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CHAPTER 6

URBAN DEVELOPMENT AND FUTURE WATER DEMAND

CHAPTER 6 URBAN DEVELOPMENT AND FUTURE WATER DEMAND

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CHAPTER 6 URBAN DEVELOPMENT AND FUTURE WATER DEMAND

6.1 URBAN DEVELOPMENT PLANNING

6.1.1 Development Framework

(1) Urban Development of the Study Area

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

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

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

This type of urbanization has also encouraged growth on the peripheries where basic infrastructure services are sorely lacking. In the lower lands where urban development is intensifying and where proper drainage

facilities are virtually absent, vulnerability to flooding is heightened. And as the water table here is high, the danger of human contact with untreated wastes becomes greater.

(2) Growth of the Study Area

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

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

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

(3) Land Use Development

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

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

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

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

(4) Population

(a) Present Population Distribution

Study Area

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

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

Antipolo Area

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

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

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

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

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

(b) Population Growth of the Study Area

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

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

(c) Population Projections up to Year 2010

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

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

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

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

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

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

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

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

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

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

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

(5) Economic Growth

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

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

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

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

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

6.1.2 Urban Development Plan

(1) Basic Structure Plan

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

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

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

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

(2) Study Area Planning

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

(a) Antipolo Area Development Plan

Development and Growth of Antipolo

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

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

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

Antipolo Study Area

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

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

Land Use Projection

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

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

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

The present subdivision development is more than sufficient for the Antipolo area's expected expansion within the next five years. However, according to the present and anticipated growth of Metro Manila, the

area is expected to be the main means of absorbing future population growth requiring new subdivision to be developed.

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

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

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

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

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

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

6.1.3 Conclusions

(1) Land Use Plan

The land use plan is general (Figure 6.1.9) though it can be amended according to authorized decision from time to time. The land use plan shall be regulated under zoning regulations which may be dictated by the authorized regional or municipal agency. Such regulations should be

strictly enforced in regard to each kind of development and any proposal shall be subjected to the stipulations.

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

Urban Consolidation Zone

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

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

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

Complementary Urban Satellites

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

(2) Residential and Open Areas

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

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

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

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

(3) Industry and Tourism

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

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

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

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

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

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

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

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

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

(5) Flooding Area

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

(6) Preservation Areas

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

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

(7) Zoning Regulations

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

6.2 WATER DEMAND PROJECTION

6.2.1 Scope

The water demand projection for the water supply system of MWSS is done to determine the domestic, commercial, and industrial water demand in MSA, from the city/municipal level down to the barangay level especially for the specified Antipolo Study Area, and also, to update the projection that was made through the previous projects conducted by the MWSS. The present projection was arrived at through calculations using updated data on present water consumption, population, income growth, change of water tariff, economic growth, etc.

From the menu of available projection methods, such as time-series trend analysis, regression analysis, factorial analysis, piling up of detailed water use, etc., this study opted for a kind of multiple regression analysis, which was also adopted in the Manila Water Supply Project III (MWSP III) and the Angat Water Supply Optimization Project (AWSOP).

So that planning for the respective areas may be unified, a general adoption of the methods and data used in the Fringe Area Water Supply Project (FAWSP) and the Rizal Province Water Supply Improvement Project (RPWSIP, now RPWSP) was made, to the extent warranted in the areas covered by both projects.

6.2.2 Water Demand Projection

(1) Present Condition

a) Domestic Water Consumption

The derivation of the figure for the equivalent served population rests on these assumptions: for house service connections, the average number of users per connection is 8.1 (MWSS Consumer Survey, 1981); and for public faucets, the average number of users is 486 (60 times of H.S.C.), the same figure being used for projection by Corporate Planning Group of MWSS (CORPLAN). A different assumption, however, was applied to some areas under FAWSP, e.g., Imus, Antipolo, Montalban and San Mateo -- an assumption resulting from the detailed investigation of each area by

FAWSP.

The data on billed water consumption and number of house service connections are shown in Table 6.2.1. These were prepared by the Computer Service Center of the MWSS.

Of the billed domestic water, metering losses accounted for about 9.57 percent. This ratio was estimated from the results of a field survey conducted under the Manila Water Supply Rehabilitation Project II (MWSRP II).

Calculations on present per capita water consumption were made based on recorded water consumption and the estimated served population (Table 6.2.2). For house service connections, the average per capita water consumption is 170 liter per capita per day (lpcd). This consumption type recorded a low of 51 lpcd in Las Piñas and a high of 324 lpcd in Parañaque.

Average per capita water consumption from public faucets is 19 lpcd, ranging from 9 lpcd in Makati to 79 lpcd in Antipolo. For purposes of statistical analysis, however, using these figures raises questions as they are much influenced by the accuracy of assumptions. The number of public faucets is very limited for this kind of statistical analysis. The estimated per capita consumption from public faucets is thus not suitable for the projection of future water consumption.

Municipalities with low per capita consumption are generally found in areas experiencing water supply constraints, e.g., Caloocan City, Las Piñas, Malabon, Muntinlupa, Navotas, Pateros, Taguig, Valenzuela, and some municipalities in the provinces of Cavite and Rizal. Because of insufficient water supply, water consumption in these areas is suppressed. Considering their potential demand to be higher, a rapid increase in water consumption will be seen after improvement of water supply situation is effected by MWSS through several ongoing projects such as AWSOP, Manila South Water Distribution Project (MSWDP), and FAWSP. This improvement is factored into the demand projection for these areas.

For the BP799 area in Rizal Province, no useful data on water consump-

tion was obtained. The data prepared by RPWSIP were utilized for the projection of future water consumption.

b) Commercial Water Consumption

The total billed commercial consumption in 1990 averaged 303,732 m^3/day as shown in Table 6.2.3. The larger part of this consumption was taken up by the NCR, amounting to 99.2% of the total. In particular, Manila, Quezon City and Makati combined to share of 97.1% of the total. The commercial sector of Cavite and Rizal consumed only 0.4% and 0.5%, respectively, of the total commercial consumption.

After adjustment for meter error, the average consumption per meter connection was placed at 8.119 m^3/day, ranging from 0.734 m^3/day in Muntinlupa to 14.910 m^3/day for Makati. The correction factor used for adjustment was based on the survey result conducted by the Manila Water Supply Rehabilitation Project I (MWSRP I) and was calculated at +13.33%.

Thus, the recorded billed consumption of large meters such as commercial and industrial sector was increased by 13.33% for data processing.

For the BP799 area, no useful data on water consumption of commercial sector were available.

c) Industrial Water Consumption

The total billed industrial consumption in 1990 averaged 74,552 m^3/day as shown in Table 6.2.4. Most of this was also consumed in the NCR, amounting to 96.3% of the total, almost the same figure for its commercial consumption. Of this percentage, more than half was also accounted for by Manila, Quezon City and Makati which combined to a total share of 54.8% of total consumption. In the case of Mandaluyong and Pasig, the parity between commercial and industrial consumption breaks as the figure for industrial consumption share is higher, i.e., 3.3% for commercial and 9.2% for industrial in Mandaluyong, and 2.7% and 9.6% in Pasig. The industrial sector of Cavite and Rizal consumed only 1.4% and 2.3% respectively, of the total industrial consumption. After making the same adjustment for meter error as that done for the commercial sector, the average consumption per meter connection became 10.788

m^3/day, ranging from 0.756 m^3/day in Muntinlupa to 29.897 m^3/day in Man daluyong. For the BP799 area, no useful data on the water consumption of the industrial sector were available.

d) Groundwater Consumption

As discussed in Subsection 2.2.2, MWSS has been pumping up a yearly average of about 29,922,000 m^3 of groundwater for the last 6 years. This volume is equivalent to about 82,000 m^3/day or 3.4% of all MWSS water production for the same period.

In addition to the pumpage by MWSS, groundwater pumpage of the private sector in 1990 amounted to a daily average of about 840,700 m^3. Around 45% or about 379,000 m^3 of pumpage by the private sector was used for domestic use. This volume is equivalent to 44% of served water by MWSS. The population with private water supply systems was estimated to be about 38% of the population with MWSS water supply system, in consideration of said per capita water consumption and private pumpage for domestic use (Table 6.2.2). Thus, about 31% of the water demand in domestic use was supplied from the private groundwater pumpage.

As shown in Table 6.2.3, it is estimated that about 106,800 m^3/day or 24% of total water demand for commercial use was supplied by the private sector.

In contrast to the commercial water consumption, about 81% of the total water demand for industrial use amounting to about 354,900 m^3/day was supplied by the private sector (Table 6.2.4).

(2) Water Consumption Projection

a) Domestic Water Consumption

Projections of domestic consumption were computed separately for general and blighted populations. Population and per capita water consumption were determined for each group.

Per Capita Water Consumption

Domestic water consumption is affected by income growth and water tariff change with some extent of elasticity for both factors. The projection for a given year is done by first determining the per capita domestic water consumption in that year. This may be given by the following formula:

$$PCC(I) = PCC(I-1) \times [1+(PCIG(I-1)+(TI(I-1) \times PED)]$$

where:

I	=	year
PCC(I)	=	per capita consumption for year I
PCIG(I)	=	per capita income growth in real terms in year I
IED	=	income elasticity consumption
TI(I)	=	tariff increase in real terms in year I
PED	=	price elasticity of consumption

Data on per capita income growth, water tariff increases, income elasticity, and price elasticity are assumed by CORPLAN as shown in Table 6.2.5. For the general population, CORPLAN assumed a continuous decrease of per capita income up to the year 2010. Tariff was assumed to increase continuously starting year 1993, by 1.38% annually. Income elasticity and price elasticity computed by CORPLAN are 0.30 and -0.20 respectively. Per capita consumption in the year 2010, therefore, was computed to decrease to about 87% of that in 1990.

Projected per capita consumption of the blighted population in the year 2010 was also computed to decrease slightly due to tariff increase, even with the assumption of stability in their per capita income. Table 6.2.5 also shows the computation results for both groups.

Computation results show rather low per capita consumption relative to those in foreign countries. In previous studies, i.e., FAWSP and RPWSIP, increasing per capita consumption were assumed in projecting future water consumption.

This Study, therefore, set the per capita consumption of the general population at 180 lpcd for the year 1995 and 200 lpcd for 2010. Said settings are in harmony with the per capita consumption in typically

developed areas such as Manila and Quezon City. For the years between 1995 and 2010, per capita consumptions were interpolated. For some municipalities with present high per capita consumption, that is, those with more than 200 lpcd, per capita consumption in the year 2010 was set in consideration of present consumption.

The per capita consumption in some areas which presently lack water, but which are expected to benefit from AWSOP and MSWDP, was assumed to substantially increase by the year 1995. The per capita consumption in those areas was also set at 180 lpcd, considering the present water consumption amount and the distance from the central distribution system.

For municipalities located in the outlying areas but which are covered by the ongoing projects, i.e., FAWSP and RPWSP, the per capita consumption applied in each project was also adopted in this Study for consistency. For areas in Cavite, however, the same per capita consumption as the one for NCR was adopted.

Table 6.2.6 presents the adopted per capita consumption of each city/municipality for selected years.

Per capita consumption of the blighted population is limited by the water supply capacity of faucets. Their consumption was calculated to be 30 lpcd, on the assumption that they get their water from public faucets having a 24-hour flow rate of 10 liter/min. and a service rate of 486 persons per faucet. In projecting their consumption, setting the per capita consumption at 35 lpcd seems to be appropriate, considering the estimated present per capita consumption from public faucets was that presented in Table 6.2.2. This per capita consumption is held to be constant up to the year 2010.

Projected Population

The population of each city/municipality in the future that was projected in Section 6.1 contains general and blighted population categories. The projected population under such categories were adopted for the projection of water consumption.

For some areas, the estimated year-1990 general population is smaller than the estimated equivalent number of population for house service connections. This means that a part of the blighted population have house service connections instead of public faucets. For those areas, therefore, corrections were made on the ratio of blighted population to total population, with the assumption that the estimated equivalent number of population for house service connections is equal to the general population of the area.

Moreover, since beneficiaries of private sector supply systems may also be categorized under general population, around 80% of the NCR population was estimated to fall under this category as shown in Table 3.2.3. Therefore, the ratio of the total blighted population was adjusted at 20% of total population in accordance with the respective shares of the estimated blighted population in each municipality in year-1990 as shown in Table 6.2.7.

Assuming these blighted population ratios will be constant in the future, the future populations were projected for both groups.

The ratio of population served by MWSS was determined by city/municipality for each projection year in view of the estimated present served population by MWSS and private water supply systems presented in Table 6.2.2.

For the areas covered by FAWSP and RPWSP, the served population projected in the reports of these projects were adopted after adjusting the projected population of each area.

Domestic Consumption

Total domestic consumption is obtained by multiplying per capita consumption and population over all cities and municipalities for each projection year. Computation results at 5-year intervals for years 1995-2010 are presented in Tables 6.2.8 to 6.2.11.

b) Commercial Water Consumption

Commercial water consumption is similarly influenced by economic growth

and tariff changes in real terms, with some extent of elasticity on both factors.

The annual commercial consumption in a given year may be given by the following formula:

$$CD(I) = CD(I-1) \times [1+(CG(I-1) \times COED)+(CTI(I-1) \times CPED)]$$

where:

I = Year
CD(I) = Total commercial consumption in year I
CG(I) = GDP growth rate in service sector in year I
COED = output elasticity of consumption in service sector
CTI(I)= tariff increase in real terms in year I
CPED = price elasticity of consumption

Data on GDP growth in the service sector discussed in Section 6.1 were applied for this projection. Data on tariff increases, output elasticity, and price elasticity were assumed by CORPLAN as shown in Table 6.2.12. As computed, commercial consumption in the year 2010 in the MSA, excluding the BP799 area, will be more than double the estimated present demand.

The share of MWSS water supply to the total commercial consumption was calculated at 76.3% based on the actual billed water consumption and the estimated total commercial consumption (Table 6.2.3). The amount of privately supplied water for commercial consumption was about 106,800 m3/day based on the groundwater use survey. Assuming that the share of private supply and the share of the consumption of each city/municipality will be stable in the future, the commercial consumption in the future was projected as shown in Table 6.2.13. For the areas under BP799, commercial consumption was computed using the methods adopted in RPWSP.

It is estimated that MWSS shall supply 801,100 m3/day for commercial consumption in the year 2010. This amount is equivalent to 2.3 times of the presently supplied amount for commercial use.

c) Industrial Water Consumption

Industrial water consumption in the future is projected in the same way as commercial water consumption.

The projected growth of the GDP for the industrial sector as discussed in Section 6.1 was applied for the projection of industrial consumption. Data on tariff increases, output elasticity, and price elasticity that were assumed by CORPLAN were also adopted for the Study and are shown in Table 6.2.14.

Industrial consumption in the year 2010 is estimated to be about 1.8 times of estimated present demand.

The share of MWSS water supply to the total industrial consumption is calculated at 19.2% based on the actual billed water consumption and the results of the groundwater use survey (Table 6.2.4). The private supply for industrial consumption in 1990 was about 354,900 m^3/day. Assuming that the share of the private supply and the share of the consumption by each city/municipality will be stable in the future, the industrial consumption in the future was projected as shown in Table 6.2.15. For the areas covered by RPWSP, industrial consumptions were computed using the respective methods adopted in RPWSP.

It is estimated that MWSS shall supply 223,700 m^3/day for industrial consumption in the year 2010. This amount is equivalent to 2.6 times of present MWSS industrial consumption.

(3) Total Water Demand

The total water demand is obtained by summing up the domestic, commercial, and industrial consumption that are projected for each year. Also added to this demand are the water losses during distribution.

Present Non-Revenue Water of MWSS exceeds 50% of total distributed amount, and it includes various components e.g., meter error, illegal connections, leakage, and so on. The projected future consumption, however, excludes leakage. The MWSS water demand thus involves adding the amount of leakage.

The size of projected water demand, given the currently high NRW ratios, will be affected substantially by the leakage ratios that are adopted. MWSS aims to reduce the NRW ratio to 25% in its reduction program under MWSRP I and II which are under current implementation.

Reducing the NRW ratios to such levels may, however, be difficult to achieve as present ratios are still high. Even AWSOP already adopted higher NRW ratios in its feasibility stage. But even these higher ratios were revised for higher ones at AWSOP's detailed design stage.

For reasons of comparison, three cases were presented for the above said ratios, from which the leakage ratios to be used in water demand projection in this study was determined.

The first case (Case 1) is based on the projection by CORPLAN. Leakage amount will be reduced to 25.2% of total demand in year 1995, to 21% in years 2000, 2005, and 2010.

The second case (Case 2) is based on the ratios used in AWSOP's feasibility study stage. These NRW ratios, 30% in year 1995 and 25% in years 2000, 2005 and 2010, are higher than those CORPLAN.

In the ongoing detailed design stage of AWSOP, leakage ratios higher than those in Case 2 were adopted: 35% for year 1996. The third case (Case 3) had this considered such that the ratio for 1995 is 35%, that for 2000 is 30%, and 25% for years 2005 and 2010.

All three cases are tabulated below. The ratios applied in Case 3 are the ones adopted by this Study for the projection of water demand.

ADOPTED LOSS RATIO (% to Total Supply)

	1995	2000	2005	2010
CASE 1	25.2	21.0	21.0	21.0
CASE 2	30.0	25.0	25.0	25.0
CASE 3	35.0	30.0	25.0	25.0

The computation results for years 1995, 2000, 2005, and 2010 are summarized in Tables 6.2.16 to 6.2.18 and Figures 6.2.1 to 6.2.3.

6.2.3 Supply Capacity Against Demand

A yearly water demand and supply analysis for the period 1995 to 2000 and for years 2005 and 2010 was made considering the projected water demand and the planned water supply capacity.

The projected water demand was allocated by expected water source, assuming the ratio of supplied water by source as shown in Tables 6.2.19 to 6.2.22. The location of respective area, the present coverage of the Central Distribution System (CDS) and existing groundwater pumping capacity were considered for this assumption. In this assumption, Bacoor and Kawit in Cavite will be served through CDS. Areas in Rizal, however, are generally supplied with groundwater except some areas which are close to existing CDS.

Taking the assumption that the planned and ongoing projects to augment the water source and treatment capacity will be implemented on schedule, a comparison of surface water supply capacity and water demand for each particular year was done (Table 6.2.23 and Figure 6.2.4). From this comparison, the following were noted:

a. AWSOP is indispensable to meet demand.

b. The surface water supply capacity will not be critical to meet demand until 2010 even if produced water is supplied to NCR and a part of Cavite and Rizal, and the augmentation of water source is conducted on schedule.

c. If implementation of UATP and MNEWSP is delayed, water supply situation will be critical by the year 2005.

d. Required groundwater pumpage will increase to about 1,278,000 m^3/day in 2010 including discharge by private sector.

e. The share of groundwater in total water supply will decrease down to about 24.6% in 2010.

f. If the Bulacan Bulk Water Supply Project is implemented, implementation of MWSP III shall be advanced as early as possible.

Otherwise supply situation will be critical soon after year 2005. Though water amount to be allotted for the Bulacan project shall be decided based on the probable implementation schedule of MNEWSP, UATP, and MWSP III, the proposed amount for its Phase I (1996; 100,200 m3/day, 2000; 131,100 m3/day) can be secured if UATP is executed on schedule. However, supply of all

proposed amount for Phase II (2010; 398,400 m3/day) before completion of MWSP III will make MWSS water supply situation critical.

6.2.4 Groundwater Discharge Projection

(1) Outline of Scenarios

For preparation of data to be used in the simulation of future groundwater level in Metro Manila, projection of groundwater discharge was done using the projected groundwater demand in the study area. For that purpose, the following four scenarios were prepared considering the probability of assumptions stated in each case.

Basic Assumptions:

a. AWSOP will be completed in 1996.

b. UATP will be completed in 1998.

c. MNEWSP will be completed in 1997. Water source for the whole area of Montalban, San Mateo, and a part of Marikina will be converted to the Wawa Dam the next year. Groundwater utilization facilities to be constructed to meet demand by that year will be operated continuously from that year onward.

d. MSWDP will be completed in 1995.

Scenario 1 (Basic Scenario):

The increase of commercial and industrial water demand will be in pro-

portion to the estimated present share of the MWSS and the Private sector, except in some areas within CDS such as Manila, Pasay, Quezon, Caloocan, Makati, Malabon, Mandaluyong, Navotas, and San Juan. In these areas, said increase will be covered by MWSS only. In Cavite area, only Bacoor and Kawit will be supplied by CDS.

The calculations done in Subsections 6.2.2 and 6.2.3 were based on this scenario.

Scenario 2 (Optimistic Scenario):

The same assumption on commercial and industrial water demand in Scenario 1. However, commercial and industrial water demand increase in the private sector from year 2001 is converted to MWSS. Municipalities in the Cavite area will be supplied by CDS.

Scenario 3 (Most Optimistic Scenario):

The same assumption on commercial and industrial water demand in Scenario 1. However, commercial and industrial water demand increase in the private sector from year 1996 is converted to MWSS. Municipalities in the Cavite area will be supplied by CDS.

Scenario 4 (Pessimistic Scenario):

The same assumption on commercial and industrial water demand in Scenario 1. However, implementation of projects mentioned in Basic Assumptions is delayed for 2 years. In the Cavite area, only Bacoor and Kawit will be supplied by CDS.

Difference between assumptions in each scenario can be summarized briefly as shown in Table 7.3.1.

(2) Projected Groundwater Discharge

In accordance with the just said scenarios, the future groundwater demand was projected.

Using the future groundwater demand projection results, the distribution

of groundwater discharge was projected for each scenario. To increase the probability of the projection, adjustment including interpolation was done on the projected discharge between the years 1991 to 1999 for several areas in Cavite and Rizal so as to moderate the rate of increase of discharge. Projections for each scenario are summarized in Tables 6.2.24 to 6.2.27.

In Scenario 1, groundwater discharge will increase to 1,278,000 m^3/day, which is equivalent to 1.37 times of estimated present discharge.

In Scenario 2, total discharge will increase to 1,139,000 m^3/day or 1.22 times of present level, and 1,064,000 m^3/day or 1.14 times in the Scenario 3.

In the Scenario 4, which is pessimistic but has a high probability, total discharge will be 1,295,000 m^3/day or 1.39 times of present discharge amount.

For all scenarios, areas in Cavite and Rizal require much increase of groundwater discharge.

6.2.5 Water Demand Projection in Antipolo Basin

(1) Present Situation

a) Existing System

The Poblacion area of Antipolo which occupies the center of the Antipolo Basin was initially served by the water supply system constructed by the then Bureau of Public Works. The system includes 6 deepwells and about 20 km of distribution pipelines. When Antipolo became a part of the MWSS service area in 1976, the system was turned over to MWSS.

To meet the water demand, MWSS constructed an additional 4 deepwells for the system: 2 wells in 1981; 1 well in 1982; and 1 well in 1983. A total of 10 deepwells have therefore been operational since those times. All of these wells are currently operated on 24-hour basis. Their various capacities range from 210 liter/min. to 1,400 liter/min. Due to limited water source and rugged terrain of the area, rationing is

done in the system via control of valves.

At present, the system has about 33.59 km of distribution pipelines. A distribution reservoir is not provided in the system so that the pumped groundwater is directly injected into the distribution pipes after some extent of chlorination.

b) Water Consumption

The Computer Service Center of MWSS summarized as shown in Table 6.2.28 the existing number of connections and water consumption in 1990 of the MWSS water supply system in the Antipolo Basin.

Observations regarding this table are summarized below:

a. Total water consumption in the basin is rather small in comparison with the share of no. of connections due to small water consumption in industrial sector.

b. The share of domestic consumption is in accord with the share of no. of connections.

c. The character of the area in the basin may be categorized as a residential area with small scale commercial enterprises.

d. Per capita domestic consumption may be estimated as follows:
2,962 m^3/day / (3,535 conn. x 8.1 person/conn.)
= 103.4 lpcd

According to the groundwater use survey conducted in this study, 26 deepwells are operated in the basin in addition to the 10 deepwells of MWSS. The discharge and water consumption by use obtained by the survey is summarized in Table 6.2.29.

Thus, the MWSS system discharged about half of the total groundwater discharge in the basin. Only 33.5% of MWSS discharge was billed as revenue water in 1990. Though a part of NRW seems to be consumed by illegal connections, most of it is considered to be leakage in view of the rather low per capita consumption estimated for the area. Survey on

this matter was conducted by FAWSP in 1989. As a result of that survey, ratios for leakage and unbilled consumption during that time were estimated at 68.2% and 0.2% of production amount, respectively.

(2) Water Demand Projection

a) Domestic Water Consumption

The population projected in Section 6.1 was adopted for the projection of water demand in the basin. MWSS service ratio was determined in accordance with the planned service coverage of the MWSS system and the extent of urbanization. MWSS service coverage was determined under the following assumptions:

a. The service area within the basin boundary will be limited by the year 2000, except for the present service area that is out of the basin.

b. The service area will continuously expand outward from the central area (poblacion).

c. The priority of service will be laid on the present developed area, and it will be covered by the year 2000.

d. Present developed area closely located outside the basin will be covered after the year 2001.

e. The basin will be fully covered by the system by the year 2010.

Figures 6.2.5 and 6.2.6 present the service coverage in selected years.

Population in the service area can be derived by multiplication of population and service ratio. In 1995, it will be about 71,000, including those in the present service area outside of the basin, and which is about 67% of the population in the basin. It will increase to about 195,000 or about 110% of basin population in the year 2010. Since the estimated present served population is about 29,000 (3,535 conn. x 8.1), the served population in 2010 will be about 6.8 times of present served population (Table 6.2.30).

The domestic water demand in the MWSS's system in the basin were computed as shown in Table 6.2.31 adopting the same per capita consumption as those applied in the previous projection in FAWSP.

b) Commercial Water Consumption

The water consumption of the commercial sector computed in Subsection 6.2.2 was adopted in projecting commercial water consumption.

Based on the data presented in Table 6.2.28, 51% of the MWSS commercial consumption projected for the Antipolo municipality is considered to be consumed in the basin.

Allocation to each barangay was done in accordance with the domestic consumption share of each barangay. The computation results for the entire basin and the MWSS system are presented in Tables 6.2.32 and 6.2.33.

c) Industrial Water Consumption

The water consumption in industrial sector computed in Subsection 6.2.2 was adopted in the projection of industrial water consumption.

Based on the data presented in Table 6.2.28, 3% of the MWSS industrial consumption projected for Antipolo municipality is considered to be consumed in the basin. The present private industrial consumption, in addition to the MWSS industrial consumption, was added to the total demand, considering that the bulk of it was consumed by a few poultry farms.

Allocation to each barangay was executed in accordance with the share of the domestic consumption. The computation results for the entire basin and the MWSS system are presented in Tables 6.2.32 and 6.2.33.

d) Distribution Loss

Losses during water distribution are mainly caused by leakage. Though the present leakage ratio is considerably high, probably amounting to more than 50%, a ratio of 30% was applied for the projection up to the

year 2000, and 25% after that, in anticipation of the benefits of the NRW reduction program and of new projects to be implemented in the basin, including the high rate replacement of old distribution pipes.

e) Total Demand

Total water demand in the basin and in the MWSS service area are summarized in Tables 6.2.32 and 6.2.33.

(3) Analysis on Supply Capacity and Projected Demand

Projected water demand for the Antipolo basin is summarized as shown in Table 6.2.34. Because of the limited yield of the groundwater resource in the basin, additional water sources in the future shall be mainly obtained from surface water resources. Based on the computer simulation of the groundwater condition in the basin, a groundwater discharge of about 27,800 m^3/day is considered to be the maximum limit of discharge in the basin. Augmentation of water source, as implied in the table, is a course that should be immediately pursued.

Due to the pumpage of existing groundwater pumping facilities, the water source augmentation by groundwater resource is limited up to 8,300 m^3/day. Of this figure, 2,070 m^3/day will be obtained through rehabilitation of existing MWSS's deepwells. Therefore, the additional pumpage resulting from the development of new wells shall be limited to a total of 6,274 m^3/day.

After augmentation of the groundwater resource, supply capacity will be able to meet the demand until the year 1998, on a daily average basis. On a daily maximum basis, however, supply capacity will not be able to satisfy the demand from 1995 onward.

Further augmentation is thus required, and at an average of about 1,800 m^3/day in the year 2000 and about 18,100 m^3/day in the year 2010, assuming maximum groundwater production capacity is about 27,400 m^3/day (Table 6.2.34 and Figure 6.2.7). On a daily maximum basis, amount of augmentation is 15,500 m^3/day in 2000 and 40,900m^3/day in 2010.

TABLE 6.1.1 TOTAL POPULATION, HOUSEHOLD POPULATION AND NUMBER OF HOUSEHOLDS IN THE STUDY AREA (1990)

CITY/MUNICIPALITY	TOTAL POPULATION	HOUSEHOLD POPULATION	NUMBER OF HOUSEHOLDS
METRO MANILA	7,928,867	7,887,861	1,567,665
1. Manila	1,598,918	1,585,887	308,874
2. Pasay City	366,623	364,959	73,642
3. Quezon City	1,666,766	1,659,940	331,760
4. Calookan City	761,011	759,420	150,972
5. Las Pinas	296,851	296,645	57,774
6. Makati	452,734	450,163	89,310
7. Malabon	278,380	278,161	58,051
8. Mandaluyong	244,538	242,526	49,065
9. Marikina	310,010	309,103	60,090
10. Muntinlupa	276,972	268,960	53,449
11. Navotas	186,799	186,642	38,864
12. Parañaque	307,717	306,865	61,252
13. Pasig	397,309	396,764	77,621
14. Pateros	51,401	51,359	9,808
15. San Juan	126,708	125,815	24,338
16. Taguig	266,080	265,043	53,153
17. Valenzuela	340,050	339,609	69,642
CAVITE	457,020	456,569	91,396
1. Bacoor	159,685	159,663	30,928
2. Cavite City	91,641	91,480	19,040
3. Imus	92,125	91,875	18,648
4. Kawit	47,755	47,755	9,767
5. Noveleta	20,409	20,409	4,012
6. Rosario	45,405	45,387	9,001
RIZAL	980,194	978,596	189,712
1. Angono	46,014	45,439	8,941
2. Antipolo	207,842	207,665	40,852
3. Baras	16,880	16,880	3,163
4. Binangonan	127,561	127,421	24,378
5. Cainta	126,839	126,680	24,775
6. Cardona	32,962	32,958	6,264
7. Jala-Jala	16,318	16,318	3,035
8. Morong	32,165	32,165	6,255
9. Pililla	32,771	32,771	6,131
10. Montalban	67,074	67,011	12,891
11. San Mateo	82,310	82,289	16,079
12. Tanay	58,410	58,196	11,089
13. Taytay	112,403	112,163	21,881
14. Teresa	20,645	20,640	3,978
T O T A L	9,366,081	9,323,026	1,848,773

Source: National Statistics Office
1990 Census of Population and Housing

TABLE 6.1.2 POPULATION DISTRIBUTION IN ANTIPOLO (1990)

MUNICIPALITY/ BARANGAY	TOTAL POPULATION	HOUSEHOLD POPULATION	NUMBER OF HOUSEHOLDS
ANTIPOLO	207,842	207,665	40,852
1. Bagong Nayon	18,002	18,002	3,472
2. Beverly Hills	1,034	1,034	191
3. Calawis	1,662	1,662	353
4. Cupang	25,696	25,690	5,005
5. Dalig	20,334	20,334	3,964
6. De La Paz	21,033	21,033	4,158
7. Inarawan	4,965	4,965	1,023
8. Mambugan	15,636	15,611	2,970
9. Mayamot	15,887	15,887	3,142
10. San Isidro	19,260	19,248	3,776
11. San Jose	26,121	26,049	5,067
12. San Juan	1,394	1,394	298
13. San Luis	6,241	6,241	1,340
14. San Roque	17,227	17,165	3,287
15. Sta. Cruz	13,340	13,340	2,806

Source: National Statistics Office
1990 Census of Population and Housing (Report No. 2-A)

TABLE 6.1.3 POPULATION DISTRIBUTION, LAND AREA AND POPULATION DENSITY: ANTIPOLO AREA (1990, 2000 AND 2010)

BARANGAY/ MUNICIPALITY	POPULATION						LAND AREA (Ha.)		DENSITY S.A. (Person per Ha.)		
	1990		2000		2010		Total				
	Barangay	Study Area	Barangay	Study Area	Baragay	Study Area	Barangay	Study Area	1990	2000	2010
1. Bagong Nayon	18,002	14,402	27,647	22,117	37,637	30,110	648.0	319.2	45	69	94
2. Santa Cruz	13,340	9,338	20,538	14,377	27,995	19,597	1,108.0	778.4	12	18	25
3. De La Paz	21,033	21,033	32,269	32,269	43,906	43,906	420.6	420.6	50	77	104
4. Beverly Hills	1,034	1,034	1,767	1,767	2,532	2,532	31.4	31.4	33	56	81
5. San Roque	17,227	17,227	26,465	26,465	36,034	36,034	380.4	380.4	45	70	95
6. Dalig	20,344	14,241	31,204	21,843	42,461	29,723	556.5	332.6	43	66	89
7. San Jose	26,121	13,061	40,029	20,014	54,428	27,214	5,640.1	270.0	48	74	101
8. San Isidro	19,260	19,260	29,566	29,566	40,240	40,240	360.8	360.8	53	82	112
9. San Luis	6,241	3,121	9,712	4,856	13,311	6,656	697.2	233.6	13	21	28
SUB-TOTAL	142,602	112,717	219,196	173,274	298,544	236,012	9,843.0	3,127.0	36	55	75
10. Taytay	-----	7,970	------	10,517	------	13,978	------	764.8	10	14	18
11. Angono	-----	1,750	------	2,705	------	4,189	------	935.0	2	3	4
12. Binangonan	-----	700	------	958	------	1,334	------	141.0	5	7	9
13. Teresa	-----	210	------	256	------	318	------	120.0	2	2	3
SUB-TOTAL	-----	10,630	------	14,436	------	19,819	------	1,960.8	5	7	10
TOTAL		123,347		187,710		255,831		5,087.8	24	37	50

TABLE 6.1.4 POPULATION DISTRIBUTION, LAND AREA AND POPULATION DENSITY: AQUIFER BASIN ZONE (1990, 2000 AND 2010)

BARANGAY/ MUNICIPALITY	POPULATION						LAND AREA (Ha.)		DENSITY S.A. (Person per Ha.)		
	1990		2000		2010		Total				
	Barangay	Study Area	Barangay	Study Area	Baragay	Study Area	Barangay	Study Area	1990	2000	2010
BARANGAY											
Santa Cruz	13,340	4,002	20,538	6,161	27,995	8,399	1,108.0	123.6	32	50	68
De La Paz	21,033	16,826	32,269	25,815	43,906	35,125	420.6	159.4	106	162	220
San Roque	17,227	15,504	26,465	23,819	36,034	32,431	380.4	308.4	50	77	105
Dalig	20,344	14,241	31,204	21,843	42,461	29,723	556.5	332.6	43	66	89
San Jose	26,121	13,061	40,028	20,014	54,428	27,214	5,640.1	270.0	48	74	101
San Isidro	19,260	15,408	29,566	23,653	40,240	32,192	360.8	169.0	91	140	190
San Luis	6,241	3,121	9,712	4,856	13,311	6,656	697.2	233.6	13	21	28
MUNICIPALITY											
Angono	——	1,750	——	2,705	——	4,189	——	572.4	3	5	7
Binangonan	——	700	——	958	——	1,334	——	141.0	5	7	9
Teresa	——	210	——	256	——	318	——	120.0	2	2	3
TOTAL	123,566	84,823	189,782	130,080	258,375	177,581	9,163.6	2,430.0	35	54	73

TABLE 6.1.5 GROWTH RATE OF THE STUDY AREA'S POPULATION (1990-2010)

CITY/MUNICIPALITY	ANNUAL GROWTH RATE				
	1990/ 1980	1995/ 1990	2000/ 1995	2005/ 2000	2010/ 2005
I. METRO MANILA	2.83	2.47	2.07	1.73	1.42
1. Manila	-0.27	0.82	0.47	0.20	0.00
2. Pasay City	2.34	2.28	1.98	1.86	1.59
3. Quezon City	3.50	3.15	2.96	2.76	2.47
4. Calookan City	4.79	2.74	2.31	1.89	1.56
5. Las Pinas	7.69	6.63	5.77	5.00	4.28
6. Makati	3.68	1.55	1.14	0.81	0.53
7. Malabon	3.69	1.88	1.43	1.08	0.77
8. Mandaluyong	1.67	1.67	1.24	0.91	0.62
9. Marikina	3.74	2.95	2.41	1.96	1.56
10. Muntinlupa	6.99	4.50	3.82	3.24	2.70
11. Navotas	3.85	2.11	1.64	1.26	0.94
12. Parañaque	3.81	3.65	3.05	2.54	2.08
13. Pasig	3.84	3.21	2.65	2.17	1.75
14. Pateros	2.36	2.56	2.06	1.64	1.27
15. San Juan	-0.33	1.01	0.64	0.36	0.13
16. Taguig	6.77	3.12	2.57	2.10	1.68
17. Valenzuela	4.63	4.63	4.10	3.49	2.93
II. CAVITE	3.43	3.11	2.69	2.33	1.92
1. Bacoor	5.69	4.16	3.61	3.11	2.63
2. Cavite City	0.44	1.46	1.14	1.03	0.49
3. Imus	4.43	3.02	2.57	2.17	1.79
4. Kawit	1.93	2.90	2.46	2.07	1.70
5. Noveleta	3.44	2.67	2.25	1.88	1.53
6. Rosario	3.09	3.14	2.68	2.26	1.88
III. RIZAL	5.46	3.20	2.84	2.52	2.07
1. Angono	5.28	3.59	3.07	2.56	2.03
2. Antipolo	10.83	4.61	4.01	3.40	2.79
3. Baras	3.89	2.42	2.01	1.59	1.17
4. Binangonan	4.33	1.97	1.60	1.22	0.84
5. Cainta	7.44	5.22	4.56	3.90	3.24
6. Cardona	2.75	1.31	1.00	0.68	0.35
7. Jala-Jala	2.91	1.75	1.40	1.04	0.68
8. Montalban	4.50	2.44	2.02	1.61	1.17
9. Morong	2.36	1.42	1.36	1.69	1.47
10. Pililla	3.23	1.96	1.58	1.21	0.83
11. San Mateo	4.52	2.31	1.91	1.50	1.09
12. Tanay	3.46	2.42	2.01	1.59	1.17
13. Taytay	3.79	2.83	2.72	3.08	2.61
14. Teresa	3.13	0.82	0.55	0.27	0.03

TABLE 6.1.6 POPULATION PROJECTION FOR THE STUDY AREA, 1990-2010

CITY/MUNICIPALITY	1980 (CENSUS)	1990 (CENSUS)	1995	2000	2005	2010
I. NCR	5,970,307	7,928,867	8,971,800	9,948,977	10,847,652	11,649,608
1. Manila	1,642,708	1,598,918	1,666,014	1,705,567	1,723,126	1,723,147
2. Pasay City	289,927	366,623	402,932	433,048	457,147	475,225
3. Quezon City	1,174,605	1,666,766	1,870,519	2,049,017	2,200,635	2,323,154
4. Caloocan City	471,323	761,011	872,801	979,527	1,076,883	1,164,630
5. Las Pinas	137,537	296,851	413,469	551,808	708,704	878,109
6. Makati	375,424	452,734	489,333	517,961	539,315	553,794
7. Malabon	192,433	278,380	305,870	328,653	346,868	360,515
8. Mandaluyong	206,906	244,538	265,870	282,944	296,044	305,315
9. Marikina	213,199	310,010	359,368	405,480	447,289	483,621
10. Muntinlupa	137,704	276,972	346,829	419,918	493,739	565,215
11. Navotas	127,092	186,799	207,567	225,328	240,031	251,550
12. Paranaque	210,115	307,717	369,370	430,253	488,493	541,964
13. Pasig	270,583	397,309	466,552	532,663	593,888	648,283
14. Pateros	40,590	51,401	58,438	64,776	70,318	74,945
15. San Juan	131,063	126,708	133,478	137,583	140,304	141,007
16. Taguig	135,143	266,080	311,031	353,627	392,792	427,323
17. Valenzuela	213,955	340,050	432,359	530,824	632,076	731,811
II. CAVITE	324,273	457,020	534,043	611,062	686,825	756,085
1. Bacoor	90,364	159,685	196,636	235,538	275,150	313,838
2. Cavite City	87,666	91,641	98,576	104,379	109,908	112,628
3. Imus	59,103	92,125	107,162	121,860	135,818	148,542
4. Kawit	39,368	47,755	55,217	62,446	69,254	75,407
5. Noveleta	14,460	20,409	23,325	26,102	28,673	30,955
6. Rosario	33,312	45,405	53,127	60,737	68,022	74,715
III. RIZAL	567,346	980,194	1,150,043	1,325,537	1,503,547	1,667,350
1. Angono	27,136	46,014	55,062	64,219	72,979	80,788
2. Antipolo	70,377	207,842	261,738	319,849	379,154	435,886
3. Baras	11,434	16,880	19,051	21,063	22,808	24,182
4. Binangonan	82,702	127,561	140,791	152,533	162,155	169,117
5. Cainta	60,280	126,839	164,650	206,860	251,447	295,646
6. Cardona	25,024	32,962	35,194	36,995	38,270	38,952
7. Jala-Jala	12,199	16,318	17,814	19,109	20,131	20,826
8. Montalban	42,749	67,074	75,766	83,837	90,845	96,318
9. Morong	25,387	32,165	34,528	36,957	40,222	43,304
10. Pililla	23,716	32,771	36,137	39,119	41,556	43,312
11. San Mateo	53,014	82,310	92,401	101,679	109,620	115,769
12. Tanay	41,303	58,410	65,923	72,889	78,925	83,678
13. Taytay	76,930	112,403	129,481	148,322	173,025	197,131
14. Teresa	15,095	20,645	21,507	22,106	22,410	22,441
TOTAL	6,861,926	9,366,081	10,655,886	11,885,576	13,038,024	14,073,043

Source: Estimation made by the Study Team based on NSO data

TABLE 6.1.7 POPULATION PROJECTIONS FOR THE MUNICIPALITY OF ANTIPOLO, 1990-2010

MUNICIPALITY/ BARANGAY	1990	1995	2000	2005	2010
ANTIPOLO	207,842	261,738	319,849	379,154	435,886
1. Bagong Nayon	18,002	22,644	27,647	32,752	37,637
2. Beverly Hills	1,034	1,385	1,767	2,161	2,532
3. Calawis	1,662	2,172	2,725	3,293	3,831
4. Cupang	25,696	32,283	39,380	46,620	53,551
5. Dalig	20,344	25,566	31,204	36,956	42,461
6. De La Paz (Pob.)	21,033	26,441	32,269	38,215	43,906
7. Inarawan	4,965	6,312	7,767	9,254	10,673
8. Mambugan	15,636	19,680	24,039	28,487	32,743
9. Mayamot	15,887	19,995	24,423	28,941	33,264
10. San Isidro	19,260	24,220	29,566	35,020	40,240
11. San Jose	26,121	32,815	40,028	47,385	54,428
12. San Juan	1,394	1,838	2,319	2,813	3,280
13. San Luis	6,241	7,910	9,712	11,553	13,311
14. San Roque	17,227	21,673	26,465	31,355	36,034
15. Sta. Cruz	13,340	16,804	20,538	24,349	27,995

Source: Estimation made by the Study Team based on NSO data. Due to the absence of population data at barangay level prior to 1990, population projections at barangay level were based on the growth rate of the whole Antipolo municipality.

TABLE 6.1.8 BLIGHTED POPULATION BY CITY/MUNICIPALITY, NATIONAL CAPITAL REGION

CITY/ MUNICIPALITY	1982			1985			1990		
	NHA BLIGHTED POPULATION ESTIMATES	TOTAL POPULATION	%	NHA BLIGHTED POPULATION ESTIMATES	TOTAL POPULATION	%	BLIGHTED POPULATION ESTIMATES	TOTAL POPULATION	%
1. MANILA	545,496	1,723,044	32	470,237	1,765,903	26.6	425,312	1,598,918	26.6
2. CALOOCAN CITY	130,080	492,549	26	196,507	543,903	36.2	304,404	761,011	40.0
3. PASAY CITY	76,902	294,709	26	289,490	331,861	87.2	319,695	366,623	87.2
4. QUEZON CITY	371,904	1,296,099	29	566,415	1,377,927	41.1	755,045	1,666,766	45.3
5. LAS PINAS	29,592	98,655	30	35,235	207,770	17.0	53,433	296,851	18.0
6. MAKATI	81,612	393,537	21	77,033	421,367	18.3	82,850	452,734	18.3
7. MALABON	48,883	203,313	24	51,092	220,198	23.2	79,617	278,380	28.6
8. MANDALUYONG	63,570	217,505	29	68,629	233,844	29.3	86,811	244,538	35.5
9. MARIKINA	32,484	204,995	16	80,000	259,807	30.8	105,035	310,010	33.9
10. MUNTINLUPA	39,594	116,754	34	47,200	183,694	25.7	79,491	276,972	28.7
11. NAVOTAS	56,020	129,314	43	73,683	147,365	50.0	93,399	186,799	50.0
12. PARANAQUE	36,180	156,955	23	22,580	266,741	8.5	32,310	307,717	10.5
13. PASIG	37,898	309,337	12	78,348	334,771	23.4	112,836	397,309	28.4
14. PATEROS	2,946	45,277	7	8,000	48,347	16.5	8,481	51,401	16.5
15. SAN JUAN	21,972	135,590	16	15,000	142,444	10.5	13,304	126,708	10.5
16. TAGUIG	49,614	134,238	37	38,231	166,308	23.0	66,529	266,080	25.0
17. VALENZUELA	21,060	160,841	13	157,500	290,552	54.2	187,027	340,050	55.0
TOTAL	1,645,807	6,112,712	27	2,275,180	6,942,207	32.8	2,805,579	7,928,867	35.4

TABLE 6.1.9 BLIGHTED POPULATION PROJECTION, NCR

YEAR	TOTAL POPULATION (Thousands)	GROSS BLIGHTED POPULATION (Thousands)	% OF THE TOTAL POPULATION
1985	6,942.21	2,275.18	32.8
1986	7,036.55	2,305.09	32.7
1987	7,244.38	2,414.25	33.3
1988	7,462.03	2,533.21	33.9
1989	7,690.01	2,663.38	34.6
1990	7,928.87	2,805.57	35.4
1995	8,971.80	3,172.40	35.4
2000	9,948.98	3,512.38	35.3
2005	10,847.65	3,820.59	35.2
2010	11,649.61	4,091.27	35.1

Source: NHA-CORPLAN (1985-1990)
STUDY TEAM (1995-2010)

TABLE 6.1.10 PER CAPITA INCOME GROWTH (%)

YEAR	PER CAPITA INCOME GROWTH (%)		
	SECTOR		
	1	2	3
1987	-1.37	-1.37	0.00
1988	-3.95	-3.95	0.00
1989	-7.37	-7.37	0.00
1990	-9.17	-9.17	0.00
1991	14.72	14.72	0.00
1992	-17.64	-17.64	0.00
1993	-1.22	-1.22	0.00
1994	-1.43	-1.43	0.00
1995	1.49	1.49	0.00
1996	3.11	3.11	0.00
1997	-3.01	-3.01	0.00
1998	-2.92	-2.92	0.00
1999	-3.00	-3.00	0.00
2000	-12.31	-12.31	0.00
2001	-1.28	-1.28	0.00
2002	-1.18	-1.18	0.00
2003	-1.08	-1.08	0.00
2004	-1.00	-1.00	0.00
2005	-0.91	-0.91	0.00
2006	-0.84	-0.84	0.00
2010	-0.56	-0.56	0.00

1. General Population
2. Urban Development Beneficiaries
3. Blighted Population

Source: MWSS (CORPLAN)

TABLE 6.1.11 GROSS DOMESTIC PROJECT (GDP), NATIONAL CAPITAL REGION

YEAR	INDUSTRIAL GDP (M)	INDUSTRIAL GROWTH RATE	SERVICE GDP (M)	SERVICE GROWTH RATE
1983	16645		15586	
1984	15022	-9.75	13901	-10.81
1985	13840	-7.87	13185	-5.15
1986	13640	-1.45	13093	-0.70
1987	14669	7.54	13539	3.41
1988	15431	5.19	14663	8.30
1989	16430	6.47	15480	5.57
1990	17844	8.61	16405	5.98
1991	18605	4.23	17340	5.70
1992	19651	5.62	17956	3.55
1993	20653	5.10	18767	4.51
1994	21650	4.83	19638	4.64
1995	22687	4.79	20467	4.22
1996	26729	4.60	21298	4.06
1997	24710	4.13	22114	3.83
1998	25728	4.12	22909	3.60
1999	26741	3.94	23735	3.60
2000	27755	3.79	24563	3.49
2001	28773	3.67	25383	3.34
2002	29787	3.53	26203	3.23
2003	30797	3.39	27020	3.12
2004	31811	3.29	27838	3.03
2005	32825	3.19	28660	2.95
2006	33839	3.09	29481	2.86
2007	34853	3.00	30300	2.78
2008	35867	2.91	31120	2.70
2009	36880	2.83	31939	2.63
2010	37894	2.75	32759	2.57

Note:

(1) Data for 1983 to 1985 were estimates as of June 1986 and were taken from NEDA.

(2) Projections for 1987 to 1992 were obtained from Projections of Regional Development Plans 1987-1992.

(3) Projection for 1993 to 2010 were estimates made by the Study Team.

TABLE 6.1.12 ESTIMATED AREA BY LAND CATEGORY, ANTIPOLO AREA, 1991

BARANGAY/ MUNICIPALITY	LAND USE: BUILT-UP Residential Institutional Facilities	COMMERCIAL	INDUSTRIAL	OPEN SPACE	AGRICULTURAL Ricefield Cropland Plantation	FOREST/ GRASSLAND Forest Grassland Shrubland Pasture	OTHERS Wetland Quarry	LAND AREA (Ha.)
Bagong Nayon	69.1	2.8	-	36.2	44.0	157.1	10.0	319.2
Sta. Cruz	115.0	1.0	-	147.6	85.0	385.0	44.8	778.4
De la Paz	56.0	1.8	-	134.6	72.0	156.2	-	420.6
Beverly Hills	20.0	-	-	7.0	4.4	-	-	31.4
San Roque	95.0	2.0	5.0	74.4	87.0	117.0	-	380.4
Dalig	85.0	0.8	6.0	75.0	100.5	65.3	-	332.6
San Jose	58.0	2.0	3.6	47.0	90.5	68.9	-	270.0
San Isidro	43.4	2.0	0.4	82.0	57.0	176.0	-	360.8
San Luis	10.0	-	-	13.6	30.0	180.0	-	233.6
Taytay	115.2	-	5.2	122.6	41.8	477.0	-	764.8
Angono	45.0	-	10.8	35.0	149.0	665.2	30.0	935.0
Binangonan	6.8	-	6.4	-	10.6	117.2	-	141.0
Teresa	-	-	-	0.8	21.2	95.0	-	120.0
TOTAL	721.5	12.4	37.4	775.8	796.0	2,659.9	84.8	5087.8

TABLE 6.1.13 ESTIMATED AREA BY LAND CATEGORY, ANTIPOLO AREA, 2020

BARANGAY/ MUNICIPALITY	LAND USE							LAND AREA (Ha.)
	BUILT-UP Residential Institutional Facilities	COMMERCIAL	INDUSTRIAL	OPEN SPACE	AGRICULTURAL Ricefield Cropland Plantation	FOREST/ GRASSLAND Forest Grassland Shrubland Pasture	OTHERS	
Bagong Nayon	118.0	3.9	-	20.1	29.2	135.6	12.4	319.2
Sta. Cruz	298.5	2.0	-	134.0	58.6	285.3	-	778.4
De la Paz	151.2	3.6	-	95.8	35.0	135.0	-	420.6
Beverly Hills	29.6	-	-	-	1.8	-	-	31.4
San Roque	168.6	4.0	6.0	61.8	42.8	97.2	-	380.4
Dalig	155.5	3.2	6.0	28.2	88.5	51.2	-	332.6
San Jose	114.0	3.8	6.5	15.4	66.5	63.8	-	270.0
San Isidro	108.4	3.5	1.0	54.2	38.4	155.3	-	360.8
San Luis	32.7	-	-	8.8	26.5	165.6	-	233.6
Taytay	224.4	-	7.0	63.4	49.2	420.8	-	764.8
Angono	130.5	-	15.2	20.0	145.2	597.7	26.4	935.0
Binangonan	10.5	-	6.4	-	10.6	113.5	-	141.0
Teresa	2.0	-	-	-	24.0	94.0	-	120.0
TOTAL	1,543.9	24.0	48.1	501.7	616.3	2,315.0	38.8	5,087.8

TABLE 6.2.1 NUMBER OF CONNECTIONS AND BILLED CONSUMPTION IN 1990

CITY /MUNICIPALITY	NUMBER OF SERVICE CONNECTIONS					WATER CONSUMPTION IN 1990 (CUBIC METER)						% TO TOTAL
	DOM	P.F.	COM.	IND.	OTHERS	DOM	P.F.	COM.	IND.	OTHERS	TOTAL	
I. NCR	587,778	462	41,010	5,763	528	275,826,999	1,430,279	109,937,991	24,761,109	1,442,756	413,399,174	97.4
CITY OF MANILA	155,052	86	14,452	707	88	75,898,348	354,831	42,357,787	4,760,534	811,457	124,284,877	29.3
PASAY CITY	25,087	33	1,307	161	8	10,198,494	62,164	5,327,980	292,085	3,565	15,884,288	3.7
QUEZON CITY	147,326	167	10,695	1,712	276	73,012,881	498,558	27,807,459	5,762,759	466,346	107,548,003	25.3
CALOOCAN CITY	44,673	41	2,535	718	5	16,102,242	118,420	3,675,980	2,973,311	8,800	22,878,553	5.4
LAS PINAS	7,939	8	315	32	13	1,082,472	13,573	199,821	38,095	12,195	1,346,156	0.3
MAKATI	40,210	5	3,199	294	8	22,351,210	7,495	15,313,713	1,494,580	5,532	39,172,530	9.2
MALABON	18,012	19	599	368	1	6,240,013	58,209	1,033,252	1,923,024	360	9,254,858	2.2
MANDALUYONG	21,345	19	1,123	257	4	9,453,861	51,006	3,610,376	2,508,080	3,510	15,626,893	3.7
MARIKINA	28,315	23	1,298	503	3	13,818,472	95,034	1,249,818	452,522	356	15,616,202	3.7
MUNTINLUPA	5,585	0	105	11	95	1,315,447	0	25,061	1,704	24,090	1,366,302	0.3
NAVOTAS	13,795	6	471	126	3	3,214,442	19,807	855,258	650,139	1,343	4,540,989	1.1
PARANAQUE	13,552	17	1,045	168	3	11,830,787	42,757	2,160,859	539,614	1,254	14,575,271	3.4
PASIG	32,630	21	1,105	266	11	15,810,304	45,118	3,010,142	2,600,769	1,088	21,467,421	5.1
PATEROS	2,349	0	34	3	0	628,561	0	17,946	1,135	0	647,642	0.2
SAN JUAN	12,851	8	920	146	1	8,633,477	45,615	2,641,428	386,174	805	11,706,899	2.8
TAGUIG	4,060	3	61	8	1	1,188,990	7,620	116,262	2,771	270	1,315,913	0.3
VALENZUELA	15,077	6	775	263	2	5,046,998	10,072	734,929	373,813	585	6,166,377	1.5
II. CAVITE	16,879	17	731	53	1,293	4,304,555	43,328	394,069	33,818	335,131	5,111,901	1.2
BACOOR	3,881	5	132	3	58	941,683	19,813	86,403	585	21,883	1,070,467	0.3
CAVITE CITY	7,807	8	395	32	218	1,982,973	17,099	234,181	19,886	56,740	2,310,879	0.5
IMUS	978	0	58	6	1	284,472	0	20,855	1,779	536	307,642	0.1
KAVIT	3,055	4	119	9	663	825,494	6,416	39,294	10,754	174,127	1,056,085	0.2
NOVELETA	507	0	5	1	104	117,848	0	1,592	300	28,112	147,852	0.0
ROSARIO	651	0	23	2	249	152,085	0	11,744	514	56,633	218,976	0.1
III. RIZAL	17,116	9	654	180	15	4,892,593	27,582	530,031	635,331	2,307	6,087,844	1.4
ANGONO	-	-	-	-	-	-	-	-	-	-	-	-
ANTIPOLO	4,445	1	223	41	3	1,316,107	1,416	194,554	570,630	481	2,083,188	0.5
BARAS	-	-	-	-	-	-	-	-	-	-	-	-
BINANGONAN	-	-	-	-	-	-	-	-	-	-	-	-
CAINTA	3,003	2	134	26	8	995,747	4,142	144,691	14,206	1,275	1,160,061	0.3
CARDONA	-	-	-	-	-	-	-	-	-	-	-	-
JARA-JARA	-	-	-	-	-	-	-	-	-	-	-	-
MONTALBAN	2,039	0	35	10	3	546,674	0	13,395	5,022	440	565,531	0.1
MORONG	-	-	-	-	-	-	-	-	-	-	-	-
PILILLA	-	-	-	-	-	-	-	-	-	-	-	-
SAN MATEO	3,678	4	107	47	0	841,283	12,224	59,772	17,650	0	930,929	0.2
TANAY	-	-	-	-	-	-	-	-	-	-	-	-
TAYTAY	3,951	2	154	56	1	1,192,782	9,800	117,619	27,823	111	1,348,135	0.3
TERESA	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	621,773	488	42,395	5,996	1,836	285,024,147	1,501,189	110,862,091	25,430,258	1,781,234	424,598,919	100.0

SOURCE : COMPUTER SERVICE CENTER, MWSS

TABLE 6.2.2 STATUS OF DOMESTIC WATER SUPPLY BY MWSS AND PRIVATE SYSTEMS

CITY/MUNICIPALITY	1990 CENSUS POPULATION (1)	MWSS HOUSE SERVICE CONNECTION: AVG. DAILY CONSUMPTION AMOUNT (M3/D) (2)	% TO TOTAL (3)	CONNECTIONS: NUMBER (4)	EQUIVALENT NO. OF POPULATION (5)	% TO TOTAL POP. (6)	AVERAGE PER CAPITA CONS. (LPCD) (7)	CORR'D PER CAPITA CONS. (LPCD) (8)	MWSS PUBLIC FAUCETS: AVERAGE DAILY CONSUMP. (M3/D) (9)	PUBLIC FAUCETS: NUMBER (10)	EQUIV. NO. OF POP. (11)	% TO TOTAL POP. (12)	AVERAGE PER CAPITA CONS. (LPCD) (13)	CORR'D PER CAPITA CONS. (LPCD) (14)	EQUIVALENT NO. OF POPULATION SERVED BY MWSS: TOTAL (HSC+PF) (15)	% TO TOTAL POP. (16)	PRIVATE WELL: DOMESTIC SUPPLY AMOUNT (M3/D) (17)	ESTIMATED SERVED POPULATION (18)	SHARE IN SUPPLY AMOUNT (%) (19)	EQUIVALENT NO. OF POPULATION SERVED BY MWSS & PRIVATE SYSTEM: TOTAL (20)	% TO TOTAL (21)
I. NCR	7,928,867	755,690	96.8	587,778	4,761,302	60.0	158.7	174	3,919	462	226,532	2.8	17.5	19	4,985,534	62.9	256,935	1,351,526	16.3	6,341,059	80.0
1. Manila	1,598,598	207,941	26.6	155,052	1,255,921	78.5	165.6	181	972	86	43,796	2.6	22.3	25	1,297,717	81.2	2,214	12,284	1.0	1,309,921	81.9
2. Pasay City	366,623	27,941	3.6	25,087	203,205	55.4	137.5	151	170	33	16,038	4.4	10.6	12	219,243	59.8	5,827	32,372 *	15.9	251,615	68.6
3. Quezon City	1,656,766	200,235	25.6	147,326	1,193,361	71.6	167.6	184	1,366	167	83,162	4.9	16.8	18	1,276,503	76.5	30,315	170,583	12.4	1,445,006	86.7
4. Caloocan City	751,011	44,116	5.6	44,573	361,851	47.5	121.5	134	324	41	19,926	2.6	16.9	18	381,777	50.2	19,133	106,317 *	28.2	488,094	64.1
5. Las Pinas	256,851	2,366	0.4	7,339	64,306	21.7	46.1	51	37	8	3,888	1.3	9.6	10	68,194	23.0	53,141	317,650 *	94.6	385,844	129.9
6. Makati	452,754	61,236	7.8	48,210	385,701	71.9	188.0	206	21	5	2,430	0.5	8.5	9	388,131	72.5	10,075	68,506	15.1	377,337	83.3
7. Malabon	278,388	17,096	2.2	18,812	165,697	52.6	117.3	128	159	19	9,234	3.3	17.3	19	155,131	55.7	1,892	10,511 *	9.1	165,642	59.5
8. Mandaluyong	244,538	25,931	3.3	21,245	172,855	70.7	169.8	164	140	19	9,234	3.8	15.1	17	182,128	74.5	1,495	9,108	5.0	191,236	78.2
9. Marikina	313,010	37,859	4.8	28,315	239,352	76.5	165.1	181	260	23	11,178	3.6	23.3	26	249,530	79.6	5,340	29,525	11.3	279,054	87.1
10. Muntinlupa	275,972	3,634	0.5	5,505	44,591	16.1	80.8	89	-	-	0	-	-	-	44,591	16.1	49,108	232,822 *	92.5	317,413	114.6
11. Navotas	186,799	8,807	1.1	13,795	111,740	59.8	73.8	86	54	6	2,916	1.6	18.6	20	114,656	61.4	1,691	9,398 *	14.8	124,053	66.4
12. Paranaque	307,717	22,413	4.2	13,552	109,771	35.7	265.3	324	117	13	8,283	2.7	14.2	16	118,033	38.4	47,553	145,978	57.2	265,011	85.1
13. Pasig	397,309	43,316	5.5	32,633	264,303	66.5	163.9	180	124	21	10,206	2.6	12.1	13	274,509	69.1	9,223	51,361	16.2	325,871	82.0
14. Pateros	51,601	1,722	0.2	2,345	19,027	37.0	90.5	99	-	-	0	-	-	-	19,027	37.0	0	0 *	0.0	19,027	37.0
15. San Juan	126,108	23,653	3.0	13,851	104,093	82.2	227.2	249	125	8	3,888	3.1	32.1	35	107,981	85.2	252	1,013	1.0	108,993	86.0
16. Taguig	266,080	3,358	0.4	4,060	32,886	12.4	99.1	108	21	3	1,458	0.5	14.3	16	34,344	12.9	21,514	119,522 *	85.7	153,866	57.8
17. Valenzuela	349,050	13,827	1.8	15,077	122,124	35.9	113.2	124	28	6	2,916	0.9	9.5	10	125,040	36.8	3,157	17,539 *	11.2	142,579	41.9
II. CAVITE	657,020	11,792	1.5	16,879	136,133	25.8	86.6	95	119	17	8,262	1.8	14.4	16	144,395	31.6	46,864	260,354	78.2	404,749	88.6
1. Bacoor	159,685	2,580	0.3	3,881	31,436	19.7	82.1	90	54	5	2,430	1.5	22.3	24	33,866	21.2	31,501	175,039 *	91.6	208,905	130.8
1. Cavite City	81,641	5,633	0.7	7,807	63,237	69.0	85.5	94	47	8	3,888	4.2	12.0	13	67,125	73.2	849	4,717 *	12.6	71,841	78.4
3. Imus	82,125	179	0.1	578	7,335	8.9	106.3	116	-	0	0	0.0	-	-	7,335	8.9	3,268	18,156 *	79.3	25,491	27.7
4. Kawit	49,755	2,262	0.3	3,055	24,746	51.8	91.4	100	18	4	1,944	4.1	9.0	10	26,690	55.9	2,830	15,722 *	53.1	42,412	88.8
5. Noveleta	33,405	323	0.0	507	4,107	20.1	78.6	86	-	0	0	0.0	-	-	4,107	20.1	5,659	31,439 *	94.8	35,546	174.3
6. Rosario	45,405	417	0.1	651	5,273	11.6	79.0	87	-	0	0	0.0	-	-	5,273	11.6	2,751	15,282 *	85.8	20,555	45.3
III. RIZAL	980,194	13,434	1.7	17,116	139,459	14.2	96.1	105	76	9	3,216	0.3	23.5	26	142,715	14.6	65,171	362,061	81.8	504,776	51.5
1. Angono	46,014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Antipolo	207,842	3,626	0.5	4,445	36,005	17.3	100.1	110	4	1	54	0.0	11.8	13	36,059	17.3	29,367	163,150 *	88.1	199,209	95.8
3. Baras	16,880	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Binangonan	127,561	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Cainta	126,839	2,728	0.3	3,803	24,324	19.2	112.2	123	11	2	972	0.8	11.7	13	25,296	19.9	9,223	51,517 *	75.5	76,813	60.6
6. Cardona	32,362	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Jala-Jala	16,318	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Rodriguez	67,374	1,498	0.2	2,003	15,994	23.7	94.2	103	0	0	0	0.0	-	-	15,994	23.7	4,244	23,578 *	72.1	39,682	58.9
9. Morong	32,165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10. Pililla	32,771	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11. San Mateo	82,310	1,305	0.2	1,678	31,263	38.0	72.7	81	33	4	1,218	1.5	27.5	30	32,481	39.5	2,647	14,706 *	50.8	47,187	57.3
12. Tanay	58,610	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13. Taytay	112,403	1,356	0.4	1,951	32,003	28.5	102.1	113	27	2	972	0.9	27.6	30	32,975	29.3	13,648	109,111 *	84.5	142,086	126.4
14. Teresa	20,865	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	9,566,081	780,888	100.0	621,773	5,036,834	52.8	155.0	170	4,113	488	238,010	2.5	17.6	19	5,272,844	56.3	378,970	1,977,941	30.6	7,250,785	77.4

(5)=((4)x3.1 (7)=(2)/(5)x1000 (8)=(7)x1.0957 (11)=(10)x486 (13)=(9)/(11)x1000 (14)=(13)x1.0957 (15)=(5)+(11) (16)=(17)/(6)x1000 (19)=(17)/([(2)+(9)]*1.0957+(17))*100 (20)=(15)+(18)

* Assumed per capita consumption of 180 lpcd was used instead of estimated per capita consumption considering suppressed water supply condition.

TABLE 6.2.3 STATUS OF COMMERCIAL CONSUMPTION IN 1990

CITY/MUNICIPALITY	AVG. DAILY BILLED MWSS COMMERCIAL CONSUM.			NUMBER OF MWSS METER CONNECTION	CONSUMPTION PER METER CONNECTION		PRIVATE WELL COMM'L PUMPAGE (M3/DAY)	ESTIMATED TOTAL COMM'L CONSUM. (M3/DAY)	% TO TOTAL (%)	SHARE OF PRIVATE WELL (%)
	AMOUNT (M3/DAY)	CORRECTED (M3/DAY)	% TO TOTAL		BILLED (M3/DAY)	CORRECTED (M3/DAY)				
I. NCR	301,200	341,350	99.2	41,010	7.345	8.324	93,315	434,665	96.4	21.5
1. Manila	116,049	131,518	38.2	14,452	8.030	9.100	4,665	136,183	30.2	3.4
2. Pasay City	14,597	16,543	4.8	1,907	7.655	8.675	8,795	25,338	5.6	34.7
3. Quezon City	76,185	86,340	25.1	10,695	7.123	8.073	27,641	113,981	25.3	24.3
4. Calookan City	10,071	11,414	3.3	2,535	3.973	4.502	3,674	15,088	3.3	24.4
5. Las Pinas	547	620	0.2	315	1.738	1.970	3,678	4,299	1.0	85.6
6. Makati	41,955	47,548	13.8	3,189	13.156	14.910	11,721	59,269	13.1	19.8
7. Malabon	2,831	3,208	0.9	989	2.862	3.244	2,016	5,224	1.2	38.6
8. Mandaluyong	9,891	11,210	3.3	1,123	8.808	9.982	2,128	13,338	3.0	16.0
9. Marikina	3,424	3,881	1.1	1,288	2.659	3.013	1,400	5,280	1.2	26.5
10. Muntinlupa	69	78	0.0	106	0.648	0.734	8,230	8,308	1.8	99.1
11. Navotas	1,795	2,035	0.6	471	3.812	4.320	621	2,655	0.6	23.4
12. Paranaque	5,920	6,709	1.9	1,045	5.665	6.420	4,914	11,624	2.6	42.3
13. Pasig	8,247	9,346	2.7	1,105	7.463	8.458	6,658	16,004	3.5	41.6
14. Pateros	49	56	0.0	34	1.446	1.639	0	56	0.0	0.0
15. San Juan	7,237	8,201	2.4	920	7.866	8.915	97	8,299	1.8	1.2
16. Taguig	319	361	0.1	61	5.222	5.918	3,655	4,016	0.9	91.0
17. Valenzuela	2,014	2,282	0.7	775	2.598	2.944	3,423	5,705	1.3	60.0
II. CAVITE	1,080	1,224	0.4	731	1.477	1.674	5,175	6,399	1.4	80.9
1. Bacoor	237	268	0.1	132	1.793	2.032	703	971	0.2	72.4
2. Cavite City	642	727	0.2	398	1.612	1.827	3,480	4,207	0.9	82.7
3. Imus	57	65	0.0	54	1.058	1.199	644	709	0.2	90.9
4. Kawit	108	122	0.0	119	0.905	1.025	0	122	0.0	0.0
5. Noveleta	4	5	0.0	5	0.872	0.989	0	5	0.0	0.0
6. Rosario	32	36	0.0	23	1.399	1.585	348	385	0.1	90.5
III. RIZAL	1,452	1,646	0.5	654	2.220	2.516	8,338	9,983	2.2	83.5
1. Angono	-	-	-	-	-	-	-	-	-	-
2. Antipolo	533	604	0.2	223	2.390	2.709	2,763	3,367	0.7	82.1
3. Baras	-	-	-	-	-	-	-	-	-	-
4. Binangonan	-	-	-	-	-	-	-	-	-	-
5. Cainta	396	449	0.1	134	2.958	3.353	3,173	3,622	0.8	87.6
6. Cardona	-	-	-	-	-	-	-	-	-	-
7. Jala-Jala	-	-	-	-	-	-	-	-	-	-
8. Montalban	37	42	0.0	36	1.019	1.155	844	886	0.2	95.3
9. Morong	-	-	-	-	-	-	-	-	-	-
10. Pililla	-	-	-	-	-	-	-	-	-	-
11. San Mateo	164	186	0.1	107	1.530	1.734	390	576	0.1	67.8
12. Tanay	-	-	-	-	-	-	-	-	-	-
13. Taytay	322	365	0.1	154	2.092	2.371	1,167	1,532	0.3	76.2
14. Teresa	-	-	-	-	-	-	-	-	-	-
TOTAL	303,732	344,219	100.0	42,395	7.164	8.119	106,828	451,047	100.0	23.7

TABLE 6.2.4 STATUS OF INDUSTRIAL CONSUMPTION IN 1990

CITY/MUNICIPALITY	AVG. DAILY BILLED MWSS INDUSTRIAL CONSUM.			NUMBER OF MWSS METER CONNECTION	CONSUMPTION PER METER CONNECTION		PRIVATE WELL IND'L PUMPAGE (M3/DAY)	ESTIMATED TOTAL IND'L CONS. (M3/DAY)	% TO TOTAL	SHARE OF PRIVATE WELL (%)
	BILLED (M3/DAY)	CORRECTED (M3/DAY)	% TO TOTAL		BILLED (M3/DAY)	CORRECTED (M3/DAY)				
I. NCR	71,792	81,361	96.3	6,291	11.412	12.933	280,687	362,048	82.4	77.5
1. Manila	15,545	17,617	20.9	795	19.554	22.160	5,786	23,403	5.3	24.7
2. Pasay City	810	918	1.1	169	4.793	5.432	3,375	4,293	1.0	78.6
3. Quezon City	17,066	19,341	22.9	1,988	8.585	9.729	32,368	51,708	11.8	62.6
4. Calookan City	8,170	9,259	11.0	723	11.300	12.806	4,665	13,923	3.2	33.5
5. Las Pinas	138	156	0.2	51	2.702	3.062	20,959	21,115	4.8	99.3
6. Makati	4,110	4,658	5.5	302	13.609	15.423	3,383	8,041	1.8	42.1
7. Malabon	5,270	5,972	7.1	369	14.281	16.184	14,565	20,537	4.7	70.9
8. Mandaluyong	6,881	7,799	9.2	261	26.365	29.879	5,353	13,151	3.0	40.7
9. Marikina	1,241	1,406	1.7	506	2.452	2.779	6,833	8,239	1.9	82.9
10. Muntinlupa	71	80	0.1	106	0.667	0.756	34,280	34,360	7.8	99.8
11. Navotas	1,785	2,023	2.4	129	13.836	15.681	1,739	3,762	0.9	46.2
12. Paranaque	1,482	1,679	2.0	171	8.666	9.821	17,691	19,370	4.4	91.3
13. Pasig	7,128	8,079	9.6	277	25.734	29.165	60,077	68,156	15.5	88.1
14. Pateros	3	4	0.0	3	1.037	1.175	1,756	1,760	0.4	99.8
15. San Juan	1,059	1,200	1.4	147	7.201	8.161	59	1,259	0.3	4.7
16. Taguig	8	9	0.0	9	0.926	1.049	41,198	41,208	9.4	100.0
17. Valenzuela	1,026	1,162	1.4	285	3.599	4.079	26,600	27,763	6.3	95.8
II. CAVITE	1,014	1,149	1.4	1,346	0.753	0.853	5,889	7,037	1.6	83.7
1. Bacoor	62	70	0.1	61	1.014	1.149	0	70	0.0	0.0
2. Cavite City	210	238	0.3	250	0.840	0.952	0	238	0.1	0.0
3. Imus	6	7	0.0	7	0.906	1.027	530	538	0.1	98.7
4. Kawit	507	574	0.7	672	0.754	0.854	0	574	0.1	0.0
5. Noveleta	78	88	0.1	105	0.741	0.840	0	88	0.0	0.0
6. Rosario	151	171	0.2	251	0.602	0.682	5,358	5,530	1.3	96.9
III. RIZAL	1,747	1,980	2.3	195	8.959	10.153	68,328	70,308	16.0	97.2
1. Angono	-	-	-	-	-	-	-	-	-	-
2. Antipolo	1,565	1,773	2.1	44	35.561	40.301	12,025	13,798	3.1	87.1
3. Baras	-	-	-	-	-	-	-	-	-	-
4. Binangonan	-	-	-	-	-	-	-	-	-	-
5. Cainta	42	48	0.1	34	1.247	1.414	36,173	36,221	8.2	99.9
6. Cardona	-	-	-	-	-	-	-	-	-	-
7. Jala-Jala	-	-	-	-	-	-	-	-	-	-
8. Montalban	15	17	0.0	13	1.151	1.305	2,941	2,958	0.7	99.4
9. Morong	-	-	-	-	-	-	-	-	-	-
10. Pililla	-	-	-	-	-	-	-	-	-	-
11. San Mateo	48	55	0.1	47	1.029	1.166	604	658	0.1	91.7
12. Tanay	-	-	-	-	-	-	-	-	-	-
13. Taytay	77	87	0.1	57	1.343	1.522	16,586	16,672	3.8	99.5
14. Teresa	-	-	-	-	-	-	-	-	-	-
TOTAL	74,552	84,490	100.0	7,832	9.519	10.788	354,904	439,394	100.0	80.8

Billed Water Consumption categorized in Others are included in Industrial Consumption

TABLE 6.2.5 PER CAPITA DOMESTIC WATER DEMAND GROWTH

FOR GENERAL POPULATION

YEAR	PCIG(I) (1)	IED (2)	IR1(I) (3)	TI(I) (4)	PED (5)	IR2(I) (6)	IR(I) (7)	II(I) (8)
1990	-9.17	0.30	-2.75	-0.77	-0.20	0.15	-2.60	1.0000
1991	14.72	0.30	4.42	-2.53	-0.20	0.51	4.92	1.0492
1992	-17.64	0.30	-5.29	-0.31	-0.20	0.06	-5.23	0.9943
1993	-1.22	0.30	-0.37	1.38	-0.20	-0.28	-0.64	0.9880
1994	-1.43	0.30	-0.43	1.38	-0.20	-0.28	-0.71	0.9810
1995	1.49	0.30	0.45	1.38	-0.20	-0.28	0.17	0.9827
1996	3.11	0.30	0.93	1.38	-0.20	-0.28	0.66	0.9891
1997	-3.01	0.30	-0.90	1.38	-0.20	-0.28	-1.18	0.9775
1998	-2.92	0.30	-0.88	1.38	-0.20	-0.28	-1.15	0.9662
1999	-3.00	0.30	-0.90	1.38	-0.20	-0.28	-1.18	0.9548
2000	-12.31	0.30	-3.69	1.38	-0.20	-0.28	-3.97	0.9169
2001	-1.28	0.30	-0.38	1.38	-0.20	-0.28	-0.66	0.9109
2002	-1.18	0.30	-0.35	1.38	-0.20	-0.28	-0.63	0.9052
2003	-1.08	0.30	-0.32	1.38	-0.20	-0.28	-0.60	0.8997
2004	-1.00	0.30	-0.30	1.38	-0.20	-0.28	-0.58	0.8945
2005	-0.91	0.30	-0.27	1.38	-0.20	-0.28	-0.55	0.8896
2006	-0.84	0.30	-0.25	1.38	-0.20	-0.28	-0.53	0.8849
2007	-0.77	0.30	-0.23	1.38	-0.20	-0.28	-0.51	0.8804
2008	-0.70	0.30	-0.21	1.38	-0.20	-0.28	-0.49	0.8762
2009	-0.63	0.30	-0.19	1.38	-0.20	-0.28	-0.46	0.8721
2010	-0.56	0.30	-0.17	1.38	-0.20	-0.28	-0.44	0.8682

FOR BLIGHTED POPULATION

YEAR	PCIG(I) (1)	IED (2)	IR1(I) (3)	TI(I) (4)	PED (5)	IR2(I) (6)	IR(I) (7)	II(I) (8)
1990	0.00	0.11	0.00	-0.77	-0.06	0.05	0.05	1.0000
1991	0.00	0.11	0.00	-2.53	-0.06	0.15	0.15	1.0015
1992	0.00	0.11	0.00	-0.31	-0.06	0.02	0.02	1.0017
1993	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	1.0009
1994	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	1.0000
1995	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9992
1996	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9984
1997	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9976
1998	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9967
1999	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9959
2000	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9951
2001	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9943
2002	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9934
2003	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9926
2004	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9918
2005	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9910
2006	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9902
2007	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9893
2008	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9885
2009	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9877
2010	0.00	0.11	0.00	1.38	-0.06	-0.08	-0.08	0.9869

SOURCE: CORPLAN

(1) Per capita income growth in real terms in year I (%)
(2) Income elasticity of consumption
(3) Increase rate by income growth in year I (1) * (2) (%)
(4) Tariff increase in real terms in year I (%)
(5) Price elasticity of consumption
(6) Increase rate by tariff increase in year I (4) * (5) (%)
(7) Increase rate in year I (%)
(8) Increase index in year I, 1.0000 in base year 1990

TABLE 6.2.6 PER CAPITA DOMESTIC CONSUMPTION PROJECTION

CITY/MUNICIPALITY	1990	1995	2000	2005	2010
I. NCR	174				
CITY OF MANILA	181	186	191	195	200
PASAY CITY *a	151	180	187	193	200
QUEZON CITY	184	188	192	196	200
CALOOCAN CITY *a	134	180	187	193	200
LAS PINAS *s	51	180	187	193	200
MAKATI	206	210	213	217	220
MALABON *a	128	180	187	193	200
MANDALUYONG	164	180	187	193	200
MARIKINA	181	186	190	195	200
MUNTINLUPA *s	89	180	187	193	200
NAVOTAS *a	86	180	187	193	200
PARANAQUE	324	305	287	268	250
PASIG	180	185	190	195	200
PATEROS *a	99	180	187	193	200
SAN JUAN	249	249	249	250	250
TAGUIG *a	109	180	187	193	200
VALENZUELA *a	124	180	187	193	200
II. CAVITE	95				
BACOOR *s, f	90	180	187	193	200
CAVITE CITY *f	94	180	187	193	200
IMUS *f	116	180	187	193	200
KAWIT *f	100	180	187	193	200
NOVELETA **	86	180	187	193	200
ROSARIO *f	87	180	187	193	200
III. RIZAL	105				
ANGONO *r	-	141	160	181	205
ANTIPOLO *f	110	138	149	155	162
BARAS *r	-	141	160	181	205
BINANGONAN *r	-	141	160	181	205
CAINTA *a	123	180	187	193	200
CARDONA *r	-	141	160	181	205
JARA-JARA *r	-	141	160	181	205
MONTALBAN *f	103	111	118	124	129
MORONG *r	-	141	160	181	205
PILILLA *r	-	141	160	181	205
SAN MATEO *f	81	178	190	204	219
TANAY *r	-	141	160	181	205
TAYTAY *a	112	180	187	193	200
TERESA *r	-	141	160	181	205

1. Areas with <*a> have suppressed demand due to low water pressure, and be expected to be improved by AWSOP.
2. Areas with <*s> also have suppressed demand due to low water pressure, and be expected to be improved by MSWDP.
3. Areas with <*f> have suppressed demand due to limited water sources, and be expected to be improved by FAWSP.
4. Areas with <*r> are merged area under BP799, and be expected to be improved by RPWSIP.
5. Per capita water demand in Noveleta was assumed to be same as the one in Kawit

TABLE 6.2.7 MODIFIED WATER-BLIGHTED POPULATION IN THE NCR, BY CITY/MUNICIPALITY

CITY/ MUNICIPALITY	1990 TOTAL POPULATION	1990 BLIGHTED POPULATION	1990 %	1995 TOTAL POPULATION	1995 WATER BLIGHTED POPULATION	2000 TOTAL POPULATION	2000 WATER BLIGHTED POPULATION	2005 TOTAL POPULATION	2005 WATER BLIGHTED POPULATION	2010 TOTAL POPULATION	2010 WATER BLIGHTED POPULATION
1. Manila City	1,598,918	244,184	15.3	1,666,014	253,102	1,705,567	257,958	1,723,126	259,690	1,723,147	258,959
2. Pasay City	366,623	116,339	31.7	402,932	127,193	433,048	136,092	457,147	143,156	475,225	148,397
3. Quezon City	1,666,766	337,037	20.2	1,870,519	376,263	2,049,017	410,335	2,200,635	439,136	2,323,154	462,274
4. Caloocan City	761,011	216,709	28.5	872,801	247,245	979,527	276,244	1,076,883	302,624	1,164,630	326,356
5. Las Pinas	296,851	38,040	12.8	413,469	52,707	551,808	70,029	708,704	89,621	878,109	110,730
6. Makati	452,734	58,982	13.0	489,333	63,417	517,961	66,829	539,315	69,337	553,794	70,997
7. Malabon	278,380	56,680	20.4	305,870	61,952	328,653	66,271	346,868	69,696	360,515	72,233
8. Mandaluyong	244,538	51,004	20.9	265,870	55,164	282,944	58,445	296,044	60,935	305,315	62,665
9. Marikina	310,010	57,422	18.5	359,368	66,217	405,480	74,381	447,289	81,760	483,621	88,151
10. Muntinlupa	276,972	56,591	20.4	346,829	70,494	419,918	84,969	493,739	99,553	565,215	113,642
11. Navotas	186,799	53,436	28.6	207,567	59,067	225,328	63,836	240,031	67,760	251,550	70,811
12. Paranaque	307,717	23,002	7.5	369,370	27,466	430,253	31,851	488,493	36,035	541,964	39,866
13. Pasig	397,309	80,329	20.2	466,552	93,837	532,663	106,657	593,888	118,495	648,283	128,982
14. Pateros	51,401	6,038	11.7	58,438	6,828	64,776	7,535	70,318	8,151	74,945	8,663
15. San Juan	126,708	9,471	7.5	133,478	9,925	137,583	10,185	140,304	10,350	141,007	10,372
16. Taguig	266,080	47,363	17.8	311,031	55,075	353,627	62,339	392,792	68,998	427,323	74,851
17. Valenzuela	340,050	133,147	39.2	432,359	168,407	530,824	205,839	632,076	244,234	731,811	281,971
T O T A L	7,928,867	1,585,773	20.0	8,971,800	1,794,360	9,948,977	1,989,795	10,847,652	2,169,530	11,649,608	2,329,922

TABLE 6.2.8 PROJECTED DOMESTIC WATER CONSUMPTION IN 1995, BY CITY/MUNICIPALITY

CITY/MUNICIPALITY	TOTAL POPULATION (1995)			PER CAPITA CONSUMPTION		DOMESTIC CONSUMPTION (1995)			MWSS CONNECTED %			MWSS CONNECTED POPULATION			MWSS DOMESTIC CONSUMPTION			PRIVATE DOM. CONSUMPTION		
	TOTAL	GENERAL	WATER BLIGHTED	GEN'L (LPCD)	BL'D (LPCD)	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)	GEN'L POP.	WATER BL'D POP.	MWSS TOTAL POP.	GENERAL POP.	WATER BLIGHTED POP.	TOTAL POP.	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)
I. NCR	9,971,800	7,177,440	1,794,360	192	35	1,379,394	62,805	1,442,197	80	30	70	5,777,280	542,543	6,319,823	1,107,301	18,989	1,126,290	272,094	43,816	315,907
CITY OF MANILA	1,666,014	1,412,912	253,102	186	35	262,886	8,859	271,745	95	30	85	1,342,266	15,931	1,418,197	249,742	2,658	252,399	13,144	6,201	19,345
PASAY CITY *a	402,932	275,739	127,193	180	35	49,633	4,452	54,085	85	30	68	234,338	38,158	272,536	42,188	1,336	43,524	7,445	3,116	10,561
QUEZON CITY	1,870,518	1,494,256	376,262	188	35	280,548	13,169	293,717	95	30	82	1,419,543	112,879	1,532,422	266,521	3,951	270,472	14,027	9,218	23,246
CALOOCAN CITY *a	872,801	625,556	247,245	180	35	112,600	8,654	121,254	70	30	59	437,883	74,174	512,083	78,820	2,596	81,416	33,780	6,058	39,838
LAS PINAS *a	613,469	360,762	52,707	180	35	64,933	1,845	66,782	45	30	43	162,343	15,812	178,155	29,222	553	29,775	35,715	1,291	37,007
MAKATI	489,333	425,916	63,417	210	35	89,221	2,220	91,451	90	30	82	383,324	19,025	402,349	80,338	656	80,974	8,923	1,554	10,477
MALABON *a	305,870	243,918	61,952	180	35	43,905	2,168	46,074	70	30	62	170,742	18,586	189,328	30,734	650	31,384	13,172	1,518	14,689
MANDALUYONG	265,870	210,306	55,564	180	35	37,923	1,931	39,858	95	30	82	200,173	16,549	216,720	36,031	599	36,630	1,896	1,352	3,248
MARIKINA	359,368	293,151	66,217	186	35	54,422	2,318	56,741	95	30	83	278,492	19,865	298,359	51,702	695	52,397	3,721	1,622	4,343
MUNTINLUPA *a	366,829	276,335	90,494	180	35	49,740	2,467	52,208	40	30	38	110,534	21,148	131,682	19,896	740	20,636	29,844	1,787	31,631
NAVOTAS *a	237,567	148,500	89,067	180	35	26,730	2,067	28,797	90	30	73	133,650	17,720	151,370	24,057	620	24,677	2,673	1,448	4,120
PARANAQUE *a	389,370	341,904	47,466	305	35	104,333	981	105,294	60	40	59	205,142	10,987	216,129	62,600	385	62,984	41,733	577	42,310
PASIG	466,552	372,735	93,837	185	35	68,833	3,284	72,117	90	30	78	335,444	28,151	363,595	61,949	985	62,935	6,883	2,299	9,182
PATEROS *a	58,438	51,610	6,828	180	35	9,290	239	9,529	45	30	43	23,224	2,048	25,273	4,180	72	4,252	5,109	167	5,277
SAN JUAN	133,478	122,553	9,925	249	35	30,794	347	31,141	95	65	91	117,375	4,466	121,841	29,254	156	29,410	1,540	191	1,731
TAGUIG *a	311,031	255,956	55,075	180	35	46,072	1,928	48,000	20	30	22	51,191	16,523	67,714	9,214	578	9,793	36,858	1,349	38,207
VALENZUELA *a	432,359	263,952	168,407	180	35	47,511	5,894	53,406	65	30	51	171,559	50,522	222,081	30,882	1,768	32,651	16,629	4,126	20,755
II. CAVITE	534,843	516,406	18,437	180	35	92,773	652	93,425	48	30	47	245,188	5,667	250,853	44,133	198	44,332	48,640	454	49,094
BACOOR *f,a	196,636	189,262	7,374	180	35	34,067	258	34,325	45	30	44	85,168	2,212	87,380	15,330	77	15,408	18,737	181	18,918
CAVITE CITY *f	98,536	96,654	1,922	180	35	17,398	67	17,465	63	54	63	60,654	1,335	61,989	10,918	35	10,954	6,480	31	6,511
IMUS *f	107,182	103,813	3,369	180	35	18,686	117	18,804	41	28	41	43,845	937	43,982	7,748	33	7,781	10,938	84	11,023
KAWIT *f	55,217	54,555	662	180	35	9,820	23	9,843	69	67	69	37,702	462	38,164	6,786	15	6,802	3,034	5	3,041
NOVELETA	23,325	22,511	814	180	35	4,052	28	4,080	25	30	25	5,628	266	5,872	1,013	9	1,022	3,039	20	3,059
ROSARIO *f	53,127	48,511	4,616	180	35	8,750	158	8,908	27	18	25	12,989	797	13,786	2,338	28	2,366	6,483	130	6,542
III. RIZAL	1,349,930	660,355	689,575	154	34	101,805	16,835	118,640	47	10	33	306,031	46,718	354,749	45,785	1,752	47,536	56,021	15,083	71,104
ANGONO *r	55,062	22,025	33,037	141	35	3,115	1,156	4,271	100	0	40	22,325	0	22,325	3,115	0	3,115	0	1,156	1,156
ANTIPOLO *f	261,738	208,674	53,064	138	39	28,796	2,066	30,864	37	23	34	76,831	12,370	89,201	10,608	682	11,090	18,188	1,384	19,574
BARAS *r	15,051	898	14,153	141	31	127	558	685	100	0	5	898	0	898	127	0	127	0	558	558
BINANGONAN *r	140,791	49,553	91,238	141	34	7,008	3,109	10,117	100	0	35	49,553	0	49,553	7,008	0	7,008	0	3,109	3,109
CAINTA *a	164,650	131,720	32,930	180	35	23,710	1,153	24,862	25	10	26	32,930	3,879	42,809	5,927	166	6,093	17,782	987	18,769
CARDONA *r	35,194	3,465	31,729	141	32	490	966	1,456	100	0	10	3,465	0	3,465	490	0	490	0	966	966
JALA-JALA *r	17,814	517	17,297	141	31	73	542	615	100	0	3	517	0	517	73	0	73	0	542	542
MONTALBAN *f	75,766	58,944	16,822	141	33	8,538	657	7,195	55	43	52	32,179	6,841	39,020	5,636	267	5,903	1,902	390	3,292
MORONG *r	24,528	6,750	17,778	141	31	955	861	1,816	100	0	20	6,750	0	6,750	955	0	955	0	861	861
PILILLA *r	35,137	4,968	31,169	141	32	703	993	1,696	100	0	14	4,968	0	4,968	703	0	703	0	993	993
SAN MATEO *f	92,401	50,515	41,886	178	39	8,995	1,638	10,630	46	24	35	32,239	3,859	32,139	5,997	385	6,352	5,028	1,251	6,278
TANAY *r	85,810	15,347	50,463	141	33	2,170	1,656	3,826	100	0	33	15,347	0	15,347	2,170	0	2,170	0	1,656	1,656
TAYTAY *a	125,681	103,585	25,896	180	35	18,645	906	19,552	35	10	34	36,255	1,769	44,024	6,526	232	6,798	12,119	634	12,756
TERESA *r	23,507	3,394	18,113	141	32	480	575	1,055	100	0	16	3,394	0	3,394	480	0	480	0	575	575
TOTAL	10,655,773	8,353,201	2,302,572	168	35	1,573,973	80,290	1,654,262	78	26	65	6,330,498	594,929	6,925,425	1,197,219	20,939	1,218,158	376,754	59,351	436,105

NOTE: 1. Areas with (*a) have suppressed demand due to low water pressure, and be expected to be improved by AWSOP.
2. Areas with (*a) also have suppressed demand due to low water pressure, and be expected to be improved by MSWDP.
3. Areas with (*f) have suppressed demand due to limited water sources, and be expected to be improved by PAWSP.
4. Areas with (*r) are merged area under BP795, and be expected to be improved by RPWSIP.

