CHAPTER 8 GROUNDWATER DEVELOPMENT PLAN

8.1 REHABILITATION PLAN OF MWSS WELLS

According to the water supply plan of MWSS, the municipalities of Antipolo, Montalban, San Mateo, Muntinlupa, Cavite, Imus, Kawit and Rosario shall depend on groundwater supply up to 1995 or 2000. Other municipalities shall also have to rely on groundwater until the surface water supply system shall have been completed. It is therefore necessary to augment the groundwater supply capacity by the rehabilitation of existing MWSS wells.

Most of MWSS wells are superannuated in the pumping unit. Those presently active could possibly be damaged in the near future. The plan aims to rehabilitate 100 active and inactive MWSS wells. Technical specifications and a manual for the work shall also be prepared as part of this plan.

The number of target wells are as follows.

1) Operated at present : 73
2) Defective pumping unit : 18
3) Standby : 9

It is expected that the pumping rate of active wells shall be increased at an average of 207 CMD per well. The increase of pumpage due to the rehabilitation of damaged and standby wells is assumed at 690 CMD per well. Thus, the combined total pumpage increment for 100 rehabilitated wells is expected to be around 27,500 CMD.

The total project cost for the rehabilitation of 100 wells is about 53 million pesos. While the average cost of water per unit volume of a newly constructed well is 0.81 peso, it is 0.69 peso for rehabilitated well. The project is thus beneficial from the economic viewpoint. Project implementation requires 16 months (Figure 8.1.1).

8.2 GROUNDWATER DEVELOPMENT PLAN IN ANTIPOLO

A new groundwater development plan in Antipolo is proposed based on the anticipated growth of population and the consideration that the Antipolo area shall solely rely on groundwater sources until after the extension of CDS shall have been completed.

As estimated through computer simulations, the optimal pumpage of the Antipolo groundwater basin is about 28,000 CMD. Since existing deep wells presently abstract groundwater at about 19,500 CMD, the exploitable volume of groundwater amounts to a maximum of about 8,000-8,500 CMD. After rehabilitation, the increase in water volume is expected to be about 2,000 CMD. Therefore the increase in pumpage as a result of the contribution of the newly constructed wells is about 6,000 CMD. The total pumpage of the Antipolo groundwater basin should be able to meet the water demand in the area until 1998.

As part of the groundwater development plan, a standard design for the seven new wells was made. This standard well is 8 inches in diameter and 150 m in depth. It also has a wire wound screen. Total pumpage of these new wells is 5,810 CMD. The wells are distributed at the central part of the groundwater basin, with the distribution duly considering the thickness of the aquifer (Figures 8.2.1 and 8.2.2).

The project cost of the groundwater development is estimated at 48.3 million pesos including the expenditures for 6 elevated water tanks(Figure 8.2.3), land aquisition and engineering cost. Sixteen months are required for the project implementation.

8.3 SURFACE WATER SUPPLY PLAN IN ANTIPOLO

It is anticipated that groundwater sources cannot meet the water demand after 1999. Therefore, a plan of augmentation of water supply from the CDS is proposed. The plan calls for the conveyance of surface water to the Antipolo area through extension of the transmission line that will be constructed in AWSOP. The transmission route is proposed to be laid from Pasig to Antipolo town passing by the side of Cogeo Village along the Marcos and Sumulong Highways. Since the area is located in the

Antipolo Plateau, which is more than 200m in elevation, two (2) booster pumping stations and two (2) distribution reservoirs shall be constructed (Figures 8.3.1 to 8.3.5). Two (2) mini-booster pumping stations will be provided for distribution to high-elevated area.

The project implementation period has two phases. Phase 1 shall transmit water at an average of 1,800 CMD and a maximum of 15,500 CMD. Phase 2 shall transmit an average of 18,100 CMD and a maximum of 40,900 CMD. The cost of the project is estimated to be 406 million pesos for phase 1 and 455 million pesos for phase 2 (Tables 8.3.1 and 8.3.2). Considering that two years and six months shall be needed for planning and design and four years for construction, the project must commence in 1994 (Figure 8.3.6).

8.4 Project Evaluation

From the financial and the economic viewpoints, the phase 1 project was evaluated. The phase 1 project involves rehabilitation of existing wells, construction of new wells, and construction of surface water supply system.

Financial Analysis

The major potential sources of funds for the proposed project are the operating and the non-operating sources. Operating sources are the excess of revenue over expenses. Non-operating sources include loans, government equity, and grants. It is assumed that the loans will come from the Asian Development Bank (ADB) with a rate of interest at 6.36% per annum. The contribution of the Philippine government to equity is also assumed to be not more than 30 % of the total project cost.

The total project cost is P802.97 million, the breakdown of which is shown in Table 8.4.1. The breakdown of foreign and local cost is also presented in Table 8.4.1.

The project's revenues will be generated from water sales. Estimation of water sales is based on demand for water (or Billed Water). Only augmented water, however, is accounted for in the projection of revenues.

The computed financial internal rate of return (FIRR) for the 30-year project life used for analysis is 4.46% as presented in Table 8.4.2. Though this value is rather small, it is higher than the 3.47% of the Weighted Average Cost of Capital (WACC).

As reference, the financial feasibility of a part of the proposed project, the rehabilitation and new well construction, i.e., the groundwater development portion, was verified (Tables 8.4.3 and 8.4.4). Eighty percent (80%) of initially proposed cost for the distribution system was also included in this case for the reduction of leakage and distribution of increased water. In this case, FIRR was indicated at 11.43% and estimated WACC was 3.46%.

Economic Analysis

In the economic benefits of the projects were measured in terms of:

a) Economic Value of Water - Satisfaction of consumer
b) Health Benefit - Decrease of water-borne diseases
c) Fire Protection - Installation of more fire hydrants and increased water pressure
d) Land Value Increase - Increase of productivity

The shadow pricing system was devised for items that are not economically valued by the purely financial price mechanism. Thus, it was assumed that the true cost of foreign exchange will be increased by 20%. Likewise, unskilled labor costs was reduced by 50%. Skilled labor was valued at its going rate. The economic project cost is P491.02 million.

The total economic cost is expressed as the adjusted project cost plus replacement cost plus operating and maintenance cost. The present value of the total economic cost is P1,449.74 million for 30-year project life.

Since the EIRR of 17.19% exceeds the desirable opportunity cost of capital of 15%, the project is considered economically feasible (Table 8.4.5).

As reference, the economic feasibility of the groundwater development portion was also verified as presented in Table 8.4.6. In this case, EIRR was computed at 17.20% due to insufficient augmentation of water to meet demand--assuming a slower increase of land value than that possible under full-scale project implementation.

TABLE 8.3.1 PROJECT COST FOR PHASE 1

(in Thousand Pesos)

Construction Cost			
1. Transmission Pipeline			58,343
2. Booster Pumping Station No.1			
	Civil & Arch. Work	8,227	
	Mechanical Work	14,976	
	Electrical Work	19,020	
	Sub Total		42,223
3. Booster Pumping Station No.2			
	Civil & Arch. Work	7,249	
	Mechanical Work	19,104	
	Electrical Work	22,848	
	Sub Total		49,201
4. Communication Wiring (for telecontrol system)			5,383
5. Distribution Reservoir			
	Civil & Arch. Work	11,412	
	Mechanical Work	2,896	
	Sub Total		14,308
6. Distribution System			
	Distribution Main	65,355	
	Inner Network	23,761	
	Fire Hydrant	3,461	
	Service Connection	58,570	
	Sub Total		151,147
Construction Cost Total			320,605
Engineering Cost	(D/D 8%, C/S 4%)		38,473
Land Acquisition	(B.P.S. 1 & 2, Reservoir)		9,585
Total			368,663
Physical Contingency	10%		36,866
GRAND TOTAL			405,529

TABLE 8.3.2 PROJECT COST FOR PHASE 2

(in Thousand Pesos)

Construction Cost			
1. Transmission Pipeline			95,862
2. Booster Pumping Station No.1			
	Civil and Arch. Work	7,652	
	Mechanical Work	14,492	
	Electrical Work	19,020	
	Sub Total		41,164
3. Booster Pumping Station No.2			
	Civil and Arch. Work	6,583	
	Mechanical Work	18,620	
	Electrical Work	22,848	
	Sub Total		48,051
4. Distribution Reservoir No.1			
	Civil and Arch. Work	11,412	
	Mechanical Work	3,795	
	Sub Total		15,207
5. Distribution Reservoir No.2			
	Civil and Arch. Work	3,494	
	Mechanical Work	1,168	
	Sub Total		4,662
6. Booster Pumping Station No.3			
	Pump House	826	
	Mech. and Elec. Work	273	
	Sub Total		1,099
7. Booster Pumping Station No.4			
	Pump House	560	
	Mech. and Elec. Work	190	
	Sub Total		750
8. Distribution System			
	Distribution Main	88,168	
	Inner Network	25,603	
	Fire Hydrant	2,005	
	Service Connection	45,192	
	Sub Total		160,968
Construction Cost Total			367,763
Engineering Cost	(D/D 8%, C/S 4%)		44,132
Land Acquisition	(Reservoir 1 & 2)		1,760
Total			413,655
Physical Contingency	10%		41,365
GRAND TOTAL			455,020

