In regard to groundwater management, the NWRB functions include the control of well drilling, the abstraction of groundwater, data collections, water rights, rules and regulations, inter-agency agreements and registration of wells. The Water Rights Division mainly deals with these matters.

The MWSS, which does the studies regarding groundwater management in Metro Manila, is deputized by NWRB to investigate and assess the water permit applications within the MSA. NWRB consults the MWSS on how much pumpage/withdrawal should be allowed to the applicants based on the MWSS's evaluation of the current groundwater condition in the locality.

For provincial areas the LWUA and the NIA act as the responsible agencies, being deputized by the NWRB in the appraisal of water permit.

The Environmental Management Bureau (EMB), formerly National Environmental Protection Council (NEPC), is also a member of the NWRB, representing DENR. The EMB is deputized by the NWRB to deal with water permit applicants for industrial use.

9.2.2 Legal Aspects

(1) The Water Code

The Water Code of the Philippines was enacted by Presidential Decree No. 1067 in December 1976. Its implementing Rules and Regulations were promulgated in 1979.

The objectives and the underlying principle of this code are stated in Articles 2 and 3. As clearly mentioned in Art. 2, the main objective is to establish the basic principles and framework regarding the appropriation, control and conservation of water resources to achieve the optimum development and rational utilization of these resources.

The Code states that all waters belong to the State and the utilization, exploitation, development, conservation and protection of water resources shall be subject to the control and regulation of the government through the National Water Resources Council (now the National Water Resources Board (NWRB)).

The need for a water permit is stated in Article 13 of the Code and to wit: No one who shall engage in municipal water supply or irrigation has any legal basis for appropriating groundwater and distributing it to customers without first securing a water permit.

The Code allows the owner of the land where the water is found to use it for domestic purposes, provided that such use be registered when required by NWRB (as stated in Art. 6). For all other situations, the Code and its Implementing Rules and Regulations set forth the process for securing a water permit.

(2) Water Permit

At present, the water permit is the principal method of managing groundwater resources in the Philippines. Based on the Water Code and its implementing Rules and Regulations, the water permit applications are processed as illustrated in Figure 9.2.2. The process is summarized as follows.

The application for water permit is filed at the Office of the DPWH District Engineer, NIA Provincial Irrigation Office, NPC Regional Office or the Office of the Water District, whichever is deputized by the NWRB in the provinces. In Metro Manila, it is filed directly at the NWRB.

Copies of correct applications are posted for sixty (60) days. If there is no protest, a technical appraisal is made by deputized agency.

In Metro Manila, the MWSS recommends the allowable pumpage/withdrawal for the applicant. After the recommended pumpage is received by the NWRB, a "permit to drill" is issued by the NWRB, this permit being valid for 6 months. Upon issuance of the permit, the NWRB requires that a report on the drilling operations of the well be submitted before it issues a water permit. The drilling report is re-evaluated by the NWRB to see if the recommended allowable withdrawal of water by the MWSS is attainable by the well. In the issuance of water permit, the withdrawable amount that is granted by the NWRB is the lesser figure between the recommended pumpage and actual yield of the well.

However, several problems regarding water permit had been pointed out in a previous investigation on the control of well drillings and abstractions (NEPC, 1987). Major issues pointed out were:

1) Practical limitations in administration and enforcement;

2) Permit gives no incentive to the abstractor for him to be efficient in his use of water; and

3) Permit charges do not reflect a sufficient cost to reflect water scarcity, nor allow non-permit holders to be compensated.

(3) Other Policies and Regulations in the Water Code

Other important policies on groundwater stated in the Water Code are as follows:

a) In Art. 32, the NWRB declares the existence of a "Control Area" and promulgates rules and regulations for the coordinated development, protection, and utilization of groundwater and surface water. Control Area is an area of land where subterranean water or groundwater and surface water are so interrelated that withdrawal and use in one inevitably affects the other.

   The concept of Control Area is important and useful in designating the area of groundwater regulation.

b) Art. 70 states that without prior permit no person shall utilize an existing well or pond or spread waters for recharging subterranean or groundwater supplies.

c) Art. 95 specifies the order of preference in the use of water. Between two or more appropriations of water from the same source of supply, priority shall be in accord with the time-order in which water permits were secured; however, when the priority in terms of time-order cannot be determined, the order of preference is:

   a. Domestic and municipal use
   b. Irrigation

c. Power generation
d. Fisheries
e. Livestock raising
f. Industrial use, and
g. Other uses.

d) In Section 7 of the Code's Implementing Rules and Regulations, an annual water charge for all appropriators is prescribed in accordance with the following schedule:

Rate of Withdrawal (liter/sec)	Charge per liter/sec (Pesos)
Not more than 30	0.50
More than 30 but not exceeding 50	0.75
More than 50	1.00

9.3 REGULATION OF PUMPAGE

As discussed in the previous section, regulations already exist for groundwater abstraction. However, many regulations are presently being ignored or not applied because of the difficulties and delays encountered in implementing them. Institutional strengthening to support the technical and regulatory measures in groundwater management is therefore urgently needed.

Sections 23 to 25 of the Water Code include provisions regarding the declaration of "Control Areas". Based on the provision, it is clear that the NWRB has the mandate to declare "Control Areas" and to issue regulations for said areas governing the development, protection and utilization of groundwater.

The Control Area may be designated in the area where saline water has intruded and where development of an alternative water source is needed. Pumping may be regulated and reduced in the Control Area in order to recover groundwater levels. The following paragraphs describe a proposed plan of regulation.

(1) Zoning of Regulated Area

The proposed plan has the Metro Manila groundwater basin subdivided into three (3) areas for groundwater regulation (Figure 9.4.1). 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 "A" and "B" areas, including Antipolo groundwater basin.

(2) Schedule of Regulation

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

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

b) 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.

c) Third Stage (Monitoring and Adjustment): Groundwater use shall be re-organized by purpose and by area considering the order of preference in the use of groundwater.

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

9.4 A TENTATIVE TARGET OF GROUNDWATER MANAGEMENT

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

Pumpage Control Settings

1) Regulated Area

A regulated area for groundwater pumpage was established along the coastal area of Metro Manila (Figure 9.4.1), 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. (south) Caloocan City, 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, and the target regulated pumpage is expected to be reached by year-2000. The 5-year period from 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 rates. Seven (7) pumpage regulation plans were made for the simulations:

Plan (a): Year-1995 pumpage of Scenario 1 is maintained up to 2010. (Figures 9.4.2 and 9.4.4)

Plan (b): Target regulated pumpage by 2000 is the 1990 pumpage. (Figures 9.4.2 and 9.4.4)

Plan (c): Target regulated pumpage by 2000 is 90% of the 1990 pumpage. (Figures 9.4.2 and 9.4.4)

Plan (d): Target regulated pumpage by 2000 is 80% of the 1990 pumpage. (Figures 9.4.3 and 9.4.5)

Plan (e): Target regulated pumpage by 2000 is 70% of the 1990 pumpage. (Figures 9.4.3 and 9.4.5)

Plan (f): Target regulated pumpage by 2000 is 60% of the 1990 pumpage. (Figures 9.4.3 and 9.4.5)

Plan (g): Target regulated pumpage by 2000 is 50% of the 1990 pumpage. (Figures 9.4.3 and 9.4.5)

Results of the Simulations

The results are summarized in Table 9.4.1 and Figures 9.4.6 to 9.4.11.

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 by year 2000. Maximum drawdowns of 9.7m in the north and 18.7m in the south are predicted, which are mainly due to the increase in pumpage between 1991 and 1995.

Plan (c) to plan (g) reduce the 1995 pumpage to target regulated pumpages lesser than the 1990 pumpage level. The recovery of the piezometric heads upon the level of the target regulated pumpage in the 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 pumpage regulation not only in the coastal area but also in the inland area.

9.5 IMPLEMENTING BODY FOR GROUNDWATER MANAGEMENT

The NWRB should be the lead agency for the implementation of the proposed groundwater management plan 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.

In order to implement the groundwater management plan in Metro Manila, a special committee may be established and be composed of the present NWRB Board members; the heads of the six Departments and the four line agencies (MWSS, LWUA, NPC and NIA).

The Groundwater Monitoring Unit (GMU) belonging to the Planning and

Programming Department (PPD) of MWSS is the organization responsible for groundwater studies. Considering the importance of the role of the GMU in groundwater development and management in the MSA, the strengthening of its organization by elevation of its organizational level and beefing up of its manpower is necessary. A better organizational arrangement would be to create a division that will handle the groundwater investigation, the design and construction of test wells, observation and monitoring of water levels and water quality, the analysis of data, and the hydrogeologic evaluation. Concurrently, the division shall act as the technical advisory staff in the proposed NWRB groundwater management committee.

9.6 SUBSTITUTIONAL WATER SUPPLY

The substitutional water supply system must be constructed in the areas of regulation prior to the enforcement of the relevant implementing rules and regulations of the Water Code. Measures for the substitutional water supply are 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. Groundwater is mainly used for the foods, the chemical, the leather and the textile industries. Accordingly, saving and rational use of groundwater should be targeted in these industries. Here, additional empirical research is required.

9.7 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 was made in order to effectively monitor groundwater levels and quality of the Guadalupe aquifers in the Metro Manila groundwater basin (Figure 9.7.1.).

A set of observation wells--one shallow and one deep--shall be constructed per monitoring location (Figure 9.7.2), except for ten sites where only one well shall be drilled. These wells are designed to facilitate automatic measurement of water level and quality (EC) and periodic collection of water samples for the 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, in conjunction with the groundwater database and the simulation models installed in the MWSS, will be used as a regular tool of groundwater management.

TABLE 9.4.1 SIMULATION RESULTS OF REGULATED DISCHARGE

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) (north) (masl)	(south) (masl)	Maximum head change in regulated area('10-'90) (north) (m)	(south) (m)	Simulated head in 2010(upper)(masl) Head change since 1990(lower)(masl) 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.