TABLE 6.2.9 PROJECTED DOMESTIC WATER CONSUMPTION BY CITY/MUNICIPALITY IN 2000

CITY/MUNICIPALITY	TOTAL POPULATION (2000)			PER CAPITA CONSUMPTION		DOMESTIC CONSUMPTION (2000)			MWSS CONNECTED %			MWSS CONNECTED POPULATION			MWSS DOMESTIC CONSUMPTION			PRIVATE DOMESTIC CONSUMPTION		
	TOTAL	GENERAL	WATER BLIGHTED	GEN'L (LPCD)	BL'D (LPCD)	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)	GEN'L POP.	WATER BL'D POP.	MWSS TOTAL POP.	GENERAL POP.	WATER BLIGHTED POP.	TOTAL POP.	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)
I. NCR	9,948,977	7,959,182	1,989,795	196	35	1,562,378	69,643	1,632,014	88	60	83	7,026,290	1,193,877	8,220,167	1,378,416	41,786	1,420,202	183,955	27,857	211,812
CITY OF MANILA	1,705,567	1,447,529	257,958	191	35	276,065	9,029	285,097	95	60	90	1,375,228	154,775	1,530,003	262,265	5,417	267,682	13,803	3,611	17,415
PASAY CITY *a	433,048	296,555	136,092	187	35	55,422	4,763	60,195	90	60	81	267,260	81,655	348,916	49,889	2,858	52,747	5,543	1,905	7,448
QUEZON CITY	1,049,017	1,628,682	410,335	192	35	314,355	14,362	328,717	95	60	88	1,556,748	246,201	1,802,949	298,637	8,617	307,254	15,718	5,745	21,462
CALOOCAN CITY *a	979,523	783,283	276,244	187	35	131,280	9,663	140,948	80	60	74	562,527	165,746	728,273	105,024	5,801	110,825	26,256	3,867	30,123
LAS PINAS *a	551,808	481,779	70,029	187	35	89,932	2,451	92,383	75	60	73	361,335	42,017	403,352	67,449	1,471	68,920	22,483	980	23,463
MAKATI	517,961	451,132	66,829	213	35	96,093	2,339	98,432	95	60	90	428,576	40,097	468,673	91,288	1,403	92,691	4,805	936	5,740
MALABON *a	328,653	262,382	66,271	187	35	48,978	2,319	51,297	80	60	76	209,906	39,762	249,668	39,182	1,392	40,574	9,796	928	10,723
MANDALUYONG	282,944	224,499	58,445	187	35	41,906	2,046	43,952	95	60	88	213,274	35,067	248,341	39,811	1,227	41,038	2,095	818	2,914
MARIKINA	805,480	331,099	74,381	190	35	63,052	2,603	65,656	95	60	89	314,544	44,629	359,173	59,900	1,562	61,462	3,153	1,041	4,194
MUNTINLUPA *a	619,918	334,949	84,969	187	35	62,524	2,974	65,498	75	60	72	251,211	50,982	302,193	46,893	1,784	48,677	15,631	1,190	16,821
NAVOTAS *a	225,328	161,452	63,836	187	35	30,145	2,234	32,379	95	60	85	152,417	38,302	191,719	28,538	1,341	29,878	1,507	894	2,401
PARANAQUE *a	630,253	398,402	31,851	287	35	114,249	1,115	115,364	80	60	79	318,721	19,111	337,832	91,399	669	92,068	22,850	446	23,296
PASIG	532,663	426,006	106,657	190	35	80,850	3,733	84,583	85	60	88	404,706	63,994	468,700	76,807	2,240	79,047	4,042	1,493	5,536
PATEROS *a	64,776	57,241	7,535	187	35	10,685	264	10,949	80	60	69	40,068	4,521	44,589	7,479	158	7,638	3,205	105	3,311
SAN JUAN	137,583	127,398	10,185	249	35	31,784	356	32,141	95	60	92	121,028	6,111	127,139	30,195	214	30,409	1,589	143	1,732
TAGUIG *a	153,627	291,288	62,339	187	35	54,374	2,182	56,556	90	60	68	260,502	37,480	241,305	38,062	1,309	39,371	16,312	873	17,185
VALENZUELA *a	530,824	324,985	205,839	187	35	60,664	7,204	67,868	75	60	69	243,738	123,504	367,242	45,498	4,323	49,820	15,166	2,882	18,048
II. CAVITE	631,062	593,551	17,511	187	35	110,796	613	111,409	71	46	70	420,474	7,997	428,471	78,688	280	78,768	32,308	333	32,641
BACOOR *f,a	235,538	228,354	7,184	187	35	42,626	251	42,878	80	60	79	182,683	6,310	186,994	34,101	151	34,252	8,525	101	8,626
CAVITE CITY *f	104,379	102,876	1,503	187	35	19,204	53	19,256	78	58	78	80,123	877	80,998	14,956	31	14,987	4,248	22	4,270
IMUS *f	121,860	118,797	3,063	187	35	22,175	107	22,283	57	39	57	67,728	1,207	68,928	12,641	42	12,683	3,524	65	3,589
KAWIT *f	62,446	61,928	518	187	35	11,560	18	11,578	84	76	84	52,015	393	52,408	9,709	14	9,723	1,850	4	1,855
NOVELETA	26,102	25,354	748	187	35	4,733	26	4,759	64	48	64	16,311	360	16,671	3,045	13	3,057	1,688	14	1,702
ROSARIO *f	60,737	56,242	4,495	187	35	10,499	157	10,656	38	19	37	21,623	850	22,473	4,036	30	4,066	6,462	128	6,590
III. RIZAL	1,325,412	863,057	462,355	165	35	142,335	16,187	158,891	66	11	47	569,460	52,168	621,628	94,949	2,042	96,991	47,755	14,145	61,900
ANGONO *r	64,289	32,180	32,109	160	35	5,138	1,124	6,262	100	0	50	32,110	0	32,110	5,138	0	5,138	0	1,124	1,124
ANTIPOLO *f	319,649	262,155	56,694	149	42	39,166	2,381	41,547	44	24	40	115,023	13,383	128,403	17,128	582	17,590	22,058	1,819	23,877
BARAS *r	21,063	1,183	19,880	160	31	189	610	799	100	0	6	1,183	0	1,183	189	0	189	0	610	610
BINANGONAN *r	152,533	68,131	84,402	160	34	10,902	2,873	13,775	100	0	45	68,131	0	68,131	10,902	0	10,902	0	2,873	2,873
CAINTA *a	206,680	186,174	20,686	187	35	34,752	724	35,476	70	60	69	130,322	12,412	142,733	24,323	434	24,761	10,426	290	10,715
CARDONA *r	36,955	3,545	33,050	160	30	631	1,005	1,636	100	0	11	3,945	0	3,945	631	0	631	0	1,005	1,005
JALA-JALA *r	19,109	1,681	17,428	160	31	269	542	811	100	0	9	1,681	0	1,681	269	0	269	0	542	542
MONTALBAN *f	83,637	68,024	15,613	116	42	8,050	664	8,714	67	44	62	45,243	6,902	52,145	5,354	290	5,644	2,696	374	3,070
MORONG *r	36,557	7,332	29,125	160	31	1,253	900	2,153	100	0	21	7,832	0	7,832	1,253	0	1,253	0	980	980
PILILLA *r	39,119	7,254	31,865	160	32	1,161	1,010	2,171	100	0	19	7,254	0	7,254	1,161	0	1,161	0	1,010	1,010
SAN MATEO *f	101,699	60,602	41,077	150	42	11,539	1,725	13,264	56	26	44	33,817	10,575	44,392	6,439	444	6,883	5,100	1,281	6,381
TANAY *r	72,764	24,525	48,239	160	33	3,924	1,570	5,494	100	0	34	24,525	0	24,525	3,924	0	3,924	0	1,570	1,570
TAYTAY *a	148,322	133,490	14,832	187	35	24,918	519	25,437	70	60	69	93,443	8,899	102,342	17,463	311	17,754	7,475	208	7,683
TERESA *r	22,105	4,951	17,155	160	31	792	539	1,331	100	0	22	4,951	0	4,951	792	0	792	0	539	539
TOTAL	11,885,451	9,415,790	2,469,661	192	35	1,815,509	86,443	1,902,214	85	51	78	8,016,224	1,254,042	9,270,266	1,551,854	44,107	1,595,962	264,018	42,335	306,353

NOTE: 1. Areas with (*a) have suppressed demand due to low water pressure, and be expected to be improved by AWSOP.
2. Areas with (*s) also have suppressed demand due to low water pressure, and be expected to be improved by MSWDP.
3. Areas with (*f) have suppressed demand due to limited water sources, and be expected to be improved by FAWSP.
4. Areas with (*r) are merged area under RPT99, and be expected to be improved by RPWSIP.

TABLE 6.2.10 PROJECTED DOMESTIC WATER CONSUMPTION IN 2005, BY CITY/MUNICIPALITY

CITY/MUNICIPALITY	TOTAL POPULATION (2005)			PER CAPITA CONSUMPTION		DOMESTIC CONSUMPTION (2005)			MWSS CONNECTED %			MWSS CONNECTED POPULATION			MWSS DOMESTIC CONSUMPTION			PRIVATE DOMESTIC CONSUMPTION		
	TOTAL	GENERAL	WATER BLIGHTED	GEN'L (LPCD)	BL'D (LPCD)	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)	GEN'L POP.	WATER BL'D POP.	MWSS TOTAL POP.	GENERAL POP.	WATER BLIGHTED POP.	TOTAL POP.	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)
I. NCR	10,847,652	8,678,122	2,169,530	200	35	1,738,884	75,934	1,814,818	91	79	87	1,895,823	1,518,671	9,414,493	1,561,188	53,153	1,614,341	157,696	22,780	180,476
CITY OF MANILA	1,723,125	1,463,436	259,690	195	35	285,687	9,089	294,976	95	79	91	1,390,264	181,783	1,572,047	271,593	6,362	277,955	14,284	2,737	17,021
PASAY CITY *a	457,147	313,991	143,156	193	35	60,705	5,010	65,715	95	79	87	298,291	100,209	398,501	57,590	3,507	61,177	3,035	1,503	4,538
QUEZON CITY	2,200,635	1,761,499	439,136	196	35	345,108	15,330	360,477	95	79	90	1,673,424	307,395	1,980,819	327,852	10,759	338,611	17,255	4,611	21,866
CALOOCAN CITY *a	1,076,883	774,259	302,624	193	35	149,650	10,592	160,282	85	79	81	658,121	211,836	869,957	127,237	1,414	134,651	22,454	3,178	25,631
LAS PINAS *a	708,704	619,083	89,621	193	35	119,689	3,137	122,826	85	79	83	526,220	62,135	588,955	101,736	2,196	103,932	17,953	941	18,894
MAKATI	539,315	469,978	69,337	217	35	101,751	2,427	104,178	95	79	92	446,479	48,536	495,015	96,683	1,699	98,362	5,068	728	5,816
MALABON *a	366,868	277,172	89,696	193	35	53,587	2,438	56,026	85	79	82	235,596	48,787	284,383	45,548	1,708	47,256	8,038	732	8,770
MANDALUYONG	296,044	235,109	60,935	193	35	45,454	2,133	47,587	95	79	90	223,354	42,654	266,008	43,182	1,493	44,675	2,272	640	2,913
MARIKINA	467,289	385,529	81,760	195	35	71,357	2,862	74,219	95	79	90	369,253	57,232	426,485	67,788	2,003	69,793	3,568	858	4,426
MUNTINLUPA *a	433,739	394,186	39,553	193	35	76,209	3,484	79,694	85	79	82	335,058	69,687	404,745	64,778	2,439	67,217	11,431	1,045	12,477
NAVOTAS *a	240,031	172,271	67,760	193	35	33,306	2,372	35,677	95	80	88	163,657	47,432	211,089	31,640	1,660	33,300	1,665	711	2,377
PARANAQUE *a	488,493	452,458	36,035	268	35	121,433	1,261	122,694	85	80	84	384,590	25,224	409,814	103,218	883	104,101	18,215	378	18,593
PASIG	593,888	475,393	118,495	195	35	92,651	4,147	96,798	95	80	90	451,924	82,946	534,870	88,018	2,902	90,921	4,633	1,244	5,877
PATEROS *a	70,318	62,163	8,151	193	35	12,019	285	12,304	80	70	79	49,734	5,706	55,439	9,615	200	9,815	2,404	85	2,489
SAN JUAN	140,384	129,554	10,350	250	35	32,455	362	32,818	95	70	93	123,657	7,245	130,901	30,833	254	31,086	1,623	109	1,732
TAGUIG *a	392,792	323,794	68,998	193	35	62,600	2,415	65,015	80	70	78	259,035	48,299	307,334	50,089	1,690	51,779	12,520	724	13,245
VALENZUELA *a	632,076	387,842	244,234	193	35	74,983	8,548	83,531	85	70	79	329,665	170,964	500,630	63,735	5,984	69,719	11,247	2,564	13,812
II. CAVITE	686,825	670,951	15,874	193	35	129,717	556	130,273	80	54	80	538,523	8,529	547,040	104,114	298	104,412	25,603	258	25,861
BACOOR *f,g	275,150	268,616	6,534	193	35	51,932	229	52,161	85	70	85	228,324	4,574	232,897	44,143	160	44,303	7,790	69	7,858
CAVITE CITY *f	109,538	108,804	1,104	193	35	21,035	39	21,074	93	85	93	101,384	940	102,324	19,601	33	19,634	1,435	6	1,440
IMUS *f	135,818	133,081	2,737	193	35	25,729	96	25,825	68	42	67	90,389	1,155	91,544	17,475	40	17,516	8,254	55	8,309
KAWIT *f	69,254	68,838	416	193	35	13,309	15	13,323	95	100	96	65,722	416	66,138	12,706	15	12,721	603	0	603
NOVELETA	28,633	28,010	663	193	35	5,435	23	5,458	76	63	76	21,412	415	21,827	4,140	15	4,154	1,276	9	1,284
ROSARIO *f	68,022	63,601	4,421	193	35	12,256	155	12,451	49	23	47	31,290	1,220	32,510	6,049	36	6,085	6,247	119	6,366
III. RIZAL	1,503,411	1,052,571	450,840	175	35	184,124	15,568	200,092	74	13	56	775,195	59,681	834,586	137,608	2,350	139,958	46,523	13,618	60,141
ANGONO *r	72,978	43,787	29,192	181	35	7,923	1,022	8,949	100	0	60	43,787	0	43,787	7,923	0	7,927	0	1,022	1,022
ANTIPOLO *f	379,154	315,179	59,975	155	44	49,458	2,639	52,097	50	22	45	160,880	13,295	174,175	24,929	585	25,514	24,529	2,054	26,583
BARAS *r	22,808	2,215	20,593	181	31	401	629	1,030	100	0	10	2,215	0	2,215	401	0	401	0	629	629
BINANGONAN *r	162,155	87,908	74,247	181	34	15,915	2,520	18,435	100	0	56	87,908	0	87,908	15,915	0	15,915	0	2,520	2,520
CAINTA *a	251,447	225,303	25,145	193	35	43,752	880	44,632	80	70	79	181,042	17,601	198,643	35,001	616	35,617	8,750	256	9,006
CARDONA *r	38,270	4,645	33,625	181	30	841	1,021	1,862	100	0	12	4,645	0	4,645	841	0	841	0	1,021	1,021
JALA-JALA *r	20,133	3,137	16,994	181	31	568	526	1,094	100	0	15	3,137	0	3,137	568	0	568	0	526	526
MONTALBAN *f	90,845	77,107	13,438	124	44	9,560	591	10,152	76	48	72	58,758	6,387	65,145	7,351	281	7,632	2,303	310	2,614
MORONG *r	40,222	9,763	30,459	181	31	1,768	940	2,708	100	0	26	9,763	0	9,763	1,768	0	1,768	0	940	940
PILILLA *r	41,556	11,935	29,621	181	31	2,161	928	3,089	100	0	23	11,935	0	11,935	2,161	0	2,161	0	928	928
SAN MATEO *f	109,620	71,756	37,854	204	44	14,643	1,666	16,307	66	27	53	47,653	10,086	57,739	9,722	444	10,166	4,919	1,222	6,141
TANAY *r	78,785	32,489	46,300	181	32	5,882	1,497	7,379	100	0	43	32,489	0	32,489	5,882	0	5,882	0	1,497	1,497
TAYTAY *a	183,025	155,723	27,303	193	35	30,106	606	30,712	80	70	78	124,578	12,112	135,690	24,065	424	24,489	6,021	182	6,203
TERESA *r	22,410	6,315	16,095	181	31	1,143	504	1,647	100	0	28	6,315	0	6,315	1,143	0	1,143	0	504	504
TOTAL	13,037,888	10,401,643	2,636,245	197	35	2,052,725	92,458	2,145,183	89	68	82	9,209,467	1,586,672	10,796,119	1,822,902	55,802	1,878,704	229,823	36,656	266,479

NOTE: 1. Areas with (*a) have suppressed demand due to low water pressure, and be expected to be improved by AMSDP.
2. Areas with (*s) also have suppressed demand due to low water pressure, and be expected to be improved by MSWDP.
3. Areas with (*f) have suppressed demand due to limited water sources, and be expected to be improved by PAWSP.
4. Areas with (*r) are merged area under RPT99, and be expected to be improved by RPWSIP.

TABLE 6.2.11 PROJECTED DOMESTIC WATER CONSUMPTION in 2010, BY CITY/MUNICIPALITY

CITY/MUNICIPALITY	TOTAL POPULATION (2010)			PER CAPITA CONSUMPTION		DOMESTIC CONSUMPTION (2010)			MWSS CONNECTED %			MWSS CONNECTED POPULATION			MWSS DOMESTIC CONSUMPTION			PRIVATE DOM. CONSUMPTION		
	TOTAL	GENERAL	WATER BLIGHTED	GEN'L (LPCD)	BL'D (LPCD)	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)	GEN'L POP.	WATER BL'D POP.	MWSS TOTAL POP.	GENERAL POP.	WATER BLIGHTED POP.	TOTAL POP.	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)	GENERAL (M3/D)	WATER BLIGHTED (M3/D)	TOTAL (M3/D)
I. NCR	11,649,608	9,315,686	2,329,922	284	35	1,905,230	81,547	1,986,777	92	75	89	8,581,340	1,747,441	10,328,281	1,753,985	61,160	1,814,246	152,144	20,387	172,531
CITY OF MANILA	1,723,147	1,464,188	258,959	280	35	292,624	9,064	301,981	95	75	92	1,390,978	194,233	1,585,198	278,196	6,788	284,993	14,642	2,266	16,908
PASAY CITY *a	475,225	336,828	138,397	280	35	65,566	5,194	70,760	95	75	89	320,487	111,298	431,784	62,057	3,895	65,953	3,268	1,298	4,567
QUEZON CITY	2,323,158	1,660,880	662,274	280	35	372,176	16,180	388,356	95	75	91	1,767,836	346,705	2,114,542	353,567	12,135	365,702	18,603	4,045	22,654
CALOOCAN CITY *a	1,164,630	838,274	326,356	280	35	167,655	11,422	179,077	90	75	86	756,446	244,769	999,214	150,889	8,567	159,456	16,765	2,856	19,621
LAS PINAS *a	578,109	367,379	210,730	280	35	153,416	3,676	157,351	85	75	84	652,272	83,047	735,320	130,454	2,807	133,261	23,021	969	23,990
MAKATI	553,796	482,797	70,997	220	35	106,215	2,485	108,700	95	75	92	458,657	53,248	511,905	100,904	1,854	102,758	5,311	621	5,932
MALABON *a	360,515	288,282	72,233	280	35	57,656	2,528	60,185	90	75	87	259,454	54,135	313,629	51,891	1,896	53,787	5,766	632	6,398
MANDALUYONG	386,315	282,659	62,665	280	35	48,530	2,193	50,723	95	75	91	230,517	46,599	277,116	46,103	1,545	47,648	2,825	548	3,373
MARIKINA	482,621	395,470	86,151	280	35	79,094	3,085	82,179	95	75	91	335,697	66,113	401,810	75,133	2,314	77,453	3,955	771	4,726
MUNTINLUPA *a	565,215	451,573	113,642	280	35	90,315	3,977	94,292	85	75	83	383,827	85,232	469,069	76,767	2,983	79,750	13,547	994	14,542
NAVOTAS *a	251,550	180,739	70,811	280	35	36,148	2,478	38,626	95	75	89	111,702	53,103	224,810	34,140	1,859	36,199	1,800	620	2,427
PARANAQUE *a	541,556	502,098	39,868	250	35	125,525	1,395	126,920	85	75	84	426,783	29,899	456,682	106,696	1,046	107,742	18,829	349	19,178
PASIG	648,283	519,301	128,982	280	35	145,550	4,514	150,375	95	75	91	493,336	96,736	590,072	98,667	3,386	102,053	5,193	1,129	6,322
PATEROS *a	74,565	66,282	8,663	280	35	18,256	303	18,560	90	75	88	59,654	6,497	66,151	11,931	227	12,158	1,325	76	1,401
SAN JUAN	141,037	130,635	10,372	250	35	32,659	363	33,022	95	75	94	124,103	7,799	131,882	31,026	272	31,298	1,633	91	1,724
TAGUIG *a	427,223	352,472	74,851	280	35	70,494	2,620	73,114	90	75	87	317,224	56,139	373,363	63,445	1,965	65,410	7,049	655	7,704
VALENZUELA *a	731,611	443,840	287,771	280	35	89,568	9,869	99,437	90	75	84	424,856	211,478	636,334	80,911	7,402	88,313	8,991	2,467	11,464
II. CAVITE	756,085	744,387	11,698	280	35	148,877	409	149,287	87	56	86	644,697	6,454	651,150	128,939	227	129,167	19,938	182	20,120
BACOOR *f,s	313,838	308,644	4,194	280	35	61,883	154	62,043	85	75	85	263,027	3,296	266,323	52,805	115	52,921	9,283	38	9,322
CAVITE CITY *f	112,628	111,952	676	280	35	22,390	24	22,414	100	100	100	111,952	676	112,628	22,390	24	22,414	0	0	0
IMUS *f	148,542	146,579	1,963	280	35	29,316	69	29,385	85	61	84	124,258	995	125,253	24,852	35	24,886	4,464	34	4,498
KAWIT *f	75,409	75,106	301	280	35	15,021	11	15,032	100	100	100	75,105	302	75,407	15,021	11	15,032	0	0	0
NOVELETA	38,955	38,476	479	280	35	6,055	17	6,112	87	69	86	25,432	328	26,751	5,086	11	5,096	811	5	816
ROSARIO *f	74,715	70,930	3,885	280	35	14,188	136	14,382	62	23	60	43,932	837	44,825	8,786	31	8,818	5,380	105	5,484
III. RIZAL	1,667,207	1,242,272	424,936	186	36	230,791	15,185	245,976	81	14	64	1,006,835	61,132	1,067,967	190,411	2,405	192,815	40,381	12,780	53,161
ANGONO *r	89,788	56,552	33,236	285	35	11,583	848	12,431	100	0	70	56,552	0	56,552	11,583	0	11,583	0	848	848
ANTIPOLO *f	635,886	376,317	59,569	162	46	60,883	2,742	63,623	58	19	53	218,993	11,261	230,254	35,430	518	35,948	25,453	2,222	27,675
BARAS *r	24,182	3,412	20,770	285	30	699	630	1,329	100	0	18	3,412	0	3,412	699	0	699	0	630	630
BINANGONAN *r	169,113	106,367	61,050	285	34	22,135	2,063	24,198	100	0	64	108,067	0	108,067	22,135	0	22,135	0	2,063	2,063
CAINTA *a	295,646	266,382	29,565	280	35	53,238	1,035	54,251	90	75	89	239,473	22,173	261,647	47,895	776	48,671	5,322	259	5,580
CARDONA *r	38,952	5,348	33,604	285	30	1,095	1,020	2,115	100	0	14	5,348	0	5,348	1,095	0	1,095	0	1,020	1,020
JALA-JALA *r	20,826	4,821	16,005	285	31	988	490	1,478	100	0	23	4,821	0	4,821	988	0	988	0	490	490
MORONG *r	96,316	85,317	11,001	129	46	10,963	506	11,475	83	44	78	80,530	4,788	75,318	9,068	220	9,288	1,901	286	2,187
PILILLA *r	43,304	11,367	31,937	285	31	3,447	986	3,413	100	0	28	11,947	0	11,947	3,447	0	3,447	0	986	986
RODRIGUEZ *r	43,312	14,371	28,341	285	31	3,067	882	3,949	100	0	35	14,371	0	14,371	3,067	0	3,067	0	882	882
SAN MATEO *f	115,769	83,360	32,409	215	46	18,250	1,491	19,750	77	25	63	64,384	8,105	72,489	14,103	373	14,476	4,157	1,118	5,274
TANAY *r	83,535	42,939	42,596	285	32	8,385	1,366	9,751	100	0	49	40,939	0	40,939	8,385	0	8,385	0	1,366	1,366
TAYTAY *s	197,131	177,418	19,713	280	35	35,484	690	36,174	90	75	89	159,676	14,785	174,461	31,935	517	32,452	3,548	172	3,721
TERESA *r	22,461	7,721	14,720	285	31	1,581	458	2,039	100	0	34	7,721	0	7,721	1,581	0	1,581	0	458	458
TOTAL	14,072,900	11,306,345	2,766,555	202	35	2,284,899	97,141	2,382,040	91	66	86	10,233,371	1,815,047	12,048,418	2,072,436	63,792	2,136,228	212,463	33,349	245,812

NOTE: 1. Areas with (*a) have suppressed demand due to low water pressure, and be expected to be improved by AWSOP.
2. Areas with (*s) also have suppressed demand due to low water pressure, and be expected to be improved by NSWDP.
3. Areas with (*f) have suppressed demand due to limited water sources, and be expected to be improved by PAWSP.
4. Areas with (*r) are merged area under RPT99, and be expected to be improved by RPWSIP.

TABLE 6.2.12 COMMERCIAL WATER DEMAND GROWTH PROJECTION

YEAR	CG(I) (1)	COED(I) (2)	IR1(I) (3)	CTI(I) (4)	CPED(I) (5)	IR2(I) (6)	IR(I) (7)	II(I) (8)	DEMAND (9)
1990	5.98	1.06	6.34	-3.34	-0.11	0.37	6.71	1.0000	451,047
1991	5.70	1.06	6.04	-1.77	-0.11	0.19	6.24	1.0624	479,177
1992	3.55	1.06	3.76	-0.61	-0.11	0.07	3.83	1.1031	497,530
1993	4.51	1.06	4.78	-0.54	-0.11	0.06	4.84	1.1564	521,611
1994	4.64	1.06	4.92	1.01	-0.11	-0.11	4.81	1.2120	546,686
1995	4.22	1.06	4.47	-0.11	-0.11	0.01	4.49	1.2664	571,207
1996	4.06	1.06	4.30	-0.52	-0.11	0.06	4.36	1.3216	596,116
1997	3.83	1.06	4.06	-0.62	-0.11	0.07	4.13	1.3762	620,724
1998	3.60	1.06	3.82	-0.58	-0.11	0.06	3.88	1.4296	644,807
1999	3.60	1.06	3.82	-0.22	-0.11	0.02	3.84	1.4845	669,568
2000	3.49	1.06	3.70	-3.99	-0.11	0.44	4.14	1.5459	697,277
2001	3.34	1.06	3.54	-0.22	-0.11	0.02	3.56	1.6010	722,132
2002	3.23	1.06	3.42	-0.21	-0.11	0.02	3.45	1.6562	747,023
2003	3.12	1.06	3.31	-0.20	-0.11	0.02	3.33	1.7113	771,893
2004	3.03	1.06	3.21	-0.19	-0.11	0.02	3.23	1.7667	796,846
2005	2.95	1.06	3.13	-0.18	-0.11	0.02	3.15	1.8223	821,921
2006	2.86	1.06	3.03	-0.17	-0.11	0.02	3.05	1.8778	846,993
2007	2.78	1.06	2.95	-0.16	-0.11	0.02	2.96	1.9335	872,101
2008	2.70	1.06	2.86	-0.15	-0.11	0.02	2.88	1.9892	897,204
2009	2.63	1.06	2.79	-0.14	-0.11	0.02	2.80	2.0449	922,355
2010	2.57	1.06	2.72	-0.13	-0.11	0.01	2.74	2.1009	947,613

SOURCE: (1) Studt Team, (2, 4, 5) CORPLAN

(1) GDP growth rate in service sector in real terms in year I (%)
(2) Output elasticity of consumption in service sector
(3) Increase rate by GDP growth in year I (1)x(2) (%)
(4) Tariff increase in real terms in year I (%)
(5) Price elasticity of consumption
(6) Increase rate by tariff increase in year I (4)x(5) (%)
(7) Increase rate in year I (%)
(8) Increase index in year I. (1.0000 in base year 1990)
(9) Projected total commercial demand (M3/D) (8) x 451,047

TABLE 6.2.13 MWSS COMMERCIAL CONSUMPTION PROJECTION

CITY/MUNICIPALITY	1990 ESTIMATED CONSUMPTION				1995			2000			2005			2010		
	TOTAL QT'TY (M3/DAY)	% IN TOTAL	MWSS SHARE (%)	PRIV. SHARE (%)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)
I. MCR	434,665	96.4	78.5	21.5	550,461	448,632	101,829	671,952	561,191	110,761	792,069	672,476	119,593	913,196	784,697	128,498
1. Manila *	136,183	30.2	96.6	3.4	172,462	167,797	4,665	210,526	205,861	4,665	248,160	243,494	4,665	286,109	281,444	4,665
2. Pasay City *	25,338	5.6	65.3	34.7	32,088	23,293	8,795	39,170	30,375	8,795	46,172	37,377	8,795	53,233	44,438	8,795
3. Quezon City *	113,981	25.3	75.7	24.3	144,346	116,705	27,641	176,204	148,563	27,641	207,702	180,061	27,641	239,464	211,824	27,641
4. Caloocan City *	15,068	3.3	75.6	24.4	19,107	15,433	3,674	23,324	19,650	3,674	27,494	23,820	3,674	31,698	28,024	3,674
5. Las Pinas	4,299	1.0	14.4	85.6	5,444	786	4,658	6,646	959	5,686	7,833	1,131	6,703	9,031	1,303	7,728
6. Makati *	59,269	13.1	80.2	19.8	75,058	63,337	11,721	91,624	79,903	11,721	108,003	96,282	11,721	124,519	112,798	11,721
7. Malabon *	5,224	1.2	61.4	38.6	6,616	4,600	2,016	8,076	6,060	2,016	9,519	7,504	2,016	10,975	8,959	2,016
8. Mandaluyong *	13,338	3.0	84.0	16.0	16,891	14,763	2,128	20,620	18,491	2,128	24,305	22,177	2,128	28,022	25,894	2,128
9. Marikina	5,280	1.2	73.5	26.5	6,687	4,914	1,773	8,163	5,999	2,164	9,622	7,071	2,551	11,094	8,153	2,941
10. Muntinlupa	8,308	1.8	0.9	99.1	10,521	99	10,423	12,843	120	12,723	15,139	142	14,997	17,454	163	17,291
11. Navotas *	2,655	0.6	76.6	23.4	3,363	2,742	621	4,105	3,484	621	4,839	4,218	621	5,578	4,958	621
12. Paranaque	11,624	2.6	57.7	42.3	14,720	8,497	6,223	17,969	10,372	7,597	21,181	12,226	8,955	24,420	14,096	10,324
13. Pasig	16,004	3.5	58.4	41.6	20,268	11,836	8,431	24,741	14,448	10,292	29,163	17,031	12,132	33,623	19,636	13,987
14. Pateros	56	0.0	100.0	0.0	71	71	0	86	86	0	102	102	0	117	117	0
15. San Juan *	8,299	1.8	98.8	1.2	10,510	10,413	97	12,829	12,732	97	15,122	15,025	97	17,435	17,338	97
16. Taguig	4,016	0.9	9.0	91.0	5,086	457	4,629	6,208	558	5,650	7,318	658	6,660	8,437	758	7,679
17. Valenzuela	5,705	1.3	40.0	60.0	7,224	2,898	4,326	8,819	3,528	5,291	10,395	4,158	6,237	11,985	4,794	7,191
II. CAVITE	6,399	1.4	19.1	80.9	8,103	1,550	6,554	9,892	1,892	8,000	11,660	2,230	9,430	13,443	2,571	10,873
1. Bacoor	971	0.2	27.6	72.4	1,230	340	890	1,502	415	1,087	1,770	489	1,281	2,041	564	1,477
2. Cavite City	4,207	0.9	17.3	82.7	5,327	921	4,406	6,503	1,124	5,379	7,666	1,325	6,341	8,838	1,528	7,310
3. Imus	709	0.2	9.1	90.9	898	82	816	1,096	100	996	1,292	118	1,174	1,490	136	1,354
4. Kawit	122	0.0	100.0	0.0	155	155	0	189	189	0	222	222	0	256	256	0
5. Noveleta	5	0.0	100.0	0.0	6	6	0	8	8	0	9	9	0	10	10	0
6. Rosario	385	0.1	9.5	90.5	487	46	441	595	56	538	701	66	635	808	77	732
III. RIZAL	9,393	2.2	16.5	83.5	15,668	5,109	10,559	20,285	7,396	12,889	25,513	10,320	15,193	31,370	13,854	17,517
1. Angono	-	-	-	-	623	623	0	1,028	1,028	0	1,585	1,585	0	2,317	2,317	0
2. Antipolo	3,367	0.7	17.9	82.1	4,264	765	3,499	5,205	934	4,271	6,136	1,101	5,035	7,074	1,269	5,805
3. Baras	-	-	-	-	25	25	0	38	38	0	80	80	0	140	140	0
4. Binangonan	-	-	-	-	1,402	1,402	0	2,180	2,180	0	3,183	3,183	0	4,427	4,427	0
5. Cainta	1,822	0.8	12.4	87.6	4,587	569	4,018	5,600	695	4,905	6,601	819	5,782	7,610	944	6,667
6. Cardona	-	-	-	-	98	98	0	126	126	0	168	168	0	219	219	0
7. Jala-Jala	-	-	-	-	15	15	0	54	54	0	114	114	0	198	198	0
8. Montalban	886	0.2	4.7	95.3	1,122	53	1,069	1,370	64	1,305	1,614	76	1,539	1,861	87	1,774
9. Morong	-	-	-	-	191	191	0	251	251	0	354	354	0	489	489	0
10. Pililla	-	-	-	-	141	141	0	232	232	0	432	432	0	613	613	0
11. San Mateo	576	0.1	32.2	67.8	729	235	494	890	287	603	1,049	338	711	1,209	390	819
12. Tanay	-	-	-	-	434	434	0	785	785	0	1,176	1,176	0	1,677	1,677	0
13. Taytay	1,532	0.3	23.8	76.2	1,941	462	1,478	2,369	565	1,804	2,792	665	2,127	3,219	767	2,452
14. Teresa	-	-	-	-	96	96	0	158	158	0	229	229	0	316	316	0
TOTAL	451,047	100.0	76.3	23.7	574,232	455,291	118,941	702,129	570,478	131,651	829,242	685,026	144,216	958,009	801,121	156,888

TABLE 6.2.14 INDUSTRIAL WATER DEMAND GROWTH PROJECTION

YEAR	IG(I) (1)	IOED(I) (2)	IR1(I) (3)	ITI(I) (4)	IPED(I) (5)	IR2(I) (6)	IR(I) (7)	II(I) (8)	DEMAND (9)
1990	8.61	0.78	6.72	-2.81	-0.11	0.31	7.02	1.0000	439,394
1991	4.23	0.78	3.30	-1.77	-0.11	0.19	3.49	1.0349	454,747
1992	5.62	0.78	4.38	-0.52	-0.11	0.06	4.44	1.0809	474,941
1993	5.10	0.78	3.98	-0.45	-0.11	0.05	4.03	1.1244	494,070
1994	4.83	0.78	3.77	0.84	-0.11	-0.09	3.68	1.1658	512,227
1995	4.79	0.78	3.74	-0.09	-0.11	0.01	3.75	1.2094	531,415
1996	4.60	0.78	3.59	-0.42	-0.11	0.05	3.63	1.2534	550,728
1997	4.13	0.78	3.22	-0.52	-0.11	0.06	3.28	1.2945	568,784
1998	4.12	0.78	3.21	-0.49	-0.11	0.05	3.27	1.3368	587,369
1999	3.94	0.78	3.07	-0.17	-0.11	0.02	3.09	1.3781	605,530
2000	3.79	0.78	2.96	-3.97	-0.11	0.44	3.39	1.4249	626,075
2001	3.67	0.78	2.86	-0.19	-0.11	0.02	2.88	1.4659	644,128
2002	3.53	0.78	2.75	-0.17	-0.11	0.02	2.77	1.5066	661,984
2003	3.39	0.78	2.64	-0.16	-0.11	0.02	2.66	1.5467	679,604
2004	3.29	0.78	2.57	-0.15	-0.11	0.02	2.58	1.5866	697,156
2005	3.19	0.78	2.49	-0.15	-0.11	0.02	2.50	1.6264	714,618
2006	3.09	0.78	2.41	-0.14	-0.11	0.02	2.43	1.6658	731,952
2007	3.00	0.78	2.34	-0.14	-0.11	0.02	2.36	1.7051	749,192
2008	2.91	0.78	2.27	-0.14	-0.11	0.02	2.29	1.7440	766,313
2009	2.83	0.78	2.21	-0.13	-0.11	0.01	2.22	1.7828	783,338
2010	2.75	0.78	2.15	-0.13	-0.11	0.01	2.16	1.8213	800,253

SOURCE: (1) Study Team, (2, 4, 5) CORPLAN

(1) GDP growth rate in industrial sector in real terms in year I (%)
(2) Output elasticity of consumption in industrial sector
(3) Increase rate by GDP growth in year I (1) * (2) (%)
(4) Tariff increase in real terms in year I (%)
(5) Price elasticity of consumption
(6) Increase rate by tariff increase in year I (4) * (5) (%)
(7) Increase rate in year I (%)
(8) Increase index in year I. (1.0000 in base year 1990)
(9) Projected total industrial demand (M3/D) (8) x 439,394

TABLE 6.2.15 MWSS INDUSTRIAL CONSUMPTION PROJECTION

CITY/MUNICIPALITY	1990 ESTIMATED CONSUMPTION				1995			2000			2005			2010		
	TOTAL QT'TY (M3/DAY)	% IN TOTAL	MWSS SHARE (%)	PRIV. SHARE (%)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)	TOTAL QT'TY (M3/D)	MWSS QT'TY (M3/D)	PRIVATE QT'TY (M3/D)
I. NCR	362,048	82.4	22.5	77.5	437,871	113,331	324,540	515,868	146,218	369,650	588,825	176,980	411,846	659,386	206,731	452,655
1. Manila *	23,403	5.3	75.3	24.7	28,304	22,518	5,786	33,346	27,560	5,786	38,062	32,276	5,786	42,623	36,837	5,786
2. Pasay City *	4,293	1.0	21.4	78.6	5,192	1,817	3,375	6,116	2,742	3,375	6,981	3,607	3,375	7,818	4,443	3,375
3. Quezon City *	51,708	11.8	37.4	62.6	62,538	30,170	32,368	73,677	41,310	32,368	84,097	51,730	32,368	94,175	61,807	32,368
4. Caloocan City *	13,823	3.2	66.5	33.5	16,839	12,175	4,665	19,839	15,174	4,665	22,644	17,980	4,665	25,358	20,693	4,665
5. Las Pinas	21,115	4.8	0.7	99.3	25,537	189	25,348	30,086	222	29,863	34,341	254	34,087	38,456	284	38,171
6. Makati *	8,041	1.8	57.9	42.1	9,725	6,342	3,383	11,458	8,074	3,383	13,078	9,694	3,383	14,645	11,262	3,383
7. Malabon *	20,537	4.7	29.1	70.9	24,838	10,273	14,565	29,263	14,698	14,565	33,401	18,836	14,565	37,404	22,839	14,565
8. Mandaluyong *	13,151	3.0	59.3	40.7	15,906	10,553	5,353	18,739	13,386	5,353	21,389	16,036	5,353	23,952	18,599	5,353
9. Marikina	8,239	1.9	17.1	82.9	9,965	1,701	8,264	11,739	2,004	9,736	13,400	2,287	11,113	15,005	2,561	12,444
10. Muntinlupa	34,360	7.8	0.2	99.8	41,556	97	41,459	48,958	114	48,844	55,882	130	55,751	62,578	146	62,432
11. Navotas *	3,762	0.9	53.8	46.2	4,550	2,811	1,739	5,360	3,621	1,739	6,118	4,379	1,739	6,852	5,112	1,739
12. Paranaque	19,390	4.4	8.7	91.3	23,427	2,031	21,396	27,600	2,393	25,207	31,503	2,731	28,772	35,278	3,059	32,220
13. Pasig	68,156	15.5	11.9	88.1	82,430	9,770	72,659	97,113	11,511	85,602	110,847	13,139	97,708	124,130	14,713	109,417
14. Pateros	1,760	0.4	0.2	99.8	2,128	4	2,124	2,507	5	2,502	2,862	6	2,856	3,205	6	3,198
15. San Juan *	1,259	0.3	95.3	4.7	1,522	1,463	59	1,794	1,735	59	2,047	1,988	59	2,293	2,234	59
16. Taguig	41,208	9.4	0.0	100.0	49,838	11	49,826	58,715	13	58,702	67,019	15	67,004	75,050	17	75,033
17. Valenzuela	27,863	6.3	4.2	95.8	33,577	1,406	32,171	39,558	1,656	37,902	45,153	1,891	43,262	50,564	2,117	48,446
II. CAVITE	7,037	1.6	16.3	83.7	8,511	1,389	7,122	10,027	1,637	8,391	11,445	1,868	9,577	12,817	2,092	10,725
1. Bacoor	78	0.0	100.0	0.0	85	85	0	100	100	0	114	114	0	128	128	0
2. Cavite City	238	0.1	100.0	0.0	288	288	0	339	339	0	387	387	0	433	433	0
3. Imus	538	0.1	1.3	98.7	650	9	641	766	10	756	874	12	862	979	13	966
4. Kawit	574	0.1	100.0	0.0	694	694	0	818	818	0	934	934	0	1,045	1,045	0
5. Noveleta	88	0.0	100.0	0.0	107	107	0	126	126	0	143	143	0	161	161	0
6. Rosario	5,530	1.3	3.1	96.9	6,688	207	6,481	7,879	244	7,635	8,993	278	8,715	10,071	312	9,759
III. RIZAL	70,308	16.0	2.8	97.2	90,479	3,347	87,131	108,913	5,440	103,472	127,524	9,149	118,375	146,764	14,834	131,930
1. Angono	-	-	-	-	1,121	196	925	1,850	555	1,295	2,854	1,284	1,570	4,170	2,502	1,668
2. Antipolo	13,198	3.1	12.9	87.1	16,688	2,145	14,543	19,661	2,527	17,134	22,441	2,884	19,557	25,130	3,230	21,901
3. Baras	-	-	-	-	46	8	38	68	20	48	144	65	79	252	151	101
4. Binangonan	-	-	-	-	2,523	442	2,081	3,924	1,177	2,747	5,723	2,572	3,151	7,968	4,781	3,187
5. Cainta	36,221	8.2	0.1	99.9	43,807	58	43,748	51,610	68	51,541	58,903	76	58,831	65,968	88	65,880
6. Cardona	-	-	-	-	177	31	146	227	68	159	303	136	167	395	237	158
7. Jala-Jala	-	-	-	-	27	5	22	97	23	68	204	92	112	355	213	142
8. Montalban	2,958	0.7	0.6	99.4	3,578	21	3,557	4,215	24	4,191	4,811	28	4,784	5,388	31	5,357
9. Morong	-	-	-	-	344	60	284	451	135	316	636	286	350	881	529	352
10. Pililla	-	-	-	-	253	44	209	417	125	292	778	350	428	1,104	662	442
11. San Mateo	658	0.1	8.3	91.7	796	66	730	938	78	860	1,071	89	982	1,199	100	1,099
12. Tanay	-	-	-	-	782	137	645	1,413	424	989	2,118	953	1,165	3,019	1,811	1,208
13. Taytay	16,672	3.8	0.5	99.5	20,164	105	20,059	23,756	124	23,632	27,116	141	26,975	30,365	158	30,207
14. Teresa	-	-	-	-	173	30	143	286	86	200	411	185	226	570	342	228
TOTAL	439,394	100.0	19.2	80.8	536,861	118,068	418,793	634,808	153,295	481,513	727,795	187,997	539,798	818,967	223,657	595,310

* Future demand increase was assumed to be shouldered by MWSS only.

TABLE 6.2.16 SUMMARY OF PROJECTED WATER DEMAND (CASE 1)

YEAR	MWSS SERVED WATER DEMAND (M3/D)					LOSS RATIO	MWSS SERVICE SHARE (%)			
	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	TOTAL	%	DOM.	COM.	IND.	TOTAL
1995	1,218,158	455,291	118,068	606,903	2,398,420	25.3	73.6	79.3	22.0	71.1
1996	1,293,719	478,328	125,113	612,073	2,509,233	24.4	75.9	79.7	22.5	72.3
1997	1,369,280	501,366	132,159	617,243	2,620,047	23.6	78.1	80.2	22.9	73.3
1998	1,444,840	524,403	139,204	622,412	2,730,860	22.8	80.1	80.6	23.4	74.4
1999	1,520,401	547,441	146,250	627,582	2,841,674	22.1	82.1	80.9	23.8	75.3
2000	1,595,962	570,478	153,295	632,752	2,952,487	21.4	83.9	81.2	24.1	76.3
2005	1,878,704	685,026	187,997	737,565	3,489,292	21.1	87.6	82.6	25.8	78.6
2010	2,136,228	801,121	223,657	847,102	4,008,108	21.1	89.7	83.6	27.3	80.1

YEAR	PRIVATELY SERVED WATER DEMAND (M3/D)			
	DOMESTIC	COMMERCIAL	INDUSTRIAL	TOTAL
1995	436,105	118,941	418,793	973,839
1996	410,155	121,483	431,337	962,975
1997	384,204	124,025	443,881	952,110
1998	358,254	126,567	456,425	941,246
1999	332,303	129,109	468,969	930,381
2000	306,353	131,651	481,513	919,517
2005	266,479	144,216	539,798	950,493
2010	245,812	156,888	595,310	998,010

YEAR	TOTAL WATER DEMAND (M3/D)				
	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	TOTAL
1995	1,654,263	574,232	536,861	606,903	3,372,259
1996	1,703,873	599,811	556,450	612,073	3,472,208
1997	1,753,484	625,391	576,040	617,243	3,572,157
1998	1,803,094	650,970	595,629	622,412	3,672,106
1999	1,852,705	676,550	615,219	627,582	3,772,055
2000	1,902,315	702,129	634,808	632,752	3,872,004
2005	2,145,183	829,242	727,795	737,565	4,439,785
2010	2,382,040	958,009	818,967	847,102	5,006,118

TABLE 6.2.17 SUMMARY OF PROJECTED WATER DEMAND (CASE 2)

YEAR	MWSS SERVED WATER DEMAND (M3/D)					LOSS RATIO	MWSS SERVICE SHARE (%)			
	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	TOTAL	%	DOM.	COM.	IND.	TOTAL
1995	1,218,158	455,291	118,068	762,978	2,554,495	29.9	73.6	79.3	22.0	72.4
1996	1,293,719	478,328	125,113	766,254	2,663,414	28.8	75.9	79.7	22.5	73.4
1997	1,369,280	501,366	132,159	769,529	2,772,333	27.8	78.1	80.2	22.9	74.4
1998	1,444,840	524,403	139,204	772,805	2,881,253	26.8	80.1	80.6	23.4	75.4
1999	1,520,401	547,441	146,250	776,080	2,990,172	26.0	82.1	80.9	23.8	76.3
2000	1,595,962	570,478	153,295	779,356	3,099,091	25.1	83.9	81.2	24.1	77.1
2005	1,878,704	685,026	187,997	909,422	3,661,149	24.8	87.6	82.6	25.8	79.4
2010	2,136,228	801,121	223,657	1,042,123	4,203,129	24.8	89.7	83.6	27.3	80.8

YEAR	PRIVATELY SERVED WATER DEMAND (M3/D)			
	DOMESTIC	COMMERCIAL	INDUSTRIAL	TOTAL
1995	436,105	118,941	418,793	973,839
1996	410,155	121,483	431,337	962,975
1997	384,204	124,025	443,881	952,110
1998	358,254	126,567	456,425	941,246
1999	332,303	129,109	468,969	930,381
2000	306,353	131,651	481,513	919,517
2005	266,479	144,216	539,798	950,493
2010	245,812	156,888	595,310	998,010

YEAR	TOTAL WATER DEMAND (M3/D)				
	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	TOTAL
1995	1,654,263	574,232	536,861	762,978	3,528,334
1996	1,703,873	599,811	556,450	766,254	3,626,389
1997	1,753,484	625,391	576,040	769,529	3,724,444
1998	1,803,094	650,970	595,629	772,805	3,822,498
1999	1,852,705	676,550	615,219	776,080	3,920,553
2000	1,902,315	702,129	634,808	779,356	4,018,608
2005	2,145,183	829,242	727,795	909,422	4,611,642
2010	2,382,040	958,009	818,967	1,042,123	5,201,139

TABLE 6.2.18 SUMMARY OF PROJECTED WATER DEMAND (CASE 3)

YEAR	MWSS SERVED WATER DEMAND (M3/D)					LOSS RATIO	MWSS SERVICE SHARE (%)			
	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	TOTAL	%	DOM.	COM.	IND.	TOTAL
1995	1,218,158	455,291	118,068	950,068	2,741,585	34.7	73.6	79.3	22.0	73.8
1996	1,293,719	478,328	125,113	957,289	2,854,450	33.5	75.9	79.7	22.5	74.8
1997	1,369,280	501,366	132,159	964,510	2,967,314	32.5	78.1	80.2	22.9	75.7
1998	1,444,840	524,403	139,204	971,731	3,080,179	31.5	80.1	80.6	23.4	76.6
1999	1,520,401	547,441	146,250	978,952	3,193,043	30.7	82.1	80.9	23.8	77.4
2000	1,595,962	570,478	153,295	986,173	3,305,908	29.8	83.9	81.2	24.1	78.2
2005	1,878,704	685,026	187,997	909,422	3,661,149	24.8	87.6	82.6	25.8	79.4
2010	2,136,228	801,121	223,657	1,042,123	4,203,129	24.8	89.7	83.6	27.3	80.8

YEAR	PRIVATELY SERVED WATER DEMAND (M3/D)			
	DOMESTIC	COMMERCIAL	INDUSTRIAL	TOTAL
1995	436,105	118,941	418,793	973,839
1996	410,155	121,483	431,337	962,975
1997	384,204	124,025	443,881	952,110
1998	358,254	126,567	456,425	941,246
1999	332,303	129,109	468,969	930,381
2000	306,353	131,651	481,513	919,517
2005	266,479	144,216	539,798	950,493
2010	245,812	156,888	595,310	998,010

YEAR	TOTAL WATER DEMAND (M3/D)				
	DOMESTIC	COMMERCIAL	INDUSTRIAL	LOSS	TOTAL
1995	1,654,263	574,232	536,861	950,068	3,715,424
1996	1,703,873	599,811	556,450	957,289	3,817,424
1997	1,753,484	625,391	576,040	964,510	3,919,424
1998	1,803,094	650,970	595,629	971,731	4,021,425
1999	1,852,705	676,550	615,219	978,952	4,123,425
2000	1,902,315	702,129	634,808	986,173	4,225,425
2005	2,145,183	829,242	727,795	909,422	4,611,642
2010	2,382,040	958,009	818,967	1,042,123	5,201,139

TABLE 6.2.19 DISTRIBUTION OF WATER DEMAND IN 1995, BY SOURCE

CITY/ MUNICIPALITY	WATER DEMAND (M3/D)			MWSS BREAKDOWN (%)		MWSS BREAKDOWN (M3/D)		PRIVATE	GROUND-	G.W.
	MWSS	PRIVATE	TOTAL	SURFACE WATER	GROUND-WATER	SURFACE WATER	GROUND-WATER	GROUND-WATER	WATER TOTAL	SHARE (%)
I. NCR	2,597,312	742,276	3,339,588	98.3	1.7	2,552,414	44,898	742,276	787,174	23.6
1. Manila	681,100	29,796	710,897	100.0	0.0	681,100	0	29,796	29,796	4.2
2. Pasay City	105,590	22,731	128,321	95.2	4.8	100,508	5,082	22,731	27,813	21.7
3. Quezon City	642,072	83,254	725,326	97.1	2.9	623,746	18,326	83,254	101,580	14.0
4. Caloocan City	167,729	48,176	215,905	100.0	0.0	167,729	0	48,176	48,176	22.3
5. Las Pinas	47,307	67,013	114,320	96.3	3.7	45,573	1,734	67,013	68,747	60.1
6. Makati	231,774	25,581	257,355	96.8	3.2	224,414	7,360	25,581	32,941	12.8
7. Malabon	71,165	31,270	102,435	98.3	1.7	69,921	1,244	31,270	32,514	31.7
8. Mandaluyong	95,271	10,729	106,000	100.0	0.0	95,271	0	10,729	10,729	10.1
9. Marikina	90,788	14,380	105,169	100.0	0.0	90,788	0	14,380	14,380	13.7
10. Muntinlupa	32,049	83,453	115,501	78.1	21.9	25,030	7,019	83,453	90,472	78.3
11. Navotas	46,507	6,480	52,987	99.3	0.7	46,194	313	6,480	6,793	12.8
12. Paranaque	113,095	69,929	183,025	98.4	1.6	111,327	1,768	69,929	71,697	39.2
13. Pasig	130,063	90,273	220,336	99.8	0.2	129,807	256	90,273	90,529	41.1
14. Pateros	6,657	7,401	14,057	100.0	0.0	6,657	0	7,401	7,401	52.6
15. San Juan	63,517	1,887	65,404	100.0	0.0	63,517	0	1,887	1,887	2.9
16. Taguig	15,787	92,662	108,449	94.6	5.4	14,940	847	92,662	93,509	86.2
17. Valenzuela	56,841	57,261	114,101	98.3	1.7	55,892	949	57,261	58,210	51.0
II. CAVITE	67,529	62,769	130,299	22.3	77.7	15,061	52,468	62,769	115,237	88.4
1. Bacoor	22,617	19,808	42,425	66.6	33.4	15,061	7,556	19,808	27,364	64.5
2. Cavite City	17,375	10,917	28,293	0.0	100.0	0	17,375	10,917	28,293	100.0
3. Imus	11,245	12,480	23,725	0.0	100.0	0	11,245	12,480	23,725	100.0
4. Kawit	10,929	3,041	13,971	0.0	100.0	0	10,929	3,041	13,971	100.0
5. Noveleta	1,621	3,059	4,680	0.0	100.0	0	1,621	3,059	4,680	100.0
6. Rosario	3,742	13,464	17,205	0.0	100.0	0	3,742	13,464	17,205	100.0
III. RIZAL	76,743	168,794	245,537	17.1	82.9	13,094	63,649	168,794	232,443	94.7
1. Angono	4,628	2,081	6,709	100.0	0.0	4,628	0	2,081	2,081	31.0
2. Antipolo	19,999	37,816	57,816	0.0	100.0	0	19,999	37,816	57,816	100.0
3. Baras	188	596	784	0.0	100.0	0	188	596	784	100.0
4. Binangonan	10,414	5,190	15,604	0.0	100.0	0	10,414	5,190	15,604	100.0
5. Cainta	10,616	66,356	76,972	45.5	54.5	4,830	5,786	66,356	72,142	93.7
6. Cardona	728	1,112	1,840	0.0	100.0	0	728	1,112	1,840	100.0
7. Jala-Jala	109	564	673	0.0	100.0	0	109	564	673	100.0
8. Montalban	5,680	7,918	13,599	0.0	100.0	0	5,680	7,918	13,599	100.0
9. Morong	1,419	1,145	2,564	0.0	100.0	0	1,419	1,145	2,564	100.0
10. Pililla	1,045	1,202	2,247	0.0	100.0	0	1,045	1,202	2,247	100.0
11. San Mateo	6,648	7,502	14,150	0.0	100.0	0	6,648	7,502	14,150	100.0
12. Tanay	3,225	2,301	5,526	0.0	100.0	0	3,225	2,301	5,526	100.0
13. Taytay	11,331	34,291	45,622	32.1	67.9	3,636	7,695	34,291	41,986	92.0
14. Teresa	713	718	1,431	0.0	100.0	0	713	718	1,431	100.0
TOTAL	2,741,584	973,839	3,715,423	94.1	5.9	2,580,569	161,015	973,839	1,134,854	30.5

TABLE 6.2.20 DISTRIBUTION OF WATER DEMAND IN 2000, BY SOURCE

CITY/ MUNICIPALITY	WATER DEMAND (M3/D)			MWSS BREAKDOWN (%)		MWSS BREAKDOWN (M3/D)		PRIVATE	GROUND-WATER	G.W.
	MWSS	PRIVATE	TOTAL	SURFACE WATER	GROUND-WATER	SURFACE WATER	GROUND-WATER	GROUND-WATER	TOTAL	SHARE (%)
I. NCR	3,039,444	692,223	3,731,667	98.5	1.5	2,994,546	44,898	692,223	737,121	19.8
1. Manila	715,862	27,866	743,728	100.0	0.0	715,862	0	27,866	27,866	3.7
2. Pasay City	122,662	19,618	142,280	95.9	4.1	117,580	5,082	19,618	24,700	17.4
3. Quezon City	710,182	81,471	791,653	97.4	2.6	691,856	18,326	81,471	99,797	12.6
4. Caloocan City	208,070	38,462	246,532	100.0	0.0	208,070	0	38,462	38,462	15.6
5. Las Pinas	100,145	59,013	159,158	98.3	1.7	98,411	1,734	59,013	60,747	38.2
6. Makati	258,098	20,844	278,943	97.1	2.9	250,738	7,360	20,844	28,204	10.1
7. Malabon	87,616	27,304	114,921	98.6	1.4	86,372	1,244	27,304	28,548	24.8
8. Mandaluyong	104,166	10,395	114,560	100.0	0.0	104,166	0	10,395	10,395	9.1
9. Marikina	99,235	16,094	115,328	100.0	0.0	99,235	0	16,094	16,094	14.0
10. Muntinlupa	69,874	78,387	148,261	90.0	10.0	62,855	7,019	78,387	85,406	57.6
11. Navotas	52,977	4,761	57,737	99.4	0.6	52,664	313	4,761	5,074	8.8
12. Paranaque	149,761	56,100	205,861	98.8	1.2	147,993	1,768	56,100	57,868	28.1
13. Pasig	150,009	101,430	251,439	99.8	0.2	149,753	256	101,430	101,686	40.4
14. Pateros	11,041	5,813	16,854	100.0	0.0	11,041	0	5,813	5,813	34.5
15. San Juan	64,108	1,888	65,996	100.0	0.0	64,108	0	1,888	1,888	2.9
16. Taguig	57,060	81,537	138,597	98.5	1.5	56,213	847	81,537	82,384	59.4
17. Valenzuela	78,578	61,241	139,818	98.8	1.2	77,629	949	61,241	62,190	44.5
II. CAVITE	117,566	49,032	166,598	39.7	60.3	46,709	70,858	49,032	119,890	72.0
1. Bacoor	49,666	9,713	59,379	84.8	15.2	42,110	7,556	9,713	17,269	29.1
2. Cavite City	23,500	9,649	33,148	0.0	100.0	0	23,500	9,649	33,148	100.0
3. Imus	18,277	11,351	29,628	0.0	100.0	0	18,277	11,351	29,628	100.0
4. Kawit	15,328	1,855	17,183	30.0	70.0	4,598	10,730	1,855	12,585	73.2
5. Noveleta	4,558	1,702	6,260	0.0	100.0	0	4,558	1,702	6,260	100.0
6. Rosario	6,238	14,763	21,001	0.0	100.0	0	6,238	14,763	21,001	100.0
III. RIZAL	148,897	178,262	327,159	42.2	57.8	62,799	86,098	178,262	264,360	80.8
1. Angono	7,907	2,419	10,326	100.0	0.0	7,907	0	2,419	2,419	23.4
2. Antipolo	30,215	45,283	75,498	6.1	93.9	1,834	28,381	45,283	73,664	97.6
3. Baras	291	658	949	0.0	100.0	0	291	658	949	100.0
4. Binangonan	16,775	5,620	22,395	0.0	100.0	0	16,775	5,620	22,395	100.0
5. Cainta	36,463	67,162	103,625	84.1	15.9	30,677	5,786	67,162	72,948	70.4
6. Cardona	971	1,164	2,135	0.0	100.0	0	971	1,164	2,135	100.0
7. Jala-Jala	414	610	1,024	0.0	100.0	0	414	610	1,024	100.0
8. Montalban	8,189	8,566	16,755	18.4	81.6	1,505	6,684	8,566	15,250	91.0
9. Morong	1,928	1,216	3,144	0.0	100.0	0	1,928	1,216	3,144	100.0
10. Pililla	1,786	1,302	3,088	0.0	100.0	0	1,786	1,302	3,088	100.0
11. San Mateo	10,354	7,844	18,198	21.5	78.5	2,224	8,130	7,844	15,974	87.8
12. Tanay	6,039	2,559	8,598	0.0	100.0	0	6,039	2,559	8,598	100.0
13. Taytay	26,346	33,120	59,466	70.8	29.2	18,651	7,695	33,120	40,815	68.6
14. Teresa	1,219	739	1,958	0.0	100.0	0	1,219	739	1,958	100.0
TOTAL	3,305,908	919,517	4,225,424	93.9	6.1	3,104,053	201,854	919,517	1,121,371	26.5

TABLE 6.2.21 DISTRIBUTION OF WATER DEMAND IN 2005, BY SOURCE

CITY/ MUNICIPALITY	WATER DEMAND (M3/D)			MWSS BREAKDOWN (%)		MWSS BREAKDOWN (M3/D)		PRIVATE	GROUND-WATER TOTAL	G.W. SHARE (%)
	MWSS	PRIVATE	TOTAL	SURFACE WATER	GROUND-WATER	SURFACE WATER	GROUND-WATER	GROUND-WATER		
I. NCR	3,311,729	711,915	4,023,644	98.6	1.4	3,266,831	44,898	711,915	756,813	18.8
1. Manila	738,301	27,472	765,773	100.0	0.0	738,301	0	27,472	27,472	3.6
2. Pasay City	136,214	16,708	152,922	96.3	3.7	131,132	5,082	16,708	21,790	14.2
3. Quezon City	760,536	81,874	842,410	97.6	2.4	742,210	18,326	81,874	100,200	11.9
4. Caloocan City	235,267	33,970	269,237	100.0	0.0	235,267	0	33,970	33,970	12.6
5. Las Pinas	140,422	59,684	200,105	98.8	1.2	138,688	1,734	59,684	61,418	30.7
6. Makati	272,451	20,920	293,371	97.3	2.7	265,091	7,360	20,920	28,280	9.6
7. Malabon	98,128	25,351	123,479	98.7	1.3	96,884	1,244	25,351	26,595	21.5
8. Mandaluyong	110,518	10,394	120,911	100.0	0.0	110,518	0	10,394	10,394	8.6
9. Marikina	105,535	18,090	123,625	100.0	0.0	105,535	0	18,090	18,090	14.6
10. Muntinlupa	89,985	83,225	173,211	92.2	7.8	82,966	7,019	83,225	90,244	52.1
11. Navotas	55,863	4,737	60,600	99.4	0.6	55,550	313	4,737	5,050	8.3
12. Paranaque	158,744	56,320	215,064	98.9	1.1	156,976	1,768	56,320	58,088	27.0
13. Pasig	161,455	115,717	277,172	99.8	0.2	161,199	256	115,717	115,973	41.8
14. Pateros	13,229	5,346	18,575	100.0	0.0	13,229	0	5,346	5,346	28.8
15. San Juan	64,133	1,888	66,020	100.0	0.0	64,133	0	1,888	1,888	2.9
16. Taguig	69,925	86,909	156,834	98.8	1.2	69,078	847	86,909	87,756	56.0
17. Valenzuela	101,024	63,311	164,335	99.1	0.9	100,075	949	63,311	64,260	39.1
II. CAVITE	144,680	44,868	189,548	41.3	58.7	59,719	84,961	44,868	129,829	68.5
1. Bacoor	59,874	9,140	69,014	87.4	12.6	52,318	7,556	9,140	16,696	24.2
2. Cavite City	28,461	7,781	36,242	0.0	100.0	0	28,461	7,781	36,242	100.0
3. Imus	23,527	10,346	33,873	0.0	100.0	0	23,527	10,346	33,873	100.0
4. Kawit	18,502	603	19,105	40.0	60.0	7,401	11,101	603	11,704	61.3
5. Noveleta	5,742	1,284	7,027	0.0	100.0	0	5,742	1,284	7,027	100.0
6. Rosario	8,573	15,715	24,288	0.0	100.0	0	8,573	15,715	24,288	100.0
III. RIZAL	204,739	193,711	398,449	48.7	51.3	99,731	105,008	193,711	298,718	75.0
1. Angono	12,701	2,592	15,293	100.0	0.0	12,701	0	2,592	2,592	16.9
2. Antipolo	39,332	51,175	90,506	21.8	78.2	8,572	30,760	51,175	81,934	90.5
3. Baras	642	708	1,350	0.0	100.0	0	642	708	1,350	100.0
4. Binangonan	25,501	5,671	31,172	0.0	100.0	0	25,501	5,671	31,172	100.0
5. Cainta	48,686	73,627	122,313	88.1	11.9	42,900	5,786	73,627	79,413	64.9
6. Cardona	1,347	1,188	2,535	0.0	100.0	0	1,347	1,188	2,535	100.0
7. Jala-Jala	911	638	1,549	0.0	100.0	0	911	638	1,549	100.0
8. Montalban	10,188	8,936	19,124	34.4	65.6	3,504	6,684	8,936	15,620	81.7
9. Morong	2,833	1,290	4,123	0.0	100.0	0	2,833	1,290	4,123	100.0
10. Pililla	3,462	1,356	4,818	0.0	100.0	0	3,462	1,356	4,818	100.0
11. San Mateo	14,124	7,833	21,958	42.4	57.6	5,994	8,130	7,833	15,963	72.7
12. Tanay	9,425	2,662	12,087	0.0	100.0	0	9,425	2,662	12,087	100.0
13. Taytay	33,754	35,304	69,058	77.2	22.8	26,059	7,695	35,304	42,999	62.3
14. Teresa	1,832	730	2,562	0.0	100.0	0	1,832	730	2,562	100.0
TOTAL	3,661,148	950,493	4,611,641	93.6	6.4	3,426,281	234,867	950,493	1,185,360	25.7

TABLE 6.2.22 DISTRIBUTION OF WATER DEMAND IN 2010, BY SOURCE

CITY/ MUNICIPALITY	WATER DEMAND (M3/D)			MWSS BREAKDOWN (%)		MWSS BREAKDOWN (M3/D)		PRIVATE GROUND-WATER	GROUND-WATER TOTAL	G.W. SHARE (%)
	MWSS	PRIVATE	TOTAL	SURFACE WATER	GROUND-WATER	SURFACE WATER	GROUND-WATER			
I. NCR	3,740,899	753,685	4,494,583	98.8	1.2	3,696,001	44,898	753,685	798,583	17.8
1. Manila	804,366	27,359	831,725	100.0	0.0	804,366	0	27,359	27,359	3.3
2. Pasay City	153,165	16,736	169,901	96.7	3.3	148,083	5,082	16,736	21,818	12.8
3. Quezon City	852,444	82,662	935,106	97.9	2.1	834,118	18,326	82,662	100,988	10.8
4. Caloocan City	277,565	27,960	305,524	100.0	0.0	277,565	0	27,960	27,960	9.2
5. Las Pinas	179,932	69,889	249,821	99.0	1.0	178,198	1,734	69,889	71,623	28.7
6. Makati	302,437	21,036	323,473	97.6	2.4	295,077	7,360	21,036	28,396	8.8
7. Malabon	114,113	22,979	137,092	98.9	1.1	112,869	1,244	22,979	24,223	17.7
8. Mandaluyong	122,989	10,456	133,445	100.0	0.0	122,989	0	10,456	10,456	7.8
9. Marikina	117,556	20,112	137,668	100.0	0.0	117,556	0	20,112	20,112	14.6
10. Muntinlupa	106,746	94,265	201,011	93.4	6.6	99,727	7,019	94,265	101,284	50.4
11. Navotas	61,692	4,787	66,479	99.5	0.5	61,379	313	4,787	5,100	7.7
12. Paranaque	166,529	61,722	228,251	98.9	1.1	164,761	1,768	61,722	63,490	27.8
13. Pasig	181,869	129,726	311,595	99.9	0.1	181,613	256	129,726	129,982	41.7
14. Pateros	16,376	4,600	20,975	100.0	0.0	16,376	0	4,600	4,600	21.9
15. San Juan	67,826	1,880	69,706	100.0	0.0	67,826	0	1,880	1,880	2.7
16. Taguig	88,247	90,416	178,664	99.0	1.0	87,400	847	90,416	91,263	51.1
17. Valenzuela	127,045	67,101	194,147	99.3	0.7	126,096	949	67,101	68,050	35.1
II. CAVITE	178,439	41,718	220,157	41.8	58.2	74,549	103,890	41,718	145,608	66.1
1. Bacoor	71,216	10,799	82,015	89.4	10.6	63,660	7,556	10,799	18,355	22.4
2. Cavite City	32,500	7,310	39,810	0.0	100.0	0	32,500	7,310	39,810	100.0
3. Imus	33,381	6,818	40,199	0.0	100.0	0	33,381	6,818	40,199	100.0
4. Kawit	21,778	0	21,778	50.0	50.0	10,889	10,889	0	10,889	50.0
5. Noveleta	7,289	816	8,105	0.0	100.0	0	7,289	816	8,105	100.0
6. Rosario	12,275	15,975	28,250	0.0	100.0	0	12,275	15,975	28,250	100.0
III. RIZAL	283,791	202,608	486,399	53.7	46.3	152,420	131,371	202,608	333,979	68.7
1. Angono	19,296	2,516	21,812	100.0	0.0	19,296	0	2,516	2,516	11.5
2. Antipolo	53,929	55,380	109,309	33.7	66.3	18,149	35,780	55,380	91,160	83.4
3. Baras	1,165	731	1,896	0.0	100.0	0	1,165	731	1,896	100.0
4. Binangonan	36,874	5,250	42,124	0.0	100.0	0	36,874	5,250	42,124	100.0
5. Cainta	66,270	78,127	144,397	91.3	8.7	60,484	5,786	78,127	83,913	58.1
6. Cardona	1,825	1,178	3,003	0.0	100.0	0	1,825	1,178	3,003	100.0
7. Jala-Jala	1,646	632	2,278	0.0	100.0	0	1,646	632	2,278	100.0
8. Montalban	12,542	9,318	21,860	46.7	53.3	5,858	6,684	9,318	16,002	73.2
9. Morong	4,076	1,318	5,394	0.0	100.0	0	4,076	1,318	5,394	100.0
10. Pililla	5,108	1,324	6,432	0.0	100.0	0	5,108	1,324	6,432	100.0
11. San Mateo	19,954	7,193	27,147	59.3	40.7	11,824	8,130	7,193	15,323	56.4
12. Tanay	13,968	2,574	16,542	0.0	100.0	0	13,968	2,574	16,542	100.0
13. Taytay	44,504	36,380	80,884	82.7	17.3	36,809	7,695	36,380	44,075	54.5
14. Teresa	2,634	686	3,320	0.0	100.0	0	2,634	686	3,320	100.0
TOTAL	4,203,129	998,010	5,201,139	93.3	6.7	3,922,970	280,159	998,010	1,278,170	24.6

TABLE 6.2.23 ANALYSIS ON WATER SUPPLY AND SUPPLY CAPACITY

YEAR	MWSS WATER DEMAND (M3/D)			MWSS PRODUCTION FROM SURFACE WATER (M3/D)					EXCESS IN PRODUCTION (M3/D)	REQUIRED GROUNDWATER SUPPLY (M3/D)		
	TOTAL	W/I CDS	LOSS (%)	EXISTING	ANGAT (ON-GOING)	WAWA (PLANNED)	UMIRAY (PLANNED)	TOTAL (M3/D)		MWSS	PRIVATE	TOTAL
1995	2,741,584	2,646,504	35.0	2,234,700	-	-	-	2,234,700	(411,804)	161,015	973,839	1,134,854
1996	2,854,449	2,761,986	34.0	2,234,700	1,231,200	-	-	3,465,900	703,914	169,183	962,975	1,132,157
1997	2,967,314	2,877,467	33.0	2,234,700	1,231,200	68,400	-	3,534,300	656,833	177,351	952,110	1,129,461
1998	3,080,178	2,992,949	32.0	2,234,700	1,231,200	68,400	738,700	4,273,000	1,280,051	185,518	941,246	1,126,764
1999	3,193,043	3,108,430	31.0	2,234,700	1,231,200	68,400	738,700	4,273,000	1,164,570	193,686	930,381	1,124,068
2000	3,305,908	3,223,912	30.0	2,234,700	1,231,200	68,400	738,700	4,273,000	1,049,088	201,854	919,517	1,121,371
2005	3,661,148	3,548,890	25.0	2,234,700	1,231,200	68,400	738,700	4,273,000	724,110	234,867	950,493	1,185,360
2010	4,203,129	4,050,388	25.0	2,234,700	1,231,200	68,400	738,700	4,273,000	222,612	280,159	998,010	1,278,169

WATER PRODUCTION:

1. EXISTING; actual average production in last 5 years: 2,352,364 M3/D
   actual production loss in MWSS in 1990; 1.5%
   assumed production loss in the future: 5%
   2,352,364 x 95% = 2,234,746
2. ANGAT; AWSOP 15CMS x 95% (production loss: 5%)
3. WAWA; MNEWSP 72MLD x 95% (production loss: 5%)
4. UMIRAY; UATP 9CMS x 95% (production loss: 5%)
5. Demand for MWSS in Angono and Taytay is assumed to be supplied with surface water through RPWSP.

TABLE 6.2.24 SUMMARY OF GROUNDWATER DISCHARGE (SCENARIO 1)

SYSTEM	MWSS WELL					PRIVATE WELL					TOTAL				
CITY/MUNICIPALITY	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
I. NCR	32,961	44,898	44,898	44,898	44,898	640,937	666,580	692,223	711,915	753,685	673,898	711,478	737,121	756,813	798,583
1. Manila	0	0	0	0	0	12,665	20,265	27,866	27,472	27,359	12,665	20,265	27,866	27,472	27,359
2. Pasay City	4,461	5,082	5,082	5,082	5,082	17,997	18,807	19,618	16,708	16,736	22,458	23,889	24,700	21,790	21,818
3. Quezon City	14,186	18,326	18,326	18,326	18,326	91,324	86,397	81,471	81,874	82,662	105,510	104,723	99,797	100,200	100,988
4. Caloocan City	0	0	0	0	0	27,476	32,969	38,462	33,970	27,960	27,476	32,969	38,462	33,970	27,960
5. Las Pinas	1,527	1,734	1,734	1,734	1,734	81,778	70,395	59,013	59,684	69,889	83,305	72,129	60,747	61,418	71,623
6. Makati	3,772	7,360	7,360	7,360	7,360	25,179	23,012	20,844	20,920	21,036	28,951	30,372	28,204	28,280	28,396
7. Malabon	554	1,244	1,244	1,244	1,244	18,473	22,889	27,304	25,351	22,979	19,027	24,133	28,548	26,595	24,223
8. Mandaluyong	0	0	0	0	0	8,976	9,685	10,395	10,394	10,456	8,976	9,685	10,395	10,394	10,456
9. Marikina	0	0	0	0	0	13,573	14,833	16,094	15,090	20,112	13,573	14,833	16,094	15,090	20,112
10. Muntinlupa	5,777	7,019	7,019	7,019	7,019	91,618	85,003	78,387	83,225	94,265	97,395	92,022	85,406	90,244	101,284
11. Navotas	106	313	313	313	313	4,051	4,406	4,761	4,737	4,787	4,157	4,719	5,074	5,050	5,100
12. Paranaque	1,147	1,768	1,768	1,768	1,768	70,158	63,129	56,100	56,320	61,722	71,305	64,897	57,868	58,088	63,490
13. Pasig	49	256	256	256	256	75,958	88,694	101,430	115,717	129,726	76,007	88,950	101,686	115,973	129,982
14. Pateros	0	0	0	0	0	1,756	3,785	5,813	5,346	4,600	1,756	3,785	5,813	5,346	4,600
15. San Juan	0	0	0	0	0	408	1,148	1,888	1,888	1,880	408	1,148	1,888	1,888	1,880
16. Taguig	640	847	847	847	847	66,367	73,952	81,537	86,909	90,416	67,007	74,799	82,384	87,756	91,263
17. Valenzuela	742	949	949	949	949	33,180	47,210	61,241	63,311	67,101	33,922	48,159	62,190	64,260	68,050
II. CAVITE	26,970	47,610	70,858	84,961	103,890	57,927	53,479	49,032	44,868	41,718	84,897	101,090	119,890	129,829	145,608
1. Bacoor	6,314	7,556	7,556	7,556	7,556	32,210	20,961	9,713	9,140	10,799	38,524	28,517	17,269	16,696	18,355
2. Cavite City	6,714	11,926	20,988	27,133	32,500	4,328	6,988	9,649	7,781	7,310	11,042	18,914	30,637	34,914	39,810
3. Imus	1,654	9,965	18,277	23,527	33,381	4,443	7,897	11,351	10,346	6,818	6,097	17,862	29,628	33,873	40,199
4. Kawit	4,329	7,529	10,730	11,101	10,889	2,830	2,342	1,855	603	0	7,159	9,872	12,585	11,704	10,889
5. Noveleta	7,070	7,070	7,070	7,070	7,289	5,659	3,680	1,702	1,284	816	12,729	10,750	8,772	8,354	8,105
6. Rosario	889	3,563	6,238	8,573	12,275	8,457	11,610	14,763	15,715	15,975	9,346	15,173	21,001	24,288	28,250
III. RIZAL	29,808	58,598	86,098	105,008	131,371	141,838	160,050	178,262	193,711	202,608	171,646	218,948	264,360	298,718	333,979
1. Angono	-	0	0	0	0	-	1,210	2,419	2,592	2,516	-	1,210	2,419	2,592	2,516
2. Antipolo	11,621	19,999	28,381	30,760	35,780	44,155	44,719	45,283	51,175	55,380	55,776	64,718	73,664	81,934	91,160
3. Baras	-	165	291	642	1,165	-	329	658	708	731	-	474	949	1,350	1,896
4. Binangonan	-	8,388	15,775	25,501	36,874	-	2,810	5,620	5,671	5,250	-	11,198	22,395	31,172	42,124
5. Cainta	3,785	4,786	5,786	5,786	5,786	48,619	57,891	67,162	73,627	78,127	52,404	62,676	72,948	79,413	83,913
6. Cardona	-	485	971	1,347	1,825	-	582	1,164	1,168	1,178	-	1,067	2,135	2,535	3,003
7. Jala-Jala	-	207	414	911	1,646	-	305	610	638	632	-	512	1,024	1,549	2,278
8. Montalban	3,243	5,650	6,684	6,684	6,684	8,030	8,298	8,566	8,936	9,318	11,273	13,948	15,250	15,620	16,002
9. Morong	-	964	1,928	2,833	4,076	-	608	1,216	1,290	1,318	-	1,572	3,144	4,123	5,394
10. Pililla	-	893	1,786	3,462	5,108	-	651	1,302	1,356	1,324	-	1,544	3,088	4,818	6,432
11. San Mateo	4,706	6,648	8,130	8,130	8,130	3,641	5,743	7,844	7,833	7,193	8,347	12,391	15,974	15,963	15,323
12. Tanay	-	3,019	6,039	9,425	15,988	-	1,280	2,559	2,682	2,574	-	4,299	8,598	12,087	16,542
13. Taytay	6,453	7,074	7,695	7,695	7,695	37,393	35,256	33,120	35,304	36,380	43,846	42,330	40,815	42,999	44,075
14. Teresa	-	609	1,219	1,832	2,634	-	370	739	730	686	-	979	1,958	2,562	3,320
TOTAL	89,739	151,406	201,855	234,866	280,159	840,702	880,109	919,517	950,493	998,010	930,441	1,031,515	1,121,372	1,185,360	1,278,170

TABLE 6.2.25 SUMMARY OF GROUNDWATER DISCHARGE (SCENARIO 2)

SYSTEM	MWSS WELL					PRIVATE WELL					TOTAL				
CITY/MUNICIPALITY	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
I. NCR	32,961	44,898	44,898	44,898	44,898	640,937	666,580	692,223	660,885	652,943	673,898	711,478	737,121	705,786	697,841
1. Manila	0	0	0	0	0	12,665	20,265	27,866	27,472	27,359	12,665	20,265	27,866	27,472	27,359
2. Pasay City	4,461	5,082	5,082	5,082	5,082	17,997	18,807	19,618	16,708	16,736	22,458	23,889	24,700	21,790	21,818
3. Quezon City	14,186	18,326	18,326	18,326	18,326	91,324	86,397	81,471	81,874	82,662	105,510	104,723	99,797	100,200	100,988
4. Caloocan City	0	0	0	0	0	27,476	32,969	38,462	33,970	27,960	27,476	32,969	38,462	33,970	27,960
5. Las Pinas	1,527	1,734	1,734	1,734	1,734	81,778	70,395	59,013	54,464	59,540	83,305	72,129	60,747	56,198	61,274
6. Makati	3,772	7,360	7,360	7,360	7,360	25,179	23,012	20,844	20,920	21,036	28,951	30,372	28,204	28,280	28,396
7. Malabon	554	1,244	1,244	1,244	1,244	18,473	22,889	27,304	25,351	22,979	19,027	24,133	28,548	26,595	24,223
8. Mandaluyong	0	0	0	0	0	8,976	9,685	10,395	10,394	10,456	8,976	9,685	10,395	10,394	10,456
9. Marikina	0	0	0	0	0	13,573	14,833	16,094	16,326	16,626	13,573	14,833	16,094	16,326	16,626
10. Muntinlupa	5,777	7,019	7,019	7,019	7,019	91,618	85,003	78,387	74,843	76,108	97,395	92,022	85,406	81,062	83,127
11. Navotas	106	313	313	313	313	4,051	4,406	4,761	4,737	4,787	4,157	4,719	5,074	5,050	5,100
12. Paranaque	1,147	1,768	1,768	1,768	1,768	70,158	63,129	56,100	51,397	51,981	71,305	64,897	57,868	53,165	53,749
13. Pasig	49	256	256	256	256	75,958	88,694	101,430	101,771	102,216	76,007	88,950	101,686	102,027	102,472
14. Pateros	0	0	0	0	0	1,756	3,785	5,813	4,992	3,904	1,756	3,785	5,813	4,992	3,904
15. San Juan	0	0	0	0	0	408	1,148	1,888	1,888	1,880	408	1,148	1,888	1,888	1,880
16. Taguig	640	847	847	847	847	66,367	73,952	81,537	77,597	72,057	67,007	74,799	82,384	78,444	72,904
17. Valenzuela	742	949	949	949	949	33,180	47,210	61,241	57,065	54,657	33,922	48,159	62,190	57,954	55,606
II. CAVITE	26,970	47,610	70,858	70,859	70,859	57,927	53,479	49,032	42,252	36,511	84,897	101,090	119,890	113,111	107,370
1. Bacoor	6,314	7,556	7,556	7,556	7,556	32,210	20,961	9,713	8,945	10,409	38,524	28,517	17,269	16,501	17,965
2. Cavite City	6,714	11,926	20,988	20,988	20,988	4,328	6,988	9,649	8,819	5,379	11,042	18,914	30,637	27,807	26,367
3. Imus	1,654	9,965	18,277	18,277	18,277	4,443	7,597	11,351	10,061	6,250	6,097	17,862	29,628	28,338	24,527
4. Kawit	4,329	7,529	10,730	10,730	10,730	2,830	2,342	1,855	603	0	7,159	9,872	12,585	11,333	10,730
5. Noveleta	7,070	7,070	7,070	7,070	7,070	5,659	3,680	1,702	1,284	816	12,729	10,750	8,772	8,354	7,886
6. Rosario	859	3,563	6,238	6,238	6,238	8,457	11,610	14,763	14,539	13,657	9,348	15,173	21,001	20,777	19,895
III. RIZAL	29,808	58,898	86,098	105,008	131,371	141,838	160,050	178,262	193,711	202,608	171,646	218,948	264,360	298,718	333,979
1. Angono	-	0	0	0	0	-	1,210	2,419	2,592	2,516	-	1,210	2,419	2,592	2,516
2. Antipolo	11,621	19,999	28,381	30,760	35,780	44,155	44,719	45,283	51,175	55,380	55,776	64,718	73,664	81,934	91,160
3. Baras	-	145	291	642	1,165	-	329	658	708	731	-	474	949	1,350	1,896
4. Binangonan	-	8,388	16,775	25,501	36,876	-	2,810	5,620	5,671	5,250	-	11,198	22,395	31,172	42,124
5. Cainta	3,785	4,786	5,786	5,786	5,786	48,619	57,891	67,162	73,627	78,127	52,404	62,676	72,948	79,413	83,913
6. Cardona	-	485	971	1,347	1,825	-	582	1,164	1,188	1,178	-	1,067	2,135	2,535	3,003
7. Jala-Jala	-	207	414	911	1,646	-	305	610	638	632	-	512	1,024	1,549	2,278
8. Montalban	3,243	5,680	6,684	6,684	6,684	8,030	8,295	8,566	8,936	9,318	11,273	13,975	15,250	15,620	16,002
9. Morong	-	954	1,928	2,833	4,076	-	608	1,216	1,290	1,318	-	1,572	3,144	4,123	5,394
10. Pililla	-	893	1,786	3,462	5,108	-	651	1,302	1,356	1,324	-	1,544	3,088	4,818	6,432
11. San Mateo	4,706	8,648	8,130	8,130	8,130	3,641	5,743	7,844	7,833	7,193	8,347	12,391	15,974	15,963	15,323
12. Tanay	-	3,019	6,039	9,425	13,968	-	1,280	2,559	2,662	2,574	-	4,299	8,598	12,087	16,542
13. Taytay	5,453	7,074	7,695	7,695	7,695	37,393	35,256	33,120	33,304	36,380	43,846	42,330	40,815	42,999	44,075
14. Teresa	-	509	1,219	1,832	2,634	-	370	739	730	686	-	879	1,958	2,562	3,320
TOTAL	89,739	151,406	201,855	220,765	247,128	840,702	880,109	919,517	896,850	892,062	930,441	1,031,515	1,121,372	1,117,615	1,139,190

TABLE 6.2.26 SUMMARY OF GROUNDWATER DISCHARGE (SCENARIO 3)

SYSTEM	MWSS WELL					PRIVATE WELL					TOTAL				
CITY/MUNICIPALITY	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
I. NCR	32,961	44,898	44,898	44,898	44,898	640,937	666,580	692,223	606,845	598,900	673,898	711,478	737,121	651,743	643,798
1. Manila	0	0	0	0	0	12,665	20,265	27,866	27,472	27,359	12,665	20,265	27,866	27,472	27,359
2. Pasay City	4,461	5,082	5,082	5,082	5,082	17,997	18,807	19,618	16,708	16,736	22,458	23,889	24,700	21,790	21,818
3. Quezon City	14,186	18,326	18,326	18,326	18,326	91,324	86,397	81,471	81,674	82,662	105,510	104,723	99,797	100,200	100,988
4. Caloocan City	0	0	0	0	0	27,476	32,969	38,462	33,970	27,960	27,476	32,969	38,462	33,970	27,960
5. Las Pinas	1,527	1,734	1,734	1,734	1,734	81,778	70,395	59,013	48,901	53,996	83,305	72,129	60,747	50,635	55,730
6. Makati	3,772	7,360	7,360	7,360	7,360	25,179	23,012	20,844	20,920	21,036	28,951	30,372	28,204	28,280	28,396
7. Malabon	554	1,244	1,244	1,244	1,244	18,473	22,889	27,304	25,351	22,979	19,027	24,133	28,548	26,595	24,223
8. Mandaluyong	0	0	0	0	0	8,976	9,685	10,395	10,394	10,456	8,976	9,685	10,395	10,394	10,456
9. Marikina	0	0	0	0	0	13,573	14,833	16,094	14,463	14,763	13,573	14,833	16,094	14,463	14,763
10. Muntinlupa	5,777	7,019	7,019	7,019	7,019	91,618	85,003	78,387	64,358	66,423	97,395	92,022	85,406	71,377	73,442
11. Navotas	106	313	313	313	313	4,051	4,406	4,761	4,737	4,787	4,157	4,719	5,074	5,050	5,100
12. Paranaque	1,147	1,768	1,768	1,768	1,768	70,158	63,129	56,100	46,212	46,797	71,305	64,897	57,868	47,980	48,565
13. Pasig	49	256	256	256	256	75,958	86,694	101,430	86,967	87,412	76,007	86,950	101,686	87,223	87,668
14. Pateros	0	0	0	0	0	1,756	3,785	5,813	4,613	3,525	1,756	3,785	5,813	4,613	3,525
15. San Juan	0	0	0	0	0	408	1,148	1,888	1,888	1,880	408	1,148	1,888	1,888	1,880
16. Taguig	640	847	847	847	847	66,367	73,952	81,537	67,700	62,160	67,007	74,799	82,384	68,547	63,007
17. Valenzuela	742	949	949	949	949	33,180	47,210	61,241	50,318	47,970	33,922	48,159	62,190	51,267	48,919
II. CAVITE	26,970	52,468	52,468	52,468	52,468	57,927	53,479	49,032	39,537	33,796	84,897	105,948	101,500	92,005	86,264
1. Bacoor	6,314	7,556	7,556	7,556	7,556	32,210	20,961	9,713	8,749	10,212	38,524	28,517	17,269	16,305	17,768
2. Cavite City	6,714	11,926	11,926	11,926	11,926	4,328	6,988	9,649	5,847	4,406	11,042	18,914	21,575	17,773	16,332
3. Imus	1,654	11,245	11,245	11,245	11,245	4,443	7,897	11,351	9,767	5,956	6,097	19,142	22,596	21,012	17,201
4. Kawit	4,329	10,929	10,929	10,929	10,929	2,830	2,362	1,855	603	0	7,159	13,272	12,784	11,532	10,930
5. Noveleta	7,070	7,070	7,070	7,070	7,070	5,658	3,680	1,702	1,284	816	12,729	10,750	8,772	8,354	7,886
6. Rosario	889	3,742	3,742	3,742	3,742	8,457	11,610	14,763	13,287	12,406	9,346	15,352	18,505	17,029	16,147
III. RIZAL	29,808	63,649	86,098	105,008	131,371	141,838	160,050	178,262	193,711	202,608	171,646	223,699	264,360	298,718	333,979
1. Angono	-	0	0	0	0	-	1,210	2,419	2,592	2,516	-	1,210	2,419	2,592	2,516
2. Antipolo	11,621	19,999	28,381	30,780	35,780	44,155	44,719	45,283	51,175	55,380	55,776	64,718	73,664	81,954	91,160
3. Baras	-	188	291	642	1,165	-	329	658	708	731	-	517	949	1,350	1,896
4. Binangonan	-	10,414	16,775	25,501	36,874	-	2,810	5,620	5,671	5,250	-	13,224	22,395	31,172	42,124
5. Cainta	3,785	5,786	5,786	5,786	5,786	48,619	57,891	67,162	73,627	78,127	52,404	63,677	72,948	79,413	83,913
6. Cardona	-	728	971	1,347	1,825	-	582	1,164	1,188	1,178	-	1,310	2,135	2,535	3,003
7. Jala-Jala	-	109	414	911	1,646	-	305	610	638	632	-	414	1,024	1,549	2,278
8. Montalban	3,243	5,680	6,684	6,684	6,684	8,030	8,298	8,566	8,936	9,318	11,273	13,978	15,250	15,620	16,002
9. Morong	-	1,419	1,928	2,833	4,076	-	608	1,216	1,290	1,318	-	2,027	3,144	4,123	5,394
10. Pililla	-	1,045	1,786	3,462	5,108	-	651	1,302	1,356	1,324	-	1,696	3,088	4,818	6,432
11. San Mateo	4,706	6,648	8,130	8,130	8,130	3,641	5,763	7,844	7,833	7,193	8,347	12,390	15,974	15,963	15,323
12. Tanay	-	3,225	6,039	9,425	13,968	-	1,280	2,559	2,682	2,574	-	4,504	8,598	12,087	16,542
13. Taytay	6,453	7,695	7,695	7,695	7,695	37,393	35,256	33,120	35,304	36,380	43,846	42,951	40,815	42,999	44,075
14. Teresa	-	713	1,219	1,832	2,634	-	370	739	730	686	-	1,082	1,958	2,562	3,320
TOTAL	89,739	161,015	183,465	202,374	228,738	840,702	880,109	919,517	840,092	835,304	930,441	1,041,124	1,102,982	1,042,466	1,064,041

TABLE 6.2.27 SUMMARY OF GROUNDWATER DISCHARGE (SCENARIO 4)

SYSTEM	MWSS WELL					PRIVATE WELL					TOTAL				
CITY/MUNICIPALITY	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010	1990	1995	2000	2005	2010
I. NCR	32,961	44,898	44,898	44,898	44,898	640,937	696,079	751,221	737,240	767,418	673,898	740,977	796,119	782,138	812,316
1. Manila	0	0	0	0	0	12,665	20,491	28,317	27,926	27,812	12,665	20,491	28,317	27,926	27,812
2. Pasay City	4,461	5,082	5,082	5,082	5,082	17,997	19,481	20,965	18,172	16,996	22,458	24,563	26,047	23,254	22,078
3. Quezon City	14,186	18,326	18,326	18,326	18,326	91,324	86,756	82,189	82,643	83,471	105,510	105,082	100,515	100,969	101,797
4. Caloocan City	0	0	0	0	0	27,476	35,836	44,197	37,493	31,884	27,476	35,836	44,197	37,493	31,884
5. Las Pinas	1,527	1,734	1,734	1,734	1,734	81,778	75,853	69,927	64,628	70,083	83,305	77,587	71,661	66,362	71,817
6. Makati	3,772	7,360	7,360	7,360	7,360	25,179	24,031	22,883	21,041	21,160	28,951	31,391	30,243	28,401	28,520
7. Malabon	554	1,244	1,244	1,244	1,244	18,473	23,926	29,380	26,545	24,258	19,027	25,170	30,624	27,789	25,502
8. Mandaluyong	0	0	0	0	0	8,976	9,737	10,497	10,500	10,566	8,976	9,737	10,497	10,500	10,566
9. Marikina	0	0	0	0	0	13,573	14,899	16,224	18,233	20,266	13,573	14,899	16,224	18,233	20,266
10. Muntinlupa	5,777	7,019	7,019	7,019	7,019	91,618	89,454	87,289	86,448	84,464	97,395	96,473	94,308	93,467	101,483
11. Navotas	106	313	313	313	313	4,051	4,763	5,475	4,855	4,911	4,157	5,076	5,788	5,168	5,224
12. Paranaque	1,147	1,768	1,768	1,768	1,768	70,158	67,727	65,295	58,812	61,791	71,305	69,495	67,063	60,580	63,559
13. Pasig	49	256	256	256	256	75,958	89,596	103,233	115,924	129,951	76,007	89,852	103,489	116,180	130,207
14. Pateros	0	0	0	0	0	1,756	4,325	6,895	5,841	5,145	1,756	4,325	6,895	5,841	5,145
15. San Juan	0	0	0	0	0	408	1,157	1,906	1,906	1,898	408	1,157	1,906	1,906	1,898
16. Taguig	640	847	847	847	847	66,367	79,444	92,521	89,534	93,367	67,007	80,291	93,368	90,381	94,214
17. Valenzuela	742	949	949	949	949	33,180	48,804	64,428	66,738	69,394	33,922	49,553	64,977	67,687	70,343
II. CAVITE	26,970	45,921	64,875	80,324	98,894	57,927	58,667	59,408	49,635	45,623	84,897	104,588	124,283	129,958	144,517
1. Bacoor	6,314	7,556	7,556	7,556	7,556	32,210	23,951	15,693	10,190	10,806	38,524	31,507	23,249	17,746	18,362
2. Cavite City	6,714	11,869	18,270	25,006	31,521	4,328	7,553	10,778	9,081	7,983	11,042	19,422	29,048	34,087	39,504
3. Imus	1,654	9,014	16,374	22,182	30,733	4,443	8,563	12,683	11,355	8,804	6,097	17,577	29,057	33,537	39,537
4. Kawit	4,329	7,183	10,037	10,625	10,688	2,830	2,689	2,548	1,199	301	7,159	9,872	12,585	11,823	10,989
5. Noveleta	7,070	7,070	7,070	7,070	7,070	5,659	4,067	2,475	1,579	1,042	12,729	11,137	9,545	8,649	8,112
6. Rosario	889	3,229	5,569	7,885	11,326	8,457	11,844	15,231	16,231	16,687	9,346	15,073	20,800	24,116	28,012
III. RIZAL	29,808	54,199	84,734	103,549	128,964	141,838	165,915	189,991	199,089	209,323	171,646	220,113	274,725	302,556	338,286
1. Angono	-	0	0	0	0	-	1,210	2,419	2,592	2,516	-	1,210	2,419	2,592	2,516
2. Antipolo	11,621	16,767	26,858	29,142	33,213	44,155	45,264	46,373	52,402	57,386	55,776	62,031	73,230	81,545	90,599
3. Baras	-	145	291	642	1,165	-	329	658	705	731	-	474	949	1,350	1,896
4. Binangonan	-	8,388	16,775	25,501	36,874	-	2,810	5,620	5,671	5,250	-	11,198	22,395	31,172	42,124
5. Cainta	3,785	4,786	5,786	5,786	5,786	48,619	61,036	73,454	75,421	80,308	52,404	65,822	79,240	81,207	86,094
6. Cardona	-	485	971	1,347	1,825	-	582	1,164	1,188	1,178	-	1,067	2,135	2,535	3,003
7. Jala-Jala	-	207	414	911	1,646	-	305	610	638	632	-	512	1,024	1,549	2,278
8. Montalban	3,243	4,499	6,585	6,585	6,585	8,030	8,437	8,845	9,323	9,620	11,273	12,936	15,430	15,908	16,205
9. Morong	-	964	1,928	2,833	4,076	-	608	1,216	1,290	1,318	-	1,572	3,144	4,123	5,394
10. Pililla	-	893	1,786	3,462	5,108	-	651	1,302	1,356	1,324	-	1,544	3,088	4,818	6,432
11. San Mateo	4,708	6,362	8,388	8,388	8,388	3,641	6,020	8,399	8,488	7,966	8,347	12,382	16,787	16,876	16,354
12. Tanay	-	3,019	6,039	9,425	13,968	-	1,280	2,559	2,662	2,574	-	4,299	8,598	12,087	16,542
13. Taytay	6,453	7,074	7,695	7,695	7,695	37,393	37,014	36,634	36,539	37,834	43,846	44,088	44,329	44,234	45,529
14. Teresa	-	609	1,219	1,832	2,634	-	370	739	730	686	-	979	1,958	2,562	3,320
TOTAL	89,739	145,017	194,508	228,771	272,756	840,702	920,661	1,000,620	985,883	1,022,363	930,441	1,065,678	1,195,128	1,214,654	1,295,119

TABLE 6.2.28 NUMBER OF CONNECTIONS AND WATER CONSUMPTION IN THE ANTIPOLO BASIN

AREA	NO. OF CONNECTIONS					WATER CONSUMPTION (M^3/D)				
	DOM.	P.F.	COM.	IND.	TOTAL	DOM.	P.F.	COM.	IND.	TOTAL
ANTIPOLO MUNICIPALITY	4445	1	223	44	4713	3606	4	533	1565	5707
ANTIPOLO BASIN	3535	3	172	28	3738	2962	10	270	46	3288
SHARE (%)	79.5	300	77.1	63.6	79.3	82.1	250	50.7	2.9	57.6

Note: Data on P.F. may be processed improperly. But its influence is negligible.