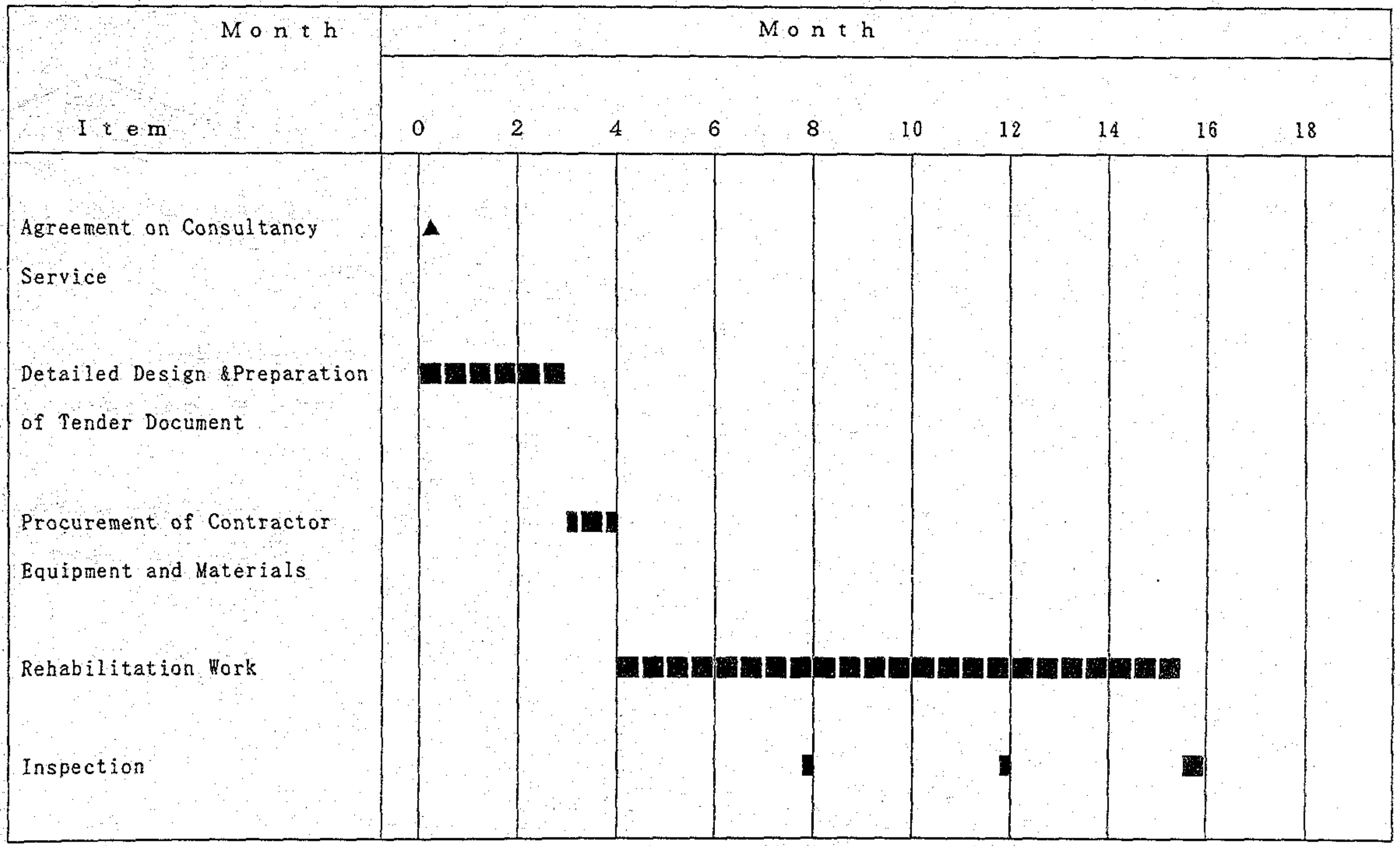


FIGURE 8.1.1 REHABILITATION SCHEDULE

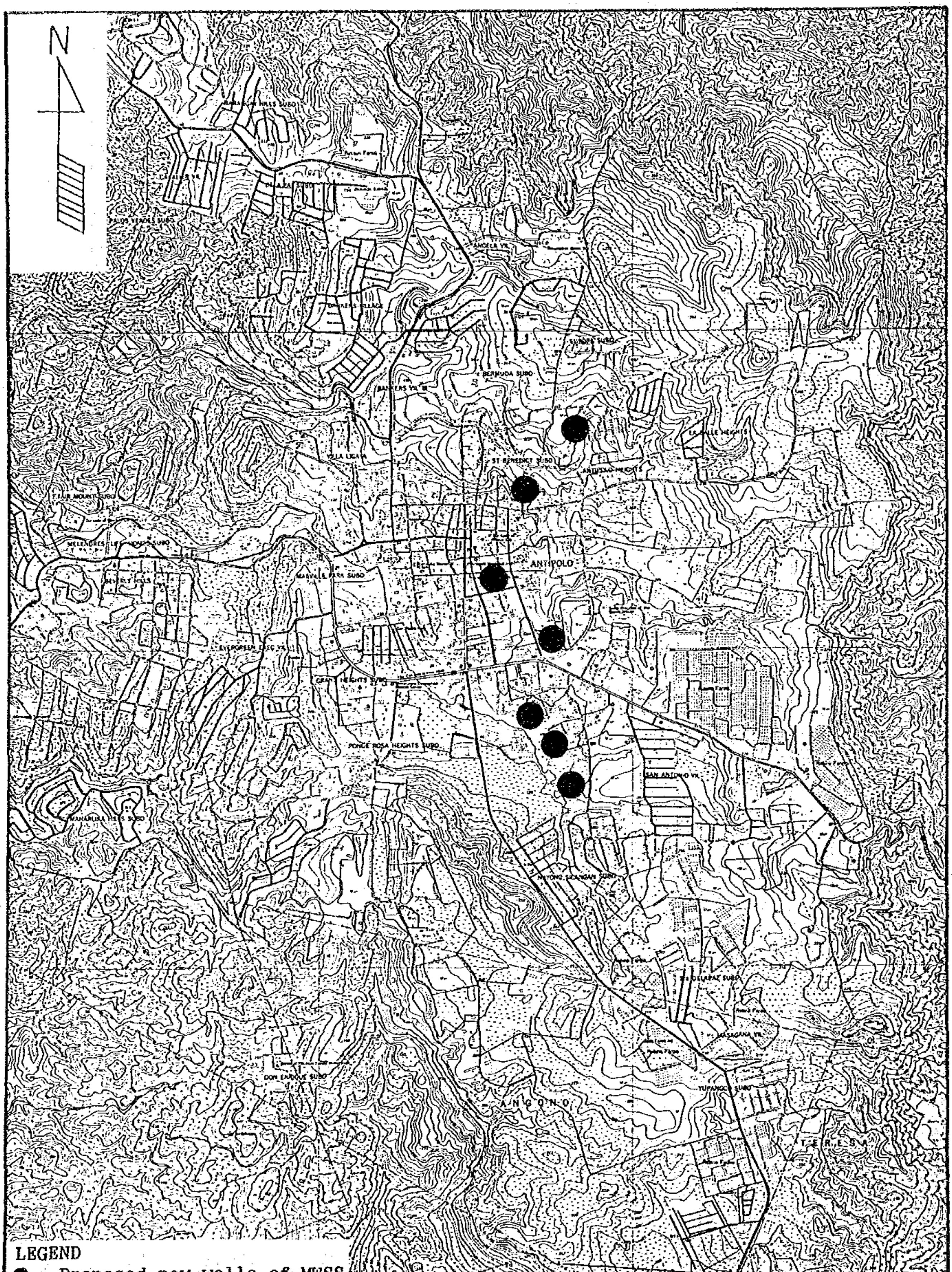
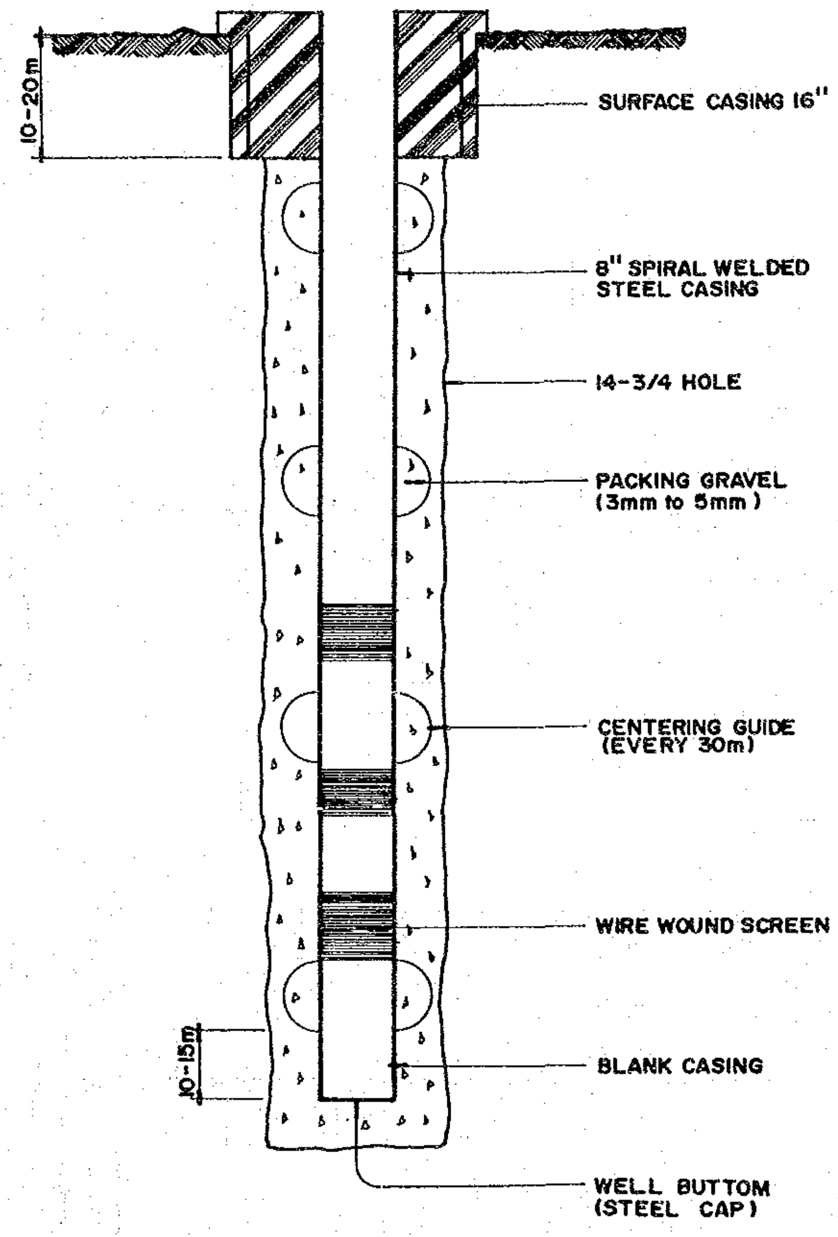
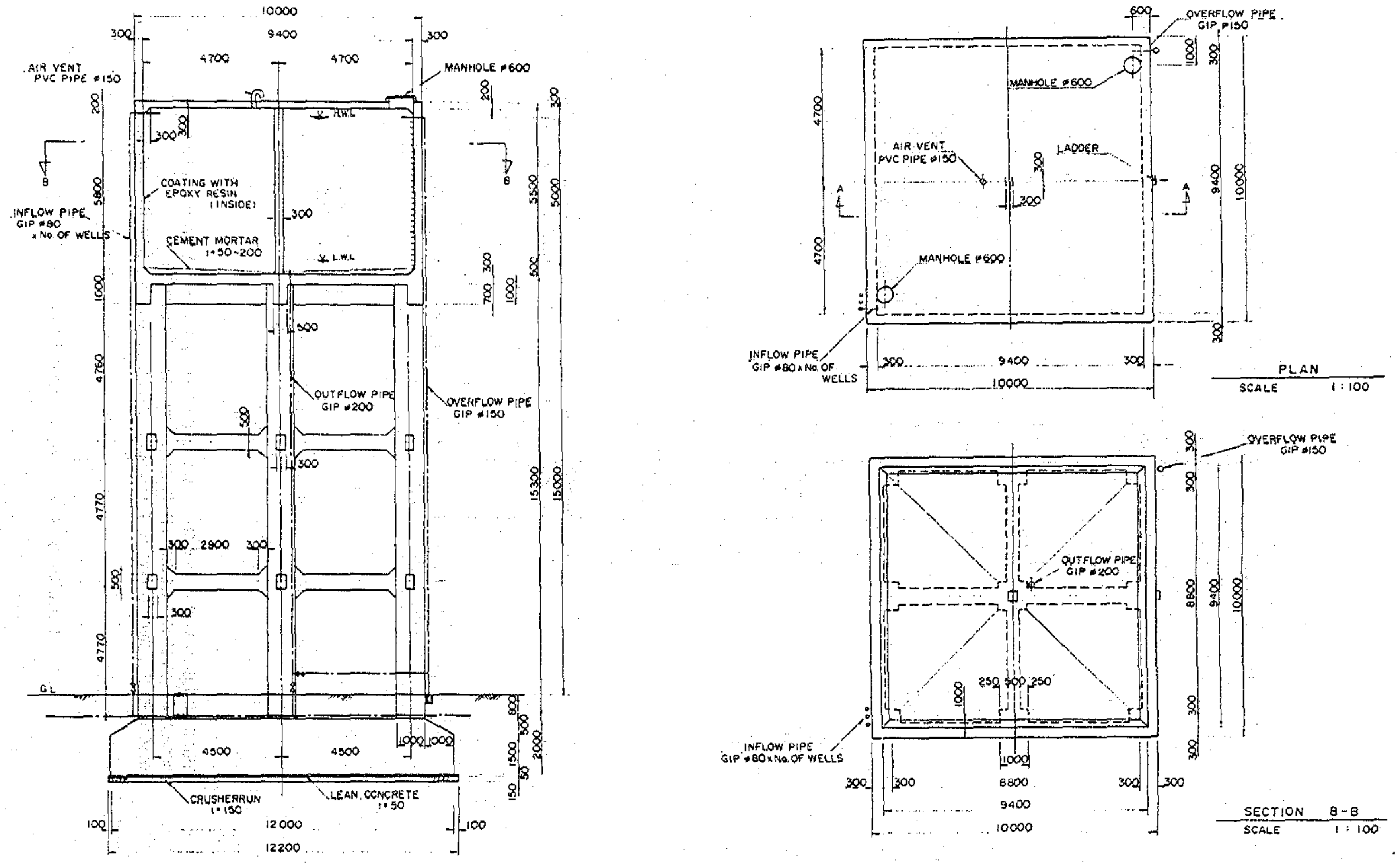


FIGURE 8.2.1 LOCATION MAP OF PLANNED NEW WELLS



RECOMMENDED WELL DEPTH: THICKNESS OF AQUIFER LAYER + 120m
SCREEN LENGTH: LESS THAN 20% OF WELL DEPTH
DISCHARGE - DRAWDOWN RELATIONSHIP/WELL: 800m / DAY IN DRAWNDOWN OF 21m

FIGURE 8.2.2 STANDARD WELL DESIGN

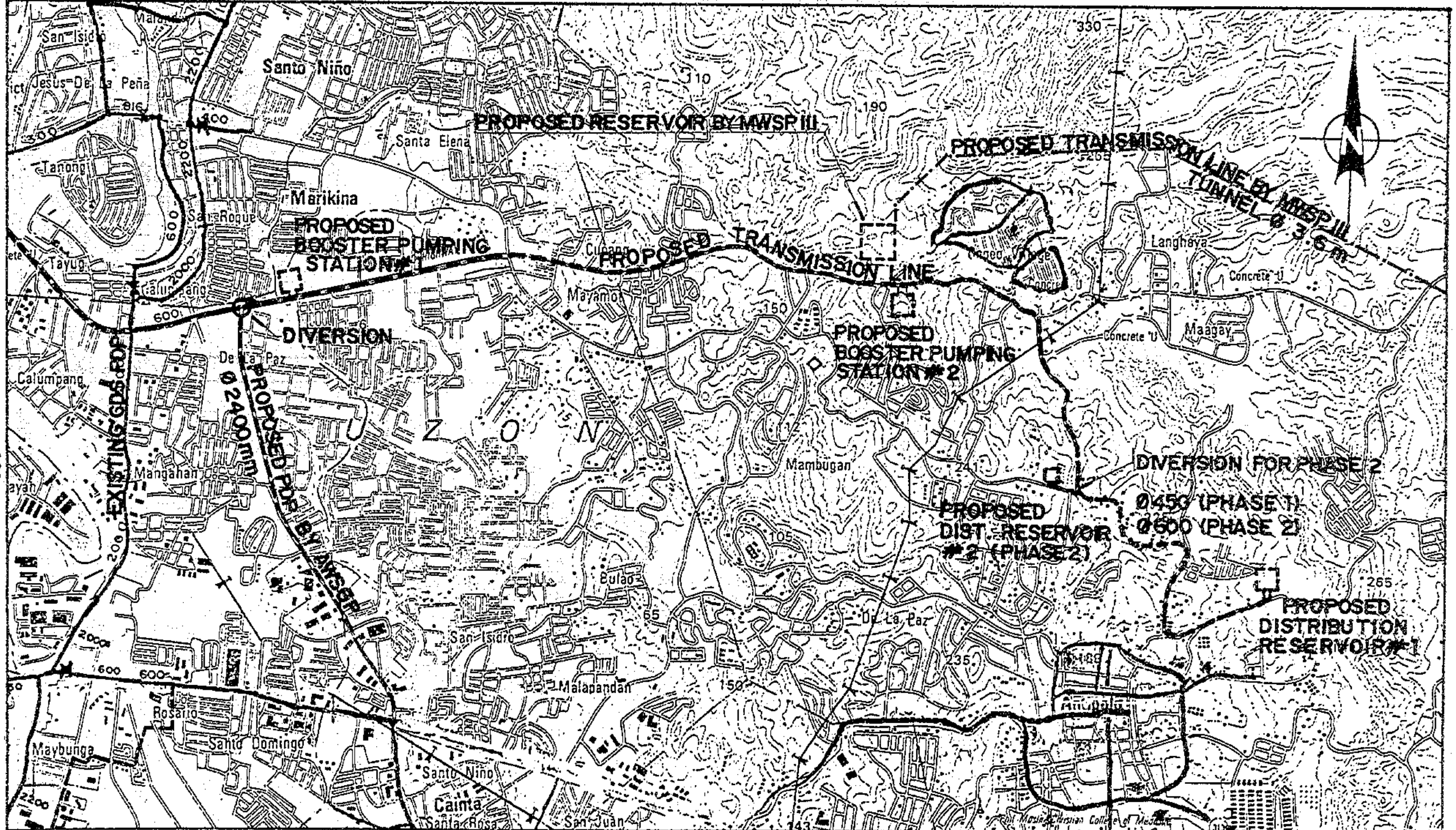


SECTION A-A
SCALE 1:100

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 8.2.3
ELEVATED WATER TANK

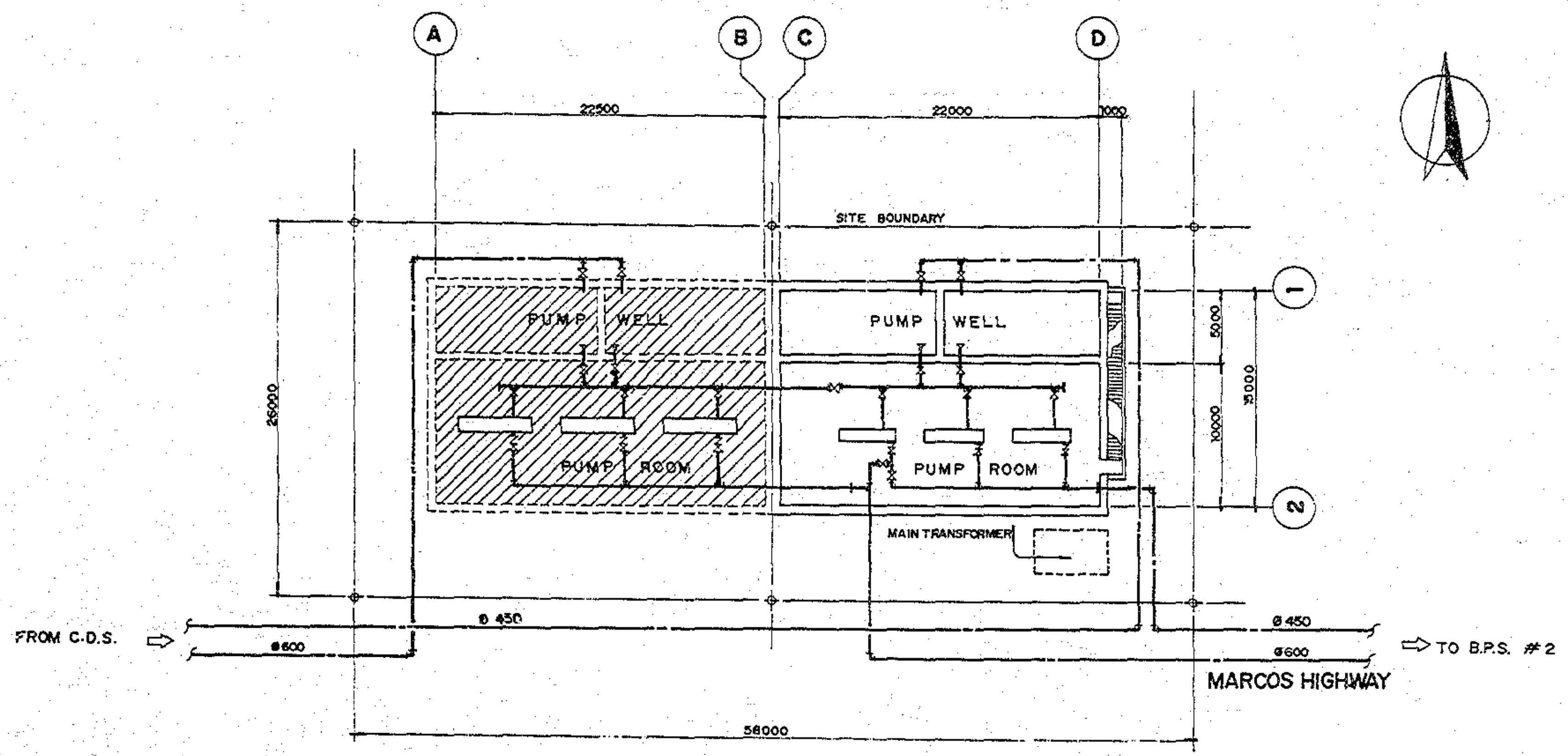


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 8.3.1

PROPOSED TRANSMISSION SYSTEM



NOTE:

PHASE 1

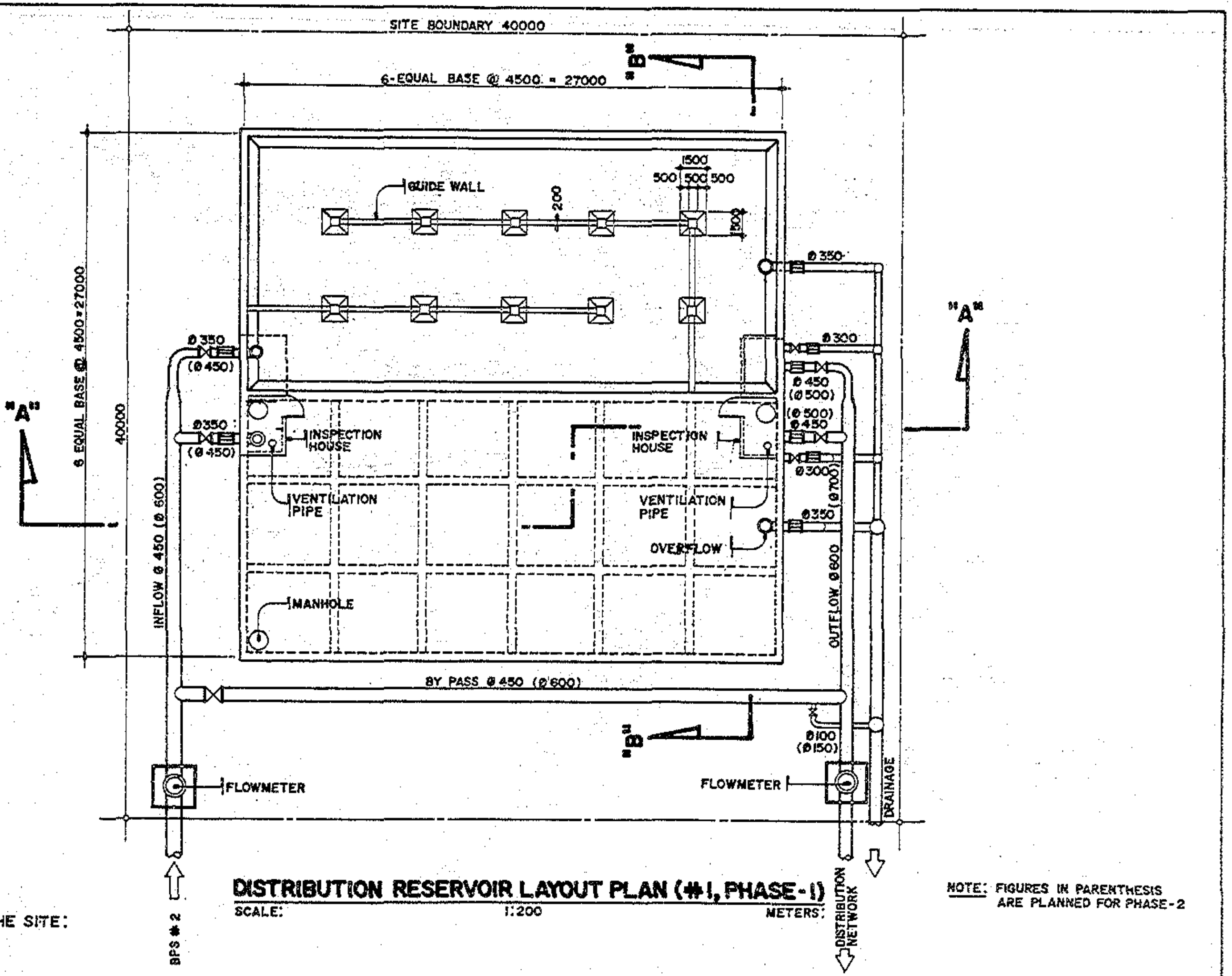
PHASE 2

BOOSTER PUMPING STATION NO.1 GENERAL LAYOUT PLAN

SCALE T. 300M

∴ REQUIRED AREA OF THE SITE
= 26 x 58m
A = 1,510m (MINIMUM)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 8.3.2
JAPAN INTERNATIONAL COOPERATION AGENCY	B.P.S.#1 GENERAL LAYOUT



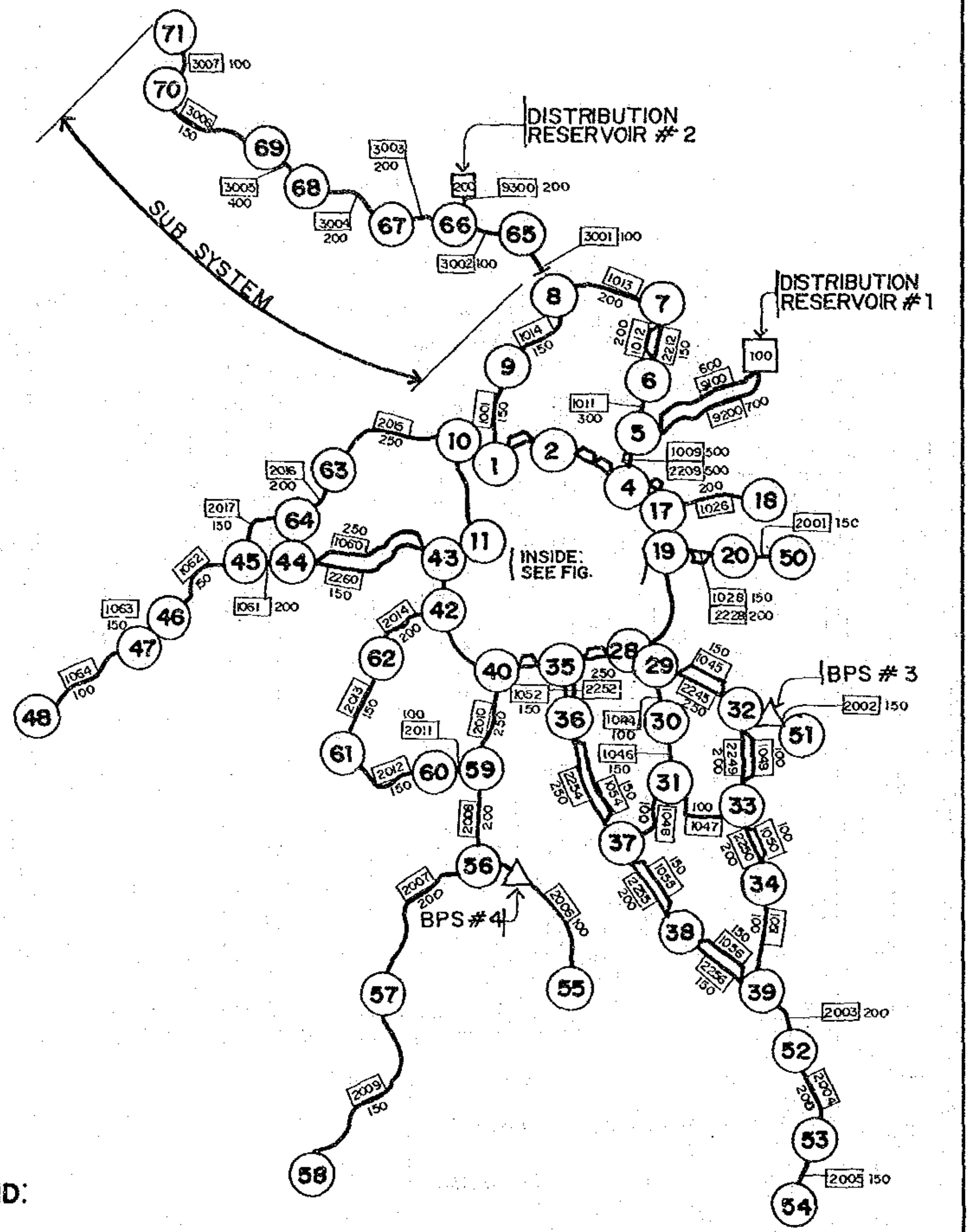
DISTRIBUTION RESERVOIR LAYOUT PLAN (#1, PHASE-I)

SCALE: 1:200 METERS:

NOTE: FIGURES IN PARENTHESIS ARE PLANNED FOR PHASE-2

* REQUIRED AREA OF THE SITE:
= 40 x 40 m.
= 1600 m^2 (MINIMUM)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 8.3.3
JAPAN INTERNATIONAL COOPERATION AGENCY	DISTRIBUTION RESERVOIR #1 (PHASE-I) GENERAL LAYOUT



LEGEND:

PIPE LINE

NODE NO.

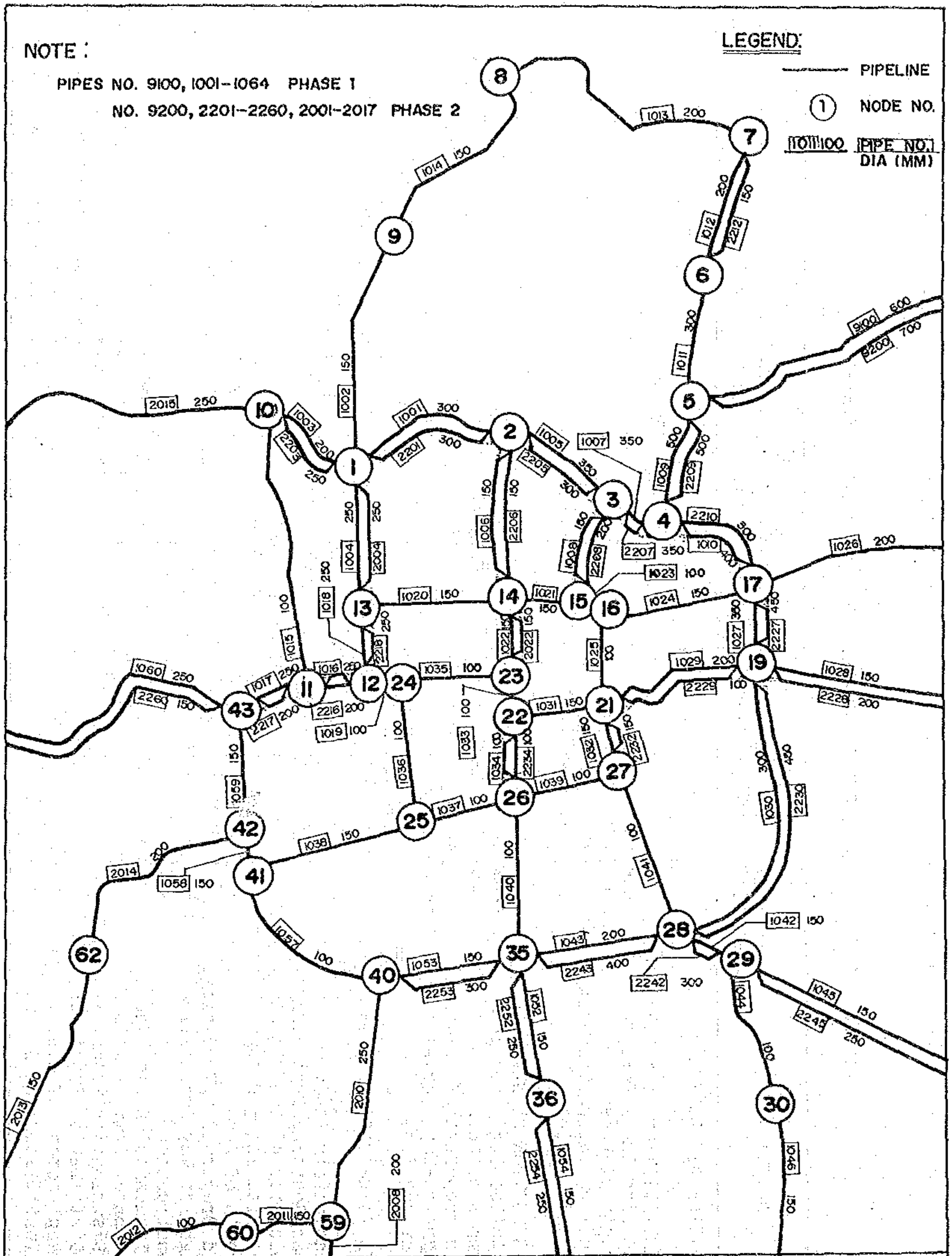
1011 100 — PIPE NO. / DIA. (MM)

NOTE: CONSTRUCTION PHASE

PIPES NO. 9100, 1001-1064 PHASE 1

NO. 9200, 2201-2260, 2001-2017, 9300, 3001-3007 PHASE 2

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 8.3.4
JAPAN INTERNATIONAL COOPERATION AGENCY	DISTRIBUTION NETWORK ANALYSIS-1



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 8.3.5

DISTRIBUTION NETWORK ANALYSIS-2

FIGURE 8.3.6 IMPLEMENTATION SCHEDULE FOR THE PROJECT (PHASE 1)

ACTIVITIES	YEAR								
	1992	1993	1994	1995	1996	1997	1998	1999	2000
GROUNDWATER DEVELOPMENT									
1. REHABILITATION OF WELLS									
Detailed Eng'g Design	****								
Prep'n of Docs.	**								
Bid Preparation/Tendering		**							
Rehabilitation		******							
2. CONSTRUCTION OF NEW WELLS									
Detailed Eng'g Design	****								
Prep'n of Docs.	**								
Bid Preparation/Tendering		**							
Right-of-Way Acquisition	**								
Construction		******	****						
SURFACE WATER DISTRIBUTION									
Feasibility Study			******						
Loan Sourcing/Proceccing			****						
Selection of Consultants			*	**					
Detailed Eng'g Design				******	**				
Prep'n of Docs.					**				
Bid Preparation/Tendering					**				
Right-of-Way Acquisition				**					
Construction									
Transmission Pipeline					****	********			
Booster Pump. Stations					****	********			
Distribution Reservoir					****	********			
Distribution Pipelines						****	********	********	****
Replacement of H.S.C.						****	****		
Installation of H.S.C.						****	********	********	****

TABLE 8.4.1 ESTIMATED PROJECT COST AND FINANCING (GROUNDWATER AND SURFACE WATER)

COMPONENTS		TOTAL COST	1992 FOREX P	1992 LOCAL P	1992 TOTAL COST	1993 FOREX P	1993 LOCAL P	1993 TOTAL COST	1994 FOREX P	1994 LOCAL P	1994 TOTAL COST	1995 FOREX P	1995 LOCAL P	1995 TOTAL COST	1996 FOREX P	1996 LOCAL P	1996 TOTAL COST
<<PROJECT COST>>																	
1. Materials	Rehab.	1,552	0	0	0	466	1,086	1,552	0	0	0	0	0	0	0	0	0
	New Well	26,407	0	0	0	4,150	9,684	13,834	3,772	8,801	12,573	0	0	0	0	0	0
	Surface W.	93,844	0	0	0	0	0	0	0	0	0	0	0	0	5,782	10,427	16,209
Materials Sub Total		121,802	0	0	0	4,616	10,770	15,385	3,772	8,801	12,573	0	0	0	5,782	10,427	16,209
2. Labor																	
Skilled	Rehab.	141	0	0	0	0	141	141	0	0	0	0	0	0	0	0	0
	New Well	1,461	0	0	0	0	751	751	0	710	710	0	0	0	0	0	0
	Surface W.	27,788	0	0	0	0	0	0	0	0	0	0	0	0	0	2,422	2,422
Skilled Labor Sub Total		29,390	0	0	0	0	892	892	0	710	710	0	0	0	0	2,422	2,422
Unskilled	Rehab.	422	0	0	0	0	422	422	0	0	0	0	0	0	0	0	0
	New Well	3,212	0	0	0	0	1,668	1,668	0	1,544	1,544	0	0	0	0	0	0
	Surface W.	20,649	0	0	0	0	0	0	0	0	0	0	0	0	0	2,220	2,220
Unskilled L. Sub Total		24,283	0	0	0	0	2,089	2,089	0	1,544	1,544	0	0	0	0	2,220	2,220
3. Equipment	Rehab.	2,724	0	0	0	2,315	409	2,724	0	0	0	0	0	0	0	0	0
	New Well	5,685	0	0	0	2,208	872	3,081	1,803	801	2,604	0	0	0	0	0	0
	Surface W.	178,325	0	0	0	0	0	0	0	0	0	0	0	0	4,173	5,923	10,096
Equipment Sub Total		186,733	0	0	0	4,524	1,281	5,805	1,803	801	2,604	0	0	0	4,173	5,923	10,096
SUB TOTAL-A (1+2+3)		362,208	0	0	0	9,139	15,032	24,172	5,575	11,856	17,431	0	0	0	9,954	20,993	30,947
4. Land Acquisition		12,335	0	2,750	2,750	0	0	0	0	0	0	0	9,565	9,565	0	0	0
5. Eng'g Serv. (D/D)	Rehab.	387	62	248	310	15	62	77	0	0	0	0	0	0	0	0	0
	New Well	2,941	471	1,882	2,353	118	471	588	0	0	0	0	0	0	0	0	0
	Surface W.	25,648	0	0	0	0	0	0	0	0	0	10,259	10,259	20,519	2,565	2,565	5,130
6. Eng'g Serv. (C/S)	Rehab.	194	0	0	0	39	155	194	0	0	0	0	0	0	0	0	0
	New Well	1,471	0	0	0	168	672	840	126	504	630	0	0	0	0	0	0
	Surface W.	12,824	0	0	0	0	0	0	0	0	0	0	0	0	641	641	1,282
SUB TOTAL-B (4+5+6)		55,800	533	4,880	5,413	340	1,360	1,700	126	504	630	10,259	19,844	30,104	3,206	3,206	6,412
6. Physical Contingency		41,801	53	488	541	948	1,639	2,587	570	1,236	1,806	1,026	1,984	3,010	1,316	2,420	3,736
7. Price Contingency		203,020	21	488	509	774	3,442	4,216	712	4,091	4,803	1,743	9,210	10,952	2,851	14,065	16,916
8. Taxes		73,837	0	488	488	0	3,612	3,612	0	2,109	2,109	0	1,984	1,984	0	4,203	4,203
SUB TOTAL-C (6+7+8)		318,657	75	1,464	1,539	1,721	8,694	10,415	1,282	7,436	8,718	2,769	13,179	15,947	4,167	20,688	24,855
GRAND TOTAL (A+B+C)		736,665	607	6,344	6,951	11,201	25,085	36,286	6,983	19,797	26,780	13,028	33,023	46,051	17,328	44,886	62,214
ADD: IDC		66,304	0	0	0	0	0	0	1,939	0	1,939	0	0	0	0	0	0
PROJECT COST TOTAL		802,969	607	6,344	6,951	11,201	25,085	36,286	8,922	19,797	28,719	13,028	33,023	46,051	17,328	44,886	62,214
<<FINANCING>>																	
1. Government Equity		240,675			6,951			5,795			2,985			46,051			13,814
2. Inter'l Cash Generation		124,874			0			0			1,939			0			0
3. Foreign Loan		437,420			0			30,491			23,795			0			48,400
FINANCING TOTAL		802,969			6,951			36,286			28,719			46,051			62,214