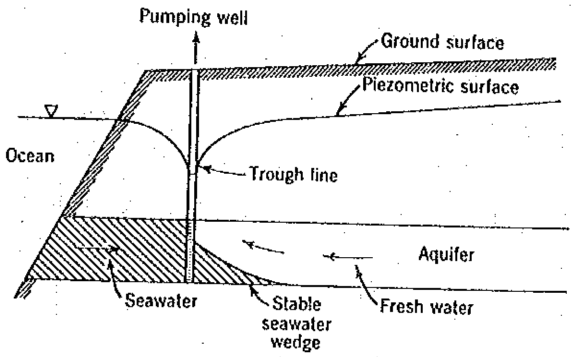


FIGURE 9.1.1 CONTROL OF SEAWATER INTRUSION BY AN EXTRACTION BARRIER FORMING A PUMPING TROUGH PARALLELING THE COAST

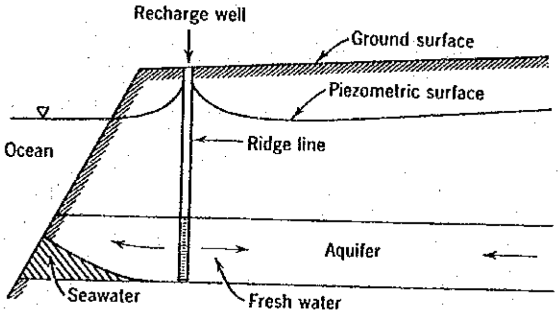


FIGURE 9.1.2 CONTROL OF SEAWATER INTRUSION BY AN INJECTION BARRIER FORMING A PRESSURE RIDGE PARALLELING THE COAST

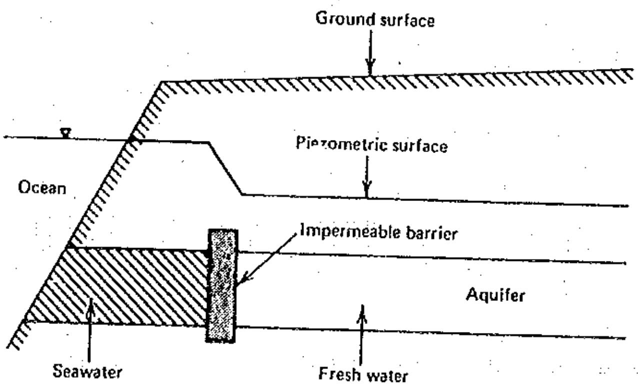


FIGURE 9.1.3 CONTROL OF SEAWATER INTRUSION BY AN IMPERMEABLE SUBSURFACE BARRIER PARALLELING THE COAST

TODD,D.K.(1980)

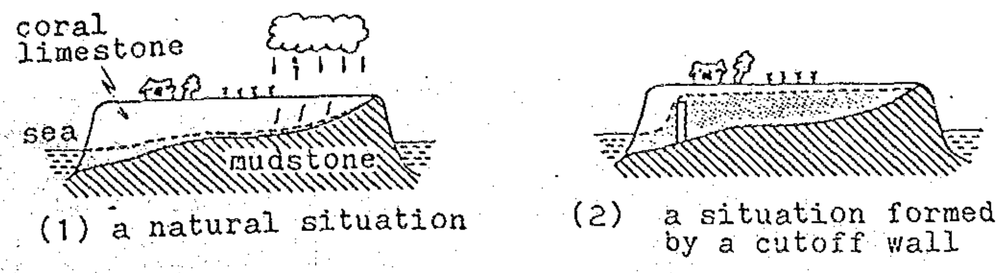


FIGURE 9.1.4(1) AN IDEA OF AN UNDERGROUND RESERVOIR

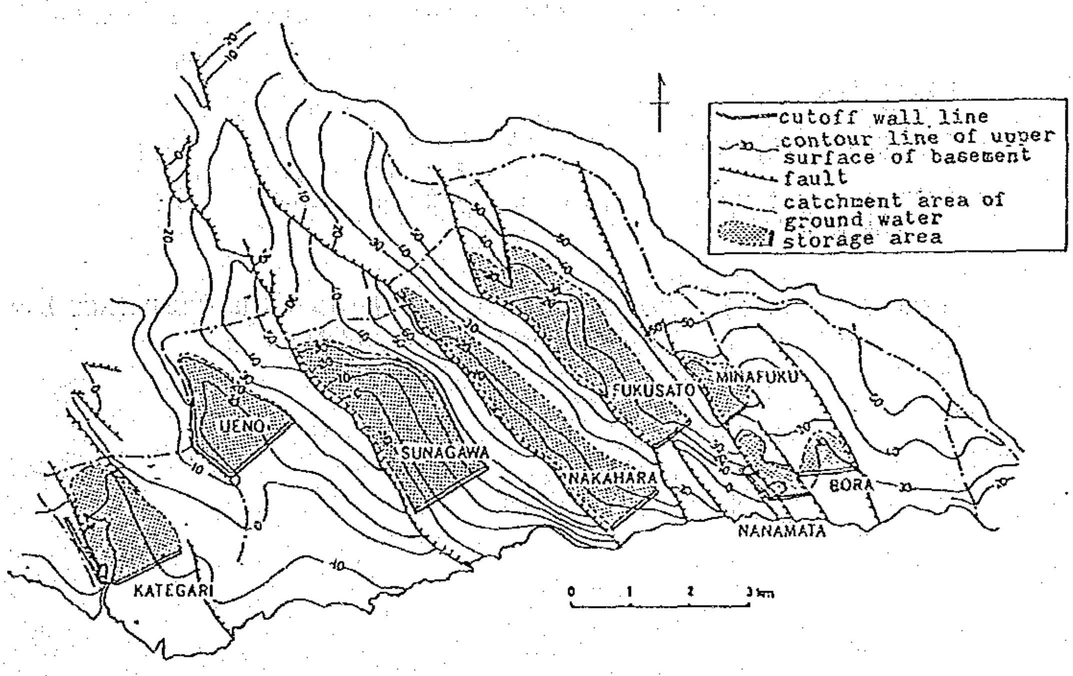


FIGURE 9.1.4(2) THE UNDERGROUND RESERVOIR DEVELOPMENT PROJECT AT MIYAKOJIMA ISLAND, JAPAN

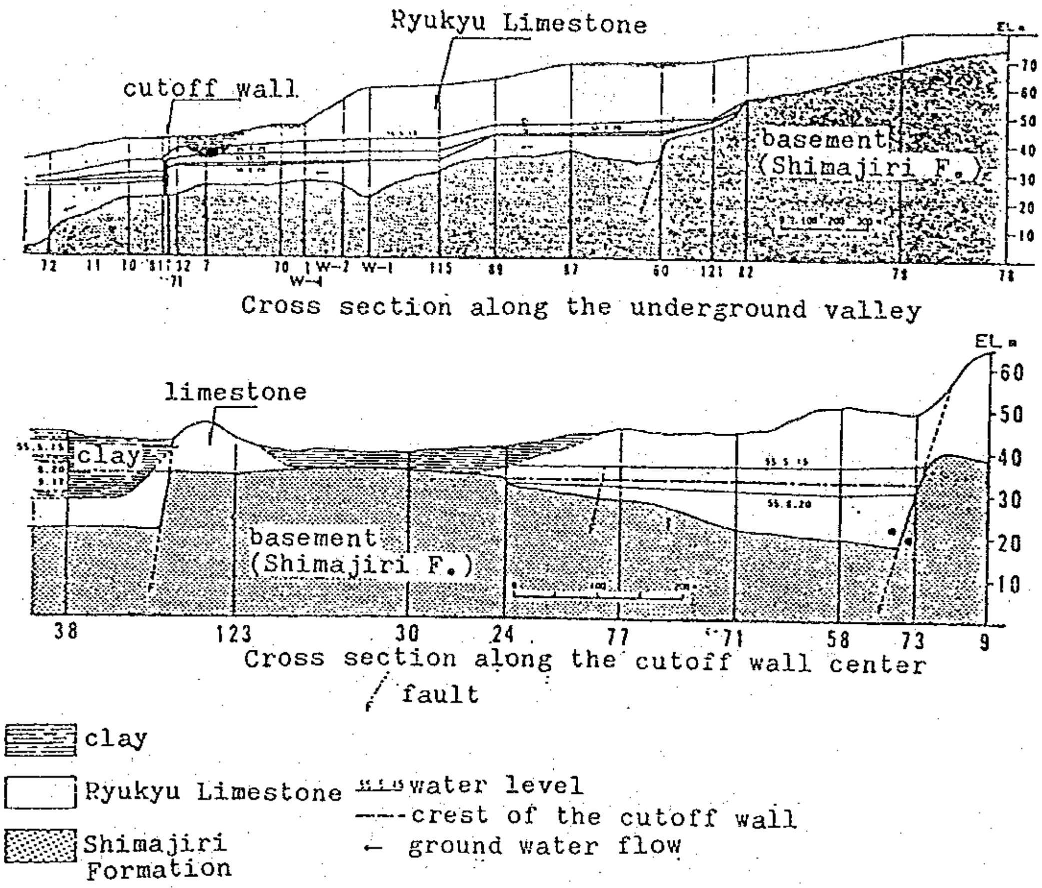
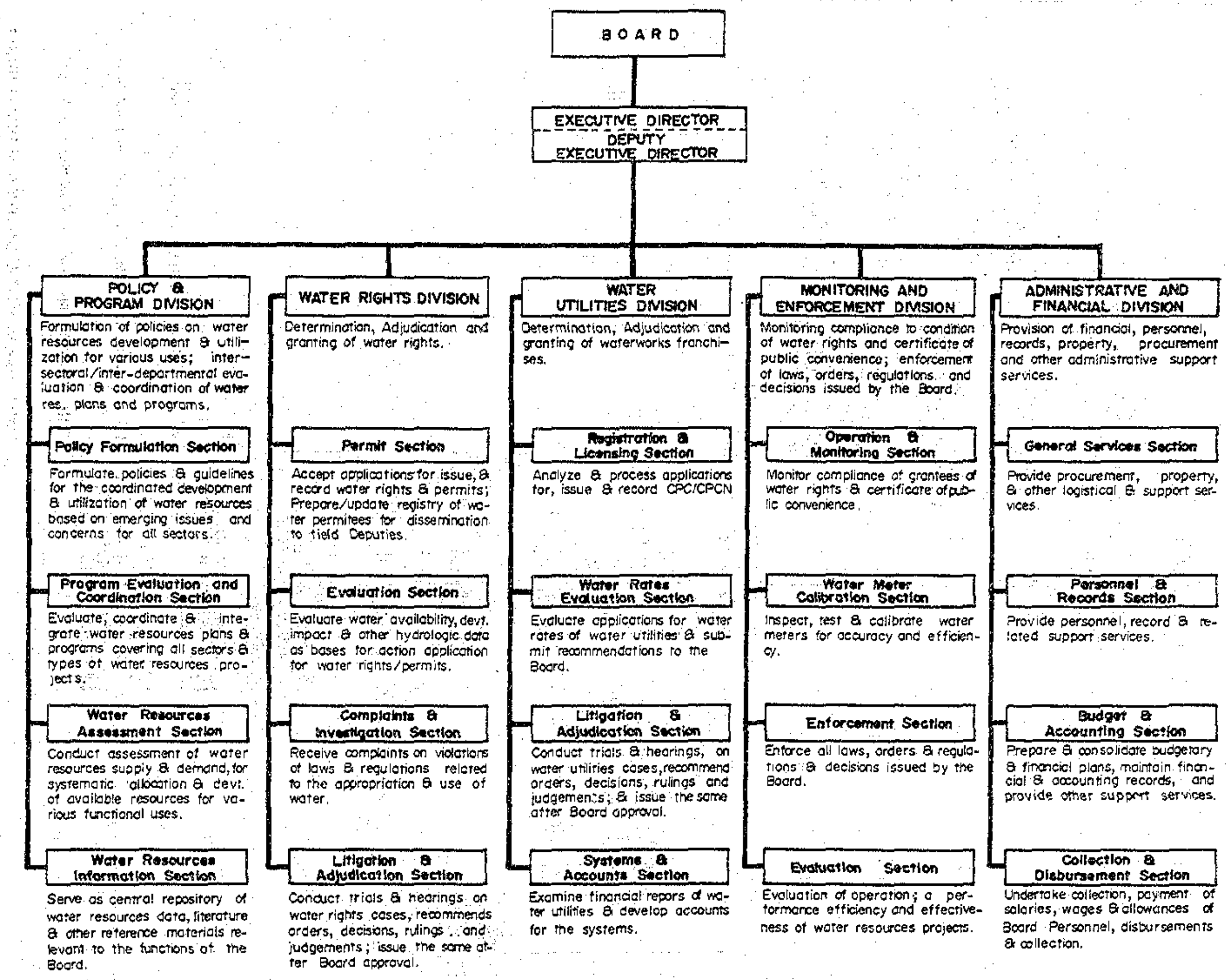


