. 3)

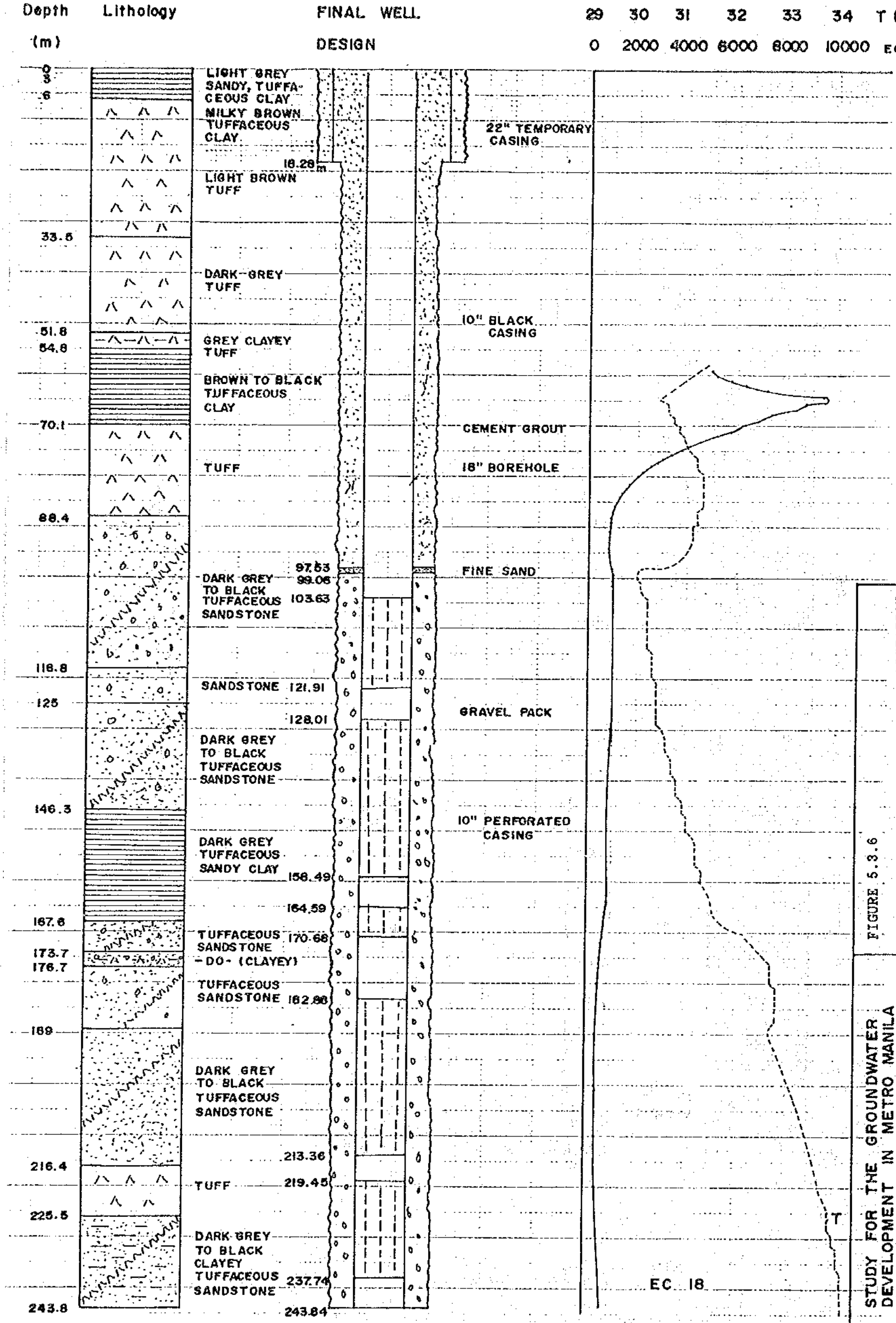


FIGURE 5.3.6 DETAILS OF MWSS WELLS FOR REHABILITATION (NAGA ROAD NO. 2)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

CHAPTER 6

URBAN DEVELOPMENT AND FUTURE WATER DEMAND

CHAPTER 6 URBAN DEVELOPMENT AND FUTURE WATER DEMAND

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6.1 URBAN DEVELOPMENT PLANNING