TABLE 8.4.1 (CONTINUATION)

COMPONENTS	TOTAL COST	1997 FOREX P	1997 LOCAL P	1997 TOTAL COST	1998 FOREX P	1998 LOCAL P	1998 TOTAL COST	1999 FOREX P	1999 LOCAL P	1999 TOTAL COST	2000 FOREX P	2000 LOCAL P	2000 TOTAL COST
<<PROJECT COST>>													
1. Materials Rehab.	1,552	0	0	0	0	0	0	0	0	0	0	0	0
New Well	26,407	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	93,844	21,564	26,448	48,012	4,431	7,080	11,511	4,373	6,553	10,925	2,905	4,280	7,186
Materials Sub Total	121,802	21,564	26,448	48,012	4,431	7,080	11,511	4,373	6,553	10,925	2,905	4,280	7,186
2. Labor													
Skilled Rehab.	141	0	0	0	0	0	0	0	0	0	0	0	0
New Well	1,461	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	27,788	0	15,763	15,763	0	3,802	3,802	0	3,509	3,509	0	2,291	2,291
Skilled Labor Sub Total	29,390	0	15,763	15,763	0	3,802	3,802	0	3,509	3,509	0	2,291	2,291
Unskilled Rehab.	422	0	0	0	0	0	0	0	0	0	0	0	0
New Well	3,212	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	20,649	0	10,057	10,057	0	3,542	3,542	0	2,957	2,957	0	1,874	1,874
Unskilled L. Sub Total	24,283	0	10,057	10,057	0	3,542	3,542	0	2,957	2,957	0	1,874	1,874
3. Equipment Rehab.	2,724	0	0	0	0	0	0	0	0	0	0	0	0
New Well	5,685	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	178,325	73,322	24,515	97,837	20,527	8,890	29,417	16,353	8,671	25,024	10,207	5,744	15,951
Equipment Sub Total	186,733	73,322	24,515	97,837	20,527	8,890	29,417	16,353	8,671	25,024	10,207	5,744	15,951
SUB TOTAL-A (1+2+3)	362,208	94,887	76,782	171,669	24,958	23,315	48,273	20,726	21,689	42,416	13,112	14,189	27,301
4. Land Acqusition	12,335	0	0	0	0	0	0	0	0	0	0	0	0
5. Eng'g Serv. (D/D) Rehab.	387	0	0	0	0	0	0	0	0	0	0	0	0
New Well	2,841	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	25,648	0	0	0	0	0	0	0	0	0	0	0	0
6. Eng'g Serv. (C/S) Rehab.	194	0	0	0	0	0	0	0	0	0	0	0	0
New Well	1,471	0	0	0	0	0	0	0	0	0	0	0	0
Surface W.	12,824	3,206	3,206	6,412	385	1,539	1,924	385	1,539	1,924	256	1,026	1,282
SUB TOTAL-B (4+5+6)	55,800	3,206	3,206	6,412	385	1,539	1,924	385	1,539	1,924	256	1,026	1,282
6. Physical Contingency	41,801	9,809	7,999	17,808	2,534	2,485	5,020	2,111	2,323	4,434	1,337	1,521	2,858
7. Price Contingency	203,020	26,026	56,610	82,636	8,007	20,985	28,992	7,781	23,040	30,821	5,659	17,516	23,175
8. Taxes	73,837	0	36,902	36,902	0	10,405	10,405	0	8,655	8,655	0	5,478	5,478
SUB TOTAL-C (6+7+8)	318,657	35,835	101,511	137,346	10,541	33,875	44,416	9,892	34,018	43,910	6,996	24,516	31,512
GRAND TOTAL (A+B+C)	736,665	133,928	181,499	315,427	35,883	58,729	94,612	31,003	57,246	88,249	20,365	39,730	60,095
ADD: IDC	66,304	3,078	0	3,078	18,193	0	18,193	20,381	0	20,381	22,712	0	22,712
PROJECT COST TOTAL	802,969	137,006	181,499	318,505	54,076	58,729	112,805	51,384	57,246	108,630	43,077	39,730	82,807
<<FINANCING>>													
1. Government Equity	240,675			63,139			39,695			36,961			25,285
2. Inter'l Cash Generation	124,874			17,721			38,692			35,024			31,498
3. Foreign Loan	437,420			237,646			34,418			36,646			26,024
FINANCING TOTAL	802,969			318,505			112,805			108,630			82,807

TABLE 8.4.2 FINANCIAL INTERNAL RATE OF RETURN
(GROUNDWATER AND SURFACE WATER)

YEAR	CASH RECEIPTS FROM OPER'N (1000P)	CASH EXPENSES FOR O & M (1000P)	INVESTMENT IN PROJECT (1000P)	FINANCIAL NET BENEFIT FLOW (1000P)
1992	0	0	6,951	(6,951)
1993	0	0	36,286	(36,286)
1994	5,394	1,337	28,719	(24,662)
1995	9,993	1,948	46,051	(38,006)
1996	14,375	3,173	62,214	(51,012)
1997	19,315	5,020	318,505	(304,210)
1998	24,957	12,624	112,805	(100,472)
1999	31,375	16,349	108,630	(93,604)
2000	38,663	23,533	82,807	(67,677)
2001	46,804	29,931	0	16,873
2002	56,083	36,571	0	19,512
2003	66,682	55,177	0	11,505
2004	78,763	52,104	0	26,659
2005	92,509	61,147	0	31,362
2006	105,478	69,914	0	35,564
2007	119,430	79,580	0	39,850
2008	134,940	90,230	0	44,710
2009	152,167	101,960	0	50,207
2010	171,287	114,873	0	56,414
2011	186,162	122,274	0	63,888
2012	201,055	130,199	0	70,856
2013	217,140	160,219	0	56,921
2014	234,511	147,784	0	86,727
2015	253,272	157,533	0	95,739
2016	273,534	167,983	0	105,551
2017	295,416	179,189	0	116,227
2018	319,050	191,209	0	127,841
2019	344,574	204,105	0	140,469
2020	372,139	217,945	0	154,194
2021	401,911	232,801	0	169,110
NPV at 3.47% WACC				100,120
FIRR				4.46%

TABLE 8.4.3 ESTIMATED PROJECT COST AND FINANCING (GROUNDWATER ONLY)

(unit: P1000)

COMPONENTS	TOTAL COST	1992 FOREX P	1992 LOCAL P	1992 TOTAL COST	1993 FOREX P	1993 LOCAL P	1993 TOTAL COST	1994 FOREX P	1994 LOCAL P	1994 TOTAL COST	1995 FOREX P	1995 LOCAL P	1995 TOTAL COST	1996 FOREX P	1996 LOCAL P	1996 TOTAL COST
<<PROJECT COST>>																
1. Materials Rehab.	1,552	0	0	0	466	1,086	1,552	0	0	0	0	0	0	0	0	0
New Well	26,407	0	0	0	4,150	9,684	13,834	3,772	8,801	12,573	0	0	0	0	0	0
Surface W.	29,915	0	0	0	2,371	3,846	6,217	3,545	5,664	9,209	3,496	5,242	8,740	2,324	3,424	5,749
Materials Sub Total	57,874	0	0	0	6,987	14,616	21,603	7,317	14,465	21,782	3,498	5,242	8,740	2,324	3,424	5,749
2. Labor																
Skilled Rehab.	141	0	0	0	0	141	141	0	0	0	0	0	0	0	0	0
New Well	1,461	0	0	0	0	751	751	0	710	710	0	0	0	0	0	0
Surface W.	9,749	0	0	0	0	2,067	2,067	0	3,042	3,042	0	2,808	2,808	0	1,833	1,833
Skilled Labor Sub Total	11,351	0	0	0	0	2,959	2,959	0	3,752	3,752	0	2,808	2,808	0	1,833	1,833
Unskilled Rehab.	422	0	0	0	0	422	422	0	0	0	0	0	0	0	0	0
New Well	3,212	0	0	0	0	1,668	1,668	0	1,544	1,544	0	0	0	0	0	0
Surface W.	8,666	0	0	0	0	1,967	1,967	0	2,834	2,834	0	2,365	2,365	0	1,499	1,499
Unskilled L. Sub Total	12,299	0	0	0	0	4,057	4,057	0	4,378	4,378	0	2,365	2,365	0	1,499	1,499
3. Equipment Rehab.	2,724	0	0	0	2,315	409	2,724	0	0	0	0	0	0	0	0	0
New Well	5,685	0	0	0	2,208	872	3,081	1,803	801	2,604	0	0	0	0	0	0
Surface W.	72,588	0	0	0	11,504	4,771	16,275	16,421	7,112	23,534	13,083	6,937	20,019	8,165	4,595	12,761
Equipment Sub Total	80,997	0	0	0	16,028	6,052	22,080	18,224	7,913	26,137	13,083	6,937	20,019	8,165	4,595	12,761
SUB TOTAL-A (1+2+3)	162,521	0	0	0	23,015	27,683	50,698	25,541	30,508	56,049	16,581	17,352	33,932	10,490	11,351	21,841
4. Land Acquisition	2,750	0	2,750	2,750	0	0	0	0	0	0	0	0	0	0	0	0
5. Eng'g Serv. (D/D) Rehab.	387	62	248	310	15	62	77	0	0	0	0	0	0	0	0	0
New Well	2,941	471	1,882	2,353	118	471	588	0	0	0	0	0	0	0	0	0
Surface W.	9,673	1,548	6,191	7,739	387	1,548	1,935	0	0	0	0	0	0	0	0	0
6. Eng'g Serv. (C/S) Rehab.	194	0	0	0	39	155	194	0	0	0	0	0	0	0	0	0
New Well	1,471	0	0	0	168	672	840	126	504	630	0	0	0	0	0	0
Surface W.	4,837	0	0	0	531	531	1,061	309	1,236	1,545	271	1,086	1,357	175	699	874
SUB TOTAL-B (4+5+6)	22,252	2,080	11,071	13,151	1,257	3,438	4,695	435	1,740	2,175	271	1,086	1,357	175	699	874
6. Physical Contingency	18,477	208	1,107	1,315	2,427	3,112	5,539	2,598	3,225	5,822	1,685	1,844	3,529	1,066	1,205	2,271
7. Price Contingency	44,358	83	1,107	1,190	1,981	6,535	8,516	3,243	10,674	13,918	2,863	8,557	11,419	2,310	7,004	9,314
8. Taxes	32,340	0	1,107	1,107	0	9,520	9,520	0	10,433	10,433	0	6,909	6,909	0	4,370	4,370
SUB TOTAL-C (6+7+8)	95,175	291	3,321	3,613	4,408	19,168	23,576	5,841	24,332	30,173	4,548	17,310	21,858	3,377	12,579	15,956
GRAND TOTAL (A+B+C)	279,948	2,372	14,392	16,764	28,680	50,289	78,969	31,817	56,580	88,398	21,400	35,747	57,147	14,041	24,629	38,670
ADD: IDC	11,399	0	0	0	0	0	0	3,129	0	3,129	3,106	0	3,106	5,164	0	5,164
PROJECT COST TOTAL	291,347	2,372	14,392	16,764	28,680	50,289	78,969	34,946	56,580	91,527	24,506	35,747	60,253	19,205	24,629	43,834
<<FINANCING>>																
1. Government Equity	74,682			16,764			18,054			18,082			13,070			8,712
2. Inter'l Cash Generation	58,255			0			11,714			19,529			14,820			12,192
3. Foreign Loan	158,410			0			49,201			53,916			32,363			22,930
FINANCING TOTAL	291,347			16,764			78,969			91,527			60,253			43,834

TABLE 8.4.4 FINANCIAL INTERNAL RATE OF RETURN (GROUNDWATER ONLY)

YEAR	CASH RECEIPTS FROM OPER'N (1000P)	CASH EXPENSES FOR OPER'N (1000P)	INVESTMENT IN PROJECT (1000P)	FINANCIAL NET BENEFIT FLOW (1000P)
1992	0	0	16,764	(16,764)
1993	2,634	96	78,969	(76,431)
1994	5,921	1,932	91,527	(87,538)
1995	9,993	3,080	60,253	(53,340)
1996	14,375	4,856	43,834	(34,315)
1997	19,315	6,573	0	12,742
1998	24,957	8,139	0	16,818
1999	30,744	9,608	0	21,136
2000	33,823	10,089	0	23,734
2001	37,230	10,598	0	26,632
2002	41,107	11,136	0	29,971
2003	45,365	22,945	0	22,420
2004	50,042	12,310	0	37,732
2005	55,176	12,949	0	42,227
2006	59,781	13,627	0	46,154
2007	64,563	14,346	0	50,217
2008	69,728	15,109	0	54,619
2009	75,307	15,919	0	59,388
2010	81,331	16,780	0	64,551
2011	87,838	17,695	0	70,143
2012	94,865	18,668	0	76,197
2013	102,454	41,233	0	61,221
2014	110,650	20,805	0	89,845
2015	119,502	21,980	0	97,522
2016	129,063	23,231	0	105,832
2017	139,388	24,566	0	114,822
2018	150,539	25,990	0	124,549
2019	162,582	27,511	0	135,071
2020	175,588	29,135	0	146,453
2021	189,635	30,870	0	158,765
	NPV at 3.46% WACC			565,807
	FIRR			11.43%

NOTE: To reduce the NRW, distribution network replacement and construction was assumed to be implemented with an amount of 80% of initial proposed project from 1993.