FIGURE 9.1.4(3) CROSS SECTION OF THE MINAFUKU SUBSURFACE DAM IN MIYAKOJIMA ISLAND, JAPAN

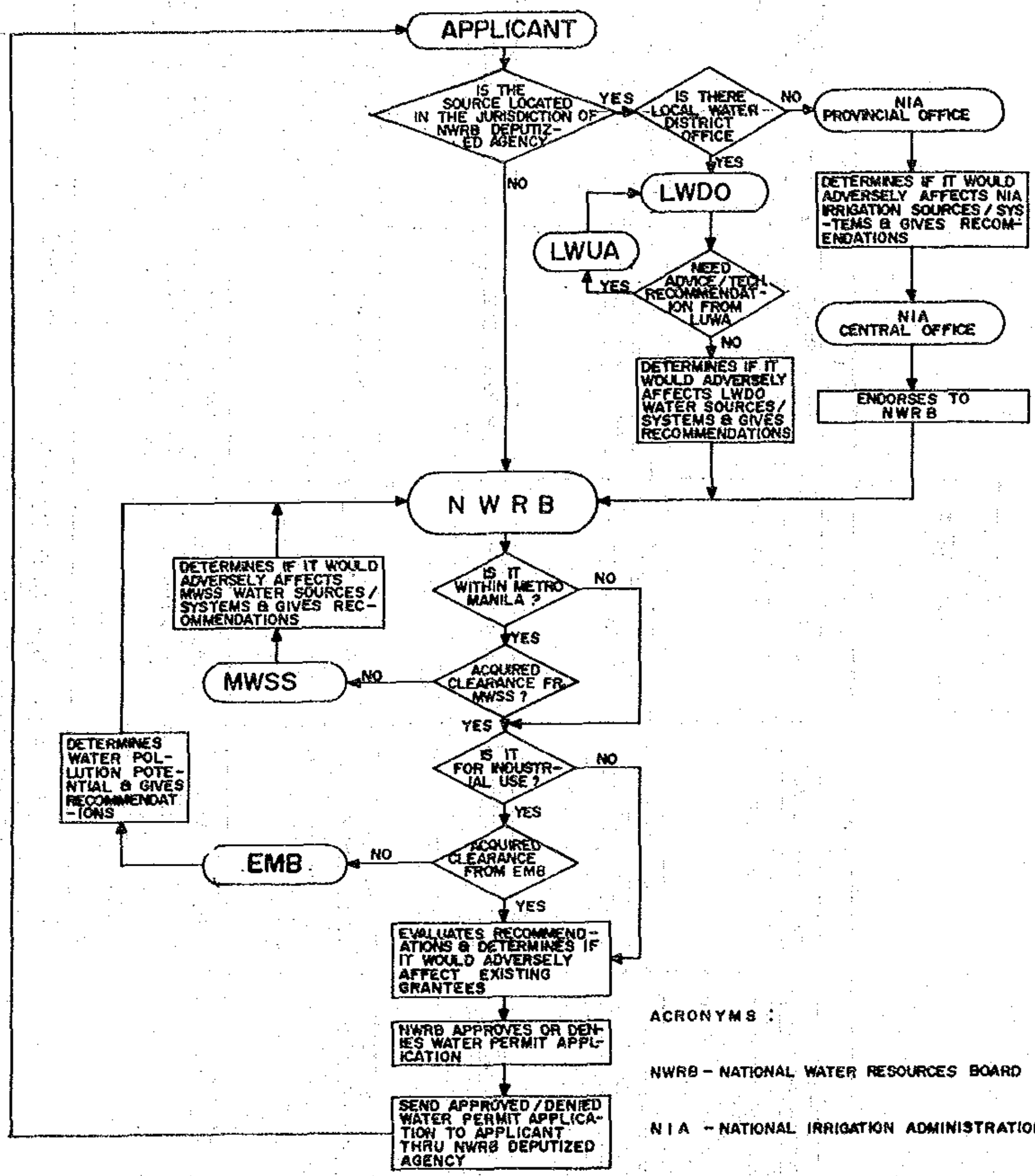


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.2.1

FUNCTIONAL CHART OF NWRB



ACRONYMS :