Source: Computer Service Center, MWSS

TABLE 6.2.29 GROUNDWATER DISCHARGE IN THE ANTIPOLO BASIN (1990)

(UNIT: MCM)

OWNER	NO. OF WELLS	DISCHARGE	USE		
			DOM.	COM.	IND.
MWSS	10	3.5803	1.1884	0.1119	0.0190
PRIVATE	26	3.5210	2.2591	0.2209	1.0410
TOTAL	36	7.1013	3.4475	0.3328	1.0600
DAILY (M^3/D)		19,456	9,445	912	2,904
MWSS %	27.7	50.4	34.5	33.6	1.8

Source: Study Team

TABLE 6.2.30 PROJECTED MWSS SERVED POPULATION

(POBLACION SYSTEM)

BARANGAY/ MUNICIPALITY	POPULATION WITHIN STUDY AREA					SERVICE RATIO (%)				POPULATION WITHIN SERVICE AREA			
	1990	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010
1. Bagong Nayon	14,402	18,115	22,117	26,202	30,110	0	0	0	0	0	0	0	0
2. Santa Cruz	9,338	11,763	14,377	17,044	19,597	0	30	50	70	0	4,313	8,522	13,718
3. De La Paz	21,033	26,441	32,269	38,215	43,906	70	80	85	90	18,509	25,815	32,483	39,515
4. Beverly Hills	1,034	1,385	1,767	2,161	2,532	90	90	95	100	1,247	1,590	2,053	2,532
5. San Roque	17,227	21,673	26,465	31,355	36,034	60	80	90	95	13,004	21,172	28,220	34,232
6. Dalig	14,241	17,896	21,843	25,869	29,723	70	80	90	95	12,527	17,474	23,282	28,237
7. San Jose	13,061	16,408	20,014	23,693	27,214	70	90	90	95	11,485	18,013	21,323	25,853
8. San Isidro	19,260	24,220	29,566	35,020	40,240	40	60	70	80	9,688	17,740	24,514	32,192
9. San Luis	3,121	3,955	4,856	5,777	6,656	0	70	90	95	0	3,399	5,199	6,323
SUB-TOTAL	112,717	141,856	173,274	205,335	236,012	47	63	71	77	66,460	109,516	145,596	182,603
10. Taytay	7,970	9,181	10,517	12,268	13,978	50	50	50	50	4,591	5,259	6,134	6,989
11. Angono	1,750	2,225	2,705	3,470	4,189	0	40	50	100	0	1,082	1,735	4,189
12. Binangonan	700	833	958	1,155	1,334	0	0	0	100	0	0	0	1,334
13. Teresa	210	234	256	289	318	0	0	0	100	0	0	0	318
SUB-TOTAL	10,630	12,473	14,436	17,182	19,819	37	44	46	65	4,591	6,341	7,869	12,830
TOTAL	123,347	154,329	187,710	222,517	255,831	46	62	69	76	71,050	115,857	153,465	195,433

TABLE 6.2.31 DOMESTIC DEMAND PROJECTION IN THE ANTIPOLO BASIN

(POBLACION SYSTEM)

BARANGAY/ MUNICIPALITY	POPULATION WITHIN THE BASIN				NWSS SERVED POPULATION				P.C.W.D (LPCD)				NWSS DOMESTIC WATER DEMAND (M3/D)				OTHER DOM. DEMAND IN BASIN				TOTAL DOM. DEMAND IN BASIN (M3/D)			
	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010
1. Bagong Nayon	0	0	0	0	0	0	0	0	138	149	155	162	0	0	0	0	0	0	0	0	0	0	0	0
2. Santa Cruz	5,041	6,161	7,305	8,399	0	4,313	8,522	13,718	138	149	155	162	0	643	1,321	2,222	696	275	0	0	696	918	1,321	2,222
3. De La Paz	21,153	25,815	30,572	35,125	18,509	25,815	32,483	39,515	138	149	155	162	2,554	3,846	5,035	6,401	365	0	0	0	2,919	3,846	5,035	6,401
4. Beverly Hills	0	0	0	0	1,247	1,590	2,053	2,532	138	149	155	162	172	237	318	410	0	0	0	0	172	237	318	410
5. San Roque	19,506	23,819	28,220	32,431	12,004	21,172	28,220	34,232	138	149	155	162	1,795	3,155	4,374	5,546	897	394	0	0	2,692	3,549	4,374	5,546
6. Dalig	17,896	21,843	25,869	29,723	12,527	17,434	23,282	28,237	138	149	155	162	1,729	2,604	3,609	4,574	741	651	401	241	2,470	3,255	4,010	4,815
7. San Jose	16,408	20,014	23,693	27,214	11,485	18,013	21,323	25,853	138	149	155	162	1,585	2,684	3,305	4,188	679	298	367	220	2,264	2,982	3,672	4,409
8. San Isidro	19,376	23,651	28,016	32,192	9,688	17,740	24,514	32,192	138	149	155	162	1,337	2,643	3,800	5,215	1,337	881	543	0	2,674	3,524	4,342	5,215
9. San Luis	3,955	4,856	5,777	6,656	0	3,399	5,199	6,323	138	149	155	162	0	506	806	1,024	546	217	90	54	546	724	895	1,078
SUB-TOTAL	103,335	126,161	149,451	171,740	65,460	109,516	145,596	182,603	138	149	155	162	9,171	16,318	22,567	29,582	5,261	2,717	1,401	515	14,432	19,035	23,968	30,097
10. Taytay	0	0	0	0	4,591	5,259	6,134	6,989	180	187	193	200	826	983	1,184	1,398	0	0	0	0	826	983	1,184	1,398
11. Angono	2,225	2,805	3,470	4,189	0	1,082	1,735	4,189	141	160	181	205	0	173	314	859	314	260	314	0	314	433	628	859
12. Binangonan	833	958	1,155	1,334	0	0	0	1,334	141	160	181	205	0	0	0	273	117	153	209	0	117	153	209	273
13. Teresa	234	256	289	318	0	0	0	318	141	160	181	205	0	0	0	65	33	41	52	0	33	41	52	65
SUB-TOTAL	3,292	3,919	4,914	5,841	4,591	6,341	7,869	12,830	180	182	190	202	826	1,156	1,498	2,595	464	454	575	0	1,290	1,610	2,073	2,595
TOTAL	106,627	130,080	154,365	177,581	71,050	115,857	153,465	195,433	141	151	157	165	9,998	17,474	24,065	32,177	5,725	3,171	1,976	515	15,723	20,645	26,041	32,692

NOTE: Served population includes served population by the system outside of the basin.

TABLE 6.2.32 WATER DEMAND PROJECTION IN THE ANTIPOLO BASIN

BARANGAY/ MUNICIPALITY	1995					2000					2005					2010				
	DOM.	COM.	IND.	LOSS.	TOTAL	DOM.	COM.	IND.	LOSS.	TOTAL	DOM.	COM.	IND.	LOSS.	TOTAL	DOM.	COM.	IND.	LOSS.	TOTAL
1. Bagong Nayon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Santa Cruz	696	0	0	0	696	918	18	3	284	1,222	1,321	31	5	452	1,809	2,222	45	7	758	3,032
3. De La Paz	2,919	100	19	1,145	4,183	3,846	105	17	1,475	5,443	5,035	117	18	1,321	6,491	6,401	129	19	1,780	8,330
4. Beverly Hills	172	7	1	77	257	237	6	1	105	349	318	7	1	109	436	410	8	1	140	560
5. San Roque	2,892	221	13	101	3,027	3,549	237	14	691	4,491	4,374	253	16	1,001	5,644	5,546	263	17	1,344	7,169
6. Dalig	2,470	67	13	500	3,050	3,255	71	11	220	3,557	4,010	84	13	511	4,618	4,815	92	14	836	5,756
7. San Jose	2,264	62	2,818	711	5,855	2,982	73	2,818	1,187	7,060	3,672	77	2,819	1,131	7,699	4,409	84	2,819	1,428	8,741
8. San Isidro	2,674	506	10	599	3,789	3,524	526	11	1,169	5,230	4,342	543	14	1,301	6,199	5,215	559	15	1,779	7,568
9. San Luis	546	0	0	0	546	724	14	2	224	963	895	19	3	276	1,193	1,078	21	3	349	1,451
SUB-TOTAL	14,432	963	2,873	3,134	21,402	19,035	1,050	2,878	5,354	28,316	23,968	1,132	2,888	6,101	34,089	30,097	1,200	2,896	8,414	42,607
10. Taytay	826	32	6	371	1,235	983	27	4	435	1,449	1,184	28	4	405	1,621	1,398	28	4	477	1,907
11. Angono	314	0	45	0	359	433	5	46	77	560	628	7	46	97	779	859	17	48	101	1,024
12. Binangonan	117	0	0	0	117	153	0	0	0	153	209	0	0	0	209	273	6	1	93	373
13. Teresa	33	0	0	0	33	41	0	0	0	41	52	0	0	0	52	65	1	0	22	89
SUB-TOTAL	1,290	32	51	371	1,744	1,610	32	50	511	2,203	2,073	35	51	502	2,661	2,595	52	53	693	3,393
TOTAL	15,723	995	2,925	3,505	23,147	20,645	1,081	2,928	5,865	30,520	26,041	1,167	2,939	6,603	36,749	32,692	1,252	2,949	9,107	46,000

NOTE: Served population includes served population by the system outside of the basin.

TABLE 6.2.33 WATER DEMAND PROJECTION IN THE MWSS SERVICE AREA

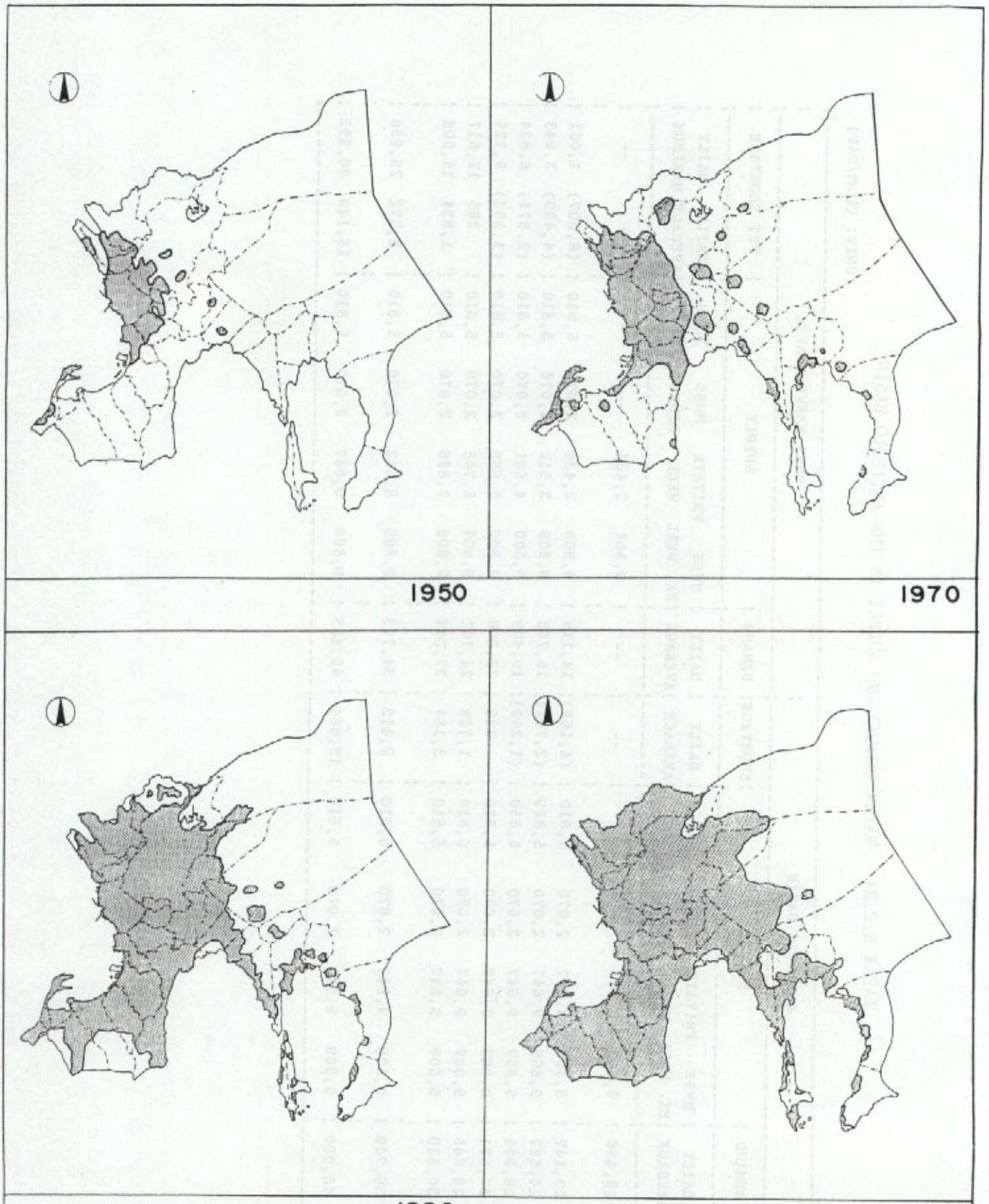
BARANGAY/ MUNICIPALITY	1995					2000					2005					2010				
	DOM.	COM.	IND.	LOSS.	TOTAL	DOM.	COM.	IND.	LOSS.	TOTAL	DOM.	COM.	IND.	LOSS.	TOTAL	DOM.	COM.	IND.	LOSS.	TOTAL
1. Bagong Nayon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Santa Cruz	0	0	0	0	0	643	18	3	284	947	1,321	31	5	452	1,809	2,222	45	7	758	3,032
3. De La Paz	2,554	100	19	1,145	3,818	3,846	105	17	1,475	5,443	5,035	117	18	1,321	6,491	6,401	129	19	1,780	8,330
4. Beverly Hills	172	7	1	77	257	237	6	1	105	349	318	7	1	109	436	410	8	1	140	560
5. San Roque	1,795	221	13	101	2,130	3,155	237	14	691	4,097	4,374	253	16	1,001	5,644	5,546	263	17	1,344	7,169
6. Dalig	1,729	67	13	500	2,309	2,604	71	11	220	2,906	3,609	84	13	511	4,217	4,574	92	14	836	5,516
7. San Jose	1,585	62	11	711	2,369	2,684	73	2,818	1,187	6,762	3,305	77	2,819	1,131	7,332	4,188	84	2,819	1,428	8,520
8. San Isidro	1,337	52	10	599	1,998	2,643	526	11	1,169	4,349	3,800	543	14	1,301	5,657	5,215	559	16	1,779	7,568
9. San Luis	0	0	0	0	0	506	14	2	224	746	806	19	3	276	1,103	1,024	21	3	349	1,397
SUB-TOTAL	9,171	509	66	3,134	12,881	16,318	1,050	2,878	5,354	25,599	22,567	1,132	2,888	6,101	32,688	29,582	1,200	2,896	8,414	42,092
10. Taytay	826	32	6	371	1,235	983	27	4	435	1,449	1,184	28	4	405	1,621	1,398	28	4	477	1,907
11. Angono	0	0	0	0	0	173	5	46	77	300	314	7	46	97	464	859	17	48	101	1,024
12. Binangonan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	273	6	1	93	373
13. Teresa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	1	0	22	89
SUB-TOTAL	826	32	6	371	1,235	1,156	32	50	511	1,750	1,498	35	51	502	2,085	2,595	52	53	693	3,393
TOTAL	9,998	541	72	3,505	14,116	17,474	1,081	2,928	5,865	27,349	24,065	1,167	2,939	6,603	34,773	32,177	1,252	2,949	9,107	45,485
SERVICE RATIO (%)	64	39	2	100	61	85	100	100	100	90	92	100	100	100	95	98	100	100	100	99

NOTE: Served population includes served population by the system outside of the basin.

TABLE 6.2.34 WATER DEMAND AND SUPPLY IN THE ANTIPOLO BASIN

(UNIT: CU.M/DAY)

	ANTIPOLO BASIN						MWSS SERVICE AREA						
	DEMAND	SUPPLY				SHORTAGE	DEMAND	SUPPLY				NET SHORTAGE	
YEAR	DAILY AVERAGE	MWSS EX. WELL	PRIVATE WELL	MWSS REHAB.	MWSS AUGMENT.	DAILY AVERAGE	DAILY AVERAGE	MWSS EX. WELL	PRIVATE WELL	MWSS REHAB.	MWSS AUGMENT.	DAILY AVERAGE	DAILY MAXIMUM
1990	19,456	9,809	9,647	--	--	--	--	9,809	2,434	--	--	--	--
1995	23,147	9,809	9,647	2,070	5,810	(4,189)	14,116	9,809	2,434	2,070	5,810	(6,007)	1,051
1996	24,622	9,809	9,647	2,070	5,810	(2,714)	16,763	9,809	3,512	2,070	5,810	(4,439)	3,943
1997	26,096	9,809	9,647	2,070	5,810	(1,240)	19,409	9,809	4,591	2,070	5,810	(2,871)	6,834
1998	27,571	9,809	9,647	2,070	5,810	235	22,056	9,809	5,669	2,070	5,810	(1,303)	9,725
1999	29,045	9,809	9,647	2,070	5,810	1,709	24,702	9,809	6,748	2,070	5,810	265	12,617
2000	30,520	9,809	9,647	2,070	5,810	3,184	27,349	9,809	7,826	2,070	5,810	1,834	15,508
2005	36,749	9,809	9,647	2,070	5,810	9,413	34,773	9,809	8,512	2,070	5,810	8,572	25,958
2010	46,000	9,809	9,647	2,070	5,810	18,664	45,485	9,809	9,647	2,070	5,810	18,149	40,892



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 6.1.1

GROWTH OF THE STUDY AREA

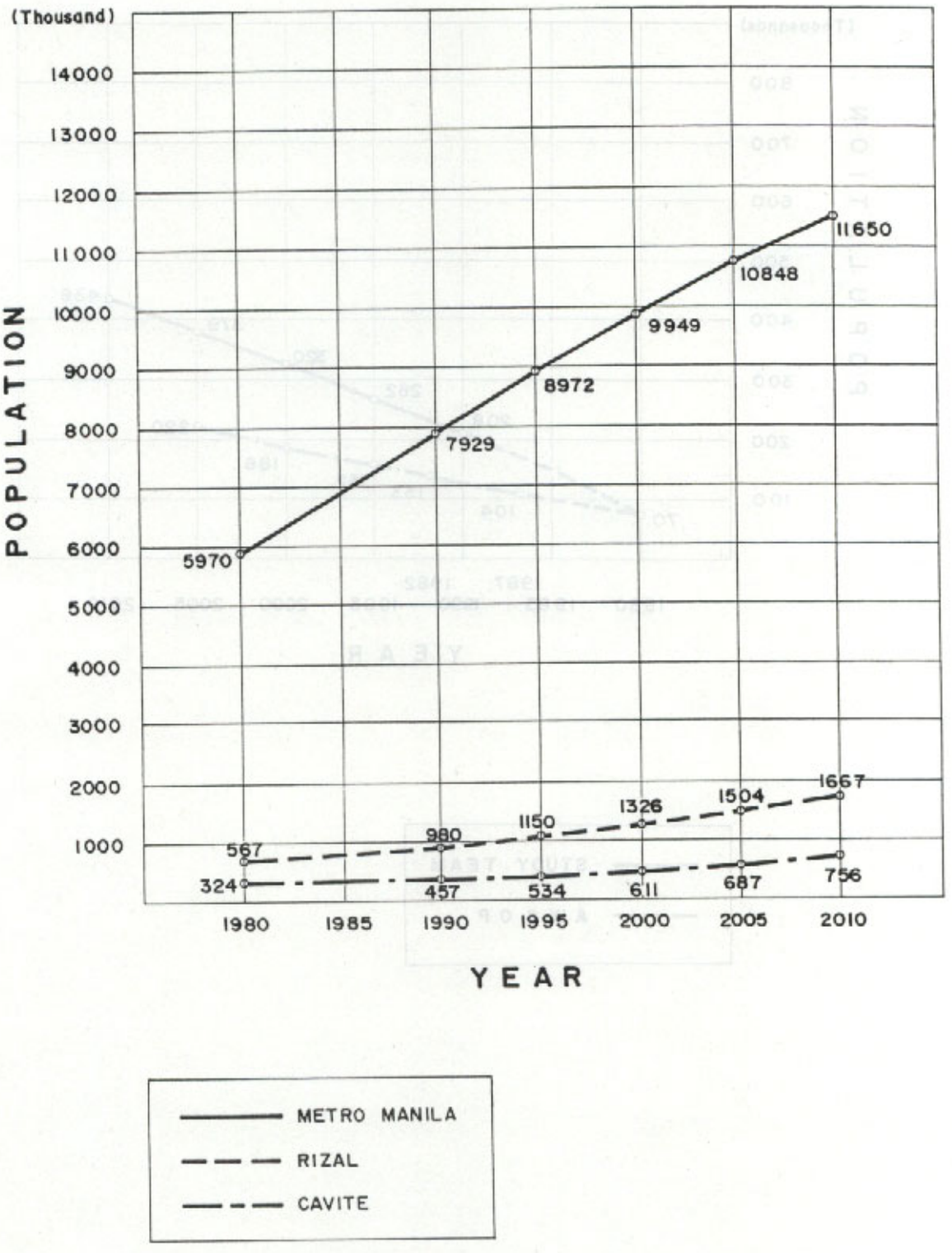


FIGURE 6.1.2

ESTIMATED POPULATION GROWTH OF THE STUDY AREA

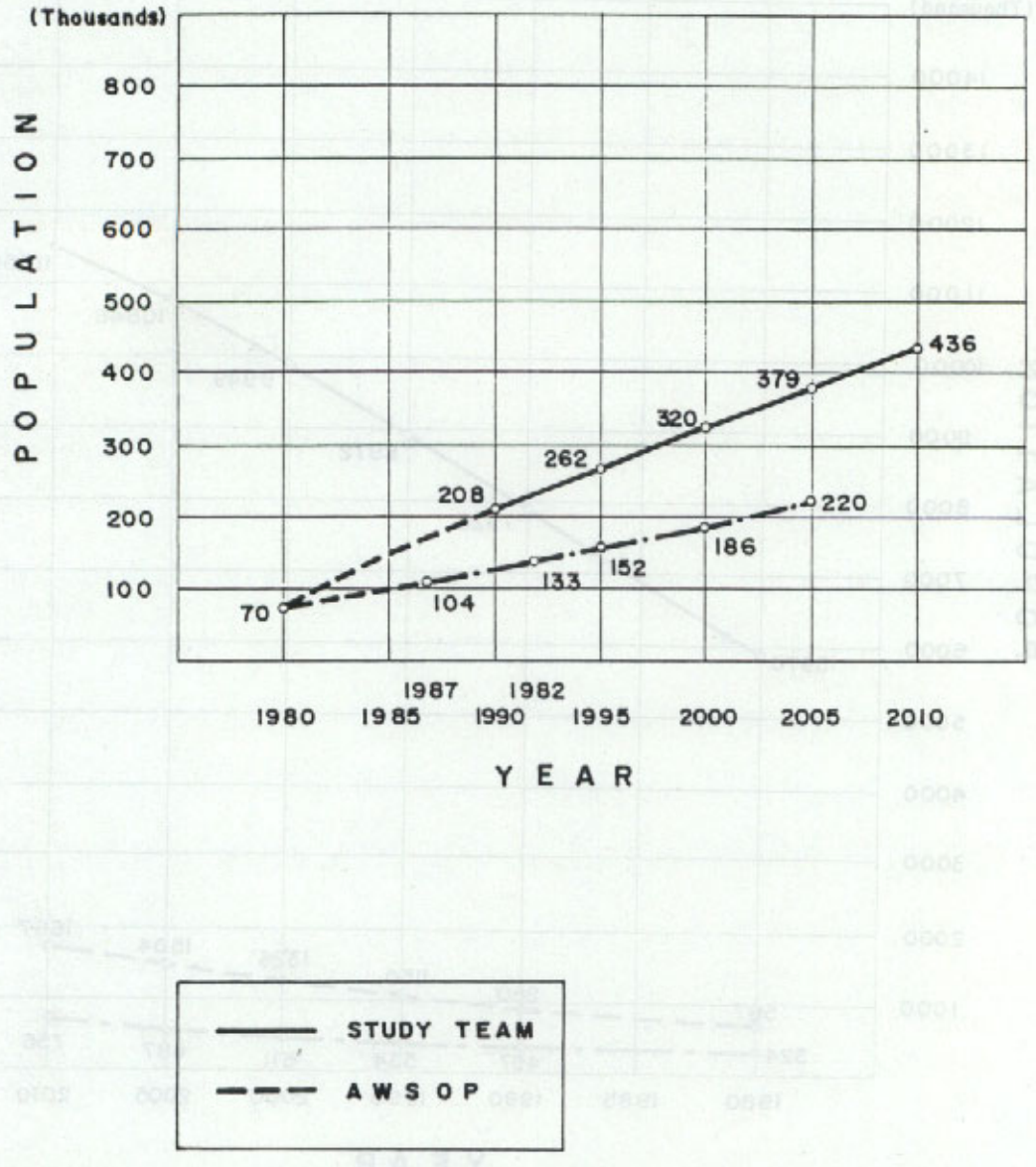
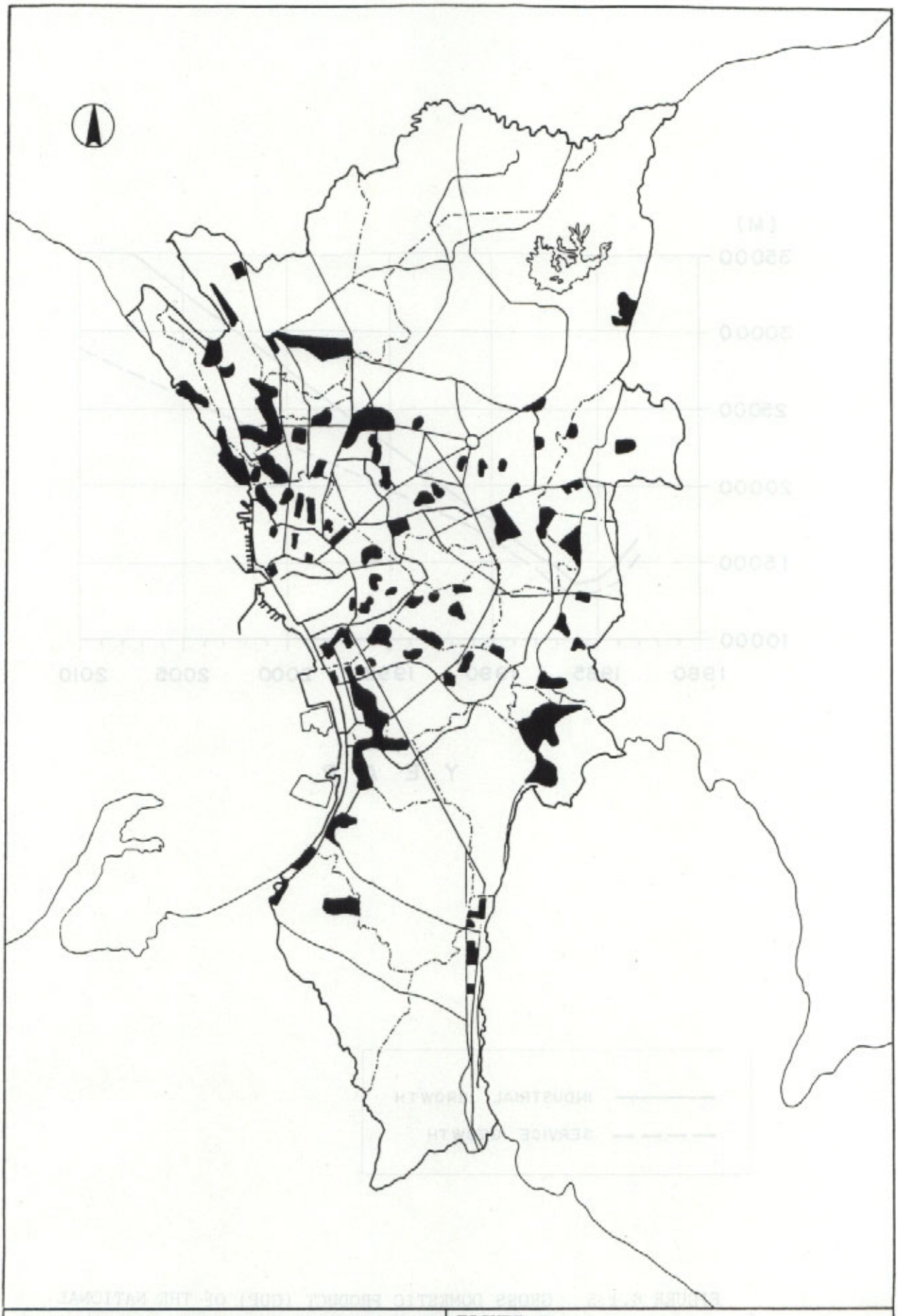


FIGURE 6.1.3 COMPARISON BETWEEN AWSOP'S AND THE JICA TEAM'S POPULATION PROJECTION FOR THE MUNICIPALITY OF ANTIPOLO



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 6.1.4
JAPAN INTERNATIONAL COOPERATION AGENCY	BLIGHTED AREAS IN THE NCR

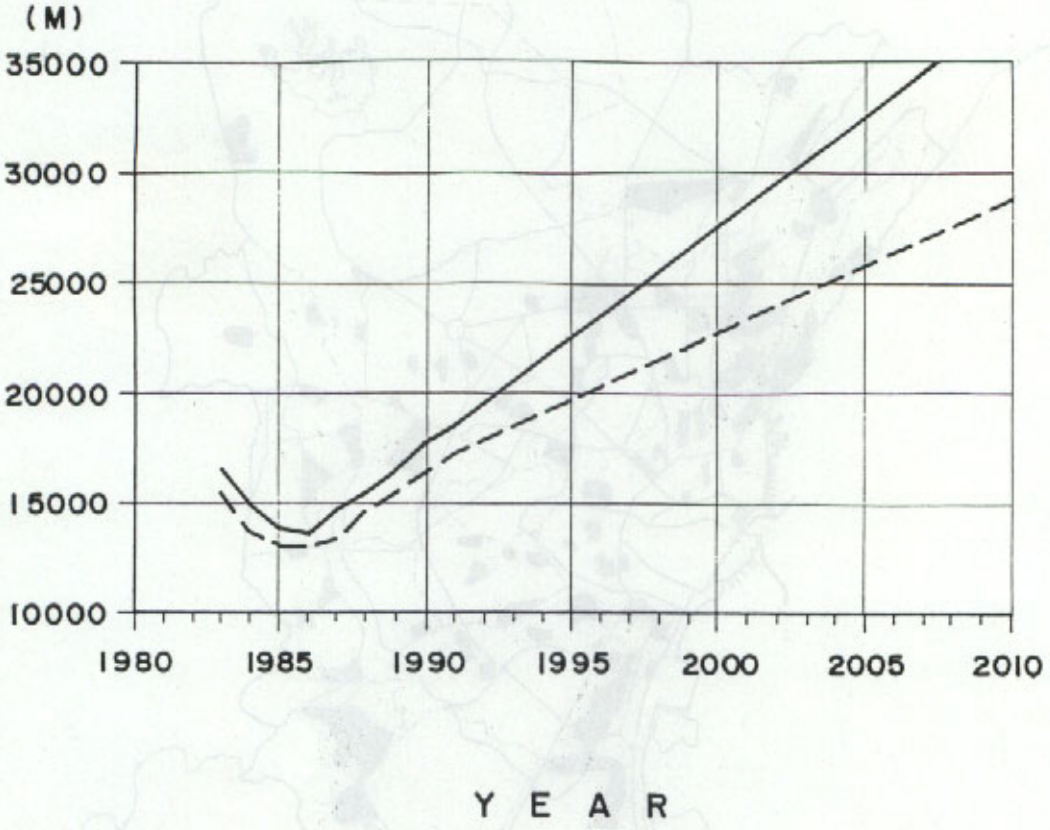
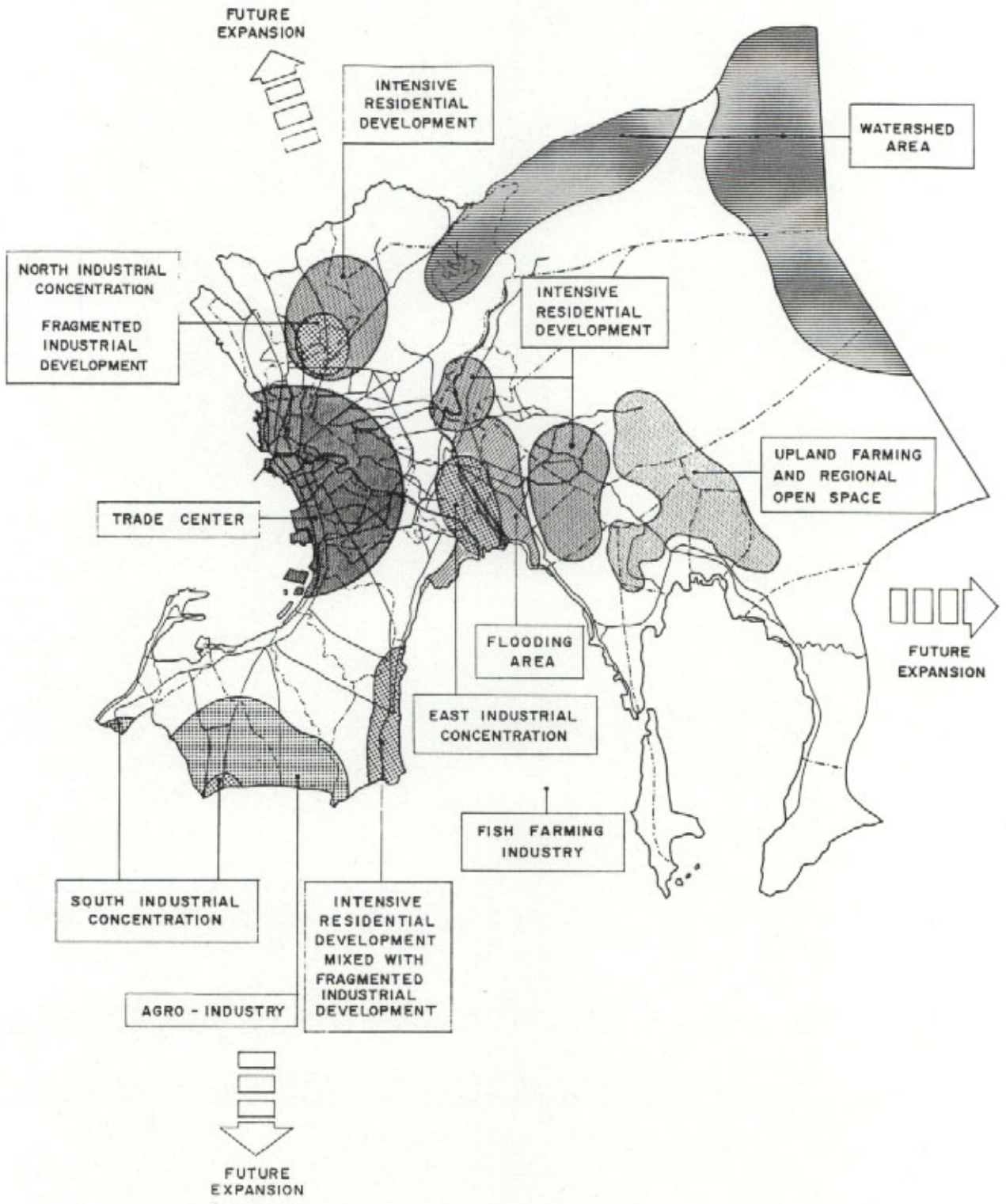
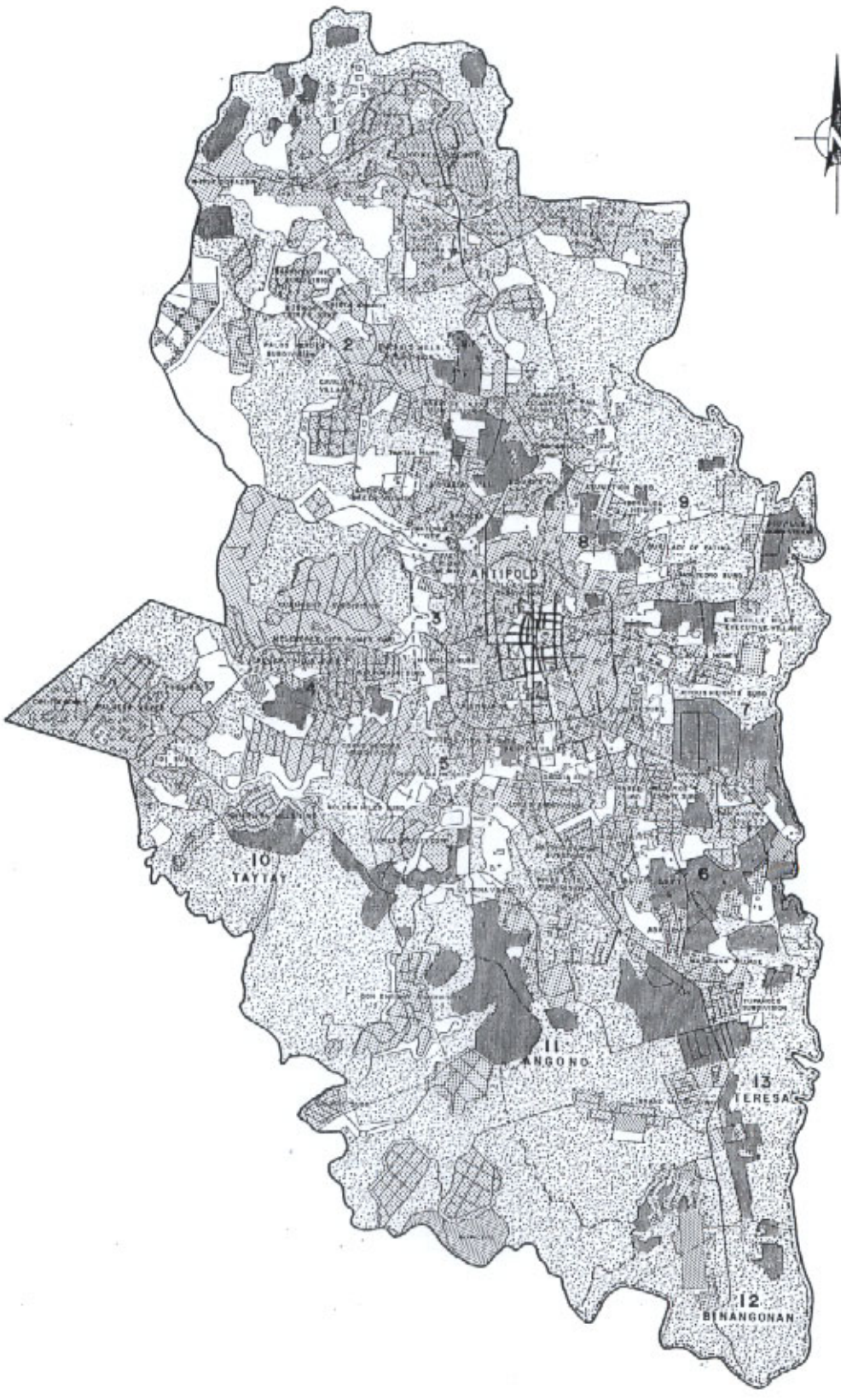


FIGURE 6.1.5 GROSS DOMESTIC PRODUCT (GDP) OF THE NATIONAL CAPITAL REGION



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 6.1.6
JAPAN INTERNATIONAL COOPERATION AGENCY	STRUCTURE PLAN



BARANGAY / MUNICIPALITY

1. Bagong Nayon
2. Sta. Cruz
3. De la Paz
4. Beverly Hills
5. San Roque
6. Dalig
7. San Jose
8. San Isidro
9. San Luis
10. Taytay
11. Angono
12. Binangonan
13. Teresa

STUDY AREA
AQUIFER BASIN ZONE
MUNICIPALITY BOUNDARY
BARANGAY BOUNDARY

LEGEND

BUILT-UP AREA
COMMERCIAL AREA
INDUSTRIAL AREA
AGRICULTURAL LAND
FOREST GRASS LAND
OPEN SPACE
OTHERS

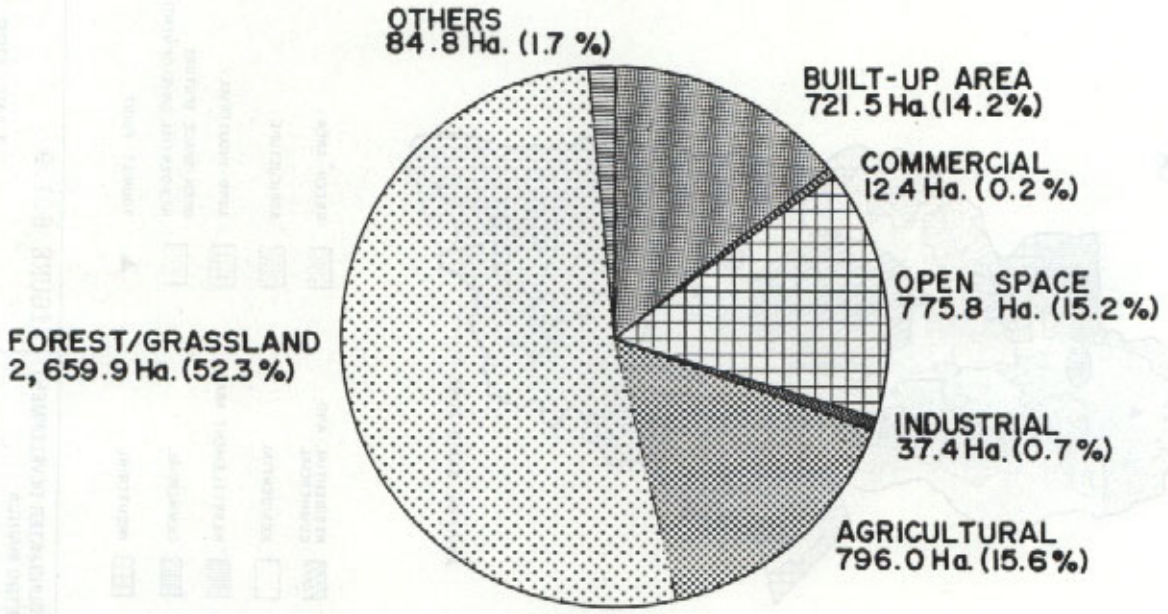
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

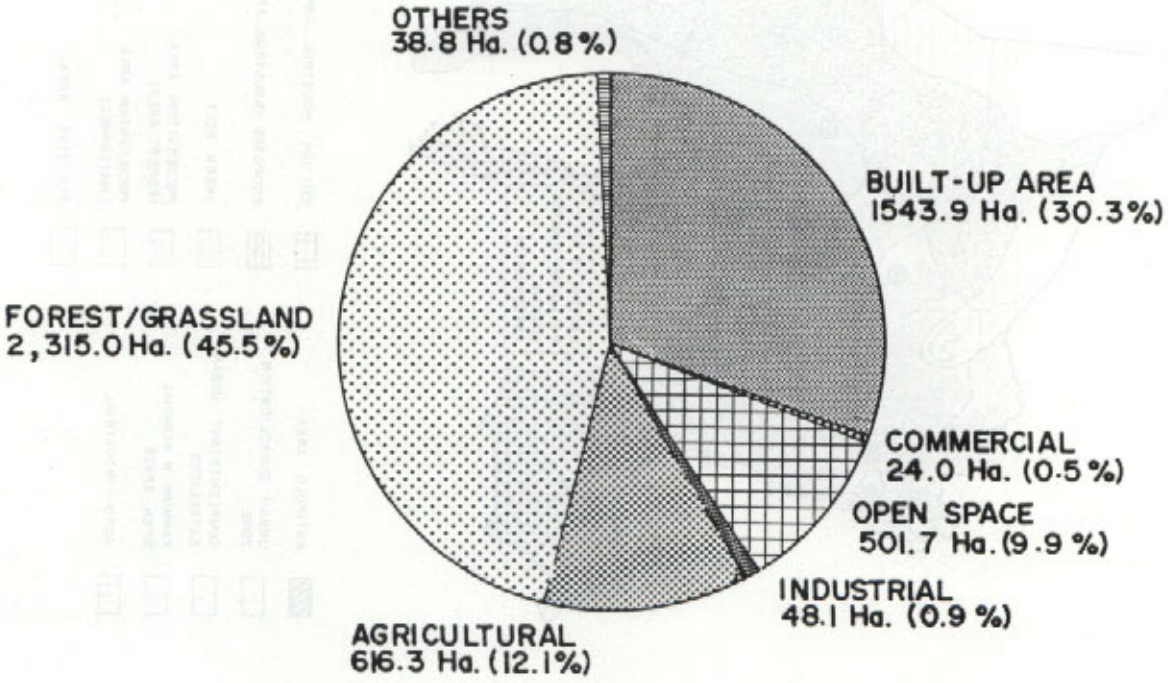
FIGURE 6.1.77

FUTURE LAND USE MAP, ANTIPOLO AREA: 2010

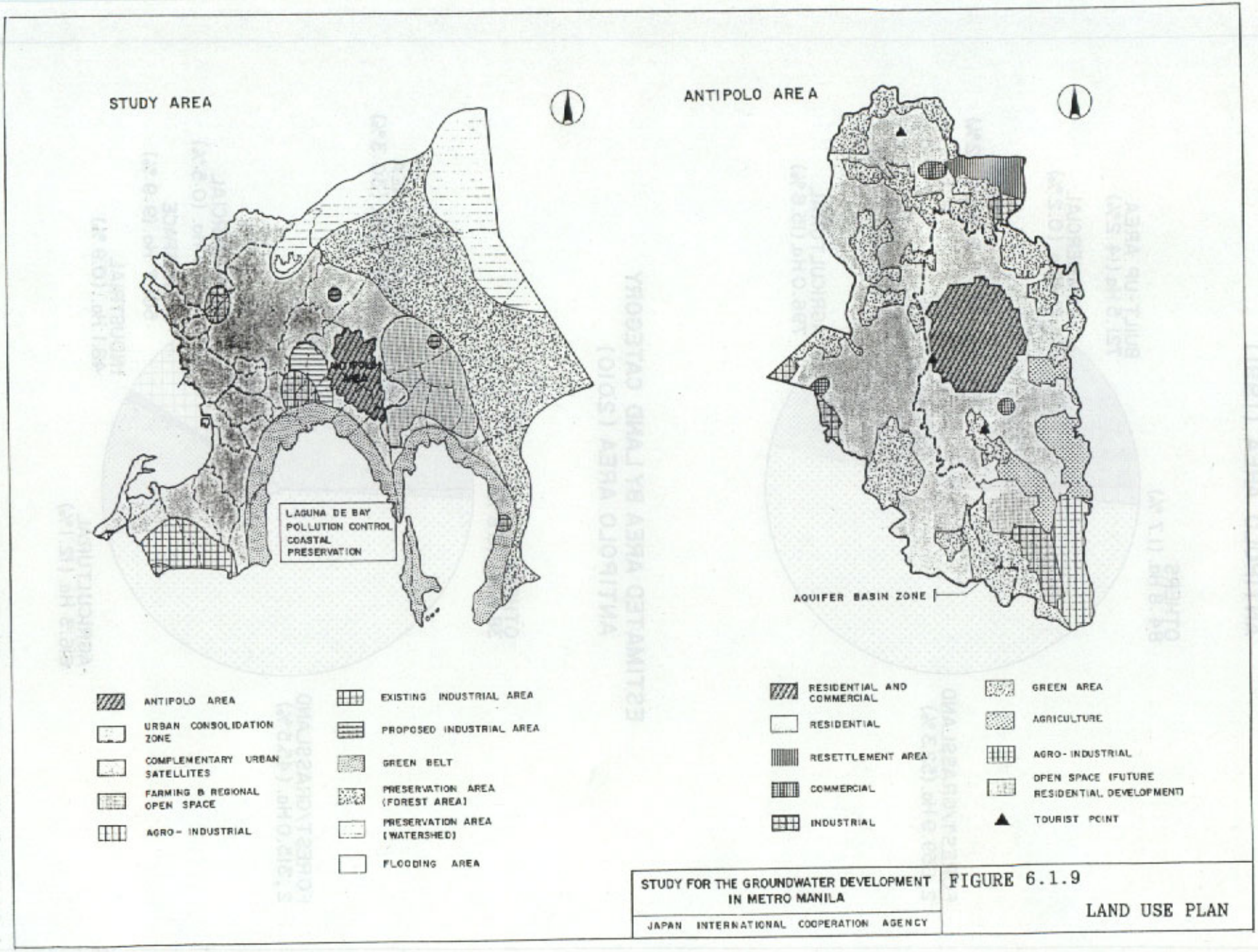
ESTIMATED AREA BY LAND CATEGORY
ANTIPOLO AREA (1991)



ESTIMATED AREA BY LAND CATEGORY
ANTIPOLO AREA (2010)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 6.1.8
JAPAN INTERNATIONAL COOPERATION AGENCY	LAND AREA COMPARISON, 1991-2010



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 6.1.9

LAND USE PLAN

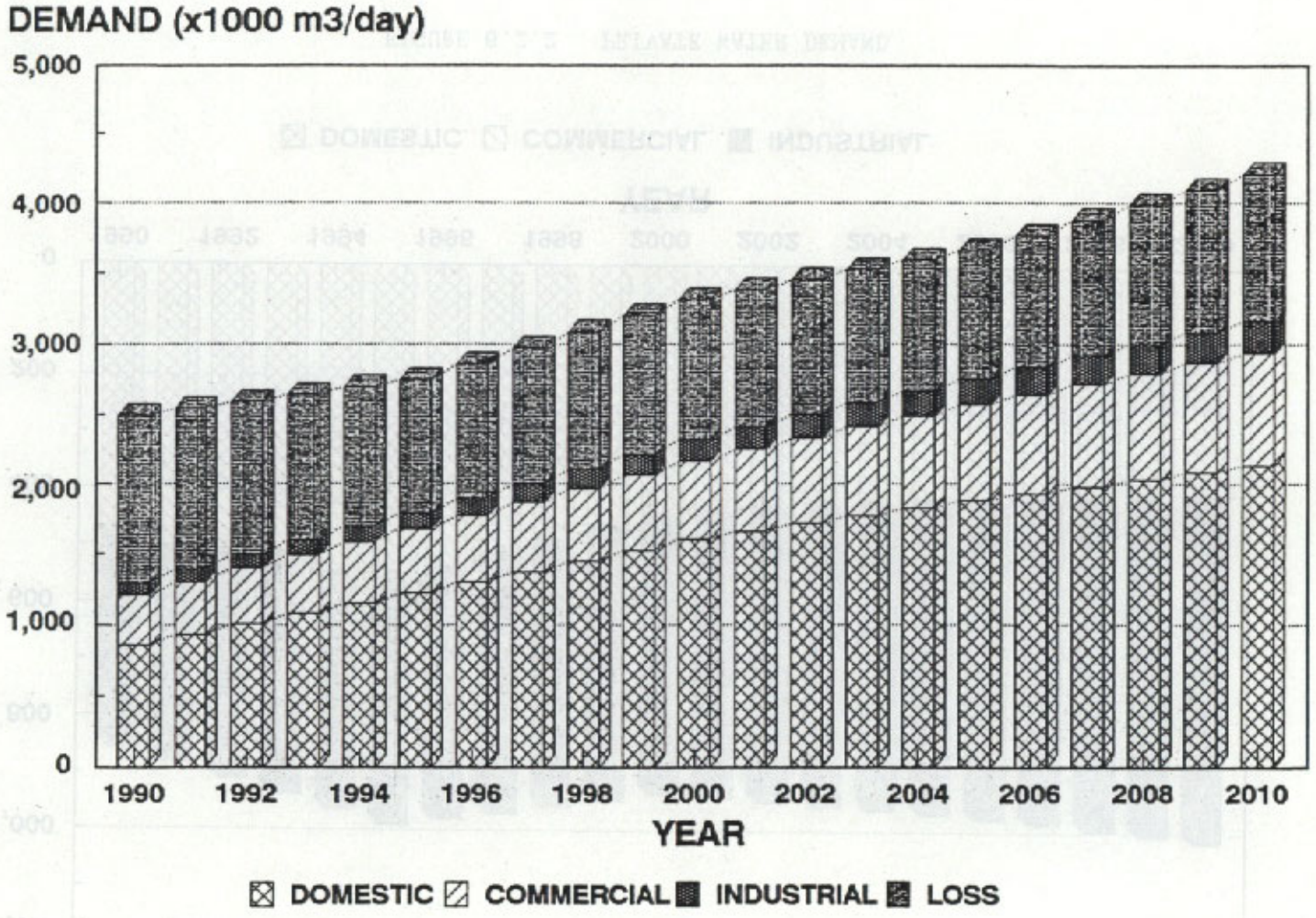


FIGURE 6.2.1 MWSS WATER DEMAND

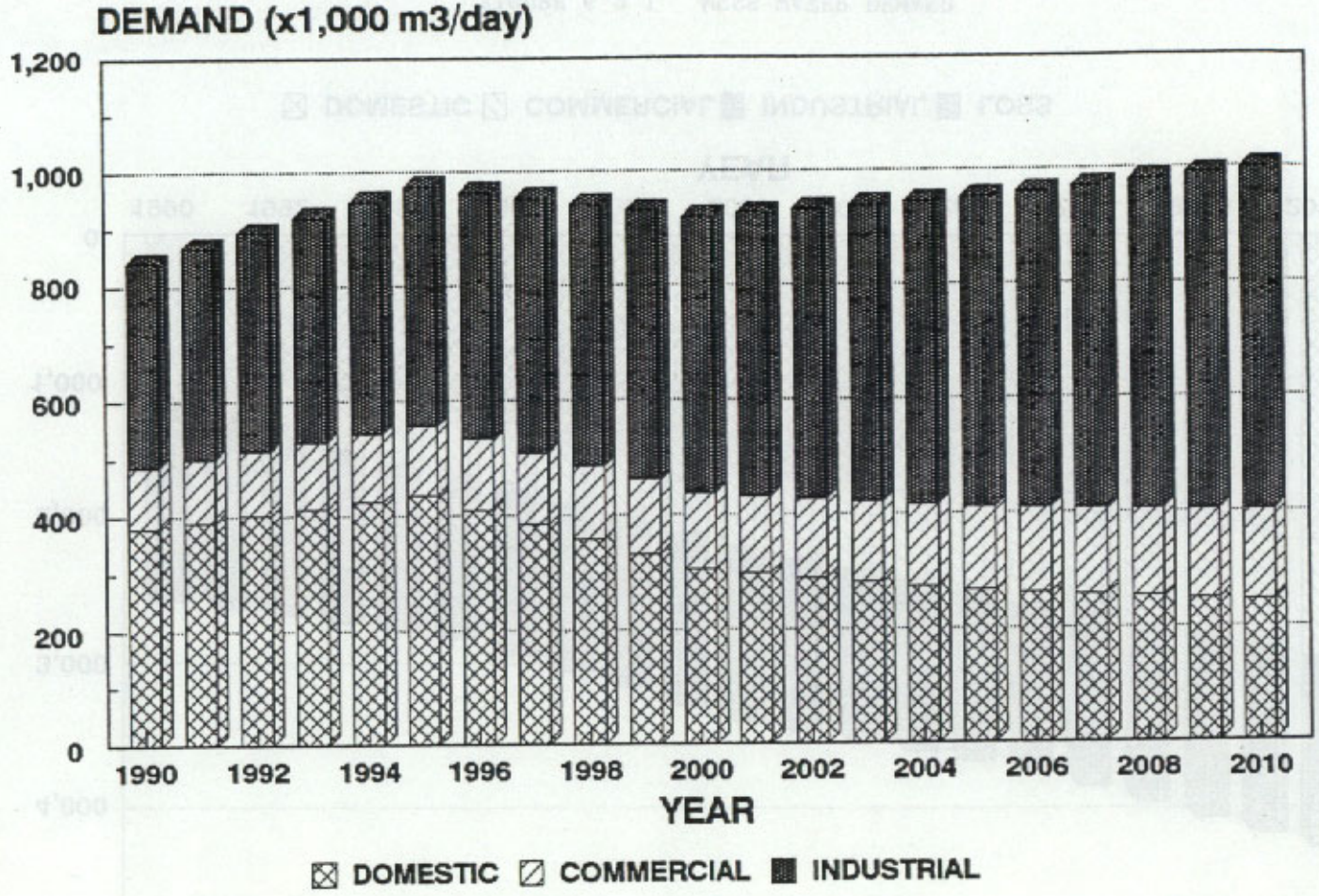


FIGURE 6.2.2 PRIVATE WATER DEMAND

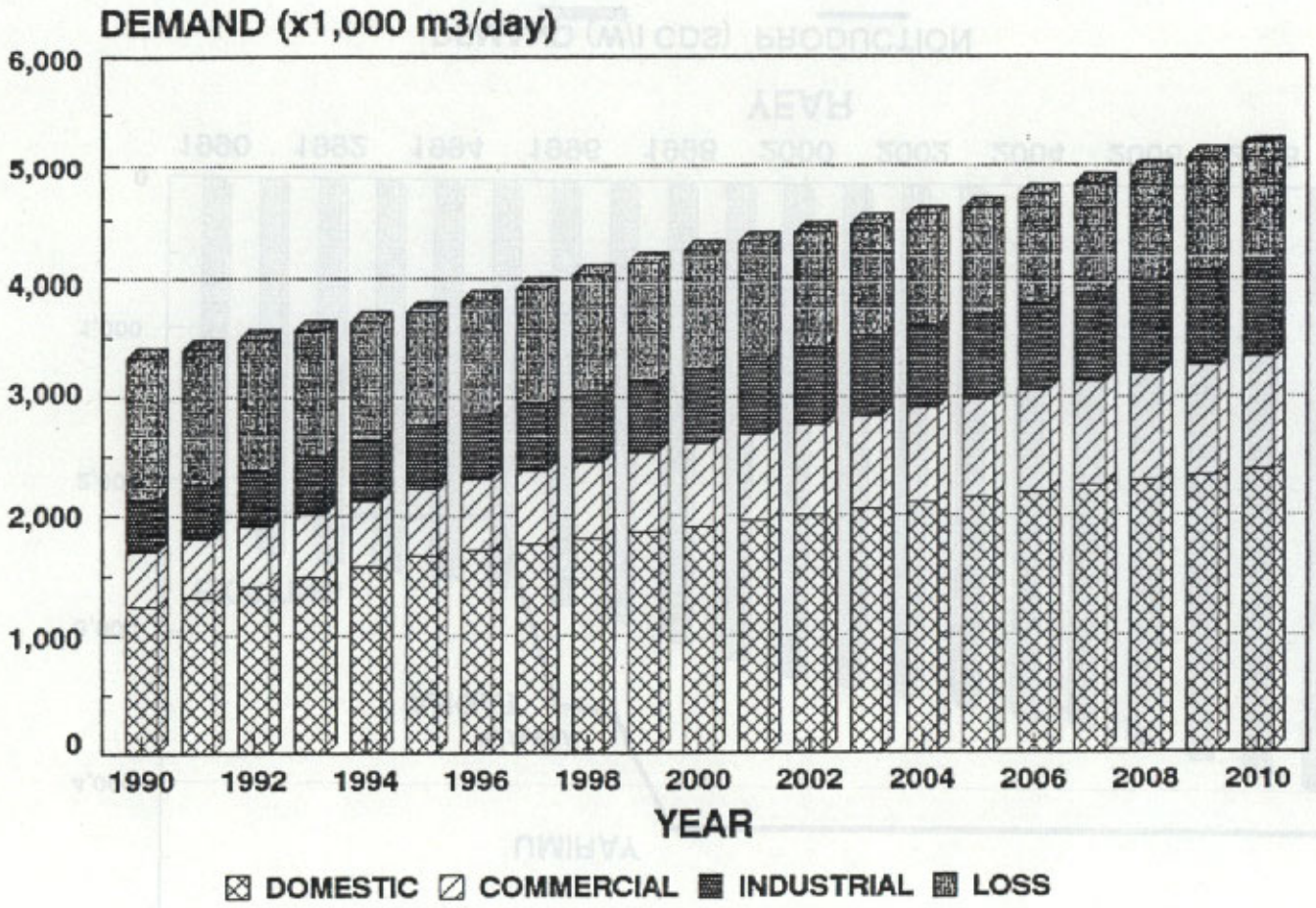


FIGURE 6.2.3 TOTAL WATER DEMAND (MWSS+PRIVATE)

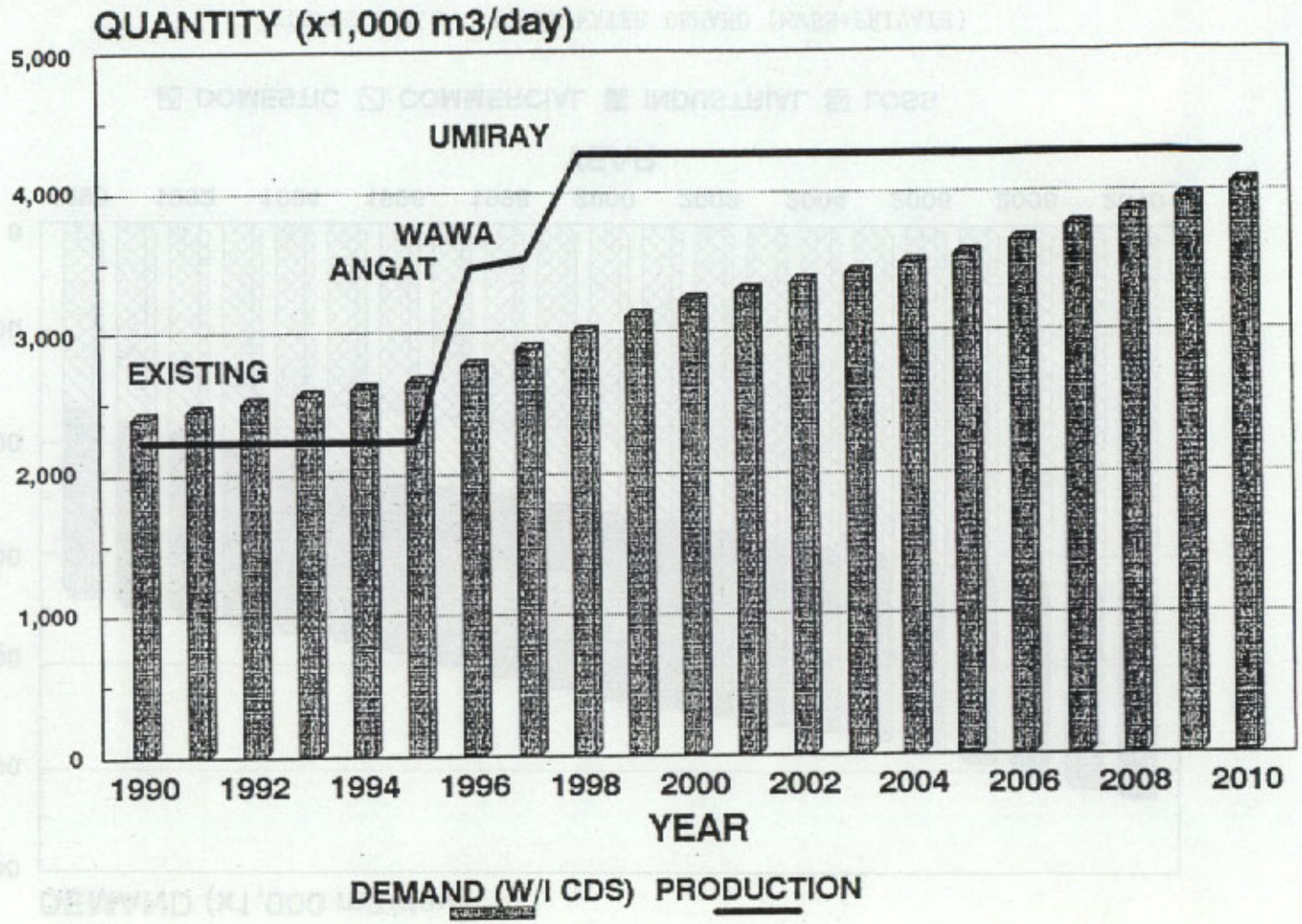
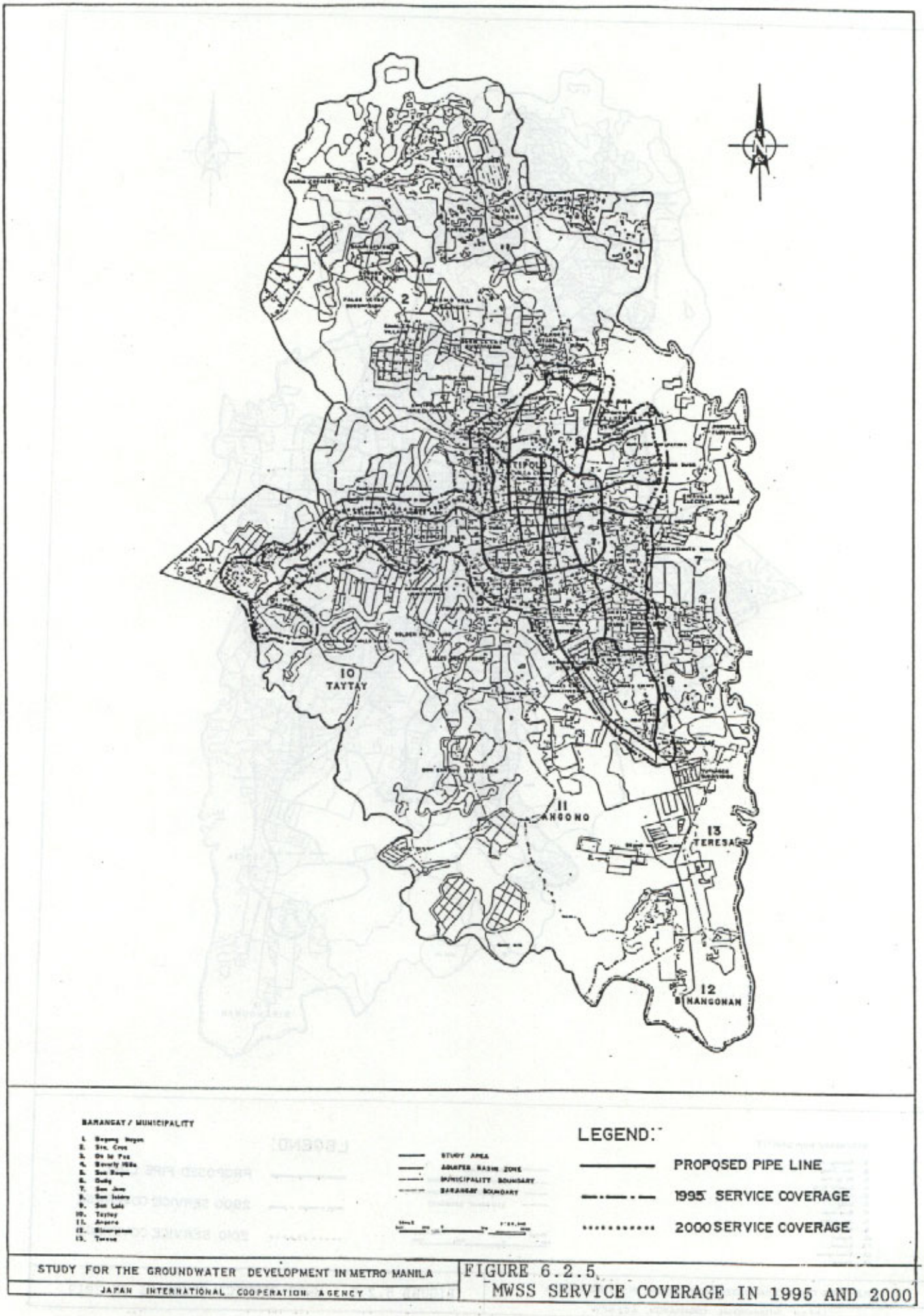


FIGURE 6.2.4 DEMAND VS. SUPPLY CAPACITY (WITHIN CDS)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

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FIGURE 6.2.5
MWSS SERVICE COVERAGE IN 1995 AND 2000

BARANGAY / MUNICIPALITY

1. Bagong Nayon
2. Sta. Cruz
3. Dela Paz
4. Beverly Hills
5. San Roque
6. Dalig
7. San Jose
8. San Isidro
9. San Luis
10. Taytay
11. Angono
12. Binangonan
13. Teresa

STUDY AREA
AQUIFER BASIN ZONE
MUNICIPALITY BOUNDARY
BARANGAY BOUNDARY

SCALE 1:50,000

LEGEND:

PROPOSED PIPE LINE
2000 SERVICE COVERAGE
2010 SERVICE COVERAGE

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FIGURE 6.2.6 MWSS SERVICE COVERAGE IN 2010

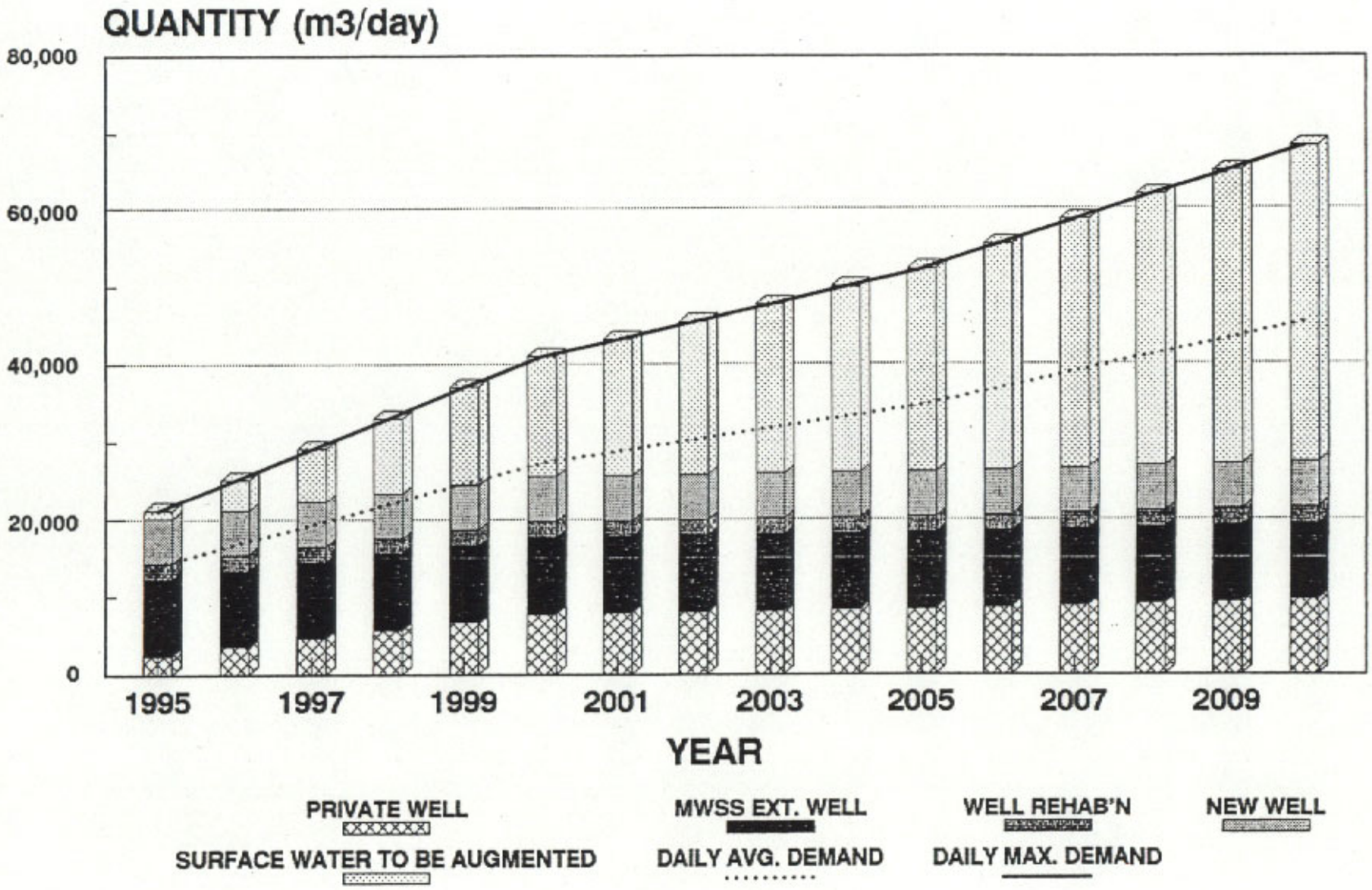

FIGURE 6.2.7 DEMAND VS. SUPPLY CAPACITY
(WITHIN MWSS SERVICE AREA IN ANTIPOLO)

CHAPTER 7

EVALUATION OF GROUNDWATER RESOURCES

CHAPTER 7 EVALUATION OF GROUNDWATER RESOURCES

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CHAPTER 7 EVALUATION OF WATER RESOURCES

7.1 GROUNDWATER MODELING

7.1.1 Groundwater Flow Model

The computer model used for the study is a quasi three-dimensional groundwater flow model (Q3P model). Its basic concept is that the groundwater in the main confined aquifer is supplied by lateral flow through the aquifer and by vertical flow through the aquitard from the overlying phreatic aquifer (Figure 7.1.1.).

Q3P solves the groundwater flow equation using a finite-element approximation. The model is based on a rectangular finite-element grid. The model is applicable to two-dimensional or three-dimensional problems even in multi-aquifer systems involving steady-state or nonsteady-state flow.

The model computes changes in piezometric heads over time caused by changes in groundwater pumpage and groundwater recharge. If future plans of groundwater pumpage are inputted to the model, it can calculate future piezometric heads.

The required input data for the model are as follows:

for model framework

Element data
Node data
Boundary conditions
Model control card

for hydrogeologic settings

Transmissivity
Storage coefficient
Aquitard thickness
Aquitard permeability

Phreatic water level
Initial piezometric heads
Direct recharge data

for groundwater use

Discharge data

The output data from the model are:

Piezometric heads distribution at each time-step
Changes of piezometric heads at specified nodes
Water balance components in specified area

The model assumes that hydrogeologic parameters such as transmissivity, storage coefficient and leakance are not affected by changes in piezometric heads. Also, the model needs to assume that those parameters and boundary conditions do not change over time. The phreatic water levels are assumed to be constant over time.

The model must be calibrated before starting actual calculations. The main procedure of model calibration involves specifying the boundary conditions and the identification of some poorly reliable hydrogeologic parameters. Generally the model is verified by the comparison of calculated piezometric heads with actual piezometric heads. Figure 7.1.2. shows the general flow of model calibration.

After all parameters and boundary conditions are fixed, the model can compute future piezometric heads based on future groundwater pumpage plans and future recharge estimates.

The groundwater flow model was applied to the Antipolo groundwater basin and the Metro Manila groundwater basin (Figure 7.1.3).

7.1.2 Solute Transport Model

The two-dimensional solute transport and dispersion model (MOC model) used in the study was originally devised by L. F. Konikow and J. D. Bredehoeft in 1978.

MOC is a two-dimensional model for the simulation of non-conservative solute transport in saturated groundwater systems. It computes changes in the spatial concentration distribution over time that are caused by convective transport, hydrodynamic dispersion, mixing or dilution from recharge, and chemical reactions.

The chemical reactions include first-order irreversible rate reaction (such as radioactive decay), reversible equilibrium-controlled absorption with linear, Fruendlich or Langmuir isotherms, and reversible equilibrium-controlled ion exchange for monovalent or divalent ions.

The model assumes that fluid density variations, viscosity changes and temperature gradients do not affect the velocity distribution. MOC does allow modeling heterogeneous and/or anisotropic aquifers.

The calculation procedure of MOC model is shown in Figure 7.1.4. MOC couples the groundwater flow equation with the non-conservative solute transport equation. The computer program uses ADI or SIP procedure to solve the finite-difference approximation of the groundwater flow equation. The SIP procedure for solving the groundwater equation is most useful when areal discontinuities in transmissivity exists or when the ADI solution does not converge.

MOC uses the method of characteristics to solve the solute transport equation. It uses a particle tracking method to represent convective transport and a two-step explicit procedure to solve the finite-difference equation describing the effects of hydrodynamic dispersion, fluid sources or sinks, and divergence of velocity.

The explicit procedure is subject to stability criteria, but the program automatically determines and implements the time-step limitations necessary to satisfy the stability criteria.

MOC uses a rectangular, block-centered, finite-difference grid for flow and transport calculations. The grid size for flow calculations is limited to 40 rows and 40 columns. The grid size for transport calculations is limited to 20 rows and 20 columns which can be assigned to any area of the flow grid.

The program allows for spatially varying diffuse recharge or discharge, saturated thickness, transmissivity, boundary conditions, initial heads and initial concentrations and unlimited number of injection or withdrawal wells.

The required input data for the model are as follows:

for model framework

Node data
Model control card
Transport calculation control card

for hydrogeologic settings

Transmissivity (Txx and Tyy)
Storage coefficient
Aquifer thickness
Leakance
Initial heads
Recharge data
Discharge data

for transport calculation

Maximum number of particles
Initial number of particles per node
Bulk density of the solid
Langmuir adsorption coefficient
Maximum adsorption capacity
Half-life of the solute
Reaction specifier
Effective porosity
Longitudinal and transverse dispersivity
Source concentration
Initial concentration

The output data from the model are:

Summarized input data table

Heads distribution in each time step
Changes of heads and concentrations at specified nodes
Water balance components in modeled area
Concentration distribution in each time-step
Chemical mass balance
Computed velocities
Computed dispersivity

The model must be calibrated before starting actual calculations. The main procedure of model calibration involves specifying boundary conditions and the identification of some poorly reliable hydrogeologic parameters and physical/chemical parameters. Generally the model should first be verified by the comparison of calculated heads with actual heads. After fixing hydrogeologic parameters and boundary conditions, the identification for solute transport calculation of parameters, boundary conditions and initial conditions will be by comparison of their actual distribution of concentration.

After all parameters and boundary conditions are fixed, the model can then compute future heads and future concentrations based on future groundwater pumpage plans and future recharge estimates.

The solute transport model was applied to the Las Piñas area to reveal the mechanism of saltwater intrusion (Figure 7.1.3).

7.2 ANTIPOLO GROUNDWATER BASIN

7.2.1 Model Parameters and Boundary Conditions

The quasi three-dimensional groundwater model was applied to the aquifer system in Antipolo plateau, eastern part of Metro Manila (see Figure 7.1.3). The Antipolo plateau forms an independent groundwater basin at the place where the Guadalupe Formation overlies the altered spilitic basalt of the Kinabuan Formation.

Member III of the Guadalupe Formation (Gs) forms fairly good aquifers. Groundwater in the uppermost weathered beds is in the phreatic condition. Groundwater in lower part of the member III is confined and forms

a main aquifer in Antipolo plateau. Member IV (Gmd) forms an aquitard or aquifuge. The altered basaltic rocks form a hydrogeologic basement of the Antipolo groundwater basin.

The quasi three-dimensional model was used to examine the dynamic groundwater flow in the basin and the effect of groundwater development. Various hydrogeologic data and parameters required for the model had been previously prepared.

A number of simplifications had been made in the representation of the hydrogeologic system in order to analyze the dynamic behavior of groundwater flow. The confined aquifer (Gs) was modeled as a main confined aquifer which is hydraulically connected to the overlying phreatic aquifer through confining layer.

The finite-element grid used in the model is shown in Figure 7.2.1. The model domain has an area of 24.56 km^2 which was divided into 393 rectangular elements of 250m x 250m. The number of elements in the x and y coordinates are 34 and 16, respectively. The number of nodes in the domain at which the heads are computed is 448.

(1) Boundary Conditions

Two different boundary conditions were specified based on the hydrogeologic interpretations (Figure 7.2.2). The outlets of major valleys were modeled as constant-head boundaries. Also assigned as a constant-head boundary is the southern perimeter of the modeled area where the aquifer in the plateau may extend south towards Laguna de Bay. The head values of constant-head boundaries were drawn from the initial heads estimation.

The rest of the nodes along the modeled perimeter were modeled as no-flow boundaries.

(2) Model Parameters

Input parameters used in the model were those collected/measured by the Study Team during stages I to III. After data processing was completed, input data for the Q3P model were prepared. These parameters were input-

ted to the model, and then modified and identified through model calibration. The period of model calibration is ten (10) years, from 1981 to 1990.

Model parameters used in the model are as follows:

(a) Transmissivity

Because of inadequate pumping test data in the modeled area, the initial transmissivity value was modeled uniformly as 100m²/d. Throughout the steady-state calibration of the model, transmissivity values from a minimum of 10 m²/d to a maximum of 2,000m²/d were identified. High transmissivity values had to be assigned to the elements along the constant-head boundaries, rivers, and around the center part of the basin. On the other hand, low transmissivity values had to be assigned to the area where the basement rocks are exposed and/or where the topographic levels are higher.

(b) Storage coefficient

The values of storage coefficient were initially and uniformly assigned as $1x10^{-3}$ because of the lack of actual data. During the nonsteady-state calculation, the values were modified by comparison of model results with field observations of piezometric heads.

Further, the Q3P model was arranged to simulate changes of piezometric heads in 1990 using estimated three-day recharge and discharge data for the identification of storage coefficient. Throughout the 120-step simulation, done with checking of range of piezometric heads, the values of storage coefficient were finally identified as 0.1 to 0.05.

(c) Aquitard thickness and permeability

The thickness and permeability of aquitard control the leakage recharge to the confined aquifer. From a result of monitored piezometric heads, the recharge in the Antipolo basin is assumed to occur as the direct recharge. Therefore, the thickness of aquitard was uniformly modeled as 20m with its permeability as

0m/d.

(d) Phreatic water level and initial heads

The phreatic water level is an important leakage recharge parameter. The Antipolo basin model assumes the recharge to be only the direct recharge from precipitation so that dummy data were inputted to the model.

The initial piezometric heads were estimated from the steady-state simulation because no figures were available for the actual heads in 1981. For the steady-state simulation, the input initial heads were prepared based on geomorphological analyses. A river level map was made from topographic maps using the same grid to model the area. The initial heads were then assumed to be 10m below the river level.

After 30 steps (30 years) of steady-state calculation using the recharge and discharge data of 1981, the stabilized piezometric heads were noted. These were then used as the initial heads of 1981 for the nonsteady-state simulation.

(e) Direct recharge

The direct recharge was estimated from the water balance computation. The daily rainfall measured at the Boso-boso station and the Science Garden station plus the daily pan-evaporation measured at Science garden were used to estimate direct recharge. The pan-evaporation data were used to compute the actual soil evaporation and evapotranspiration. The soil characteristics viz. soil type, moisture holding capacity and thickness of soil zone, as well as vegetation characteristics were taken into account in determining the surplus water from the soil zone.

Figure 7.2.3 shows the annual rainfall and computed recharge at Boso-boso station from 1981 to 1990. The annual recharge values were inputted to the model. Figure 7.2.4 shows the water balance components in the Antipolo basin using Science Garden's data from 1962 to 1989.

7.2.2 Verification of the Model

Model verification is carried out to identify input parameters and assigned boundary conditions. This process is the most important and most complicated work in groundwater modeling because the areal quantification of various parameters, which play significant roles in the groundwater regime, should be done under actual hydrogeologic constraints. Thus, the verification of the model yields a better insight on dynamic groundwater behavior in the area as well as on the limitations of the model.

(1) Steady-state Simulation

The calibration of the model was initially carried out in steady-state conditions to identify the initial heads and transmissivity of the model. The simulated piezometric heads were observed at the selected points shown in Figure 7.2.5. Using constant, year-1981 pumping rate throughout the 30-year period (30 time-steps), computation of groundwater heads proceeded on a trial-and-error basis until it reached the point when the drops in head had become approximately zero (Figure 7.2.6).

Throughout the steady-state simulation, transmissivity and boundary conditions were modified. The piezometric heads obtained from the 30-year steady-state calculation were extrapolated and used as the initial groundwater heads in 1981 for nonsteady-state simulation (Figure 7.2.7). Figure 7.2.8 shows the difference between initial piezometric heads and elevations of the bottom of the aquifer. The initial piezometric heads are located at more than 100m above the bottom of aquifer around the central part of the basin.

(2) Nonsteady-state Simulation

The nonsteady-state simulation from 1981 to 1990 was carried out to simulate transient groundwater flow and decline of piezometric heads due to groundwater pumpage. The storage coefficient was also modified and identified throughout the simulation. The simulation period is divided into 10 time-steps, each time-step having a duration of 1 year (365 days).

The groundwater discharge data in the modeled area were prepared from the groundwater use survey of the Study Team. There are ten (10) MWSS wells and twenty six (26) private wells in the area. Figure 7.2.9 shows the annual groundwater production from 1981 to 1990 based on the monthly production reports of MWSS wells and field investigations of private wells. The total groundwater production has increased from 11,419 CMD in 1981 to 19,456 CMD in 1990. The year-wise distribution of the discharge data from 1981 to 1990 were arranged for computer simulation. Figures 7.2.10 and 7.2.11 show the groundwater pumpage in 1981 and 1990, respectively.

Throughout the nonsteady-state simulation, the storage coefficient was modified through comparison of computed heads with actual heads. Further, the Q3P model was arranged to simulate changes of piezometric heads in 1990 using estimated 3-day recharge and discharge data for the identification of storage coefficient. The final storage coefficient ranges from 0.05 to 0.1.

Figure 7.2.12 shows the simulated piezometric contours in 1990. The difference between the simulated heads and bottom elevations of the aquifer is shown in Figure 7.2.13. The piezometric heads since 1981 have declined at a maximum depth of 16.4m due to the increase of discharge (Figure 7.2.14).

7.2.3 Optimal Pumpage

(1) Future Pumpage Plans

The Antipolo groundwater flow model simulated future piezometric heads for the design of optimal pumpage in the area. The simulated future period is up to the year 2010. Thus piezometric heads of 30 time-steps (30 years) from 1981 to 2010 were simulated continuously. Three (3) cases were prepared for future simulation based on the well design of new MWSS wells and the rehabilitation plan. These are:

(a) The discharge of MWSS wells in 1990 will continue up to 2010.

(b) New MWSS wells will be constructed and will pump from year 1991 to 2010 at a rate of 830 CMD per well. The discharge of existing MWSS wells will not change.

(c) New MWSS wells will be constructed and will pump from 1991 to 2010 at the rate of 830 CMD per well. The discharge of existing MWSS wells will be augmented 207 CMD per well from 1991 by well rehabilitation.

It is assumed in the above cases that the discharge of existing private wells will be the same as that in 1990 and no new private wells will be constructed. It is also assumed that future recharge will be uniform from 1991 to 2010.

(2) Future Recharge Evaluation

The recharge from rainfall is the most important parameter for evaluating the future groundwater potential in the area. As mentioned before, a 10-year recharge estimation had been carried out using daily rainfall and daily pan-evaporation data. The estimated recharge took a wide range--from 337.9mm/year to 1310.8mm/year, depending on the amount of precipitation and rainfall pattern.

The long-term statistical analysis of rainfall and recharge aids the evaluation of groundwater recharge. The meteorological data at the Sumulong and Antipolo stations were used for the analysis. The 62-year data from 1911 to 1972 were collected and arranged for annual recharge estimation. The annual rainfall and estimated annual recharge are shown in Figure 7.2.15. The average, minimum and maximum recharge for the 26-year period are 636.0mm/year, 223.3mm/year, 1682.6mm/year, respectively.

A probability analysis using the Thomas method was done. The results are shown in Table 7.2.1.

Table 7.2.1 RESULTS OF DROUGHT PROBABILITY ANALYSIS OF RECHARGE (26-YEAR DATA OF SCIENCE GARDEN)

Drought Probability	Recharge (mm/year)	Recharge to the Basin (CMD)
(Simple average)	636.0	42,799
2 years	589.9	39,697
3 years	495.1	33,318
5 years	418.8	28,183
10 years	350.2	23,567
20 years	302.0	20,323

For the future simulation, the recharge value for a 5-year drought probability was employed on the safe side. The recharge value of 28,183 CMD is the maximum groundwater potential from the water balance point of view.

(3) Future Simulation

(a) Case (a)

The evaluated recharge and the discharge in 1990 were inputted to the model. Figure 7.2.16 shows that the simulated piezometric heads will decline even though the discharge is the same as that for 1990. The simulated piezometric contours and the heights from the aquifer bottom are shown in Figure 7.2.17 and 7.2.18, respectively. The maximum drawdown from 1991 to 2010 is expected as 52.4m.

(b) Case (b)

The exploitable groundwater potential, possible number and locations of new MWSS wells were examined under different recharge conditions. The discharge of existing MWSS wells and existing private wells in 1990 will continue up to 2010. The following are the criteria for locating new wells:

i) New wells should be located where the simulated piezometric heights of Case (a) in year 2010 (Figure 7.2.18) are more than 30m because the drawdown of new wells are estimated to be 20m to 21m from static level.

ii) Existing pumping grids should be avoided for the new wells' location.

iii) The total discharge of existing wells and new wells should not exceed the recharge to the basin.

iv) Simulated piezometric heights up to the year 2010 using the new discharge data involve the new wells' discharge. The simulated piezometric heights at the sites of new wells should be more than 21m.

The possible number and locations of new wells were identified under several discharge conditions and are given in Table 7.2.1. Evaluation results are given in Table 7.2.2.