TABLE 8.4.5 ECONOMIC INTERNAL RATE OF RETURN
(GROUNDWATER AND SURFACE WATER)

YEAR	ECONOMIC BENEFITS				TOTAL ECONOMIC BENEFITS (P1,000)	TOTAL ECONOMIC COSTS (P1,000)	ECONOMIC NET BENEFITS (P1,000)
	WATER REVENUE (P1,000)	HEALTH BENEFITS (P1,000)	FIRE PROTECTION (P1,000)	LAND VALUE INCREASE (P1,000)			
1992	0	0	0	0	0	6,071	(6,071)
1993	0	0	0	0	0	30,777	(30,777)
1994	6,687	25	485	50,400	57,597	22,108	35,489
1995	10,046	51	1,010	50,400	61,507	38,200	23,307
1996	13,140	89	1,760	0	14,989	47,084	(32,095)
1997	16,229	124	2,460	82,125	100,938	221,493	(120,555)
1998	19,322	158	3,129	82,125	104,734	70,151	34,583
1999	22,411	190	3,776	82,125	108,503	66,694	41,809
2000	25,504	222	4,409	82,125	112,261	50,971	61,290
2001	28,517	240	4,750	0	33,506	20,061	13,445
2002	31,598	257	5,090	0	36,945	27,796	9,149
2003	34,749	274	5,431	0	40,454	25,131	15,323
2004	37,969	291	5,771	0	44,031	27,667	16,365
2005	41,259	308	6,112	0	47,679	29,695	17,984
2006	43,341	318	6,302	0	49,960	31,725	18,236
2007	45,423	327	6,491	0	52,242	33,756	18,486
2008	47,506	337	6,681	0	54,524	38,603	15,921
2009	49,588	347	6,871	0	56,805	40,187	16,619
2010	51,670	356	7,061	0	59,087	37,815	21,272
2011	51,670	356	7,061	0	59,087	46,559	12,528
2012	51,670	356	7,061	0	59,087	133,016	(73,930)
2013	51,670	356	7,061	0	59,087	64,633	(5,546)
2014	51,670	356	7,061	0	59,087	60,451	(1,364)
2015	51,670	356	7,061	0	59,087	52,209	6,878
2016	51,670	356	7,061	0	59,087	37,815	21,272
2017	51,670	356	7,061	0	59,087	37,815	21,272
2018	51,670	356	7,061	0	59,087	37,815	21,272
2019	51,670	356	7,061	0	59,087	37,815	21,272
2020	51,670	356	7,061	0	59,087	37,815	21,272
2021	51,670	356	7,061	0	59,087	37,815	21,272
NPV at 15.00%							5,592
EIRR							17.19%

TABLE 8.4.6 ECONOMIC INTERNAL RATE OF RETURN (GROUNDWATER ONLY)

YEAR	ECONOMIC BENEFITS				TOTAL ECONOMIC BENEFITS (P1,000)	TOTAL ECONOMIC COSTS (P1,000)	ECONOMIC NET BENEFITS (1000P)
	WATER REVENUE (P1,000)	HEALTH BENEFITS (P1,000)	FIRE PROTECTION (P1,000)	LAND VALUE INCREASE (P1,000)			
1992	0	0	0	0	0	14,972	(14,972)
1993	3,591	0	0	0	3,591	65,950	(62,359)
1994	6,687	25	485	50,400	57,597	70,111	(12,513)
1995	10,046	51	1,010	50,400	61,507	45,268	16,240
1996	13,140	89	1,760	0	14,989	31,764	(16,775)
1997	16,229	124	2,460	18,720	37,533	6,254	31,280
1998	19,322	158	3,129	18,720	41,329	7,143	34,186
1999	21,889	184	3,654	18,720	44,447	7,143	37,304
2000	21,889	184	3,654	18,720	44,447	7,143	37,304
2001	22,387	184	3,654	0	26,225	7,143	19,082
2002	22,885	184	3,654	0	26,723	12,344	14,379
2003	23,383	184	3,654	0	27,221	7,143	20,078
2004	23,882	184	3,654	0	27,719	7,143	20,577
2005	24,380	184	3,654	0	28,218	7,143	21,075
2006	24,380	184	3,654	0	28,218	7,143	21,075
2007	24,380	184	3,654	0	28,218	7,143	21,075
2008	24,380	184	3,654	0	28,218	25,724	2,494
2009	24,380	184	3,654	0	28,218	32,235	(4,017)
2010	24,380	184	3,654	0	28,218	26,362	1,856
2011	24,380	184	3,654	0	28,218	19,393	8,825
2012	24,380	184	3,654	0	28,218	12,344	15,874
2013	24,380	184	3,654	0	28,218	7,143	21,075
2014	24,380	184	3,654	0	28,218	7,143	21,075
2015	24,380	184	3,654	0	28,218	7,143	21,075
2016	24,380	184	3,654	0	28,218	7,143	21,075
2017	24,380	184	3,654	0	28,218	7,143	21,075
2018	24,380	184	3,654	0	28,218	7,143	21,075
2019	24,380	184	3,654	0	28,218	7,143	21,075
2020	24,380	184	3,654	0	28,218	7,143	21,075
2021	24,380	184	3,654	0	28,218	7,143	21,075
	NPV at 15.00%						11,207
	EIRR						17.20%

CHAPTER 9 GROUNDWATER MANAGEMENT PLAN

9.1 TARGET OF GROUNDWATER MANAGEMENT

Water supply in the Metro Manila shall for a long time depend on groundwater sources, not only for domestic use but also for commercial and industrial uses. A groundwater management plan is proposed for the twin purpose of effective use and conservation of groundwater.

A target of groundwater management is the containment/prevention of saline water intrusion in Metro Manila. A fundamental measure for this is the recovery of groundwater levels. Additional measures are the construction of cutoff walls, artificial recharge, extraction and/or injection barrier, etc.

However, these additional measures are extremely costly and would prove difficult to implement, considering the mechanism and the areal extent of saline water intrusion. The reduction of pumpage therefore is the most viable option.

The computer simulations predicted that the groundwater level shall decline by more than 50m from its present level and the saline water-intruded area to expand even in the most optimistic scenario (Pumpage in 2010: 1,064,000 CMD). Thus considered, plans for the reduction of pumpage in the Metro Manila groundwater basin were prepared and evaluated through computer simulations. A pumpage reduction plan in terms of prevention of saline water intrusion was set up in which a reduced pumpage is proposed as a tentative permissive yield of the basin, a target of the groundwater management.

9.2 REGULATION OF PUMPAGE

9.2.1 Zoning of Regulated Area

The proposed plan has the Metro Manila groundwater basin subdivided into three (3) areas for groundwater regulation. It had considered the decline of water levels, the saline water intrusion and the completions of surface water supply projects, especially AWSOP.

(A) Area of Importance (the coastal area): The area where saline water has already intruded or there is an indication of saline water intrusion.

(B) Area of Semi-Importance (the inland): The area where groundwater levels had dropped heavily and where saltwater intrusion is anticipated to occur.

(C) Area of Surveillance: The rest of the area in the Metro Manila groundwater basin contiguous to the "A" and "B" areas, including the Antipolo groundwater basin.

9.2.2 Schedule of Regulation

The schedule of regulation is divided into three (3) stages:

(1) First Stage (Investigation): The groundwater level and pumping rates of all wells, except shallow wells for domestic use, will be measured and reported periodically. The groundwater monitoring system shall be installed as a minimum requirement. Based on the data from these activities, more definite targets of pumpage reduction in each area shall be set up. The construction of new wells in the "A" area is not allowed during this stage.

(2) Second Stage (Enforcement): The reduction of pumpage in "A" and "B" areas shall be enforced considering the progress of the substitutional water supply system. The groundwater monitoring system shall be expanded during this stage.

(3) Third Stage (Monitoring and Adjustment): Groundwater use shall be re-organized by purpose and by area, with consideration to the order of preference in the use of groundwater.

The first and second stages should be completed within five (5) years.

9.2.3 Control Area

In Art. 32 of the Philippine Water Code, the NWRB promulgates rules and regulations and declares the existence of a "Control Area" for the coordinated development, protection and utilization of groundwater and surface water. The concept of Control Area is applied to the regulated areas. Rules and regulations for the enforcement shall require further studies.

9.3 TARGET REGULATION OF PUMPAGE

To prevent or contain the saline water intrusion in Metro Manila, the groundwater pumpage control settings listed hereunder were investigated. These settings were made to simulate the relations between reduction of groundwater pumpage and piezometric changes.

9.3.1 Pumpage Control Settings

(1) Regulated Area

A regulated area for groundwater pumpage was established along the coastal area of Metro Manila (Figure 9.3.1), after considering the present piezometric heads, positions of saline water intrusion, future plans for surface water supply, etc. The area covers fifteen (15) municipalities viz. Caloocan City (south), Valenzuela, Malabon, Navotas, Manila, Makati (western part), Pasay City, Parañaque, Las Piñas (northern part), Bacoor (northern part), Imus (northern part), Cavite, Kawit, Noveleta and Rosario.

(2) Time Schedule

The reduction of pumpage is assumed to begin in 1996, with the target regulated pumpage being reached by year-2000. The 5-year period, 1991 to 1995, is considered for investigation and preparation. Pumpage in this period follows Scenario 1. After year-2000, the target regulated pumpage is maintained up to year-2010. Pumpage outside the regulated areas follows Scenario 1, i.e., from 1991 up to 2010.

(3) Regulated Pumpage

A target regulated pumpage is set based on the year-1990 pumpage. The reduction of pumpage will be done for both MWSS and private wells using uniform reduction rate. Seven (7) pumpage regulation plans were made for the simulations:

Plan (a) : Year-1995 pumpage of Scenario 1 is maintained up to 2010. (Figures 9.3.2 and 9.3.4)

Plan (b) : Target regulated pumpage by 2000 is the 1990 pumpage. (Figures 9.3.2 and 9.3.4)

Plan (c) : Target regulated pumpage by 2000 is 90% of the 1990 pumpage.

Plan (d) : Target regulated pumpage by 2000 is 80% of the 1990 pumpage. (Figures 9.3.3 and 9.3.5)

Plan (e) : Target regulated pumpage by 2000 is 70% of the 1990 pumpage. (Figures 9.3.3 and 9.3.5)

Plan (f) : Target regulated pumpage by 2000 is 60% of the 1990 pumpage. (Figures 9.3.3 and 9.3.5)

Plan (g) : Target regulated pumpage by 2000 is 50% of the 1990 pumpage. (Figures 9.3.3 and 9.3.5)

9.3.2 Simulation Results

The results are summarized in Table 9.3.1 and Figures 9.3.6 to 9.3.11.

Plan (a) is the most lenient plan. The pumpage in the regulated area increases by 14.4 MCM/year from 1991 to 1995. With this plan, maximum drawdowns of 40.2m and 25.8m are expected by 2010 in the northern and southern parts of Metro Manila, respectively.

Plan (b) reduces the 1995 pumpage to the 1990 pumpage level by year 2000. Maximum drawdowns of 9.7m in the north and 18.7m in the south are predicted, and these being principally due to the increase in pumpage between 1991 and 1995.

Plan (c) to Plan (g) reduce the 1995 pumpage to target regulated pumpages that are lesser than the 1990 pumpage level. The recovery of the piezometric heads depends upon the level of the target regulated pumpage in year 2000. Maximum recoveries of 55.3m in the north and 30.7m in the south are expected in Plan (g). In Plan (g), the lowest piezometric head is -50m in Valenzuela.

Regional piezometric head recovery may differ from place to place. While recoveries may be large in the northern part of Metro Manila, they may be small in the southern part. In Cavite, the piezometric head recovers only by 12.4m under Plan (g). In most cases, such phenomenon could be explained by the dynamic behavior of groundwater flow. That is, the groundwater in the regulated area of Cavite flows towards the piezometric head depressions in Muntinlupa and Parañaque where pumpage is greater and not regulated.

The present piezometric heads must recover to prevent further saline water intrusion in the future. Toward this end, the future discharge in the regulated area should be reduced to at least 50% of the year-1990 pumpage. However, and notwithstanding the recovery of piezometric heads in the coastal area, it is still possible for saline water to intrude further inland of southern Metro Manila due to the existence of abovesaid piezometric head depressions. The results of these simulations indicate the necessity of regulating pumpage not only in the coastal area but also in the inland area.

9.4 SUBSTITUTIONAL WATER SUPPLY

The substitutional water supply system must be constructed in the regulated areas prior to the enforcement of the relevant implementing rules and regulations of the Water Code. Measures for the substitutional water supply include the development of surface water in Kaliwa River and Laguna de Bay. A fundamental measure is the implementation of Manila Water Supply Project III (MWSP III).

However, considering the progress of water supply projects, it is difficult to depend only on the substitutional water source. Present industrial use alone accounts for about 40% of groundwater abstracted in Metro Manila. As the principal users of groundwater are for the foods, the chemical, the leather and the textile industries, such industries should be targetted for savings and rational use of groundwater. Here, additional empirical research is required.

9.5 GROUNDWATER MONITORING SYSTEM

The first step in groundwater management is the collection and arrangement of accurate observation data . An allocation plan for the groundwater monitoring wells was made in order to effectively monitor groundwater levels and quality of the Guadalupe aquifers in the Metro Manila groundwater basin (Figure 9.5.1).

A set of observation wells--one shallow and one deep--shall be constructed per monitoring location, except for ten sites where only one well shall be drilled (Figure 9.5.2). These wells are designed to facilitate automatic measurement of groundwater level and quality (EC) and periodic collection of water samples for laboratory analysis. The number of locations is 30 and that of wells 50. The total construction cost is estimated to amount to 72 million pesos.

It is expected that the groundwater monitoring system, together with the groundwater database and simulation models installed in MWSS, will be used as regular tools of groundwater management.

9.6 IMPLEMENTING BODY FOR GROUNDWATER MANAGEMENT

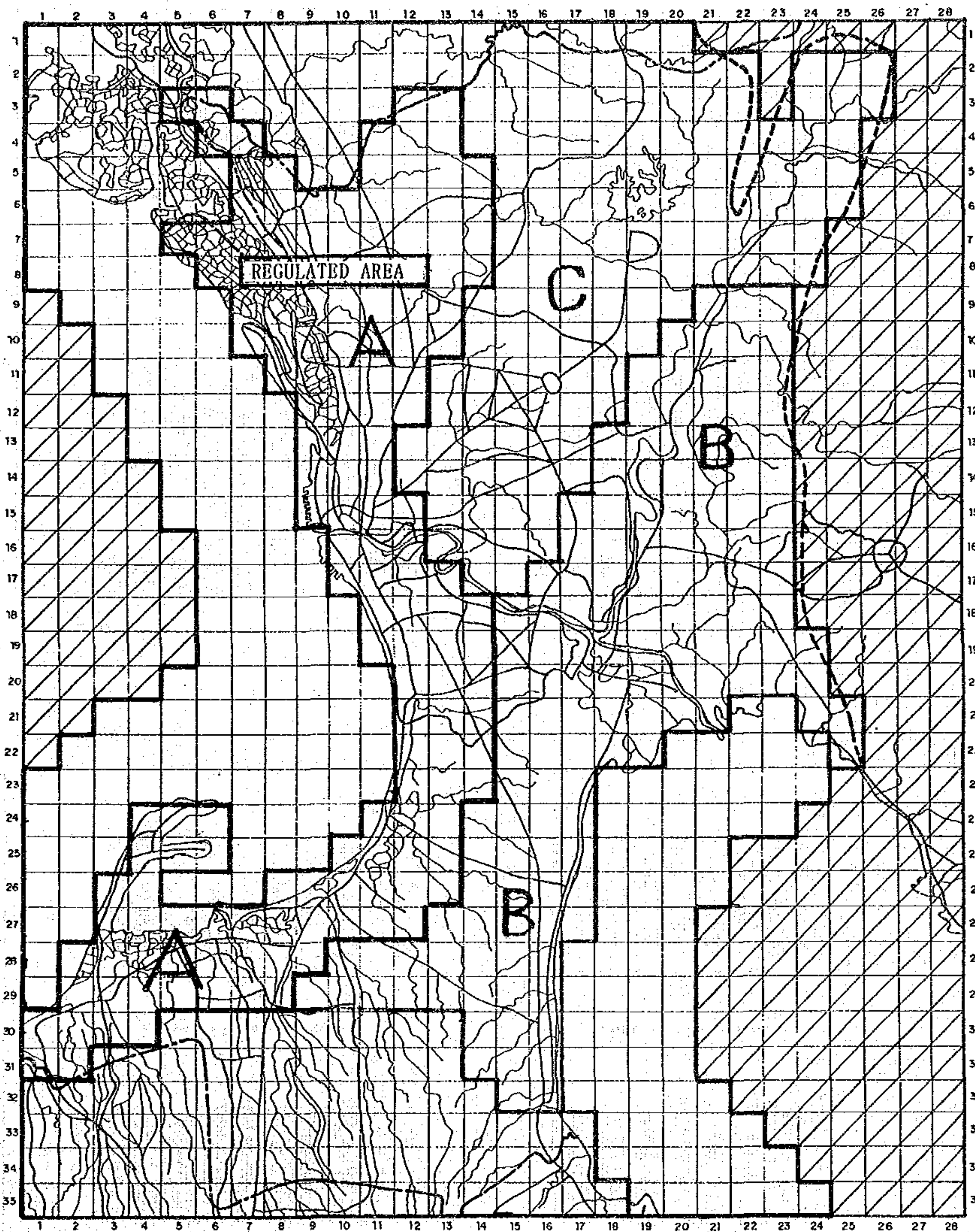
The lead agency for the implementation of the groundwater management plan should be the NWRB since it is the agency responsible for coordinating and integrating all activities related to water resources development and management in the country. The MWSS as the office responsible for the investigation, observation, analysis, and evaluation of groundwater resources in the MSA could be tasked with the technical aspects of the groundwater management plan. MWSS should therefore strengthen its organization that is responsible for groundwater studies.