NWRB – NATIONAL WATER RESOURCES BOARD

N I A – NATIONAL IRRIGATION ADMINISTRATION

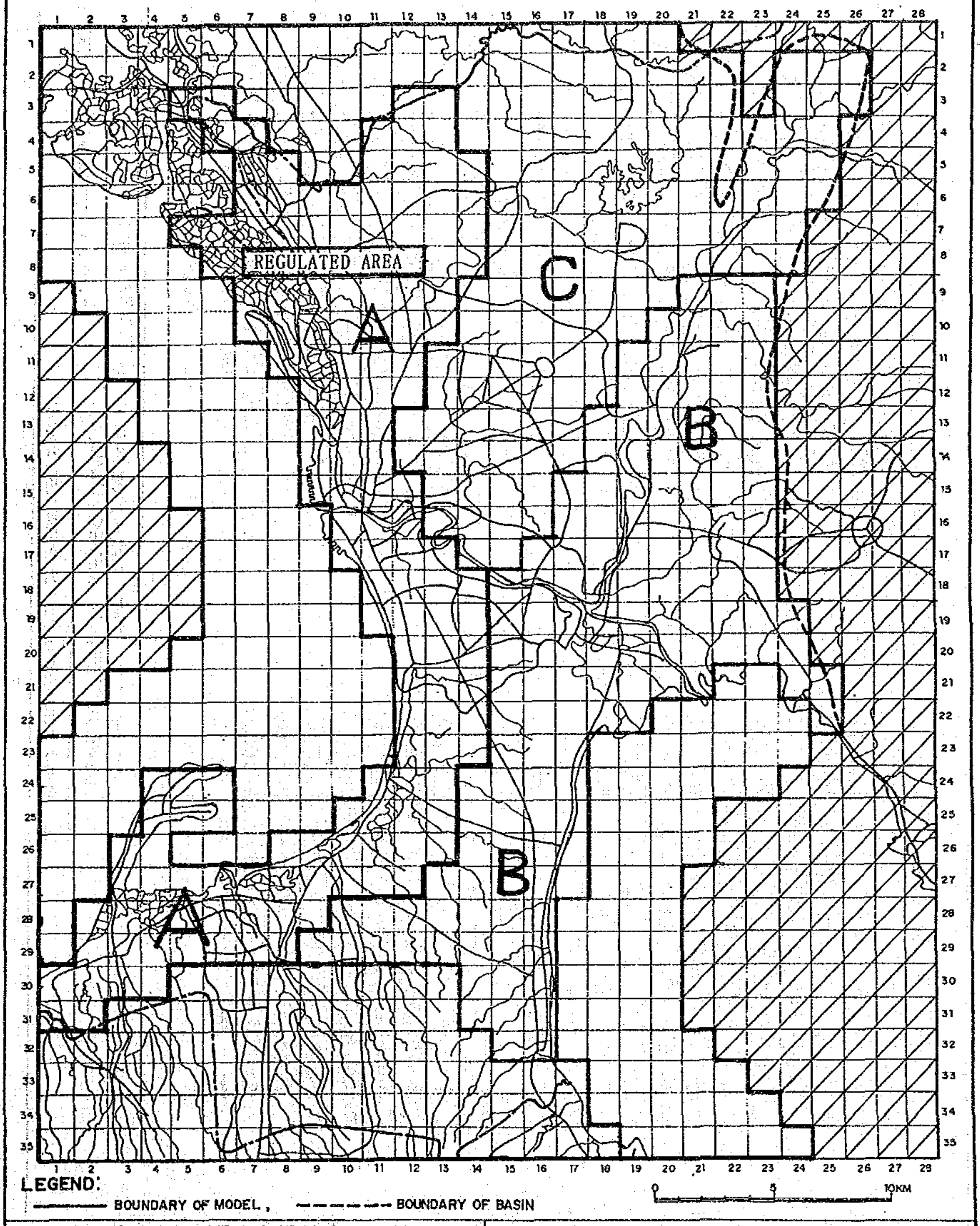
EMB – ENVIRONMENTAL MANAGEMENT BUREAU

LWUA – LOCAL WATER UTILITIES ADMINISTRATION

MWSS – METROPOLITAN WATERWORKS & SEWERAGE SYSTEM

LWDO – LOCAL WATER DISTRICT OFFICE

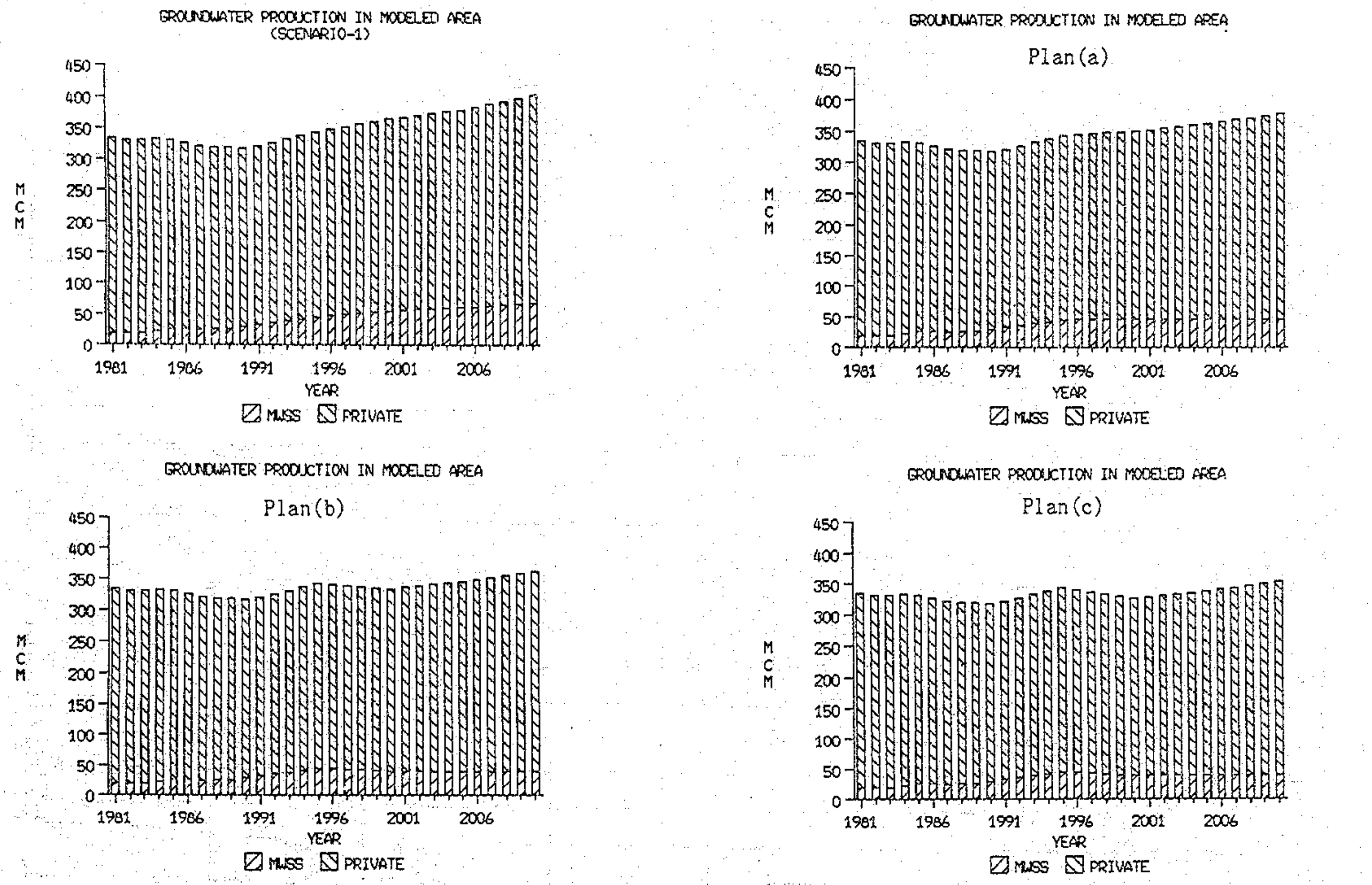
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.2.2 EXISTING WATER PERMIT PROCESSING FLOWCHART
JAPAN INTERNATIONAL COOPERATION AGENCY	



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.4.1 REGULATED AREA FOR GROUNDWATER PUMPAGE

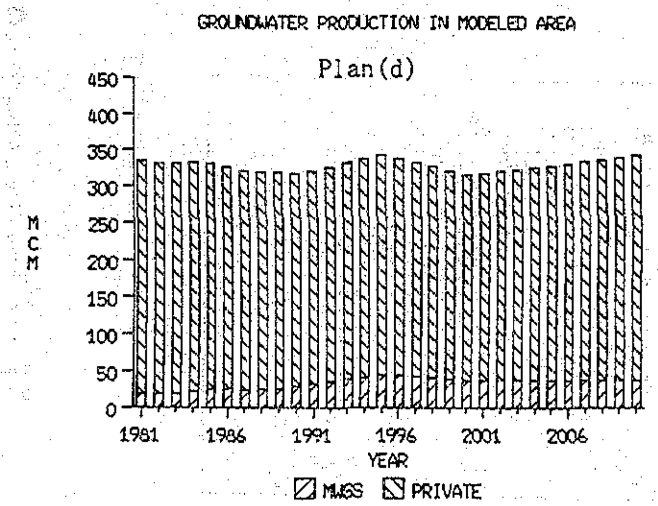


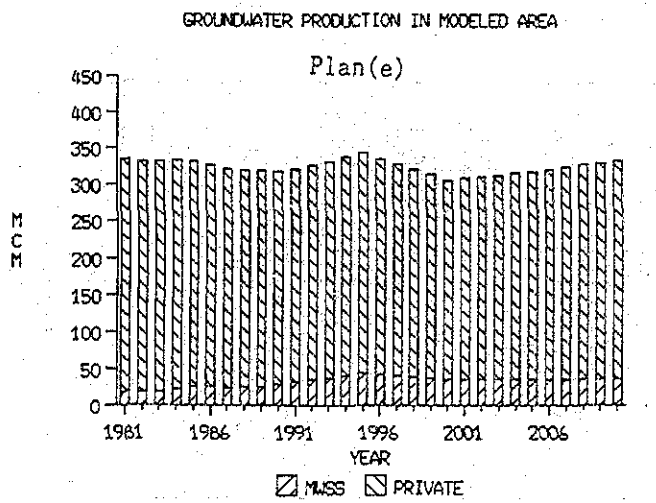
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

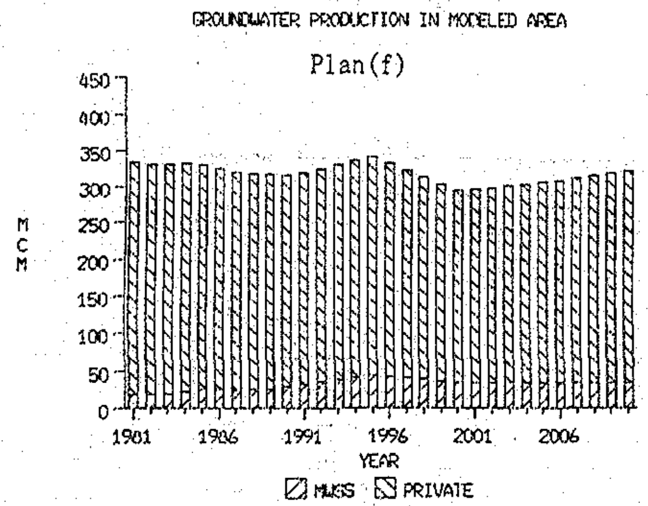
JAPAN INTERNATIONAL COOPERATION AGENCY

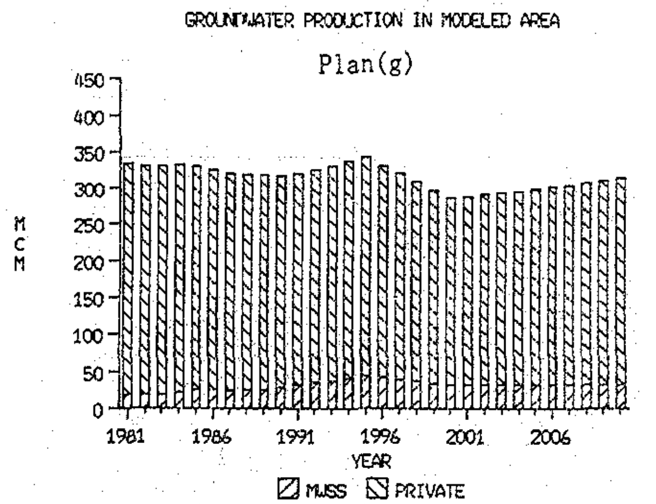
FIGURE 9.4.2

YEARLY DISCHARGE IN FUTURE PLAN (1)