Table 7.2.2 AVAILABLE NUMBER OF NEW WELLS AND EXPLOITABLE DISCHARGE UNDER DIFFERENT RECHARGE CONDITIONS

Drought Probability	Recharge (CMD)	Total Discharge (CMD)	Available New Wells (Nos.)	Exploitable Discharge (CMD)
2 years	39,697	36,056	20	16,660
3 years	33,318	30,246	13	10,790
5 years	28,183	27,756	10	8,300
10 years	23,567	22,776	4	3,320
20 years	20,323	20,286	1	830

In this case, the construction of ten (10) new wells may be optimal for future groundwater development in the area.

(c) Case (c)

A plan for the construction of new wells, as well as the augmentation of existing MWSS wells by well rehabilitation, are examined in this case. The discharge of each existing MWSS well will be augmented by 207 CMD. So, the total augmentation of existing MWSS wells is:

207 CMD x (10 MWSS existing wells) = 2,070 CMD

Under the recharge conditions of a 5-year drought probability, the total recharge to the basin is estimated as 28,183 CMD. The existing wells were pumping 19,456 CMD in 1990; so, the maximum available water from the new wells is:

28,183 CMD - 19,456 CMD - 2,070 CMD = 6,657 CMD

The simulation study that was carried out to make an optimal plan of groundwater development in the area had the piezometric heads in 2010 computed first using the increased discharge of existing wells. The number and location of new wells were determined using the same criteria as Case (b).

As a result, seven (7) new MWSS wells were found to satisfy the criteria. The optimal distribution of future discharge is shown in Figure 7.2.19. Figure 7.2.20 and Figure 7.2.21 show the piezometric contours and piezometric heights from aquifer bottom in 2010, respectively. The piezometric heads will be lower than 100m at the central part of the basin, but the piezometric heights at the new sites will be more than 21m. Figure 7.2.22 shows that the piezometric heads will almost be stabilized by the year 2010.

The total discharge in the basin is:

19,456 CMD +2,070 CMD +5,810 CMD (7 new wells) = 27,334 CMD

Figure 7.2.23 shows the estimated discharge and recharge in the optimal plan.

(4) Optimal Plan for Groundwater Development

Under the conditions mentioned above, the optimal groundwater development plan in Antipolo basin is summarized as follows:

i) Rehabilitate existing ten (10) MWSS wells
ii) Construct seven (7) new MWSS wells

However, it should be noted that this optimal plan was made under various assumptions, the most important and problematic of which is the remaining constant of the future pumpage of private wells. Actually there are many unknown factors to consider in predicting future pumpage of privately-owned wells. These may be correlated with population growth, but still many assumptions are needed.

The optimal plan was carefully examined from the water balance and hydrogeologic conditions in the basin. The groundwater potential also was evaluated on the safe side.

From the maximum groundwater potential of 29,287 CMD, existing wells are already pumping 19,456 CMD. So the maximum available water in the future is estimated only as 10,000 CMD.

Some problems could occur during the lowering of piezometric heads as reactions to groundwater development. One of these problems is the decreasing yield of existing wells. Some of these wells are so shallow that they may not be able to yield water at the same present rate. Some wells may have to install higher capacity pumps.

Since the groundwater potential and source of groundwater recharge are limited in the area, a countermeasure for groundwater conservation should also be taken into account for better utilization of groundwater resources.

7.3 METRO MANILA GROUNDWATER BASIN

The quasi three-dimensional groundwater flow model (Q3P model) was applied to the aquifer system in the Metro Manila groundwater basin.

The Guadalupe formation and Alluvium comprise a complex and confined aquifer system in the Metro Manila groundwater basin.

The eastern margin of the basin is bounded by a hilly area consisting of Pre-Quaternary formations. The aquifer system continues across northern and southern boundaries. The western margin and southeastern are bounded by Manila Bay and Laguna de Bay, respectively.

The hydrogeologic basement in the basin consists of Pre-Quaternary formations, but detailed information on basement rocks have not been collected because these are overlain by the thick Guadalupe formation. The thickness of Guadalupe aquifer system may be more than 1,000m in Manila Bay, but detailed structures about the basement of Guadalupe formation have yet to be known.

Conceptualizations and quantifications have been made in the representation of the groundwater regime in order to analyze the dynamic behavior of groundwater flow. The aquifer system up to a depth of 300m was modeled as a main confined aquifer because most of the wells in the area extract groundwater at a depth of 300m. The main aquifer is hydraulically connected to the overlying phreatic aquifer through a confining layer.

The finite-element grid used in the model is shown in Figure 7.3.1. The model domain has an area of 1404.7km^2 and is divided into 754 rectangular elements of 1350m x 1380m, which correspond to 45 seconds of longitude and latitude. The number of elements in the x and y coordinates are 28 and 35, respectively. The number of nodes in the domain where the heads are computed is 829.

7.3.1 Model Parameters and Boundary Conditions

(1) Boundary Conditions

Three (3) different boundary conditions were specified based on the hydrogeologic interpretations (Figure 7.3.10). The boundary of the eastern margin of the basin was treated as a no-flow boundary. The northern and southern perimeters of the modeled area where the aquifer extends out were assigned as constant-flow boundaries. Constant-head

boundaries were assigned to Manila bay and Laguna de Bay at the place where the distance from coastlines is about 5km. The area between con stant-head boundaries and actual coastlines was regarded as cushion zone.

(2) Model Parameters

Input parameters used in the model were those collected/measured by the Study Team during Stage I to III. After data processing was completed, input data for the Q3P model were prepared. These parameters were inputted to the model, and then modified and identified through model calibration. The period of model calibration is the ten (10) years from 1981 to 1990.

Model parameters used in the model are as follows.

(a) Transmissivity

Transmissivity was estimated from the data on specific capacity of existing wells and the pumping tests results compiled by the Study Team. The methodology of the estimation is as mentioned in Chapter 3. Transmissivity values range from $10m^2/d$ to $315m^2/d$.

(b) Storage coefficient

The initial values of storage coefficient were uniformly assigned as $1x10^{-3}$ because of the lack of actual data. But during the steady-state and nonsteady-state calculations, the values were modified by comparison of model results with field observations of piezometric heads. Finally, $1x10^{-3}$ to $1x10^{4}$ of storage coefficient is assigned to the model.

(c) Aquitard thickness and permeability

The thickness (b') and permeability of aquitard (k') control the leakage recharge to the confined aquifer as leakance (k'/b'). The aquitard thickness was obtained from the clay content map which was prepared from the well columnar sections collected by the Study Team. The thickness ranges from 7m to 53m.

The permeability of aquitard is one of the unknown parameters in the area. Thus, initial values of the permeability were uniformly assigned as $1x10^{-3}$m/d, and then modified and identified throughout the model calibrations. Final permeability ranges from $1x10^{-1}$m/d to $1x10^{-9}$m/d. The computed leakance values vary from $1x10^{-6}$/d to $2x10^{-3}$/d.

(d) Phreatic water level and initial heads

The phreatic water level is an important leakage recharge parameter. This was estimated from a geomorphological analyses. A river level map was made from topographic maps using the same grid to model the area. The phreatic water level was then assumed to be 10m below the river level. The model assumes that the phreatic water levels are invariant during the simulation.

The initial piezometric heads for the steady-state simulation were estimated using the same method mentioned. The initial piezometric heads in 1981 for the nonsteady-state simulation were prepared from the data of MWSP II (1983).

(e) Direct recharge

The direct recharge area was demarcated based on the results of groundwater leveling mentioned in Chapter 3.5.1. The model assumes that leakage recharge does not occur at the direct recharge area.

The values of direct recharge were obtained from the water balance study mentioned in Chapter 3.6. The input average recharge is 183.1mm/year, or about 8% of annual rainfall.

7.3.2 Verification of the Model

(1) Steady-state Simulation

Model verification is carried out to identify input parameters and assigned boundary conditions. This process is the most important and most complicated work in groundwater modeling because areal quantification of various parameters, which play significant roles in the ground-

water regime, should be done under actual hydrogeologic constraints. Thus, the verification of the model yields a better insight on dynamic groundwater behavior in the area as well as on the limitations of the model.

The calibration of the model was initially carried out in steady-state conditions to identify initial heads, storage coefficient, leakance and boundary conditions of the model. The simulated piezometric heads were observed at the selected points shown in Figure 7.3.3. Using a constant, year-1981 pumping rate (see Figure 7.3.4) throughout the 30-year period (30 time-steps), computation of groundwater heads proceeded on a trial and error basis until it reached the point when the difference between the computed and actual heads in 1981 had become approximately zero. Figure 7.3.5 shows the changes of piezometric heads at observation points during the steady-state simulation. The simulated piezometric contours after the 30-year steady-state calculation are shown in Figure 7.3.6.

(2) Nonsteady-state Simulation

The nonsteady-state simulation from 1981 to 1990 was carried out to simulate transient groundwater flow and decline of piezometric heads due to groundwater pumpage. The actual piezometric heads measured in 1981 were used as initial heads in the model. The leakance and storage coefficient were modified and identified throughout the simulation. The simulation period is divided into 10 time-steps, each time-step having 1 year (365 days).

The groundwater discharge data in the modeled area were prepared from the groundwater use survey of the Study Team. Figure 7.3.7 shows the annual groundwater production from 1981 to 1990 in the modeled area. Total groundwater production decreased from 333.1 MCM/year in 1981 to 310.5 MCM/year in 1990, but the production of MWSS wells increased from 18.2 MCM/year in 1981 to 29.0 MCM/year in 1990. The discharge data were arranged for computer simulation. Figure 7.3.8 shows the discharge distribution in 1990.

Throughout the nonsteady-state simulation, leakance (permeability of aquitard) and storage coefficient were modified and identified by com-

parison of computed heads with actual heads. The leakance is the most sensitive parameter in the model so that more than hundred times of test simulation was carried out to determine this parameter.

Figure 7.3.9 shows the simulated piezometric contours in 1990. The changes of piezometric heads at the observation points are shown in Figure 7.3.10. Recovery of the piezometric heads in the northern part to the central part of Metro Manila (Caloocan, Valenzuela, Manila, the western part of Quezon city, San Juan, Mandaluyong and western part of Pasig) and the Cavite area is reasonably simulated due to decreases of the discharge. However, the piezometric heads in the southern part of Metro Manila (Taguig, Parañaque, Muntinlupa, Las Piñas, Bacoor, Imus, kawit, Noveleta and Rosario) went down because the discharge increased in those areas.

7.3.3 Prediction of Future Groundwater Levels

The model can simulate future piezometric heads using future recharge and discharge plans. The duration of future simulation is the 20 years from 1991 up to 2010. The future piezometric heads are computed based on the simulated piezometric heads of 1990. The model thus computed piezometric heads at 30 time-steps (the 30 years from 1981 to 2010).

The evaluation of the future recharge to the basin is contained in the water balance study in Chapter 3.6. Five (5) cases of future groundwater levels were prepared based on future water demand projections. The scenarios used in projecting future demand were also adopted for these cases.

(a) Discharge in 1990 continues up to 2010.
(b) Scenario 1
(c) Scenario 2
(d) Scenario 3
(e) Scenario 4

Table 7.3.1 SUMMARIZES THE CHARACTERISTIC THOSE FOUR SCENARIOS.

Table 7.3.1 CHARACTERISTICS OF THE SCENARIOS

Scenario No.	MWSS Surface Water Supply Projects	Future Pumpage of Commercial & Industrial Private Wells	CDS Connection in Cavite MSA
1	On-schedule completion of ongoing projects	Increasing (1	Bacoor 100% covered, Kawit 50%, others 0%
2	Same as Scenario 1	Increases (2 up to year-2000, thereafter pumpage is constant	All municipalities covered
3	Same as Scenario 1	Increases (2 up to year-1995, thereafter pumpage is constant	All municipalities covered
4	Two years delay of completion of ongoing projects	Same as Scenario 1	Same as Scenario 1

Note: (1 With respect to future demand increases but maintaining year-1990 percentage shares
(2 With respect to future demand increases and up to the year indicated

Yearly groundwater production of each scenario in the modeled area is shown in Figure 7.3.11. In each graph, groundwater production from 1981 until 1990 is actual figure. The discharge distribution maps in the year 2010 of Scenario 1 and 2 are shown in Figure 7.3.12. The discharge distribution of Scenario 3 and 4 are shown in Figure 7.3.13.

The results of simulation are as follows:

(a) Discharge in 1990 continues up to 2010

This case assumes that the discharge of 316.572 MCM in 1990 continues up to 2010. As shown in Figure 7.3.14, and in comparison with heads in 1990, the piezometric heads in 2010 will recover at a maximum of 10.7m in the central part of Metro Manila. Decline of heads can be seen in the northern part, eastern part (along Marikina river), and southern to southwestern part of Metro Manila. A maximum drawdown of 21.7m is predicted at the northern part of Quezon City. A 16.9m drawdown will occur in Rosario.

(b) Scenario 1

The simulated piezometric contours in 2010 (Figure 7.3.14 (a)) show that a large piezometric depression appears in northwestern Metro Manila. The deepest portion will be lower than -170 masl. Also, considerable lowering of piezometric heads can be seen in the southwestern part, the southern and eastern parts of Metro Manila. In Cavite, the piezometric heads will be as deep as -90 masl.

The piezometric changes from 1991 to 2010 are shown in Figure 7.3.16 (a). Piezometric heads in 2010 rise in the southern part of Quezon City, Parañaque, Las Piñas and Bacoor. A maximum rise 20m of piezometric heads is predicted at the coastal area in Las Piñas because of decrement of discharge. However, heads will go down in the northern and southwestern parts of Metro Manila. Significant drawdowns such as 83m at north Valenzuela, 57m in Cavite and 37m in Pasig are predicted.

Figure 7.3.18 (a) shows that the piezometric heads in Cavite and Caloocan City declined for the period 1991 to 2000, then stabilized after. Constant decline can be seen in Pasig from 1991 to 2010. Piezometric heads in Las Piñas rose in the period from 1991 to 2000, but they go down gradually after 2005.

(c) Scenario 2

A large piezometric depression can be seen in the northwestern

part of Metro Manila (Figure 7.3.14 (b)). The lowest head will be -149 masl at north Valenzuela. A piezometric lowering belt in which the heads range from -60 to -80 masl lies from Cavite to Marikina through Muntinlupa and Parañaque.

Piezometric heads will go down 59m at north Valenzuela and 33m in Cavite since 1991 (see Figure 7.3.16 (b)). Heads will decline in most of Metro Manila from 1991 to 2000, then stabilize or slightly recover after 2001 as shown in Figure 7.3.18 (b).

(d) Scenario 3

This scenario is the most ideal case. All ongoing projects will be completed on schedule and be able to supply surface water to the area. But the simulated piezometric contours still show a large depression as deep as -134 masl in northwestern part of Metro Manila (Figure 7.3.15 (a)).

Heads in 2010 are 50m lower at north Valenzuela and 29m lower in Cavite than those in 1990 (Figure 7.3.27 (a)). Recovery of heads will occur in almost all areas from 2001 to 2005 due to decreasing discharge (Figure 7.3.18 (c)).

(e) Scenario 4

This is the scenario in which groundwater discharge is the maximum among the five cases. The discharge increases from 1991 to 2000 and from 2005 to 2010. As a result, the simulated piezometric heads (Figure 7.3.15 (b)) will be lower than those of Scenario 1.

The drawdowns of piezometric heads are estimated as 90m at north Valenzuela and 56m in Cavite (Figure 7.3.17 (b)). Piezometric heads in most of Metro Manila show significant declines until after 2000 when they decline gradually or stabilize (Figure 7.3.18 (d)).

The results of simulation show that a maximum drawdown of 50m will occur even in the case of Scenario 3 where the discharge is the smallest among the future groundwater use plans. This could cause severe saline water

intrusion and may damage even inland areas.

7.4 SALINE WATER INTRUSION MODEL

The Las Piñas area is one of those Metro Manila areas most affected by saline water intrusion. The intrusion may have been caused by the decline of the groundwater head which resulted from the increase in groundwater pumpage. The source of saline water in Las Piñas maybe seawater, but the mechanism has yet to be clarified.

Generally, in coastal areas like Las Piñas, salt water occurs underground, not at sea level but at a depth below sea level of about 40 times the height of the fresh water above sea level. This phenomenon, which is generally referred to as the Ghyben-Herzberg relation, is attributed to a hydrostatic equilibrium existing between the two fluids of different densities. But in many areas with extensive groundwater development, the Las Piñas area included, a hydrodynamic equilibrium may exist due to the dynamic groundwater flow caused by groundwater extraction so that the Ghyben-Herzberg relation cannot be applied directly.

Most researchers have approached the seawater intrusion problem by describing the landward movement of a discrete interface between seawater and freshwater. This approach assumes that seawater infiltrates solely from an offshore outcrop of the aquifer. If, however, a coastal aquifer is overlain by a leaky confining layer, this assumption is often inappropriate because seawater can potentially migrate from above. A discrete interface approach does not consider such leakage.

Therefore, applying this approach to the Las Piñas area poses some difficulties: (1) the aquifer system is divided into a shallow aquifer and deeper aquifers by leaky confining layers; (2) both the confined aquifers and the confining layers tilt toward the sea; and (3) the groundwater flow is very much disturbed by groundwater pumping so that the pattern of saltwater intrusion is different from that of the Ghyben-Herzberg relation.

According to the measurement of electric conductivity (EC) logging and water quality analysis in the Las Piñas area, saline water occurs in a

shallow aquifer up to a depth of 100m below mean sea level. In contrast, EC values and chloride concentration in deeper aquifers decrease with depth. This phenomenon may occur because seawater and saline surface water are forced to infiltrate into the underground with the lowering of piezometric head by the groundwater extraction.

The two-dimensional solute transport and dispersion model were employed to verify this hypothesis and to understand the mechanism of saline water intrusion. This model may also aid in predicting the quantity and location of saltwater resulting from future groundwater utilization or regulation.

The solute transport model was originally developed for plane two-dimensional problems, but it has been modified for vertical two-dimensional multiple aquifers system to allow for more detailed analysis of results.

A vertical two-dimensional model was made along the geological section line shown in Figure 7.4.1. This section line is almost perpendicular to the coastal line. The line which is taken as the x-axis for the model is divided into 40 nodes. Each nodal spacing is 100m and the width of 100m for each side of the line is taken into account for model domain.

Figure 7.4.2 shows the grid of the vertical two-dimensional model. Vertically, the elevations from +30m to -330m are modeled. Each cell is 15m-thick so that the volume of each cell is 15m x 100m x 200m = 300,000m^3.

The computer program of the solute-transport model allows a grid to have up to 40 rows and 40 columns for groundwater flow calculations. Because the numerical procedure requires that the outer rows and columns represent no-flow boundaries, the aquifer itself is then limited to have a maximum of 38 rows and 38 columns. Further, the grid size for transport calculation is limited to 20 rows and 20 columns which can be assigned to any area of the flow grid.

Therefore, the grid size for the flow calculation in Las Piñas is fixed as 24 rows and 40 columns, and transport subgrid size as 20 rows and 20

columns (see Figure 7.4.2).

Hydrogeologic unit of each cell viz. Alluvial clay, aquifer (sand) and aquiclude (clay) have been specified (Figure 7.4.3) based on the hydrogeologic section given in Figure 3.2.20.

7.4.1 Model Parameters and Boundary Conditions

(1) Model Parameters

Input parameters used in the model were those collected/measured by the Study Team during Stage I to III. After data processing was completed, input data for the MOC model were prepared. These parameters were inputted to the model, then modified and identified through model calibration.

Model parameters used in the model are as follows.

(a) Transmissivity

Transmissivity values of the aquifer came from the results of the pumping tests conducted in the test wells by the Study Team. Transmissivity of aquiclude was estimated from the core observation.

Table 7.4.1 summarizes the aquifer parameters of the hydrogeologic units. The apparent transmissivity (Taxx) which is inputted in the model is computed as Kxx x 200m because the width of each cell is 200m. The ratio of longitudinal transmissivity (Tyy) to transverse transmissivity (Txx) is assumed as 0.1 because the aquifer systems may be anisotropic due to the sedimental structure.

Table 7.4.1 HYDROGEOLOGIC UNITS AND AQUIFER PARAMETERS

Hydrogeologic unit (label)	Actual transmissivity Txx(m^2/d)	Permeability Kxx(m/d)	Apparent transmissivity Taxx (ft^2/s)
Alluvium (A)	(4.4)	1.46×10^{-1}	3.6×10^{-3}
Aquifer-1 (B)	220.0	7.30	181.9×10^{-3}
Aquiclude-1(C)	(4.4)	1.46×10^{-1}	3.6×10^{-3}
Aquifer-2 (D)	61.2	2.04	50.8×10^{-3}
Aquiclude-2(E)	(2.4)	8.00×10^{-2}	2.0×10^{-3}
Aquifer-3 (F)	33.6	1.12	27.9×10^{-3}
Aquiclude-3(G)	(2.4)	8.00×10^{-2}	2.0×10^{-3}
Aquifer-4 (H)	(30.0)	1.00	24.9×10^{-3}

( ): estimated values

(b) Storage coefficient

Storage coefficient was uniformly set to zero for the steady-state simulation.

(c) Aquifer thickness

Apparent thickness of aquifer for the model was uniformly set to 200m (656.2ft) in the modeled domain because the width of each cell is modeled as 200m. The actual aquifer thickness is the total thickness of the aquifer cells.

(d) Leakance

In this model constant-head boundaries were simulated by adjusting the leakance. A sufficiently high value (such as 1.0/s) was assigned at constant-head boundaries. In the rest of the area leakance was modeled as 0. The actual leakance in the aquifer system was expressed as (permeability of aquiclude)/(thickness of aquiclude).

(e) Initial heads

The initial heads were set at 0m except the uppermost cells representing the ground surface, the sea and marine pond. The water levels in the uppermost cells were treated as constant. Phreatic water levels were estimated from the topography.

(f) Direct recharge

The groundwater recharge was estimated from the water balance study. Because the actual area of each cell is 200m x 100m = 20,000m^2 the input recharge values was computed as

Input recharge at each cell (m^3)
= 20,000m^2 x estimated recharge (m^3/m^2)

The obtained recharge values were given to the uppermost cells representing ground surface.

(g) Discharge

The groundwater discharge was estimated from the results of the groundwater use survey. The location of pumping wells within the model domain were projected on the vertical grid. If the well structure was known, the depth of the well and the screen positions were also projected; otherwise, they were assumed. The discharge values were distributed into the cells where the screens are located (see Figure 7.4.2). It is assumed that if a cell expresses an aquiclude, groundwater is not extracted from the cell.

(h) Initial chloride concentration

The initial chloride concentration of the domain was set at 0mg/l except the cells representing the sea and marine ponds. The chloride concentration of seawater and marine ponds water was assumed at 21,500mg/l.

(i) Transport parameters

Several parameters were assigned for transport simulation. Table 7.4.2 summarizes inputted transport parameters.

Table 7.4.2 TRANSPORT PARAMETERS

Maximum number of particles	6400
Initial number of particles per node	9
Reaction specifier	NO REACTION
Effective porosity	0.05
Longitudinal dispersivity	7.00ft
Ratio of transverse to longitudinal dispersivity	1.0
Source concentration	21500mg/l

(2) Boundary Conditions

As shown in Figure 7.4.2, outer flows and columns of the flow grid were treated as no-flow boundaries. It was assumed that the phreatic water levels in the uppermost cells are constant so that the constant-head boundary condition was assigned to these cells. Cells which are located in the sea, rivers and marine ponds were also treated as constant-head boundaries.

7.4.2 Steady-State Simulation

Steady-state simulation was carried out for identification of the model. Duration of the simulation is 10 years, with values of input discharge and recharge being obtained from year-1990 data. The calculated piezometric heads show good agreement with the observed values without modification of hydrogeologic parameters (Figure 7.4.4).

After computing the groundwater flow, the solute transport model was calibrated. The boundary conditions of initial chloride concentration, effective porosity, longitudinal and transverse dispersivity are modified during model calibration. Figure 7.4.5 shows chloride concentration after a 10-year simulation using finalized parameters and boundary

conditions.

During model verification, several sets of parameters were prepared and inputted into the model in order to compare the saline water movement. The location of the source, and dispersivity were changed for this purpose.

(1) Saline Water Movement versus Time

The movement of saline water was studied under steady-state conditions. Figure 7.4.6 shows the steady-state piezometric contours in the flow grid and solute transport grid. Changes of chloride concentration were monitored at four (4) observation points. These points coincide with screen positions of the test wells as shown in Table 7.4.3.

Table 7.4.3 OBSERVATION POINTS IN THE MODEL

Observation Point	Name of Test Well (depth)
Obs-1	LPS2-3 (100m)
Obs-2	LPS2-2 (200m)
Obs-3	LPS2-1 (300m)
Obs-4	LPS3-1 (300m)

Figure 7.4.7 to Figure 7.4.9 show changes of concentration over time. The saline water moves downward and reaches the bottom of Aquiclude-1 in 2.2 years since simulation started. After passing Aquiclude-1, the saline water intrudes in Aquifer-2 along the flow direction towards the low piezometric heads. In 7.1 years since simulation started, the fore-front of saline water reaches the center of piezometric depression in Aquifer-3. After 10 years, the contour of 2000mg/l reaches the center of piezometric depression.

Figure 7.4.10 shows changes of chloride concentration at the observation points. The chloride concentration increases from the first year since simulation started at Obs-1, then it rises steeply from the second to the forth year. By the sixth year the concentration shows high salinity

that is almost the same as seawater.

At Obs-2, the chloride concentration rises 4 years after the simulation started. It then increases gradually and reaches 13,000mg/l after 10 years simulation. At Obs-3 the concentration after 10 years is only 33mg/l. Saline water appears after 6 years of simulation.

The saline water appears at Obs-4 after 5 years simulation. Then the concentration increases constantly and it reaches 6,000mg/l by the tenth year.

(2) Source of Saline Water and Dispersivity

In order to identify the source of saline water, it was modeled that the sources of saline water be located at Manila Bay (x=3,y=2) and a marine pond (3,8). In this study it is assumed that the chloride concentrations of sea water and marine pond water are the same.

Figure 7.4.11 shows simulated chloride concentrations after 4.4 years and after 10 years. The longitudinal and transverse dispersivity is 7.0ft. The saline water from Manila Bay mainly goes downwards in Aquifer-1 and intrudes slowly towards inland in Aquifer-2. The forefront moves 200m in the lateral direction. In contrast, the saline water from the marine pond goes downward in Aquifer-1, and then moves as far as 1400m in Aquifer-2 and Aquifer-3, towards the center of piezometric depression. All these observations indicate the significant contribution of marine ponds and salty rivers in saline water intrusion.

The simulated chloride concentration using 33.0ft of longitudinal and transverse dispersivity is shown in Figure 7.4.12. The locations of saline water sources are the same as those in Figure 7.4.11. The result show that the saline water from both sea and marine pond disperses wider than the previous case. The saline water moves more downwards so that the contour of 2,000mg/l does not reach the center of piezometric depression. The saline water from the sea moves only 300m in the lateral direction even in this case. However, the simulated distribution of saline water is different from the actual distribution so that the dispersivity should be smaller than 33ft.

(3) Mechanism of Saline Water Intrusion

Above results show that the groundwater flow patterns greatly affect the movement of saline water. The marine ponds also substantially contribute to the saline water occurrence. To illustrate: If the source of saline water is only the sea, the distribution of saline water is very limited near the shoreline; in case the source of the saline water is assumed to be both the sea and marine ponds, the result shows good agreement with the actual saline water distribution and concentration.

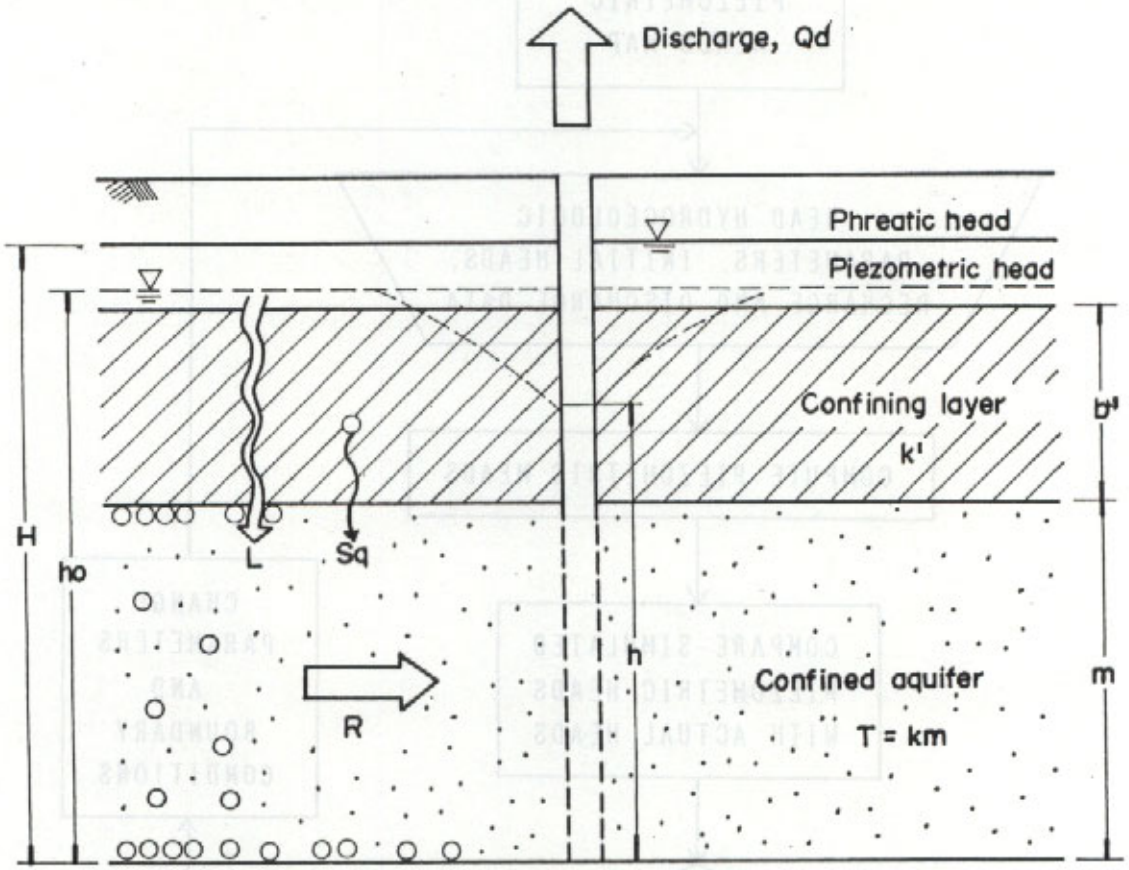
7.4.3 Future Movement of Saline Water

The groundwater flow pattern in the future will be different from the present pattern because the locations and amount of discharge may be changed. Subsequently, the pattern of saline water occurrence may also be different.

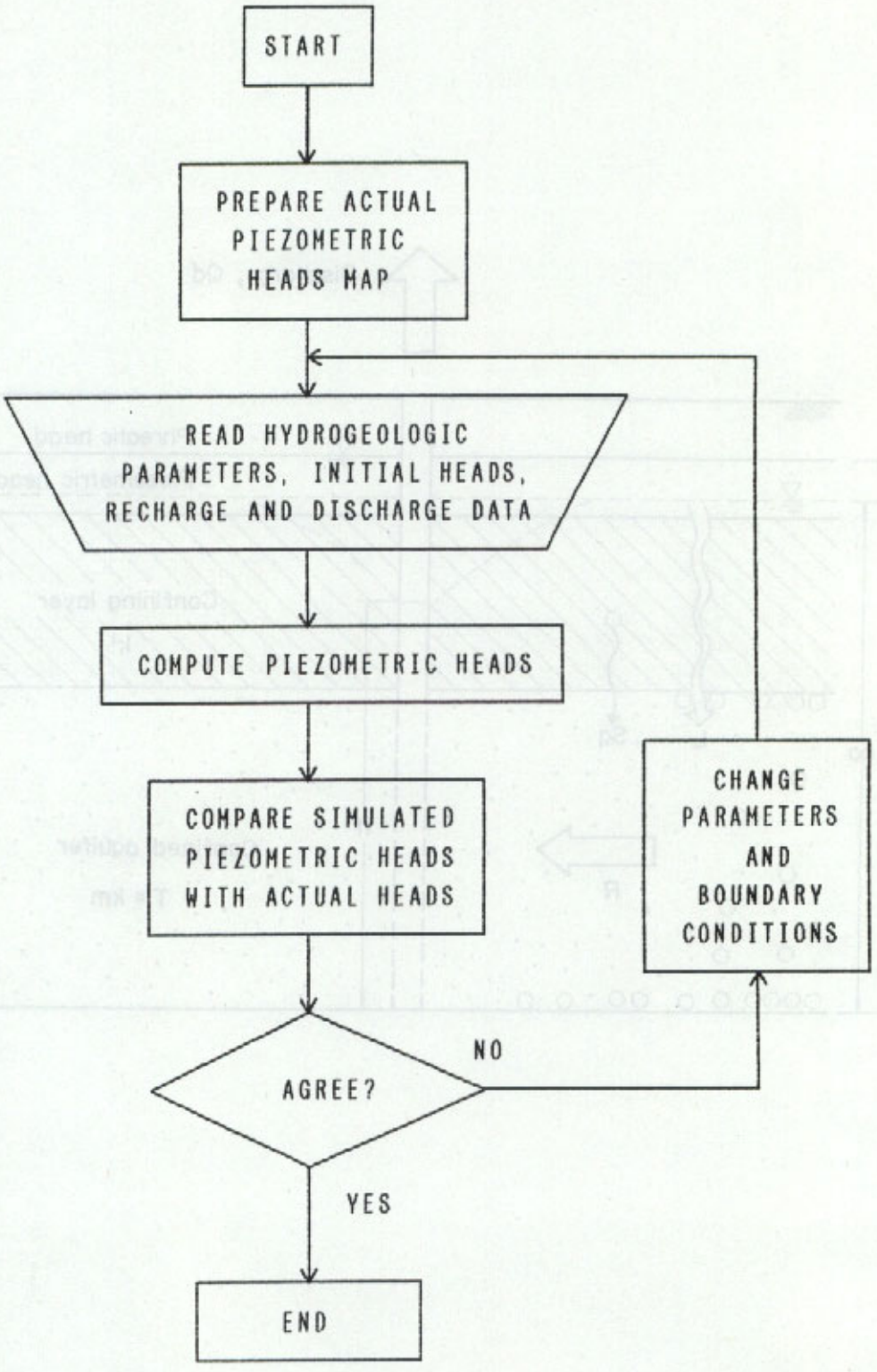
The future movement of saline water will be controlled by the future pumpage in the area. It is easily predicted that if the existing depression of piezometric heads moves more inland, or a new bigger depression is formed in the more inland part, the saline water also moves deeper inland. Also, if deeper wells are constructed to extract from deeper aquifer, saline water may intrude more deeper portions.

According to the future water demand projections, the groundwater discharge in Las Piñas, Muntinlupa and Parañaque will decrease in the future, but the discharge in Cavite area will increase. Under scenario 1 the results of the groundwater flow simulation in Metro Manila show that large piezometric depressions will occur in Cavite, at the southern part of Las Piñas, and in Muntinlupa and Parañaque in the year 2010. This will cause further saline water intrusion in the area.

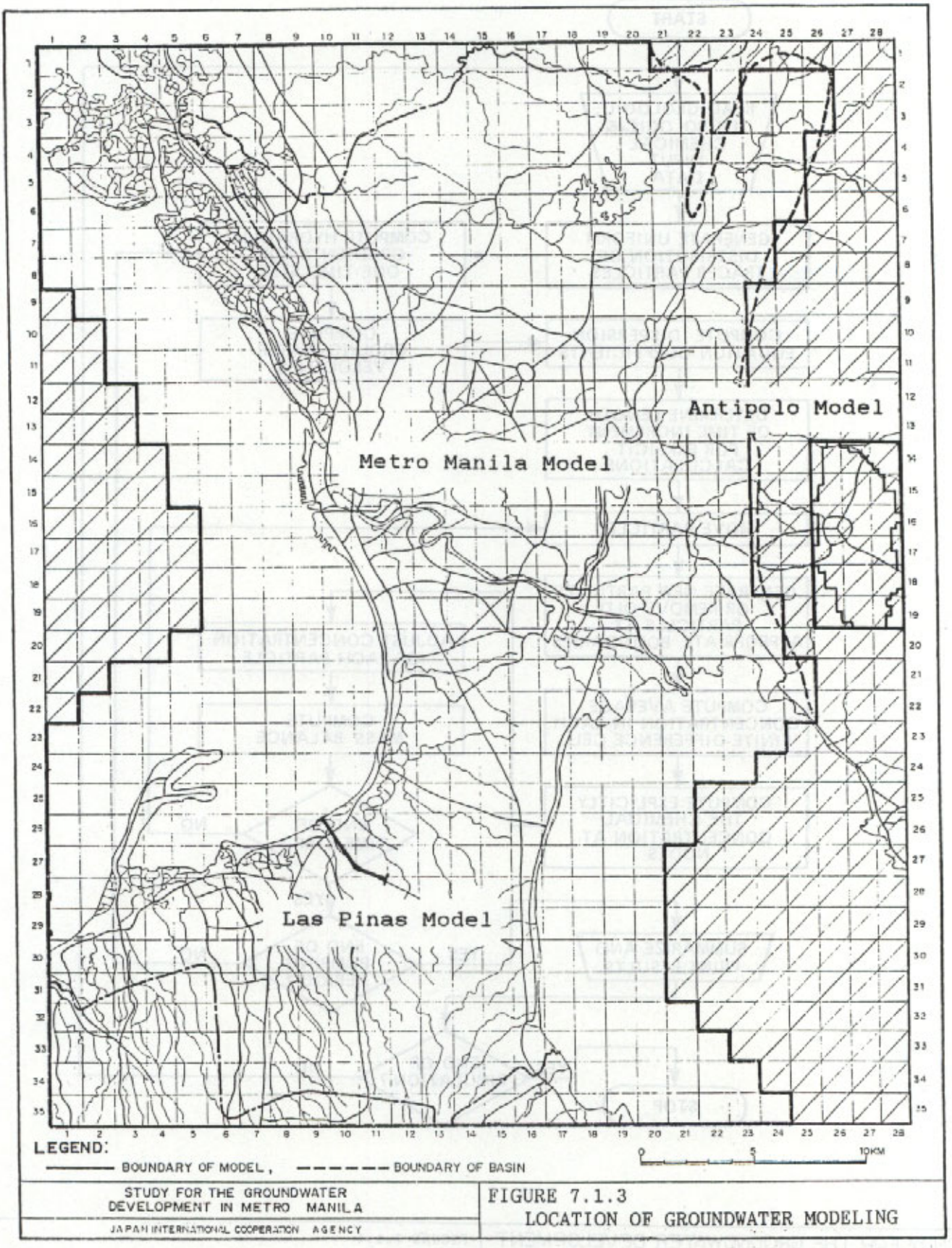
The simulation studies show that though the groundwater discharge in the coastal area is regulated, the piezometric depressions will remain in Muntinlupa and Parañaque. In this case saline water from Manila Bay will move towards the depressions, because the piezometric heads in the coastal area where saline water has already existed are higher than those in the inland area.



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.1.1 SCHEMATIC CROSS-SECTION OF THE QUASI 3-DIMENSIONAL MODEL
JAPAN INTERNATIONAL COOPERATION AGENCY	



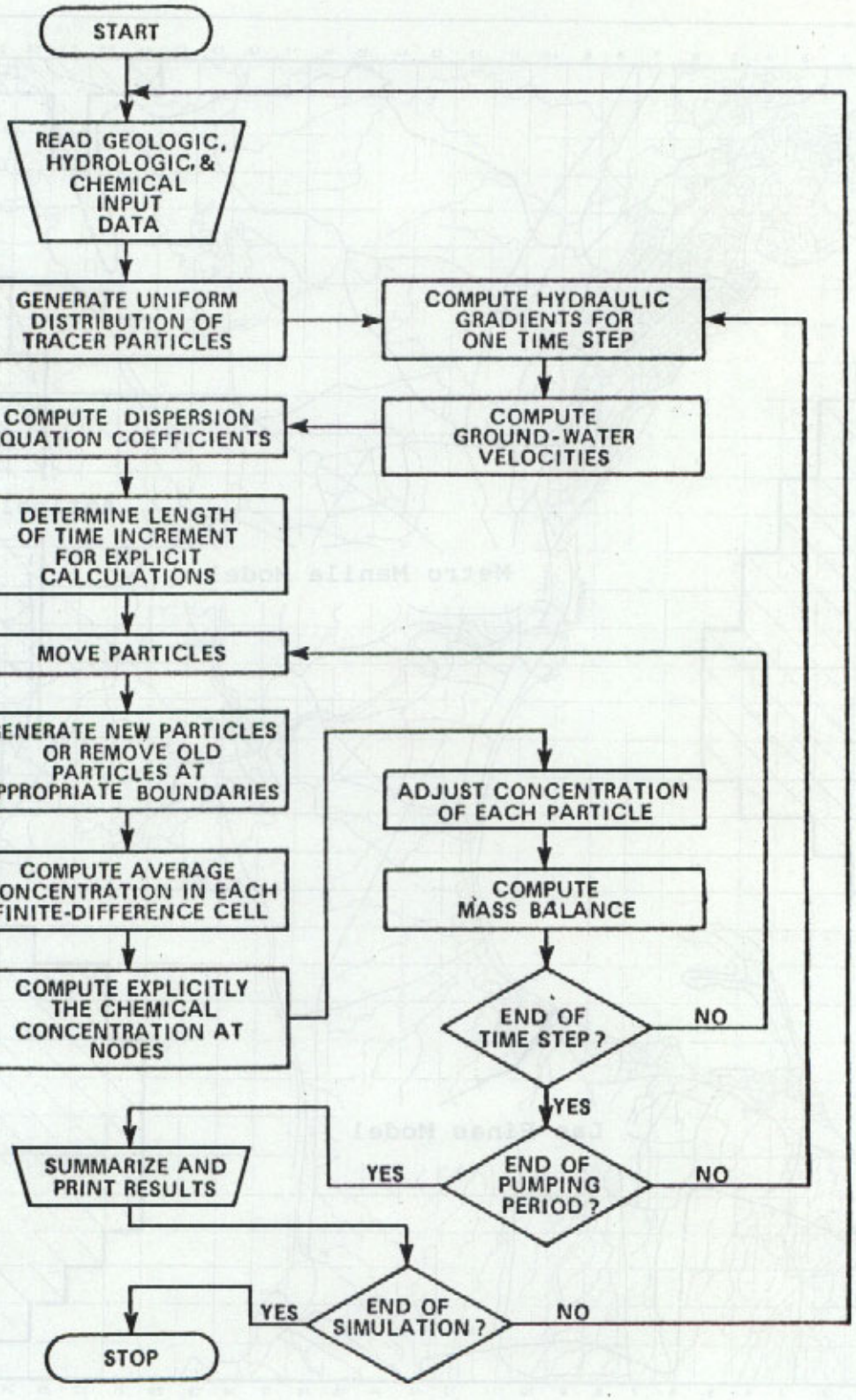
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 7.1.2 SIMPLIFIED FLOWCHART OF THE QUASI THREE-DIMENSIONAL FEM FLOW MODEL (Q3P)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.1.3
LOCATION OF GROUNDWATER MODELING

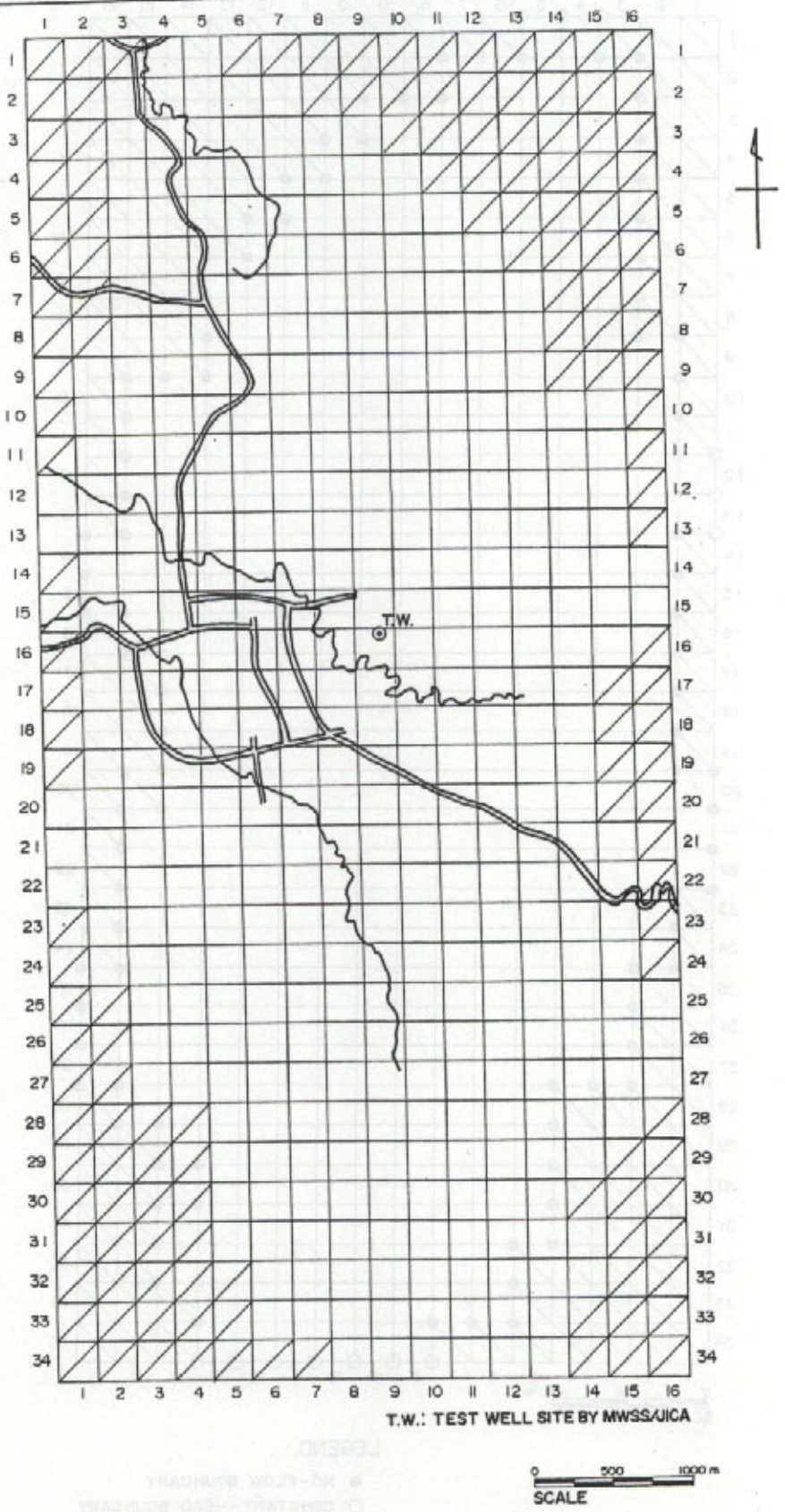


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.1.4

SIMPLIFIED FLOWCHART ILLUSTRATING THE MAJOR STEPS IN THE CALCULATION PROCEDURE



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

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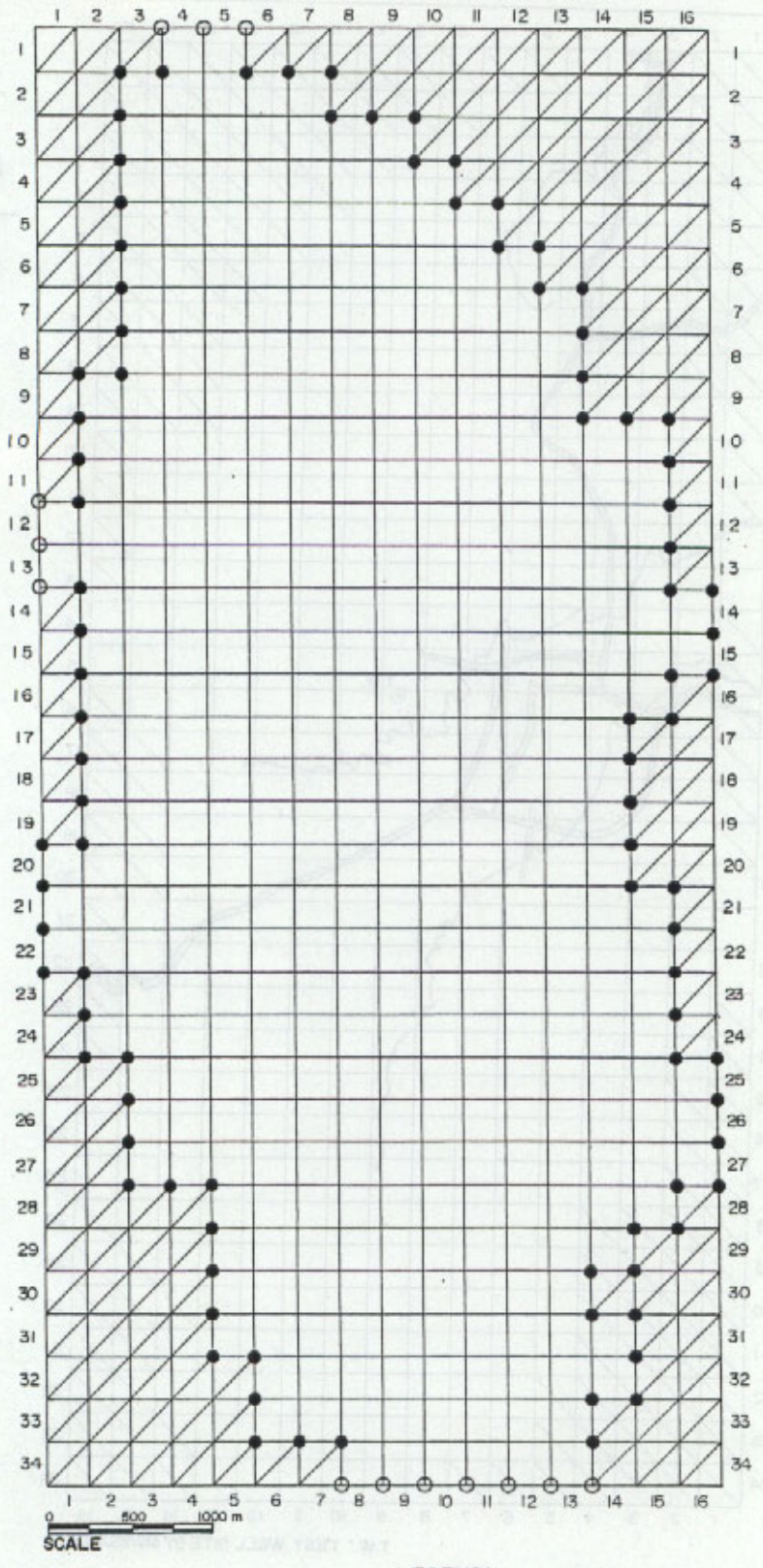
FIGURE 7.2.1
FINITE-ELEMENT GRID USED TO THE MODEL THE ANTIPOLO BASIN



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

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FIGURE 7.2.2

BOUNDARY CONDITIONS FOR THE ANTIPOLO GROUNDWATER BASIB MODEL

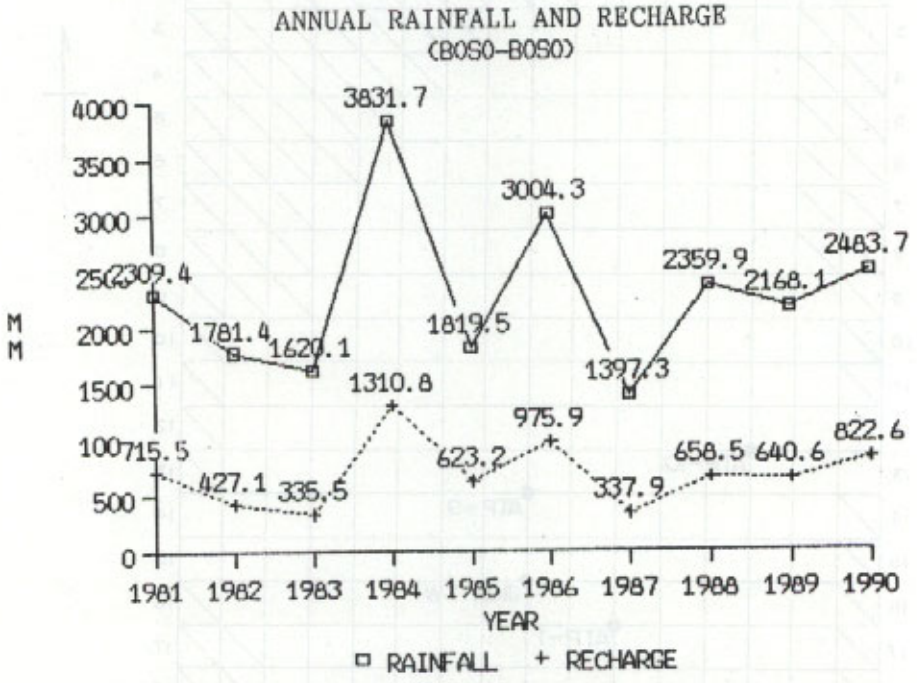


FIGURE 7.2.3
ANNUAL RAINFALL AND ESTIMATED RECHARGE AT BOSOBOSO-STATION

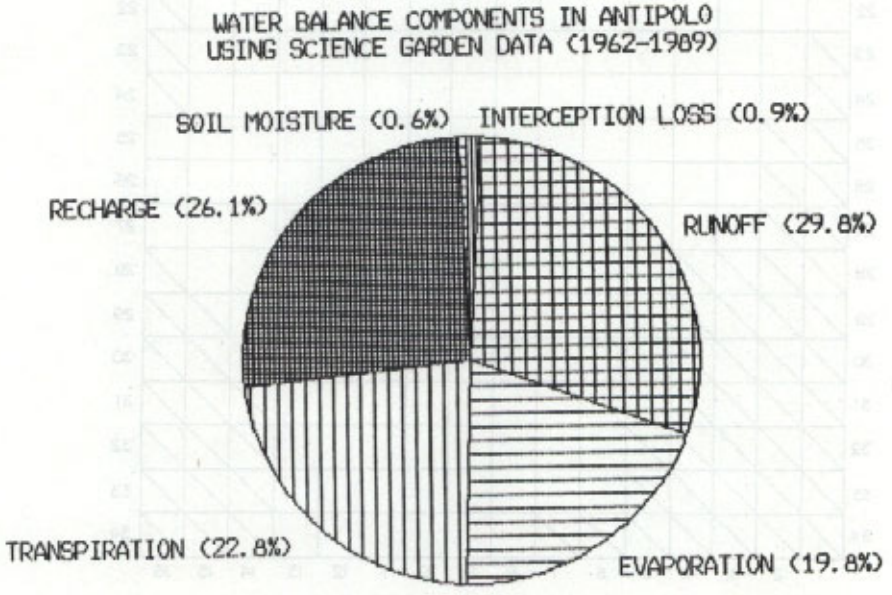
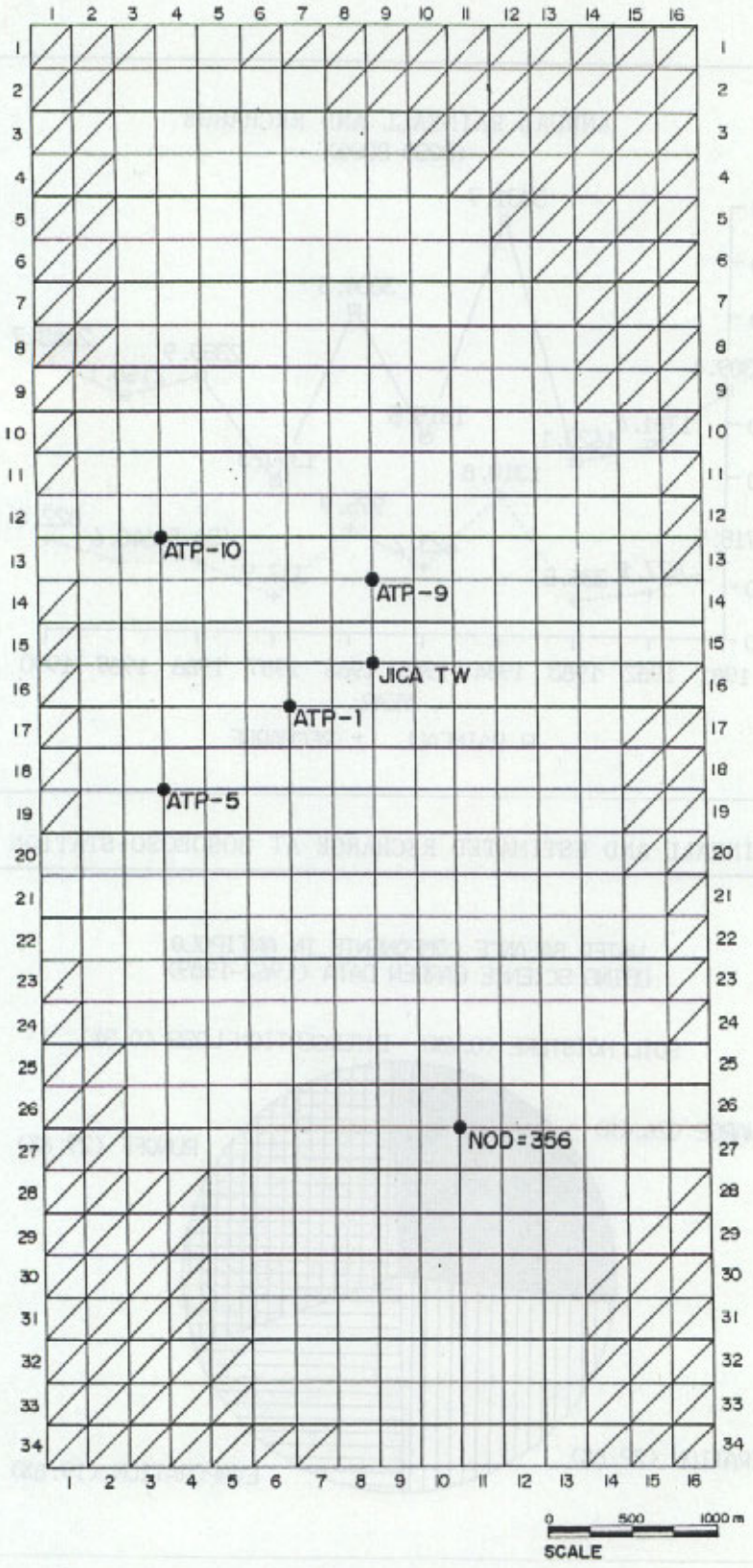


FIGURE 7.2.4
WATER BALANCE COMPONENTS IN ANTIPOLO BASIN
USING SCIENCE GARDEN DATA

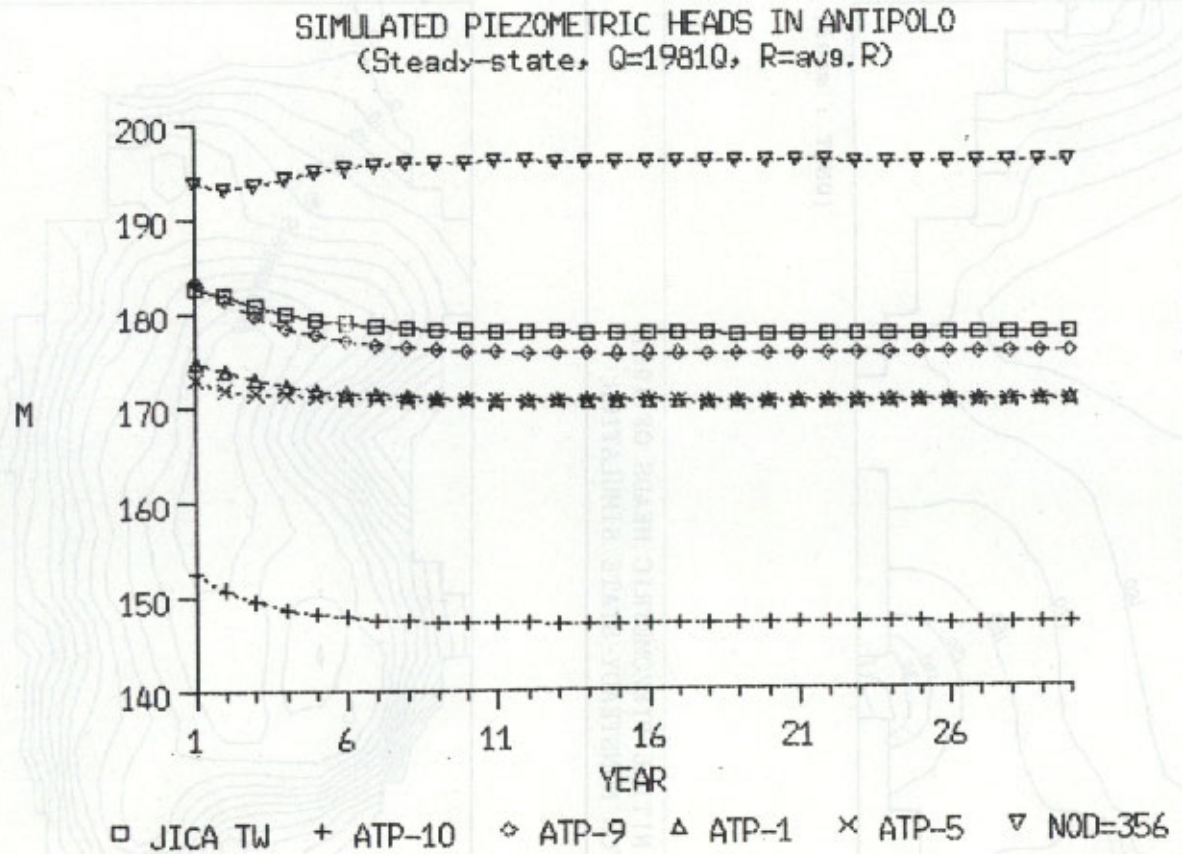


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.2.5

LOCATION OF OBSERVATION POINTS



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.2.6
JAPAN INTERNATIONAL COOPERATION AGENCY	30-STEP STEADY-STATE CALCULATION TO MAKE INITIAL HEADS OF 1981

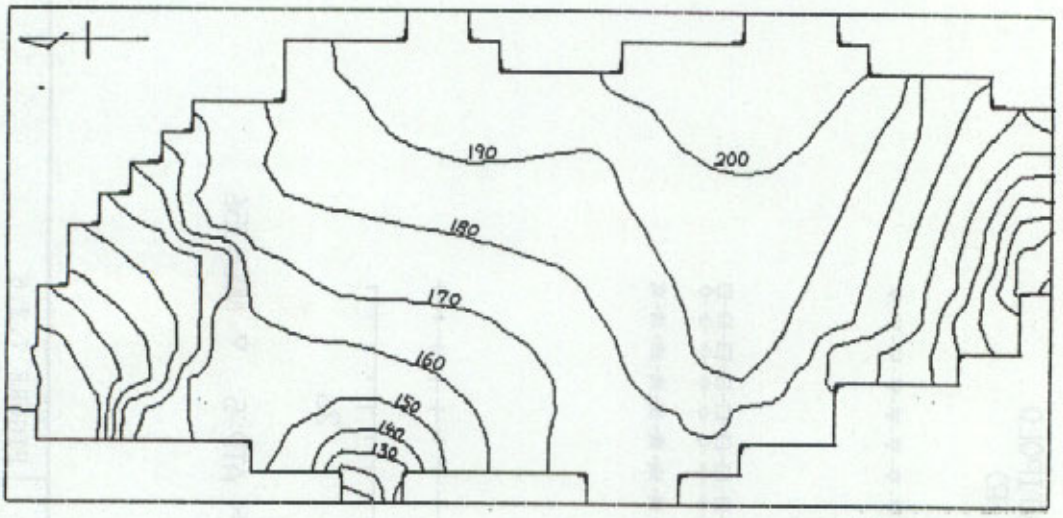


FIGURE 7.2.7 INITIAL PIEZOMETRIC HEADS OF 1981
FOR NONSTEADY-STATE SIMULATION

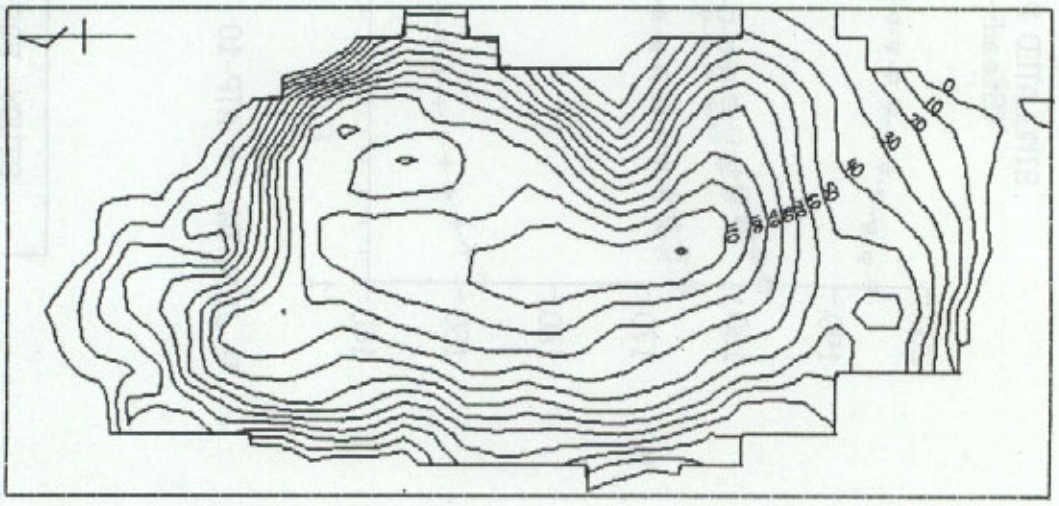
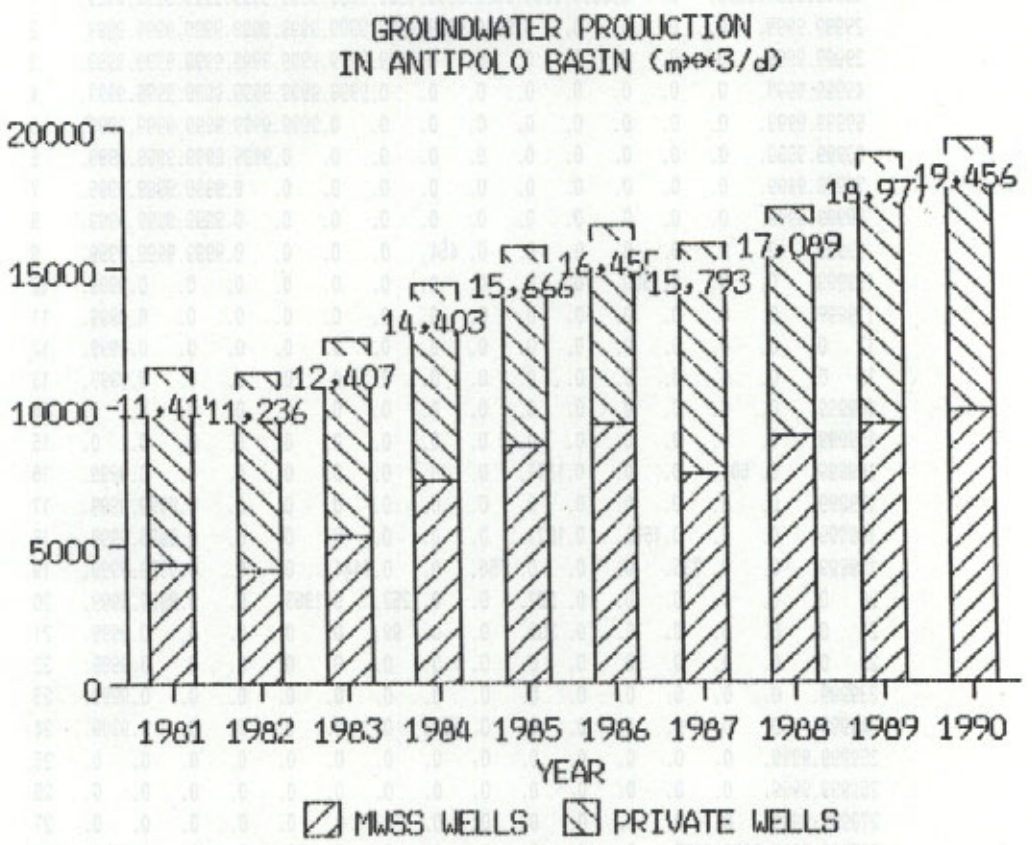


FIGURE 7.2.8
PIEZOMETRIC HEIGHTS FROM BOTTOM OF THE AQUIFER IN 1981

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	JAPAN INTERNATIONAL COOPERATION AGENCY



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.2.9 GROUNDWATER PRODUCTION IN THE ANTIPOLO BASIN (1981-1990)
JAPAN INTERNATIONAL COOPERATION AGENCY	

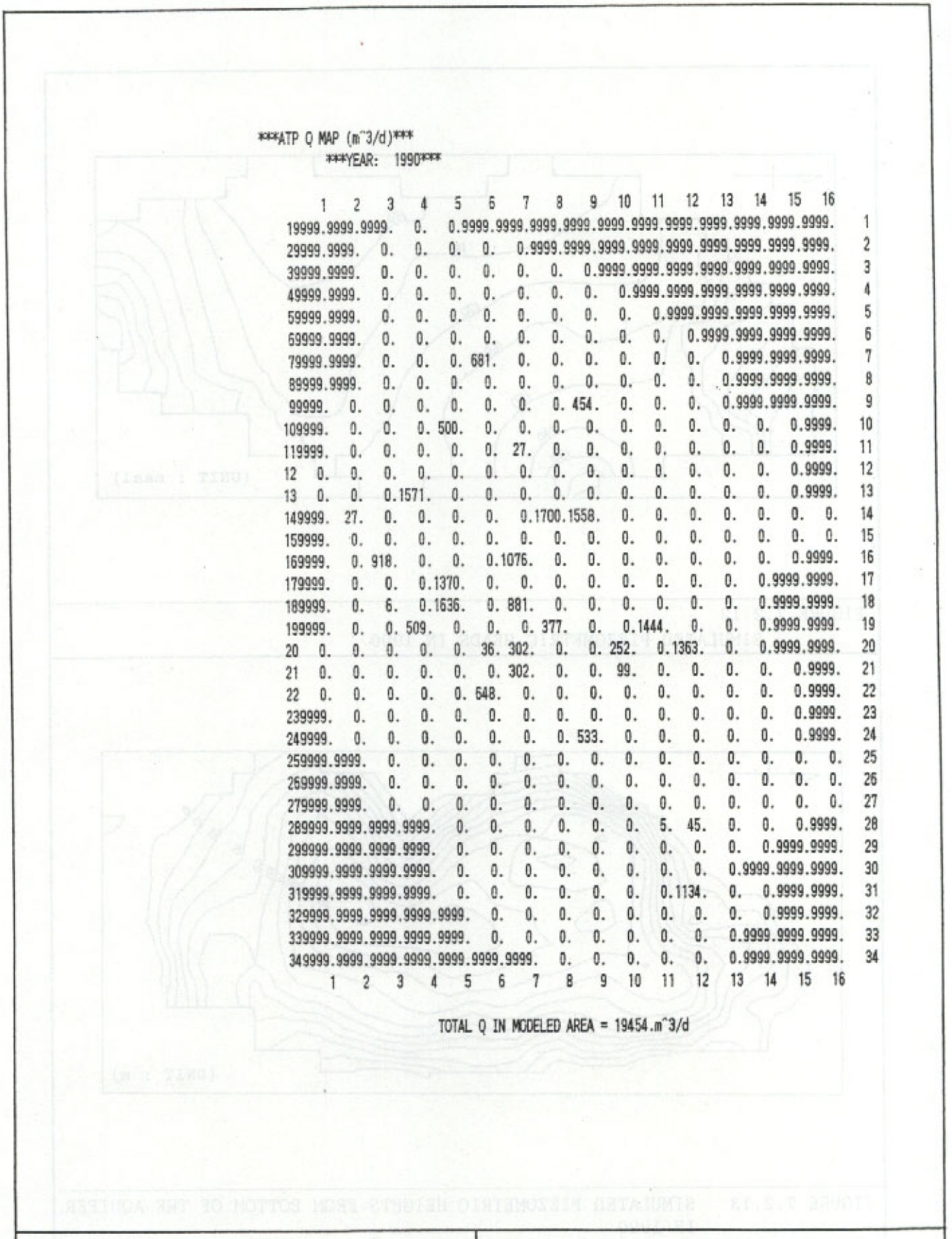
ATP Q MAP (m^3/d)

YEAR: 1981

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
19999.	9999.	9999.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	1
29999.	9999.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	2
39999.	9999.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	3
49999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	4
59999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	5
69999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	6
79999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	7
89999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	8
99999.	0.	0.	0.	0.	0.	0.	0.	454.	0.	0.	0.	0.	9999.	9999.	9999.	9
109999.	0.	0.	0.	500.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	10
119999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	11
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	12
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	13
149999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	14
159999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15
169999.	0.	601.	0.	0.	1377.	0.	0.	0.	0.	0.	0.	0.	0.	9999.		16
179999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.		17
189999.	0.	6.	1636.	0.	1021.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.		18
199999.	0.	735.	0.	0.	0.	756.	0.	0.	1444.	0.	0.	9999.	9999.			19
20	0.	0.	0.	0.	0.	302.	0.	0.	252.	0.	1363.	0.	9999.	9999.		20
21	0.	0.	0.	0.	0.	302.	0.	0.	99.	0.	0.	0.	0.	9999.		21
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.		22
239999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.		23
249999.	0.	0.	0.	0.	0.	0.	533.	0.	0.	0.	0.	0.	0.	9999.		24
259999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	25
269999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	26
279999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	27
289999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	38.	0.	0.	9999.		28
299999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.		29
309999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.		30
319999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.		31
329999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.		32
339999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.		33
349999.	9999.	9999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	9999.	9999.	9999.		34
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	

TOTAL Q IN MODELED AREA = 11419.m^3/d

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.2.10 DISCHARGE MAP IN 1981
JAPAN INTERNATIONAL COOPERATION AGENCY	



ATP Q MAP (m^3/d)
YEAR: 1990

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	9999.	9999.	9999.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	1
2	9999.	9999.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	2
3	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	3
4	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	4
5	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	5
6	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	6
7	9999.	9999.	0.	0.	0.	681.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	7
8	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	8
9	9999.	0.	0.	0.	0.	0.	0.	0.	454.	0.	0.	0.	0.	9999.	9999.	9999.	9
10	9999.	0.	0.	0.	500.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	10
11	9999.	0.	0.	0.	0.	0.	27.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	11
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	12
13	0.	0.	0.	1571.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	13
14	9999.	27.	0.	0.	0.	0.	0.	1700.	1558.	0.	0.	0.	0.	0.	0.	0.	14
15	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15
16	9999.	0.	918.	0.	0.	0.	1076.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	16
17	9999.	0.	0.	0.	1370.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	17
18	9999.	0.	6.	0.	1636.	0.	881.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	18
19	9999.	0.	0.	509.	0.	0.	0.	377.	0.	0.	1444.	0.	0.	0.	9999.	9999.	19
20	0.	0.	0.	0.	0.	36.	302.	0.	0.	252.	0.	1363.	0.	0.	9999.	9999.	20
21	0.	0.	0.	0.	0.	0.	302.	0.	0.	99.	0.	0.	0.	0.	0.	9999.	21
22	0.	0.	0.	0.	0.	648.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	22
23	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	23
24	9999.	0.	0.	0.	0.	0.	0.	0.	533.	0.	0.	0.	0.	0.	0.	9999.	24
25	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	25
26	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	26
27	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	27
28	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	5.	45.	0.	0.	0.	9999.	28
29	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	29
30	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	30
31	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	1134.	0.	0.	9999.	9999.	31
32	9999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	32
33	9999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	33
34	9999.	9999.	9999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	34
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	

TOTAL Q IN MODELED AREA = 19454.m^3/d

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.2.11
DISCHARGE MAP IN 1990

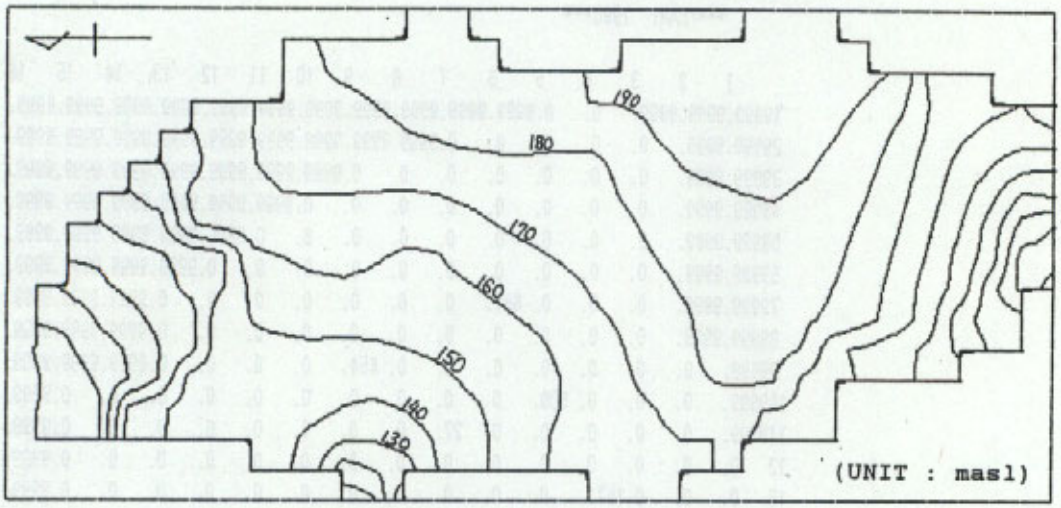


FIGURE 7.2.12
SIMULATED PIEZOMETRIC HEADS IN 1990

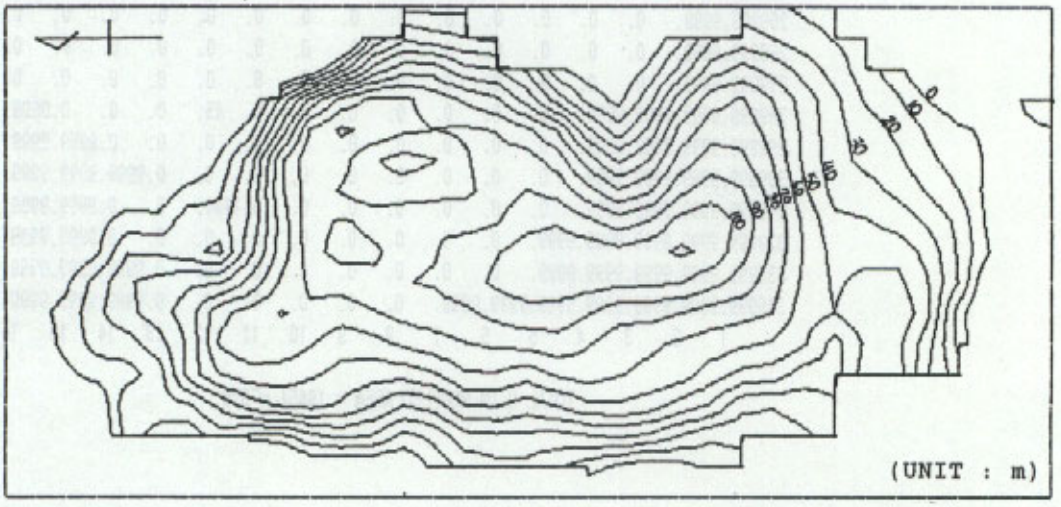
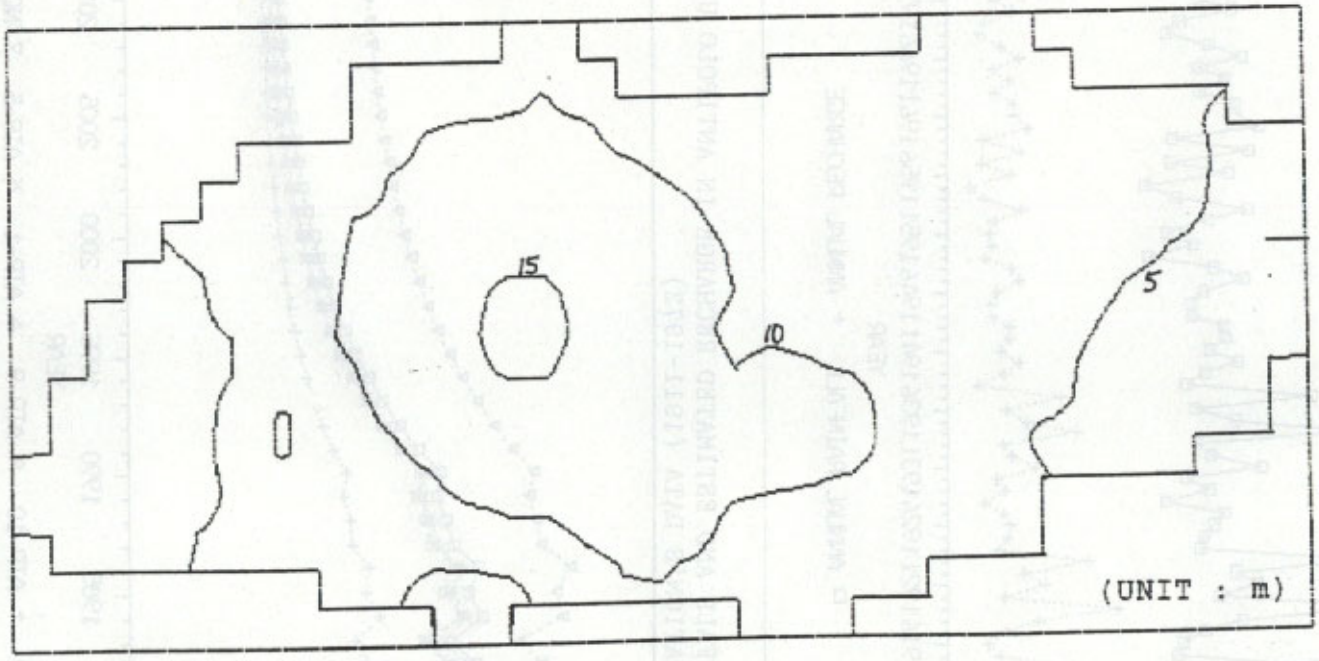


FIGURE 7.2.13 SIMULATED PIEZOMETRIC HEIGHTS FROM BOTTOM OF THE AQUIFER IN 1990

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	JAPAN INTERNATIONAL COOPERATION AGENCY



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.2.14 SIMULATED DRAWDOWN FROM 1981 TO 1990
JAPAN INTERNATIONAL COOPERATION AGENCY	

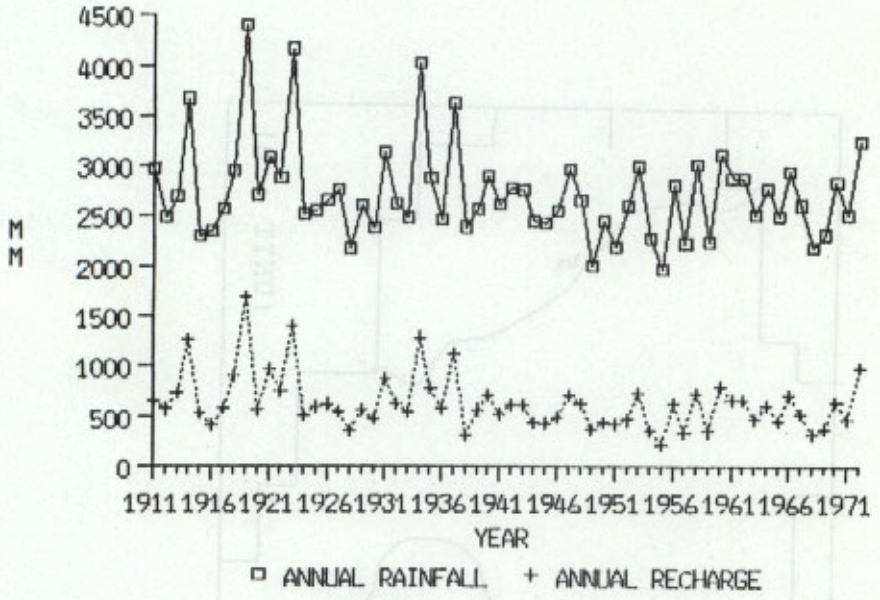


FIGURE 7.2.15
ANNUAL RAINFALL AND ESTIMATED RECHARGE IN ANTIPOLO USING SUMULONG STATION'S DATA (1911-1972)

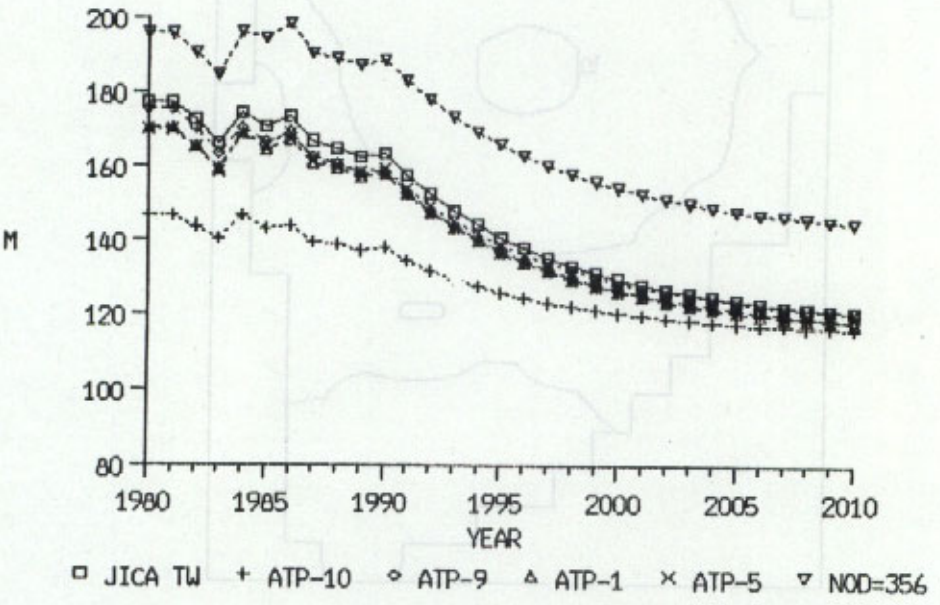


FIGURE 7.2.16
SIMULATED PIEZOMETRIC HEADS (Discharge from 1991 to 2010 = Discharge of 1990)

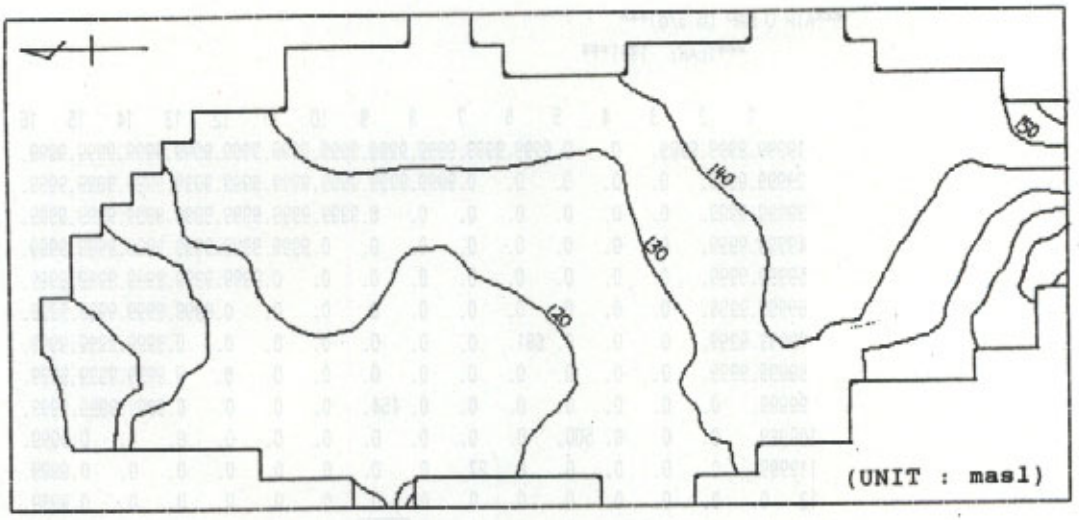


FIGURE 7.2.17
SIMULATED PIEZOMETRIC HEADS IN 2010 (Discharge from 1991 to 2010 = Discharge of 1990)

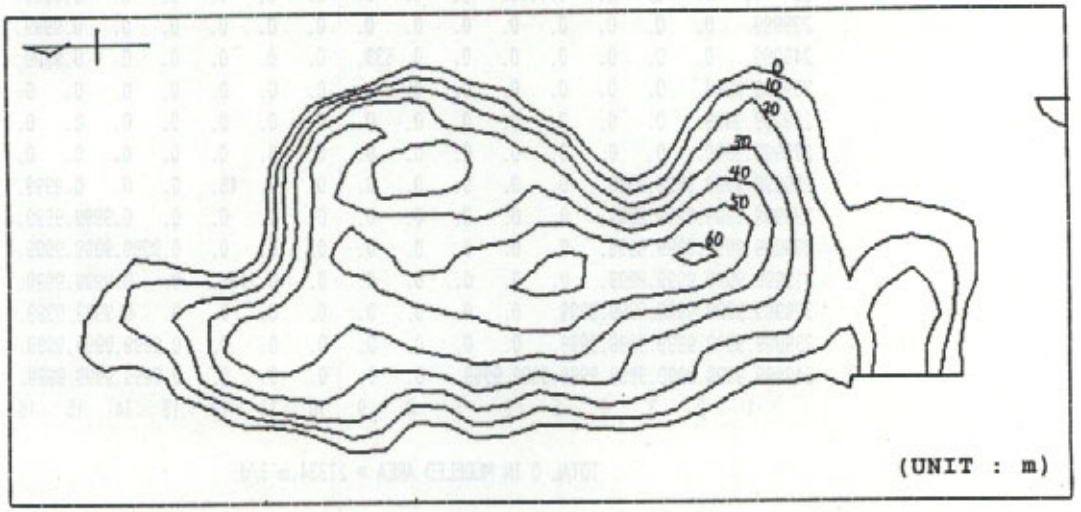


FIGURE 7.2.18 SIMULATED PIEZOMETRIC HEIGHTS FROM BOTTOM OF THE AQUIFER 2010 IN 2010 (Discharge from 1991 to 2010 = Discharge of 1990)

ATP Q MAP (m^3/d)

YEAR: 1991

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	9999.	9999.	9999.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	1
2	9999.	9999.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	2
3	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	9999.	3
4	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	9999.	4
5	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	9999.	5
6	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	9999.	6
7	9999.	9999.	0.	0.	0.	681.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	7
8	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	8
9	9999.	0.	0.	0.	0.	0.	0.	0.	454.	0.	0.	0.	0.	9999.	9999.	9999.	9
10	9999.	0.	0.	0.	500.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	10
11	9999.	0.	0.	0.	0.	0.	27.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	11
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	12
13	0.	0.	0.	1778.	0.	0.	0.	0.	[830.]	0.	0.	0.	0.	0.	0.	9999.	13
14	9999.	27.	0.	0.	0.	0.	[830.]	1907.	1765.	0.	0.	0.	0.	0.	0.	0.	14
15	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15
16	9999.	0.	1125.	0.	0.	0.	1490.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	16
17	9999.	0.	0.	0.	1577.	0.	[830.]	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	17
18	9999.	0.	6.	0.	1636.	0.	1088.	[830.]	0.	0.	0.	0.	0.	0.	9999.	9999.	18
19	9999.	0.	0.	716.	0.	0.	0.	584.	0.	0.	1444.	0.	0.	0.	9999.	9999.	19
20	0.	0.	0.	0.	0.	0.	36.	[1132.]	[830.]	0.	252.	0.	1363.	0.	0.	9999.	20
21	0.	0.	0.	0.	0.	0.	0.	302.	[830.]	0.	99.	0.	0.	0.	0.	9999.	21
22	0.	0.	0.	0.	0.	0.	648.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	22
23	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	23
24	9999.	0.	0.	0.	0.	0.	0.	0.	533.	0.	0.	0.	0.	0.	0.	9999.	24
25	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	25
26	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	26
27	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	27
28	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	5.	45.	0.	0.	0.	9999.	28
29	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	29
30	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	30
31	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	1134.	0.	0.	9999.	9999.	31
32	9999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	32
33	9999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	33
34	9999.	9999.	9999.	9999.	9999.	9999.	9999.	0.	0.	0.	0.	0.	0.	9999.	9999.	9999.	34
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	

TOTAL Q IN MODELED AREA = 27334.m^3/d

□ : Location of New MWSS Wells

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.2.19 OPTIMAL DISCHARGE PLAN IN ANTIPOLO BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	

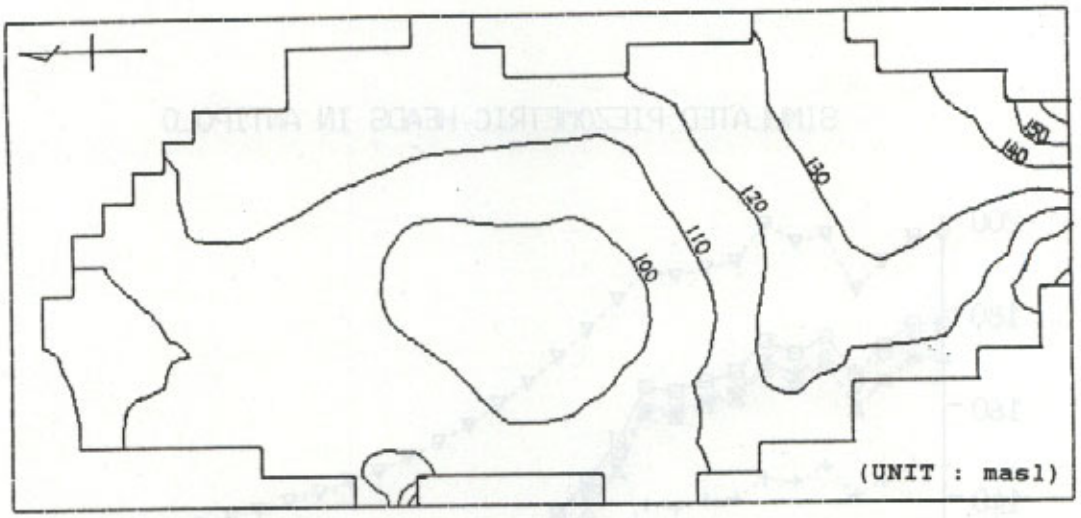


FIGURE 7.2.20
SIMULATED PIEZOMETRIC HEADS IN 2010 (Discharge from 1991 to 2010 = Optimal Plan)