TABLE 9.3.1 RESULTS OF REGULATED DISCHARGE SIMULATED

Regulation Plan	Pumpage in 2000 (upper:Metro Manila) (lower:Modeled area) (MCM)	Reduction of pumpage in regulated area (Compare to 1990) (MCM)	Lowest head in regulated area (in 2010)		Maximum head change in regulated area('10-'90)		Simulated head in 2010(upper)(masl) Head change since 1990(lower)(masl)			
			(north) (masl)	(south) (masl)	(north) (m)	(south) (m)	VLZ (masl)	CLC (masl)	MNL (masl)	CVC (masl)
(Scenario 1)	409.301 364.859	-39.653	-173.1 (VLZ)	-88.5 (CVC)	-83.1 (VLZ)	-57.4 (CVC)	-173.1 -83.1	-126.7 -51.1	-80.8 -26.7	-88.5 -57.4
a) The 1995's pumpage of Scenario 1 continues up to 2010.	394.039 349.597	-14.384	-130.2 (VLZ)	-74.2 (LPS)	-40.2 (VLZ)	-25.8 (ROS)	-130.2 -40.2	-102.1 -26.5	-63.7 -9.6	-47.5 -16.4
b) Regulated to the 1990's pumpage by 2000.	379.655 335.213	0.000	-102.7 (CLC)	-80.6 (LPS)	-9.7 (VLZ)	-18.7 (ROS)	-95.9 -5.9	-72.6 3.0	-45.2 8.9	-32.7 -1.6
c) Regulated to 90% of the 1990's pumpage by 2000.	369.857 325.415	9.798	-92.6 (CLC)	-76.4 (LPS)	14.7 (CLC)	12.8 (MNL)	-87.1 2.9	-65.6 10.0	-41.3 12.8	-29.9 1.2
d) Regulated to 80% of the 1990's pumpage by 2000.	360.060 315.618	19.595	-82.5 (CLC)	-72.2 (LPS)	24.8 (CLC)	16.7 (MNL)	-78.2 11.8	-58.3 17.3	-37.4 16.7	-27.1 4.0
e) Regulated to 70% of the 1990's pumpage by 2000.	350.260 305.818	29.393	-72.3 (CLC)	-68.0 (LPS)	35.0 (CLC)	20.5 (MNL)	-69.3 20.7	-51.1 24.5	-33.6 20.5	-24.3 6.8
f) Regulated to 60% of the 1990's pumpage by 2000.	340.462 296.020	39.190	-62.2 (CLC)	-63.8 (LPS)	45.1 (CLC)	24.4 (MNL)	-60.4 29.6	-43.9 31.7	-29.7 24.4	-21.5 9.6
g) Regulated to 50% of the 1990's pumpage by 2000.	330.653 286.211	48.988	-52.0 (CLC)	-59.6 (LPS)	55.3 (CLC)	30.7 (BCR)	-51.6 38.4	-36.7 38.9	-25.8 28.3	-18.7 12.4

BCR: Bacoor, CLC: Caloocan, CVC: Cavite, LPS: Las Piñas, MNL: Manila, ROS: Rosario, VLZ: Valenzuela

* The total discharge in entire Metro Manila is 339.611MCM in 1990, the dicharge in the modeled area is 316.572MCM in 1990.



LEGEND:

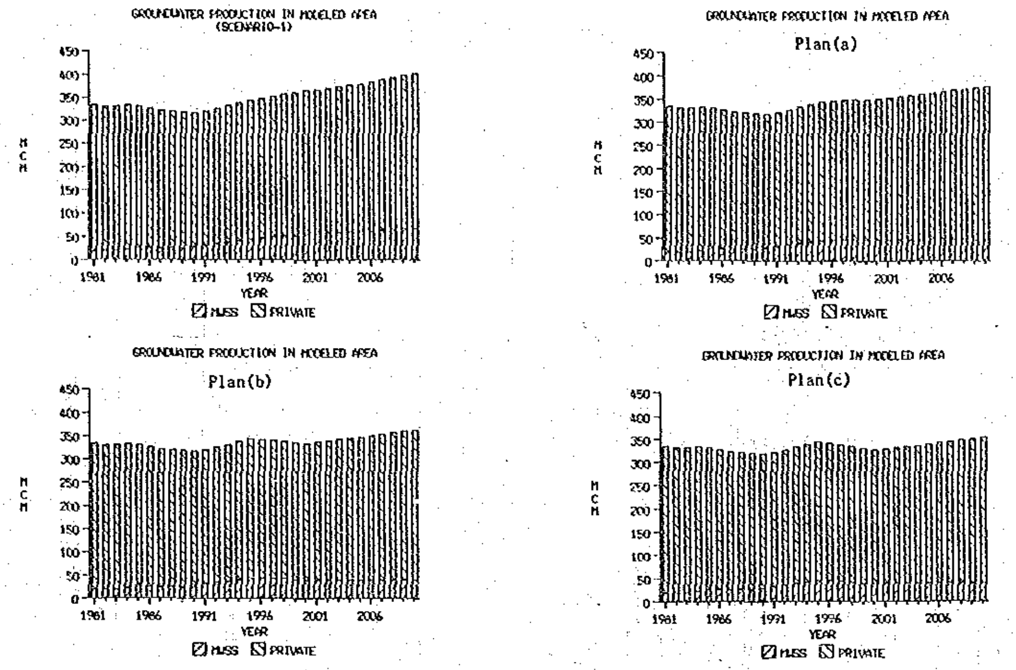
——— BOUNDARY OF MODEL ; — - — - — BOUNDARY OF BASIN

0 5 10KM

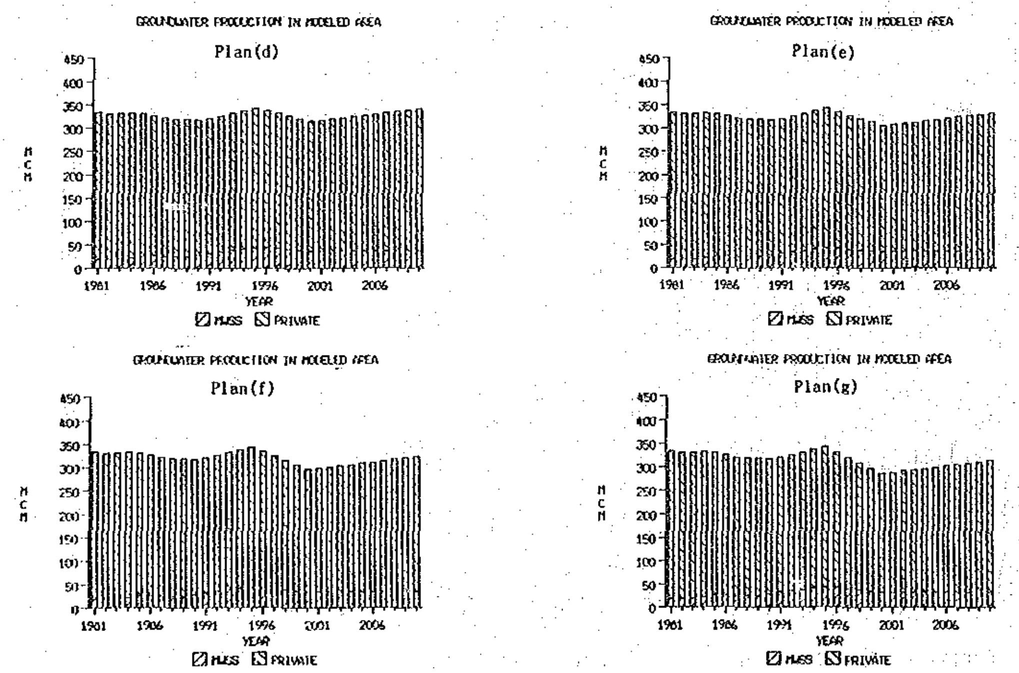
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

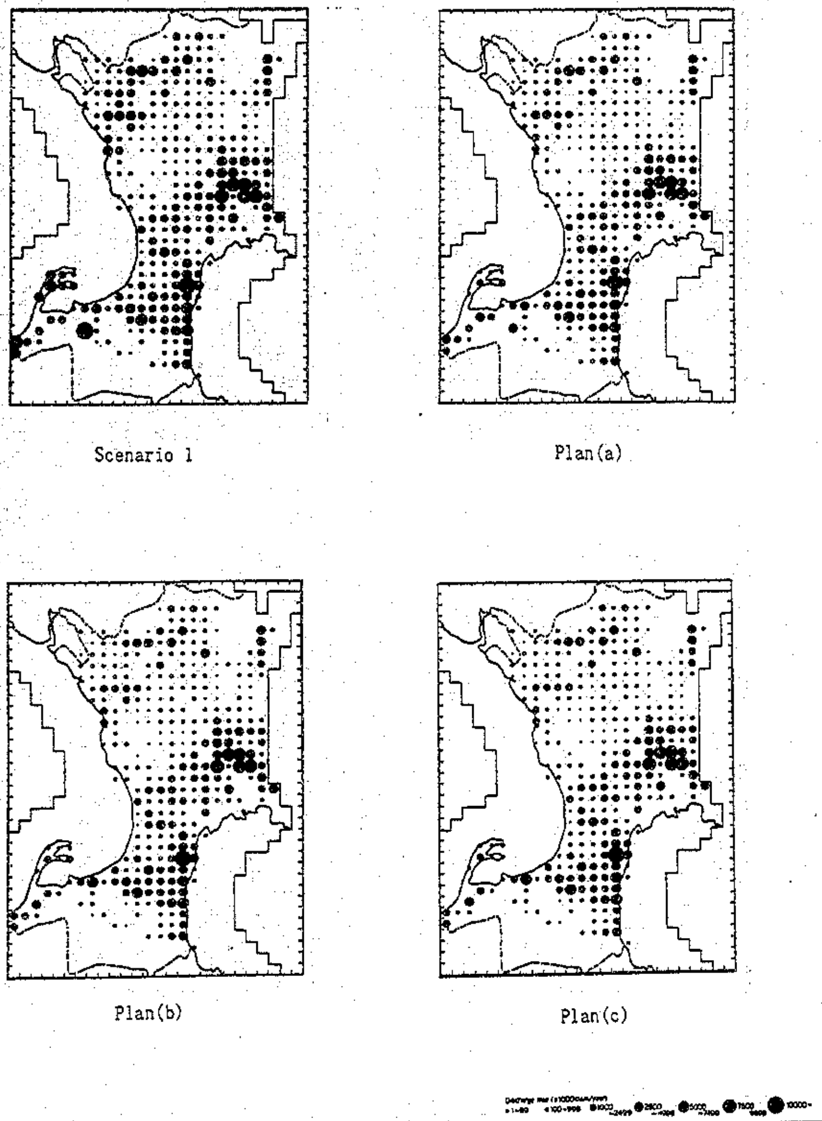
FIGURE 9.3.1 REGULATED AREA FOR GROUNDWATER PUMPAGE



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.3.2 YEARLY DISCHARGE OF FUTURE PLANS (1)
JAPAN INTERNATIONAL COOPERATION AGENCY	



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.3.3 YEARLY DISCHARGE OF FUTURE PLANS (2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

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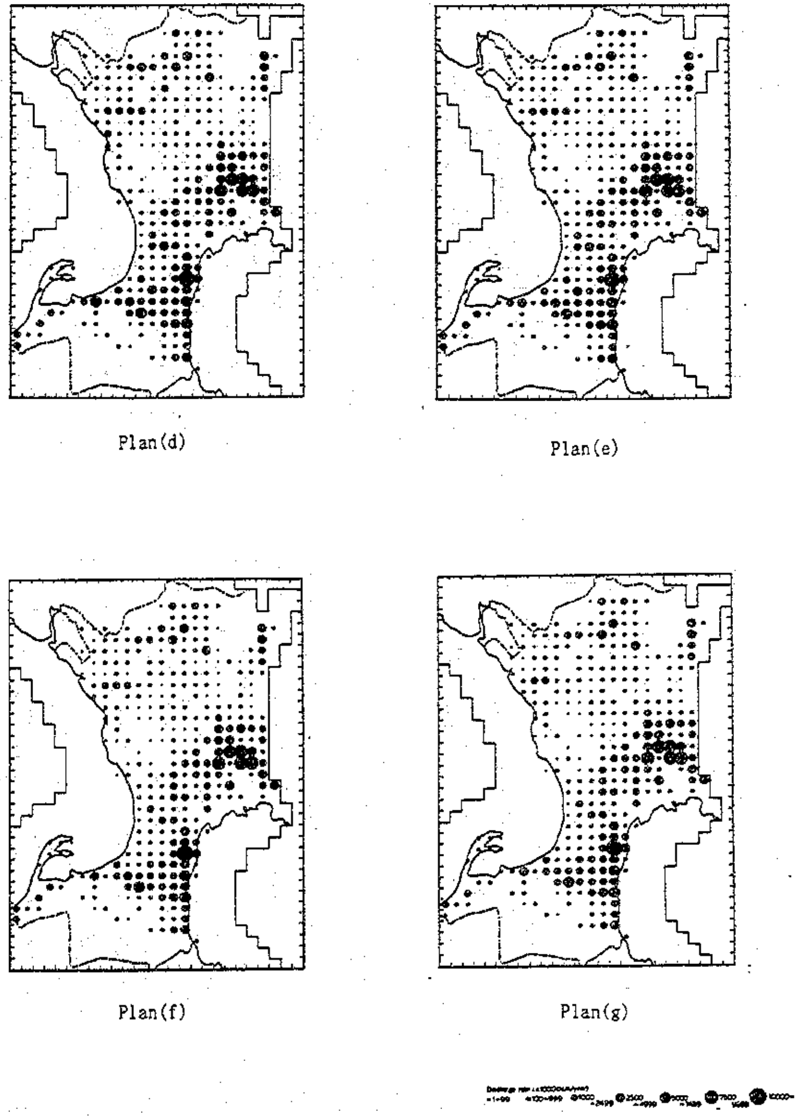
FIGURE 9.3.4 DISCHARGE DISTRIBUTION OF FUTURE PLANS IN 2010 (1)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