6.1.1 Development Framework

(1) Urban Development of the Study Area

The study for the groundwater development of the MWSS service area analyzed the data on socio-economic conditions for the insights that these may yield concerning the needs of groundwater development. As the study covers a large area and encompasses quite a number of cities and municipalities, making it feasible required setting up background information and updated data for the whole Study Area, and focusing the urban development plan on the Antipolo area (9 out of a total of 15 barangays) and some parts of its surrounding municipalities, namely, Taytay, Angono, Teresa and Binangonan, the aggregate area of which is about fifty-one (51) square kilometers.

Like most primate cities in the developing world, Metro Manila has continued to grow in a deteriorating environmental setting--urbanization accelerated with emphatic regard to economic growth with little being done to preserve or enhance the quality of the environment.

Metro Manila's rapid urbanization has led to congestion and intensification of urban activities that placed serious strains and pressures on supporting infrastructures and have rendered existing services and systems inadequate. Some of the more visible evidence of these inadequacies are decreasing water pressure, rampant illegal water and power connections, uncollected garbage, buses and jeepneys overflowing with passengers, clogged drainage networks and the proliferation of makeshift housing structures. In areas where surface water supply is not available, the unregulated pumping of groundwater has led to the depletion of aquifers and, particularly along the coast, to saline water intrusion.

This type of urbanization has also encouraged growth on the peripheries where basic infrastructure services are sorely lacking. In the lower lands where urban development is intensifying and where proper drainage facilities are virtually absent, vulnerability to flooding is heightened. And as the water table here is high, the danger of human contact with untreated wastes becomes greater.

(2) Growth of the Study Area

The geographical spread of Metro Manila, measured from the mouth of the Pasig River, has increased from an 8-kilometer radius after 1950 to some 20 kilometers in 1990.

The present trend indicates that the continuous increase of the urban area -- up to a 25 kilometer radius involving the whole Cavite area (South corridor), the Antipolo urban area (East corridor), and the urban spot locations along the Laguna coastal corridor -- may continue up to the year 2010 (Figure 6.1.1).

It is anticipated that for the Plan period (Medium Term NCR Development Plan, 1990-1994), Metro Manila shall continue to experience infilling in the main urban area. It shall undergo simultaneous outward expansion in all directions largely due to private sector-initiated development. Infilling will cause the further reduction of idle and open spaces in the core and intensification of and/or change in land use patterns. New developments are expected to proceed in a sporadic manner, and largely as opportunity responses to the free operation of market forces.

(3) Land Use Development

The social, economic and political activities in recent years effected changes in the pattern of land use which can be summarized as follows:

- increase in the number and density of blighted areas;
- the development of middle and upper class residential subdivisions on the urban periphery where land is cheaper;
- the development of townhouses and high-rise condominiums for the middle- and upper-income markets in the main urban area;
- the conversion of agricultural and fishpond areas to residen tial and/or commercial uses;
- the development of high intensity commercial activities along major transport routes;

- the emergence of intensifying suburban commercial nodes at inter sections of major transport routes in response to the need of the growing number of residential subdivisions in the suburb; and

- the location of new and relocation of existing industries at cheaper sites to the North, East and South, along major transport routes.

(4) Population

(a) Present Population Distribution

Study Area

The Study Area was estimated to have a population of about 9.4 million people in 1990. Almost 84.7 percent of this population reside in the National Capital Region.

Cavite City and the five Cavite municipalities accounted for a total of 0.46 million people, equivalent to 4.9 percent of the Study Area's population. The fourteen municipalities of Rizal have a total population of 0.98 million, equivalent to 10.4 percent of the Study Area's population (Table 6.1.1).

Antipolo Area

The 1990 Population Census (NSO) placed the total population of the Antipolo Municipality at about 207,800 or some 137,400 more than its population ten years ago (1980). Of this total, 54.2% live in urban barangay areas. Table 6.1.2 shows the total population of the Antipolo Municipality at barangay level. Annual growth rate is placed at 10.8%.

The population is mainly concentrated on 28 percent of Antipolo's area which has a total of about 30,610 hectares. Present population density is 6.8 persons per hectare.