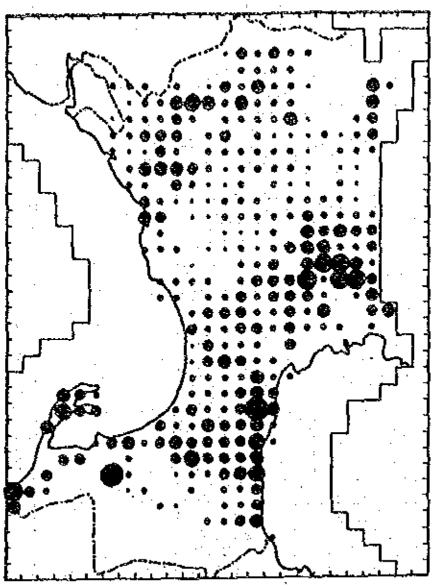




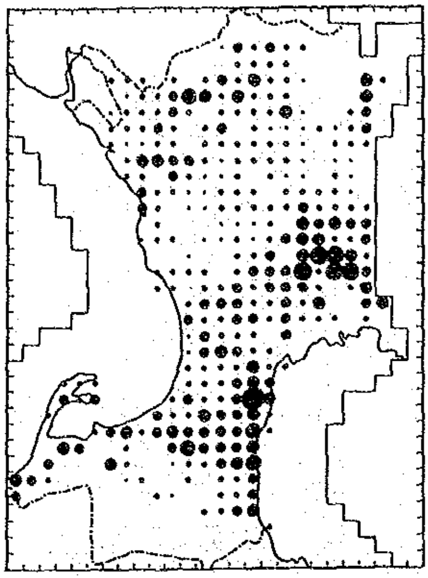




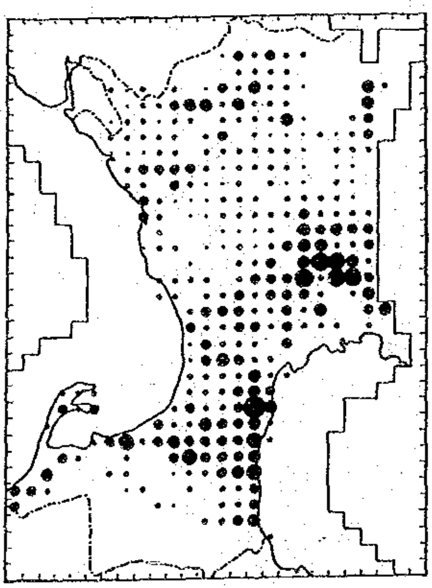
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.4.3
JAPAN INTERNATIONAL COOPERATION AGENCY	YEARLY DISCHARGE IN FUTURE PLAN (2)



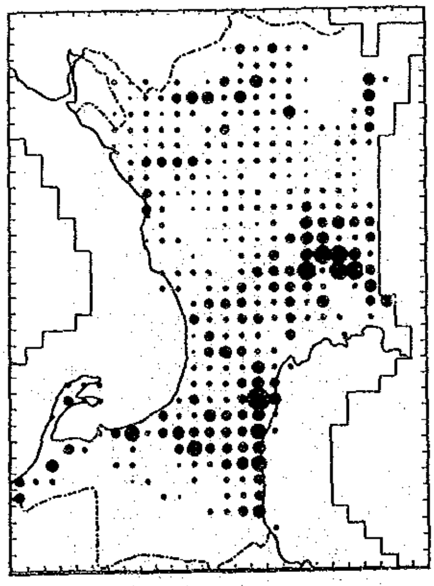
Scenario 1



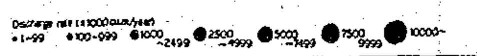
Plan(a)



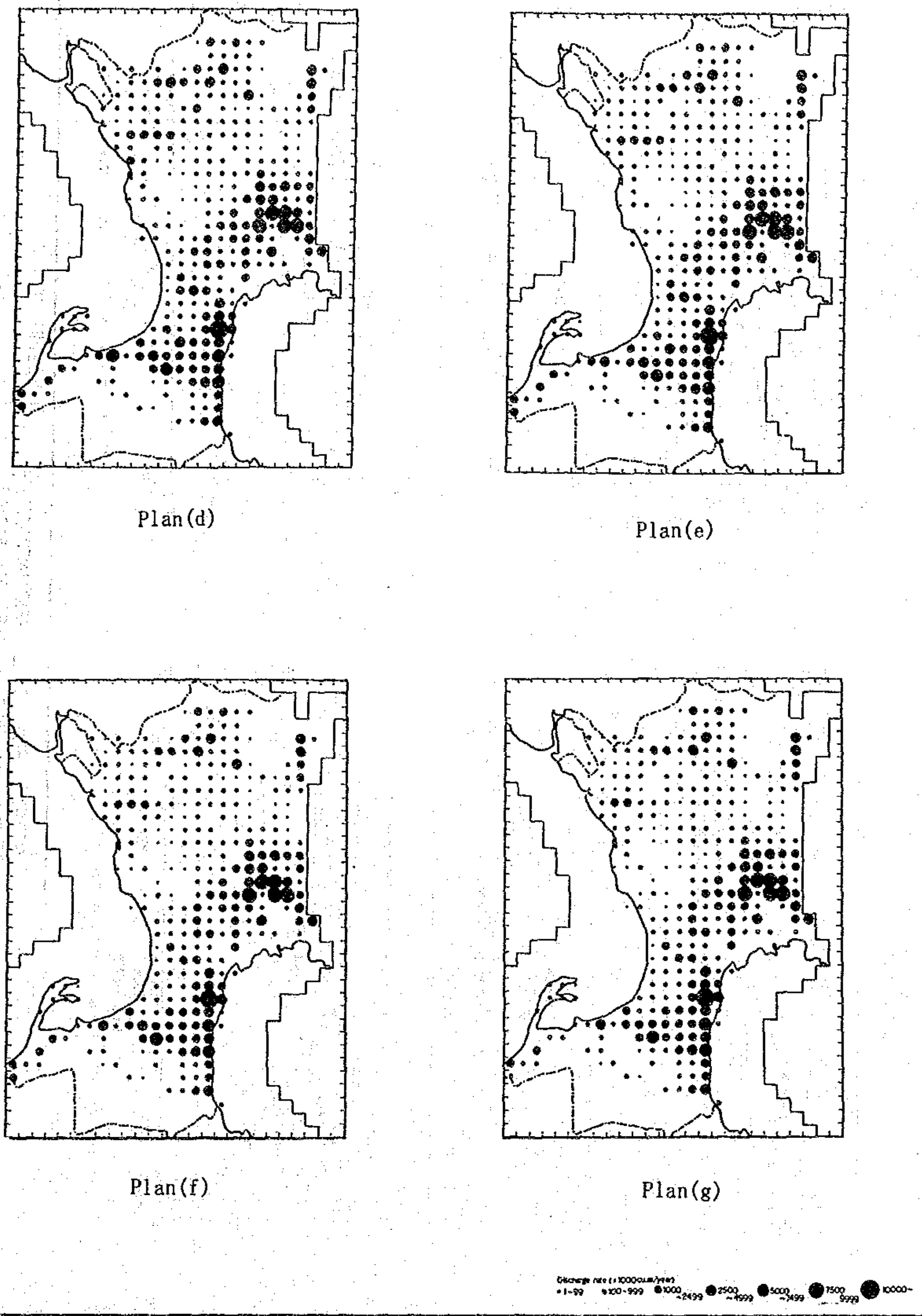
Plan(b)



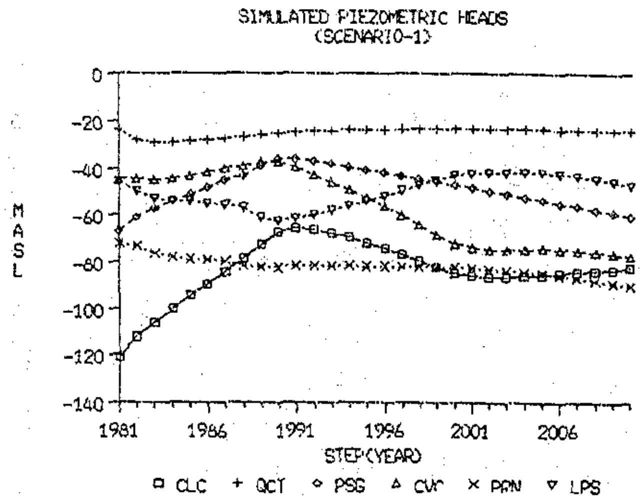
Plan(c)

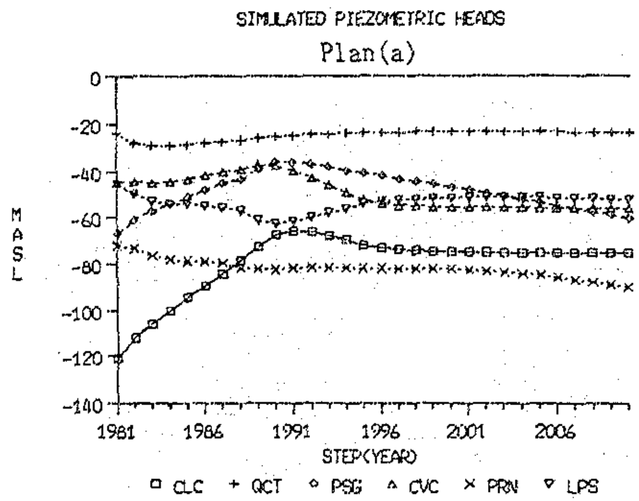


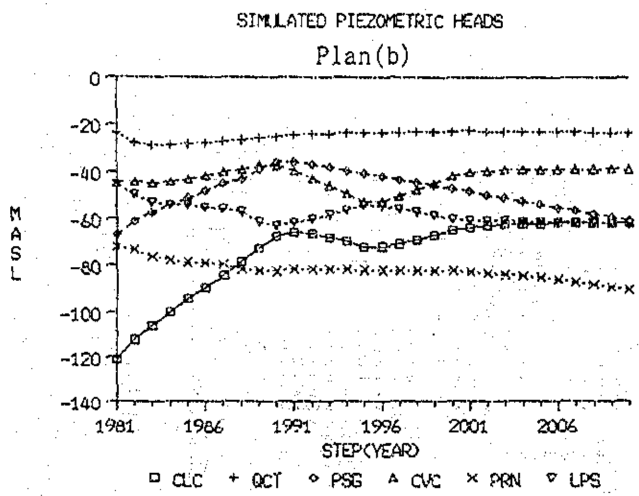
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.4.4
JAPAN INTERNATIONAL COOPERATION AGENCY	:DISCHARGE DISTRIBUTION IN FUTURE PLAN (1) IN YEAR 2010