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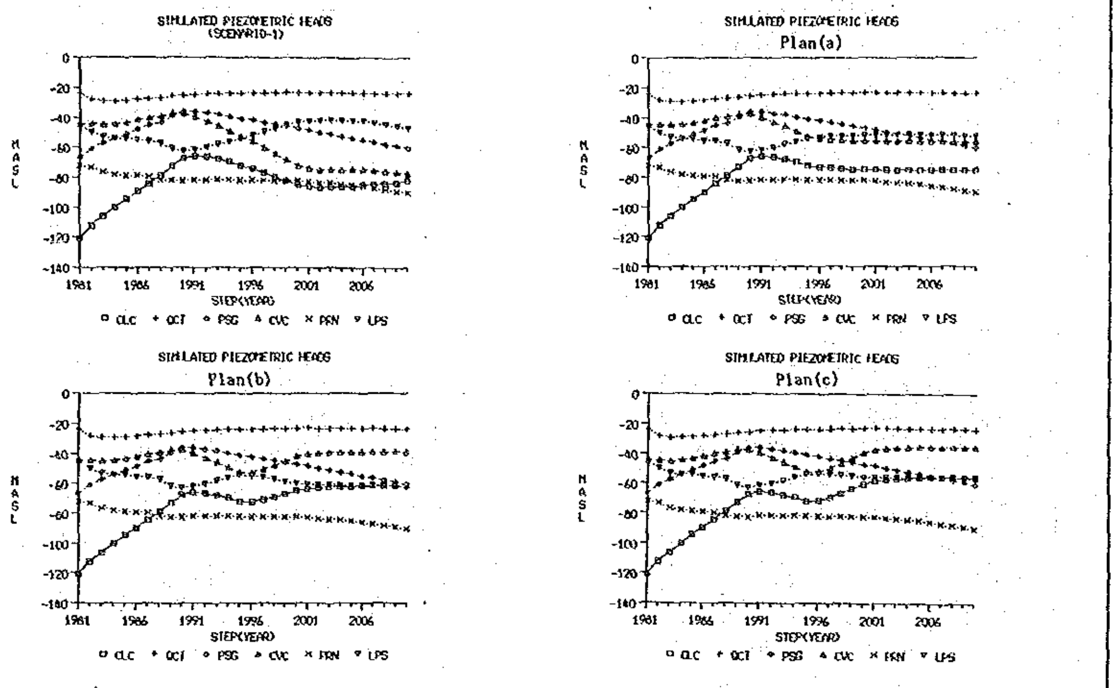
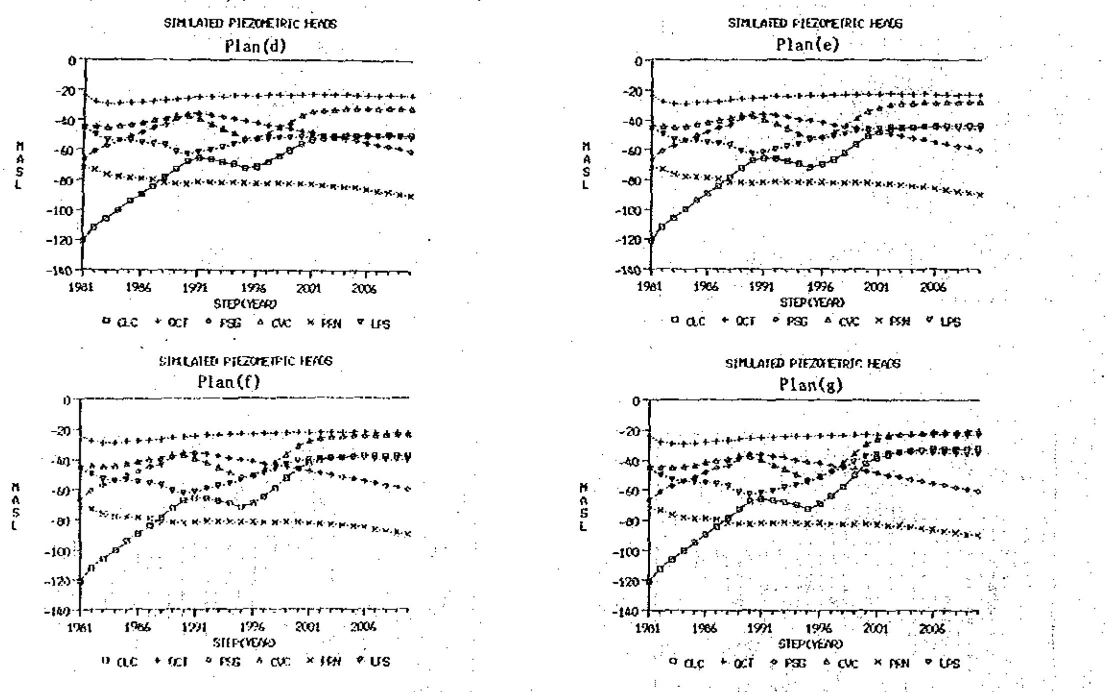
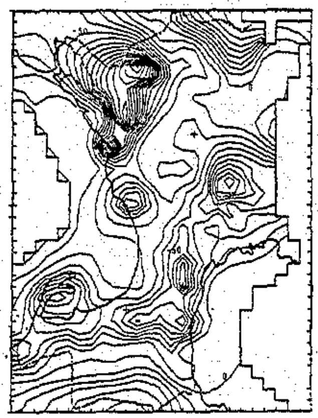
FIGURE 9.3.5 DISCHARGE DISTRIBUTION OF FUTURE PLANS IN 2010 (2)



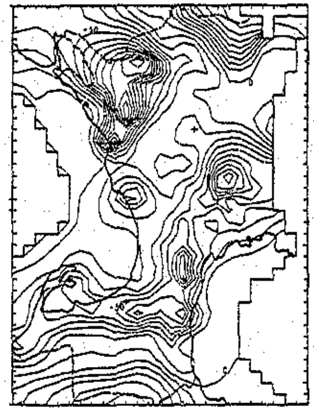
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.3.6
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC CHANGES BY THE FUTURE DISCHARGE PLANS (1)



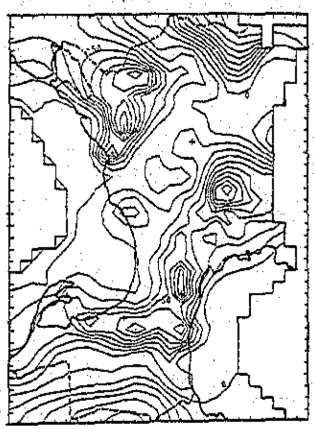
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.3.7
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC CHANGES BY THE FUTURE DISCHARGE PLANS (2)



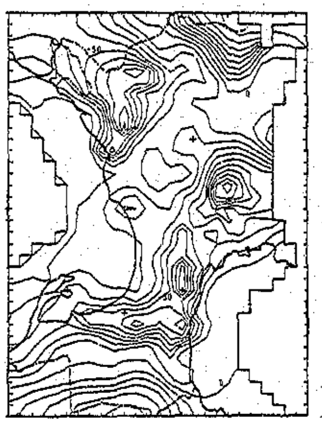
Scenario 1



Plan(a)



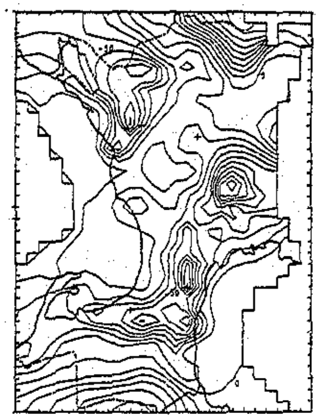
Plan(b)



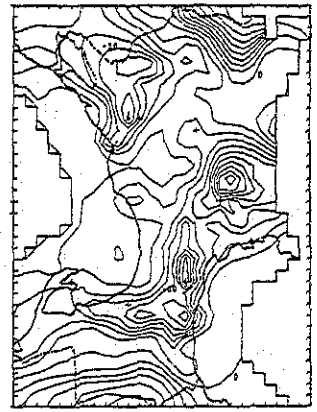
Plan(c)

(Contour Interval: 10m, Unit: masl)

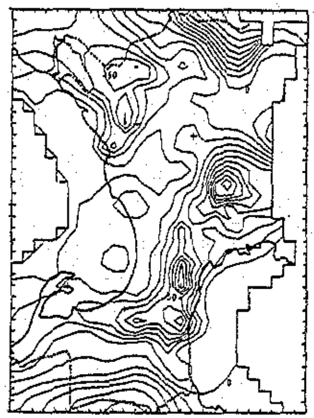
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.3.8 SIMULATED PIEZOMETRIC HEADS IN 2010 BY THE FUTURE DISCHARGE PLANS (1)
JAPAN INTERNATIONAL COOPERATION AGENCY	



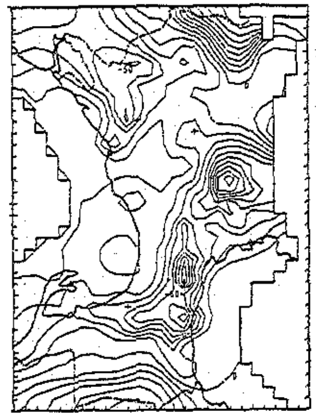
Plan(d)



Plan(e)



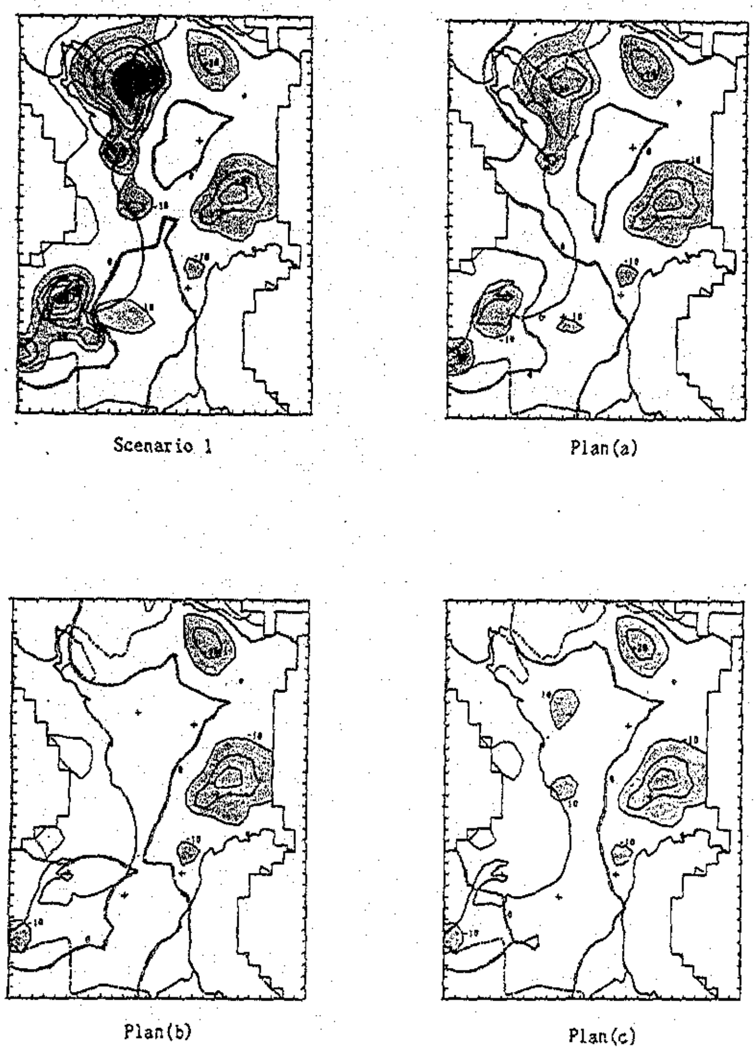
Plan(f)



Plan(g)

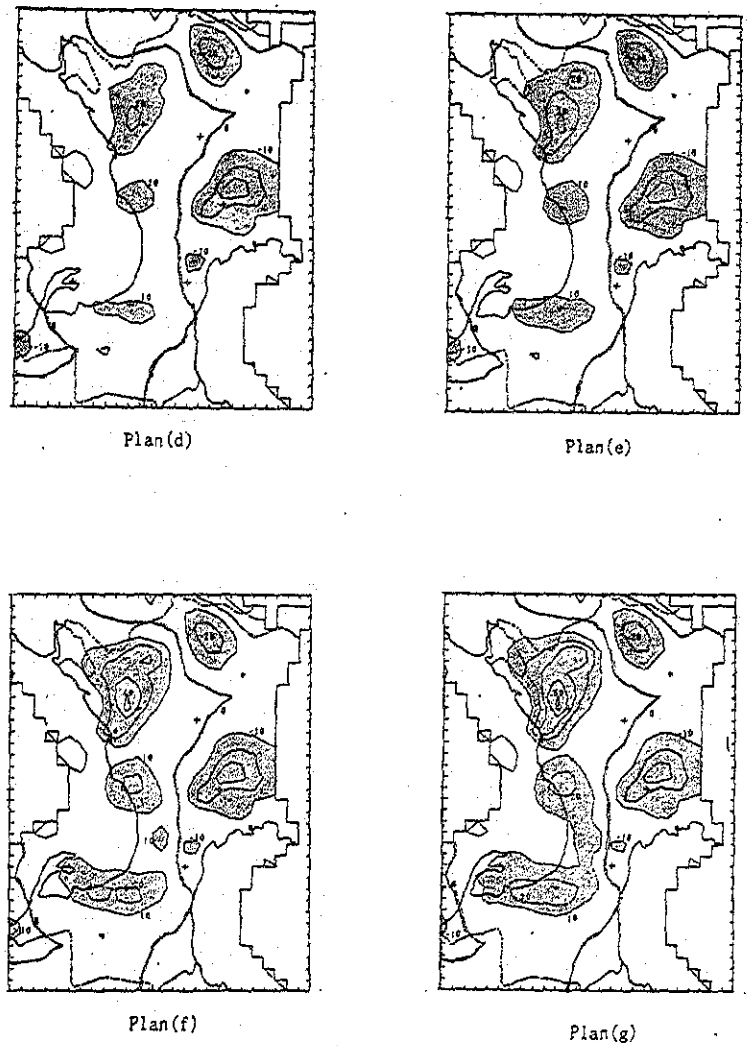
(Contour Interval: 10m, Unit: masl)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.3.9 SIMULATED PIEZOMETRIC HEADS IN 2010 BY THE FUTURE DISCHARGE PLANS (2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



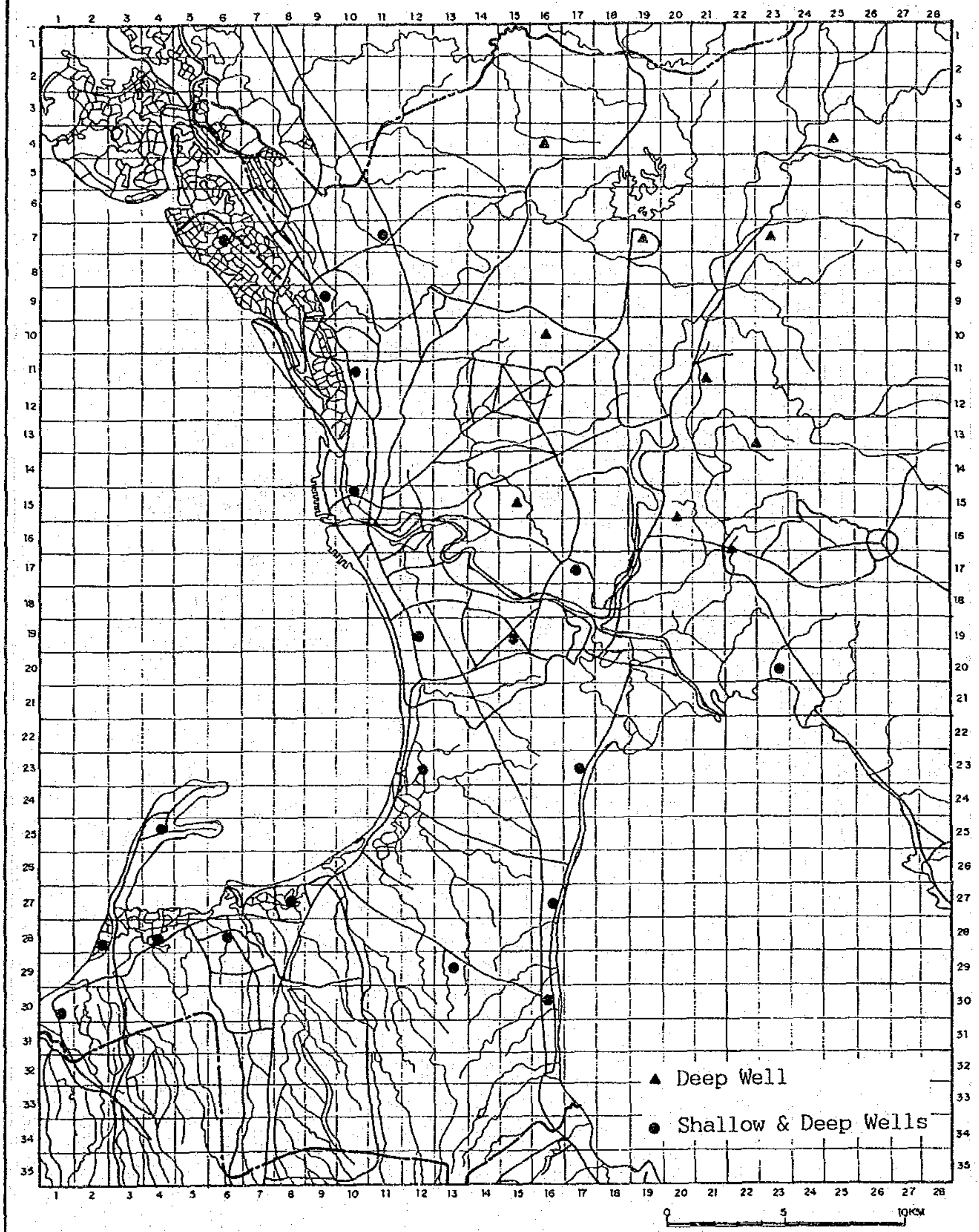
(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.3.10 SIMULATED PIEZOMETRIC CHANGES FROM 1991 TO 2010 BY THE FUTURE DISCHARGE PLANS (1)
JAPAN INTERNATIONAL COOPERATION AGENCY	