The present density of the Antipolo Study Area is 24 persons per hectare. This figure is expected to increase to 37 persons per hectare by the year 2000 and to 50 persons per hectare by the year 2010.

Full urbanization of all barangays in Antipolo may not be feasible due to its geographic characteristics. Thus, rural-urban population distribution will not change much within the next five to ten years. However, urbanization in the middle-highland zone between the Antipolo town and the Angono-Cainta-Marcos Highway route may be change drastically within 10 to 20 years (Table 6.1.3).

Table 6.1.4 shows the population distribution, density and land area within the aquifer basin zone for years 1990, 2000 and 2010.

(b) Population Growth of the Study Area

During the period 1980-1990, the population growth rate of the Study Area reached the following rates: 2.83 percent (NCR), 3.43 (Cavite) and 5.46 (Rizal).

Based on NSO data (1980), the population growth rate from 1990 to 2010 is expected to slow down slightly to an average of 2.22 percent for NCR and 2.82 percent for Cavite. For the same period, Rizal shows a slight increase with its average annual growth of 3.59 percent. Given these growth rates, the population of Cavite and Rizal are expected to double in a span of 20 years (Table 6.1.5 and Figure 6.1.2).

(c) Population Projections up to Year 2010

Total population is a determinant of total water demand. The estimate of future populations in this Study used the official population data of the National Statistics Office.

The population projections for the Study Area were based on the results of the 1980 and 1990 Census of Population and Housing (NSO), using three alternative forecasts, namely, high, medium and low. These forecasts are differentiated by the assumptions taken at the time the country attains replacement level fertility.

The projections for cities and municipalities inside the Study Area for selected years are given in Table 6.1.6 (Study Area) and Table 6.1.7 (Municipality of Antipolo at barangay level).

Figure 6.1.3 shows the comparison between the population projections made by AWSOP (Angat Water Supply Optimization Project, 1988) and the JICA Study Team for the municipality of Antipolo.

Using the same method adopted by the NSO, it may be noted that both projected population growth trends were not quite far from each other.

The variance between the two projections occurred because AWSOP's projection was based on the 1980 National Statistics Office's (NSO's) census data, which at that time was the only one available, while the Study Team's projection was based on the 1980 and the updated 1990 NSO census data. Figure 6.1.3 shows the projected population by ASWOP for the year 1990 to be half the actual 1990 NSO data.

In 1985, the National Housing Authority estimated 2.3 million people to be living in blighted areas in the NCR. This population grew to an estimated 2.8 million in 1990, or approximately one-third of the total population. This estimate included those who have benefited from the urban land reform and housing programs under the National Shelter Program.

Figure 6.1.4 shows the approximate locations of blighted areas in the NCR.

The distribution of blighted population by city/municipality and the percentage of blighted population in each municipality in 1982, 1985, and 1990 are shown in Table 6.1.8. The percentage of blighted population is notably high in Pasay City, Quezon City and Navotas.

There was no data on blighted population in other MWSS service areas outside of the NCR. It is assumed that there are few blighted areas in the Cavite and Rizal provinces.

Assuming that the high in-migration rate is checked, the blighted population is projected to grow at such rate that its proportion to total population in each municipality remains constant. The projections for the general blighted populations are given in Table 6.1.9.

(5) Economic Growth

As economic growth fosters a proportionate increase in water demand, in the same manner is per capita domestic demand for water affected. Industrial and commercial demand area also expected to increase in proportion to the growth of their respective gross domestic products.

The MWSS CORPLAN computed growth rates from special releases of the NSO on data and projections on family income. As shown in Table 6.1.10 per capita income is projected to grow in 1991 and to decrease drastically in 1992. Minimal growth is projected for the period 1994 to 2010.

Economic growth in the industrial and commercial sectors are measured in terms of the growth of their respective gross domestic products (GDP). Data on GDP for both industrial and commercial sectors in the NCR for previous years, as well as projections up to year 1992, were obtained from NEDA. The gross domestic product of the services sector was used to estimate commercial growth. The output of the industrial and commercial sectors decreased in the period 1983 to 1986. However, these sectors are projected to post positive growths from 1987 to 2010.

There were no data on industrial and commercial growths for other areas outside of NCR.