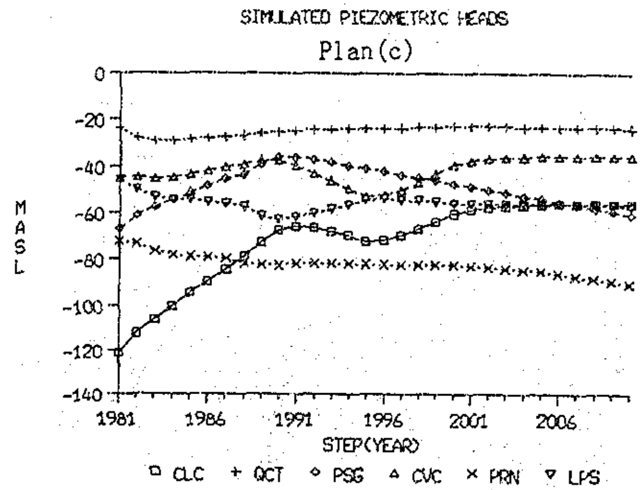


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.4.5
JAPAN INTERNATIONAL COOPERATION AGENCY	DISCHARGE DISTRIBUTION IN FUTURE PLAN (2) IN YEAR 2010

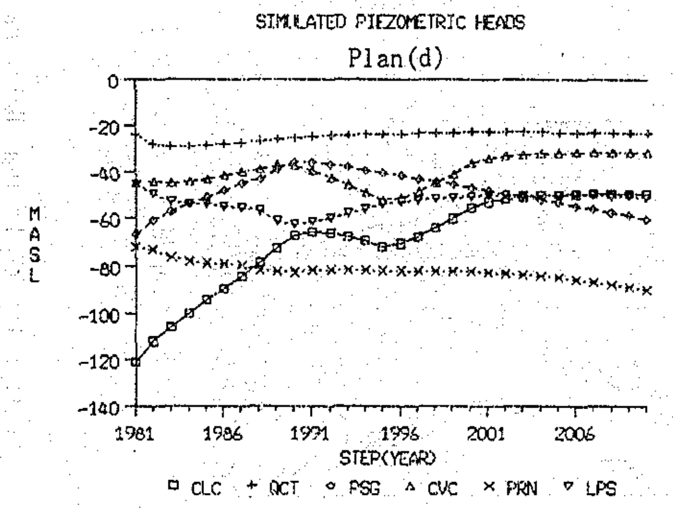


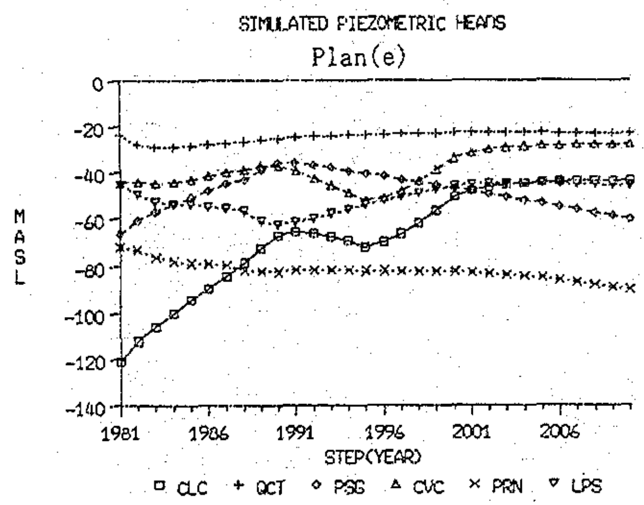


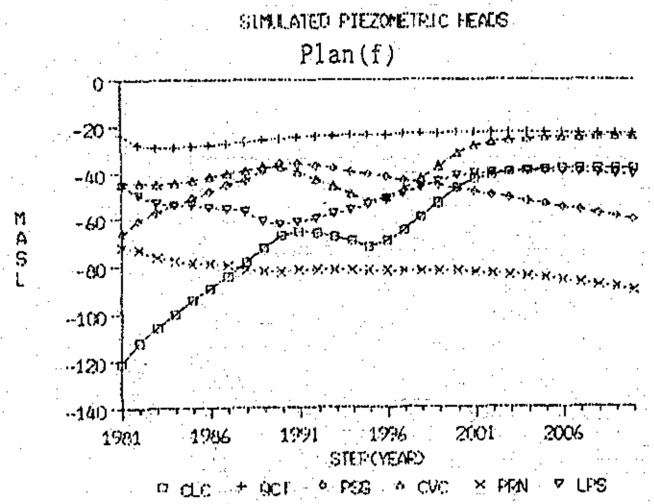


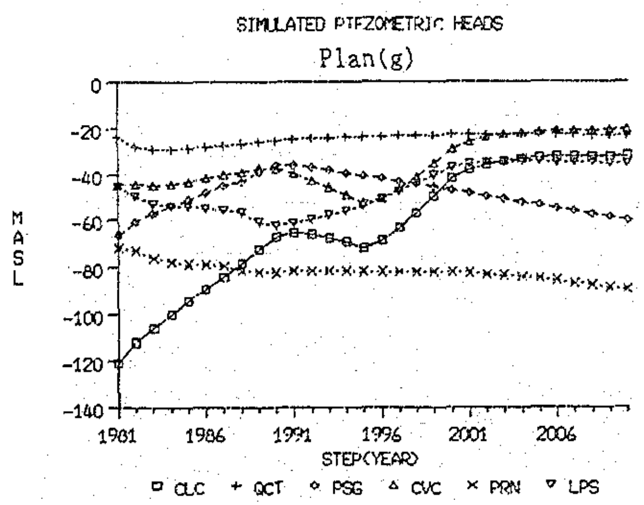


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.4.6
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC CHANGES IN FUTURE DISCHARGE PLAN (1)







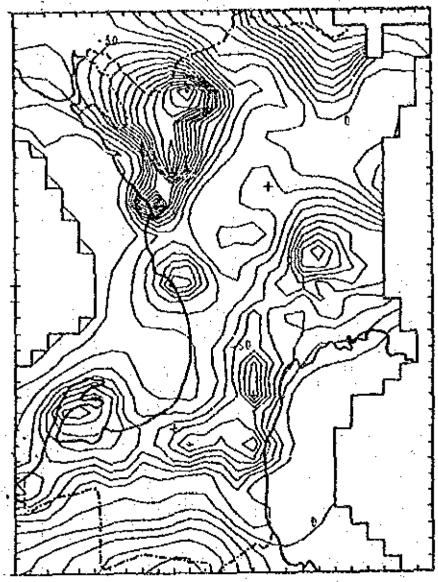


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

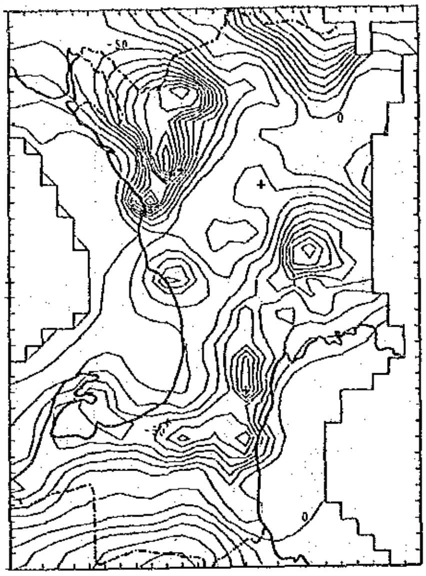
JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.4.77

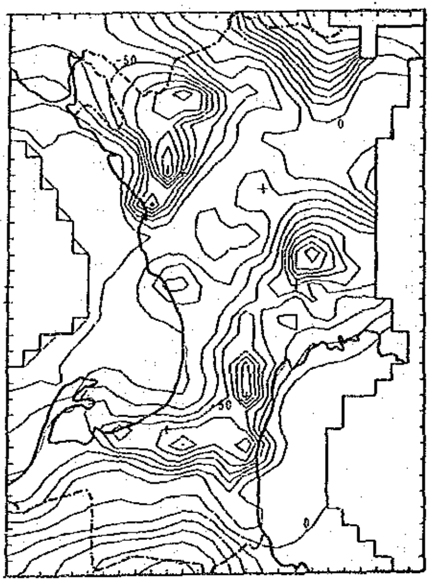
SIMULATED PIEZOMETRIC CHANGES IN FUTURE DISCHARGE PLAN (2)



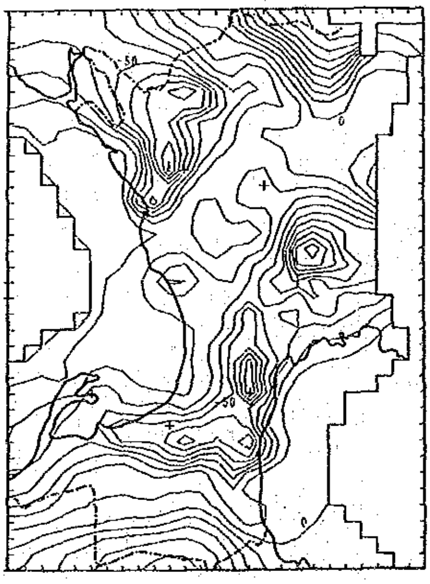
Scenario 1



Plan(a)



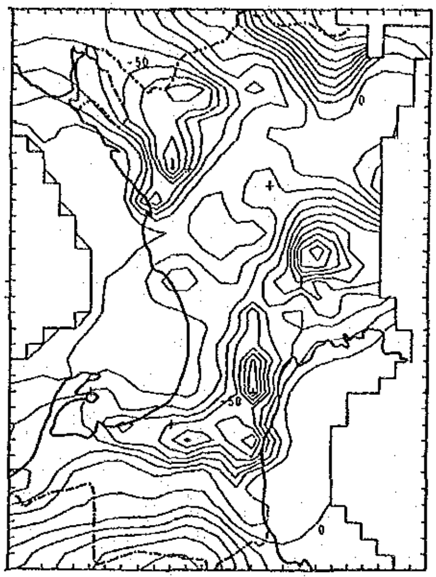
Plan(b)