(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.3.11 SIMULATED PIEZOMETRIC CHANGES FROM 1991 TO 2010 BY THE FUTURE DISCHARGE PLANS (2)
JAPAN INTERNATIONAL COOPERATION AGENCY	

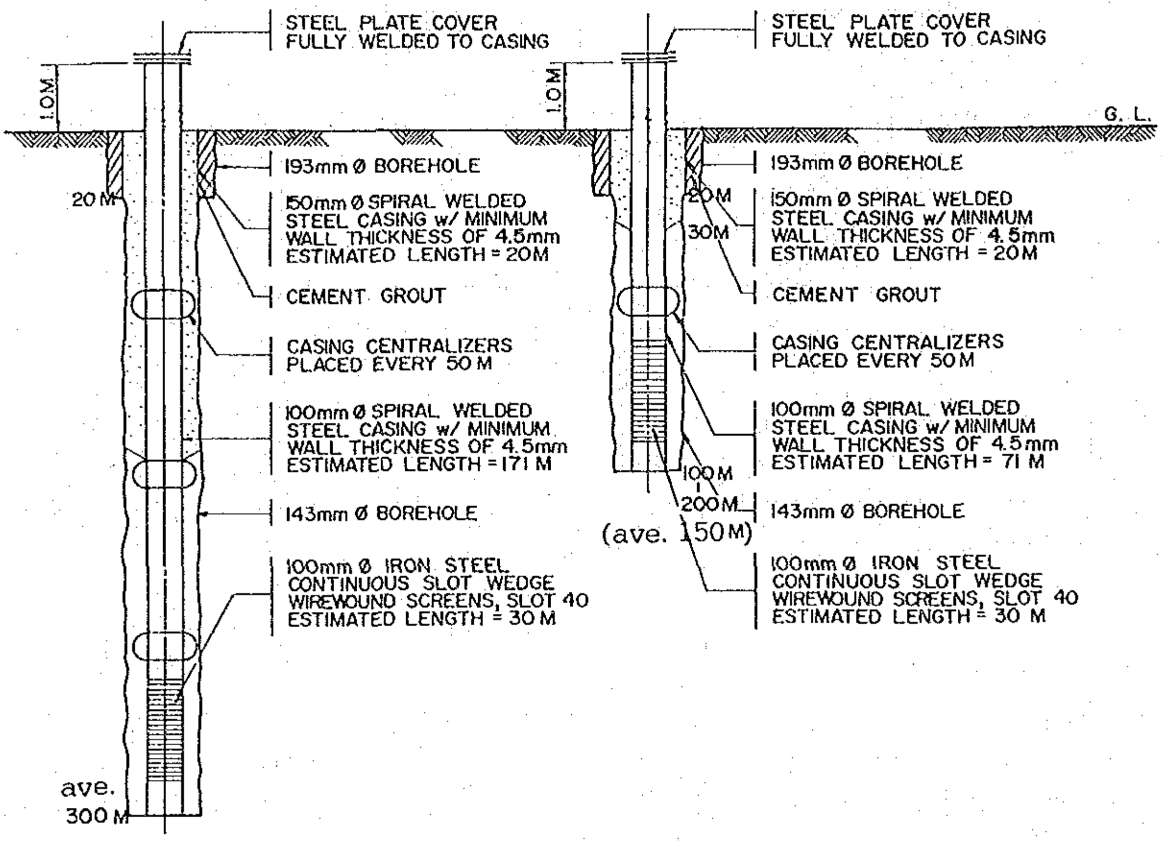


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.5.1

LOCATION MAP OF PLANNED MONITORING WELLS



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.5.2
JAPAN INTERNATIONAL COOPERATION AGENCY	PROVISIONAL DESIGN OF MONITORING WELLS

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

10.1 CONCLUSIONS

10.1.1 Rehabilitation of MWSS Wells

MWSS wells were in most cases damaged by superannuation, defective pumping units and saline water intrusion. Of the 258 MWSS wells, 52 have already been abandoned.

The proposed rehabilitation plan calls for the rehabilitation of 100 MWSS wells whose primary damage was caused by defective pumping units. Particular importance is attached to the augmentation of pumpage in areas where groundwater is the only reliable water source.

As a result of rehabilitation, an increment of 27,000 CMD of pumpage is expected. The allocation of this increment however should be made in accordance with the tentative permissive yield. The plan will cost about 53 million pesos.

10.1.2 Groundwater Development in Antipolo

The subject area of groundwater development is the small groundwater basin constituted by the Antipolo area forming an isolated plateau at elevation of 200m plus.

Based on hydrogeologic surveys and computer simulations, said basin could yield an optimum of 28,000 CMD of groundwater. Since existing wells presently abstract groundwater at a volume of about 20,000 CMD, the exploitable volume therefore is 8,000 CMD. About 2,000 CMD of this exploitable volume would be accounted for by the increment in pumpage of rehabilitated MWSS wells. The remaining 6,000 CMD is to be tapped by the seven (7) new deepwells proposed to be constructed, as discussed elsewhere in this report.

The construction cost of the proposed new wells is about 14.7 million pesos.

It is further recommended that the plan for the transmission of surface water from the CDS to the Antipolo area be implemented. Although the groundwater supply can meet the water demand in the area in daily average base for about ten years, this supply would be critical come the year 2000. It is also necessary that the construction of new private wells be regulated and, as the basin is narrow and the recharge is limited, that groundwater level and quality be monitored to prevent the decline and deterioration of the groundwater resource.

10.1.3 Saline Water Intrusion Mechanism

The mechanism of saline water intrusion in the Las Piñas area was investigated through detailed hydrogeologic surveys and computer simulations. The investigation revealed the shallow aquifers in the area within 2km from the coastline, at depths less than 100m, to be extensively contaminated by saline water. This saline water migrates towards deeper aquifers at depths of more than 200m. Computer simulation results point to the Manila Bay and marine ponds along the coast to be origins of the saline water path. The saline water intrudes, moves and diffuses inland towards areas of depression of the piezometric head. Tidal rivers and salt beds were also identified as significant sources of saline water.

If pumpage is further increased in the near future, the contamination of the deeper aquifers at depths of more than 300m would likely result.

10.1.4 Groundwater Monitoring in Metro Manila

The pumpage in the MSA would become 1,121 CMD in the year 2000 and 1,278 CMD in the year 2010 at the scenario 1, as results of the on-schedule completion of proposed and ongoing water supply projects. Under this scenario, a maximum decline of 83m from the present groundwater level is predicted to occur at the northwestern part of Metro Manila. To prevent the expansion of the saline water-intruded area, which would surely result from this decline, it is necessary that a tentative yield of the groundwater basin be set. This tentative yield should also make possible the year-round utilization of groundwater.

The tentative yield of the groundwater basin is the amount of pumpage that brings no unwanted effects, like saline water intrusion for instance. The groundwater management plan targets reducing pumpage to this tentative yield, reallocating it by area, step-by-step, and properly considering coverage of the substitutional water supply.

If the year-1990 pumpage is reduced by 50% in the coastal area--that is, 905,900 CMD for the whole basin--the results of simulation studies indicate that maximum recoveries of groundwater levels can be expected to occur at the northern and southern parts of Metro Manila, respectively at 55.3m and 30.7m. This reduced pumpage, for practical reasons, can be the tentative target yield of the groundwater management plan for the Study Area. It is noted, however, that even if saline water intrusion could still occur using this yield, it would take 15 years for saline water to reach the piezometric head depressions in southern Metro Manila. By that time, a more realistic target yield should have already been in place and the measures incorporated in the groundwater management plan are fully operational.

Monitoring of groundwater pumpage, groundwater levels and quality are requisites for effective implementation of the groundwater management plan, and for the more accurate setting of the target yield as well. The groundwater monitoring program proposed in this study is deemed to have the capability to achieve such purpose.

10.2 RECOMMENDATIONS

10.2.1 Groundwater Development

(1) Promotion of Rehabilitation Program

Considering the constraints against the early completion of the short and medium-term surface water supply projects, it is urgent that implementation of the rehabilitation project proceed at once so that the present groundwater supply may be augmented.

(2) Development and Conservation of Groundwater in Antipolo

Antipolo area is located on an isolated plateau with limited water resources. The anticipated increase of water demand in the future due to population growth makes it indispensable to develop groundwater for a short to medium term water supply. Since the groundwater basin is small and recharge is limited, groundwater development must be within the optimal yield estimated in this study. This proposal assumes that the development of private wells shall be regulated. However, this shall be further studied as an integral part of the overall groundwater management program for the whole Metro Manila.

(3) Groundwater Investigation in Rizal Province

Except for Angono, the current dependence on groundwater of the nine (9) municipalities of Rizal Province under BP 799 shall continue in the future. These municipalities located along the northern and eastern coasts of Laguna de Bay will be developed in the future to constitute the eastern corridor of Metro Manila. But as the hydrogeology of the Guadalupe Formation in this area is not investigated yet, the possibility of groundwater development is still vague. Accordingly, it is recommended that a detailed hydrogeologic study of the area be carried out in order to clarify its groundwater potential.

Plans and projects proposed in the Study are summarized in Table 10.2.1. The earliest implementation of these projects is strongly recommended.

10.2.2 Groundwater Monitoring

(1) Monitoring of Groundwater Levels and Quality

A monitoring system is vital to the plan for the management of groundwater resources. A groundwater management system using computer simulation requires accurate groundwater data which are obtained by means of periodic observation of groundwater levels and quality. It is therefore recommended that the observation of JICA test wells in Las Piñas be continued and the proposed monitoring wells be constructed soonest.

(2) Application of the Database System

The database system established in MWSS processes meteorological and hydrological data, groundwater levels, water quality data, well inventory, etc. Groundwater data of Metro Manila must be stored continuously in the future. In particular, the MWSS well inventory together with those of other agencies like NWRB and LWUA must be used and operated jointly as a common database.

(3) Improvement and Application of Groundwater Simulation Models

Groundwater simulation models established in MWSS must be improved in the future. The accurancy and reliability of the models can be improved through clarification of the hydrogeology of the area, submission by users of their record of groundwater pumping, collection and analysis of more accurate aquifer parameters, observation of groundwater levels and quality, and so forth.

Jointly with the groundwater database system and the groundwater monitoring system, groundwater models shall be applied as tools in groundwater management; specifically, in assessing and predicting groundwater levels and quality and in evaluating the permissive yield of the basin.

(4) Regional Leveling

No clear evidence of the land subsidence phenomenon in Metro Manila has been found. However, based on the records of the tidal gauging station, the mean sea level of Manila Bay appears to have risen in the past 25 years. In order to clarify whether the rise of the mean sea level was due to vertical displacements of land, it is necessary to temporarily place an immovable point in a nearby mountainous area that is composed of base rocks and use such point to conduct periodic levelings of existing and newly constructed benchmarks.

10.2.3 Groundwater Management

In order that groundwater may be used as a perennial water source in Metro Manila, it is necessary that the present chaotic groundwater development situation in the area be righted without any further delay. In this sense, the implementation of the proposed groundwater management plan is strongly recommended. Since the details of this plan have already been described in the previous chapters, several recommendations can be summarized as follows:

(1) Establishing Groundwater Management Committee

Tasked to implement groundwater management in Metro Manila, the NWRB is recommended to establish a groundwater management committee within its organization. The committee shall deal with institutional and legal measures, socio-economic assessment, analysis and evaluation of groundwater data, revision of groundwater management policies in cooperation with other concerned government agencies.

(2) Arrangement of Legislation

The groundwater management plan necessitates the regulation of pumpage in the future . Prior to actual pumpage regulation, the practical application of the Philippine Water Code to this contemplated regulation and the enforcement of the water code itself must first be thoroughly studied.

It is considered that the water code is basically applicable to the regulation of pumpage. However, studies on the practical rules and regulations regarding the designation of areas where pumpage is to be regulated, the purpose of groundwater use, the facilities for abstracting groundwater, the standard physical measurements of the facilities in a certain designated area for water rights application, the reporting of pumpage in terms quantity and quality and groundwater levels by the users, the measures to be taken during the moratorium, the penalties to be imposed, etc., should be undertaken as a preparatory program for groundwater management.

The present water code requires the groundwater users to secure water permits, except users of shallow well for domestic purpose. Measurement and reporting of groundwater levels and pumping rate are now being neglected by the users. Prior to the proposed regulation therefore, each groundwater user must be required to install a water meter and to periodically measure the groundwater level before issuing a new water right or renewing existing water permit. This requirement is considered to be feasible by a slight amendment of the present implementing rules and regulations of the water code.

(3) Organization

The Groundwater Monitoring Unit (GMU) belonging to the Planning and Programming Department (PPD) of MWSS is tasked to conduct the investigation, observation, analysis and evaluation of groundwater in the MSA. Aside from this, as MWSS is deputized by NWRB to investigate and assess the water permit applications within the MSA, GMU does the studies and recommends the allowable groundwater pumpage. Considering the importance of the role of GMU in groundwater development and management in the MSA, the strengthening of its organization by elevation of its organizational level and increasing its manpower is necessary.

In addition, GMU shall be positioned as a technical task force in the groundwater management committee for Metro Manila in the observation, monitoring, analysis and evaluation of groundwater data.

(4) Education and Training of Groundwater Engineers

It is urgent to train groundwater engineers in order to strengthen or support the organization that shall implement the proposed groundwater management program. Government agencies such as MWSS, DPWH, LWUA, and NIA must cooperate with each other and transfer their engineers to said organization. Groundwater development and management have their own comprehensive technology, and the component technology alone is already extensive. Thus vast knowledge and experience are essential. These engineers shall participate in on-the-job training in groundwater projects, training in developed countries, groundwater seminars, etc.

10.2.4 Concluding Observations

Two final observations are offered with respect to the rational use and sustained adequacy of water supply in Metro Manila. First, additional attention should be devoted on the establishment of policies on groundwater development and management. Progress in this regard can be achieved if the present concerned offices are able to integrate their responsibilities and operations. Second, significant emphasis should be placed on water supply projects which answer in a fundamental way the progressively increasing water demand in the metropolis. The implementation of the Manila Water Supply Project III (MWSP III), for instance, should be vigorously pursued. It would also substantially ease the strain on groundwater resources.

TABLE 10.2.1 SUMMARY OF GROUNDWATER DEVELOPMENT AND MANAGEMENT PROGRAM

Program	Outline	Cost x1,000 peso	Duration months
1. Rehabilitation of MWSS Wells	Rehabilitation of 100 wells in MWSS	53,000	16.0
2. Groundwater Development in Antipolo	7 deep wells (depth:150m, dia.:8") Development of 5,800 m3/day	48,320	16.0
3. Groundwater Monitoring in Metro Manila	Monitoring wells:20 units of 150m well 30 units of 300m well Recording units & Computers	72,050	36.0
4. Groundwater Investigation in Rizal Province	Detailed hydrogeologic survey	25,000	12.0
Total		198,370	

JICA