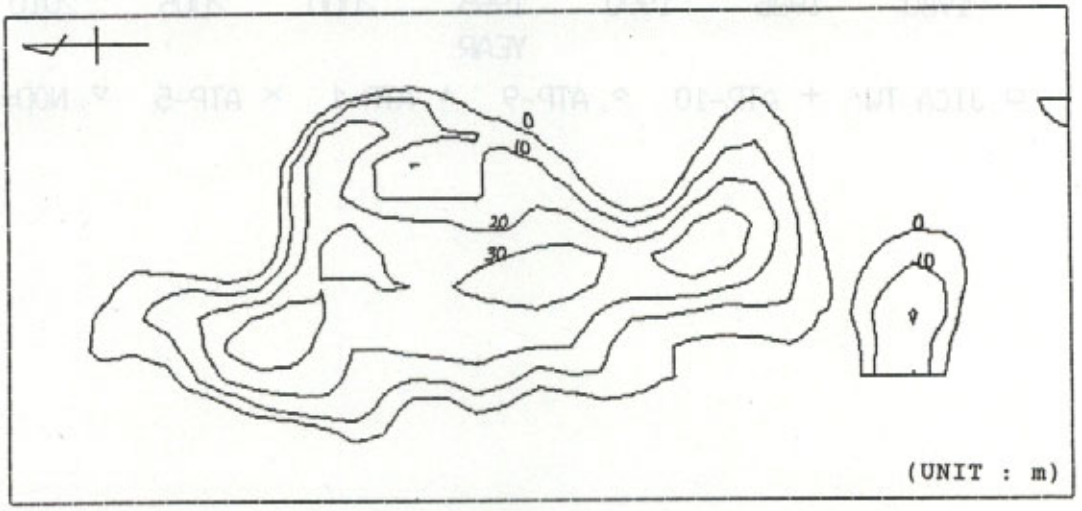
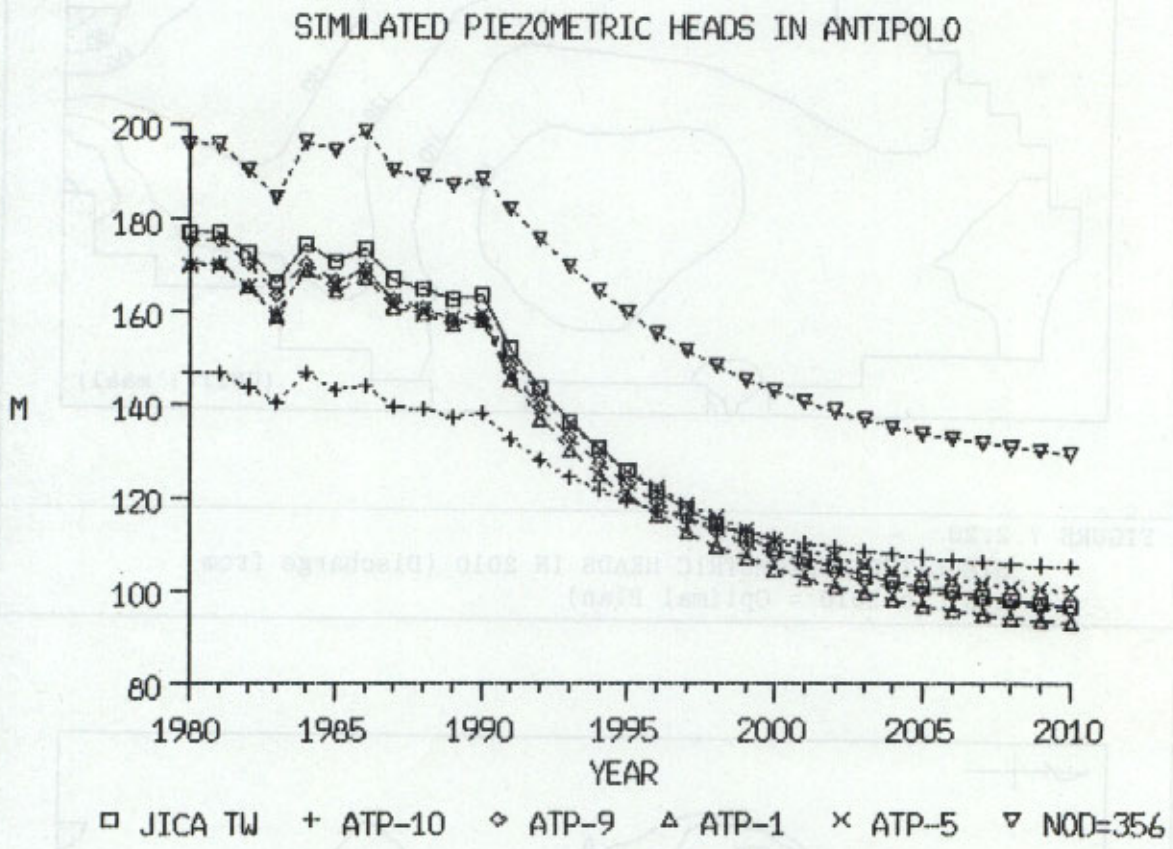
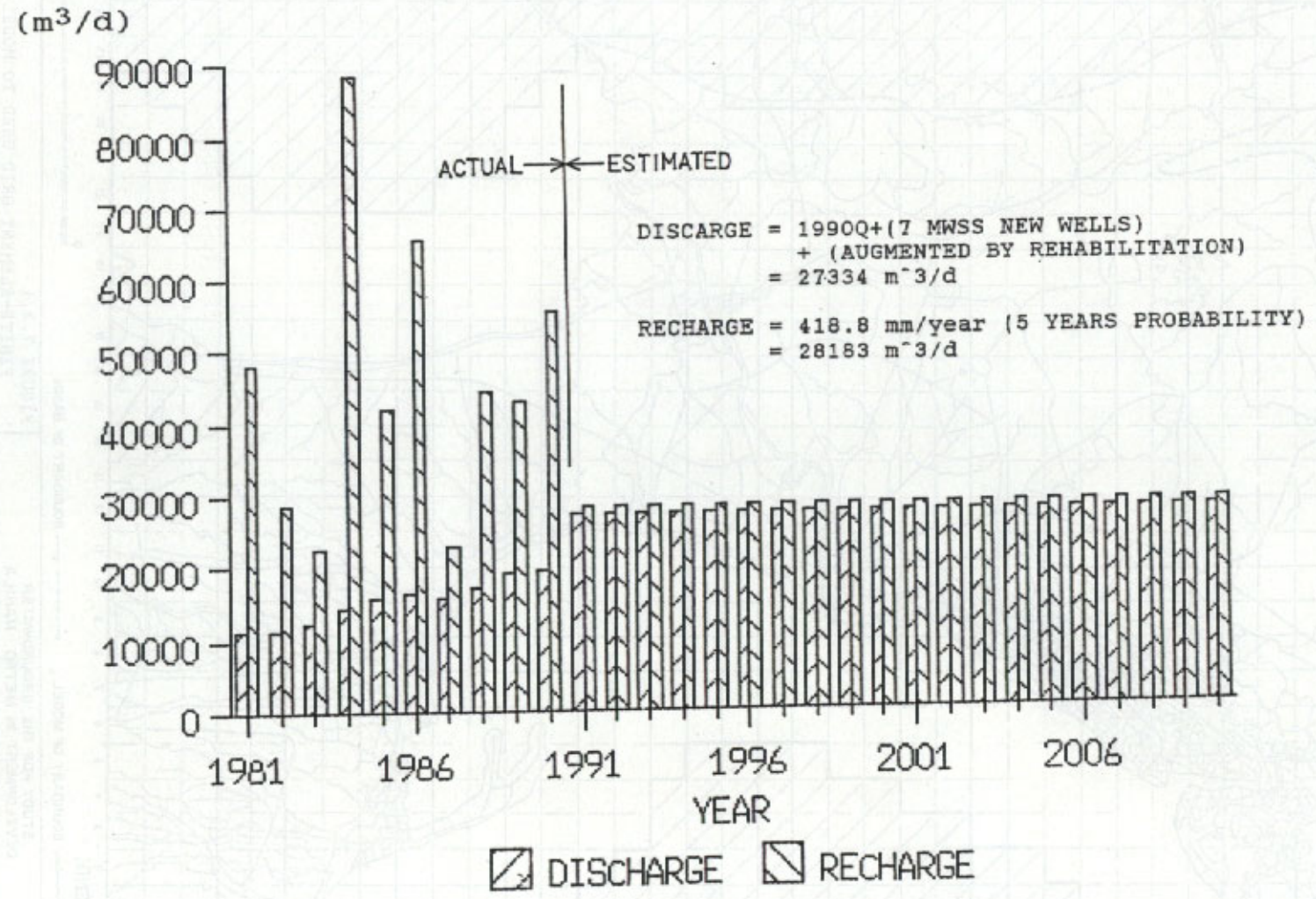


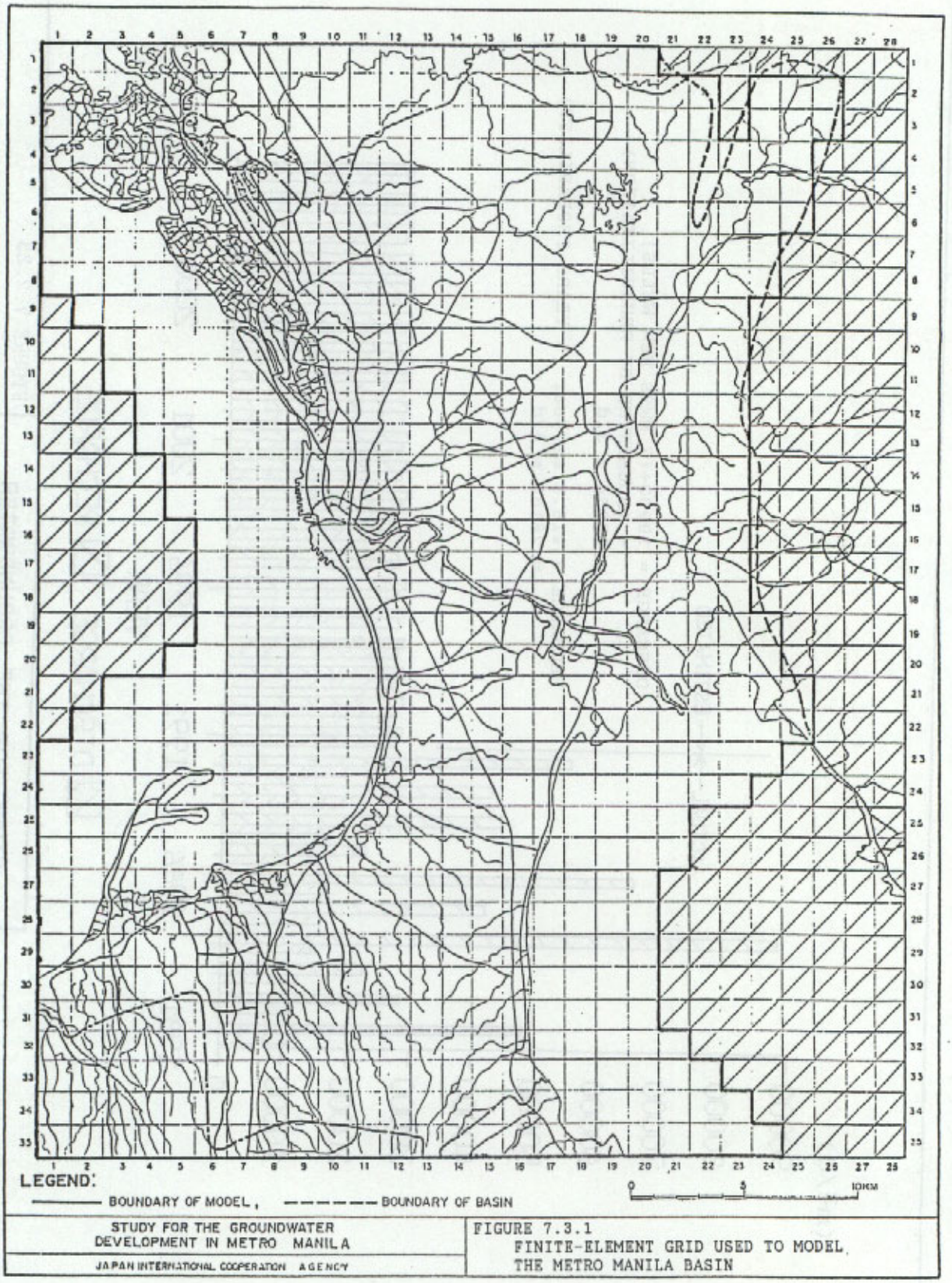
FIGURE 7.2.21
SIMULATED PIEZOMETRIC HEIGHTS FROM BOTTOM OF THE AQUIFER IN 2010 (Discharge from 1991 to 2010 = Optimal Plan)



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.2.22 SIMULATED PIEZOMETRIC HEADS (Discharge from 1991 to 2010 = Optimal Plan)
JAPAN INTERNATIONAL COOPERATION AGENCY	



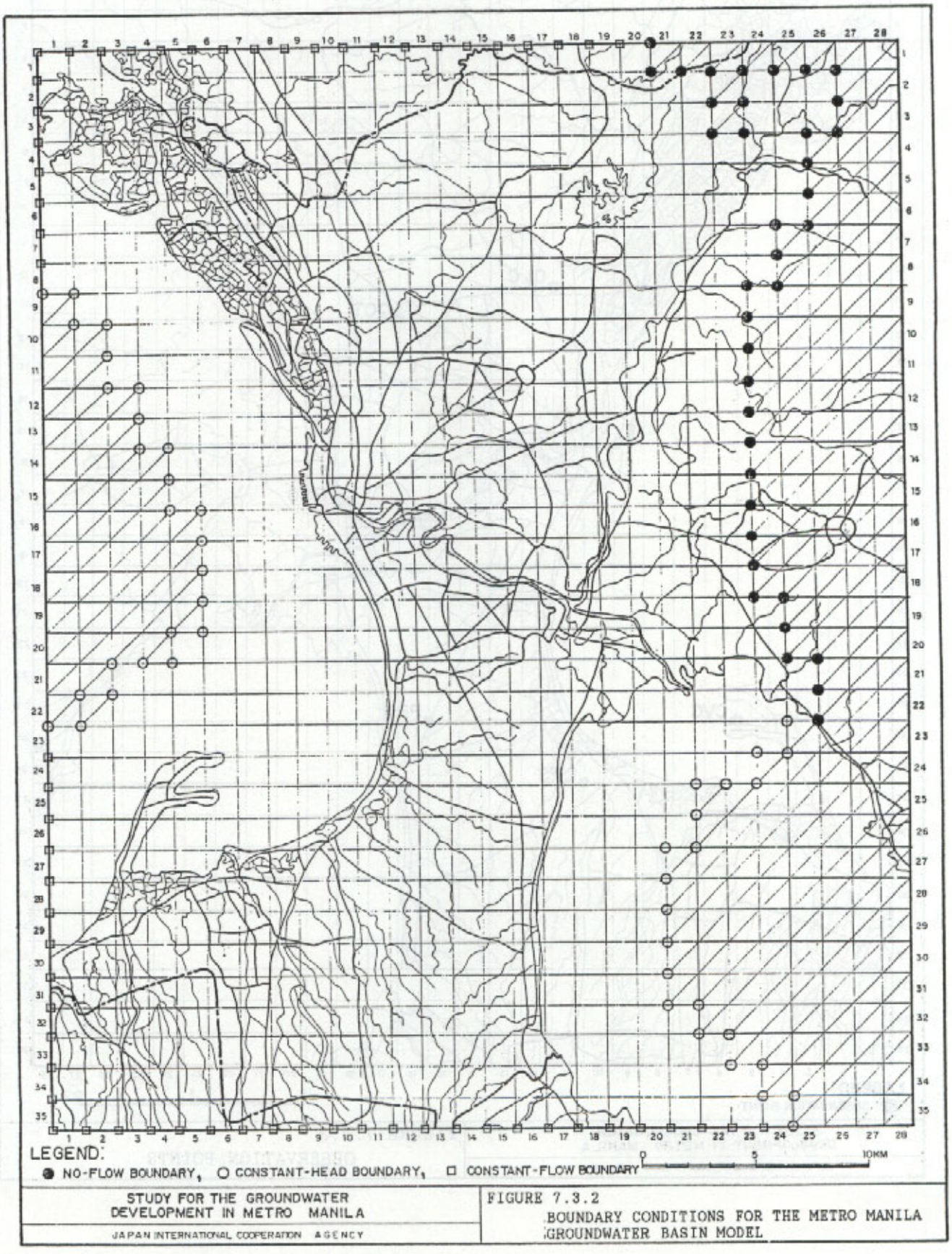
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.2.23 OPTIMAL DISCHARGE AND RECHARGE PLAN IN THE ANTIPOLO BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	



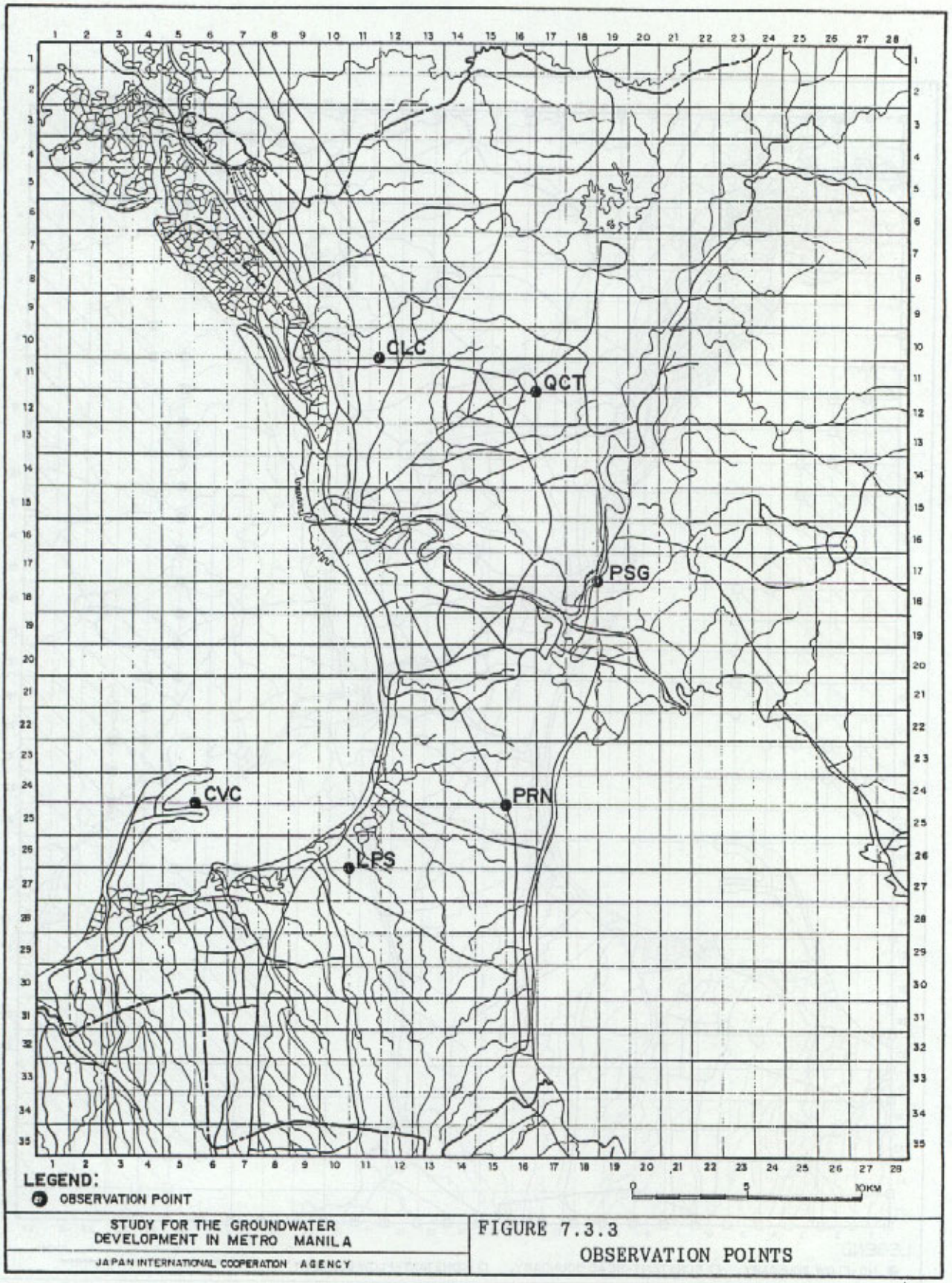
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.1
FINITE-ELEMENT GRID USED TO MODEL THE METRO MANILA BASIN



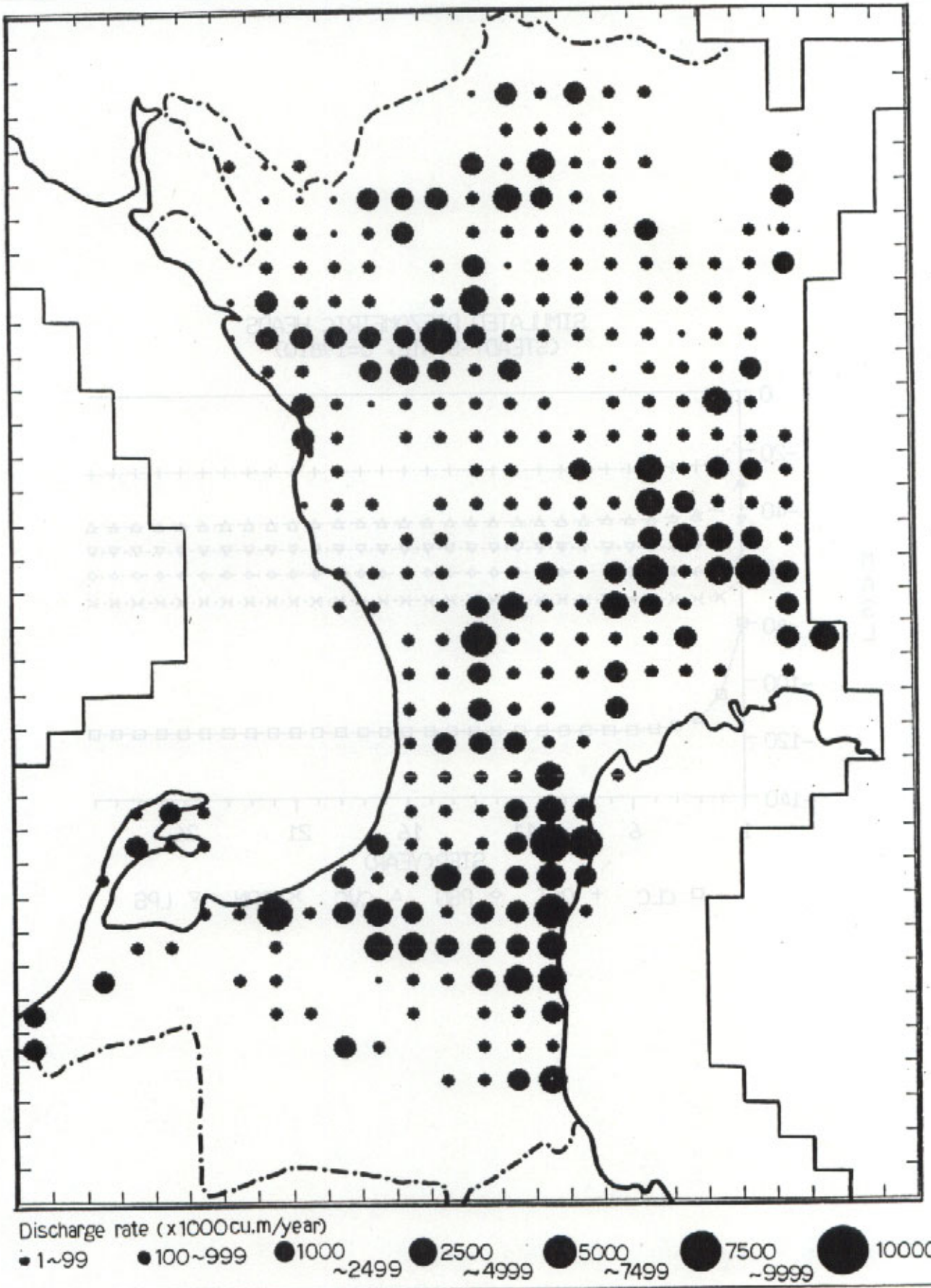
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 7.3.2 BOUNDARY CONDITIONS FOR THE METRO MANILA GROUNDWATER BASIN MODEL



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

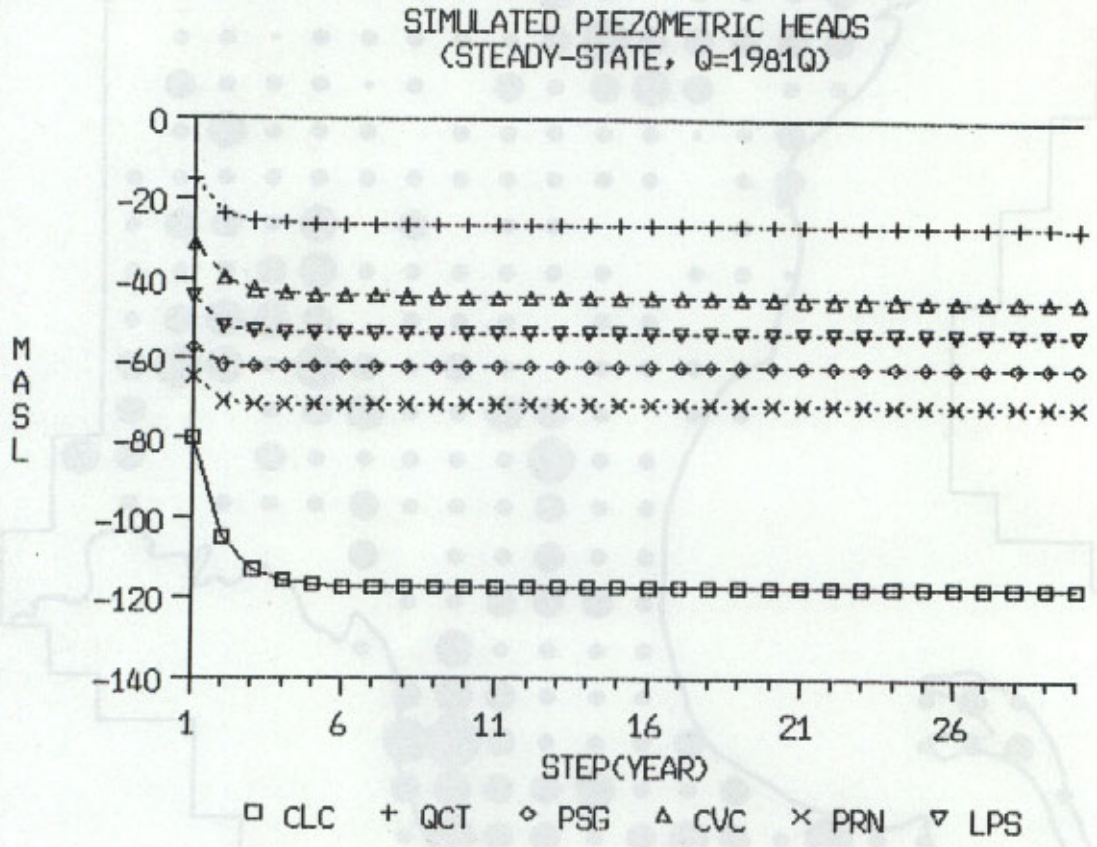
FIGURE 7.3.3
OBSERVATION POINTS



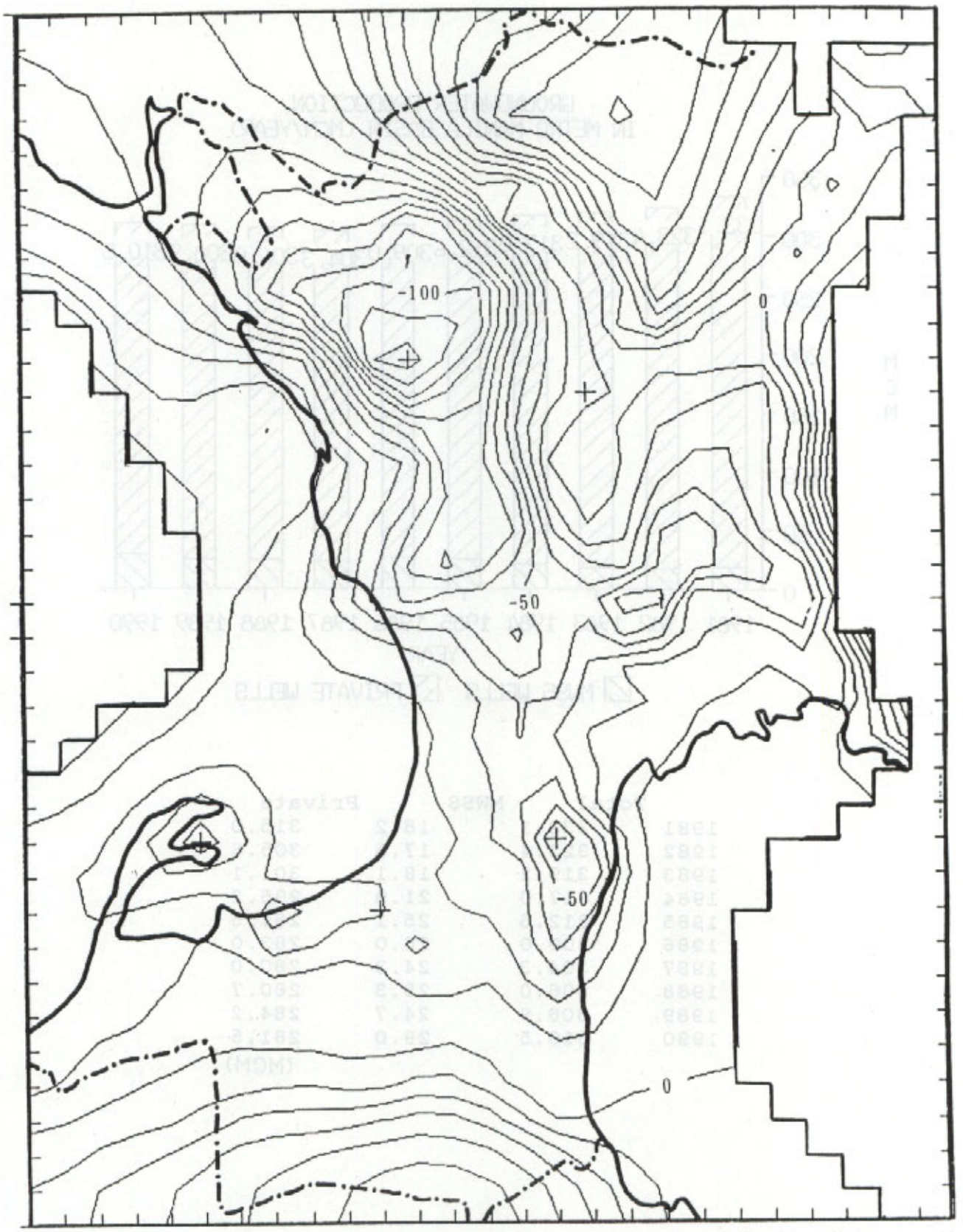
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.4
DISCHARGE DISTRIBUTION IN 1981

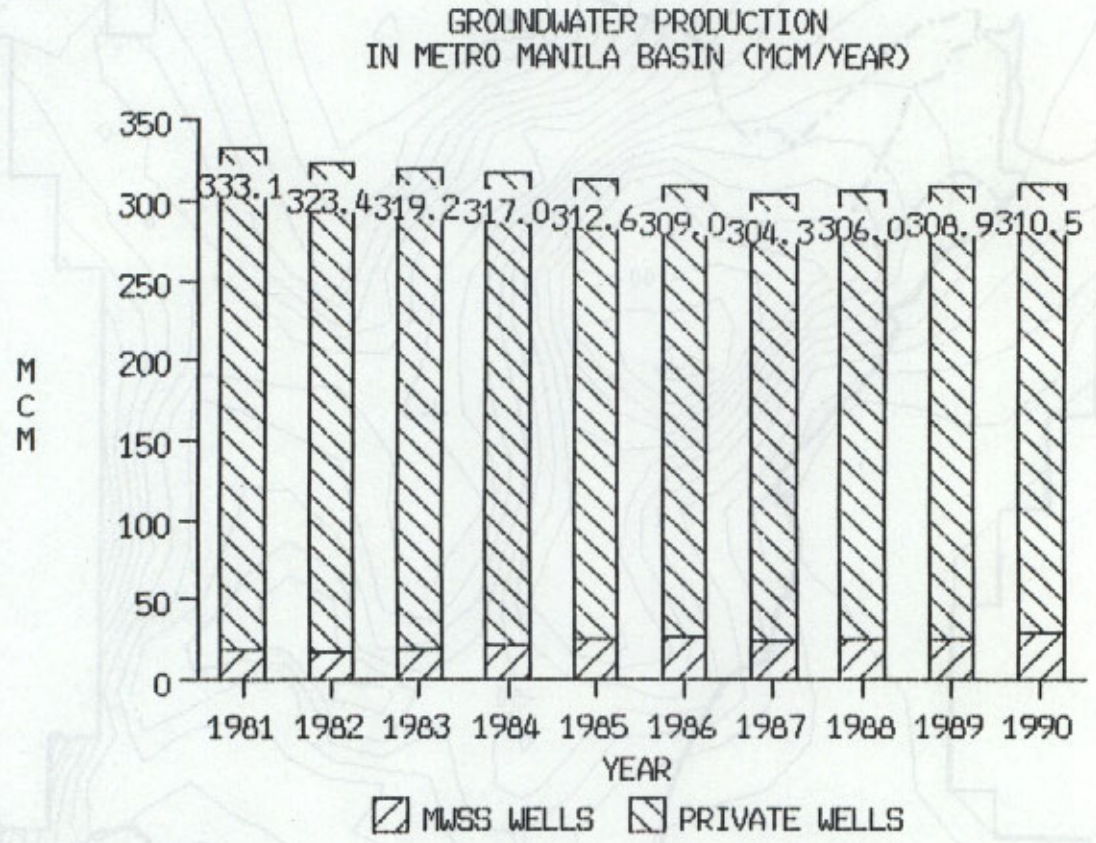


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.5 SIMULATED PIEZOMETRIC HEADS (30-STEP STEADY-STATE CALUCULATION)
JAPAN INTERNATIONAL COOPERATION AGENCY	



(Contour Interval: 10m, Unit: masl)

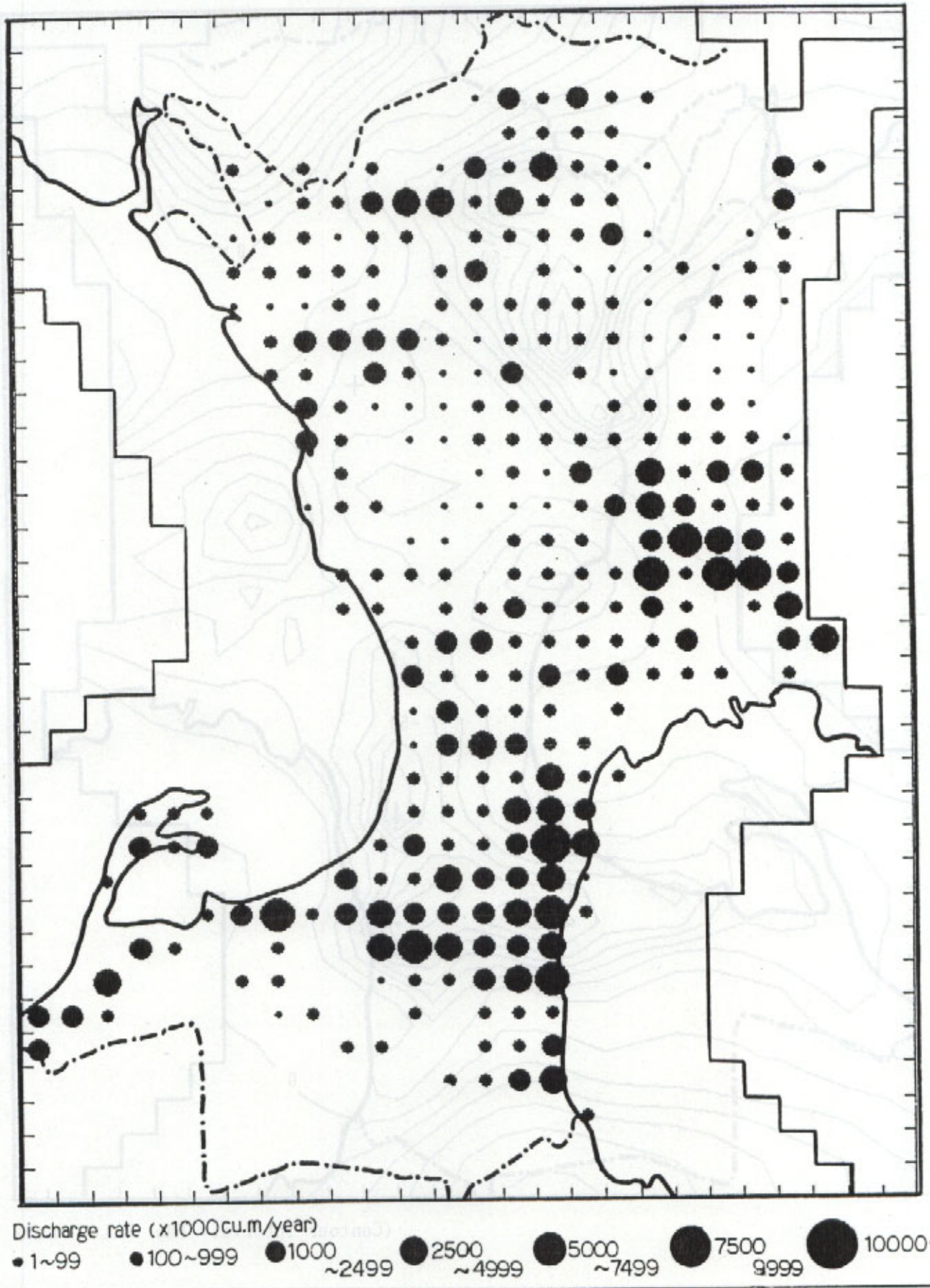
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 7.3.6 SIMULATED PIEZOMETRIC HEADS IN 1981



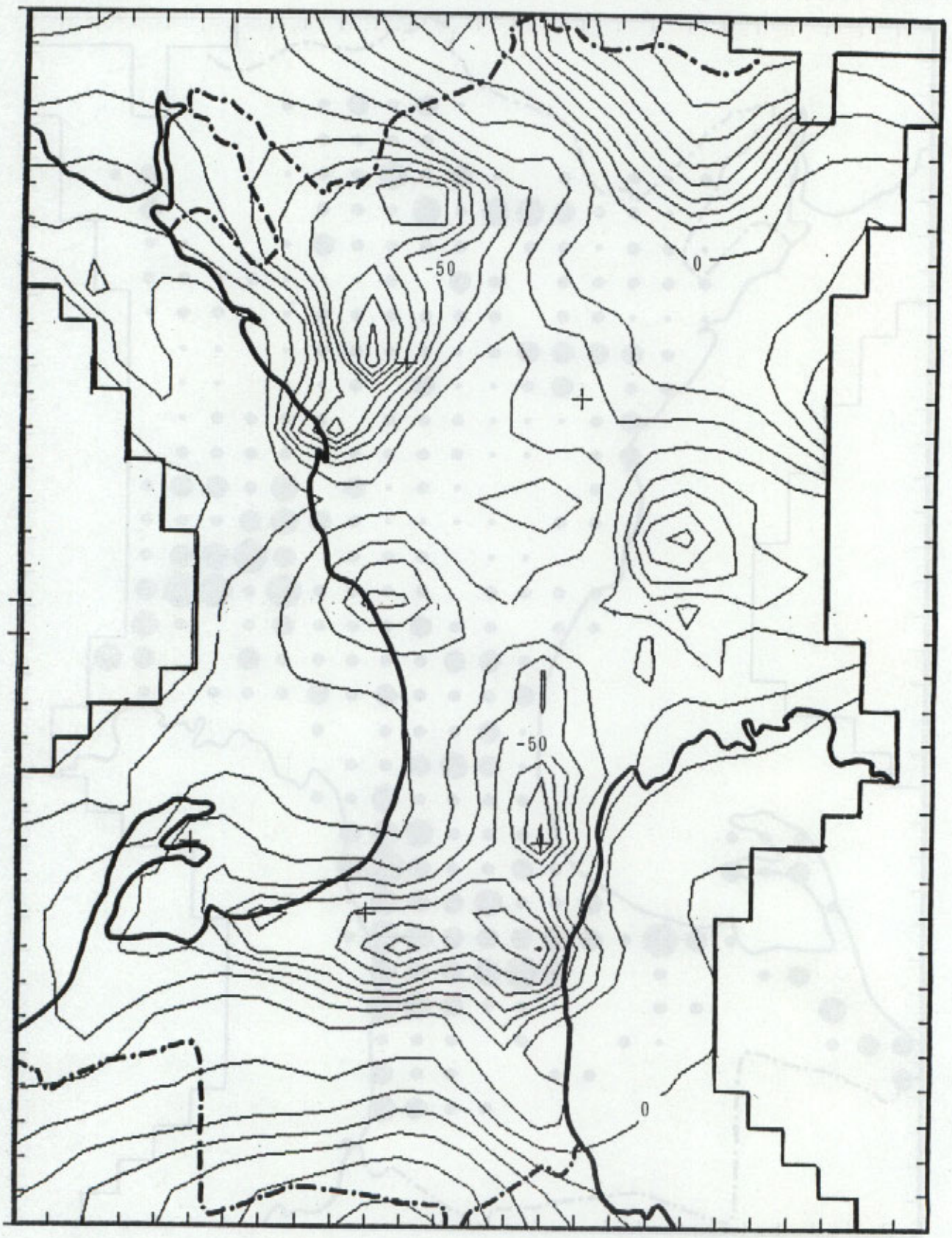
	Total	MWSS	Private
1981	333.1	18.2	315.0
1982	323.4	17.6	305.8
1983	319.2	18.1	301.1
1984	317.0	21.9	295.2
1985	312.6	25.1	287.5
1986	309.0	26.0	283.0
1987	304.3	24.3	280.0
1988	306.0	25.3	280.7
1989	308.9	24.7	284.2
1990	310.5	29.0	281.5

(MCM)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.7 GROUNDWATER PRODUCTION IN THE METRO MANILA BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	

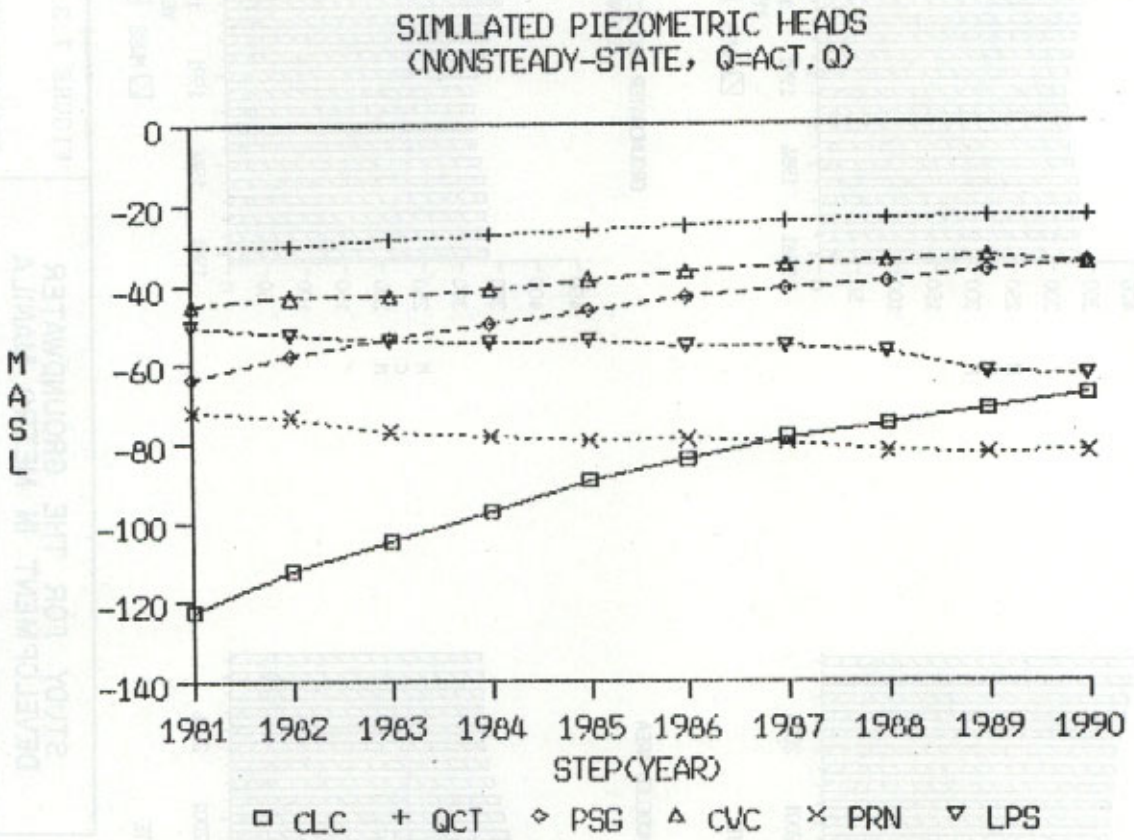


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.8
JAPAN INTERNATIONAL COOPERATION AGENCY	DISCHARGE DISTRIBUTION IN 1990

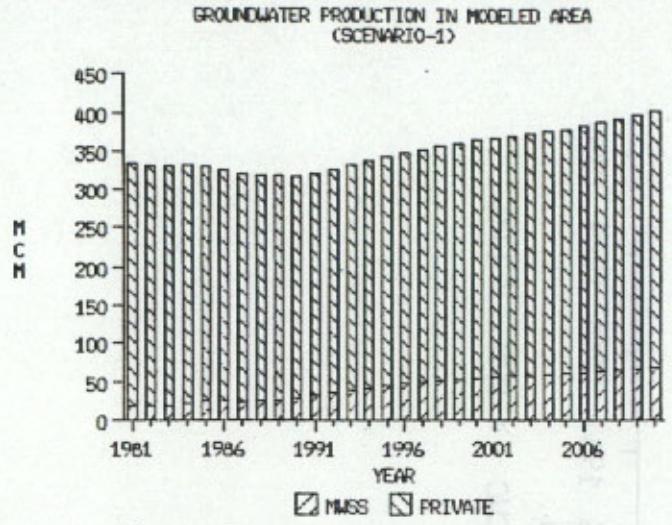


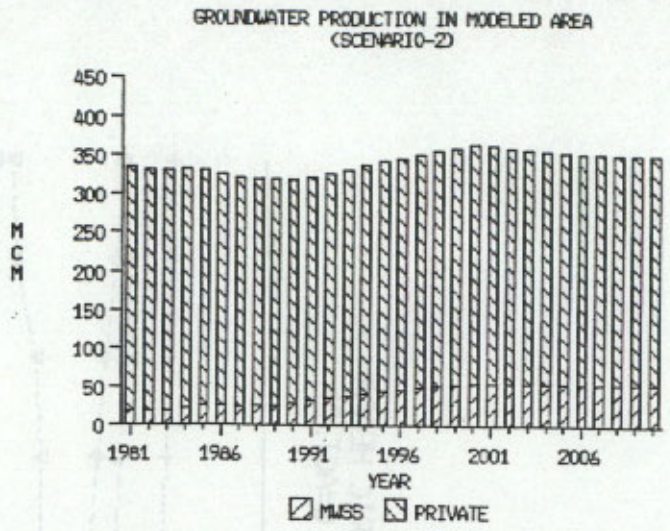
(Contour Interval: 10m, Unit: masl)

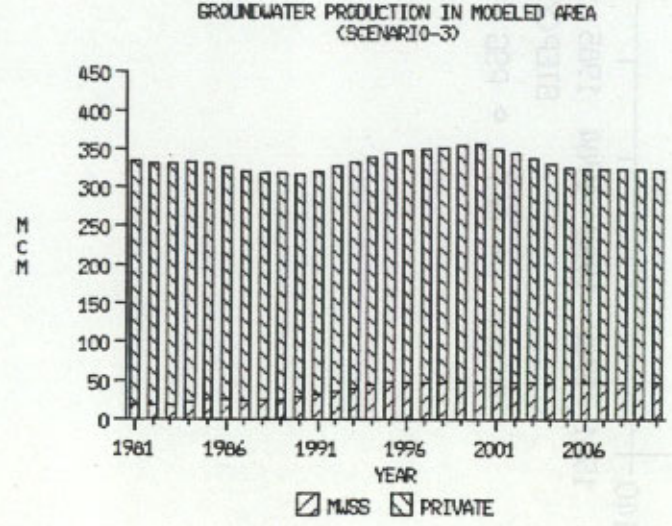
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 7.3.9 SIMULATED PIEZOMETRIC HEADS IN 1990

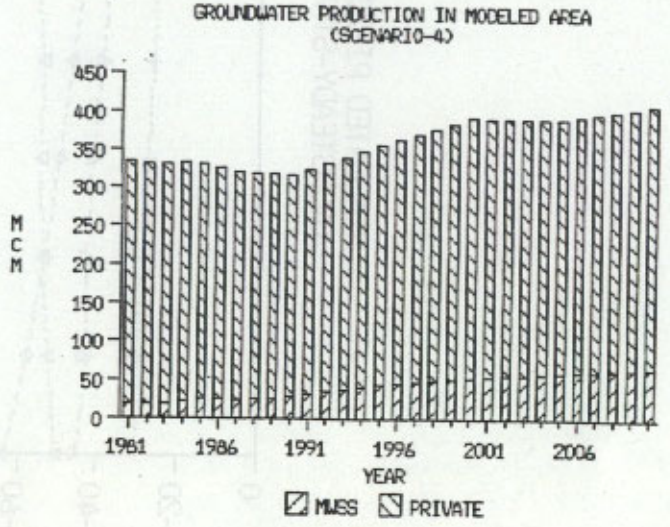


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 7.3.10 SIMULATED PIEZOMETRIC HEADS BY NONSTEADY-STATE CALCULATION

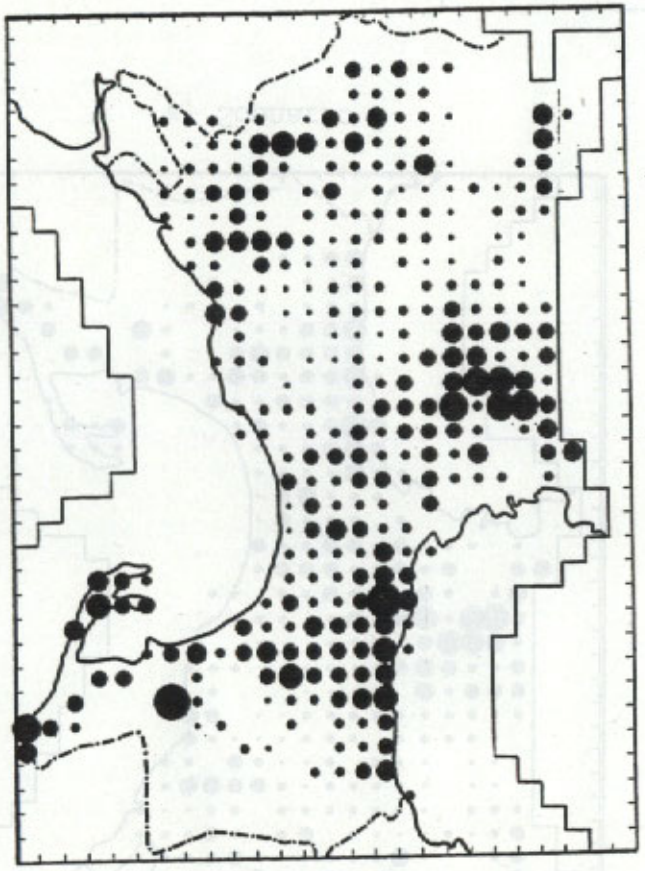




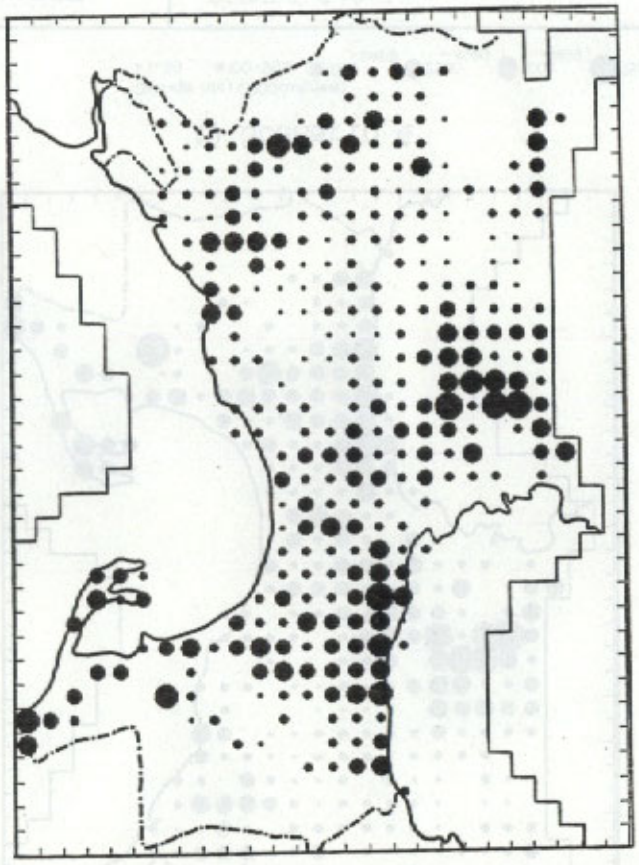




STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.11
JAPAN INTERNATIONAL COOPERATION AGENCY	GROUNDWATER PRODUCTION OF EACH SCENARIO



a) Scenario 1



b) Scenario 2

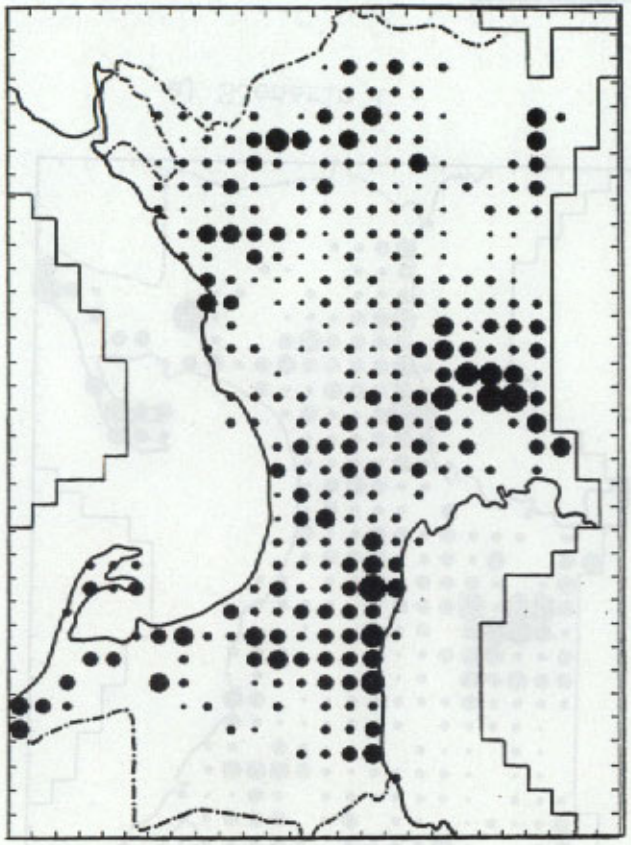
Discharge rate (x1000cum/year)
1~99 100~999 1000~2499 2500~4999 5000~7499 7500~9999 10000~

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

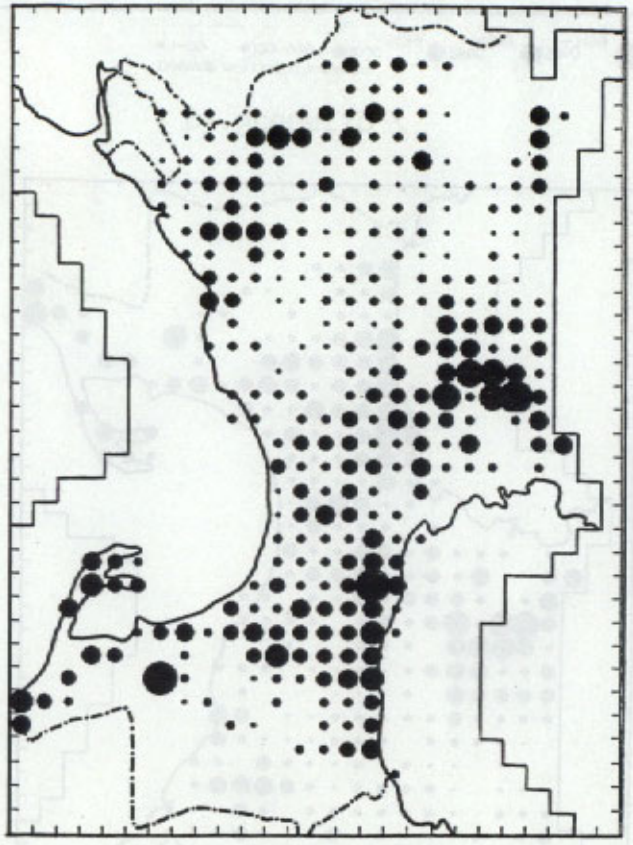
JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.12

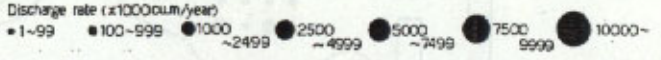
DISCHARGE DISTRIBUTION IN 2010
(Scenario 1, Scenario 2)



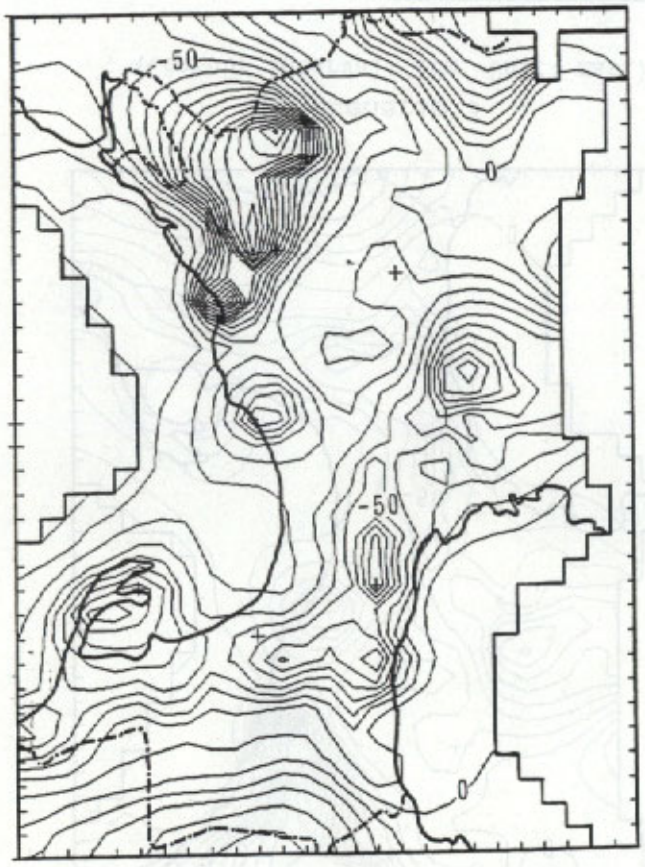
a) Scenario 3



b) Scenario 4

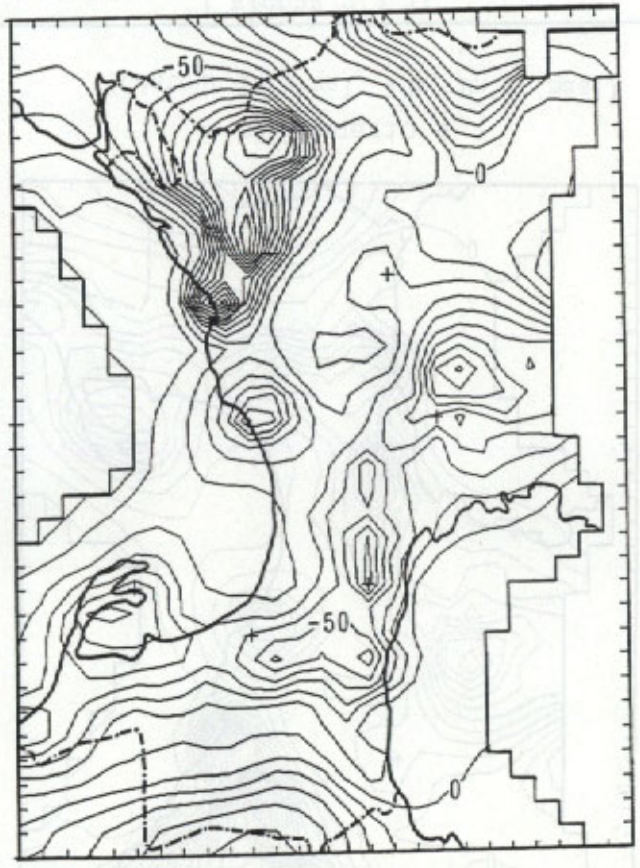


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.13
JAPAN INTERNATIONAL COOPERATION AGENCY	DISCHARGE DISTRIBUTION IN 2010 (Scenario 3, Scenario 4)



a) Scenario 1

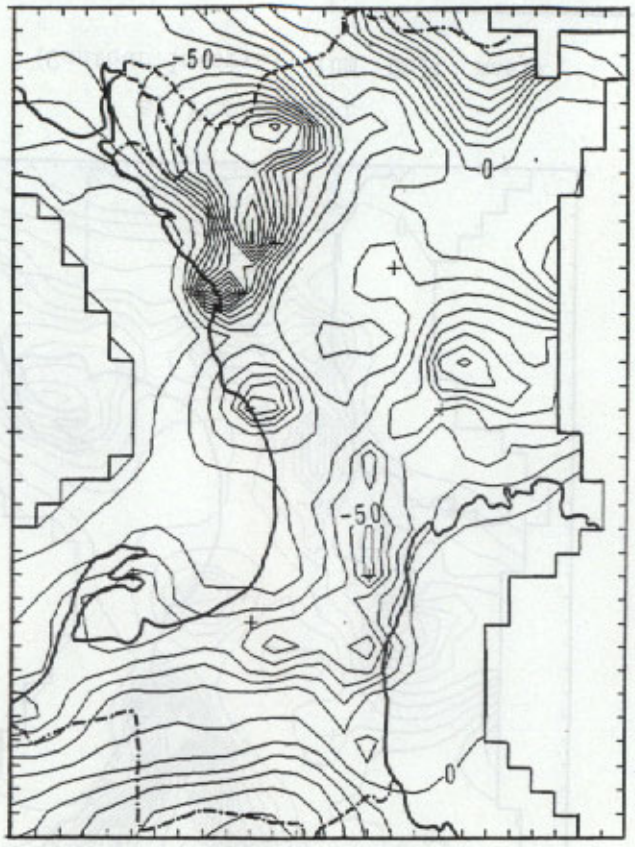
(Contour Interval: 10m, Unit: masl)



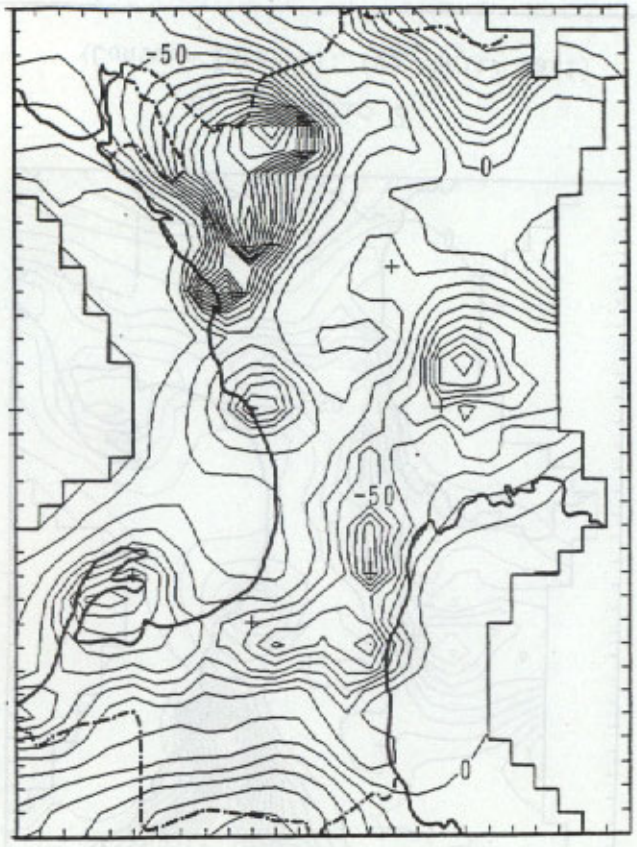
b) Scenario 2

(Contour Interval: 10m, Unit: masl)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.14 SIMULATED PIEZOMETRIC HEADS IN 2010 (Scenario 1, Scenario 2)
JAPAN INTERNATIONAL COOPERATION AGENCY	

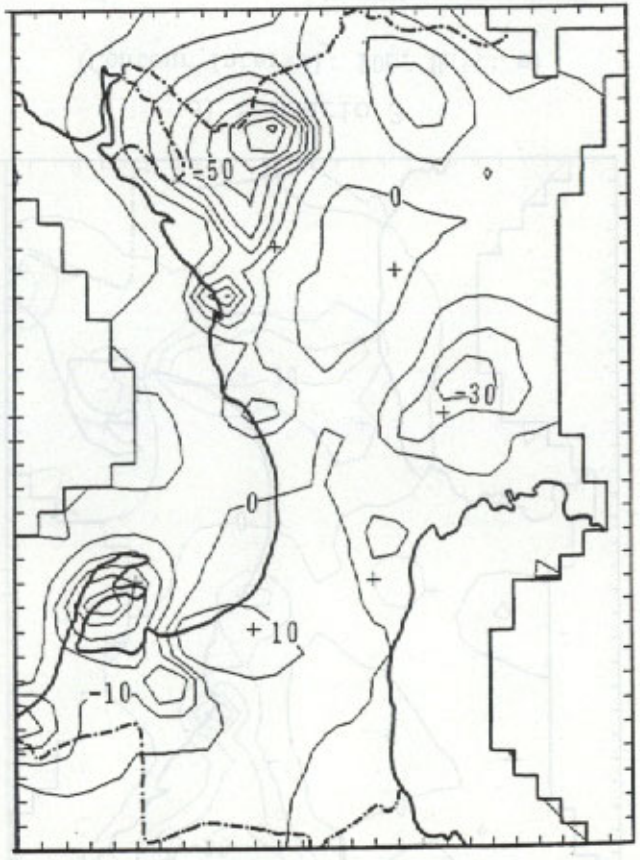


a) Scenario 3
(Contour Interval: 10m, Unit: masl)



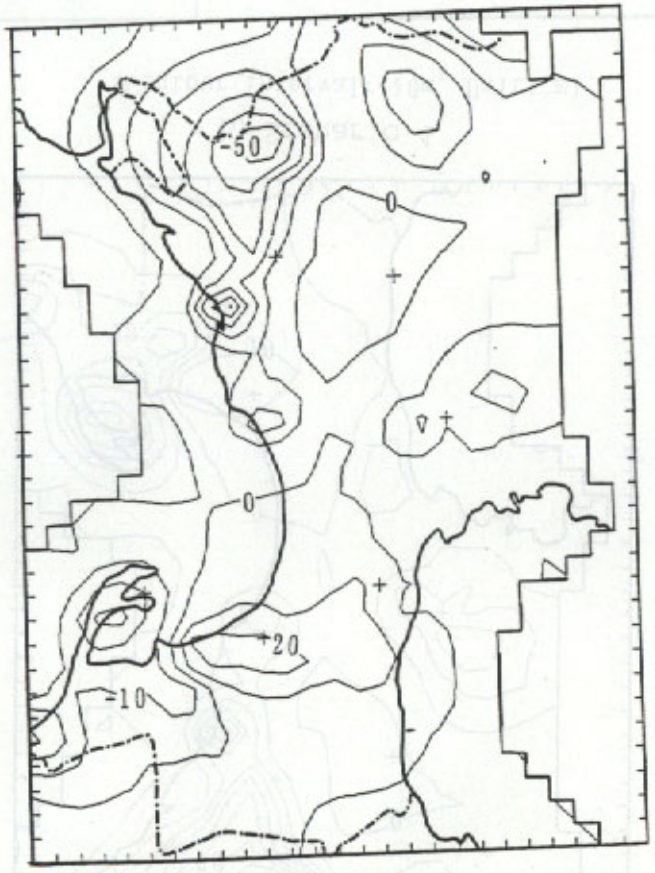
b) Scenario 4
(Contour Interval: 10m, Unit: masl)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.15
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC HEADS IN 2010 (Scenario 3, Scenario 4)



a) Scenario 1

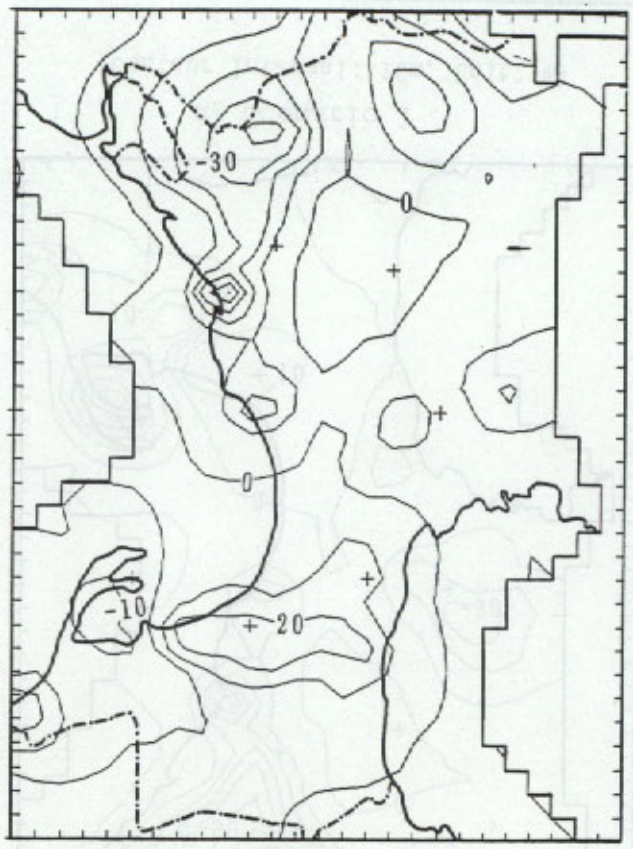
(Contour Interval: 10m, Unit: m)



b) Scenario 2

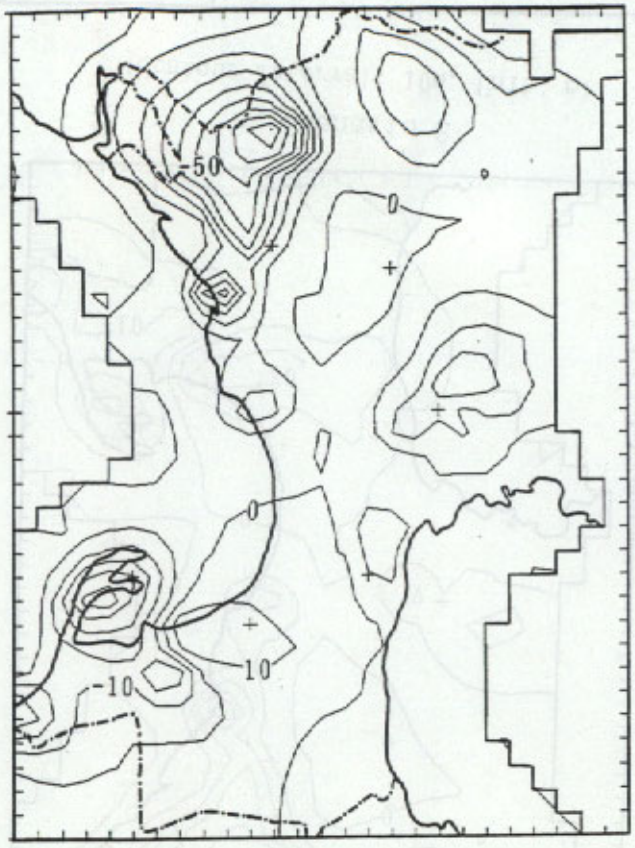
(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.16
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC CHANGES FROM 1991 TO 2010 (Scenario 1, Scenario 2)



a) Scenario 3

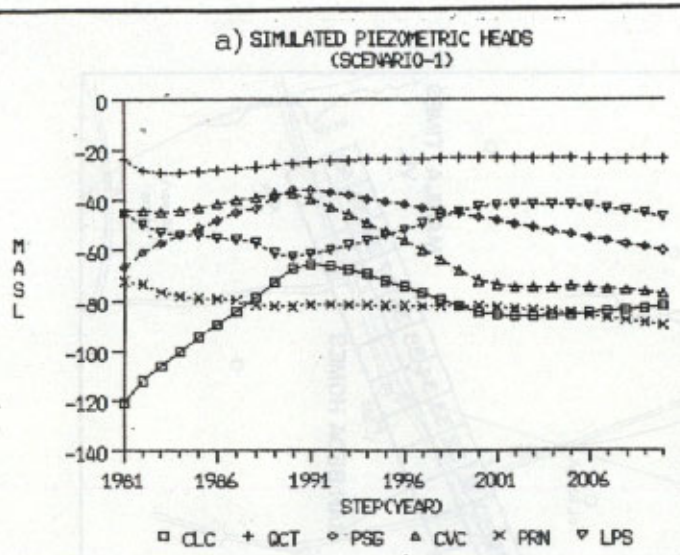
(Contour Interval: 10m, Unit: m)

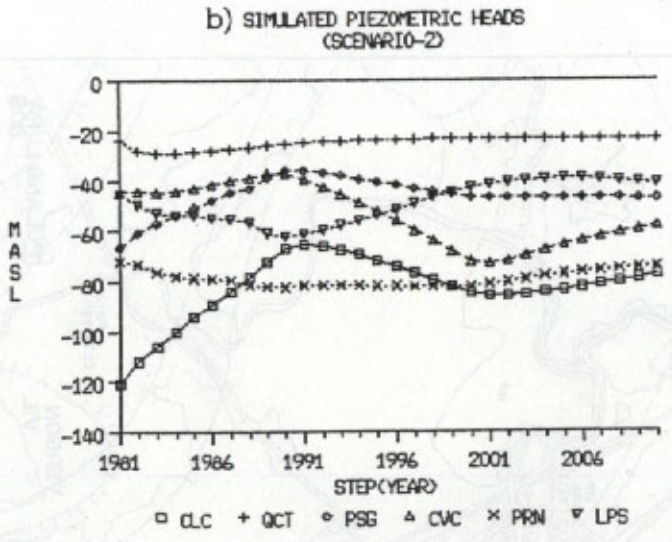


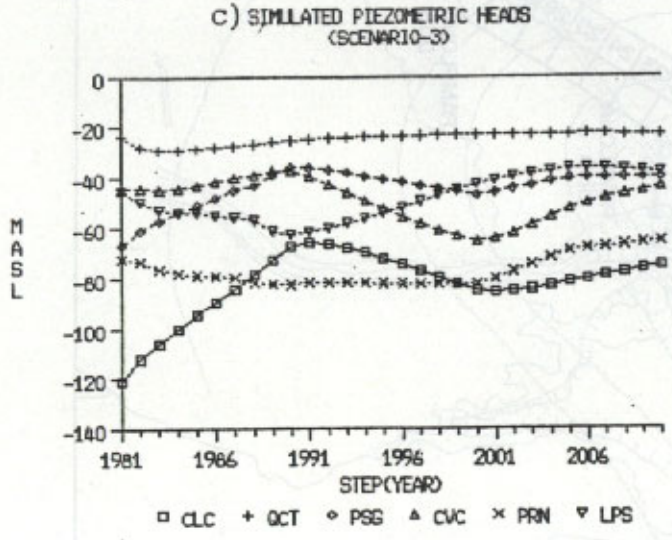
b) Scenario 4

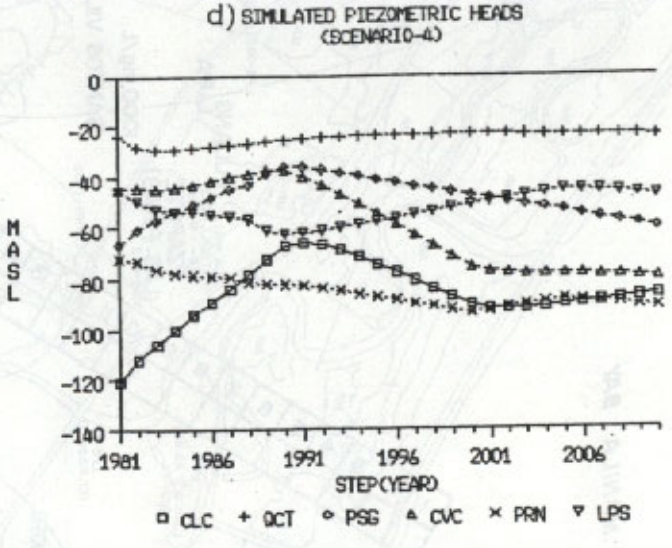
(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.3.17 SIMULATED PIEZOMETRIC CHANGES FROM 1991 TO 2010 (Scenario 3, Scenario 4)
JAPAN INTERNATIONAL COOPERATION AGENCY	







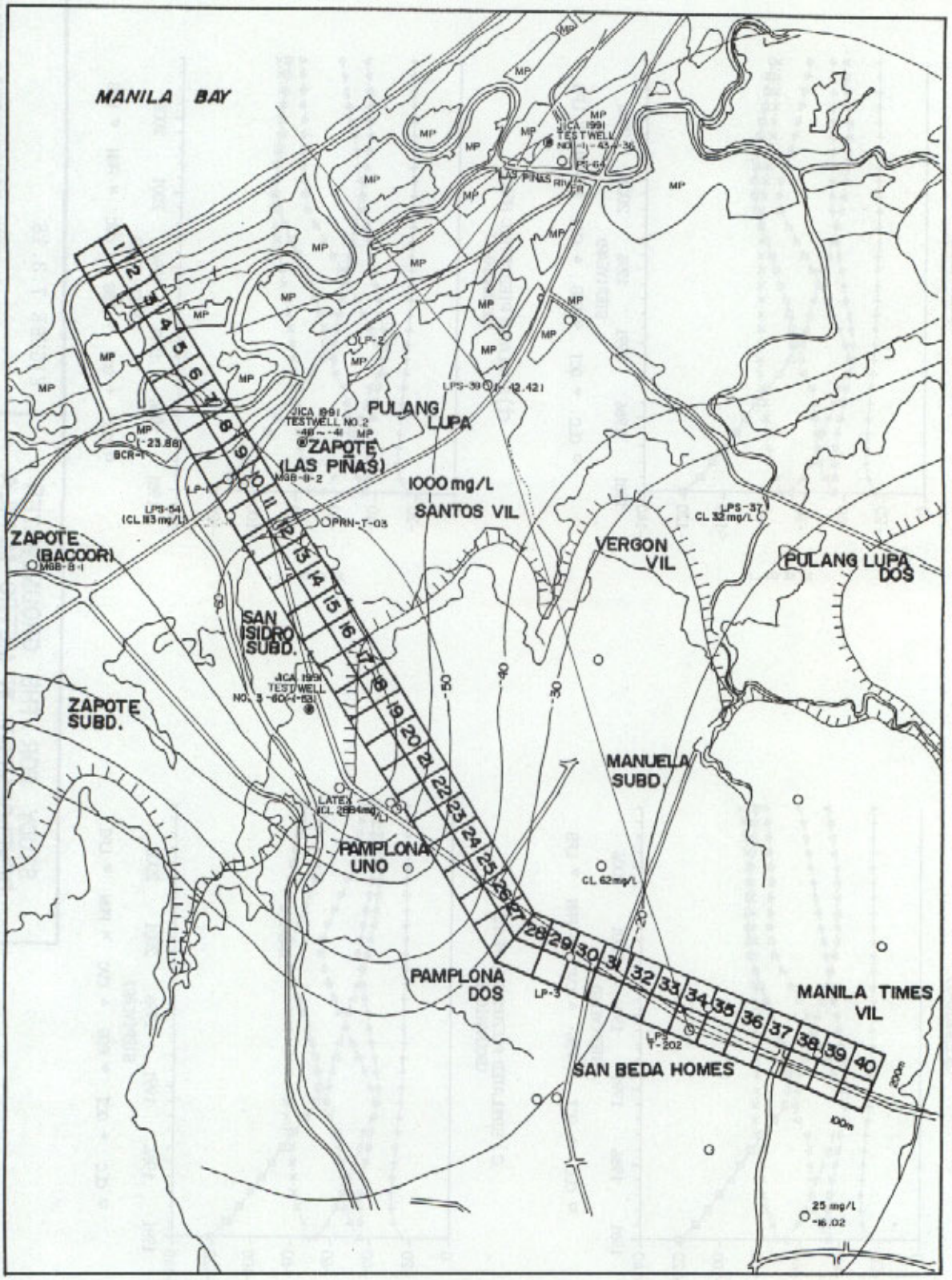


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

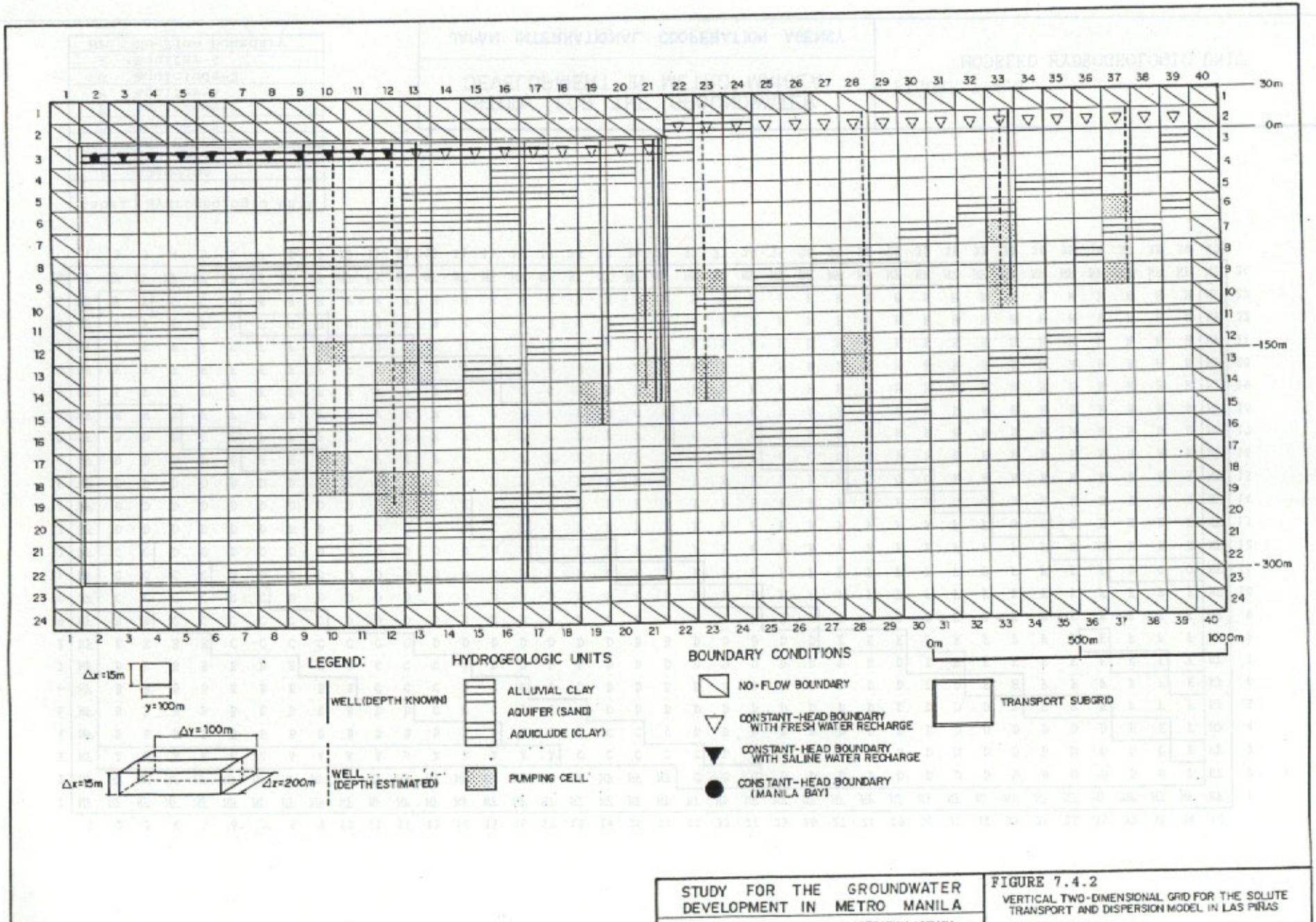
JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.3.18

SIMULATED PIEZOMETRIC CHANGES OF THE SCENARIOS



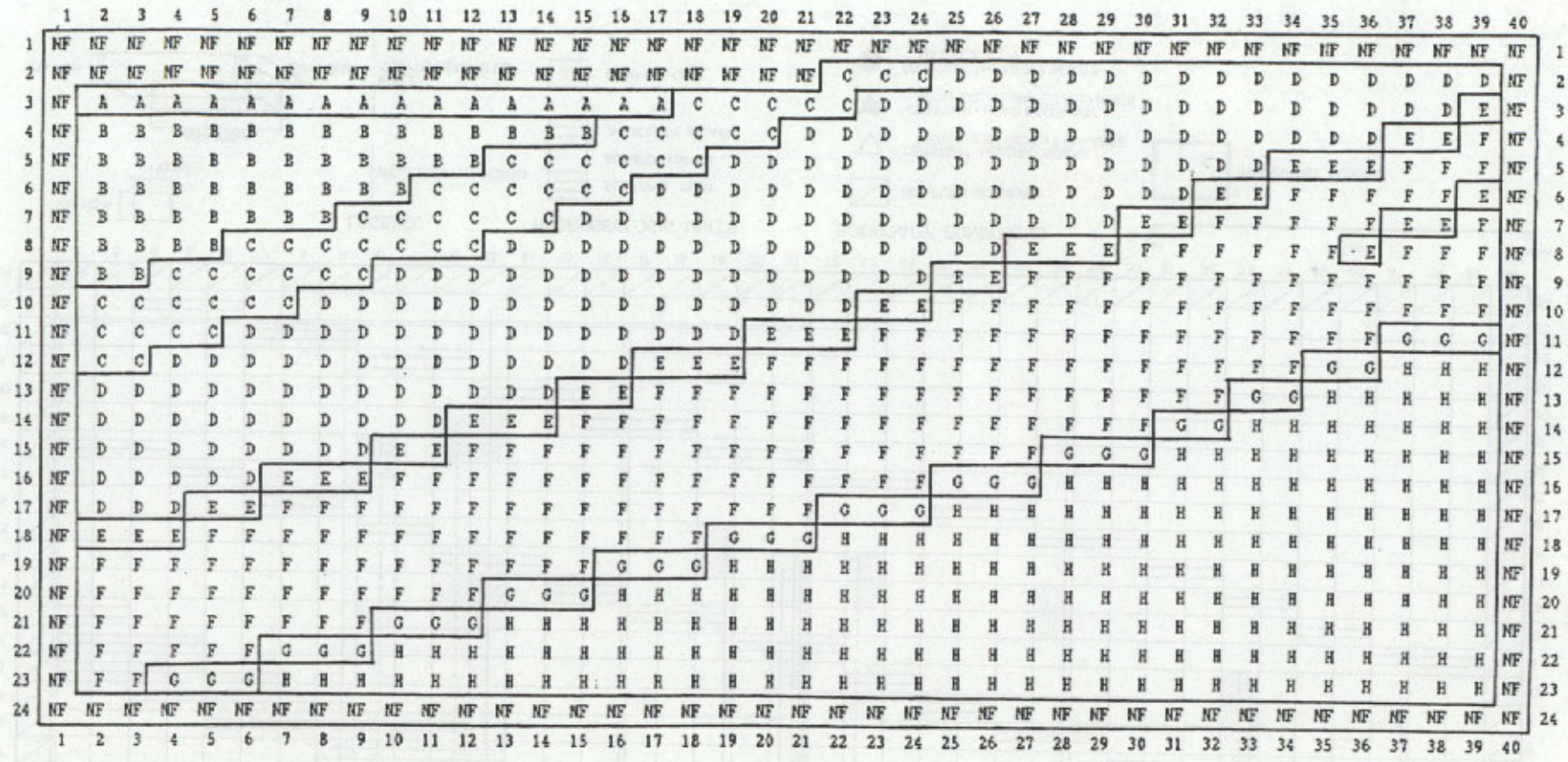
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.4.1 LOCATION OF VERTICAL TWO-DIMENSIONAL MODEL FOR SALTWATER INTRUSION ANALYSIS
JAPAN INTERNATIONAL COOPERATION AGENCY	



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.2
VERTICAL TWO-DIMENSIONAL GRID FOR THE SOLUTE TRANSPORT AND DISPERSION MODEL IN LAS PIÑAS

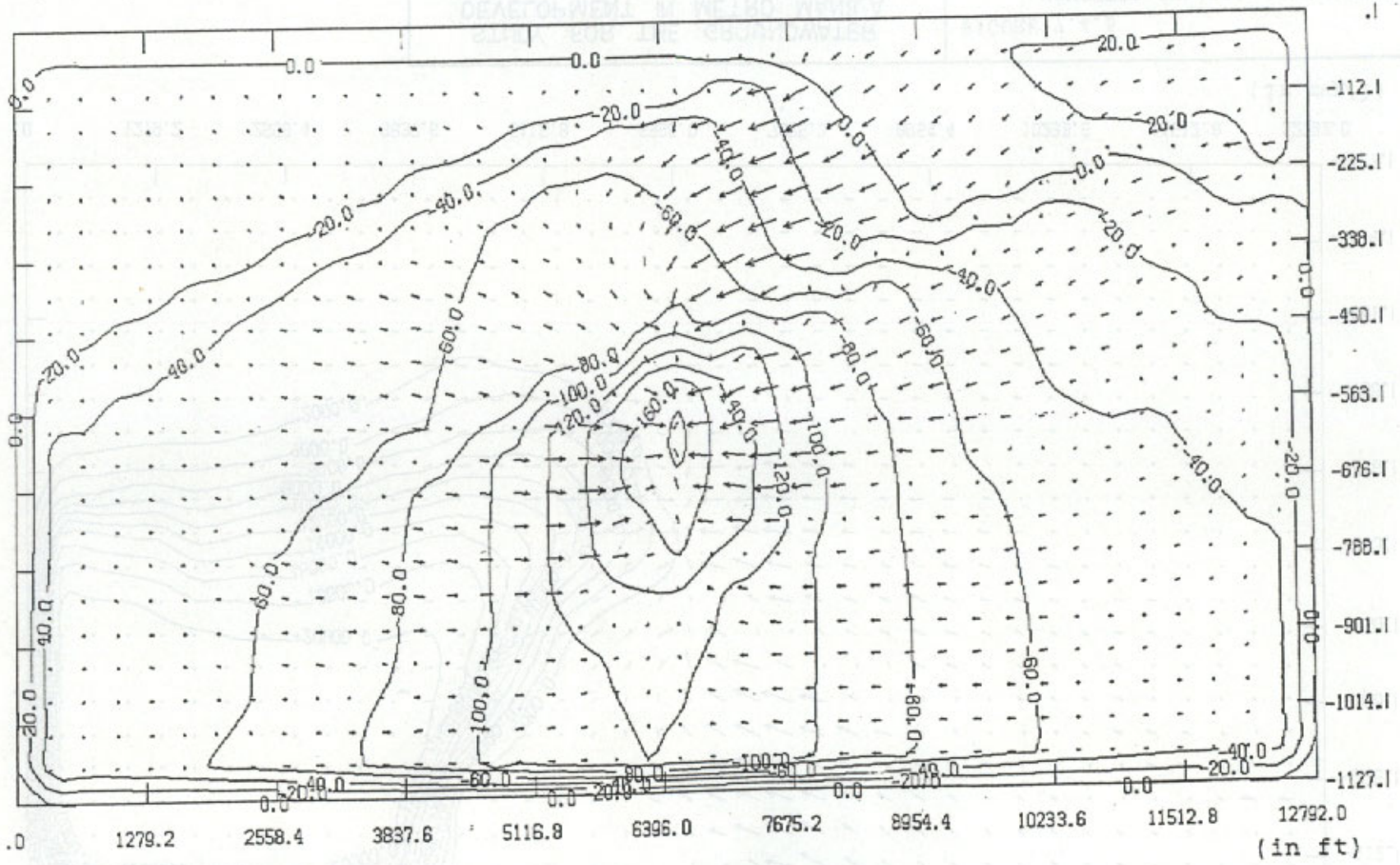


Label	Hydrogeologic Unit
A	Alluvium
B	Aquifer-1
C	Aquiclude-1
D	Aquifer-2
E	Aquiclude-2
F	Aquifer-3
G	Aquiclude-3
H	Aquifer-4
NF	No-Flow Boundary