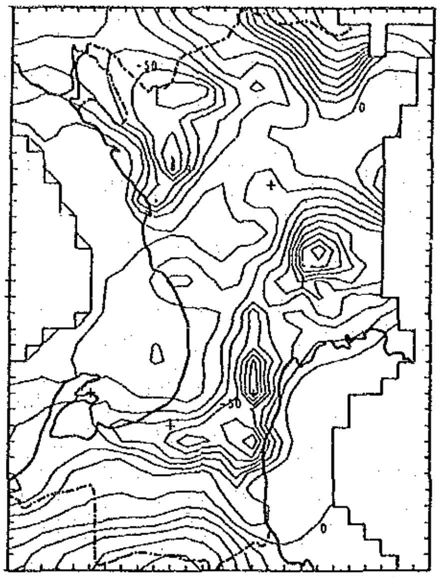
Plan(c)

(Contour Interval: 10m, Unit: masl)

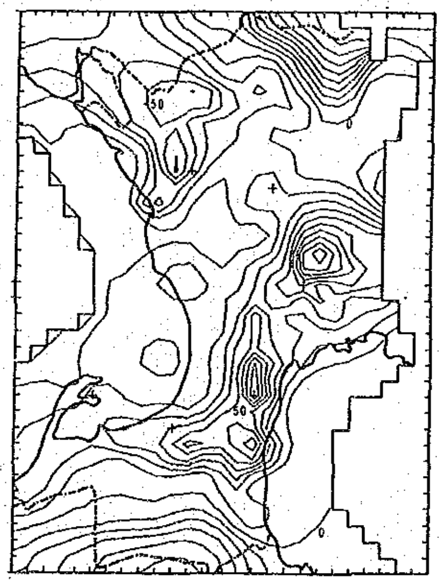
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.4.8
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS IN 2010 IN FUTURE DISCHARGE PLAN (1)



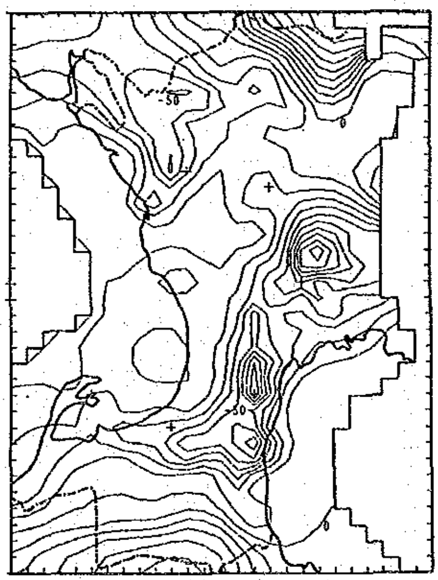
Plan(d)



Plan(e)



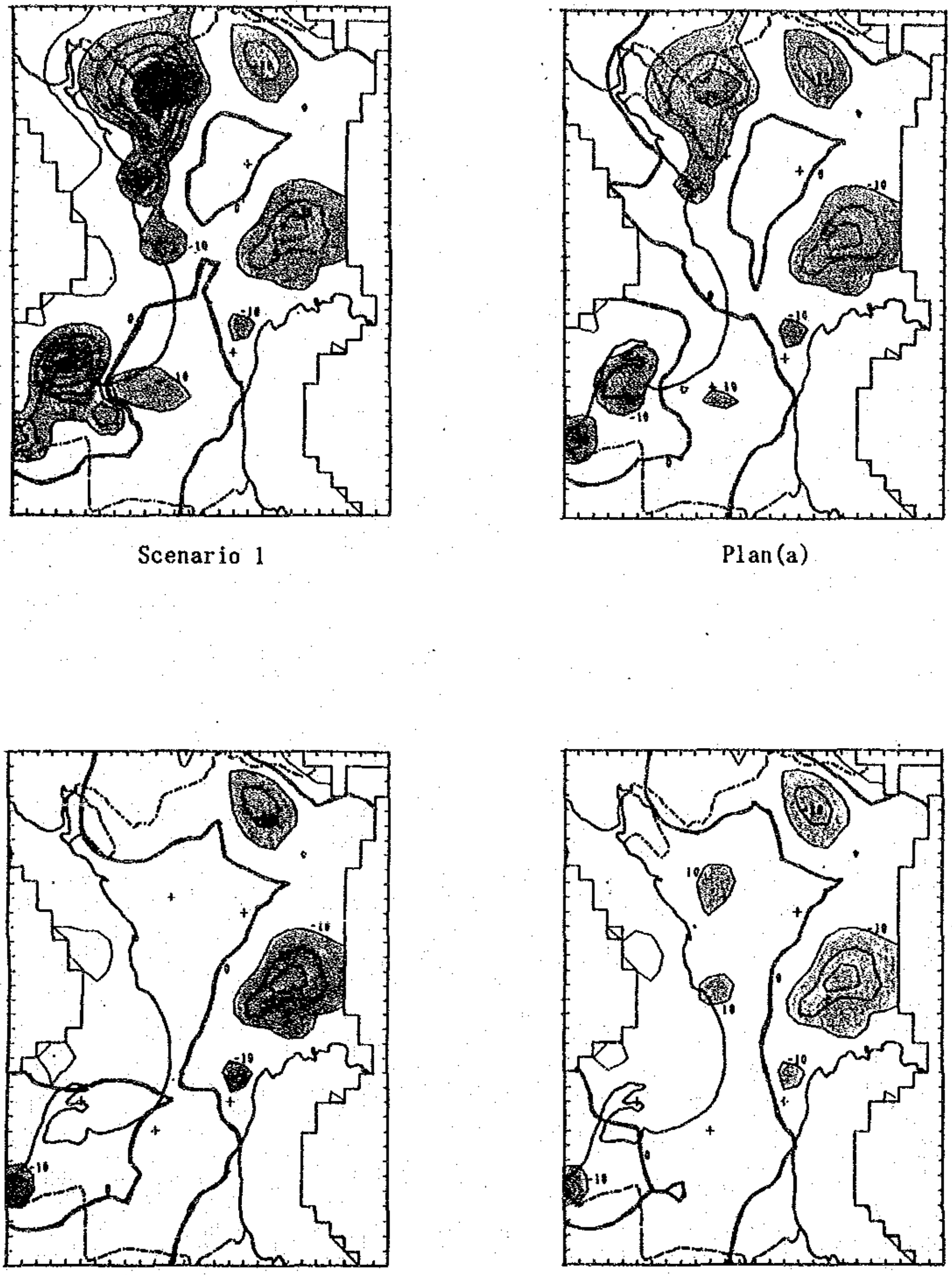
Plan(f)



Plan(g)

(Contour Interval: 10m, Unit: masl)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.4.9
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS IN 2010 IN FUTURE DISCHARGE PLAN (2)



Scenario 1 | Plan(a) | Plan(b) | Plan(c)

(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

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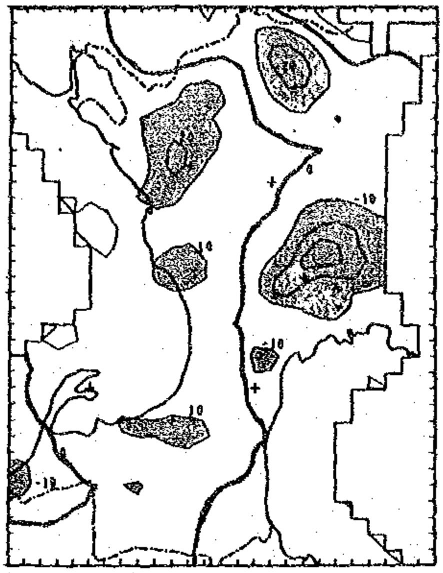
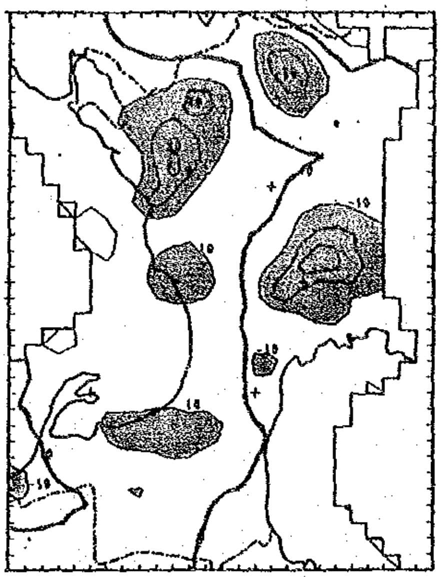
FIGURE 9.4.10

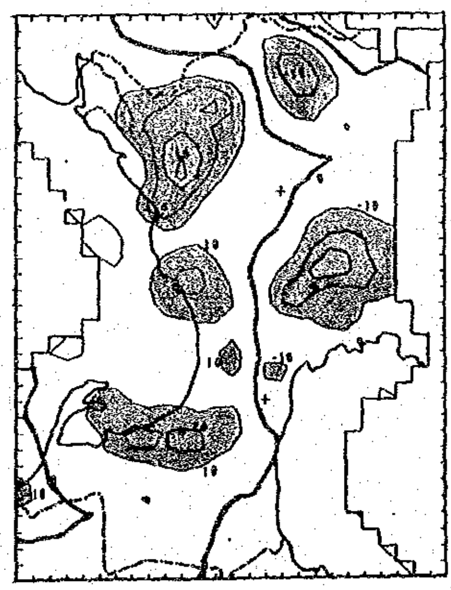
SIMULATED PIEZOMETRIC CHANGES FROM 1991-2010 IN FUTURE DISCHARGE PLAN (1)