The computed growth rates are shown in Table 6.1.11 and Figure 6.1.5.

6.1.2 Urban Development Plan

(1) Basic Structure Plan

A basic structure plan attempts to integrate and relate the various plans on what and how Metropolitan Manila and the contiguous provinces of Rizal and Cavite should be (Figure 6.1.6).

The transition area between the inner urban core and outlying area of Metropolitan Manila is seen to provide enough room for expansion while retaining a medium intensity of development. It shall have a balanced distribution of population densities, encouraging concentration of activities at selected centers, and along lines of accessibility.

The areas outside the Metropolitan complex are expected to absorb a considerable amount of urban growth. The emphasis is seen, however, on urban concentration at selected centers of activity along major transport routes, projecting a linear-cellular pattern.

The dominant influence of transportation on urban growth should be utilized to bring about desired densities of development. It is envisioned that the planned development for the outer areas shall achieve maximum benefits.

(2) **Study Area Planning**

To sum up the present situation, haphazard and sub-standard development in the metropolitan area is going on at a rapid rate. There is great disparity in residential density in the various cities/municipalities, ranging from 715 persons/hectare to as low as 49 persons/hectare.

(a) **Antipolo Area Development Plan**

Development and Growth of Antipolo

Development plans for the Antipolo area are centered on upgrading and enhancing its overall socio-economic conditions. Priorities include the increase of food production and farm income, construction of infrastructure facilities supportive of social and economic development, maintenance of existing watershed areas and other forest lands, development of potential tourist attractions, and establishments of labor-intensive, small-scale rural enterprises which will create employment opportunities. The provision of adequate basic facilities for health, education, housing and protective services is also given attention.

The locational importance of the town of Antipolo would depend largely on the direction of expansion and development of Metro Manila in the years to come. Antipolo is endowed with natural resources and a favorable climate. These advantages, however, could be overshadowed by certain factors, which could also work against the development of the town. Among these unfavorable factors are: poor infrastructure, continuous pollution of rivers and creeks, and fast-rising values of real estate.

Full urbanization in the municipality of Antipolo may not be feasible due to geographic characteristics. In the coming years however, urbanization in the East corridor may drastically change the Antipolo town and surrounding municipalities of Taytay and Angono.

Antipolo Study Area

The Antipolo Study Area, previously identified as made up of an Antipolo area plus its urbanizable peripheral areas and parts of the municipalities of Taytay, Angono, Binangonan and Teresa, has an area of about 51 square kilometers (Table 6.1.3).

This Study Area is envisioned to absorb a considerable amount of urban growth because of its strategic location, i.e., its being contiguous to Metro Manila, and also, its relatively cheaper land values, its rapid transformation of forest/grassland and agricultural land to other land uses. The growth focus is on intensive residential development and urban concentrations along major transport routes, projecting a linear-cellular pattern.

Land Use Projection

The future land use projection for the Antipolo area will attempt to prefigure this area's physical development within the next twenty years.

The factors for consideration are: a) the goals and objectives of the sectoral components of the development plan; b) land capability of sub-areas; and c) growing trend of the area.

The high slopes and rugged terrains are constraints for Antipolo's expansion of its urban area, thus limiting its urbanization. However, such constraints can be of positive use to a development perspective that is directed towards the promotion of tourism and preservation of agro-forestry.

The present subdivision development is more than sufficient for the Antipolo area's expected expansion within the next five years. However, according to the present and anticipated growth of Metro Manila, the area is expected to be the main means of absorbing future population growth requiring new subdivision to be developed.

The eastern fringe of the study area in the next 10 to 20 years will not change drastically. However, urbanization in the western fringe covered by the Antipolo town and parts of Taytay and Angono may be changed drastically in the coming 20 years.

The immigration of urban population is the basis for the future expansion of Antipolo. Antipolo's population of 207,842 in 1990 would become 435,886 by the year 2010 (Table 6.1.7). The population in the Antipolo study area will increase from 123,347 in 1990 to 255,831 by the year 2010 (Table 6.1.3).

By the year 2010, some 822 hectares will be added to the built-up area, especially along the western fringe of the Antipolo study area. This increase would come from the presently (Year 1990) open/unoccupied area, from grassland and agricultural areas, and from the "others" land category (Figure 6.1.8).