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

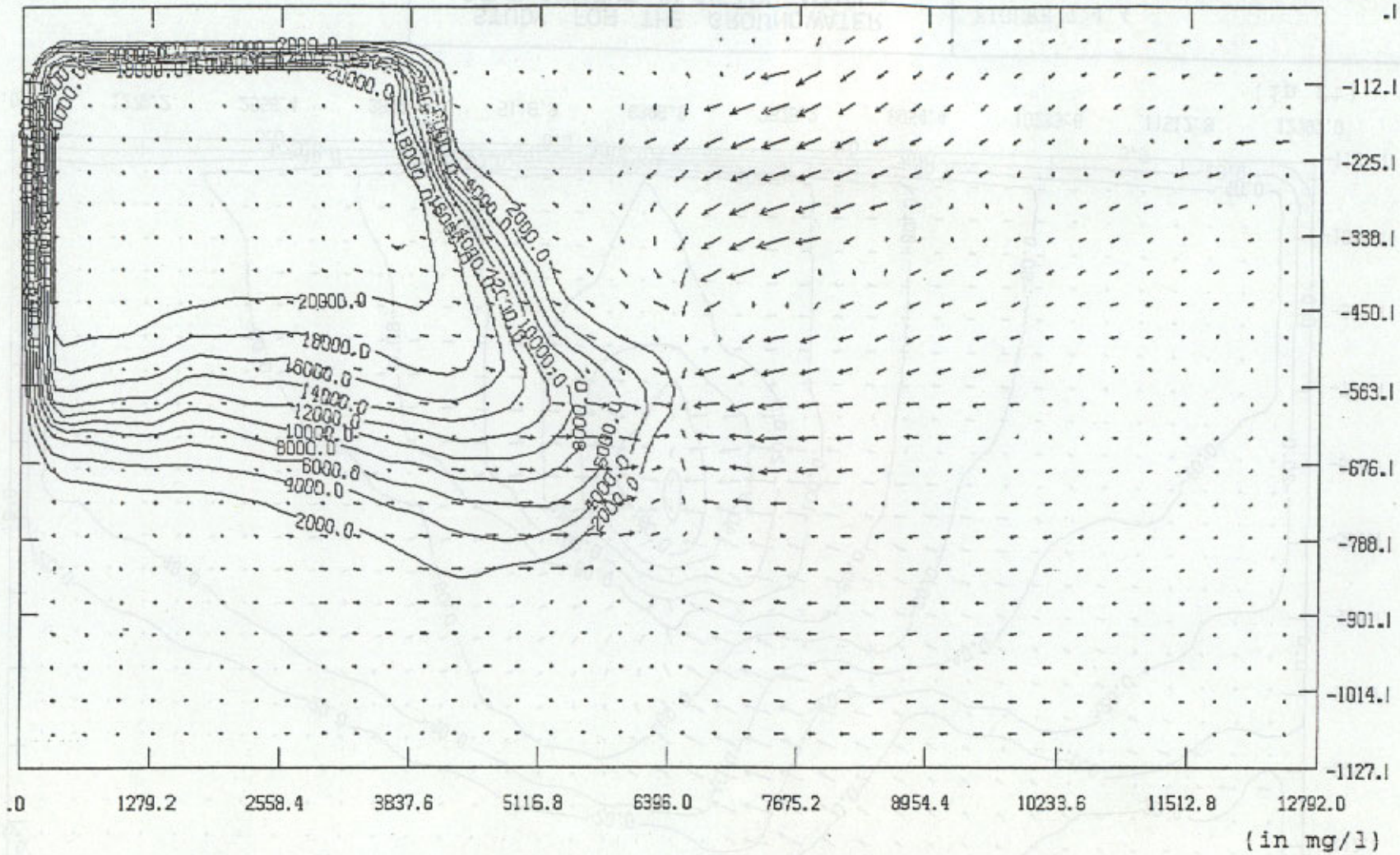
FIGURE 7.4.3
MODELED HYDROGEOLOGIC UNIT



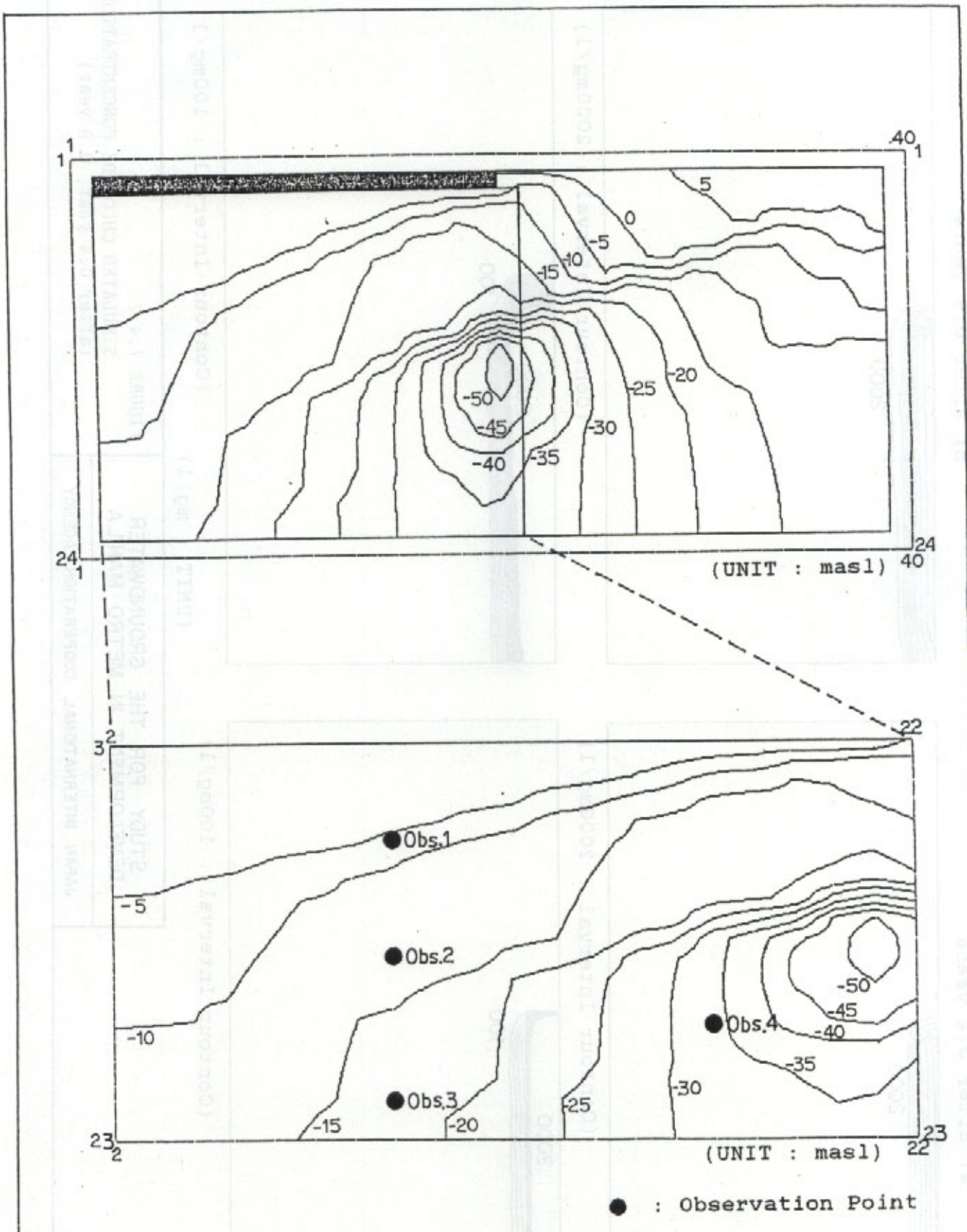
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

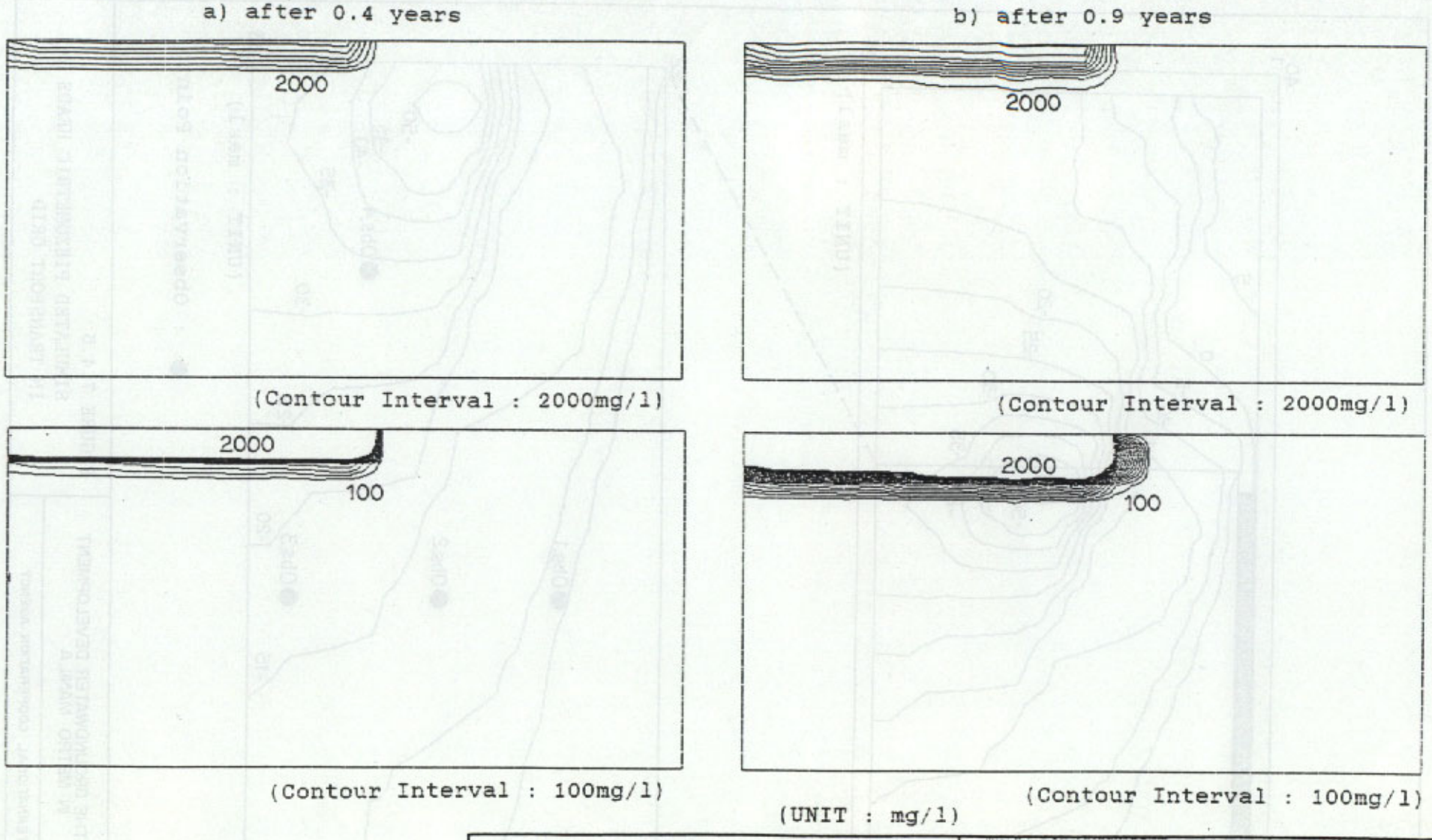
FIGURE 7.4.4
SIMULATED PIEZOMETRIC HEADS IN STEADY-STATE CONDITION



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.4.5 COMPUTED CHLORIDE CONCENTRATION AFTER 10 YEARS SIMULATION
JAPAN INTERNATIONAL COOPERATION AGENCY	



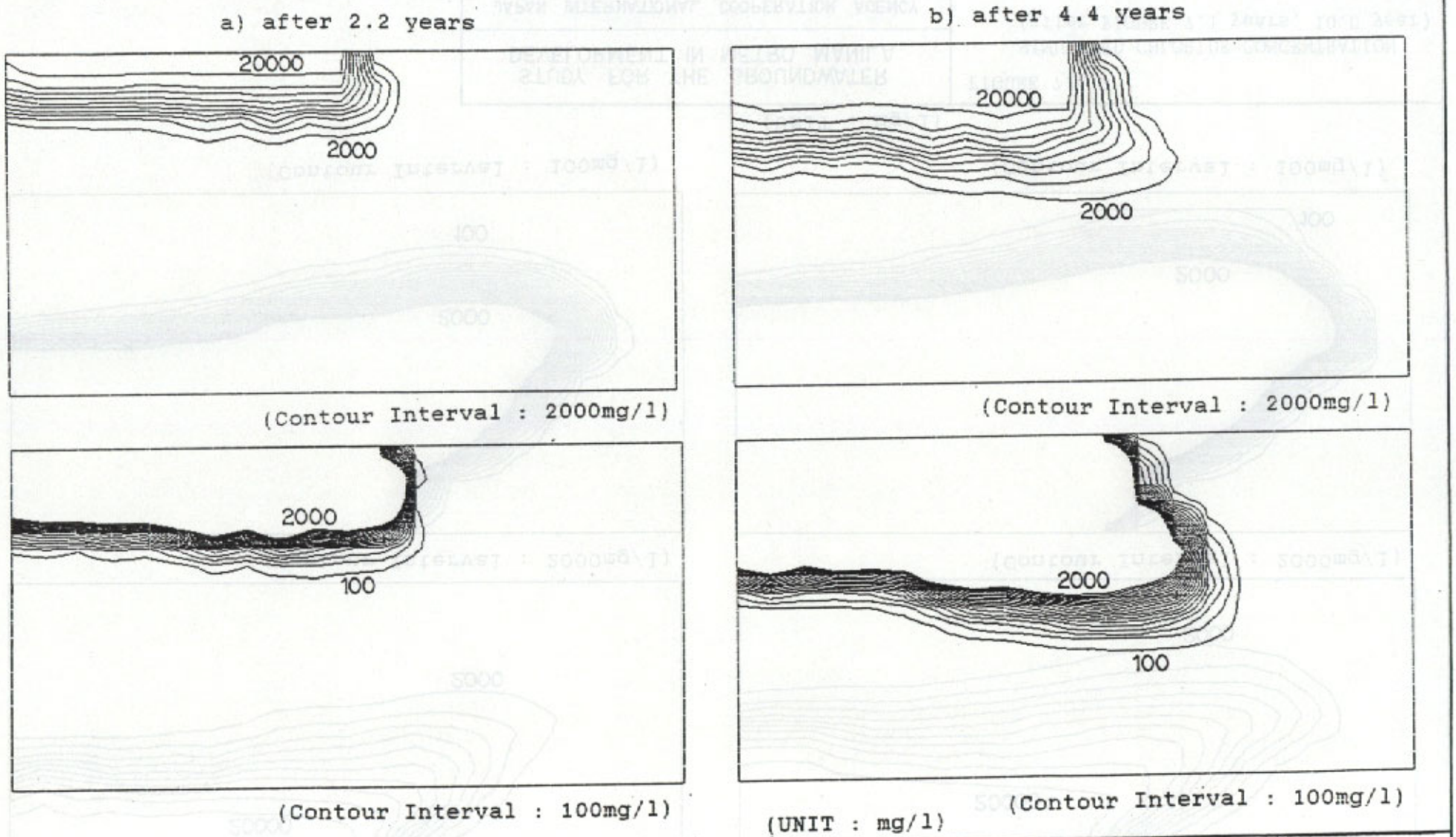
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 7.4.6 SIMULATED PIEZOMETRIC HEADS IN TRANSPORT GRID



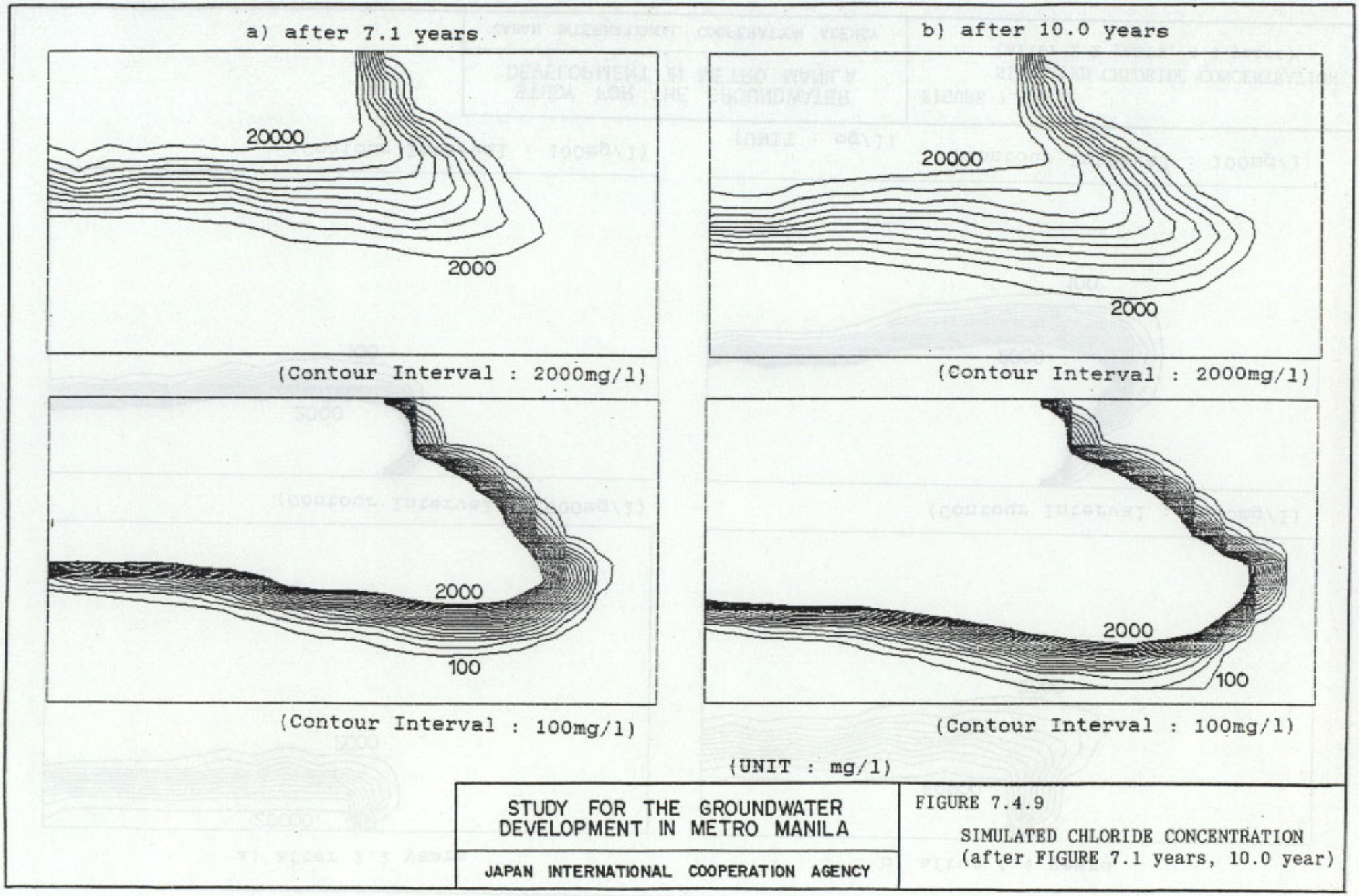
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

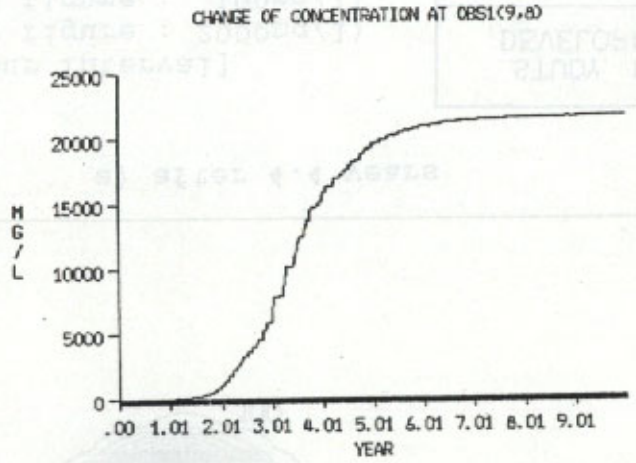
FIGURE 7.4.7
SIMULATED CHLORIDE CONCENTRATION
(after 0.4 year, 0.9 year)

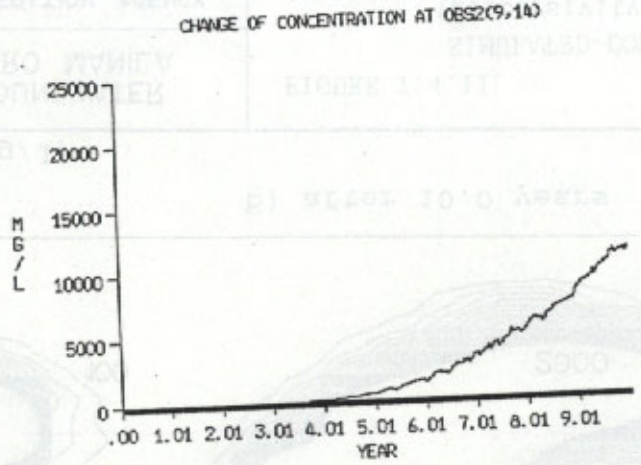


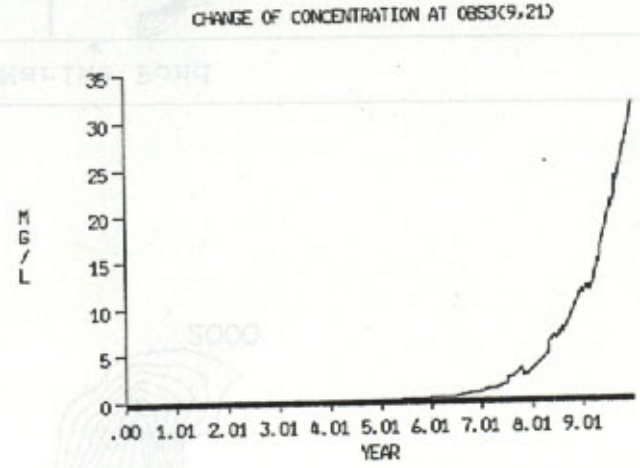
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.4.8 SIMULATED CHLORIDE CONCENTRATION (after 2.2 years, 4.4 years)
JAPAN INTERNATIONAL COOPERATION AGENCY	

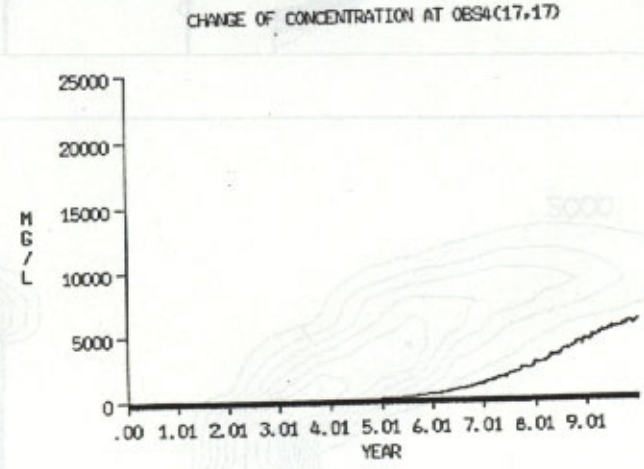


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 7.4.9 SIMULATED CHLORIDE CONCENTRATION (after FIGURE 7.1 years, 10.0 year)
JAPAN INTERNATIONAL COOPERATION AGENCY	





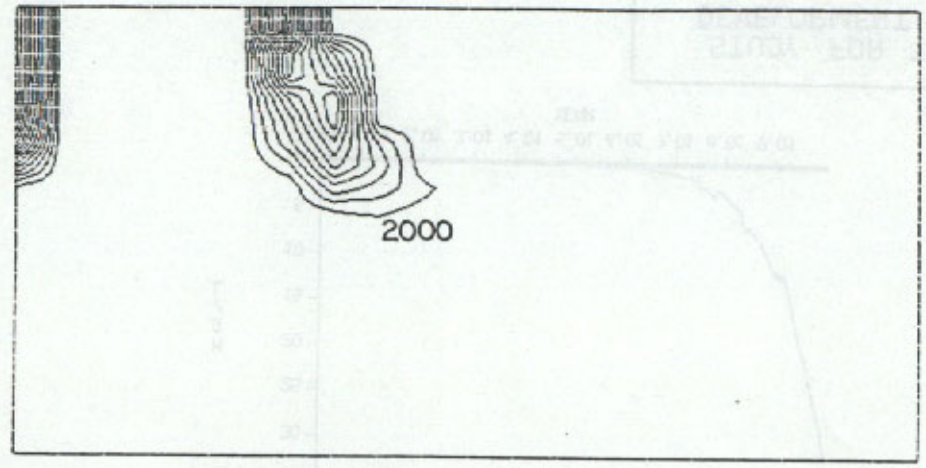


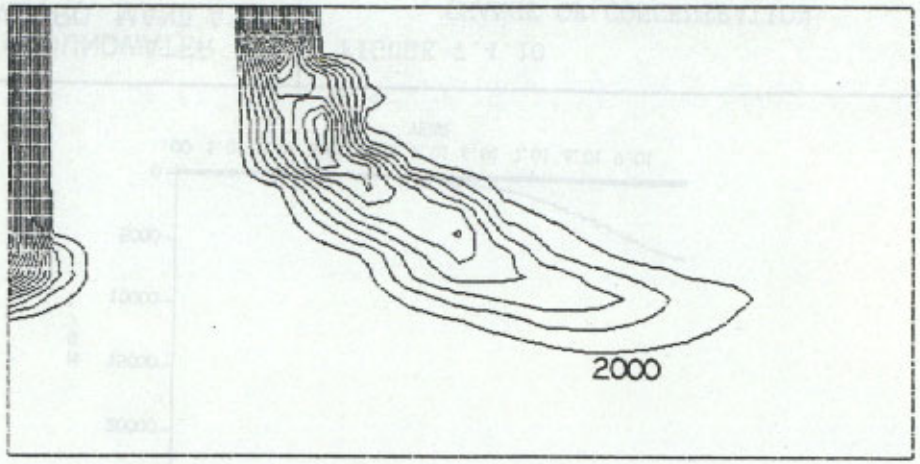


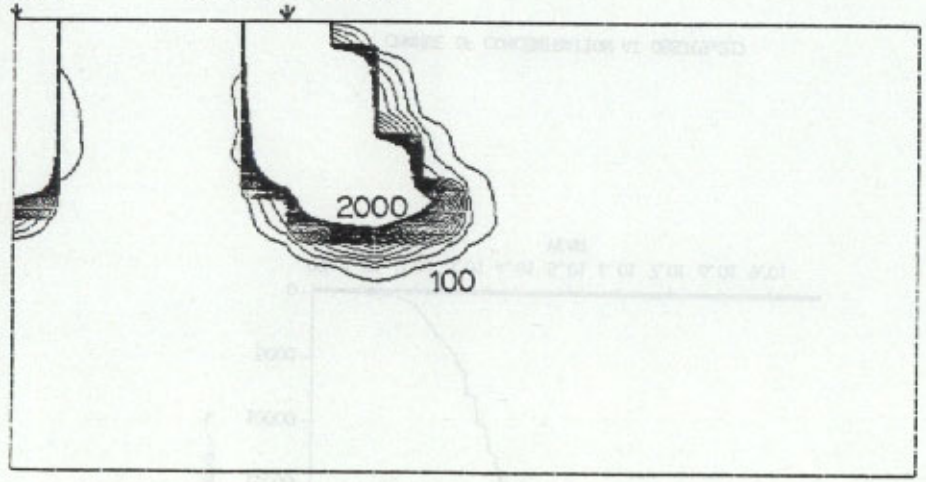
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

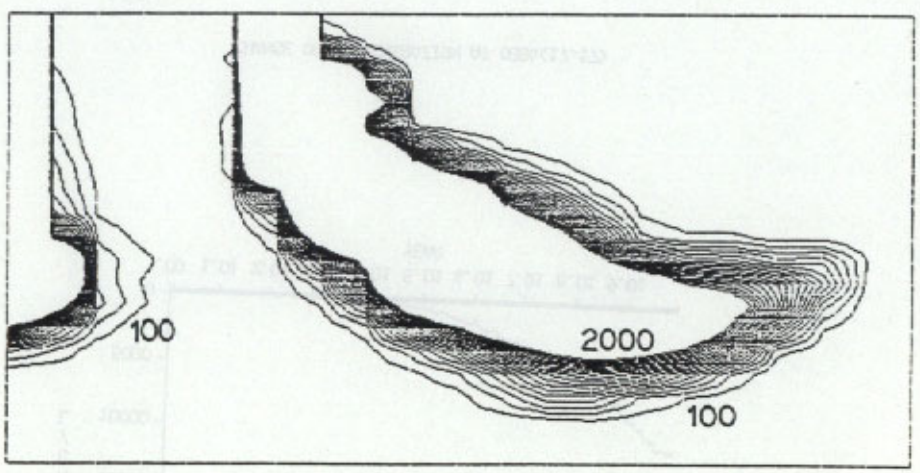
JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.10
CHANGE OF CONCENTRATION AT OBSERVATION POINTS









a) after 4.4 years

b) after 10.0 years

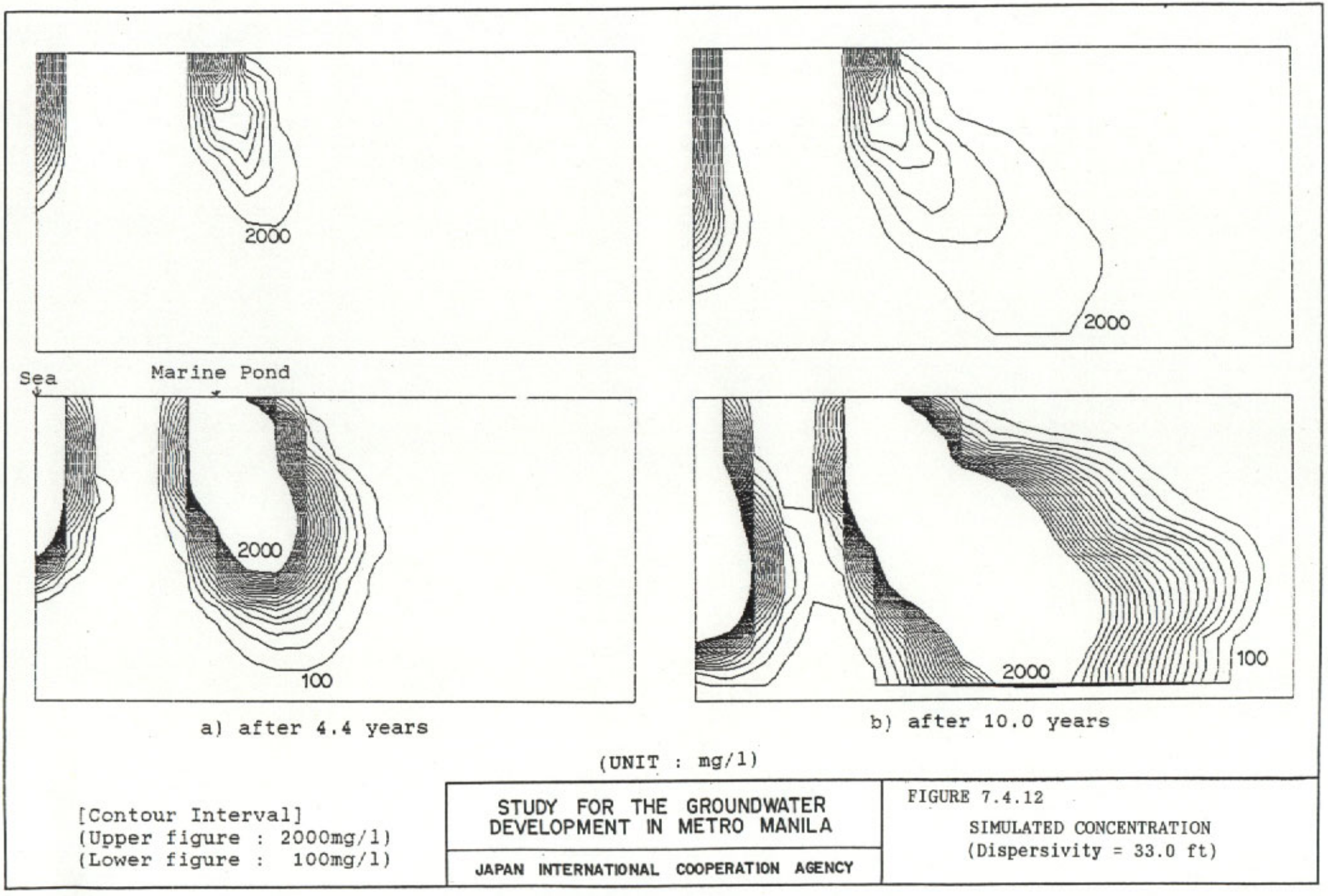
(UNIT : mg/l)

[Contour Interval]
(Upper figure : 2000mg/l)
(Lower figure : 100mg/l)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 7.4.11
SIMULATED CONCENTRATION
(Dispersivity = FIGURE 7.0ft)


2000
2000
Sea
Marine Pond
2000
100
2000
100
a) after 4.4 years
b) after 10.0 years
(UNIT : mg/l)
[Contour Interval]
(Upper figure : 2000mg/l)
(Lower figure : 100mg/l)
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA
JAPAN INTERNATIONAL COOPERATION AGENCY
FIGURE 7.4.12
SIMULATED CONCENTRATION
(Dispersivity = 33.0 ft)

CHAPTER 8

GROUNDWATER DEVELOPMENT PLAN

CHAPTER 8 GROUNDWATER DEVELOPMENT PLAN

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CHAPTER 8 GROUNDWATER DEVELOPMENT

8.1 REHABILITATION OF MWSS DEEP WELLS

8.1.1 Framework of the Rehabilitation Plan

According to the short-term water supply plan of MWSS, the municipalities of Antipolo, Montalban, San Mateo, Muntinlupa, Cavite, Imus, Kawit and Rosario shall still depend on groundwater sources up to year 1995 or 2000. Other municipalities shall also have to rely on groundwater sources until the expansion of surface water supply system and its distribution pipelines shall have been completed. Therefore, the rehabilitation of MWSS wells in these municipalities are particularly important not only to maintain but also to augment the present supply.

During the rehabilitation survey and the experimental rehabilitation work, it was observed that many active and inactive wells were damaged because of defective submersible pump units, riser pipes, etc. Therefore, the rehabilitation plan shall include those active wells presently in good condition, for they could be damaged in the near future as most pumping units have not been pulled out since the time they were installed.

Excluded from the plan are wells damaged by saline water and well cave-in, wells yielding dirty water, and dried-up wells. These wells will not be completely rehabilitated, and the cost of rehabilitating them may exceed the cost of drilling new wells.

Based on the above considerations, 100 wells were selected as candidate-wells for rehabilitation (see Table 8.1.1 for details):

1) In good condition at present : 73
2) Defective unit : 18
3) Standby/under MWSS rehabilitation : 9

The present average pumping rate of an active MWSS well is about eight (8) lps or 480 l/min or 690 CMD. This average was assumed for a rehabilitated inactive well. Based on the result of the experimental work,

the pumpage increment for a rehabilitated active well is expected to be about 207 CMD. Thus the combined total pumpage increments for 100 rehabilitated wells is expected to be around 27,462 CMD (see Table 8.1.2).

8.1.2 Work Procedure, Equipment and Materials

The work procedure for rehabilitation is summarized hereunder. Details can be found in the Appendices.

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

Equipment and materials necessary for the work are:

1) Well service machine (truck-mounted)
2) Submersible motor pump for pumping test
3) Clamp meter
4) Multi-tester
5) Riser pipes
6) Triangular weir box
7) 3/4"Ø sounding tubes
8) Conductivity meter
9) Compressor
10) Water level indicator and wires
11) Bailor
12) Wedge block
13) Fishing tools

Submersible pumps and riser pipes are provided by the contractor.

8.1.3 Project Cost

The rehabilitation cost per well is estimated as follows:

1)	Construction cost		P483,800
	Rehabilitation work		187,400
	Equipment and materials		296,400
	Submersible pump	1 unit	100,000
	Riser pipe	20 pcs.	84,800
	Submersible cables	120 m	87,600
	Sounding tube	20 pcs.	24,000
2)	Engineering Cost [12% of 1)]		58,156
	(Detailed Design and Construction Supervision)		
	Total		P541,956

Thus the total project cost for the rehabilitation of 100 wells is P54,195,600.

8.1.4 Implementation of the Project

(1) Organization

The MWSS shall be the principal implementing agency for the rehabilitation project. It shall be responsible for the execution of this project. It shall manage the budgets as well and, with the cooperation of the Consultant, guide the Contractor regarding the rehabilitation work.

The Consultant shall be responsible for: (1) planning related to the procurement of equipment and materials; (2) preparation of the tender documents; (3) execution of the tendering; (4) analysis and evaluation of bids; (5) contract negotiations with the chosen bidder; (6) procurement of equipment and materials; and (7) supervision of the rehabilitation work.

The Contractor shall be responsible for the procurement of equipment and the execution of the rehabilitation work.

(2) Schedule

A detailed project schedule for the rehabilitation work shall be prepared in the detailed design study. Described below is a tentative project schedule for the rehabilitation work.

a) The detailed design study for the investigation of candidate wells, preparation of tender documents, and tendering shall require three (3) months.

b) The procurement of contractor, equipment and materials shall require one (1) month.

c) The rehabilitation work can be done at a rate of around 10 wells per month. The construction shall require approximately 12 months, with two (2) months allowance.

8.1.5 Cost Evaluations

The well rehabilitation plan aims at augmenting the groundwater supply by approximately 27,400 CMD through 100 MWSS wells. Approximately 40 new wells (with an average yield of 700 CMD per well) must be drilled in order to supply the same volume of water.

The cost of water may be calculated by the following equation.

$$C = (A*a+B)/Q$$

where C: cost of water per volume; A: project cost; a: capital reduction rate; B: annual operation and maintenance cost; and Q: annual pumpage.

The capital reduction rate can be expressed as:

$$a = (i(i+1)^n)/((i+1)^n-1)$$

where i: rate of interest; and n: useful life in years.

Assuming i=0.055, n=20 years for a new well and n=10 years for a rehabilitated well,

a = 0.080 for n=20

a = 0.129 for n=10

The construction cost of a deep well is estimated at 12,700 pesos per meter, including submersible pump and pump house (see Section 8.2.2). Assuming a well depth of 200m, the construction cost shall be 2.54 million pesos. The cost of water, excluding the cost of operation and maintenance, is calculated as follows:

For a new well:

C= 2,540,000*40*0.08/27,400*365= 0.81 peso

For a rehabilitated well:

C= 542,000*100*0.129/27,400*365= 0.70 peso

Therefore, the rehabilitation of existing wells is more cost effective than the construction of new wells for a 10-year operation.

8.2 GROUNDWATER DEVELOPMENT IN ANTIPOLO

8.2.1 Groundwater Development Plan

(1) Existing Wells

There are ten (10) operational MWSS deep wells and twenty-six (26) private deep wells in the Antipolo area. Private wells supply water for their owners' domestic and industrial use. The MWSS wells supply water directly to Antipolo consumers via a pipeline system. As per water meter reading, MWSS charges Antipolo consumers with rates identical to those in areas where surface water is supplied. The system in Antipolo has no booster pumps, no reservoir, nor ground or elevated tanks.

MWSS deep wells are operated and monitored 24 hours a day. The location of these wells are shown in Figure 8.2.1, while their details are listed in Table 8.2.1. Details of privately-owned wells are shown in Table 8.2.2.

(2) Present Water Supply

As mentioned in the previous chapter, the year-1990 total municipal population of Antipolo is 207,842. Of this population figure, 84,823 live in the Antipolo Plateau, and of which only 34% (i.e. 28,000) are supplied with water from the distribution system.

Effective volume of water supply, excluding non-revenue water, is 3,288 CMD. Thus, with the above population data, the actual water consumption is 114 lpcd.

(3) Service Area

The service area is limited to a part of the Antipolo Plateau. The existing distribution pipelines run along the main roads near the poblacion of Antipolo. The service area is shown in Figure 6.2.5 in Section 6.2.

(4) Future Groundwater Supply

In planning the future water supply, the target year is set in the year 2000 and year 2010.

As estimated through computer simulations, the optimal pumpage of the Antipolo groundwater basin is about 28,000 CMD. This amount can meet the water demand until year 1998, after which the water demand must be supplied jointly by groundwater and surface water. The surface water shall be provided by the future expansion of the CDS. Since the present abstraction of existing deep wells is around 20,000 CMD of groundwater, the maximum exploitable volume of groundwater is about 8,000 CMD. After the rehabilitation of the 10 existing MWSS wells in Antipolo, water supply is expected to increase by about 2,000 CMD. Therefore, the total pumpage of the planned new wells to be drilled in the basin cannot exceed 6,000 CMD.

(5) Number of New Wells and Their Locations

The number of wells and their pumping rates were determined by the computer simulations described in the previous chapter. The pumping rate

of one well was assumed to be 830 CMD and the drawdown was estimated to be 20m. The planned wells are to be located in the area where the difference between the top ground surface and the computed groundwater level in the year 2010 is more than 20m.

The present pumping rates of private and MWSS wells were assumed to remain constant until the year 2010. Considering a pumping duration of 20 years, the optimal number of new wells that can be constructed in the Antipolo basin is seven (7), as computed by the simulation model.

Since 10 MWSS wells already exist in the basin, the construction of 7 new wells is limited to the area where the main aquifer, Guadalupe formation III, is thickest. This siting of wells also takes into consideration the depth of the hydrogeologic basement and future drawdown. The locations of the planned new wells are illustrated in Figure 8.2.2.

(6) Well Design

The casing diameter for a standard well design is based on the design of existing MWSS wells. The most common casing diameter is 8 inches. For ease of operation and maintenance, this casing diameter is adopted the standard well design.

The well depth is determined from the iso-depth contour map. Screen length is estimated to be less than 20% of the total well depth. A wire-wound slotted type is proposed for the screen in view of well efficiency. Centering guides are designed to be set every 30m.

The diameter of packing gravel is designed to range from 3mm to 5mm. A steel well cap is to be installed at the bottom, with suitable wall thickness.

Only one casing diameter, constant from top to bottom of the well, is to be installed in order to easily change the pump setting in case of a regional decline of groundwater level in the future. This is the reason why the telescopic type of well design is not adopted. The standard well design is illustrated in Figure 8.2.3.

(7) Pump House

The pump house design is a modified design of the MWSS pump house. Materials for the construction of the planned pump house are planned to be procured in the Philippines (Figure 8.2.4).

The planned pump house is to be made of concrete block walls, reinforced concrete foundations, slabs and columns, and galvanized roofing. Louver-type doors and concrete blocks shall be used for air ventilation. The door and window frames shall be made of iron or aluminum.

(8) Elevated Water Tanks

The water tank is provided for each group of wells aiming at effective operation of wells. Number of tanks is 6 in total. The water pumped from wells in the same group is transmitted to the same elevated tank respectively. Then stored water is distributed from the tank through one outflow pipe.

The planned elevated water tanks are to be made of reinforced concrete with rectangular shape (Figure 8.2.5). Heights of the tank is about 20m to acquire desirable minimum water head at the connection of customers. Effective water depth of the tank is designed at 5m. Required volume of the tank is as follows:

Required volume for sufficient distributions:

15 % of daily maximum water supply amount

(based on the result of actual condition survey by LWUA)

17,689 m^3/day (total capacity of wells) *0.15=2,653 m^3

2,653 m^3/ 6 tanks (No. of well group)= 442 m^3/tank

dimensions of tank 9.4mW*9.4m*L*5mH = 442 m^3

(9) Equipment and Materials

Equipment and materials shall be basically procured in the Philippines.

8.2.2 Construction Cost

The construction cost of the planned 7 new wells, including the pump houses ,pumping units and 6 elevated water tanks was estimated based on a cost survey conducted in Manila. Details are as follows:

I. Well Construction

	ITEMS	QUANTITY	COST
(1)	General mobilization, demobilization and site cleaning	LS	P 55,600
(2)	Drilling of 450mm hole/15m (dia. 16"), 375mm hole/135m (dia. 14-3/4")	150m	701,900
(3)	Furnishing and installation of dia. 16" conductor pipes/15m and dia. 8" casing pipes/ 135m and wire wound screen and installation of well bottom	LS	231,300
(4)	Electric logging	LS	14,300
(5)	Gravel packing	LS	62,000
(6)	Well development (Airlift & Overpumping)	LS	39,500
(7)	Pumping test o step-drawdown test (2 hrs x 5 steps) o continuous test (48 hours) o recovery test (8 hours)	LS	52,800
(8)	Water analysis and reporting	LS	5,400
(9)	Overhead (1,162,800x0.04)	LS	46,500

	Sub-Total		P1,209,300
II.	**Pump house**	LS	190,900
III.	**Furnishing and installation of equipment**		
(1)	Submersible pump 150gpm, TDH 150m, (27.9 KW) including riser pipes, submersible cable, and sounding tube 3/4"ø	1 unit	423,400
(2)	Water meter 4"ø	1 unit	26,300
(3)	Check valve 4"ø, 3"ø	1 unit	7,900
(4)	Gate valve 4"ø, 3"ø	1 unit	4,400
(5)	Flap valve 3"ø	1 unit	1,300
(6)	Pipe and fittings	LS	13,600
(7)	Others	LS	6,100
(8)	Overhead (P483,000x0.04)		19,320
	Sub-total		P 502,300
	WELL TOTAL		P 1,902,500
			==========
		7 wells	P 13,317,500
IV	**Elevated Water Tanks**	6 tanks	P 23,448,000
	GRAND TOTAL		P 36,765,500
			==========

Thus, the construction cost of one well is estimated to be P1,902,500. The total construction cost of the planned 7 new wells and 6 elevated water tanks is P36,765,500.

8.2.3 Project Implementation

(1) Implementation Schedule

The project implementation schedule for the construction of 7 wells and pumping stations, excluding the distribution pipelines and elevated tanks, is shown in Figure 8.2.5

This schedule has four stages: (1) Preparation; (2) Tendering; (3) Procurement of contractor; and (4) Construction of wells and elevated water tanks.

The preparation stage includes the detailed design and review of the construction plan, as well as the preparation of tender documents and the acquisition of land. Tendering consists of the bidding process and the evaluation of bids. A contractor is chosen in accordance with the evaluation. Well construction work includes the procurement of equipment and materials and the construction itself of wells and pump houses.

The construction period for one well requires two months. In the work program, two (2) drilling teams and two (2) civil work teams are proposed for the construction of seven wells and pumping stations.

(2) Operation and Maintenance (O&M)

Operation and maintenance of the existing MWSS deep wells must be conducted by the present groups of operators. Two new O&M groups must be organized for the seven new wells. The groupings are shown in Figure 8.2.6 and are listed below:

Group 1 - existing wells no.1 and no.2 plus one new well
Group 2 - existing wells no.4, no.5, and no.7
Group 3 - existing well no.10 well plus one new well
Group 4 - existing wells no.3, no.6 plus one new well
Group 5 - 3 new wells
Group 6 - existing wells no.8 and no.9 plus one new well

(3) Operation and Maintenance Cost

Existing Wells

a) Manpower cost

(1 Engineer, 3 Pump Operators (PO Foremen, 3 Sr. POs, 9 POs, 3 Casual POs)

= P1,154,280/year

b) Electric charge

(Includes generation, distribution and energy charges)

= P2,787,671/year

New Wells

a) Manpower cost

(2 Sr. POs, 6 POs)

= P456,480/year

b) Electric charge

(Includes generation, distribution and energy charges)

= P3,645,062/year

Funds for Repairs

Funds for repairs, which include the acquisition of small tools such as electrical pliers, screw drivers and pipe wrenches, (one unit for every operator):

= P31,600/year

Operation and maintenance cost for the seven new wells is P4,133,141. Total operation and maintenance cost for both existing and new wells amounts to P8,075,092.

8.3 SURFACE WATER SUPPLY PLAN IN ANTIPOLO

8.3.1 Water Supply Plan

(1) Water Source

As mentioned in Subsection 6.2.3, it is indispensable for the development of the water supply system in the Antipolo study area to have the water source augmented.

The most reliable water resource in the basin at present is groundwater. But due to the hydrogeologic characteristics of the area as mentioned previously, its yield is limited. Thus, fully utilizing the available water source yield of groundwater in the basin means pumping up through deep wells.

Other available water resources are the creeks and springs flowing down from the basin to the outside. But these creeks are already contaminated with wastewater and their flow quantity is limited, thus making them unsuitable for additional water sources.

Some springs which are also flowing down from the Antipolo plateau along the boundary of the basin may be potential sources. Most of them, however, have limited yields, especially during the dry season, and hence are not suitable as water sources for Antipolo. One of these springs, named Love Spring, had been relied upon by the people of Teresa in the 1950's and 1960's. However, the Teresa Waterworks which was tapping this spring has had to shift to deepwells in the 1980's because of the inadequate spring yield. Furthermore, after groundwater development in the future proceeds as mentioned in Sections 8.1 and 8.2, yield of springs will be poorer due to full utilization of the groundwater resource.

Thus, as far as water sources for the MWSS system in the basin is concerned, the augmentation of water means tapping sources other than the surface water in and adjacent to the basin.

In this regard, RPWSIP is considered where the construction of a treatment plant with a capacity of some 39,800 m^3/day was planned for the water supply system of Angono-Taytay. The water source for this system

is the Laguna de Bay. One alternative is to enlarge this plan and to transmit treated water from the plant to the basin. This alternative seems to be attractive. However, a basic requisite for carrying out this alternative is a good road from a candidate site of the planned treatment plant to the basin, but as this road has yet to be constructed, a long time would be needed before said alternative could materialize.

In addition to the problem about road access, there is also the concern about the great influence the abovesaid alternative could exert on the plan for the treatment plant itself due to the significant increase of treatment capacity that such alternative requires. Furthermore, the cost for construction and operation of the transmission line in the alternative just considered is not really much different from that of the plan which contemplates transmission from CDS. This is so because the difference in elevation is almost identical in both RPWSIP option and CDS plan, with the option having the slight advantage of cutting by less than 20% the length of the transmission line to the center of the basin. Seen under the light of these considerations, the inadequacy of the alternative on expanding the above treatment plant's capacity follows. The more viable option then for the source of additional water, with groundwater sources excluded, is to get this water through the CDS.

In the plan of MWSP III, treated surface water is to be transmitted from a treatment plant in Pantay to the reservoir near Cogeo Village. Transmission from this reservoir to the basin using booster pumps is deemed to be effective as costs are reduced and savings are freed for construction and operation of required facilities. However, the implementation of MWSP III has been deferred due to its large cost, but it is targeted to be completed in the year 2011.

Therefore, the most realistic and practical measure that can be immediately implemented is the transmission of the additional water from CDS.

(2) Transmission System from CDS

The nearest point to withdraw water from the CDS is on the primary distribution pipeline (PDP) with a diameter of 2,400 mm. This pipeline is planned to be constructed in AWSOP and it will cross the Marcos High-

way at Pasig or the existing PDP with a diameter of 2,000 mm near the AWSOP's proposed PDP. These crossing points are recommended locations for an intake structure.

Since the difference in elevation between the basin and the nearest point of the CDS primary distribution pipe is about 200m, several booster pumping facilities shall be provided for the transmission line.

Transmission route will be laid from Pasig to the basin, passing by Cogeo Village along the Marcos Highway and the Sumulong Highway with a total length of about 13km as illustrated on Figure 8.3.1.

At the time of implementation of MWSP III, a part of this transmission line can be utilized as a transmission line from the Cogeo reservoir to CDS. The point of origin of the transmission line to the basin will be transferred to the Cogeo reservoir at that time.

The rate of 150% of Daily Average Water Demand was adopted for the estimation of Daily Maximum Water Demand based on FAWSP study.

The outline of the proposed transmission system mentioned above is as follows:

Water Volume to be transmitted:

Based on the computation result discussed in Subsection 6.2.3, water volume to be transmitted is:

2000	1,834	m^3/day (daily average)
	15,508	m^3/day (daily maximum)
2010	18,149	m^3/day (daily average)
	40,892	m^3/day (daily maximum)

Phasing of Construction:

2-phased implementation for the years 2000 and 2010

Diameters and Material of Pipes:

Phase 1 (2000); 450mm steel pipe

Phase 2 (2010); 600mm steel pipe

Length of Pipeline and Elevation Difference:

from Pasig to Cogeo 6.2 km, 95 m
from Cogeo to Poblacion 6.4 km, 145 m

Number of Booster Pumping Stations:

2 ---- Cainta and Cogeo (along the Marcos Highway)

Required Pump Capacity:

Booster Pumping Station No.1;

(Phase 1)

Type Motor driven volute pump
Total Pumping Head 115m
Discharge 5.40 m^3/min./unit x 2 units
(+1 stand-by unit)

Total Required Output of Motors
P = 0.163x5.4x115/0.65x1.15 = 179 say 200 kW
ø250 x 5.40 m^3/min. x 115 m x 200 kW x 3 (1)
(A stand-by pump will be fully used in phase 2.)

(Phase 2)

Type Motor driven volute pump
Total Pumping Head 115m
Discharge 6.16 m^3/min./unit x 2 units
(+1 stand-by unit)

Total Required Output of Motors
P = 0.163x6.15x115/0.65x1.15 = 204 say 220 kW
ø250 x 6.15 m^3/min. x 115 m x 220 kW x 3 (1)

Booster Pumping Station No.2;

(Phase 1)

Type Motor driven volute pump
Total Pumping Head 170m
Discharge 5.40 m^3/min./unit x 2 units
(+1 stand-by unit)

Total Required Output of Motors

P = 0.163x5.40x170/0.65x1.15 = 265 say 280 kW

ø250 x 5.40 m^3/min. x 170 m x 280 kW x 3 (1)

(A stand-by pump will be fully used in phase 2.)

(Phase 2)

Type	Motor driven volute pump
Total Pumping Head	170m
Discharge	6.15 m^3/min./unit x 2 units (+1 stand-by unit)

Total Required Output of Motors

P = 0.163x6.15x170/0.65x1.15 = 284 say 315 kW

ø250 x 6.15 m^3/min. x 170 m x 315 kW x 3 (1)

Measure against Water Hammering Phenomenon:

Flywheel and Check valve

Volume of Pump Well: about 30 minutes operation

Control System: Automatic On-Off Control by water level of distribution reservoirs.

Design concept for Booster Pumping Stations are illustrated on Figures 8.3.2 to 8.3.8.

(3) Distribution System

The distribution system in the basin consists of a distribution reservoir, distribution pipeline network, service connections, fire hydrants and other miscellaneous fixtures.

Two types can be considered for the distribution system in Antipolo. One is a pressurized system using pumping facilities; the other, a gravity flowing system. In the former, pumping facilities capable of meeting peak water demand shall be furnished. The latter will not require pumping facilities. However, location of the site shall have enough elevation to distribute water. Energy costs for the pumping up of water to end-users will not be different at each system theoretically because

the necessary energy is the same in both systems. However, and if a suitable site is available, the latter is generally applied because of its lower capital and maintenance cost and stability. Since there are suitable places with appropriate elevations in the background of the Antipolo study area, the gravity flowing system was opted for by this study.

In Phase 1, one distribution reservoir will be provided in Barangay San Luis. A distribution pipeline will be installed from this reservoir.

Another distribution reservoir will be augmented at the same location in Phase 2. In addition, a small-scale reservoir will be provided in Barangay Sta. Cruz for the northwestern district of the study area. Distribution pipelines will be laid from those reservoirs separately. Thus, there will be two distribution systems in Phase 2--the main system and the sub-system. Water for the sub-system will be diverted from the transmission pipeline on the way to the main system.

The rate of 200% of Daily Average Water Demand was adopted for the estimation of Peak Hour Water Demand based on FAWSP study. Based on the analysis of the daily variation pattern of water demand in several areas conducted by LWUA, required capacity of the reservoir was determined to be equivalent to 4 hours operation of daily maximum demand. However, 5 hours was adopted for the sub-system because of its rather small-scale.

Groundwater pumped from deepwells will be injected into the distribution pipeline network through elevated water tanks.

Outline of the distribution system is as follows:

a) Phase 1

Capacity of Distribution Reservoir:

4 hours operation of daily maximum demand

Based on the hydraulic analysis of the distribution network, required capacity is:

247.77 LPS (peak flow)/ 2 x 1.5 x 4 hours.

= 2,676 m^3

Dimensions of proposed reservoir is;

27mL x 13.5mW x 4.4mH x 2 (3,200 m^3)

Design concept for the reservoir is illustrated on Figures 8.3.9 to 8.3.10.

Required pipeline and fixtures will be as follows:

Distribution Main Pipeline (Figure 8.3.11):

ø100mm	VP	8,950m
ø150mm	VP	10,390m
ø200mm	VP	3,500m
ø250mm	VP	2,190m
ø300mm	SP	1,600m
ø350mm	SP	740m
ø400mm	SP	390m
ø500mm	SP	370m
ø600mm	SP	900m
Total		29,030m

Valves:

ø100mm - ø600mm 31 units

Air Valves:

Single Type 27 units

Double Type 2 units

Pressure Reduction Valves:

ø150mm 1 unit

ø250mm 1 unit

Drain Valves:

ø100mm 27 units

ø150mm 2 units

Fire Hydrant:

ø100mm 145 units

Internal Distribution Pipeline:

ø75mm 14,515m (50% of distribution main)

ø100mm 14,515m (50% of distribution main)

Service Connections:

Replacement

Residential 3,535 units

Others 203 units

Installation

Residential 13,016 units

Others 389 units

b) Phase 2

Capacity of Distribution Reservoir:

4 hours operation of daily maximum demand

Based on the hydraulic analysis on the distribution network, required capacity was calculated at;

Main System

(233.30+350.07) LPS (peak flow)/ 2 x 1.5 x 4 hours

= 6,300 m^3

Necessary capacity to be augmented is:

6,300 - 3,200 = 3,100 m^3

Dimensions of proposed reservoir is:

27mL x 13.5mW x 4.4mH x 2 (3,200 m^3)

Sub System

50.13 LPS / 2 x 1.5 x 5 hours

= 677 m^3

Dimensions of proposed reservoir is:

9mL x 9mW x 4.4mH x 2 (712 m^3)

Required pipeline and fixtures will be as follows:

Distribution Main Pipeline (Figure 8.3.12):

ø100mm	VP	4,410m	(Main 3,080, Sub 1,330)
ø150mm	VP	9,860m	(Main 8,420, Sub 1,440)
ø200mm	VP	7,800m	(Main 6,680, Sub 1,120)
ø250mm	VP	4,540m	(Main)
ø300mm	SP	1,310m	(Main)
ø350mm	SP	180m	(Main)
ø400mm	SP	430m	(Main)
ø450mm	SP	1,090m	(Main)

ø500mm	SP	760m	(Main)
ø700mm	SP	900m	(Main)
Total		31,280m	(Main 27,390, Sub 3,890)

Valves:

ø100mm - ø700mm 33 units

Air Valves:

Single Type 28 units

Double Type 3 units

Pressure Reduction Valves:

ø100mm 1 unit

ø150mm 1 unit

Drain Valves:

ø100mm 28 units

ø150mm 3 units

Fire Hydrant:

ø100mm 88 units

Internal Distribution Pipeline:

ø75mm 15,640m (50% of distribution main)

ø100mm 15,640m (50% of distribution main)

Service Connections:

Residential 11,368 units

Others 407 units

For the main system, 2 small-scale booster pumping stations shall be provided for highly elevated districts as follows:

B.P.S No. 3 ø80 x 0.9m^3/min. x 10m x 3.7kW x 2(1)

B.P.S No. 4 ø32 x 0.1m^3/min. x 10m x 0.4kW x 2(1)

(4) Project Cost

Cost for the project, including land acquisition cost, is presented in Tables 8.3.1 and 8.3.2, and is summarized as follows:

a) Phase 1

Facilities	Cost (x1,000peso)
Transmission Pipeline	58,343
Booster Pumping Station No.1	42,223
Booster Pumping Station No.2	49,201
Communication Wiring	5,383
Distribution Reservoir	14,308
Distribution Pipelines	89,166
Fire Hydrants	3,461
Service Connections	58,570
Construction Cost Total	320,605
Engineering Cost 12%	38,473
Land Acquisition	9,585
Total	368,663
Physical Contingency 10%	36,866
GRAND TOTAL	405,529

b) Phase 2

Facilities	Cost (x1,000peso)
Transmission Pipeline	95,862
Booster Pumping Station No.1	41,164
Booster Pumping Station No.2	48,051
Distribution Reservoir No.1	15,207
Distribution Reservoir No.2	4,662
Booster Pumping Station No.3	1,099
Booster Pumping Station No.4	750
Distribution Pipelines	113,771
Fire Hydrants	2,005
Service Connections	45,192
Construction Cost Total	367,763
Engineering Cost 12%	44,132
Land Acquisition	1,760
Total	413,655
Physical Contingency 10%	41,365
GRAND TOTAL	455,020

8.3.2 Implementation Plan

As mentioned in Section 6.2, groundwater supply capacity will be enough to meet the demand--on a daily average basis--until the year 1998, if it is fully developed by that year and the water leakage control program is conducted so as to decrease the ratio to 30% of total supply amount. The project cost estimated in Subsection 8.3.1 includes the installation cost of the new pipes along the existing pipes that will be used as temporary water supply pipes during the construction stage and which shall be removed after completion of replacement. This replacement of existing pipes will substantially decrease water leakage.

The project will be divided into two phases as mentioned before. The target year of Phase 1 is the year 2000 and that of Phase 2 is the year 2010. The Phase 1 project has enough time to be implemented, excepting the time expended for the booster pumping facilities and distribution pipeline network. However, it is recommended that the Phase 2 project be implemented as soon as the Phase 1 project is completed since the supply capacity to be furnished by the latter project is aimed at meeting the demand only till the year 2000 and it will not be able to meet the demand soon after that. The implementation schedule of the Phase 1 project was roughly planned as follows:

Groundwater Development

Rehabilitation of Existing Wells	1993
Construction of New Wells	1993 - 1994

Surface Water Development

Installation of Transmission Line	1996 - 1997
Construction of Booster Pumping Stations	1996 - 1997
Construction of Distribution Reservoir	1996 - 1997
Installation of Distribution Pipelines	1997 - 2000

In this schedule, the following considerations were taken into account:

a. Preparations for the rehabilitation of existing wells will begin as soon as possible so as to complete the work by 1993.
b. Preparations for the construction of new wells will begin in 1992 sothat all 7 wells are completed by the middle of 1994.

c. Surface water distribution project will be implemented to supply water by the year 1998 because the water shortage in daily average basis will happen from the year 1999.

d. Feasibility study and detailed engineering design will entail a total time of two and a half (2.5) years, including that expended on loan sourcing/processing, bid preparation, tendering, etc.

e. Construction of the transmission line, booster pump stations, and distribution reservoirs will take one and a half years.

f. Installation of the distribution pipelines will be continuous for 3 years.

In accordance with the above considerations, the time schedule of the project in Phase 1 was prepared as presented in Figure 8.3.13.

8.4 PROJECT EVALUATION

8.4.1 Financial Feasibility Analysis

(1) General

This section discusses the financial feasibility of the project in Phase 1 and develops a financing plan in which the project will be viable. In particular, the following aspects taken into consideration:

a) the costs associated with the proposed project, which include the investment costs and the annual operating and maintenance costs;

b) the potential sources of funds, which are the operating sources (internal cash generation) and the non-operating sources (loans and government equity);

c) the required Financial Internal Rate of Return (FIRR) in projecting the annual revenue; and

d) the costs and revenues that are counted on as additional basis by execution of the project.

(2) Water Tariff

The present water tariff is shown in Table 8.4.1. In the analysis, the Overall Average Tariff projected by CORPLAN, P6.43/m^3, was adopted. In 1990, the average unit production cost per cubic meter was P2.21, based on the data presented in MWSS Annual Report 1990.

(3) Project Financing

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 was assumed that the loans will come from the Asian Development Bank (ADB). The project cost financing is assumed as shown in Table 8.4.2 and the terms include:

Principal : US$16.82M (P437.42M) (US$1=P26)
Interest : 6.36 % interest rate
Repayment
Period : Twenty years with grace period of five years

It has been assumed that the contribution of the government to equity should not reach more than 30 % of the total project cost.

(4) Cost Analysis

a) Project Cost

The total project cost is P802.97 million, the breakdown of which is shown in Table 8.4.3. The breakdown of foreign and local costs is also presented in Table 8.4.3. The assumptions used are as follows:

a. Engineering/detailed design: 8% of basic costs
b. Construction supervision: 4% of basic costs
c. Physical contingencies: 10% of materials and supplies
d. Price contingencies are based on the following:
for local costs: 10% up to 1995 and 8% from 1996 onward;
for foreign component: 4% throughout the period

e. Taxes: 30% of foreign component of equipment/machineries cost plus 10% VAT for all foreign components except engineering cost and for all local cost except labor cost

f. Interest during construction (IDC) : 6.36% per annum

g. Exchange rate: US$1 = P26.00

b) Operation and Maintenance Costs

The operation and maintenance costs include all necessary expenses at the production and distribution levels, based on the projected augmented water amount. The projected annual operation and maintenance cost from 1992 up to 2021 is presented in Table 8.4.4.

Personnel Cost

The total personnel cost incurred in 1990 by the water supply system in the Poblacion of Antipolo was P1,154,280. As there were 19 technicians as of end-1990, the average salary per month of such MWSS personnel in 1990 was estimated at P5,063.

To compute the personnel cost, the unit salary per month was assumed to be P4,000 per employee and P5,000 per engineer/technician. Since the proposed project will be integrated with the MWSS central distribution system, its operation will require additional personnel which is estimated at 5 employees for every additional 1,000 connections.

Electricity

The electricity charge was calculated based on the following terms:

.Generation Charge: P1.985/kWH for electricity consumption
.Energy Charge: P0.160/kWH for electricity consumption
.Distribution Charge: P12.60/kVA for electricity demand

Chemicals

Though water transmitted from CDS is already disinfected at the treatment plant, a cost for additional disinfection chemicals was included considering the long time that elapses before water is distributed. In

addition, water from deepwells shall be disinfected before distribution. The average dosage rate and cost of chlorine are assumed at 0.5ppm and P25.5/kg-chlorine.

Maintenance

The annual maintenance cost has been estimated as a percentage of cumulative investment amount for the considered year as shown below:

.Civil works : 0.5% per year
.Equipment : 4.0% per year
.Pipeline Networks : 0.8% per year

Water from CDS

The transmitted water from the CDS has already incurred treatment and distribution costs before its diversion to the proposed system. This cost is estimated at P2.21 per cubic meter based on the data presented in MWSS Annual Report 1990.

c) Escalation of Costs

To account for the effects of inflation, the investment costs and the annual operating and maintenance costs are escalated by applying the corresponding local and foreign inflation factors computed from inflationary trends. The escalation rate used for local inflation is 10% annually upto 1995 and 8 % from 1996 ,and that for foreign inflation is 4% annually.

(5) Financial Projections

The Project's revenues will be generated from water sales. Estimation of water sales are based on demand for water (or Billed Water). Only augmented water, however, is accounted for in the projection of revenue. The projected revenue is shown in Table 8.4.5.
The result of the projected net cash benefit is presented in Table 8.4.6. The following assumptions are used in the projection:

a) Collection efficiency - 80%

b) Provision for Bad Debts - 4%

c) Accounts receivable - 16%

The Computed Financial Internal Rate of Return (FIRR) for the 30-year project life is 4.46% as presented in Table 8.4.6. Though this value is rather small, it is higher than the Weighted Average Cost of Capital (WACC) of 3.47% as calculated below:

WEIGHTED AVERAGE COST OF CAPITAL (WACC)

	FUNDING SOURCE	% TO TOTAL COST	INTEREST RATE	WEIGHTED RATE
1)	Loan	54.5%	6.36%	3.47%
2)	Gov't Equity	30.0%	0.00%	0.00%
3)	Internal Cash Generation	15.6%	0.00%	0.00%
			WACC =	3.47%

The WACC is based on the interest rate of ADB ordinary loan at 6.36% per annum.

(6) Financial Recommendation

The recommended project is financially feasible based on the results of the computed FIRR. The computed FIRR (4.46%) exceeds the estimated 3.47% WACC. Even though the computed FIRR for the proposed project is financially feasible, it is relatively small in comparison with the desirable level for project implementation in the Philippines.

The proposed project includes three components, namely, existing well rehabilitation, new well construction and construction of surface water distribution facilities. As a reference, the financial feasibility of the groundwater development portion of the proposed project,i.e., rehabilitation and new well construction, was verified as presented in Tables 8.4.7 to 8.4.9. In this case, the direct construction cost for the Inner Network and the Fire Hydrant was also assumed to be financed by the Loans. As a result,FIRR was indicated at 11.43% and estimated WACC was 3.46%.

WACC FOR GROUNDWATER COMPONENT

FUNDING SOURCE	% TO TOTAL COST	INTEREST RATE	WEIGHTED RATE
1) Loan	54.4%	6.36%	3.46%
2) Gov't Equity	25.6%	0.00%	0.00%
3) Internal Cash Gen'n	20.0%	0.00%	0.00%
		WACC =	3.46%

Based on this analysis, it is obvious that the groundwater development portion of the proposed project has higher feasibility than the whole proposed project. Thus, from the financial point of view, the groundwater development portion of the proposed project is recommended for implementation. However, and as stated in Subsection 8.3, the importance of surface water transmission in meeting the future demand of the people in the study area cannot be overemphasized.

8.4.2 Economic Feasibility Analysis

(1) General

Economic analysis involves the evaluation of the effectiveness of the project in terms of socio-economic factors not considered in the financial analysis. The analysis includes an evaluation of benefit and cost variables involved in the proposed improvements in the water supply system.

The implementation of the project will provide the following direct and indirect benefits:

a) Direct Benefits:

- Water is essential to life and to the general well being of society.

- Water is an essential input to any production.

b) Indirect Benefits:

- It can help boost employment and the economy because any program of expenditures has "economic multiplier" for domestic activities.

- It can help augment the government budget, as any development of productive activities generates new public revenue and, therefore, the opportunity for the government to carry out new expansion programs.

- It can reduce some social and economic costs, i.e., the morbidity and mortality rates of some diseases attributed to water shortage, damages caused by fires, etc.

Correspondingly, the realization of the project will produce, besides cost of the investment and of operation & management of the proposed water supply system, other direct and indirect costs depending on:

- Families who pay the water tariff and, therefore, must reduce other consumptions.

- The economy of the country, as large quantities of imports are required.

- The government, as it must give subsidies and grants to the MWSS to help it achieve financial self-sufficiency.

The comparison between the costs and benefits shall allow an assessment of the economic feasibility of the project.

(2) Method of Analysis

The method that was adopted to give an empirical measure of the effectiveness of the project is the Economic Internal Rate of Return (EIRR).

The EIRR is the rate required to balance the present value of the economic costs. This method avoids prior determination of the discount rate.

The project is considered economically feasible if the EIRR is higher than the opportunity cost of capital, or the rate of return that can be obtained from the best alternative use of the available capital. For public investment projects such as water supply projects, the desirable opportunity cost of capital in the Philippines is considered to be 15%.

(3) Economic Benefits of the Project

The economic benefits of the project can be measured as:

- The increment in income or value of some variables "before" and "after" the project; for these computations, the benefits arising from the present system have been deducted. The benefits in this category include increase in consumer satisfaction, increase in income in some productive sectors of the local population, and increase in value of land in the Project Area.

- The reduction in costs realized through the implementation of the project.

a) Consumer Satisfaction

The benefit derived from "consumer satisfaction" includes not only benefit brought about by the actual payments for water but also by how much more consumers are willing to pay for this essential commodity. In general, water prices charged by MWSS are lower than the real value of water; hence, the people in the Project Area are assumed to be willing to obtain water in sufficient quantities at a given price. The resulting economic value of water, assuming it is 1.2 times of the water price shown in Table 8.4.11, is P1,093.3 million.

b) Health

The economic loss to society caused by water shortage and bad water quality, such as death, productive time loss due to sick workers, and expenses entailed in treating water-borne diseases, will be reduced. However, quantification of health benefits is usually difficult because cost statistics on effects of water-borne diseases are in general not disaggregated. Thus, in quantifying health benefits for purposes of this study, three factors were taken into consideration: (a) the cost of time loss due to illness, (b) the income loss due to premature death, and (c) the cost of medical expenses.

In computing the cost of time loss due to illness, it was assumed that not all those afflicted with water-borne diseases are income-earners.

Using the data obtained from the 1980 Census, RPWSIP project staff projected the population that are economically active in 1990, which is estimated at 41.09% for Antipolo, Cainta and Taytay:

Economically Active Population

	Rizal	3 areas
1. Total Population	555,533	258,499
2. Population with gainful occupation	171,348	106,235
% (2/1)	30.84%	41.09%

(Source: F/S, RPWSIP)

In this study, the economically active population ratio of 40% was adopted for the analysis.

Morbidity rate of water-borne diseases in Metro Manila for 1990 was 345 per 100,000 population. The final figure for the cost of time loss due to illness was derived by taking the economically active portion of the population as earning the minimum wage of P118/day for 8 days, and based on the assumption that workers earning P118/day are unable to work for an average of 8 days per year.

The income loss due to premature death was calculated as the product of the following: mortality rate of 21.9 per 100,000, the served population and P155,760, which represents the estimated income to be earned by the average wage earner over a period of five years (P118/day x 264 days/year x 5 years).

The cost of medical expenses was derived by multiplying morbidity rate of the served population and the average annual expenditure for medical expenses of P3,500. This figure was based on the research findings of the RPWSIP project staff on the average medical expenses which are shown in Table 8.4.12.

Finally, the sum of all three economic costs related to health benefits was adjusted by 20% to account for the fact that not all water-borne diseases are caused by a poor water system but may also be due to poor personal hygiene or lack of sewerage facilities.

The total present value of health benefits as presented in Table 8.4.13 is P7.8 million.

c) Fire Protection

The installation of fire hydrants and the increased water pressure will possibly reduce losses due to fire. The extent of fire protection is held to be in proportion to the installation of fire hydrants for each construction period/year of the improvement program. Though 100% of the Project Area is covered by fire hydrants, 20% of fire protection coverage is considered as resulting from the project.

The reduction of fire damage is assumed to be 0.75% of the combined assessed value of structures in the Project Area. The average assessed value of each structure is P500,000, with the number of structure being derived from the total population in the Project Area assuming that each dwelling unit has an average of 7 members (based on the survey result by FAWSP). The present value of fire protection benefits is projected at P155.3 million as shown in Table 8.4.15.

d) Land Value Increase

The water supply improvement project will contribute to an increase in land value of the service area. However, this increased value could be the result of a general increase of productivity due to improved infrastructure which includes a water supply project.

The portion of land values attributable to the water supply system in the service area was determined by comparing the market values of land served and not-served by the water supply system. The market values of residential land in the study area range from about P500 to P800 per sq.m. Generally, it is assumed that 20% to 25% of the incremental value of land could be attributed to the water supply system.

In this study, a land value increase of 25% was also applied. However, for the Poblacion area which is already being served by the existing system, albeit inadequately, the land value increase was estimated at 5%.

The increase of land value was projected at P429.3 million as shown in Table 8.4.16.

(4) Economic Costs of the Project

The direct cost of the project which should be transformed into economic costs are: project cost, replacement cost and operating and maintenance costs.

a) Project Cost

Shadow pricing system was devised for items that are not economically valued by the purely financial price mechanism. This scheme includes making necessary adjustments inasmuch as the foreign exchange component of the project cost may adversely affect the economy because of the reduction in foreign exchange reserves. Thus, it was assumed that the true cost of foreign exchange would be increased by 20%. Likewise, unskilled labor costs should be reduced by 50% because the opportunity cost of unskilled labor is lower than the estimated cost in the project due to the widespread disguised unemployment in the Philippines. Skilled labor was valued at its going rate. It was assumed that skilled laborers were not looking elsewhere to obtain employment or better wage. Table 8.4.17 presents the economic project cost which is P491.0 million.

b) Replacement Costs

The replacement costs or the costs incurred in order to replace mechanical equipment and other items that have outlived their usefulness are considered part of the economic costs.

The economic life of mechanical and electrical equipment was assumed to be 15 years. And the value of the replacement cost was assumed to be equivalent to 80% of the initial investment costs for equipment. Shadow pricing system was also applied to the conversion of financial costs to economic costs. Total economic replacement cost for the analysis is P167.8 million (see Table 8.4.18).

c) Operation and Maintenance Costs

Only incremental costs of personnel, power, chemicals, maintenance, and water were considered in the economic analysis. This cost category was converted to economic costs by shadow pricing items for which the market price is not sufficient. The factors for converting operation and maintenance cost to economic costs were the same as those used for adjusting the project costs. Five percent (5%) was deducted from the local portion as tax. Out of personnel cost, 50% was assumed to be unskilled labor. The total incremental operation and maintenance cost is P753.1 million (see Table 8.4.19).

d) Summary of Economic Costs

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 as shown in Table 8.4.20 is P1,449.7 million.

(5) Economic Internal Rate of Return (EIRR)

Table 8.4.21 shows the computation of the EIRR. The EIRR is 17.19%. Since this rate exceeds the desirable opportunity cost of capital of 15%, the project is considered economically feasible.

As reference, the economic feasibility of a part of a proposed project was verified, i.e., the groundwater development portion that calls for the rehabilitation of some existing wells and the construction of new ones, and is presented in Tables 8.4.22 to 8.4.30. In this case, computed EIRR is at 17.2%, assuming a lower increase of land value due to insufficient augmentation of water to meet demand, which this increase of land value being higher under a full-scale project implementation.

TABLE 8.1.1 CANDIDATE WELLS FOR REHABILITATION OF MWSS DEEPWELLS (March, 1991)

UNIT: NUMBERS OF WELLS)

MUNICIPALITY	Total wells		ACTIVE WELLS						INACTIVE WELLS					
			Good		D-pump		Total		D-pump		Stand-by +Rehab		Total	
	C	F	C	F	C	F	C	F	C	F	C	F	C	F
ANTIPOLO	15	15	11	11	4	4	15	15	0	0	0	0	0	0
BACOOR	6	8	6	8	0	0	6	8	0	0	0	0	0	0
CALOOCAN	0	2	0	0	0	0	0	0	0	0	0	2	0	2
CAINTA	5	6	2	3	1	1	3	4	1	1	1	1	2	2
CAVITE	12	12	12	12	0	0	12	12	0	0	0	0	0	0
IMUS	2	2	2	2	0	0	2	2	0	0	0	0	0	0
KAWIT	6	6	4	4	0	0	4	4	0	0	2	2	2	2
LAS PINAS	1	4	0	0	1	1	1	1	0	1	0	2	0	3
MANDALUYONG	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAKATI	8	32	1	6	3	3	4	9	2	5	2	18	4	23
MALABON	1	3	0	1	0	0	0	1	0	0	1	2	1	2
MANILA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARIKINA	0	11	0	0	0	0	0	0	0	0	0	11	0	11
MONTALBAN	3	3	3	3	0	0	2	3	0	0	0	0	0	0
MUNTINLUPA	6	6	5	5	1	1	6	6	0	0	0	0	0	0
NAVOTAS	1	1	1	1	0	0	1	1	0	0	0	0	0	0
NOVELETA	0	9	0	9	0	0	0	9	0	0	0	0	0	0
PARANAQUE	3	5	3	5	0	0	3	5	0	0	0	0	0	0
PASAY	3	3	1	1	2	2	3	3	0	0	0	0	0	0
PASIG	1	1	1	1	0	0	1	1	0	0	0	0	0	0
PATEROS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUEZON	13	17	10	14	0	0	10	14	2	2	0	1	3	3
ROSARIO	3	3	1	1	0	0	1	1	0	0	1	2	2	2
SAN JUAN	0	0	0	0	0	0	0	0	0	0	2	0	0	0
SAN MATEO	3	3	3	3	0	0	3	3	0	0	0	0	0	0
TAGUIG	1	1	1	1	0	0	1	1	0	0	0	0	0	0
TAYTAY	6	7	5	6	1	1	6	7	0	0	0	0	0	0
VALENZUELA	1	2	1	2	0	0	1	2	0	0	0	0	0	0
TOTAL	100	162	73	99	13	13	85	112	5	9	9	41	14	50

Note: C- Candidate wells for rehabilitation
F- Feasible wells for rehabilitation

TABLE 8.1.2 REHABILITATION PLAN OF MWSS DEEPWELLS

(UNIT: NUMBERS OF WELLS AND DISCHARGE RATE=m3/day)

MUNICIPALITY	Groundwater demand in 1995 (m3/day)	Actual discharge in 1990 (m3/day)	Difference (m3/day)	Target wells for rehabilitation					Expected increased discharge after rehab. (m3/day)
				Active wells		Inactive wells		Total Wells	
				Nos	Increase (m3/day)	Nos	Increase (m3/day)		
ANTIPOLO	24,525	11,616	-12,409	15	3,105	0	0	15	3,105
BACOOR	0	6,329	6,329	6	1,242	0	0	6	1,242
CALOOCAN	0	0	0	0	0	0	0	0	0
CAINTA	0	3,781	3,782	3	621	2	1,380	5	2,001
CAVITE	20,675	8,942	-11,733	12	2,484	0	0	12	2,484
IMUS	13,795	1,644	-12,151	2	414	0	0	2	414
KAWIT	0	4,329	4,239	4	828	2	1,380	6	2,208
LAS PINAS	0	1,534	1,534	1	207	0	0	1	207
MANDALUYONG	0	0	0	0	0	0	0	0	0
MAKATI	0	3,753	3,753	4	828	4	2,760	8	3,588
MALABON	0	548	548	0	0	1	690	1	690
MANILA	0	0	0	0	0	0	0	0	0
MARIKINA	0	0	0	0	0	0	0	0	0
MONTALBAN	0	3,233	3,233	3	621	0	0	3	621
MUNTINLUPA	0	5,781	5,781	6	1,242	0	0	6	1,242
NAVOTAS	0	110	110	1	207	0	0	1	207
NOVELETA	3,584	7,069	3,485	0	0	0	0	0	0
PARANAQUE	0	1,151	1,151	3	621	0	0	3	621
PASAY	0	4,466	4,466	3	621	0	0	3	621
PASIG	0	55	55	1	207	0	0	1	207
PATEROS	0	0	0	0	0	0	0	0	0
QUEZON	0	14,192	14,192	10	2,070	3	2,070	13	4,140
ROSARIO	5,840	877	-4,963	1	207	2	1,380	3	1,587
SAN JUAN	0	0	0	0	0	0	0	0	0
SAN MATEO	0	4,712	4,712	3	621	0	0	3	621
TAGUIG	0	630	630	1	207	0	0	1	207
TAYTAY	0	6,466	6,466	6	1,242	0	0	6	1,242
VALENZUELA	0	740	740	1	207	0	0	1	207
TOTAL	68,419	91,958	23,539	86	17,802	14	9,660	100	27,462

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

TABLE 8.2.1 DETAILS OF MWSS DEEPWELLS - ANTIPOLO AREA

Well No.	Casing Dia. (")	Well Depth (m)	Pumpage (MCM/year)
ATP- 1	6	83.82	0.1261
ATP- 2	8	163.06	0.2667
ATP- 3	6	150.87	0.3215
ATP- 4	8	100.00	0.3352
ATP- 5	6	151.78	0.1305
ATP- 6	8	135.32	0.1377
ATP- 7	6	91.44	0.5001
ATP- 8	8	121.94	0.6205
ATP- 9	8	121.94	0.5687
ATP-10	6	79.24	0.5733

Note: Pumpage data (1990) were derived from the Groundwater Use Survey

TABLE 8.2.2 DETAILS OF PRIVATE DEEPWELLS - ANTIPOLO AREA

Well No.	Well Name	Casing dia. (")	Well Depth (m)	Pumpage (MCM/year)
ATP-2102	STA.Lucia Realty			0.2486
ATP-2106	Assumption Grade Sch.			0.1657
ATP-2082	Citizen Dev. Realty			0.1824
ATP-2083	Dna. Angela Subd.			0.01
ATP-2006	Far East Asia Dev. Corp.			0.01
ATP-2101	Top Service Inc.#1			0.2985
ATP-2100	Top Service Inc.#2			0.2985
ATP-2065	Grand Heights Subd.			0.0821
		8	182.87	0.5271
			54.87	0.4974
ATP-2104	Unciano Medical Center			0.0552
ATP-2064	Milagros Subd.	8	183	0.0921
ATP-2093	Lores Realty #1			0.1104
ATP-2094	Lores Realty #2			0.1104
ATP-2105	Dalaya Construction			0.0132
ATP-2079	San Antonio Village			0.0363
ATP-2103	STA.Lucia Realty			0.2365
ATP-2016	Gloria HTS. Ass'n	8	121.95	0.1073
ATP-2035	Nayong Silangan #1	8	121.95	0.0221
ATP-2036	Nayong Silangan #2	8	121.95	0.0236
ATP-2037	Banaba Court Subd.	8	125.30	0.0414
ANG-2007	Maya Farms Inc.			0.0027
ANG-2008	Maya Farms Inc.			0.0069
ANG-2009	Maya Farms Inc.			0.0069
ANG-2006	Petro Finance Service I			0.0018
ANG-2010	Grand Valley Subd.			0.4139

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

TABLE 8.4.1 MWSS WATER TARIFF SCHEDULE

Customer Type/ Consumption volume	Up to 12/31/91	Effectivity Date 1992 Jan 16	Feb 16	Mar 16	Apr 16	May 16
RESIDENTAL A						
First 10 cu.m.	P18.50/conn.	P20.50	P22.50	P24.50	P26.50	P28.00
Next 10 cu.m.	2.45/cu.m.	2.65	2.85	3.05	3.25	3.40
Next 10 cu.m.	3.20/cu.m.	3.40	3.60	3.80	4.00	4.15
Next 10 cu.m.	4.25/cu.m.	4.45	4.65	4.85	5.05	5.20
Next 10 cu.m.	5.05/cu.m.	5.25	5.45	5.65	5.85	6.05
Next 10 cu.m.	5.60/cu.m.	5.80	6.00	6.20	6.40	6.55
Next 20 cu.m.	6.30/cu.m.	6.50	6.70	6.90	7.10	7.25
Next 20 cu.m.	6.95/cu.m.	7.15	7.35	7.55	7.75	7.90
Over 100 cu.m.	7.50/cu.m.	7.70	7.90	8.10	8.30	8.45
RESIDENTAL B						
First 10 cu.m.	P24.00/conn.	P26.00	P28.00	P30.00	P32.00	P33.50
Next 10 cu.m.	3.15/cu.m.	3.35	3.55	3.75	3.95	4.10
Next 10 cu.m.	3.70/cu.m.	3.90	4.10	4.30	4.50	4.65
Next 10 cu.m.	4.45/cu.m.	4.65	4.85	5.05	5.25	5.40
Next 10 cu.m.	5.15/cu.m.	5.35	5.55	5.75	5.95	6.10
Next 10 cu.m.	5.70/cu.m.	5.90	6.10	6.30	6.50	6.65
Next 20 cu.m.	6.50/cu.m.	6.70	6.90	7.10	7.30	7.45
Next 20 cu.m.	7.05/cu.m.	7.25	7.45	7.65	7.85	8.00
Over 100 cu.m.	7.60/cu.m.	7.80	8.00	8.20	8.40	8.60
COMMERCIAL						
First 25 cu.m.	P202.50/conn.	P207.50	P212.50	P217.50	P222.50	P226.25
Next 975 cu.m.	8.18/cu.m.	8.30	8.50	8.70	8.90	9.05
Over 1000 cu.m.	8.55/cu.m.	8.75	8.95	9.15	9.35	9.50
INDUSTRIAL						
First 25 cu.m.	P222.50/conn.	P227.50	P232.50	P237.50	P242.50	P246.25
Next 975 cu.m.	8.90/cu.m.	9.10	9.30	9.50	9.70	9.85
Over 1000 cu.m.	10.60/cu.m.	10.80	11.00	11.20	11.40	11.55
OVER-ALL AVERAGE TARIFF	P5.48/cu.m.	5.68	5.88	6.08	6.28	6.43

Reference : Board Resolution No. 250-91
Prepared By: The Corporate Planning Group
Date : January 17, 1992

TABLE 8.4.2 PROJECT COST FINANCING

(unit: P1000)

COMPONENTS	TOTAL COST	LOAN	GOV'T EQUITY	INTERNAL CASH G.
CONSTRUCTION WORKS				
1. Existing Well Rehabilitation	4,838	4,838	0	0
2. New Well Construction	13,317	13,317	0	0
3. Elevated Water Tanks	23,448	23,448	0	0
4. Transmission Pipeline	58,343	58,343	0	0
5. Booster Pumping Station No.1	42,223	42,223	0	0
6. Booster Pumping Station No.2	49,201	49,201	0	0
7. Communication Wiring	5,383	5,383	0	0
8. Distribution Reservoir	14,308	14,308	0	0
9. Distribution Main	65,355	65,355	0	0
10. Inner Network	23,761	0	23,761	0
11. Fire Hydrant	3,461	0	3,461	0
12. Service Connection	58,570	0	0	58,570
LAND ACQUISITION				
1. New Well Construction	350	0	350	0
2. Elevated Water Tanks	2,400	0	2,400	0
3. Surface Water Dist. Fac.	9,585	0	9,585	0
ENGINEERING SERVICES (D/D, 8%)				
1. Existing Well Rehabilitation	387	0	387	0
2. New Well Construction	2,941	0	2,941	0
3. Surface Water Dist. Fac.	25,648	0	25,648	0
ENGINEERING SERVICES (C/S, 4%)				
1. Existing Well Rehabilitation	194	0	194	0
2. New Well Construction	1,471	0	1,471	0
3. Surface Water Dist. Fac.	12,824	0	12,824	0
CONTINGENCIES				
1. Physical Contingency	41,801	27,642	14,159	0
2. Price Contingency	203,020	133,362	69,658	0
3. Taxes	73,837	0	73,837	0
4. IDC	66,304	0	0	66,304
TOTAL	802,970	437,420	240,676	124,874
%	100.00%	54.48%	29.97%	15.55%

TABLE 8.4.3 ESTIMATED PROJECT COST AND FINANCING

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	9,585	9,585	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	641	641	1,282
Surface W.	12,824	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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	17,326	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	17,326	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 8.4.3 ESTIMATED PROJECT COST AND FINANCING (cont'd)

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	2,985	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	2,985	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 Acquaition	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	2,941	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 8.4.4 OPERATION AND MAINTENANCE COST

(In Thousand Pesos)

ITEMS	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
A. SALARIES															
Add'l No. of Employees (Adm.)	0	0	0	0	0	17	40	57	67	67	67	67	67	67	67
Unit Salary (P/month) Adm.	4,162	4,245	4,330	4,416	4,505	4,595	4,687	4,780	4,876	4,973	5,073	5,174	5,278	5,383	5,491
Add'l No. of Employees (Eng.)	0	0	8	8	8	8	18	18	18	18	18	18	18	18	18
Unit Salary (P/month) Eng.	5,202	5,306	5,412	5,520	5,631	5,743	5,858	5,975	6,095	6,217	6,341	6,468	6,597	6,729	6,864
Constant Price Index Factor (L)	1.210	1.331	1.464	1.611	1.739	1.878	2.029	2.191	2.366	2.556	2.760	2.981	3.219	3.477	3.755
Total Personnel Cost per Year	0	0	63	71	78	233	594	833	1,033	1,138	1,253	1,381	1,521	1,675	1,845
B. ELECTRICITY															
Add'l Power Charge for Well Pump	0	0	854	1,089	1,975	2,859	3,745	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480
Power Charge for B.P.S. #1	0	0	0	0	0	0	0	181	860	1,393	1,926	2,459	2,992	3,525	3,951
Power Charge for B.P.S. #2	0	0	0	0	0	0	0	254	1,258	2,046	2,833	3,621	4,409	5,197	5,827
Constant Price Index Factor (F)	1.082	1.125	1.170	1.217	1.265	1.316	1.369	1.423	1.480	1.539	1.601	1.665	1.732	1.801	1.873
Total Electricity Cost per Year	0	0	999	1,325	2,499	3,762	5,125	6,996	9,766	12,190	14,792	17,583	20,573	23,774	26,705
C. CHEMICALS															
Add'l Water Distribution (m3/day)	0	0	937	1,873	3,442	5,009	6,578	8,145	9,714	10,945	12,177	13,408	14,640	15,871	16,857
Chlorine Consumption (kg/year)	0	0	171	342	628	914	1,200	1,486	1,773	1,997	2,222	2,447	2,672	2,896	3,076
Chemicals Cost P25.5/kg	0	0	4	9	16	23	31	38	45	51	57	62	68	74	78
Constant Price Index Factor (F)	1.082	1.125	1.170	1.217	1.265	1.316	1.369	1.423	1.480	1.539	1.601	1.665	1.732	1.801	1.873
Total Chemicals Cost per Year	0	0	5	11	20	31	42	54	67	78	91	104	118	133	147
D. MAINTENANCE															
Total Maintenance Cost	0	0	205	383	383	622	4,040	4,426	4,766	4,984	4,984	9,822	4,984	4,984	4,984
Constant Price Index Factor (F&L)	1.146	1.228	1.317	1.414	1.502	1.597	1.699	1.807	1.923	2.048	2.181	2.323	2.476	2.639	2.814
Total Maintenance Cost per Year	0	0	270	541	575	993	6,863	7,999	9,166	10,205	10,868	22,817	12,338	13,153	14,025
E. WATER FROM CDS															
Transmitted Water Volume (m3/day)	0	0	0	0	0	0	0	265	1,534	3,065	4,297	5,528	6,760	7,991	8,977
Annual Production Cost P2.21/m3	0	0	0	0	0	0	0	214	1,479	2,473	3,466	4,459	5,453	6,446	7,241
Constant Price Index Factor (L)	1.210	1.331	1.464	1.611	1.739	1.878	2.029	2.191	2.366	2.556	2.760	2.981	3.219	3.477	3.755
Total Water Cost per Year	0	0	0	0	0	0	0	468	3,501	6,319	9,567	13,293	17,554	22,412	27,191
TOTAL OPERATION AND MAINTENANCE COST	0	0	1,337	1,948	3,173	5,020	12,624	16,349	23,533	29,931	36,571	55,177	52,104	61,147	69,914