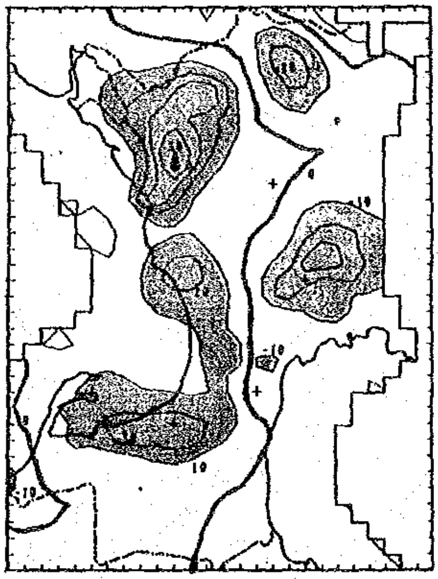
Plan(d)



Plan(e)



Plan(f)



Plan(g)

(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

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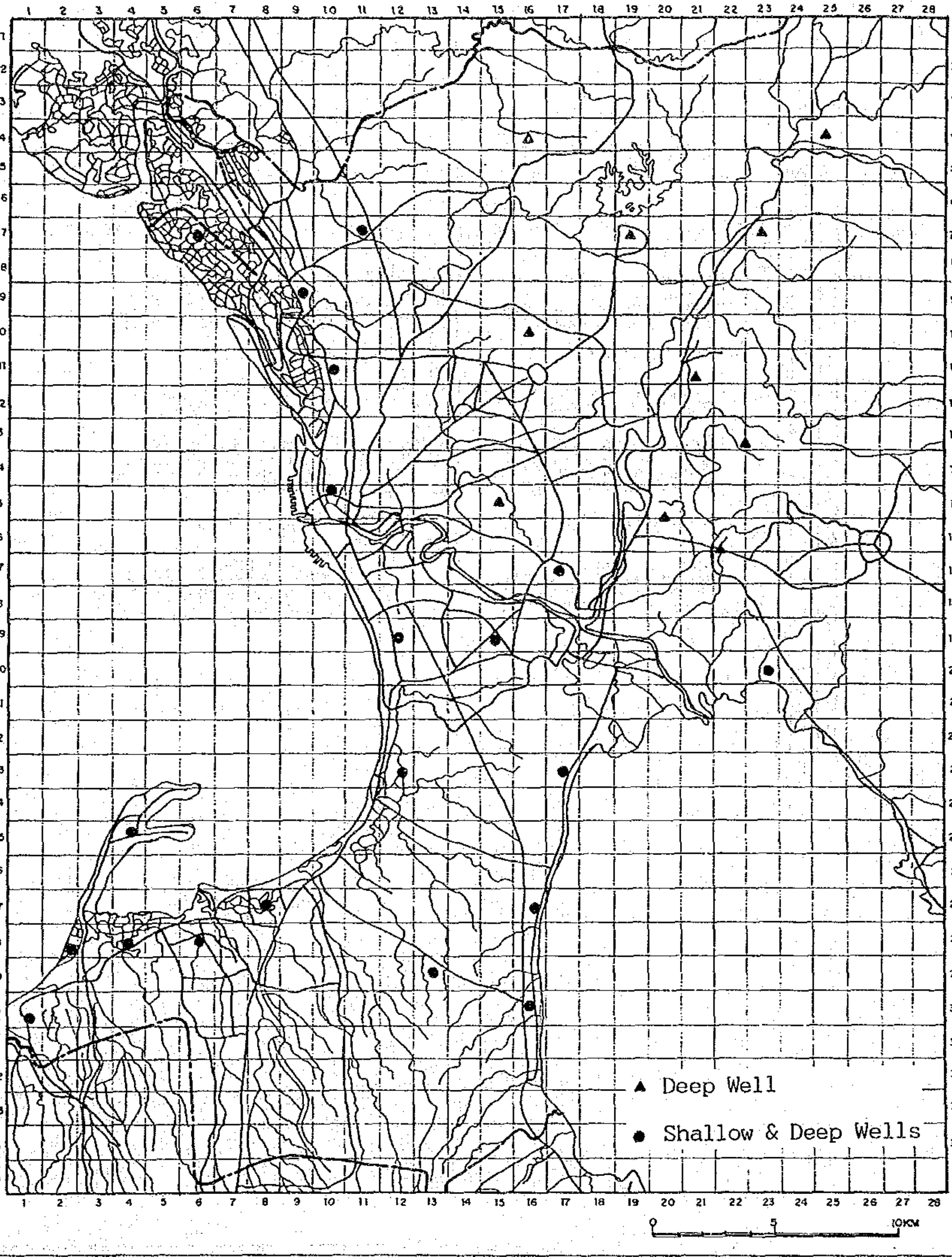
FIGURE 9.4.11

SIMULATED PIEZOMETRIC CHANGES FROM 1991-2010 IN FUTURE DISCHARGE PLAN (2)

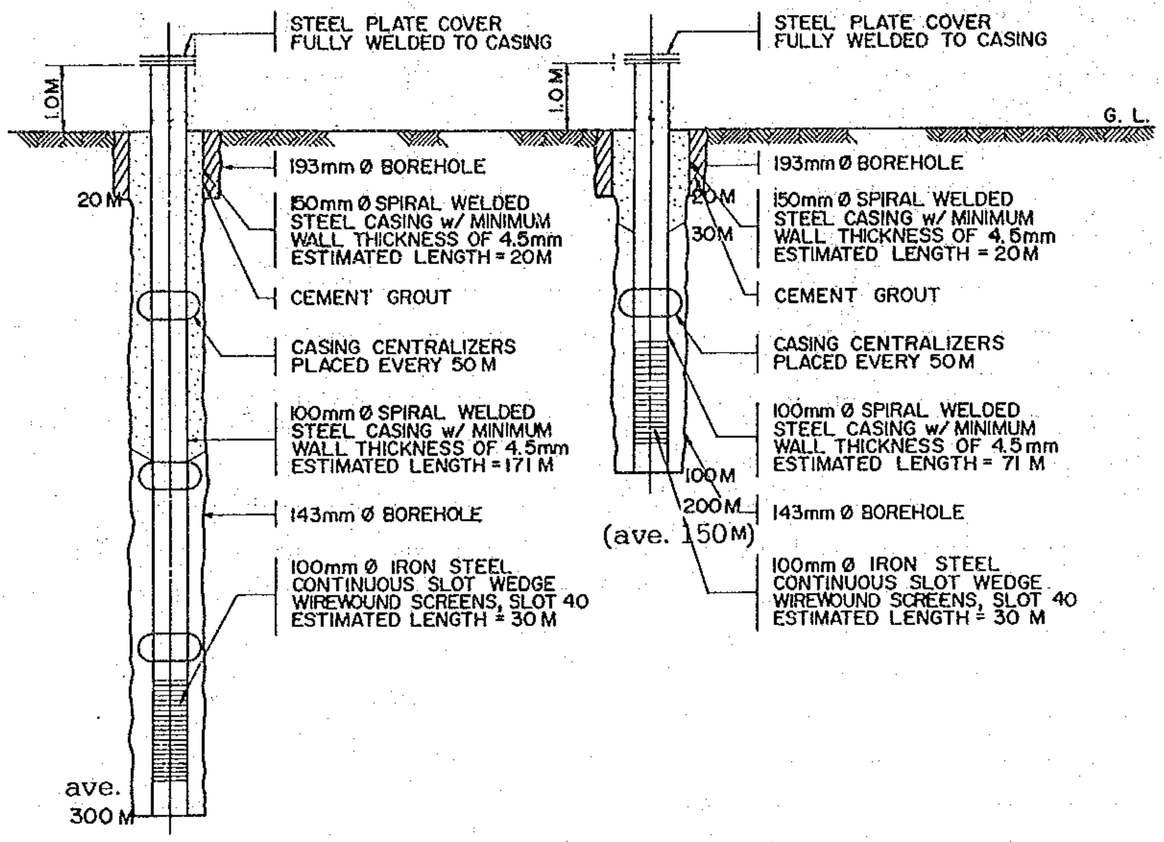


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.7.1

LOCATION MAP OF PLANNED MONITORING WELLS



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.7.2
JAPAN INTERNATIONAL COOPERATION AGENCY	PROVISIONAL DESIGN OF MONITORING WELLS

CHAPTER 10

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

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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 should however 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 14.9 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 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. These studies reveal 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 the 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 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 1,102,000 CMD in the year 2000 and 1,064,000 CMD in the year 2010, as results of the on-schedule completion of proposed and ongoing water supply projects. Under this scenario, a maximum decline of 50m 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, saline water intrusion included among these. 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 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, urgent implementation of the rehabilitation project is therefore recommended to augment the present groundwater supply.

(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, the groundwater must be developed within the optimal yield estimated in this study. This proposal considers 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 water supply of the nine (9) municipalities of Rizal Province under BP 799 shall continue in the future. These municipalities are located along the northern and eastern coasts of Laguna de Bay. The area 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 an essential component of the plan for the management of groundwater resources. The management of groundwater systems 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 that 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 on in the future. This may be achieved by the clarification of the hydrogeology of the area, submission of the record of groundwater pumping by users, collection and analysis of more accurate aquifer parameters, observation of groundwater levels and quality, and so forth. It is necessary to improve the accuracy and reliability of the models by using these information.

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

(4) Regional Leveling

Clear evidence of the land subsidence phenomenon in Metro Manila has yet to be 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 that a temporary immovable point be placed in a nearby mountainous area which is composed of base rocks and use it 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 are 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 the enforcement of this future regulation, the practical application of the Philippine Water Code in regard to such regulation and the enforcement of the water code itself must first be thoroughly studied.

The Water Code is basically applicable to the contemplated pumpage regulation. However, studies on the practical rules and regulations regarding the designation of the area where pumpage is to be regulated, the purpose for which groundwater shall be used, 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 of quantity and quality and groundwater levels by the users, the measures to be taken during the moratorium, the penalties to be imposed, etc.--all these 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 wells for domestic purpose. Measurement and reporting of groundwater levels and pumping rates 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 beefing up of 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 this 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	

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