By 2010, Antipolo area is also projected to have expanded outside its current boundaries, with the planned industrial estate some 10 km. east of the Antipolo town.

Figure 6.1.7 shows the land use projection. The future built-up area of 722 hectares in 1990 will increase to 1,544 hectares by 2010 (Table 6.1.12 and 6.1.13).

Figure 6.1.8 shows a land-use comparison of the Antipolo area between 1991 and 2010.

6.1.3 Conclusions

(1) Land Use Plan

The land use plan is general (Figure 6.1.9) though it can be amended according to authorized decision from time to time. The land use plan shall be regulated under zoning regulations which may be dictated by the authorized regional or municipal agency. Such regulations should be strictly enforced in regard to each kind of development and any proposal shall be subjected to the stipulations.

Space standards for community facilities and services and all future land use shall be governed by zonal plans under the Master Plan.

Urban Consolidation Zone

This zone constitutes the main built-up area. It is a densely populated urban area where implementation of the plan is immediately needed to avoid water shortage, pollution and unhealthy environment created by mixed and uncontrolled land use. There should be:

- No more expansion
- No new heavy industries
- Rehabilitation of blighted areas
- Upgrading of urban service
- Land use planning and update zoning ordinance
- Closure of open dump sites

The improvement/rehabilitation/maintenance of natural drainage courses and existing facilities particularly water supply, flood control/drainage and sewerage networks should be given priority so as to prevent further deterioration of the urban ecosystem.

Complementary Urban Satellites

The metropolitan concern may be mitigated through the development of growth centers outside the metropolis which will act as complementary urban satellites of the National Capital Region.

(2) Residential and Open Areas

New settlement areas have to be outside of the NCR in view of development of the east (Rizal) and south (Cavite) corridors.

In response to the annual increase of population pressure from Metro Manila, the population in the contiguous provinces will also increase. New settlement areas have been proposed in different parts of Rizal and

Cavite in order to develop the town in a planned way, controlling the haphazard urban sprawl.

Open areas are needed to provide recreational and community facilities, parks, etc.

(3) Industry and Tourism

It is necessary to create new jobs to ease the problem of unemployment. For that purpose, industries like handicrafts and cottage industries, which do not pollute the environment and will not stand as obstacles to residential planning, are to be established.

The appropriate land for industries may be located at the south of Imus and Bacoor in Cavite and at the east of Antipolo and Tanay in Rizal.

Two industrial estates are proposed in San Mateo and Antipolo (Pinugay). Other industries are to be spread over different places of the study area.

If the siting of different industries are allowed only in the places shown in the land use plan, there will be substantial savings in expenditure for development of infrastructure, unlike the current process which have industries located arbitrarily due to the lack of coordination between authorized agencies and individuals.

It will take more time to put up large-scale industries in the eastern part of Antipolo because the transportation cost is high in this mountainous area of Rizal unlike that in the Cavite area.

It would, however, be unwise to locate large and heavy industries in Antipolo area, as these would pose problems on air pollution, waste disposal, traffic congestion, among others. Moreover, the area does not have enough water supply to sustain large scale industries.

There is an ample scope to develop the tourist industry in the Antipolo area. Properly developed, the tourist industry can increase revenues and employment opportunities.

(4) Agro-Industry/Farming and Regional Open Space

The success of the agro-industrial thrusts of the provinces of Rizal and Cavite, is seen as the key to the gradual deceleration of urbanization in Metro Manila and its eventual decongestion.

(5) Flooding Area

Lower areas are not suitable for residential use, industry, etc.

(6) Preservation Areas

The relatively underdeveloped northern Marikina valley has the potential for further development, and it can meet (for many years) the projected future demands. It is to be considered as a preservation area.

Creation of a green belt and construction of dike protection around the coastal lake against erosion and flooding in the lower zones are needed.

(7) Zoning Regulations

It is necessary to formulate zoning ordinances to manage the trend of urbanization. Zoning protects residential areas from the harmful intrusions of commercial and industrial uses while simultaneously promoting business and industry as a result of the planned and orderly development that it ensures. It prevents overcrowding in buildings and land, thus, facilitating the provision and continued adequacy of water, sewerage, transportation and other facilities.