(L):Local Cost, (F): Foreign Cost, (F&L): Foregn 50% + Local 50%

TABLE 8.4.4 OPERATION AND MAINTENANCE COST (cont'd)

(In Thousand Pesos)

ITEMS	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
A. SALARIES															
Add'l No. of Employees (Adm.)	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67
Unit Salary (P/month) Adm.	5,601	5,713	5,827	5,944	6,063	6,184	6,308	6,434	6,562	6,694	6,828	6,964	7,103	7,245	7,390
Add'l No. of Employees (Eng.)	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Unit Salary (P/month) Eng.	7,001	7,141	7,284	7,430	7,578	7,730	7,884	8,042	8,203	8,367	8,534	8,705	8,879	9,057	9,238
Constant Price Index Factor (L)	4.056	4.380	4.730	5.109	5.518	5.959	6.436	6.950	7.507	8.107	8.756	9.456	10.213	11.030	11.912
Total Personnel Cost per Year	2,033	2,240	2,467	2,718	2,994	3,298	3,633	4,002	4,409	4,857	5,350	5,894	6,493	7,152	7,879
B. ELECTRICITY															
Add'l Power Charge for Well Pump	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480
Power Charge for B.P.S. #1	4,375	4,804	5,231	5,658	5,658	5,658	5,658	5,658	5,658	5,658	5,658	5,658	5,658	5,658	5,658
Power Charge for B.P.S. #2	6,458	7,089	7,719	8,350	8,350	8,350	8,350	8,350	8,350	8,350	8,350	8,350	8,350	8,350	8,350
Constant Price Index Factor (F)	1.948	2.026	2.107	2.191	2.279	2.370	2.465	2.563	2.666	2.772	2.883	2.999	3.119	3.243	3.373
Total Electricity Cost per Year	29,833	33,168	36,722	40,508	42,128	43,813	45,566	47,388	49,284	51,255	53,305	55,438	57,655	59,961	62,360
C. CHEMICALS															
Add'l Water Distribution (m3/day)	17,843	18,828	19,814	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800	20,800
Chlorine Consumption (kg/year)	3,256	3,436	3,616	3,796	3,796	3,796	3,796	3,796	3,796	3,796	3,796	3,796	3,796	3,796	3,796
Chemicals Cost P25.5/kg	83	88	92	97	97	97	97	97	97	97	97	97	97	97	97
Constant Price Index Factor (F)	1.948	2.026	2.107	2.191	2.279	2.370	2.465	2.563	2.666	2.772	2.883	2.999	3.119	3.243	3.373
Total Chemicals Cost per Year	162	178	194	212	221	229	239	248	258	268	279	290	302	314	327
D. MAINTENANCE															
Total Maintenance Cost	4,984	4,984	4,984	4,984	4,984	4,984	9,822	4,984	4,984	4,984	4,984	4,984	4,984	4,984	4,984
Constant Price Index Factor (F&L)	3.002	3.203	3.419	3.650	3.898	4.164	4.450	4.757	5.086	5.440	5.819	6.227	6.666	7.136	7.643
Total Maintenance Cost per Year	14,961	15,963	17,038	18,191	19,428	20,755	43,710	23,708	25,350	27,112	29,004	31,037	33,221	35,568	38,090
E. WATER FROM CDS															
Transmitted Water Volume (m3/day)	9,963	10,948	11,934	12,920	12,920	12,920	12,920	12,920	12,920	12,920	12,920	12,920	12,920	12,920	12,920
Annual Production Cost P2.21/m3	8,036	8,832	9,627	10,422	10,422	10,422	10,422	10,422	10,422	10,422	10,422	10,422	10,422	10,422	10,422
Constant Price Index Factor (L)	4.056	4.380	4.730	5.109	5.518	5.959	6.436	6.950	7.507	8.107	8.756	9.456	10.213	11.030	11.912
Total Water Cost per Year	32,592	38,682	45,538	53,244	57,503	62,103	67,072	72,437	78,232	84,491	91,250	98,550	106,434	114,949	124,145
TOTAL OPERATION AND MAINTENANCE COST	79,580	90,230	101,960	114,873	122,274	130,199	160,219	147,784	157,533	167,983	179,189	191,209	204,105	217,945	232,801

(L):Local Cost, (F): Foreign Cost, (F&L): Foreign 50% + Local 50%

TABLE 8.4.5 PROJECTED REVENUE

(In Thousand Pesos)

YEAR	ADD'L WATER PROD. VOLUME (MCM)	RATIO OF SOLD WATER (%)	ADD'L SOLD WATER VOLUME (MCM)	LEAKED WATER RECOVERY VOLUME (MCM)	AVERAGE WATER TARIFF (P/m3)	ADD'L WATER SALES REVENUE (1000P)	BILL COLL'N EFF. (%)	PROVISION FOR BAD DEBTS (1000P)	ACC'TS RECEIV-ABLES (1000P)	CASH RECEIPTS FROM OPER'N (1000P)
							80.00%	4.00%	16.00%	
1992	0.00	55.0%	0.00	0.00	6.43	0	0	0	0	0
1993	0.00	60.0%	0.00	0.00	7.07	0	0	0	0	0
1994	0.34	65.0%	0.22	0.64	7.78	6,743	80.00%	270	1,079	5,394
1995	0.68	70.0%	0.48	0.82	8.56	11,143	81.77%	446	1,783	9,993
1996	1.26	70.0%	0.88	0.82	9.24	15,740	82.03%	630	2,518	14,375
1997	1.83	70.0%	1.28	0.82	9.98	20,996	82.14%	840	3,359	19,315
1998	2.40	70.0%	1.68	0.82	10.78	26,997	82.21%	1,080	4,320	24,957
1999	2.97	70.0%	2.08	0.82	11.64	33,819	82.27%	1,353	5,411	31,375
2000	3.55	70.0%	2.48	0.82	12.57	41,565	82.30%	1,663	6,650	38,663
2001	4.00	71.0%	2.84	0.86	13.58	50,192	82.34%	2,008	8,031	46,804
2002	4.44	72.0%	3.20	0.90	14.67	60,065	82.36%	2,403	9,610	56,083
2003	4.89	73.0%	3.57	0.93	15.84	71,339	82.37%	2,854	11,414	66,682
2004	5.34	74.0%	3.95	0.97	17.11	84,186	82.39%	3,367	13,470	78,763
2005	5.79	75.0%	4.34	1.00	18.48	98,798	82.40%	3,952	15,808	92,509
2006	6.15	75.0%	4.61	1.00	19.95	112,087	82.47%	4,483	17,934	105,478
2007	6.51	75.0%	4.88	1.00	21.55	126,870	82.48%	5,075	20,299	119,430
2008	6.87	75.0%	5.15	1.00	23.28	143,301	82.48%	5,732	22,928	134,940
2009	7.23	75.0%	5.42	1.00	25.14	161,549	82.49%	6,462	25,848	152,167
2010	7.59	75.0%	5.69	1.00	27.15	181,799	82.49%	7,272	29,088	171,287
2011	7.59	75.0%	5.69	1.00	29.32	196,343	82.58%	7,854	31,415	186,162
2012	7.59	75.0%	5.69	1.00	31.67	212,051	82.58%	8,482	33,928	201,055
2013	7.59	75.0%	5.69	1.00	34.20	229,015	82.58%	9,161	36,642	217,140
2014	7.59	75.0%	5.69	1.00	36.94	247,336	82.58%	9,893	39,574	234,511
2015	7.59	75.0%	5.69	1.00	39.89	267,123	82.58%	10,685	42,740	253,272
2016	7.59	75.0%	5.69	1.00	43.08	288,492	82.58%	11,540	46,159	273,534
2017	7.59	75.0%	5.69	1.00	46.53	311,572	82.58%	12,463	49,851	295,416
2018	7.59	75.0%	5.69	1.00	50.25	336,498	82.58%	13,460	53,840	319,050
2019	7.59	75.0%	5.69	1.00	54.27	363,417	82.58%	14,537	58,147	344,574
2020	7.59	75.0%	5.69	1.00	58.61	392,491	82.58%	15,700	62,799	372,139
2021	7.59	75.0%	5.69	1.00	63.30	423,890	82.58%	16,956	67,822	401,911

TABLE 8.4.6 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 8.4.7 ESTIMATED PROJECT COST AND FINANCING (GROUNDWATER COMPONENT 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	3,498	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 8.4.8 OPERATION AND MAINTENANCE COST (Groundwater only)

(In Thousand Pesos)

ITEMS	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
A. SALARIES															
Add'l No. of Employees (Adm.)	0	17	25	32	40	40	40	40	40	40	40	40	40	40	40
Unit Salary (P/month) Adm.	4,162	4,245	4,330	4,416	4,505	4,595	4,687	4,780	4,876	4,973	5,073	5,174	5,278	5,383	5,491
Add'l No. of Employees (Eng.)	0	0	8	8	8	8	8	8	8	8	8	8	8	8	8
Unit Salary (P/month) Eng.	5,202	5,306	5,412	5,520	5,631	5,743	5,858	5,975	6,095	6,217	6,341	6,468	6,597	6,729	6,864
Constant Price Index Factor (L)	1.210	1.331	1.464	1.611	1.739	1.878	2.029	2.191	2.366	2.556	2.760	2.981	3.219	3.477	3.755
Total Personnel Cost per Year	0	96	222	299	392	432	475	524	577	636	700	771	850	936	1,031
B. ELECTRICITY															
Add'l Power Charge for Well Pump	0	0	854	1,089	1,975	2,859	3,745	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480
Power Charge for B.P.S. #1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Charge for B.P.S. #1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Constant Price Index Factor (F)	1.082	1.125	1.170	1.217	1.265	1.316	1.369	1.423	1.480	1.539	1.601	1.665	1.732	1.801	1.873
Total Electricity Cost per Year	0	0	999	1,325	2,499	3,762	5,125	6,376	6,631	6,896	7,172	7,459	7,757	8,068	8,390
C. CHEMICALS															
Add'l Water Production (m3/day)	0	0	937	1,873	3,442	5,009	6,578	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880
Chlorine Consumption (kg/year)	0	0	171	342	628	914	1,200	1,438	1,438	1,438	1,438	1,438	1,438	1,438	1,438
Chemicals Cost P25.5/kg	0	0	4	9	16	23	31	37	37	37	37	37	37	37	37
Constant Price Index Factor (F)	1.082	1.125	1.170	1.217	1.265	1.316	1.369	1.423	1.480	1.539	1.601	1.665	1.732	1.801	1.873
Total Chemicals Cost per Year	0	0	5	11	20	31	42	52	54	56	59	61	64	66	69
D. MAINTENANCE															
Total Maintenance Cost	0	0	536	1,023	1,295	1,470	1,470	1,470	1,470	1,470	1,470	6,308	1,470	1,470	1,470
Constant Price Index Factor (F&L)	1.146	1.228	1.317	1.414	1.502	1.597	1.699	1.807	1.923	2.048	2.181	2.323	2.476	2.639	2.814
Total Maintenance Cost per Year	0	0	706	1,446	1,946	2,348	2,497	2,657	2,827	3,010	3,205	14,654	3,639	3,879	4,137
TOTAL OPERATION AND MAINTENANCE COST	0	96	1,932	3,080	4,856	6,573	8,139	9,608	10,089	10,598	11,136	22,945	12,310	12,949	13,627

(L): Local Cost, (F): Foreign Cost, (F&L): Foreign 50% + Local 50%

TABLE 8.4.8 OPERATION AND MAINTENANCE COST (Groundwater only) (cont'd)

(In Thousand Pesos)

ITEMS	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
A. SALARIES															
Add'l No. of Employees (Adm.)	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Unit Salary (P/month) Adm.	5,601	5,713	5,827	5,944	6,063	6,184	6,308	6,434	6,562	6,694	6,828	6,964	7,103	7,245	7,390
Add'l No. of Employees (Eng.)	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Unit Salary (P/month) Eng.	7,001	7,141	7,284	7,430	7,578	7,730	7,884	8,042	8,203	8,367	8,534	8,705	8,879	9,057	9,238
Constant Price Index Factor (L)	4.056	4.380	4.730	5.109	5.518	5.959	6.436	6.950	7.507	8.107	8.756	9.456	10.213	11.030	11.912
Total Personnel Cost per Year	1,136	1,251	1,378	1,518	1,673	1,842	2,030	2,236	2,463	2,713	2,989	3,293	3,627	3,996	4,402
B. ELECTRICITY															
Add'l Power Charge for Well Pump	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480	4,480
Power Charge for B.P.S. #1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power Charge for B.P.S. #1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Constant Price Index Factor (F)	1.948	2.026	2.107	2.191	2.279	2.370	2.465	2.563	2.666	2.772	2.883	2.999	3.119	3.243	3.373
Total Electricity Cost per Year	8,726	9,075	9,438	9,816	10,208	10,616	11,041	11,483	11,942	12,420	12,917	13,433	13,971	14,529	15,111
C. CHEMICALS															
Add'l Water Production (m3/day)	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880	7,880
Chlorine Consumption (kg/year)	1,438	1,438	1,438	1,438	1,438	1,438	1,438	1,438	1,438	1,438	1,438	1,438	1,438	1,438	1,438
Chemicals Cost P25.5/kg	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37
Constant Price Index Factor (F)	1.948	2.026	2.107	2.191	2.279	2.370	2.465	2.563	2.666	2.772	2.883	2.999	3.119	3.243	3.373
Total Chemicals Cost per Year	71	74	77	80	84	87	90	94	98	102	106	110	114	119	124
D. MAINTENANCE															
Total Maintenance Cost	1,470	1,470	1,470	1,470	1,470	1,470	6,305	1,470	1,470	1,470	1,470	1,470	1,470	1,470	1,470
Constant Price Index Factor (F&L)	3.002	3.203	3.419	3.650	3.898	4.164	4.450	4.757	5.086	5.440	5.819	6.227	6.666	7.136	7.643
Total Maintenance Cost per Year	4,413	4,708	5,025	5,365	5,730	6,122	28,072	6,993	7,477	7,996	8,555	9,154	9,798	10,491	11,235
TOTAL OPERATION AND MAINTENANCE COST	14,346	15,109	15,919	16,780	17,695	18,668	41,233	20,805	21,980	23,231	24,566	25,990	27,511	29,135	30,870

(L): Local Cost, (F): Foreign Cost, (F&L): Foreign 50% + Local 50%

TABLE 8.4.9 PROJECTED REVENUE
(Groundwater only)

YEAR	ADD'L WATER PROD. VOLUME (MCM)	RATIO OF SOLD WATER (%)	ADD'L SOLD WATER VOLUME (MCM)	LEAKED WATER RECOVERY VOLUME (MCM)	AVERAGE WATER TARIFF (P/m3)	ADD'L WATER SALES REVENUE (1000P)	BILL COLL'N EFF. (%)	PROVISION FOR BAD DEBTS (1000P)	ACC'TS RECEIV-ABLES (1000P)	CASH RECEIPTS FROM OPER'N (1000P)
							80.00%	4.00%	16.00%	
1992	0.00	55.0%	0.00	0.00	6.43	0	0	0	0	0
1993	0.00	60.0%	0.00	0.47	7.07	3,292	80.00%	132	527	2,634
1994	0.34	65.0%	0.22	0.64	7.78	6,743	81.45%	270	1,079	5,921
1995	0.68	70.0%	0.48	0.82	8.56	11,143	81.77%	446	1,783	9,993
1996	1.26	70.0%	0.88	0.82	9.24	15,740	82.03%	630	2,518	14,375
1997	1.83	70.0%	1.28	0.82	9.98	20,996	82.14%	840	3,359	19,315
1998	2.40	70.0%	1.68	0.82	10.78	26,997	82.21%	1,080	4,320	24,957
1999	2.88	70.0%	2.01	0.82	11.64	33,030	82.31%	1,321	5,285	30,744
2000	2.88	70.0%	2.01	0.82	12.57	35,673	82.58%	1,427	5,708	33,823
2001	2.88	71.0%	2.04	0.86	13.58	39,403	82.53%	1,576	6,305	37,230
2002	2.88	72.0%	2.07	0.90	14.67	43,503	82.53%	1,740	6,960	41,107
2003	2.88	73.0%	2.10	0.93	15.84	48,006	82.53%	1,920	7,681	45,365
2004	2.88	74.0%	2.13	0.97	17.11	52,951	82.53%	2,118	8,472	50,042
2005	2.88	75.0%	2.16	1.00	18.48	58,380	82.53%	2,335	9,341	55,176
2006	2.88	75.0%	2.16	1.00	19.95	63,050	82.58%	2,522	10,088	59,781
2007	2.88	75.0%	2.16	1.00	21.55	68,094	82.58%	2,724	10,895	64,563
2008	2.88	75.0%	2.16	1.00	23.28	73,542	82.58%	2,942	11,767	69,728
2009	2.88	75.0%	2.16	1.00	25.14	79,425	82.58%	3,177	12,708	75,307
2010	2.88	75.0%	2.16	1.00	27.15	85,779	82.58%	3,431	13,725	81,331
2011	2.88	75.0%	2.16	1.00	29.32	92,641	82.58%	3,706	14,823	87,638
2012	2.88	75.0%	2.16	1.00	31.67	100,053	82.58%	4,002	16,008	94,865
2013	2.88	75.0%	2.16	1.00	34.20	108,057	82.58%	4,322	17,289	102,454
2014	2.88	75.0%	2.16	1.00	36.94	116,702	82.58%	4,668	18,672	110,650
2015	2.88	75.0%	2.16	1.00	39.89	126,038	82.58%	5,042	20,166	119,502
2016	2.88	75.0%	2.16	1.00	43.08	136,121	82.58%	5,445	21,779	129,063
2017	2.88	75.0%	2.16	1.00	46.53	147,010	82.58%	5,880	23,522	139,388
2018	2.88	75.0%	2.16	1.00	50.25	158,771	82.58%	6,351	25,403	150,539
2019	2.88	75.0%	2.16	1.00	54.27	171,473	82.58%	6,859	27,436	162,582
2020	2.88	75.0%	2.16	1.00	58.61	185,191	82.58%	7,408	29,631	175,588
2021	2.88	75.0%	2.16	1.00	63.30	200,006	82.58%	8,000	32,001	189,635

TABLE 8.4.10 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 8.4.11 INCREASE IN CONSUMER SATISFACTION

YEAR	ADD'L WATER PROD. VOLUME (MCM)	RATIO OF SOLD WATER (%)	ADD'L SOLD WATER VOLUME (MCM)	LEAKED WATER RECOVERY VOLUME (MCM)	AVERAGE WATER TARIFF (P/m3)	ECONOMIC VALUE PER CU.M (P/m3)	ECONOMIC WATER REVENUE (P1,000)
1992	0.00	55.0%	0.00	0.00	6.43	7.72	0
1993	0.00	60.0%	0.00	0.00	6.43	7.72	0
1994	0.34	65.0%	0.22	0.64	6.43	7.72	6,687
1995	0.68	70.0%	0.48	0.82	6.43	7.72	10,046
1996	1.26	70.0%	0.88	0.82	6.43	7.72	13,140
1997	1.83	70.0%	1.28	0.82	6.43	7.72	16,229
1998	2.40	70.0%	1.68	0.82	6.43	7.72	19,322
1999	2.97	70.0%	2.08	0.82	6.43	7.72	22,411
2000	3.55	70.0%	2.48	0.82	6.43	7.72	25,504
2001	4.00	71.0%	2.84	0.86	6.43	7.72	28,517
2002	4.44	72.0%	3.20	0.90	6.43	7.72	31,598
2003	4.89	73.0%	3.57	0.93	6.43	7.72	34,749
2004	5.34	74.0%	3.95	0.97	6.43	7.72	37,969
2005	5.79	75.0%	4.34	1.00	6.43	7.72	41,259
2006	6.15	75.0%	4.61	1.00	6.43	7.72	43,341
2007	6.51	75.0%	4.88	1.00	6.43	7.72	45,423
2008	6.87	75.0%	5.15	1.00	6.43	7.72	47,506
2009	7.23	75.0%	5.42	1.00	6.43	7.72	49,588
2010	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2011	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2012	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2013	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2014	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2015	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2016	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2017	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2018	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2019	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2020	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
2021	7.59	75.0%	5.69	1.00	6.43	7.72	51,670
TOTAL INCREASE IN CONSUMER SATISFACTION							1,093,329

* Economic value per cu.m was assumed to be 1.2 times of the price.

TABLE 8.4.12 MEDICAL EXPENSE FOR A WATER-BORNE DISEASE

ITEMS	EAST AVENUE MEDICAL CENTE	ST. LUKE'S MEDICAL CENTE	LUNG CENTER OF THE PHIL.
LABORATORY TEST			
CBC	P70.00	P110.00	P95.00
Stool Examination for Amoebiasis	35.00	70.00	60.00
Sensitibity to Antibiotics	150.00	200.00	170.00
Culture of Amoebiasis Organism	150.00	240.00	170.00
Widal Test	120.00	210.00	160.00
Blood Culture	200.00	430.00	200.00
Electrolyte Determination	120.00	210.00	180.00
Proctosigmoidiscopy	100.00	500.00	350.00
SUB-TOTAL	P945.00	P1,970.00	P1,385.00
HOSPITALIZATION			
Three (3) days confinement	@P65/day= P195.00	@P150/day= P450.00	@P100/day= P300.00
Antibiotics @P60/day for 30 days	420.00	420.00	420.00
Dextrose 4 lit. @P80/bottle	320.00	320.00	320.00
Rehydration medicine @P6.00/day	180.00	180.00	180.00
Vitamins for revitalizing body @P4.20/day for 30 days	126.00	126.00	126.00
Doctors fee average of 3 visits	195.00	450.00	300.00
SUB-TOTAL	P1,436.00	P1,946.00	P1,646.00
FOLLOW-UP (CHECK-UP)			
Stool Examination	P35.00	P70.00	P60.00
Second Culture of Amoebiasis Organism	150.00	240.00	170.00
Doctors Fee	-	100.00	100.00
Follow-up Medicines	65.00	65.00	65.00
SUB-TOTAL	P250.00	P475.00	P405.00
GRAND TOTAL	P2,631.00	P4,391.00	P3,436.00
AVERAGE OF THE THREE HOSPITALS	P3,486.00	SAY P3,500.00	

SOURCE: F/S, RPWSIP

TABLE 8.4.13 HEALTH BENEFIT

YEAR	1/ ADD'L SERVED POP'N	COST OF TIME LOSS DUE TO ILLNESS (P1,000)	LOSS DUE TO PREMATURE DEATH (P1,000)	COST OF MEDICAL EXPENSES (P1,000)	TOTAL ECONOMIC LOSS (P1,000)	ECON. LOSS REDUCTION BY PROJECT 20% (P1,000)
1992	0	0	0	0	0	0
1993	0	0	0	0	0	0
1994	4,714	6	64	57	127	25
1995	9,427	12	129	114	255	51
1996	16,429	21	224	198	444	89
1997	22,962	30	313	277	620	124
1998	29,208	38	399	353	789	158
1999	35,247	46	481	426	952	190
2000	41,151	54	561	497	1,112	222
2001	44,329	58	605	535	1,198	240
2002	47,508	62	648	574	1,284	257
2003	50,686	66	692	612	1,370	274
2004	53,865	70	735	650	1,456	291
2005	57,043	74	778	689	1,541	308
2006	58,814	77	802	710	1,589	318
2007	60,586	79	827	732	1,637	327
2008	62,357	81	851	753	1,685	337
2009	64,129	84	875	774	1,733	347
2010	65,900	86	899	796	1,781	356
2011	65,900	86	899	796	1,781	356
2012	65,900	86	899	796	1,781	356
2013	65,900	86	899	796	1,781	356
2014	65,900	86	899	796	1,781	356
2015	65,900	86	899	796	1,781	356
2016	65,900	86	899	796	1,781	356
2017	65,900	86	899	796	1,781	356
2018	65,900	86	899	796	1,781	356
2019	65,900	86	899	796	1,781	356
2020	65,900	86	899	796	1,781	356
2021	65,900	86	899	796	1,781	356
TOTAL HEALTH BENEFIT						7,832

1/ (Total served pop'n)*(Augmented water share in total production)

TABLE 8.4.14 WEIGHTED AVERAGE REPLACEMENT COST OF DWELLING UNIT

TYPE OF DWELLING UNIT	VALUE (P1000)	NO. IN RIZAL	% TO TOTAL	RVSD % FOR ANTIPOLO	WEIGHTED COST
A. Galvanized Iron/Aluminium/ Tile/Concrete/Brick Stone	1,200	9,865	9.90%	10.00%	120,000
B. Wood/Plywood	350	37,601	37.74%	40.00%	140,000
C. Mixed A & B	600	34,549	34.67%	36.00%	216,000
D. Bamboo/Sawali/Cogon/Nipa	150	12,814	12.86%	10.00%	15,000
E. Others	18	4,814	4.83%	4.00%	720
TOTAL		99,643	100.00%	100.00%	491,720
				say	500,000

(Source: F/S, RPWSIP)

Assumed Value of Replacement Cost by Dwelling Unit Type:

Type of Dwelling Unit	Unit Cost (P/m2)	Avg. Area (m2)	Total (P1000)
A. Galvanized Iron/Aluminium/ Tile/Concrete/Brick Stone	6,000	200	1,200
B. Wood/Plywood	3,500	100	350
C. Mixed A & B	4,000	150	600
D. Bamboo/Sawali/Cogon/Nipa	2,500	60	150
E. Others	1,000	18	18

TABLE 8.4.15 FIRE DAMAGE REDUCTION

YEAR	1/ ADD'L SERVED POP'N	NUMBER OF HOUSINGS	TOTAL VALUE P500,000 EACH (P1000)	0.75% OVERALL REDUCTION IN FIRE DAMAGE	RATIO OF PROTECTION	NET REDUCTION IN FIRE DAMAGE (P1000)
1992	0	0	0	0	20%	0
1993	0	0	0	0	20%	0
1994	4,714	673	323,246	2,424	20%	485
1995	9,427	1,347	673,357	5,050	20%	1,010
1996	16,429	2,347	1,173,500	8,801	20%	1,760
1997	22,962	3,280	1,640,143	12,301	20%	2,460
1998	29,208	4,173	2,086,286	15,647	20%	3,129
1999	35,247	5,035	2,517,643	18,882	20%	3,776
2000	41,151	5,879	2,939,357	22,045	20%	4,409
2001	44,329	6,333	3,166,386	23,748	20%	4,750
2002	47,508	6,787	3,393,414	25,451	20%	5,090
2003	50,686	7,241	3,620,443	27,153	20%	5,431
2004	53,865	7,695	3,847,471	28,856	20%	5,771
2005	57,043	8,149	4,074,500	30,559	20%	6,112
2006	58,814	8,402	4,201,029	31,508	20%	6,302
2007	60,586	8,655	4,327,557	32,457	20%	6,491
2008	62,357	8,908	4,454,086	33,406	20%	6,681
2009	64,129	9,161	4,580,614	34,355	20%	6,871
2010	65,900	9,414	4,707,143	35,304	20%	7,061
2011	65,900	9,414	4,707,143	35,304	20%	7,061
2012	65,900	9,414	4,707,143	35,304	20%	7,061
2013	65,900	9,414	4,707,143	35,304	20%	7,061
2014	65,900	9,414	4,707,143	35,304	20%	7,061
2015	65,900	9,414	4,707,143	35,304	20%	7,061
2016	65,900	9,414	4,707,143	35,304	20%	7,061
2017	65,900	9,414	4,707,143	35,304	20%	7,061
2018	65,900	9,414	4,707,143	35,304	20%	7,061
2019	65,900	9,414	4,707,143	35,304	20%	7,061
2020	65,900	9,414	4,707,143	35,304	20%	7,061
2021	65,900	9,414	4,707,143	35,304	20%	7,061
TOTAL FIRE DAMAGE REDUCTION						155,257

1/ (Total served pop'n)*(Augmented water share in total production)

TABLE 8.4.16 INCREASE IN LAND VALUE

YEAR	SERVICE AREA (HA)	RATIO OF BENEFIT AREA (%)	BENEFIT AREA (HA)	INCREASE OF BENEFIT AREA (HA)	NET BENEFIT AREA INCREASE (HA)	LAND PRICE (P/m2)	INCREASE IN LAND VALUE (%)	INCREASE IN LAND VALUE (P1,000)
					(60%)			
1992	420	0.0%	0.00	0.00	0.00	800	5.00%	0
1993	420	0.0%	0.00	0.00	0.00	800	5.00%	0
1994	420	50.0%	210.00	210.00	126.00	800	5.00%	50,400
1995	420	100.0%	420.00	210.00	126.00	800	5.00%	50,400
1996	420	100.0%	420.00	0.00	0.00	600	25.00%	0
1997	511	100.0%	511.25	91.25	54.75	600	25.00%	82,125
1998	603	100.0%	602.50	91.25	54.75	600	25.00%	82,125
1999	694	100.0%	693.75	91.25	54.75	600	25.00%	82,125
2000	785	100.0%	785.00	91.25	54.75	600	25.00%	82,125
TOTAL INCREASE IN LAND VALUE								429,300

TABLE 8.4.17 CONVERSION OF FINANCIAL PROJECT COSTS TO ECONOMIC COSTS

COMPONENTS	SUB-TOTAL	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
1. Materials	47,002	0	0	0	5,539	10,770	16,308	4,526	8,801	13,328	0	0	0	6,938	10,427	17,365
2. Labor																
Skilled Labor	4,024	0	0	0	0	892	892	0	710	710	0	0	0	0	2,422	2,422
Unskilled Labor	2,926	0	0	0	0	1,045	1,045	0	772	772	0	0	0	0	1,110	1,110
3. Equipment	20,605	0	0	0	5,429	1,281	6,710	2,163	801	2,964	0	0	0	5,007	5,923	10,930
4. Land Acqusition	12,335	0	2,750	2,750	0	0	0	0	0	0	0	9,585	9,585	0	0	0
5. Eng'g Serv. (D/D) Rehab.	31,675	639	2,130	2,769	160	533	692	0	0	0	12,311	10,259	22,571	3,078	2,565	5,643
6. Eng'g Serv. (C/S) Rehab.	3,141	0	0	0	248	827	1,075	151	504	655	0	0	0	769	641	1,411
6. Physical Contingency	12,463	64	488	552	1,138	1,639	2,777	684	1,236	1,920	1,231	1,984	3,216	1,579	2,420	3,999
ECONOMIC PROJECT COST	134,172	703	5,368	6,071	12,513	16,986	29,499	7,525	12,825	20,350	13,542	21,829	35,371	17,372	25,509	42,880

COMPONENTS	SUB-TOTAL	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	TOTAL COST
1. Materials Sub Total	84,289	25,877	26,448	52,325	5,318	7,080	12,397	5,247	6,553	11,800	3,486	4,280	7,767	131,291
2. Labor														
Skilled Labor Sub Total	25,365	0	15,763	15,763	0	3,802	3,802	0	3,509	3,509	0	2,291	2,291	29,390
Unskilled L. Sub Total	9,215	0	5,028	5,028	0	1,771	1,771	0	1,478	1,478	0	937	937	12,141
3. Equipment Sub Total	192,311	87,987	24,515	112,501	24,632	8,890	33,522	19,624	8,671	28,295	12,248	5,744	17,992	212,915
4. Land Acqusition	0	0	0	0	0	0	0	0	0	0	0	0	0	12,335
5. Eng'g Serv. (D/D) Rehab.	0	0	0	0	0	0	0	0	0	0	0	0	0	31,675
6. Eng'g Serv. (C/S) Rehab.	12,388	3,847	3,206	7,053	462	1,539	2,001	462	1,539	2,001	308	1,026	1,334	15,530
6. Physical Contingency	33,278	11,771	7,999	19,770	3,041	2,485	5,526	2,533	2,323	4,856	1,604	1,521	3,126	45,742
ECONOMIC PROJECT COST	356,846	129,482	82,959	212,441	33,452	25,565	59,020	27,866	24,073	51,939	17,647	15,799	33,446	491,018

TABLE 8.4.18 ECONOMIC REPLACEMENT COST

COMPONENTS	SUBTOTAL COST	2008 FOREX P	2008 LOCAL P	2008 TOTAL COST	2009 FOREX P	2009 LOCAL P	2009 TOTAL COST	2010 FOREX P	2010 LOCAL P	2010 TOTAL COST	2011 FOREX P	2011 LOCAL P	2011 TOTAL COST
<<ECONOMIC COSTS>>													
Rehab. of Existing Wells *	0	0	0	0	0	0	0	0	0	0	0	0	0
New Wells Construction	5,189	2,120	698	2,818	1,731	641	2,372	0	0	0	0	0	0
Surface Water Facilities	8,744	0	0	0	0	0	0	0	0	0	4,006	4,738	8,744
Total	13,934	2,120	698	2,818	1,731	641	2,372	0	0	0	4,006	4,738	8,744

COMPONENTS	TOTAL COST	2012 FOREX P	2012 LOCAL P	2012 TOTAL COST	2013 FOREX P	2013 LOCAL P	2013 TOTAL COST	2014 FOREX P	2014 LOCAL P	2014 TOTAL COST	2015 FOREX P	2015 LOCAL P	2015 TOTAL COST
<<ECONOMIC COSTS>>													
Rehab. of Existing Wells *	0	0	0	0	0	0	0	0	0	0	0	0	0
New Wells Construction	5,189	0	0	0	0	0	0	0	0	0	0	0	0
Surface Water Facilities	162,593	70,389	19,612	90,001	19,706	7,112	26,818	15,699	6,937	22,636	9,799	4,595	14,394
Total	167,783	70,389	19,612	90,001	19,706	7,112	26,818	15,699	6,937	22,636	9,799	4,595	14,394

* Costs for Rehab. of Existing Wells are counted as O & M Cost.

TABLE 8.4.19 ECONOMIC OPERATION AND MAINTENNCE COST

YEAR	DE-ESCALATED FINANCIAL O & M COST					CONVERTED ECONOMIC O & M COST					TOTAL ECONOMIC O & M COST (P1000)
	SALARIES (L) (P1000)	ELEC'Y (F) (P1000)	CHEMICALS (F) (P1000)	MAINT. (F & L) (P1000)	WATER (L) (P1000)	SALARIES (L) (P1000)	ELEC'Y (F) (P1000)	CHEMICALS (F) (P1000)	MAINT. (F & L) (P1000)	WATER (L) (P1000)	
1992	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0
1994	40	854	4	205	0	29	1,025	5	220	0	1,278
1995	40	1,089	9	383	0	29	1,307	11	412	0	1,758
1996	40	1,975	16	383	0	29	2,370	19	412	0	2,829
1997	108	2,859	23	622	0	77	3,431	28	669	0	4,204
1998	250	3,745	31	4,040	0	178	4,494	37	4,343	0	9,052
1999	318	4,915	38	4,426	214	227	5,898	46	4,758	203	11,131
2000	358	6,598	45	4,766	1,479	255	7,918	54	5,123	1,405	14,755
2001	358	7,918	51	4,984	2,473	255	9,502	61	5,358	2,349	17,525
2002	358	9,239	57	4,984	3,466	255	11,087	68	5,358	3,293	20,061
2003	358	10,560	62	9,822	4,459	255	12,672	74	10,559	4,236	27,796
2004	358	11,880	68	4,984	5,453	255	14,256	82	5,358	5,180	25,131
2005	358	13,201	74	4,984	6,446	255	15,841	89	5,358	6,124	27,667
2006	358	14,258	78	4,984	7,241	255	17,110	94	5,358	6,879	29,695
2007	358	15,315	83	4,984	8,036	255	18,378	100	5,358	7,634	31,725
2008	358	16,373	88	4,984	8,832	255	19,648	106	5,358	8,390	33,756
2009	358	17,430	92	4,984	9,627	255	20,916	110	5,358	9,146	35,785
2010	358	18,487	97	4,984	10,422	255	22,184	116	5,358	9,901	37,815
2011	358	18,487	97	4,984	10,422	255	22,184	116	5,358	9,901	37,815
2012	358	18,487	97	4,984	10,422	255	22,184	116	5,358	9,901	37,815
2013	358	18,487	97	9,822	10,422	255	22,184	116	10,559	9,901	43,015
2014	358	18,487	97	4,984	10,422	255	22,184	116	5,358	9,901	37,815
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	(do)	(do)	(do)	(do)	(do)	(do)	(do)	(do)	(do)	(do)	(do)
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
2021	358	18,487	97	4,984	10,422	255	22,184	116	5,358	9,901	37,815
TOTAL	8,672	360,053	1,983	129,165	182,790	6,179	432,064	2,380	138,852	173,651	753,125

TABLE 8.4.20 SUMMARY OF ECONOMIC COST

YEAR	ECONOMIC PROJECT COST (P1000)	ECONOMIC REPLACEMENT COST (P1000)	ECONOMIC O & M COST (P1000)	TOTAL ECONOMIC COST (P1000)
1992	6,071	0	0	6,071
1993	29,499	0	1,278	30,777
1994	20,350	0	1,758	22,108
1995	35,371	0	2,829	38,200
1996	42,880	0	4,204	47,084
1997	212,441	0	9,052	221,493
1998	59,020	0	11,131	70,151
1999	51,939	0	14,755	66,694
2000	33,446	0	17,525	50,971
2001	0	0	20,061	20,061
2002	0	0	27,796	27,796
2003	0	0	25,131	25,131
2004	0	0	27,667	27,667
2005	0	0	29,695	29,695
2006	0	0	31,725	31,725
2007	0	0	33,756	33,756
2008	0	2,818	35,785	38,603
2009	0	2,372	37,815	40,187
2010	0	0	37,815	37,815
2011	0	8,744	37,815	46,559
2012	0	90,001	43,015	133,016
2013	0	26,818	37,815	64,633
2014	0	22,636	37,815	60,451
2015	0	14,394	37,815	52,209
2016	0	0	37,815	37,815
2017	0	0	37,815	37,815
2018	0	0	37,815	37,815
2019	0	0	37,815	37,815
2020	0	0	37,815	37,815
2021	0	0	37,815	37,815
	491,017	167,783	790,939	1,449,739

TABLE 8.4.21 ECONOMIC INTERNAL RATE OF RETURN

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 8.4.22 INCREASE IN CONSUMER SATISFACTION
(Groundwater only)

YEAR	ADD'L WATER PROD. VOLUME (MCM)	RATIO OF SOLD WATER (%)	ADD'L SOLD WATER VOLUME (MCM)	LEAKED WATER RECOVERY VOLUME (MCM)	AVERAGE WATER TARIFF (P/m3)	ECONOMIC VALUE PER CU.M (P/m3)	ECONOMIC WATER REVENUE (P1,000)
1992	0.00	55.0%	0.00	0.00	6.43	7.72	0
1993	0.00	60.0%	0.00	0.47	6.43	7.72	3,591
1994	0.34	65.0%	0.22	0.64	6.43	7.72	6,687
1995	0.68	70.0%	0.48	0.82	6.43	7.72	10,046
1996	1.26	70.0%	0.88	0.82	6.43	7.72	13,140
1997	1.83	70.0%	1.28	0.82	6.43	7.72	16,229
1998	2.40	70.0%	1.68	0.82	6.43	7.72	19,322
1999	2.88	70.0%	2.01	0.82	6.43	7.72	21,889
2000	2.88	70.0%	2.01	0.82	6.43	7.72	21,889
2001	2.88	71.0%	2.04	0.86	6.43	7.72	22,387
2002	2.88	72.0%	2.07	0.90	6.43	7.72	22,885
2003	2.88	73.0%	2.10	0.93	6.43	7.72	23,383
2004	2.88	74.0%	2.13	0.97	6.43	7.72	23,882
2005	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2006	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2007	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2008	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2009	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2010	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2011	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2012	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2013	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2014	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2015	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2016	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2017	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2018	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2019	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2020	2.88	75.0%	2.16	1.00	6.43	7.72	24,380
2021	2.88	75.0%	2.16	1.00	6.43	7.72	24,380

* Economic value per cu.m was assumed to be 1.2 times of the price.

TABLE 8.4.23 HEALTH BENEFIT
(groundwater only)

YEAR	1/ ADD'L SERVED POP'N	COST OF TIME LOSS DUE TO ILLNESS (P1,000)	LOSS DUE TO PREMATURE DEATH (P1,000)	COST OF MEDICAL EXPENSES (P1,000)	TOTAL ECONOMIC LOSS (P1,000)	ECO'C LOSS REDUCTION BY PROJECT 20% (P1,000)
1992	0	0	0	0	0	0
1993	0	0	0	0	0	0
1994	4,714	6	64	57	127	25
1995	9,427	12	129	114	255	51
1996	16,429	21	224	198	444	89
1997	22,962	30	313	277	620	124
1998	29,208	38	399	353	789	158
1999	34,100	44	465	412	921	184
2000	34,100	44	465	412	921	184
2001	34,100	44	465	412	921	184
2002	34,100	44	465	412	921	184
2003	34,100	44	465	412	921	184
2004	34,100	44	465	412	921	184
2005	34,100	44	465	412	921	184
2006	34,100	44	465	412	921	184
2007	34,100	44	465	412	921	184
2008	34,100	44	465	412	921	184
2009	34,100	44	465	412	921	184
2010	34,100	44	465	412	921	184
2011	34,100	44	465	412	921	184
2012	34,100	44	465	412	921	184
2013	34,100	44	465	412	921	184
2014	34,100	44	465	412	921	184
2015	34,100	44	465	412	921	184
2016	34,100	44	465	412	921	184
2017	34,100	44	465	412	921	184
2018	34,100	44	465	412	921	184
2019	34,100	44	465	412	921	184
2020	34,100	44	465	412	921	184
2021	34,100	44	465	412	921	184
TOTAL HEALTH BENEFIT						4,686

1/ (Total served pop'n)*(Augmented water share in total production)

TABLE 8.4.24 FIRE DAMAGE REDUCTION
(groundwater only)

YEAR	1/ ADD'L SERVED POP'N	NUMBER OF HOUSINGS	TOTAL VALUE P500,000 EACH (P1000)	0.75% OVERALL REDUCTION IN FIRE DAMAGE	RATIO OF PROTECTION	NET REDUCTION IN FIRE DAMAGE (P1000)
1992	0	0	0	0	20%	0
1993	0	0	0	0	20%	0
1994	4,714	673	323,211	2,424	20%	485
1995	9,427	1,347	673,357	5,050	20%	1,010
1996	16,429	2,347	1,173,500	8,801	20%	1,760
1997	22,962	3,280	1,640,143	12,301	20%	2,460
1998	29,208	4,173	2,086,286	15,647	20%	3,129
1999	34,100	4,871	2,435,714	18,268	20%	3,654
2000	34,100	4,871	2,435,714	18,268	20%	3,654
2001	34,100	4,871	2,435,714	18,268	20%	3,654
2002	34,100	4,871	2,435,714	18,268	20%	3,654
2003	34,100	4,871	2,435,714	18,268	20%	3,654
2004	34,100	4,871	2,435,714	18,268	20%	3,654
2005	34,100	4,871	2,435,714	18,268	20%	3,654
2006	34,100	4,871	2,435,714	18,268	20%	3,654
2007	34,100	4,871	2,435,714	18,268	20%	3,654
2008	34,100	4,871	2,435,714	18,268	20%	3,654
2009	34,100	4,871	2,435,714	18,268	20%	3,654
2010	34,100	4,871	2,435,714	18,268	20%	3,654
2011	34,100	4,871	2,435,714	18,268	20%	3,654
2012	34,100	4,871	2,435,714	18,268	20%	3,654
2013	34,100	4,871	2,435,714	18,268	20%	3,654
2014	34,100	4,871	2,435,714	18,268	20%	3,654
2015	34,100	4,871	2,435,714	18,268	20%	3,654
2016	34,100	4,871	2,435,714	18,268	20%	3,654
2017	34,100	4,871	2,435,714	18,268	20%	3,654
2018	34,100	4,871	2,435,714	18,268	20%	3,654
2019	34,100	4,871	2,435,714	18,268	20%	3,654
2020	34,100	4,871	2,435,714	18,268	20%	3,654
2021	34,100	4,871	2,435,714	18,268	20%	3,654
TOTAL FIRE DAMAGE REDUCTION						92,877

1/ (Total served pop'n)*(Augmented water share in total production)

TABLE 8.4.25 INCREASE IN LAND VALUE

YEAR	SERVICE AREA (HA)	RATIO OF BENEFIT AREA (%)	BENEFIT AREA (HA)	INCREASE OF BENEFIT AREA (HA)	NET BENEFIT AREA INCREASE (HA)	LAND PRICE (P/m2)	INCREASE IN LAND VALUE (%)	INCREASE IN LAND VALUE (P1,000)
					(60%)			
1992	420	0.0%	0.00	0.00	0.00	800	5.00%	0
1993	420	0.0%	0.00	0.00	0.00	800	5.00%	0
1994	420	50.0%	210.00	210.00	126.00	800	5.00%	50,400
1995	420	100.0%	420.00	210.00	126.00	800	5.00%	50,400
1996	420	100.0%	420.00	0.00	0.00	600	10.00%	0
1997	472	100.0%	472.00	52.00	31.20	600	10.00%	18,720
1998	524	100.0%	524.00	52.00	31.20	600	10.00%	18,720
1999	576	100.0%	576.00	52.00	31.20	600	10.00%	18,720
2000	628	100.0%	628.00	52.00	31.20	600	10.00%	18,720
TOTAL INCREASE IN LAND VALUE								175,680

TABLE 5.4.26 CONVERSION OF FINANCIAL PROJECT COSTS TO ECONOMIC COSTS
(GROUNDWATER ONLY)

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
1. Materials	61,899	0	0	0	8,384	14,616	23,000	8,780	14,465	23,246	4,198	5,242	9,440	2,789	3,424	6,214
2. Labor																
Skilled Labor	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 Labor	6,150	0	0	0	0	2,028	2,028	0	2,189	2,189	0	1,183	1,183	0	749	749
3. Equipment	92,097	0	0	0	19,233	6,052	25,285	21,869	7,913	29,782	15,699	6,937	22,636	9,798	4,595	14,394
4. Land Acqusition	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)	13,522	2,496	8,321	10,817	624	2,080	2,704	0	0	0	0	0	0	0	0	0
6. Eng'g Serv. (C/S)	6,825	0	0	0	885	1,358	2,242	522	1,740	2,262	326	1,086	1,412	210	699	909
7. Physical Contingency	20,074	250	1,107	1,357	2,913	3,112	6,025	3,117	3,225	6,342	2,022	1,844	3,866	1,280	1,205	2,485
ECONOMIC PROJECT COST	214,667	2,746	12,178	14,924	32,039	32,205	64,244	34,289	33,284	67,573	22,245	19,098	41,344	14,077	12,505	26,583

TABLE 5.4.27 ECONOMIC REPLACEMENT COST (Groundwater only)

(unit: P1000)

COMPONENTS	TOTAL COST	2008 FOREX P	2008 LOCAL P	2008 TOTAL COST	2009 FOREX P	2009 LOCAL P	2009 TOTAL COST	2010 FOREX P	2010 LOCAL P	2010 TOTAL COST	2011 FOREX P	2011 LOCAL P	2011 TOTAL COST
<<ECONOMIC COST>>													
Rehab. of Existing Wells *	0	0	0	0	0	0	0	0	0	0	0	0	0
New Wells Construction	5,457	2,120	835	2,955	1,731	769	2,500	0	0	0	0	0	0
Surface Water Facilities	69,685	11,044	4,580	15,624	15,764	6,828	22,592	12,559	6,659	19,219	7,539	4,411	12,250
Total	75,142	13,164	5,416	18,581	17,495	7,597	25,092	12,559	6,659	19,219	7,539	4,411	12,250

* Costs for Rehab. of Existing Wells are counted as O & M Cost

TABLE 8.4.28 ECONOMIC OPERATION AND MAINTENNCE COST (GROUNDWATER ONLY)

YEAR	DE-ESCALATED FINANCIAL O & M COST				CONVERTED ECONOMIC O & M COST				TOTAL ECONOMIC O & M COST (P1000)
	SALARIES (L) (P1000)	ELEC'Y (F) (P1000)	CHEMICALS (F) (P1000)	MAINT. (F&L) (P1000)	SALARIES (L) (P1000)	ELEC'Y (F) (P1000)	CHEMICALS (F) (P1000)	MAINT. (F&L) (P1000)	
1992	0	0	0	0	0	0	0	0	0
1993	68	0	0	0	48	0	0	0	48
1994	140	854	4	536	100	1,025	5	576	1,706
1995	168	1,089	9	1,023	120	1,307	11	1,100	2,538
1996	200	1,975	16	1,295	143	2,370	19	1,392	3,924
1997	200	2,859	23	1,470	143	3,431	28	1,580	5,181
1998	200	3,745	31	1,470	143	4,494	37	1,580	6,254
1999	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2000	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2001	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2002	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2003	200	4,480	37	6,308	143	5,376	44	6,781	12,344
2004	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2005	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2006	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2007	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2008	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2009	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2010	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2011	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2012	200	4,480	37	1,470	143	5,376	44	1,580	7,143
2013	200	4,480	37	6,308	143	5,376	44	6,781	12,344
2014	200	4,480	37	1,470	143	5,376	44	1,580	7,143
	(do)	(do)	(do)	(do)	(do)	(do)	(do)	(do)	(do)
2021	200	4,480	37	1,470	143	5,376	44	1,580	7,143
TOTAL	5,576	113,562	934	49,272	3,973	136,274	1,121	52,968	194,336

TABLE 8.4.29 SUMMARY OF ECONOMIC COST
(GROUNDWATER ONLY)

YEAR	ECONOMIC PROJECT COST (P1000)	ECONOMIC REPLACEMENT COST (P1000)	ECONOMIC O & M COST (P1000)	TOTAL ECONOMIC COST (P1000)
1992	14,924	0	48	14,972
1993	64,244	0	1,706	65,950
1994	67,573	0	2,538	70,111
1995	41,344	0	3,924	45,268
1996	26,583	0	5,181	31,764
1997	0	0	6,254	6,254
1998	0	0	7,143	7,143
1999	0	0	7,143	7,143
2000	0	0	7,143	7,143
2001	0	0	7,143	7,143
2002	0	0	12,344	12,344
2003	0	0	7,143	7,143
2004	0	0	7,143	7,143
2005	0	0	7,143	7,143
2006	0	0	7,143	7,143
2007	0	0	7,143	7,143
2008	0	18,581	7,143	25,724
2009	0	25,092	7,143	32,235
2010	0	19,219	7,143	26,362
2011	0	12,250	7,143	19,393
2012	0	0	12,344	12,344
2013	0	0	7,143	7,143
2014	0	0	7,143	7,143
2015	0	0	7,143	7,143
2016	0	0	7,143	7,143
2017	0	0	7,143	7,143
2018	0	0	7,143	7,143
2019	0	0	7,143	7,143
2020	0	0	7,143	7,143
2021	0	0	7,143	7,143
	214,668	75,142	201,479	491,289

TABLE 8.4.30 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%

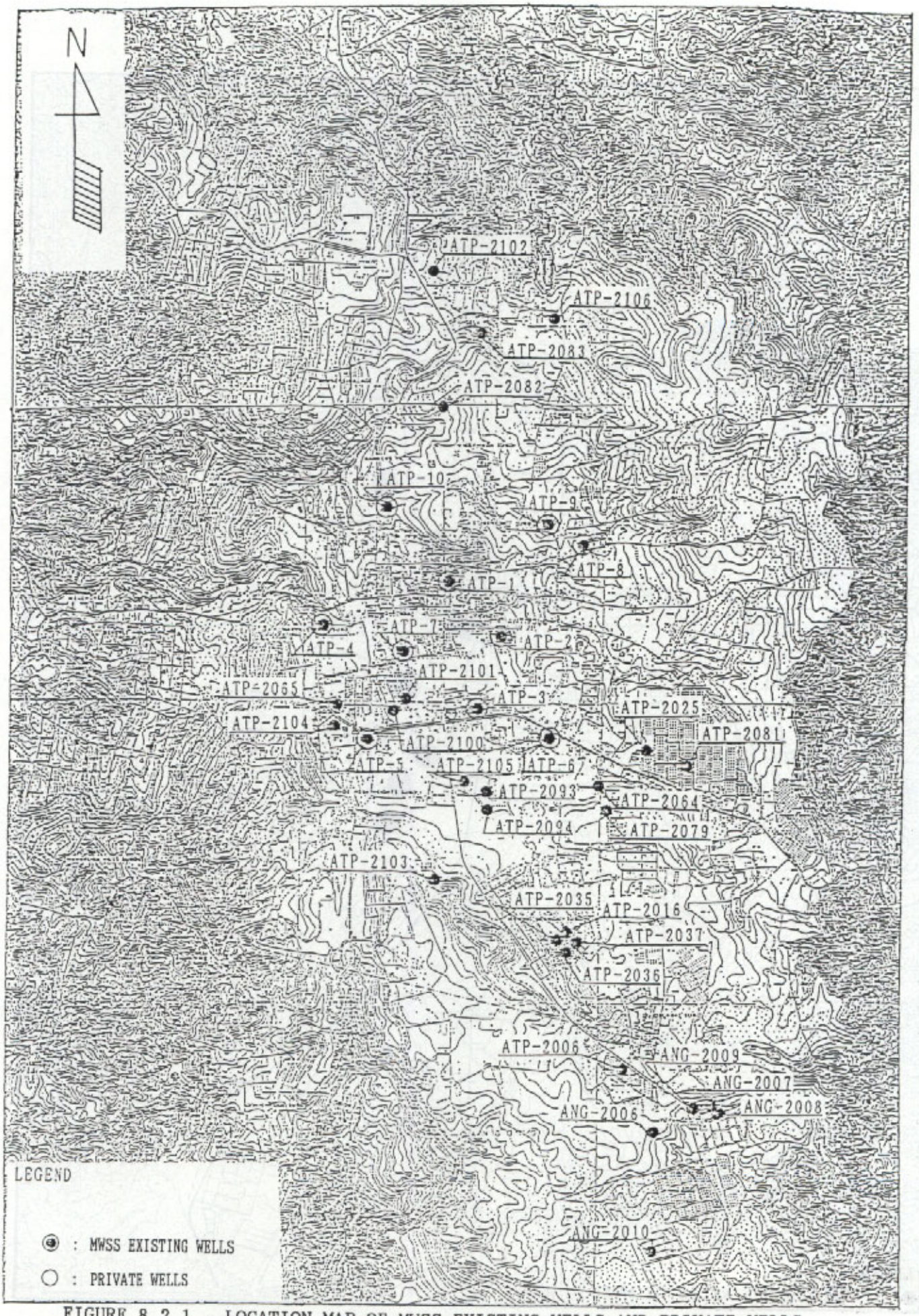


FIGURE 8.2.1 LOCATION MAP OF MWSS EXISTING WELLS AND PRIVATE WELLS IN ANTIPOLO AREA

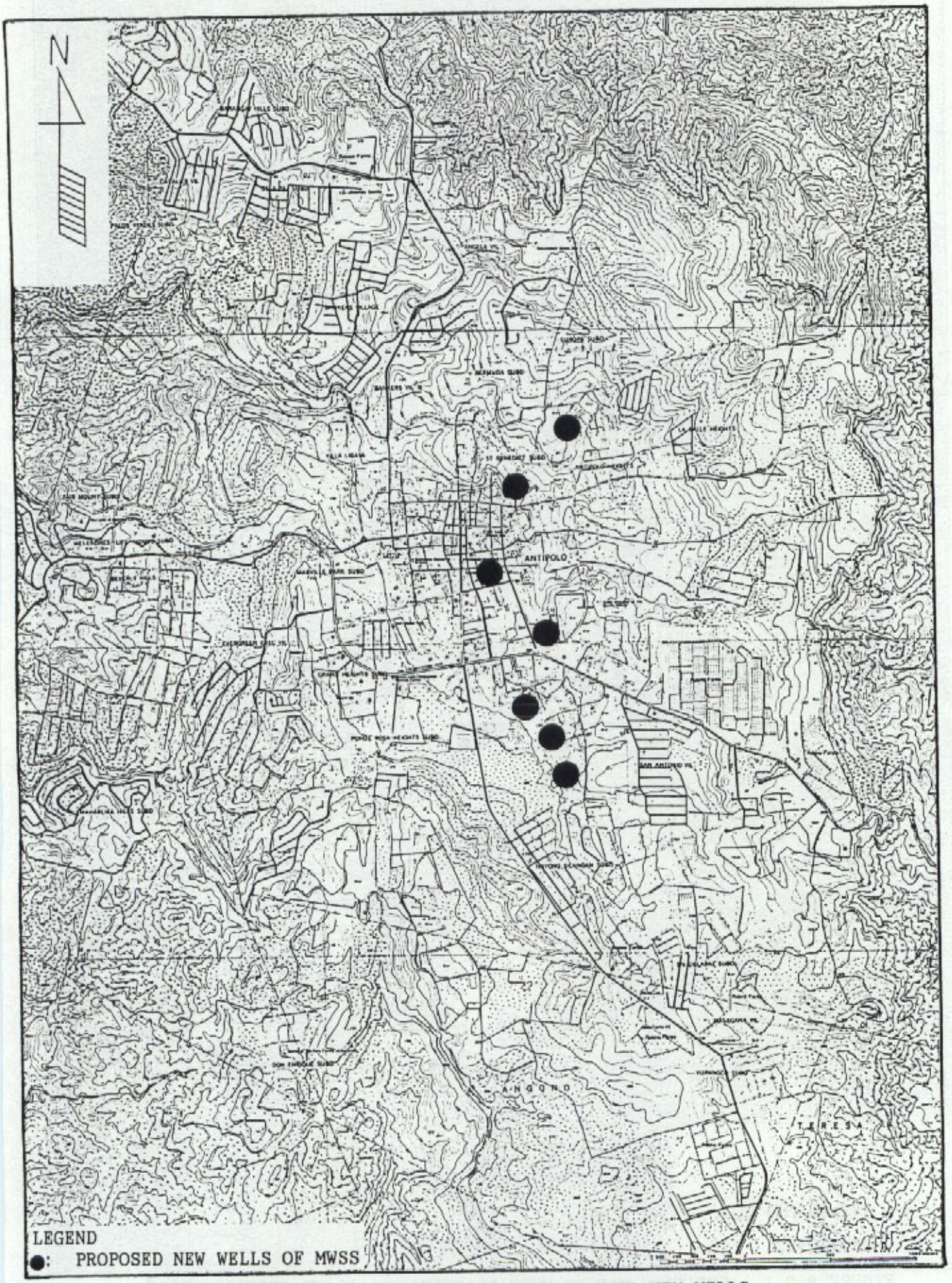
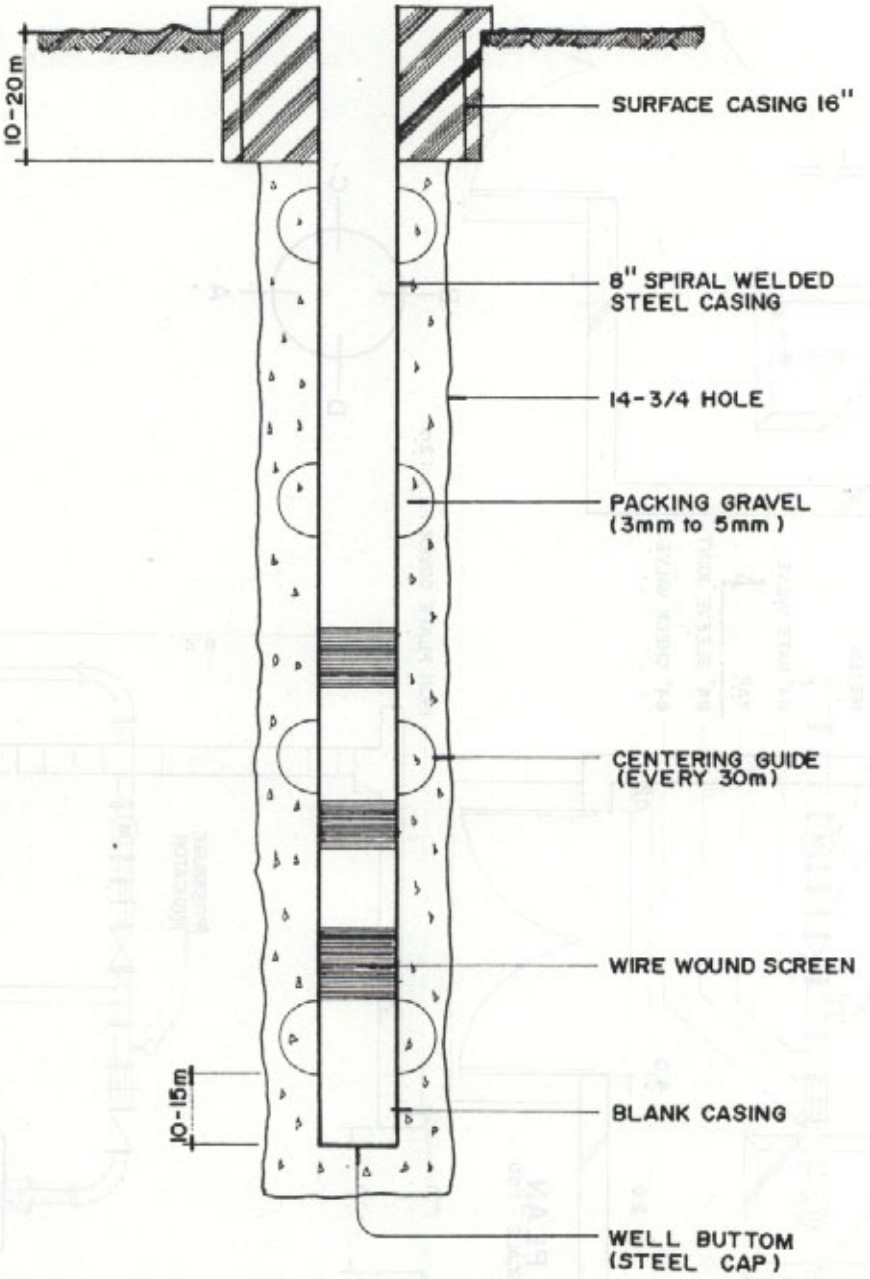
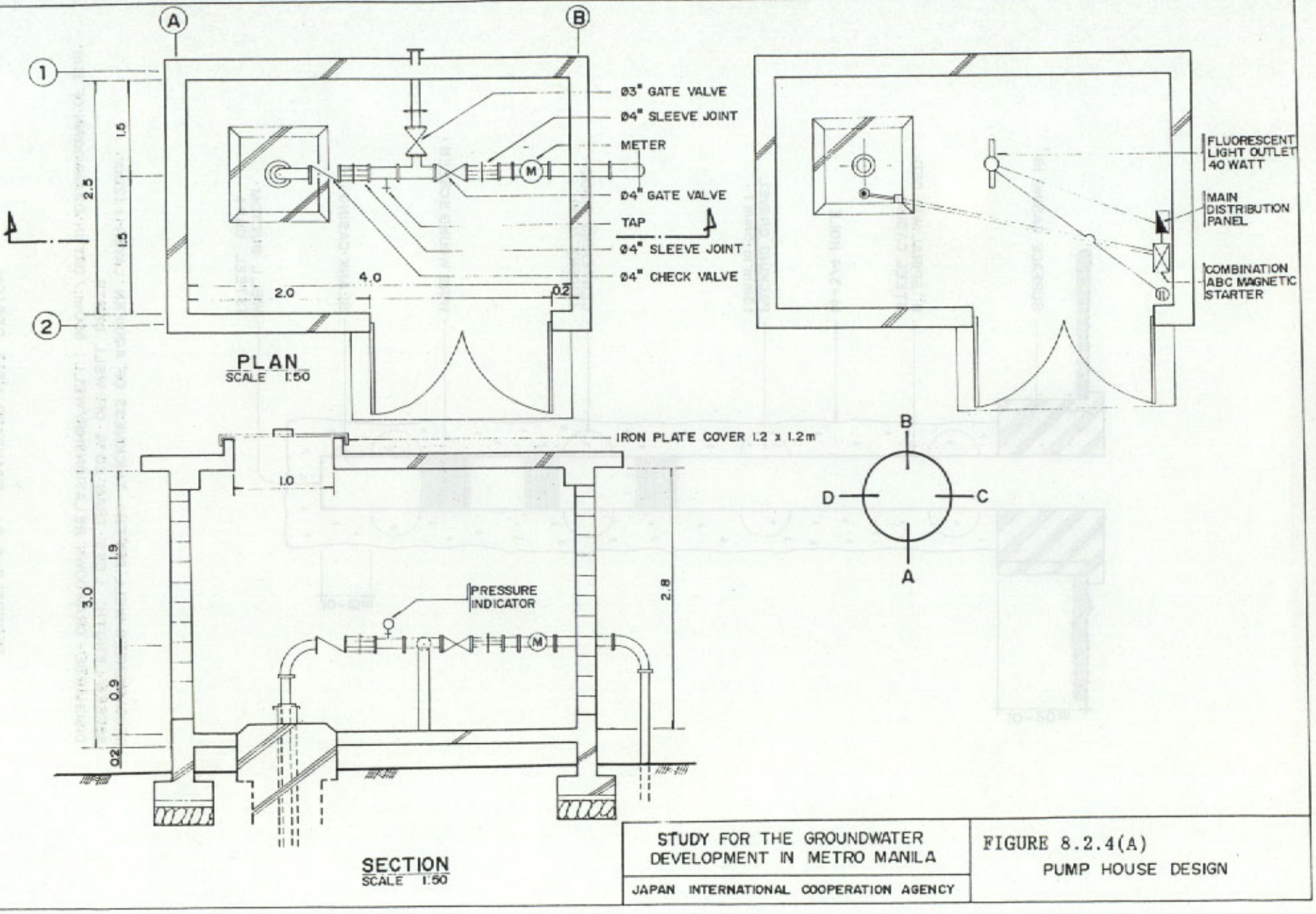


FIGURE 8.2.2 LOCATION MAP OF PLANNED NEW WELLS



RECOMMENDED WELL DEPTH: THICKNESS OF AQUIFER LAYER 1 (20m
SCREEN LENGTH: LESS THAN 20% OF WELL DEPTH
DISCHARGE - DRAWDOWN RELATIONSHIP/WELL: 800m / DAY IN DRAWNDOWN OF 21m

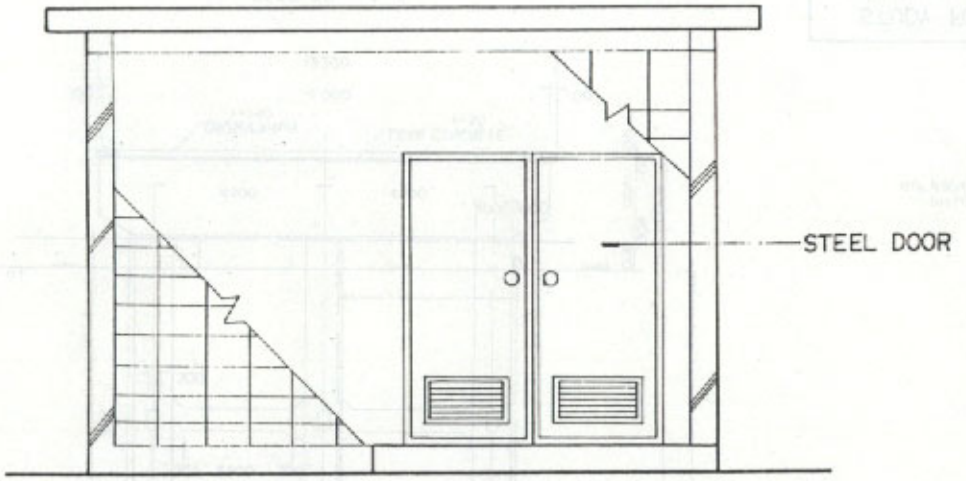
FIGURE 8.2.3 STANDARD WELL DESIGN



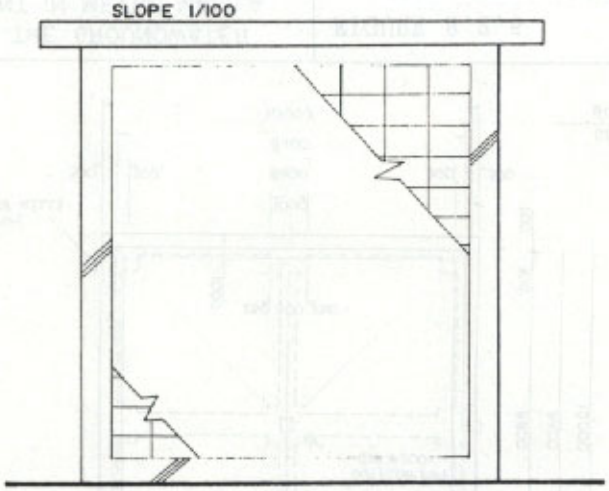
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 8.2.4(A)
PUMP HOUSE DESIGN



A



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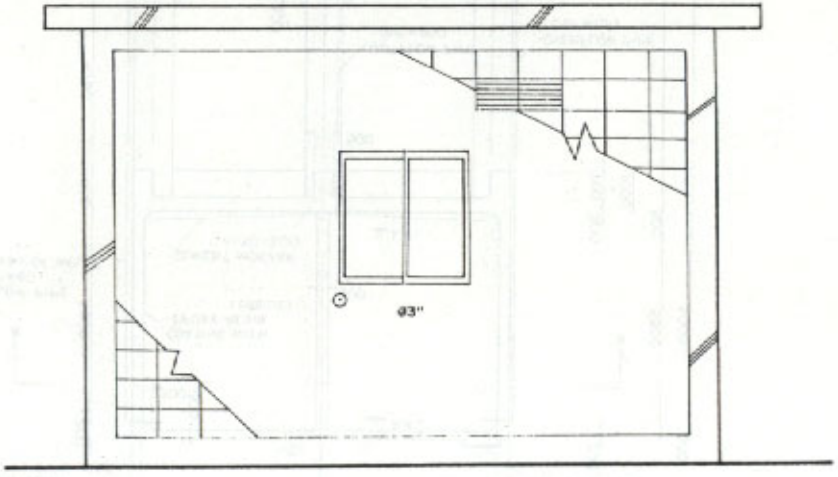
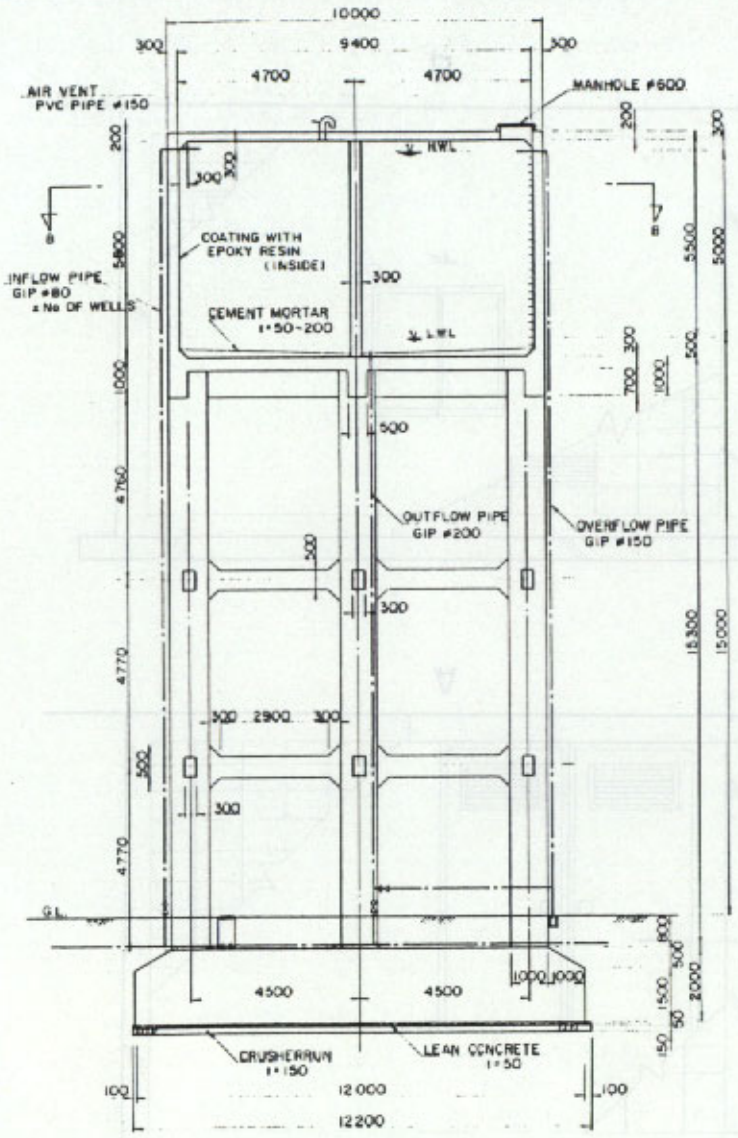
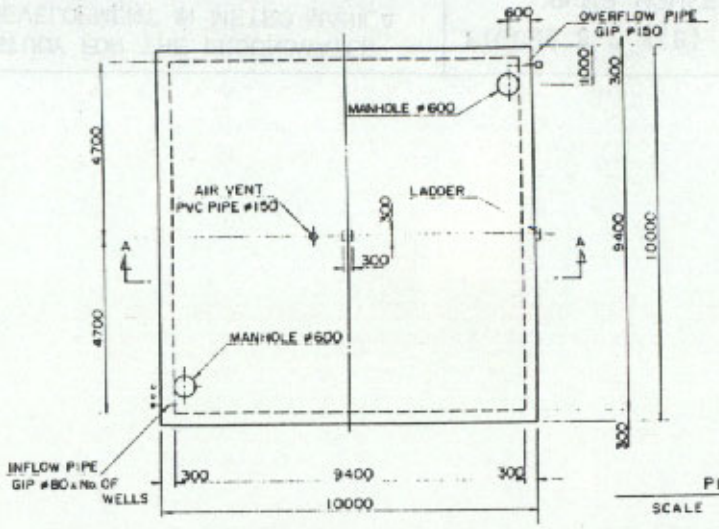


B

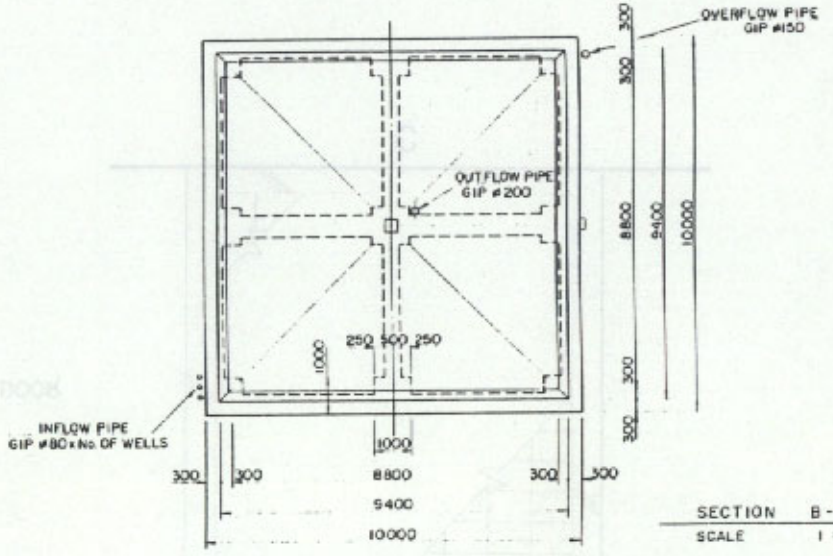
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 8.2.4(B) PUMP HOUSE DESIGN
JAPAN INTERNATIONAL COOPERATION AGENCY	



SECTION A-A
SCALE 1 : 100



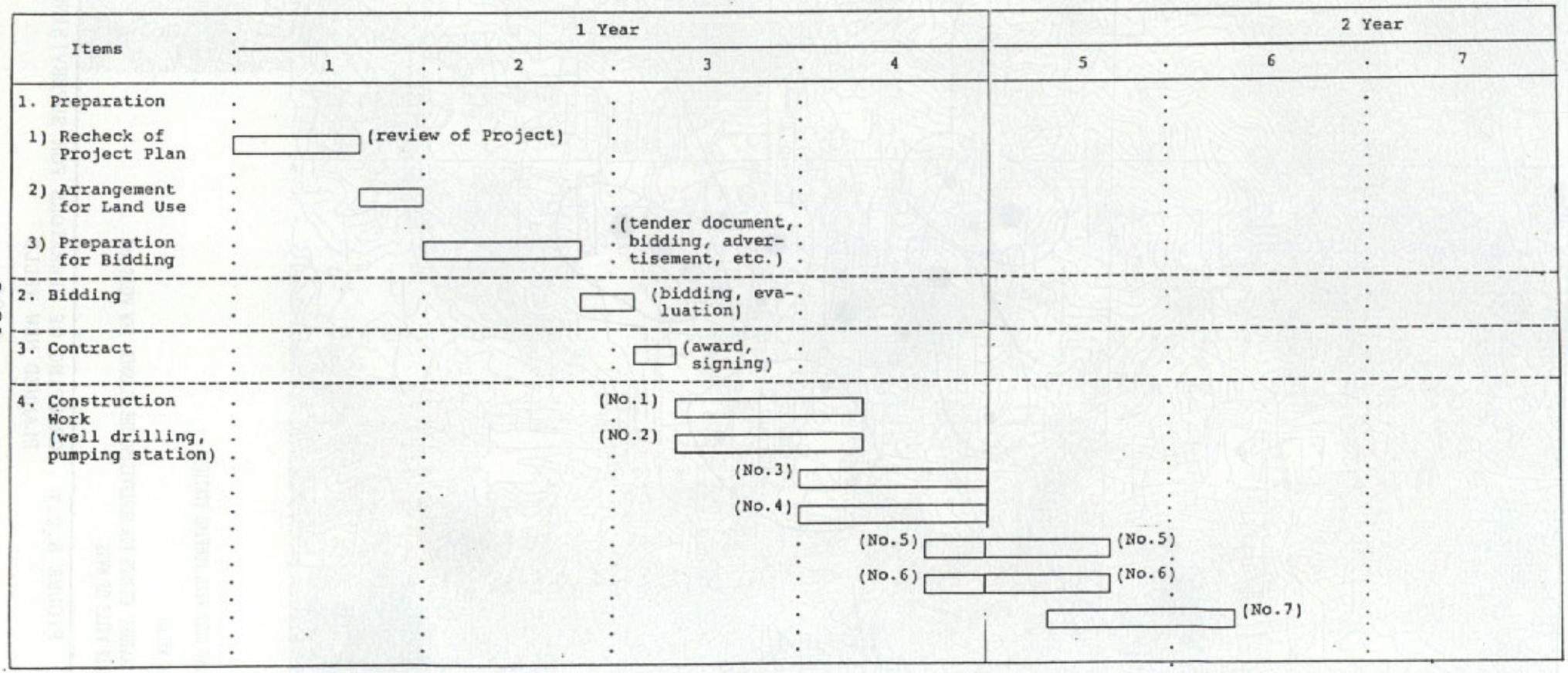
PLAN
SCALE 1 : 100



SECTION B-B
SCALE 1 : 100

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 8.2.5 ELEVATED WATER TANK

FIGURE 8.2.6 IMPLEMENTATION SCHEDULE FOR FUTURE PROJECT



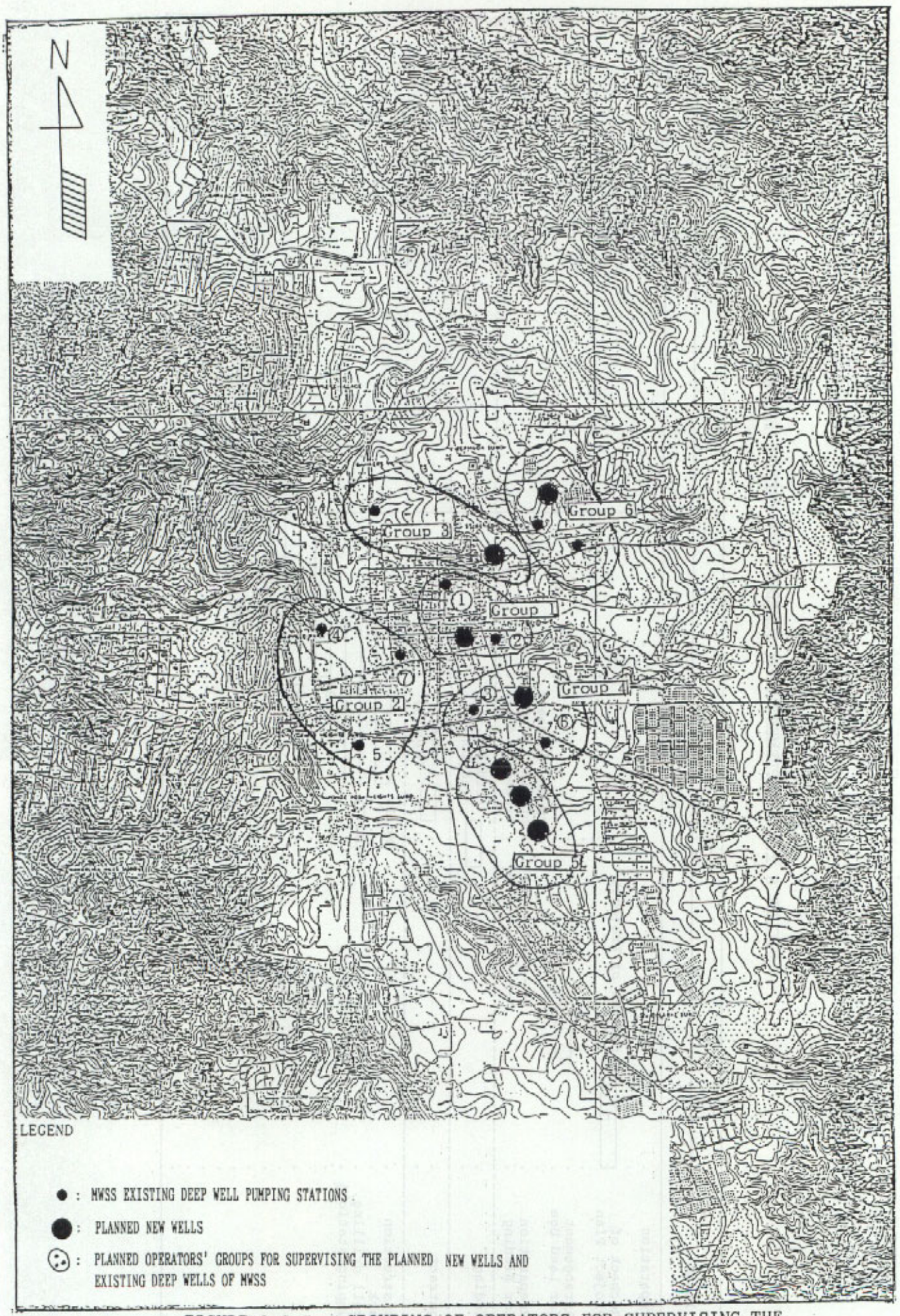
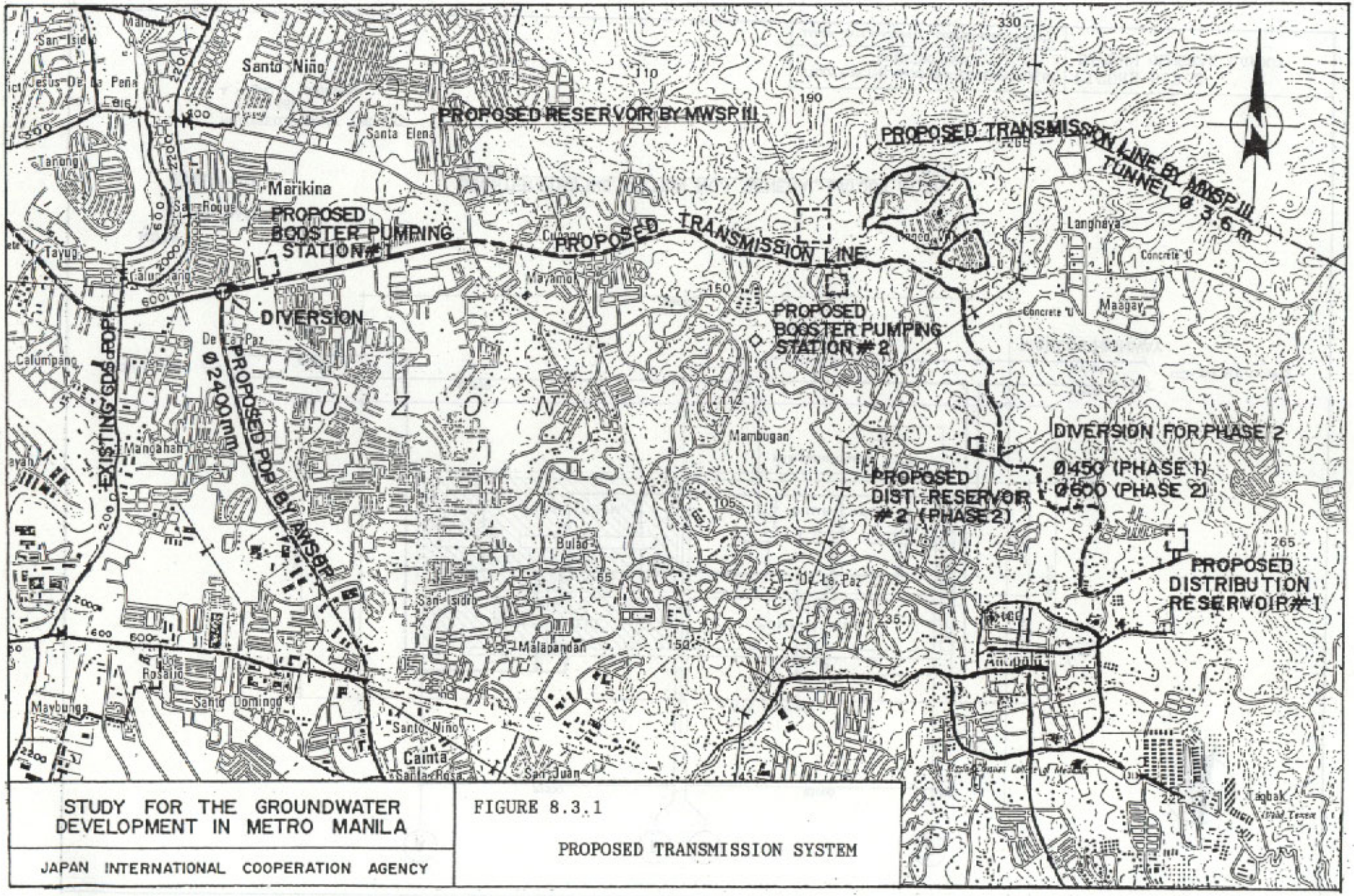


FIGURE 8.2.7 GROUPING OF OPERATORS FOR SUPERVISING THE PLANNED NEW WELLS

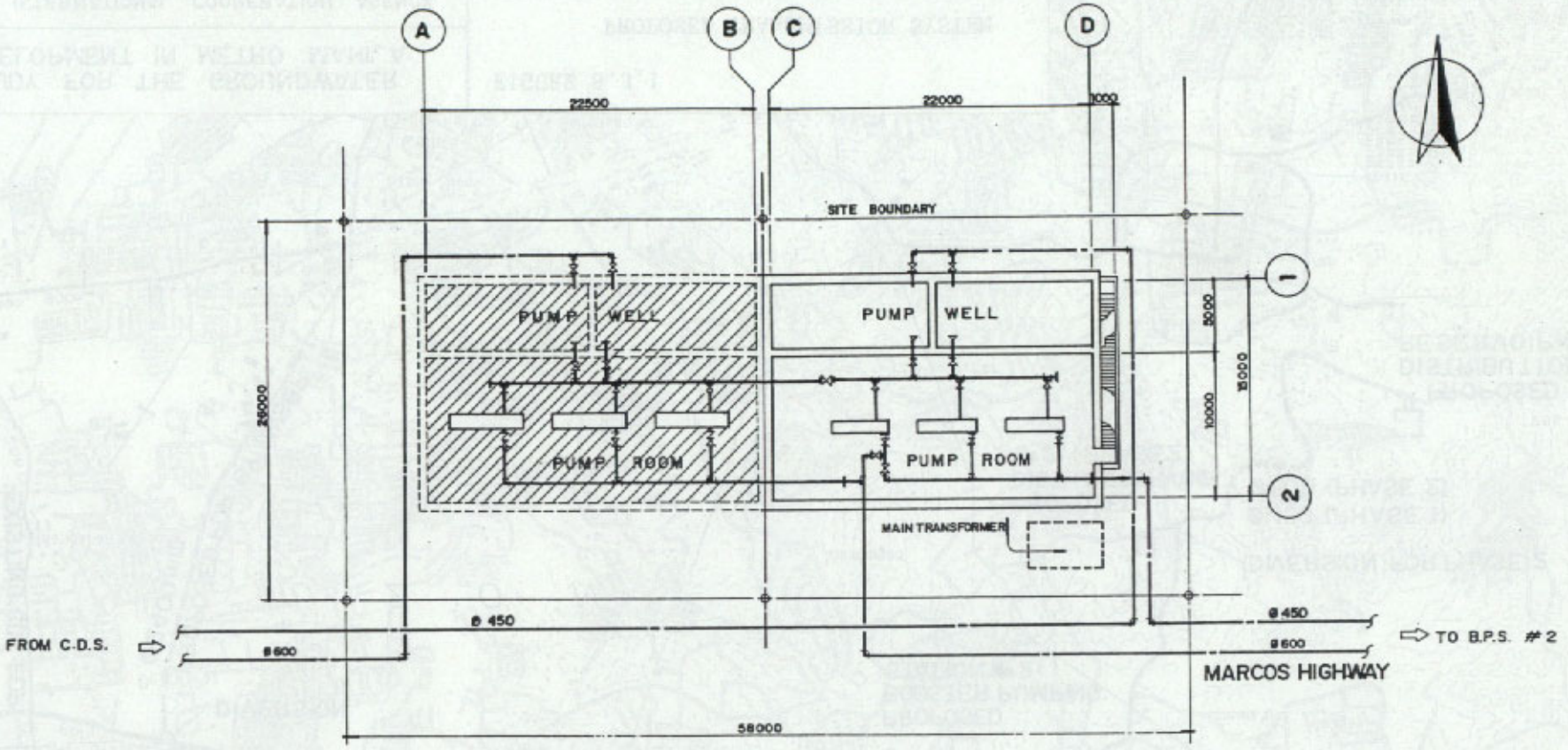


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 8.3.1

PROPOSED TRANSMISSION SYSTEM



NOTE:

PHASE 1

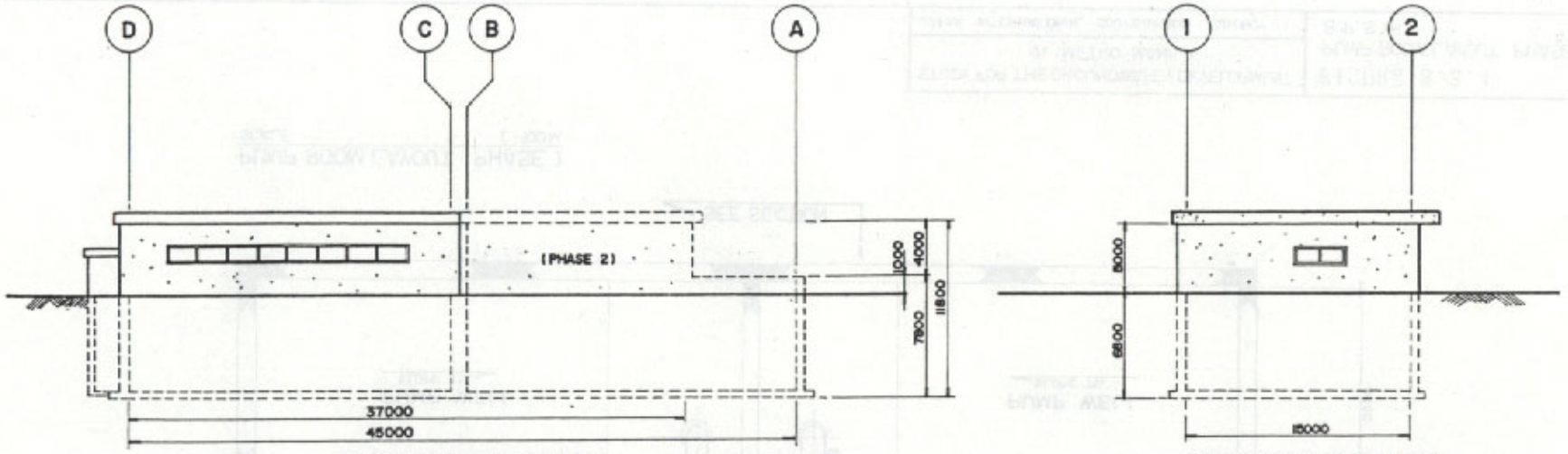
PHASE 2

BOOSTER PUMPING STATION NO.1 GENERAL LAYOUT PLAN

SCALE 1: 300M

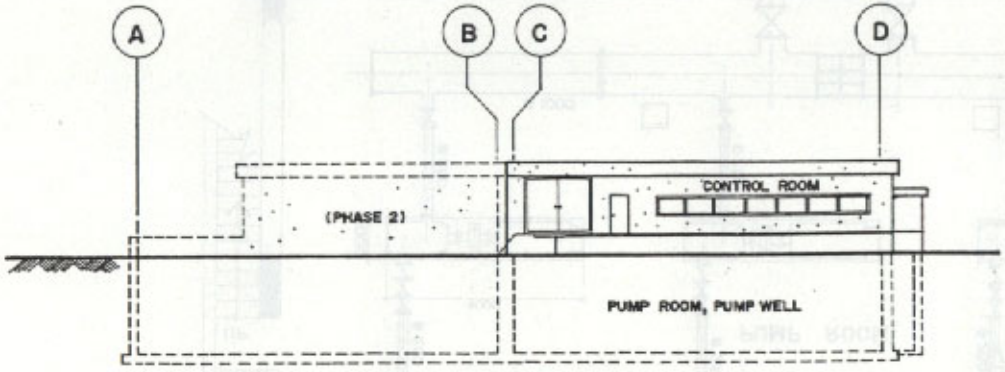
∴ REQUIRED AREA OF THE SITE
= 26 x 58m
A = 1,510m (MINIMUM)

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

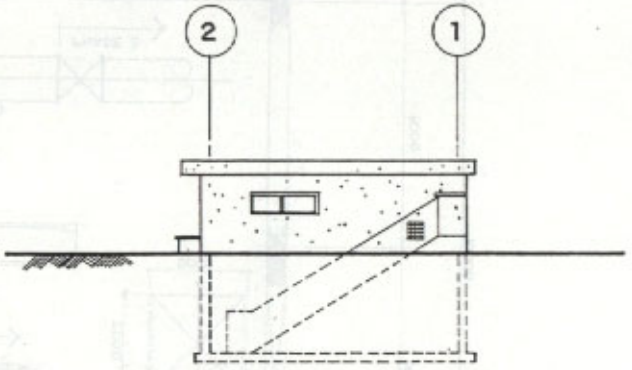


NORTH SIDE ELEVATION
(BACK SIDE)

WEST SIDE ELEVATION



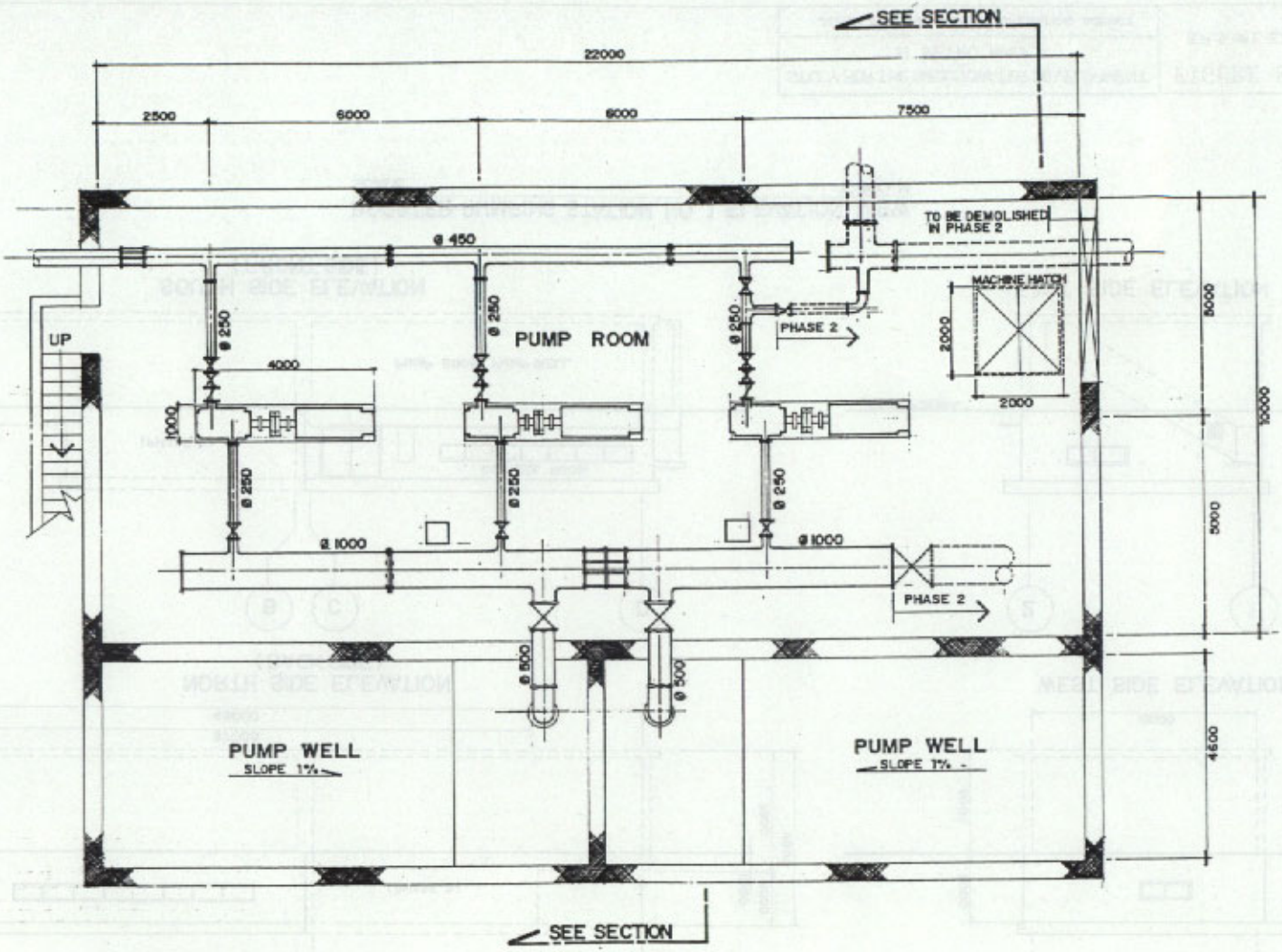
SOUTH SIDE ELEVATION
(FRONT SIDE)



EAST SIDE ELEVATION

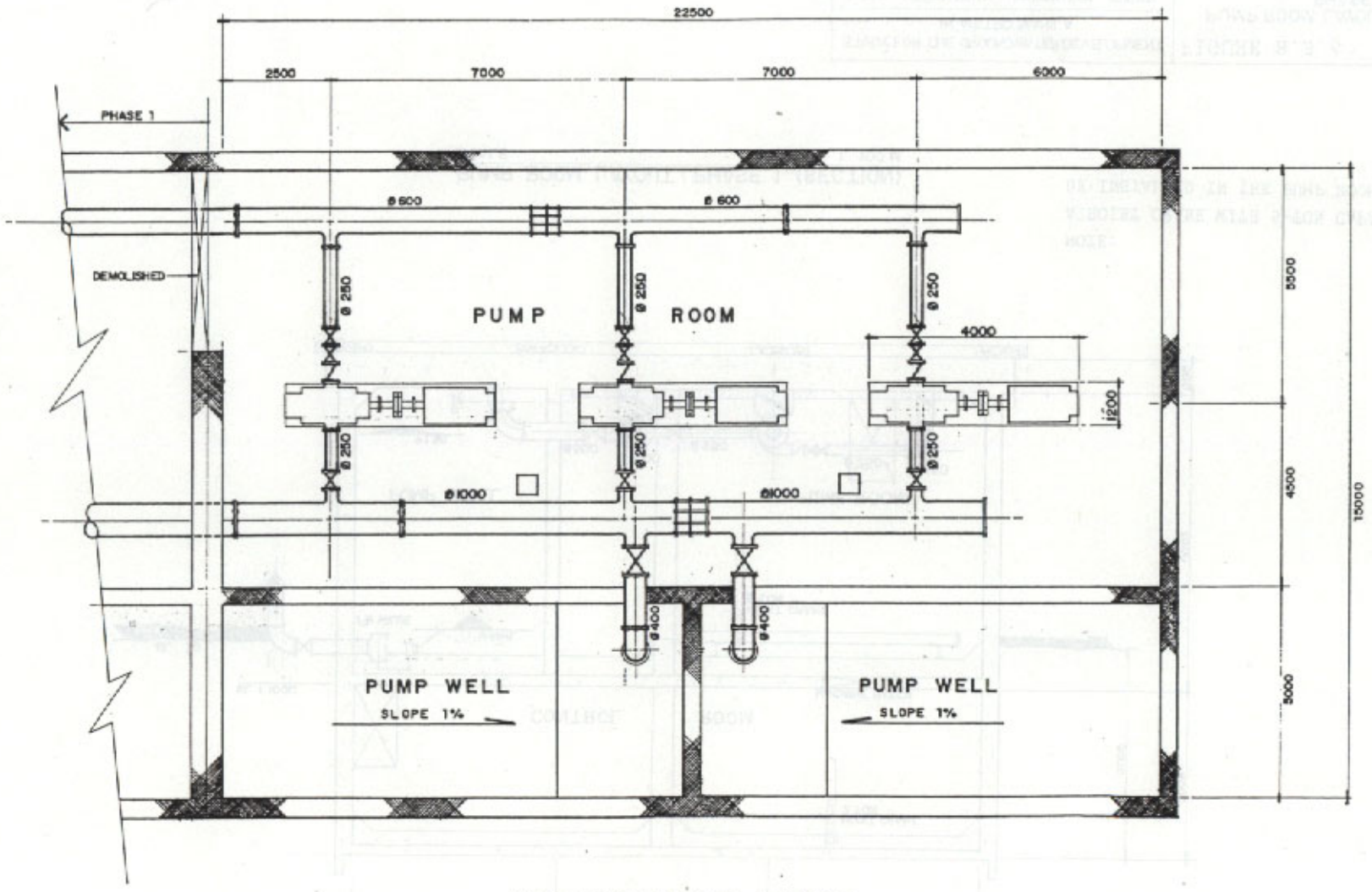
BOOSTER PUMPING STATION NO. 1 ELEVATION VIEW
SCALE 1: 300 M

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 8.3.3 B.P.S. #1 ELEVATION VIEW



PUMP ROOM LAYOUT PHASE 1
SCALE 1: 100 M

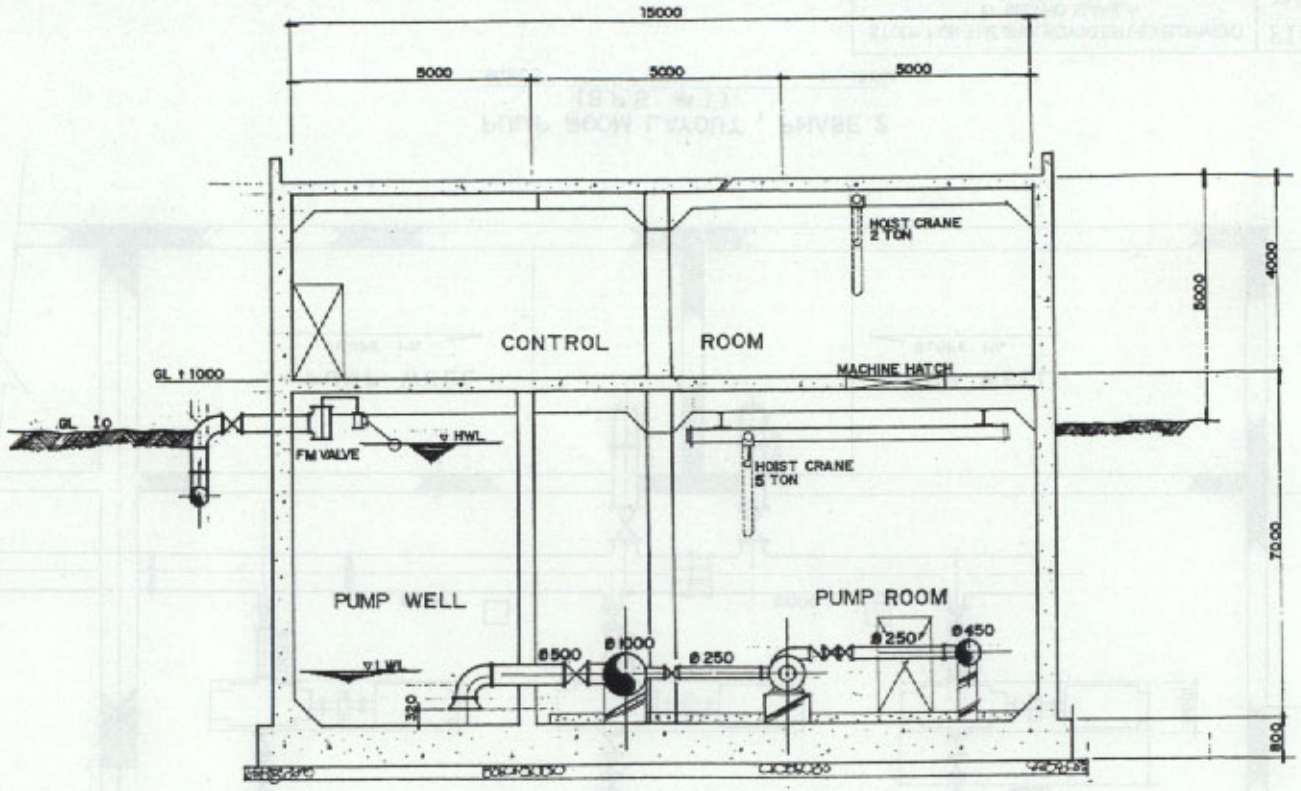
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 8.3.4 PUMP ROOM LAYOUT PHASE 1 B.P.S #1



PUMP ROOM LAYOUT , PHASE 2
(B.P.S. #1)

SCALE 1: 100M

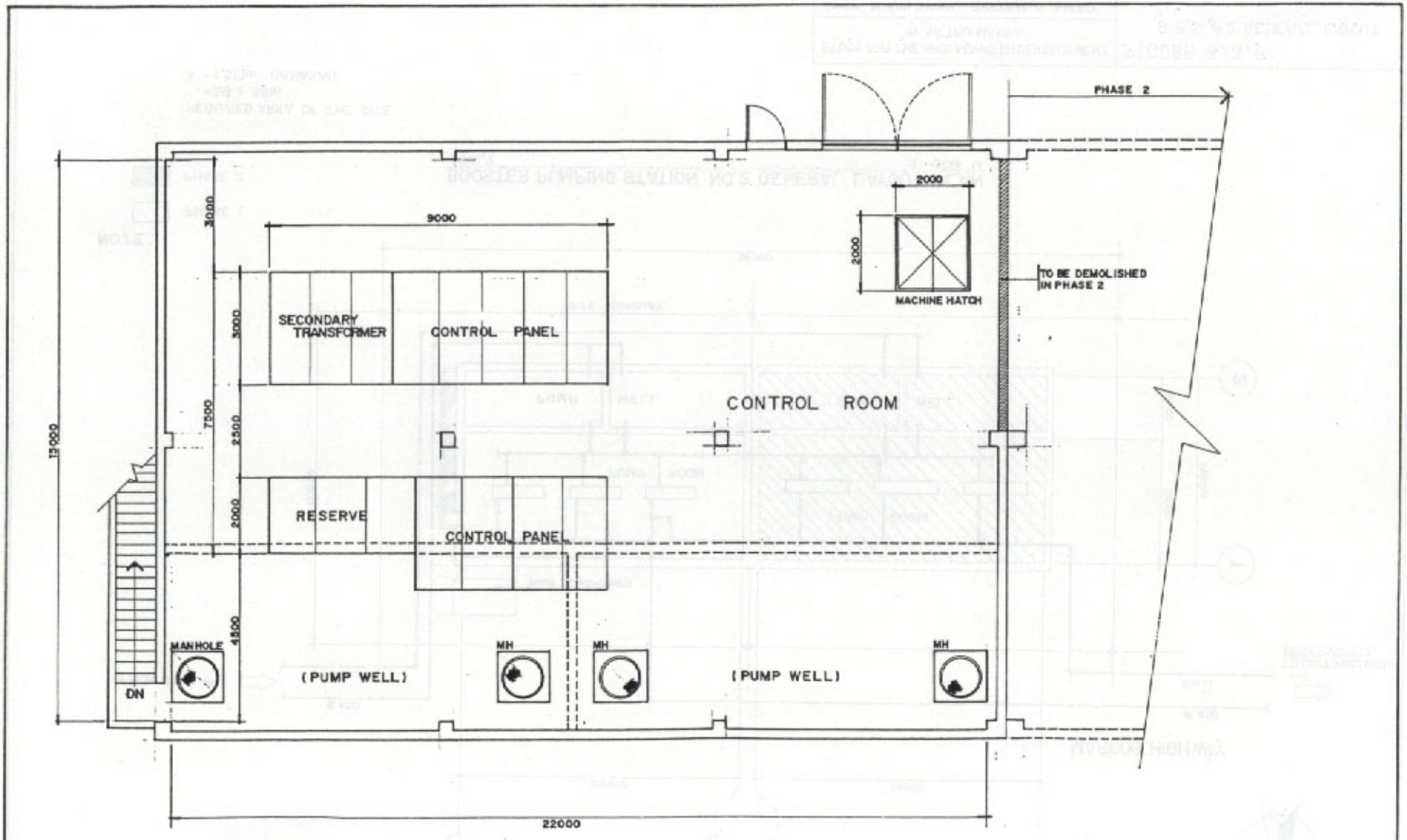
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 8.3.5 PUMP ROOM LAYOUT, PHASE 2 B.P.S. #1



NOTE:
A HOIST CRANE WITH 5-TON CAPACITY SHOULD BE INSTALLED IN THE PUMP ROOM OF PHASE 2

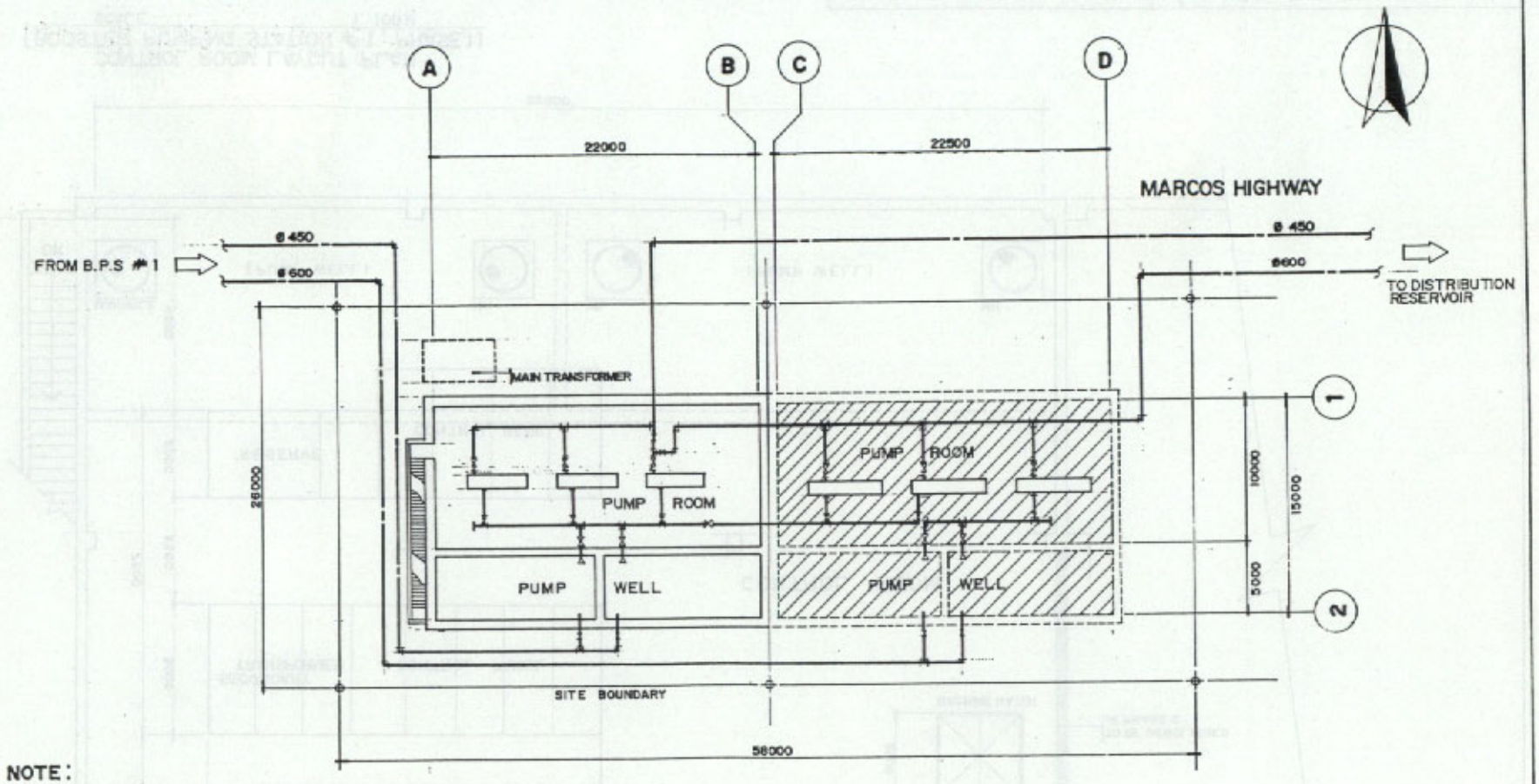
PUMP ROOM LAYOUT (PHASE 1 (SECTION)
SCALE 1: 100 M

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 8.3.6 PUMP ROOM LAYOUT (SECTION) PHASE 1



CONTROL ROOM LAYOUT PLAN
(BOOSTER PUMPING STATION #1, PHASE 1)
SCALE 1: 100M

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 8.3.7 CONTROL ROOM LAYOUT PLAN B.P.S. #1 PHASE 1



NOTE:

PHASE 1

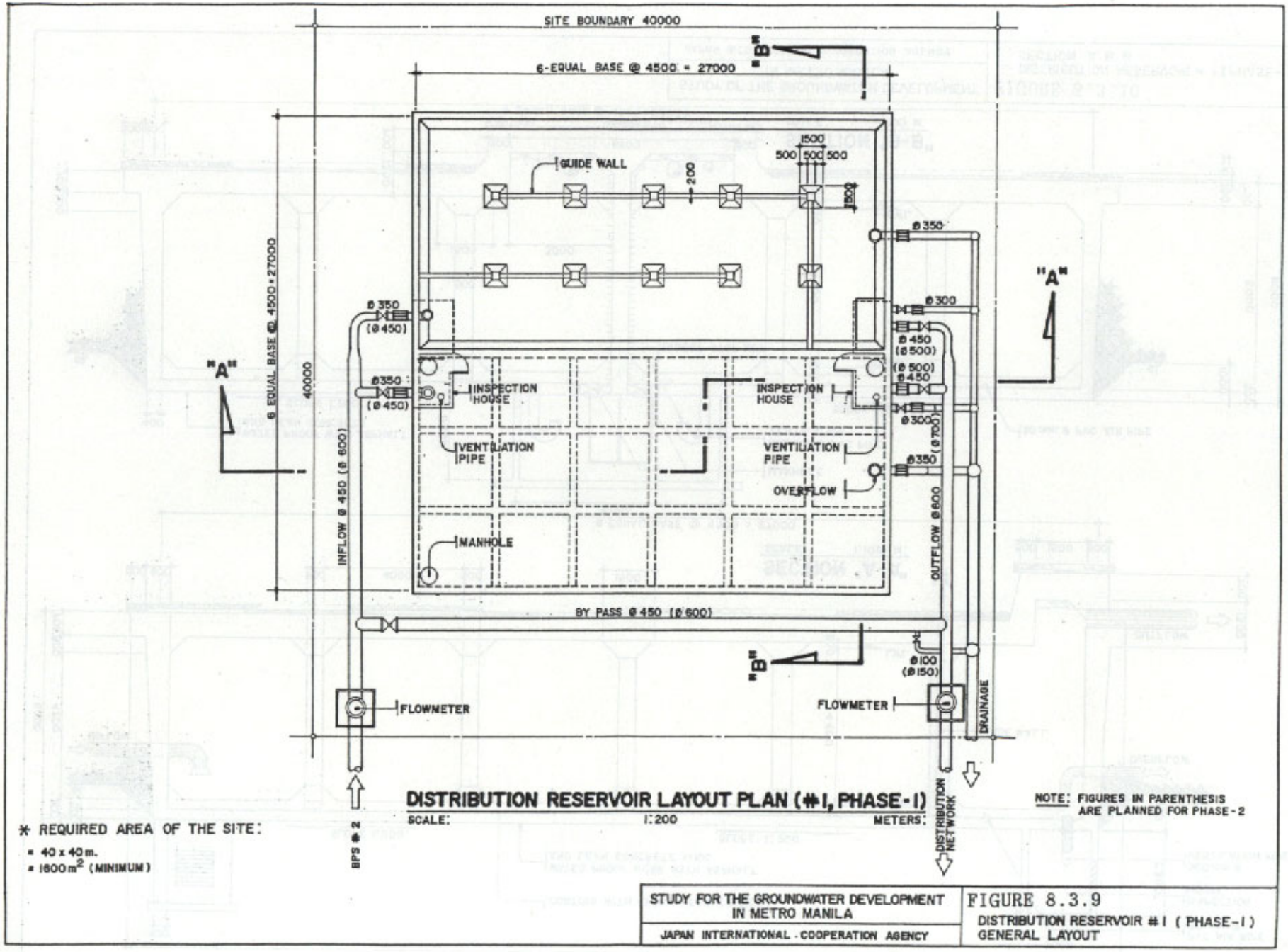
PHASE 2

BOOSTER PUMPING STATION NO.2 GENERAL LAYOUT PLAN

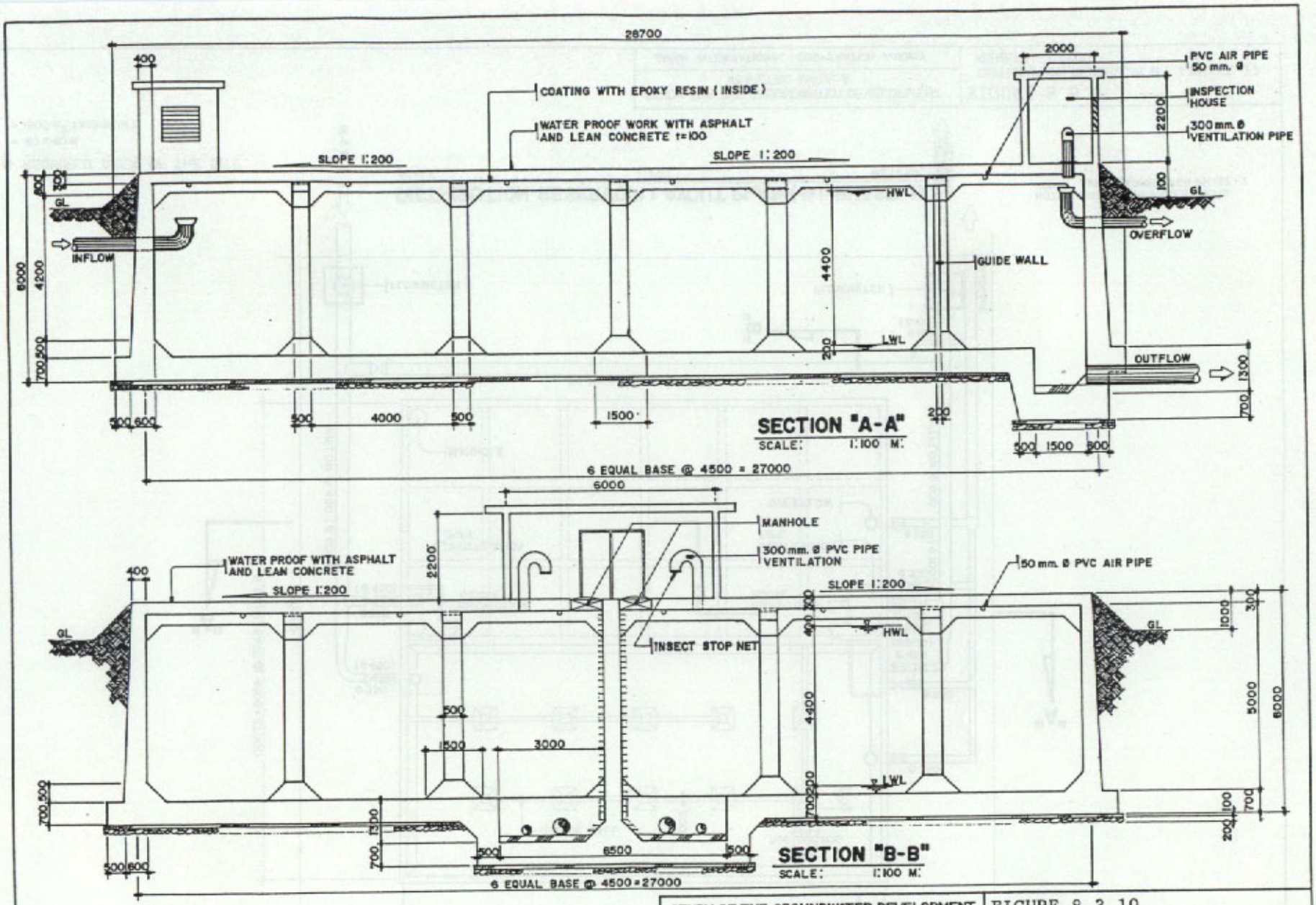
SCALE 1: 300 M

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

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 8.3.8 B.P.S. #2 GENERAL LAYOUT



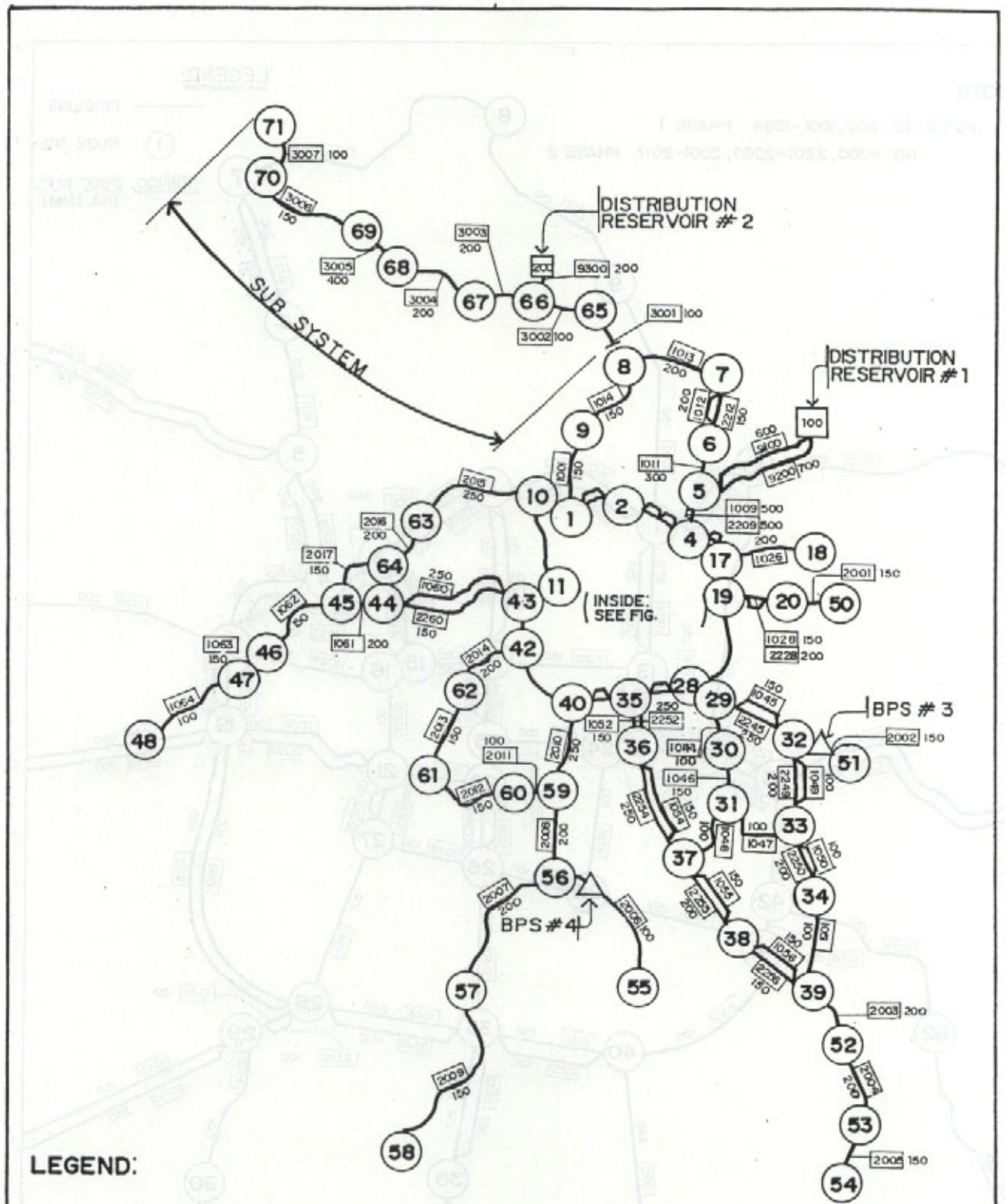
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 8.3.9
JAPAN INTERNATIONAL COOPERATION AGENCY	DISTRIBUTION RESERVOIR #1 (PHASE-1) GENERAL LAYOUT



STUDY OF THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 8.3.10
DISTRIBUTION RESERVOIR # 1 (PHASE-1)
SECTION A & B

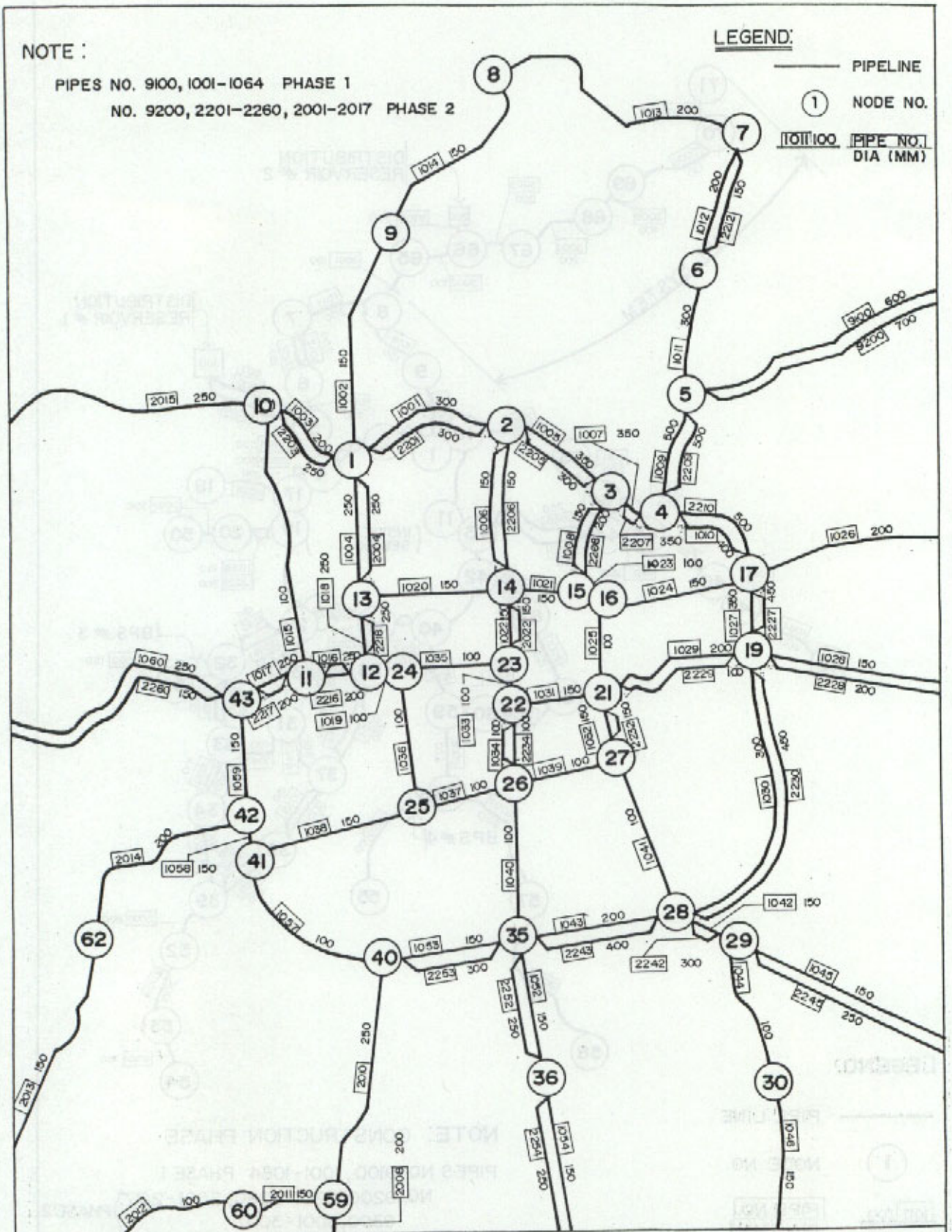


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 8.3.11

DISTRIBUTION NETWORK ANALYSIS - 1

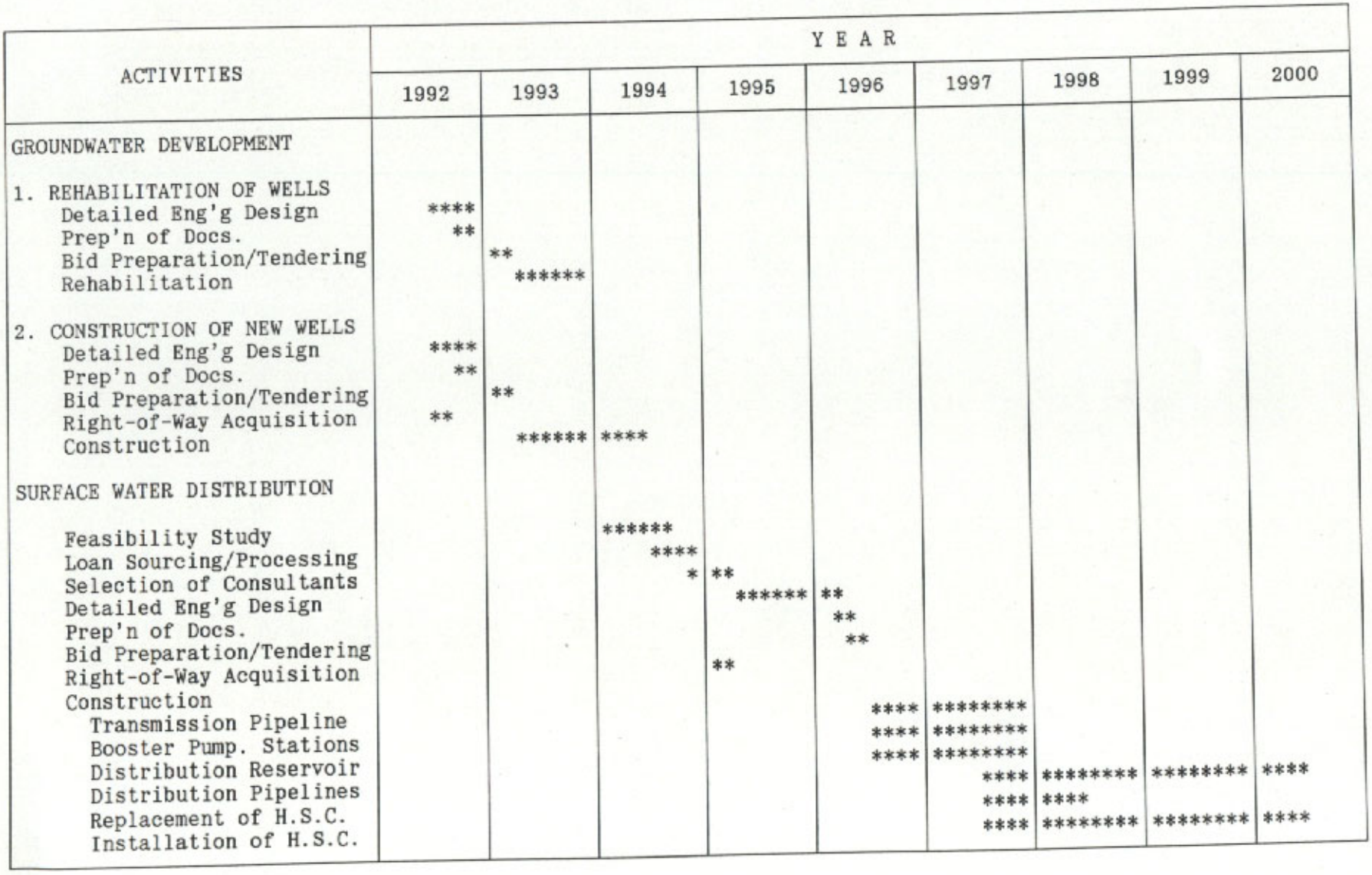


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 8.3.12
DISTRIBUTION NETWORK ANALYSIS-2

FIGURE 8.3.13 IMPLEMENTATION SCHEDULE FOR THE PROJECT (PHASE 1)



CHAPTER 9

GROUNDWATER MANAGEMENT PLAN

CHAPTER 9 GROUNDWATER MANAGEMENT PLAN

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CHAPTER 9 GROUNDWATER MANAGEMENT PLAN

9.1 OBJECTIVES OF GROUNDWATER MANAGEMENT

9.1.1 Permissive Yield as a Target

Water level decline, saline water intrusion and land subsidence are negative responses of the natural aquifer system to human activities. They are anathema to the rational utilization of groundwater so that it is necessary for any sound groundwater management system to put up preventive measures for them.

Groundwater management must be forwarded under a pertinent selection of management objective. The objective, in other word, "target" of the management may be represented by "safe yield". The safe yield of a groundwater basin is the yearly amount of water which can be withdrawn from it without producing an undesired result (Todd, 1959).

Determination of safe yield of a groundwater basin requires identification of undesired results. Four factors are generally considered:

1) Recharge to the basin
2) Economics of pumpage from the basin
3) Quality of the groundwater
4) Water rights in and near the basin

In this study, however, the term "permissive yield" is used instead of safe yield. The permissive yield is the amount of groundwater which can be allowed to be withdrawn from the basin considering the benefits and risk for the inhabitants who are living there and using groundwater (Water Balance Research Group, 1976). Most importantly, the permissive yield used in this study considers the four factors enumerated above.

9.1.2 Prevention of Saline Water Intrusion

It is considered that even with the combined output of the various ongoing surface water supply projects, water supply in the MSA for a long time, shall still depend on groundwater sources, not only for

municipal use but also for commercial and industrial uses. An objective of groundwater management is to sustain the use of groundwater, with the saline water intrusion in Metro Manila being contained or prevented. Thus, the permissive yield may be determined by giving importance to the quality of groundwater.

According to Todd (1980), methods for controlling intrusion vary widely depending on the source of the saline water, extent of intrusion , local geology, groundwater use, and economic factors. Alternative methods are summarized as follows:

1) Modification of Pumping Pattern

Changing the locations of pumping wells by dispersing them inland and reducing the pumping of existing wells can effect recovery of groundwater levels and establish a seaward hydraulic gradient.

2) Artificial Recharge

Groundwater levels can be raised and maintained by artificial recharge, using surface spreading for unconfined aquifers and recharge wells for confined aquifers. However, this method necessitates development of a supplemental water source.

3) Extraction Barrier

An extraction barrier is created by maintaining a continuous pumping trough with a line of wells adjacent to the sea. Seawater flows inland from the ocean to the trough, while fresh water within the basin flows seaward toward the trough, as shown in Figure 9.1.1. The water pumped is brackish and normally is discharged into the sea.

4) Injection Barrier

This method maintains a pressure ridge along the coast by a line of recharge wells. Injected fresh water flows both seaward and landward, as indicated in Figure 9.1.2. High-quality imported water is required for recharge into wells. A combination of injection and extraction barriers is feasible. While this arrangement reduces both recharge and extraction

rates, it requires a large number of wells.

5) Subsurface Barrier

Construction of an impermeable subsurface barrier parallel to the coast and through the vertical extent of the aquifer can effectively prevent the inflow of seawater into the basin (Figure 9.1.3). Materials for constructing a barrier might include sheet piling, puddled clay, emulsified asphalt, cement grout, bentonite, silica gel, calcium acrylate, or plastics. Chief problems are construction cost and resistance to earthquakes and chemical erosion.

Construction of injection barrier requires artificial recharge. This method needs fresh surface water to be injected, virtually making it inapplicable not only in terms of construction cost, but also on the availability of fresh surface water in Metro Manila. On the other hand, extraction barrier is risky considering the locations of existing pumping wells. In addition, groundwater levels had already dropped heavily in the inland areas of Las Piñas, Parañaque, Muntinlupa, etc., thus making the extraction barrier also not applicable.

An example of a subsurface barrier is the underground cutoff wall that was constructed in Miyakojima Island, Japan to dam up and store groundwater. As illustrated in Figure 9.1.4, the underground cutoff wall not only dams groundwater that courses to the sea but also prevents seawater intrusion. In this case, the depth of the top of the impermeable bed is shallow, only about 50 to 60m. In contrast, the depth of salinized aquifer in the coastal areas of Metro Manila is approximately 100m. In addition, saline water intrudes into deep aquifers laterally from Manila Bay and vertically from shallow aquifer through leakage.

Therefore, the construction of cutoff walls, or of artificial recharge wells and extraction wells are extremely costly and would prove difficult to implement, considering the mechanism and the areal extent of saline water intrusion in the coastal area of Metro Manila. The reduction of pumpage is the most viable option.

The computer simulation predicted that the groundwater level shall decline by more than 50m from its present level, and the saline water

intruded area shall 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 established, in which a reduced pumpage is proposed as a tentative permissive yield of the basin, a target of the groundwater management.

9.2 INSTITUTIONAL AND LEGAL ASPECTS

9.2.1 Institutional Structure

Presently, the National Water Resources Board (NWRB) is the body responsible for coordinating and integrating all activities related to water resources development and management.

The Board is attached to the Department of Public Works and Highways (DPWH) and is composed of the heads of six departments and four line agencies involved in water resources. The departments are the DPWH, Department of Agriculture (DA), the National Economic and Development Authority (NEDA), the Department of Trade and Industry (DTI), the Department of Health (DOH), and the Department of Environment and Natural Resources (DENR); and the line agencies are the Metropolitan Waterworks and Sewerage System (MWSS), the National Irrigation Administration (NIA), the Local Water Utilities Administration (LWUA) and the National Power Corporation (NPC).

The NWRB has a full-time working staff composed of some 71 engineers, specialists, economists, and legal specialists and some 60 administrative, financial and technical support personnel.

The NWRB operates through its five divisions, which have four (4) sections each, as illustrated in Figure 9.2.1. The organizational structure is in consonance with NWRB's operational programs and directed to the main functional areas of Policy Formulation; Program/Project Evaluation and Coordination; Water Use Regulation; Regulation of Water Utilities Operations; and Monitoring of Water Appropriation and Utilization.

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 above-said 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	-35.7 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.

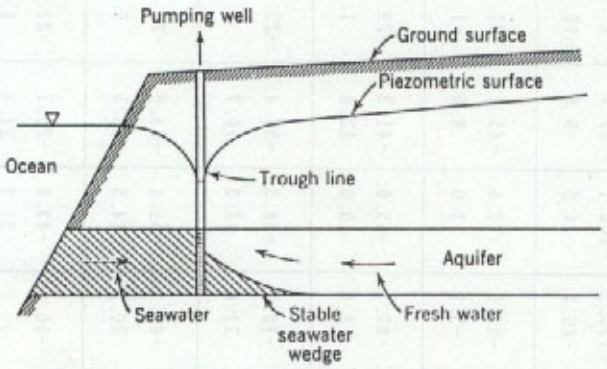


FIGURE 9.1.1 CONTROL OF SEAWATER INTRUSION BY AN EXTRACTION BARRIER FORMING A PUMPING TROUGH PARALLELING THE COAST

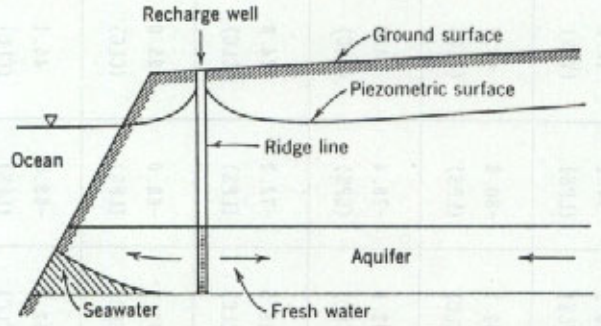


FIGURE 9.1.2 CONTROL OF SEAWATER INTRUSION BY AN INJECTION BARRIER FORMING A PRESSURE RIDGE PARALLELING THE COAST

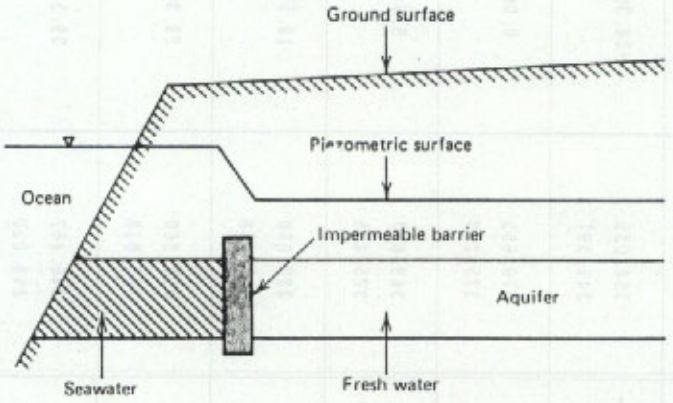


FIGURE 9.1.3 CONTROL OF SEAWATER INTRUSION BY AN IMPERMEABLE SUBSURFACE BARRIER PARALLELING THE COAST

TODD, D.K. (1980)

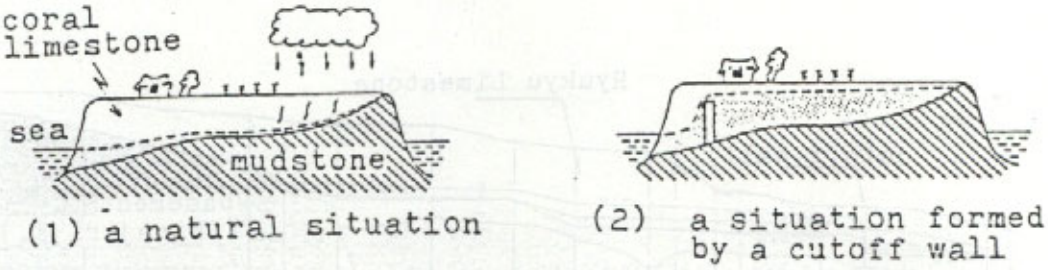


FIGURE 9.1.4(1) AN IDEA OF AN UNDERGROUND RESERVOIR

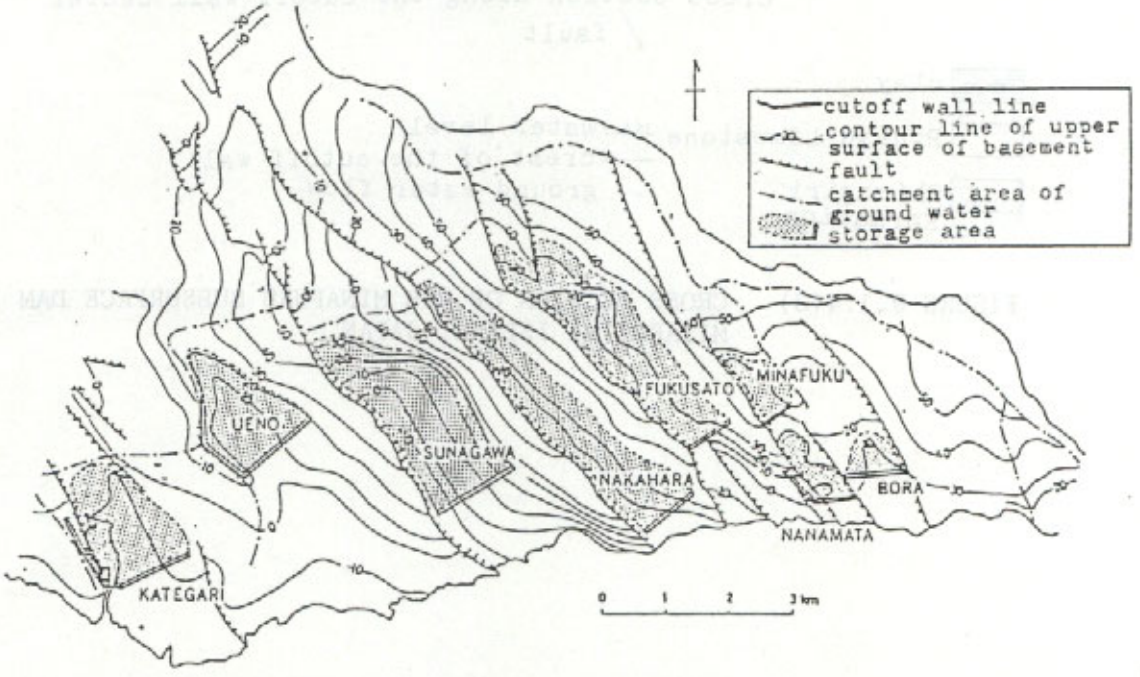


FIGURE 9.1.4(2) THE UNDERGROUND RESERVOIR DEVELOPMENT PROJECT AT MIYAKOJIMA ISLAND, JAPAN

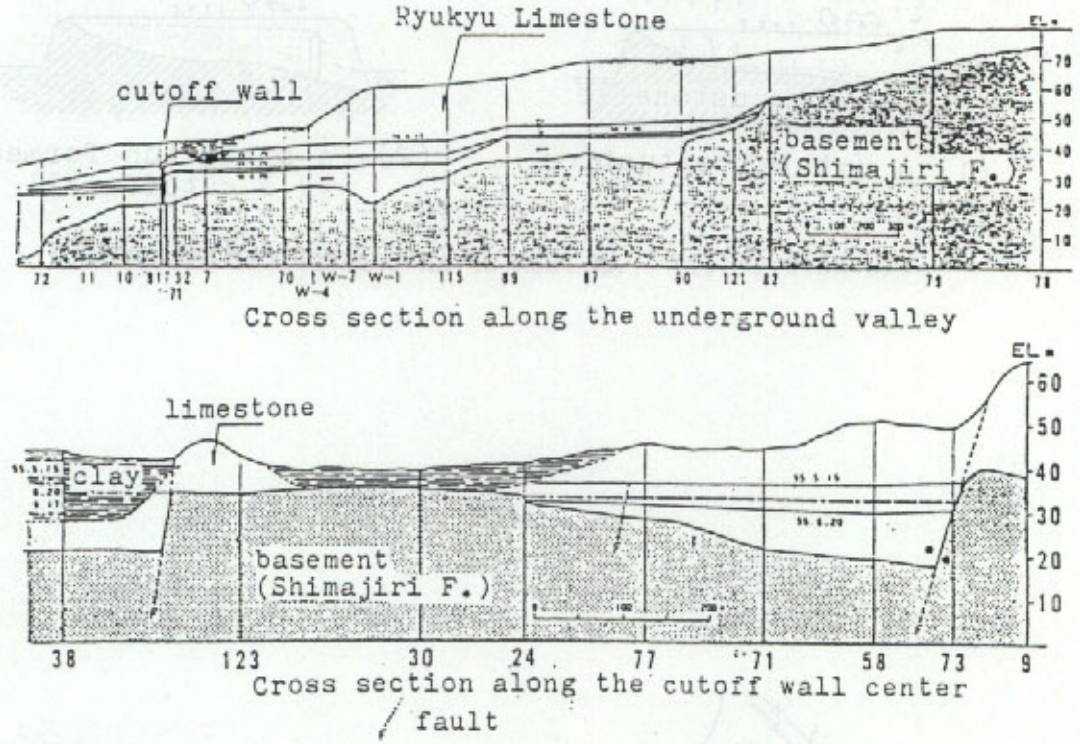
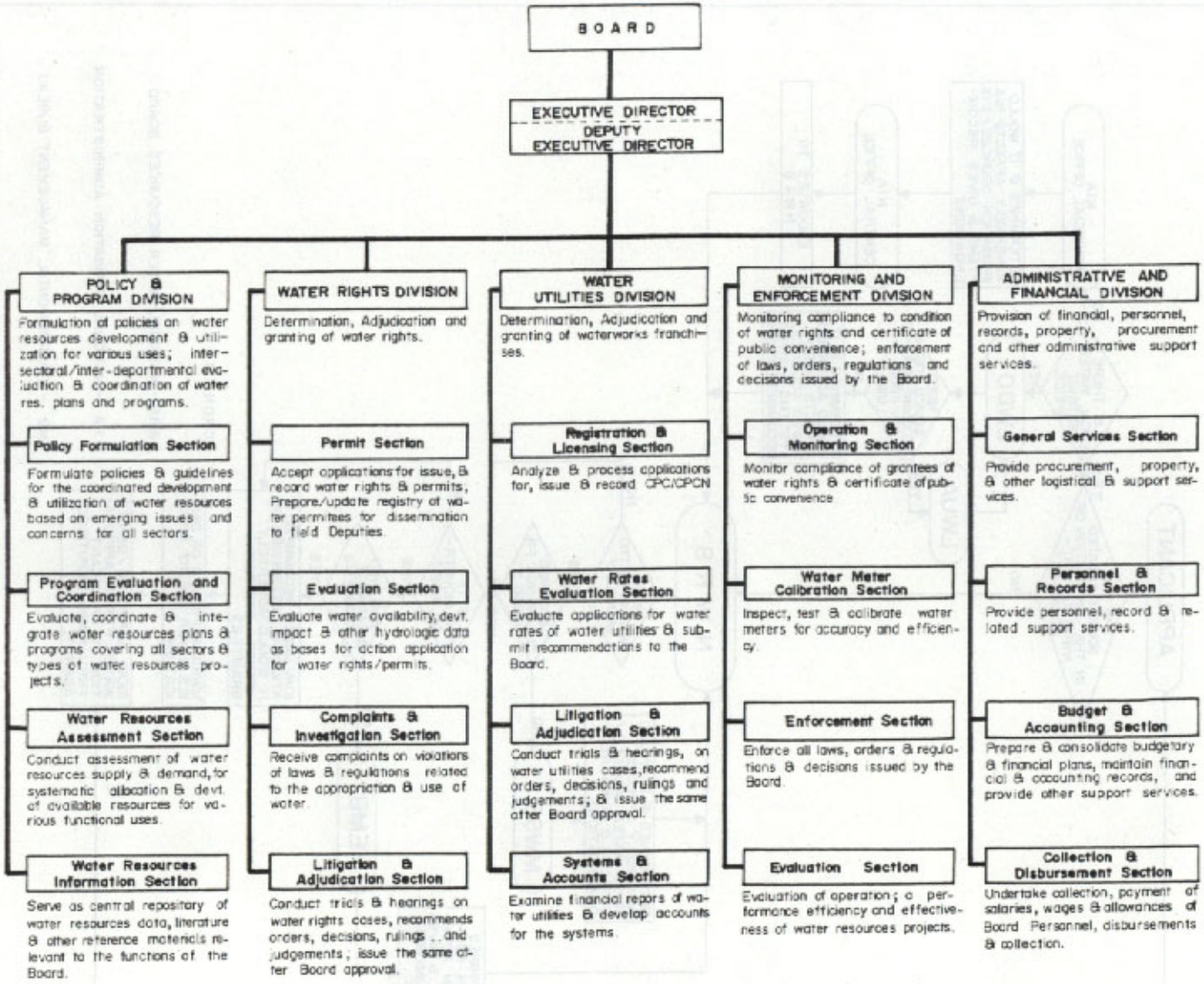


FIGURE 9.1.4(3) CROSS SECTION OF THE MINAFUKU SUBSURFACE DAM IN MIYAKOJIMA ISLAND, JAPAN

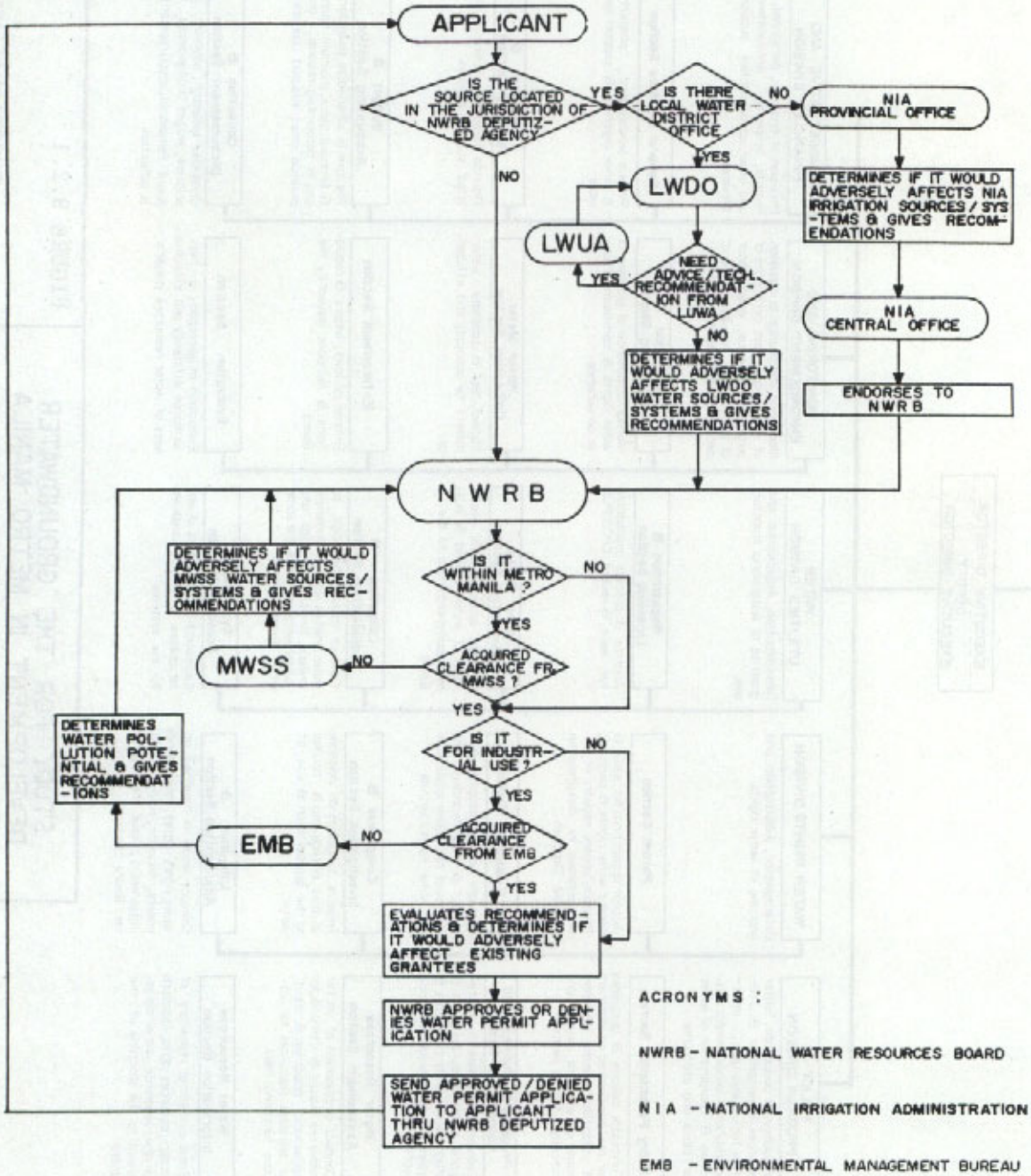


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.2.1

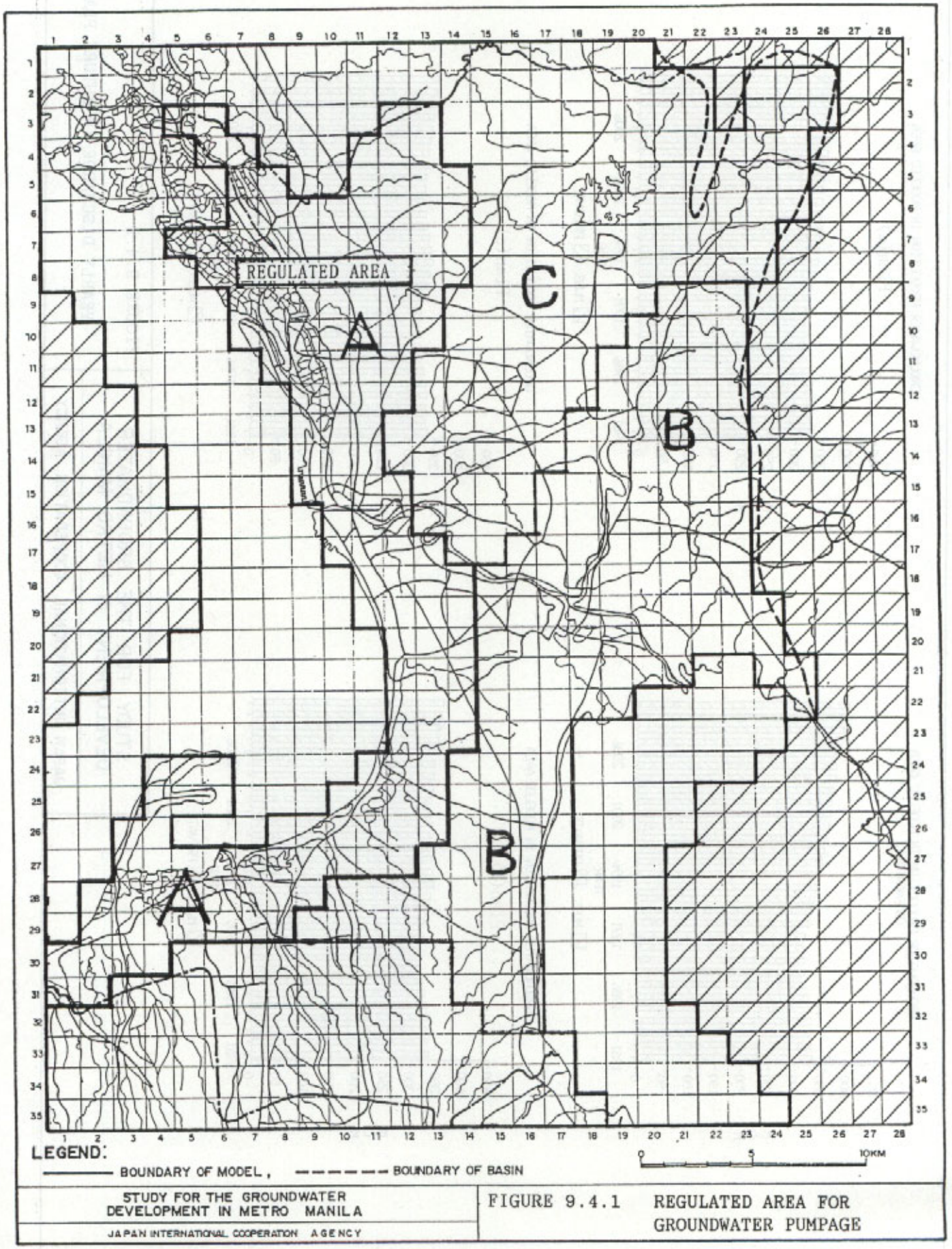
FUNCTIONAL CHART OF NWRB



STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

JAPAN INTERNATIONAL COOPERATION AGENCY

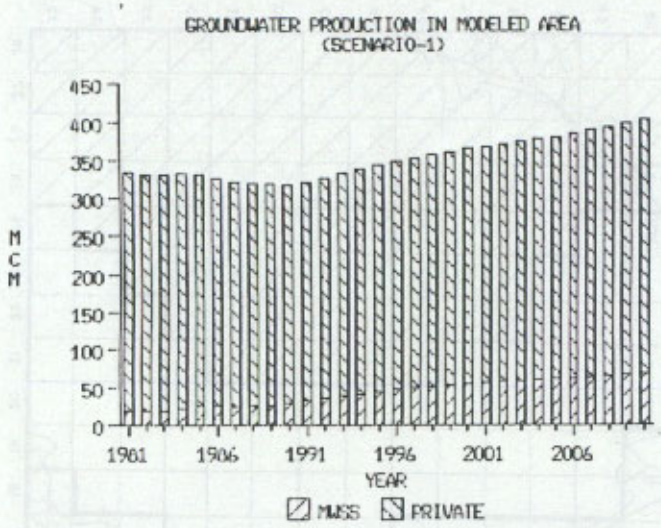
FIGURE 9.2.2 EXISTING WATER PERMIT PROCESSING FLOWCHART

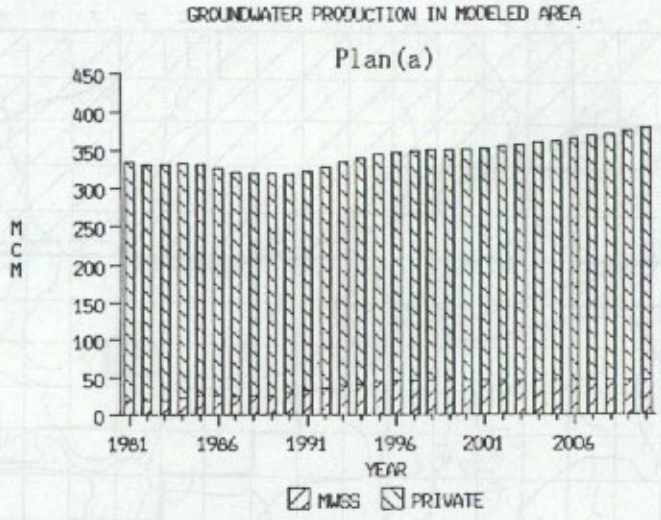


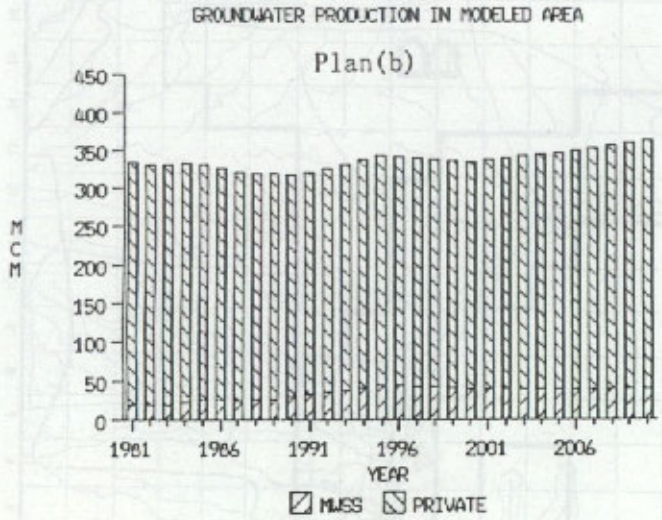
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

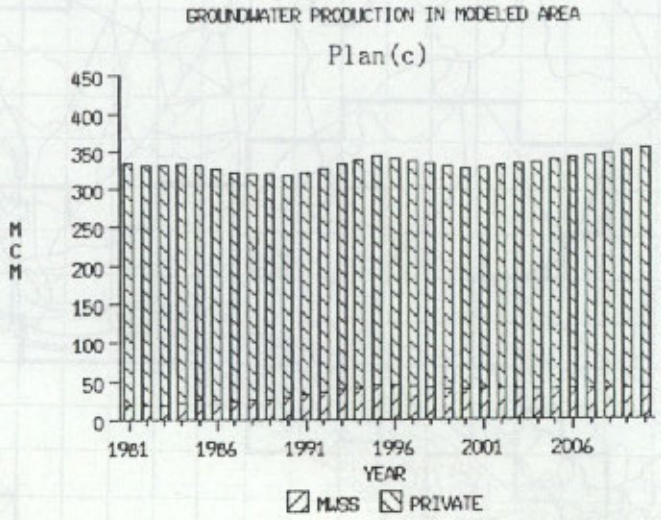
JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9.4.1 REGULATED AREA FOR GROUNDWATER PUMPAGE

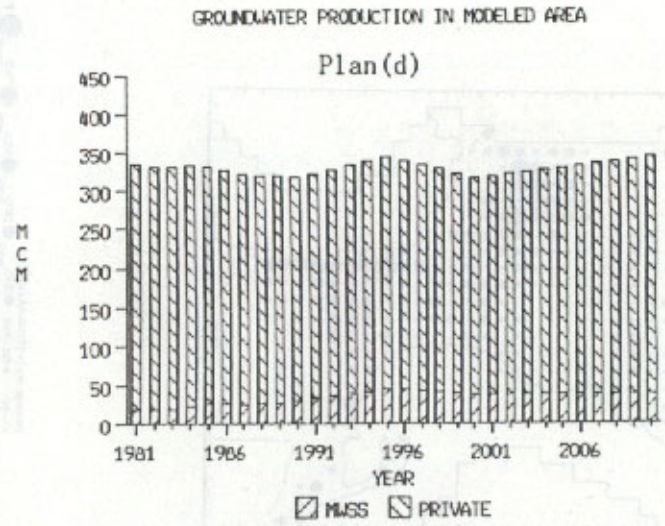


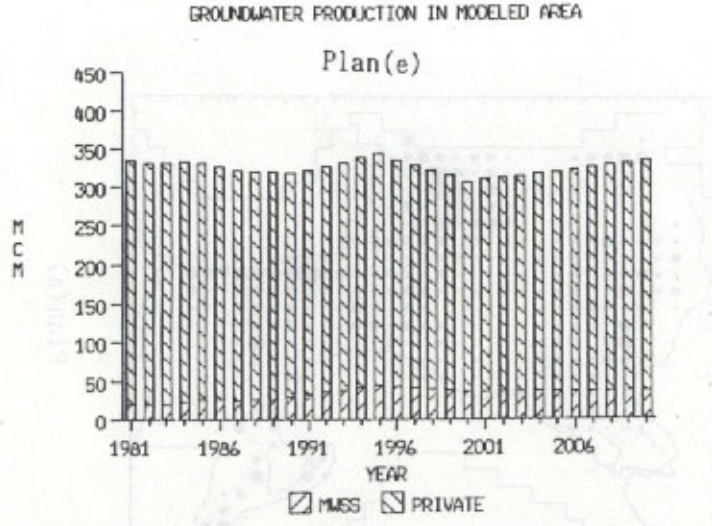


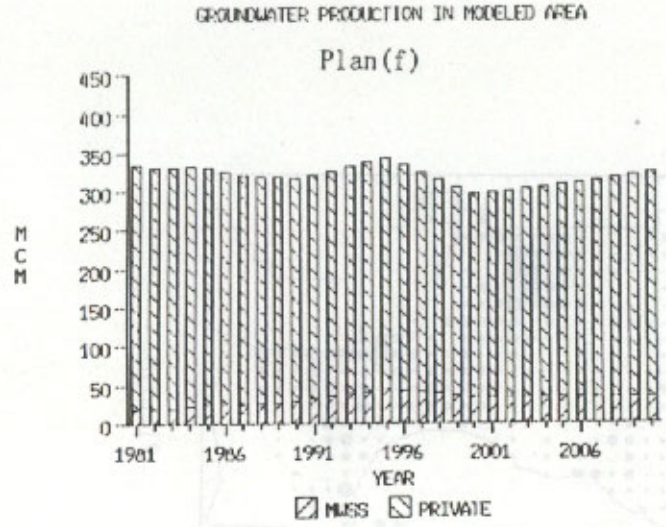


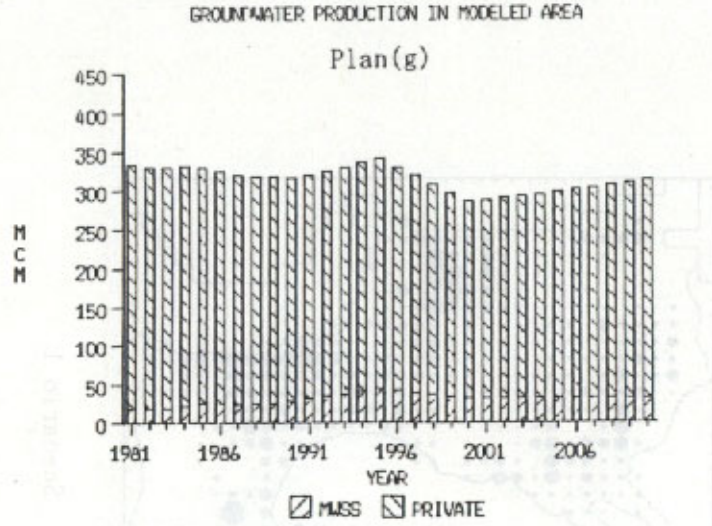


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.4.2
JAPAN INTERNATIONAL COOPERATION AGENCY	YEARLY DISCHARGE IN FUTURE PLAN (1)

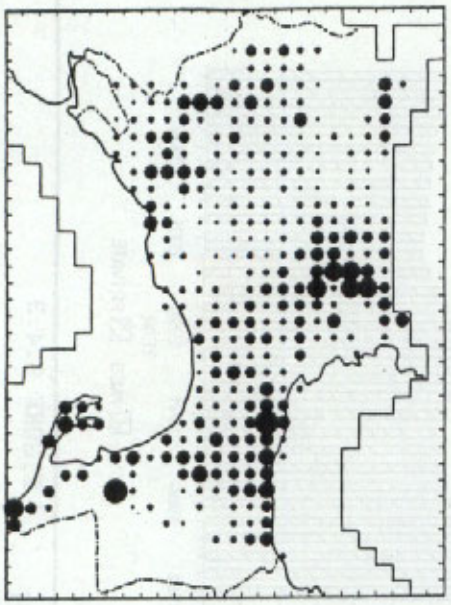




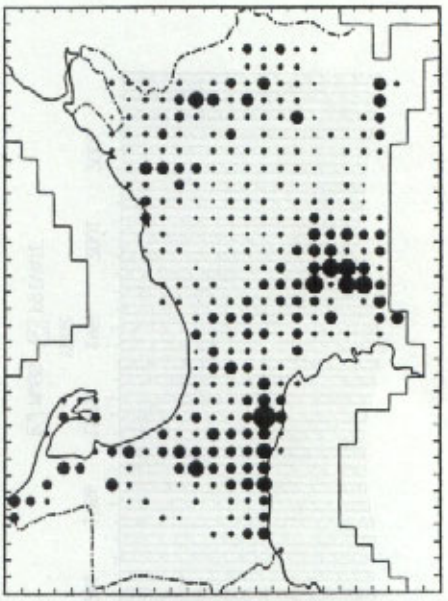




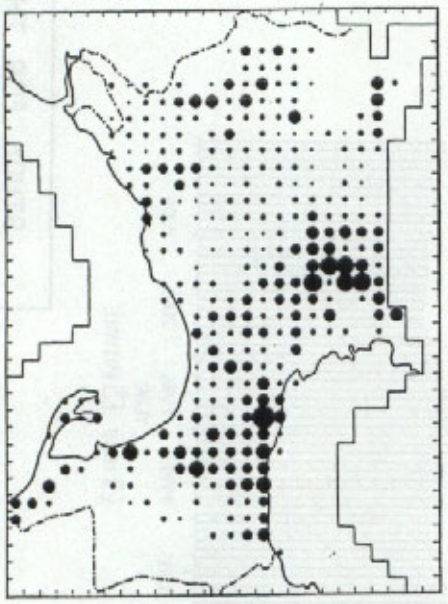
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.4.3
JAPAN INTERNATIONAL COOPERATION AGENCY	YEARLY DISCHARGE IN FUTURE PLAN (2)



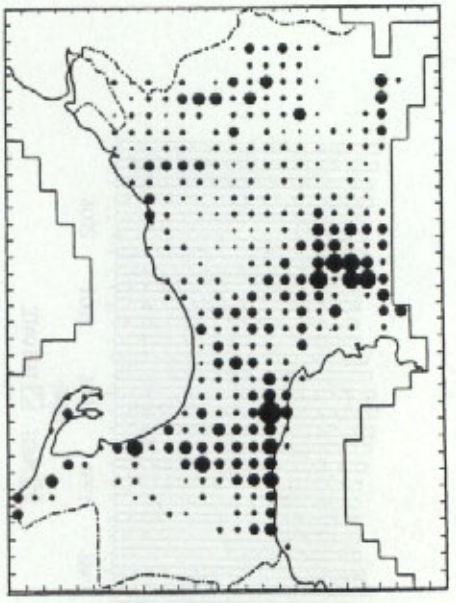
Scenario 1



Plan(a)

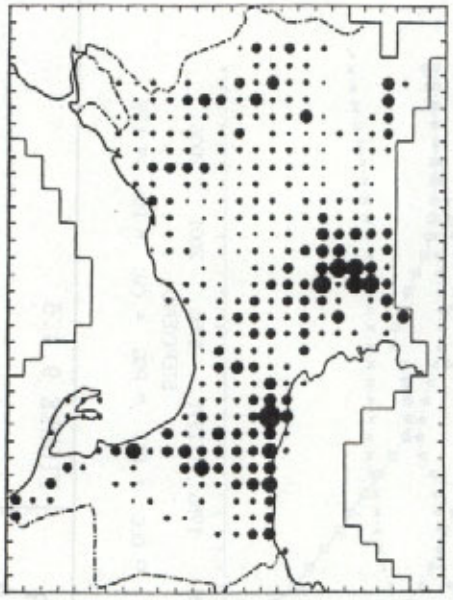


Plan(b)

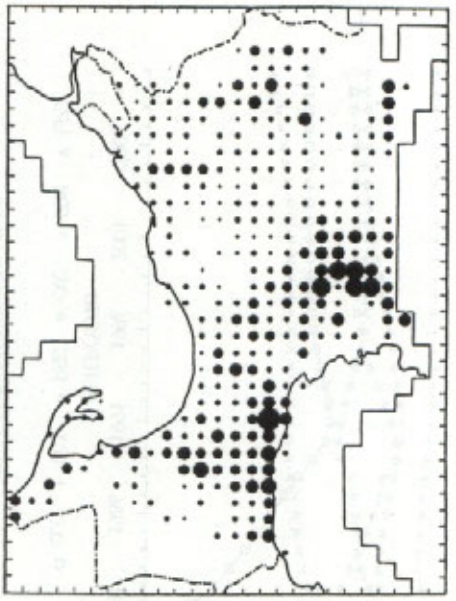


Plan(c)

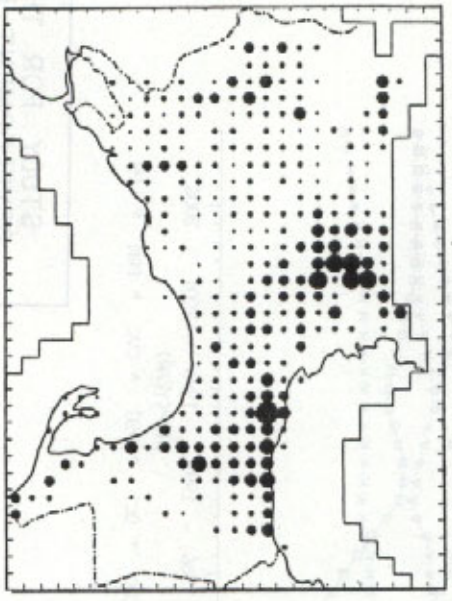
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 9.4.4 DISCHARGE DISTRIBUTION IN FUTURE PLAN (1) IN YEAR 2010



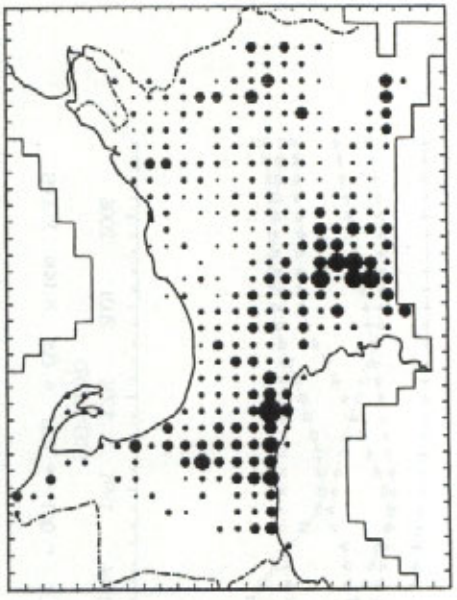
Plan(d)



Plan(e)

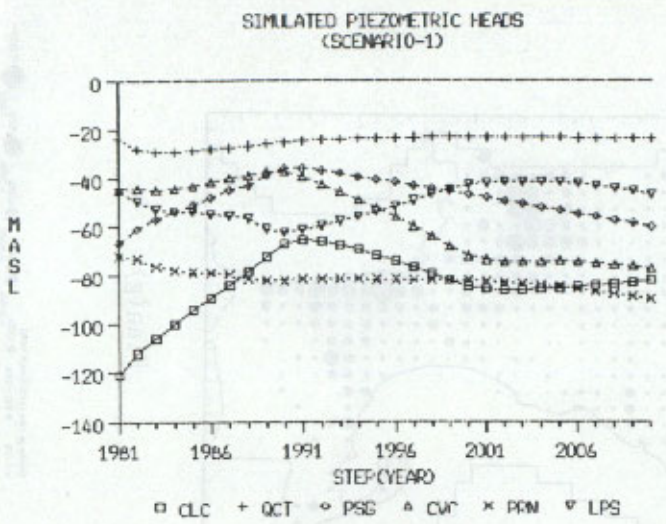


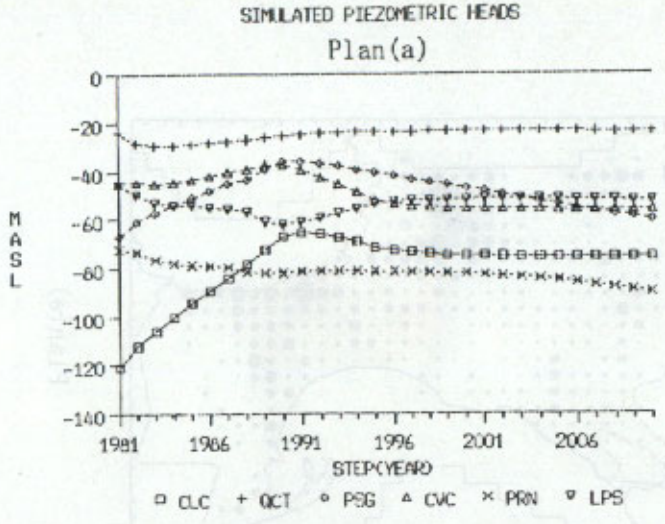
Plan(f)

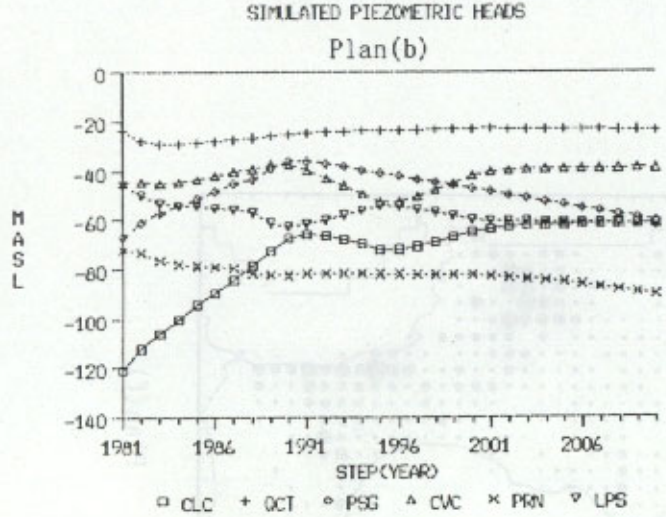


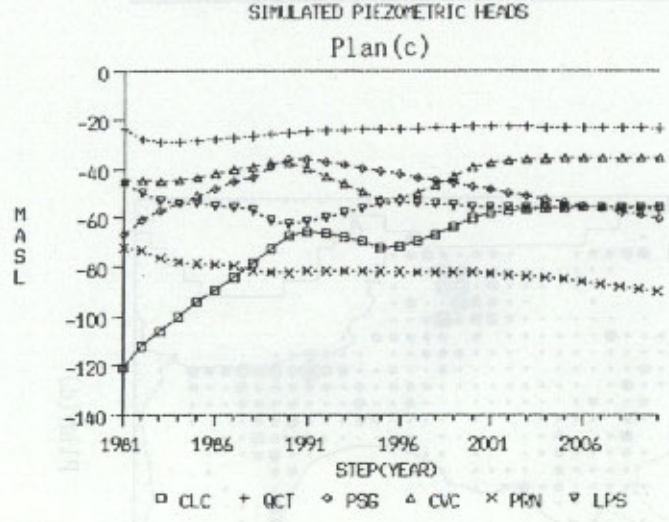
Plan(g)

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

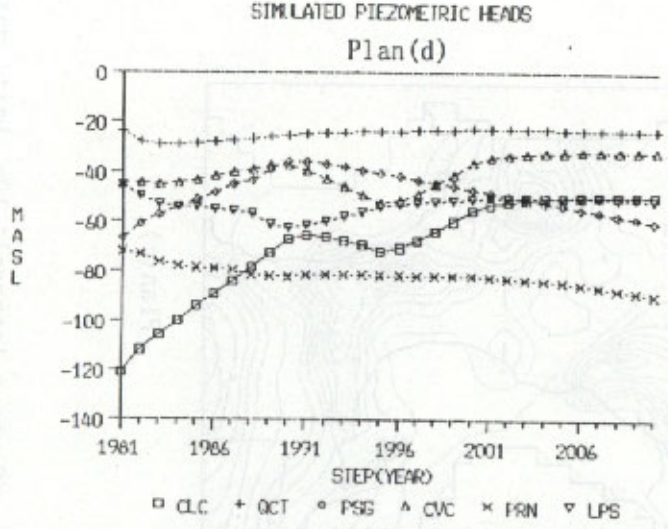


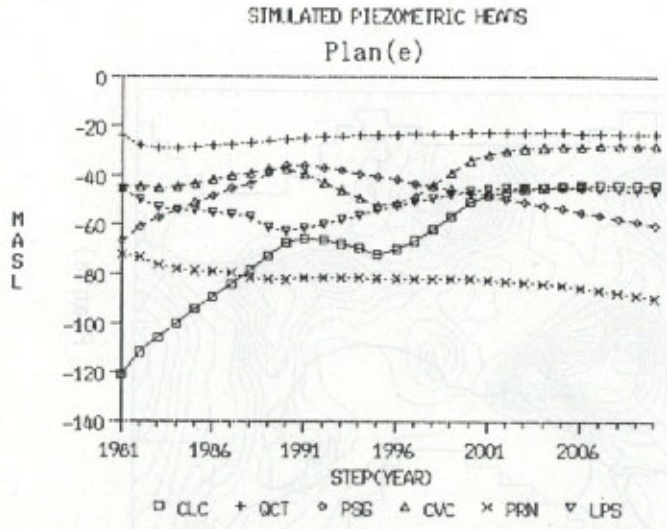


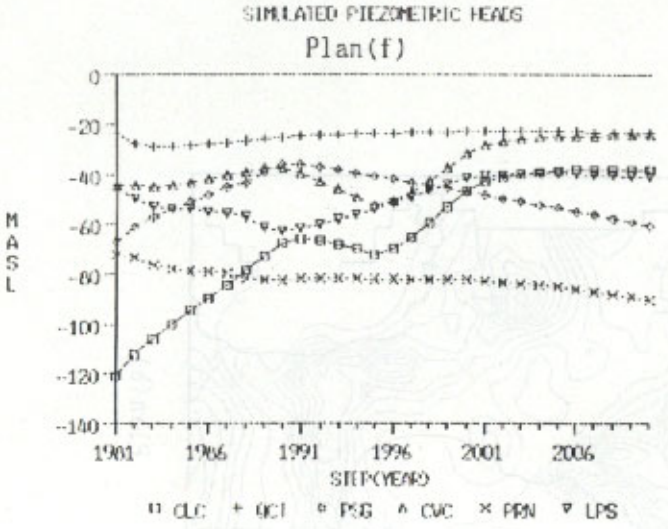


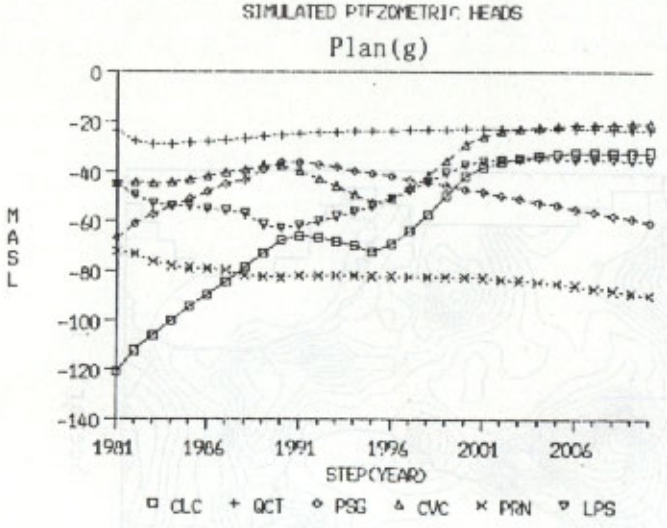


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.4.6
JAPAN INTERNATIONAL COOPERATION AGENCY	SIMULATED PIEZOMETRIC CHANGES IN FUTURE DISCHARGE PLAN (1)

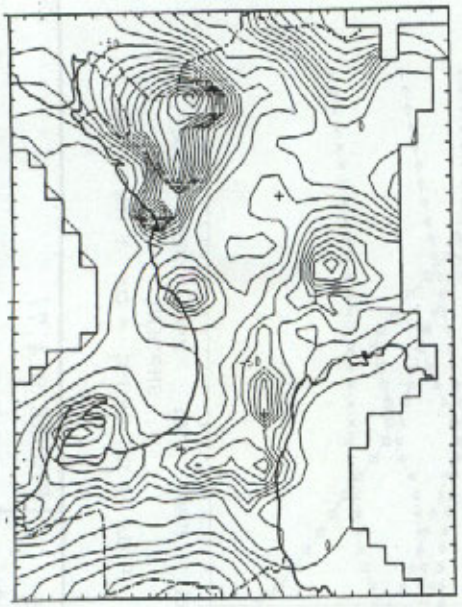








STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 9.4.77 SIMULATED PIEZOMETRIC CHANGES IN FUTURE DISCHARGE PLAN (2)



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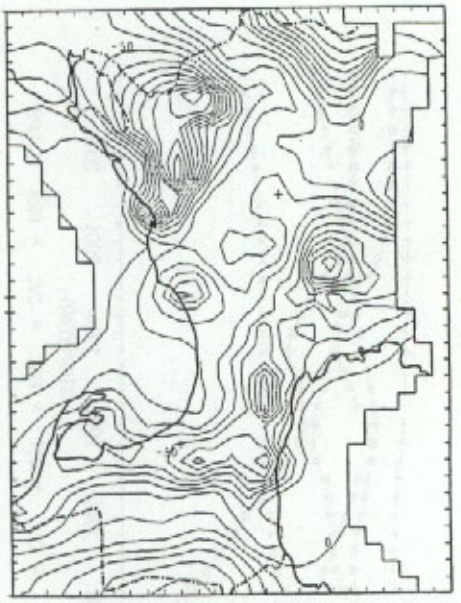

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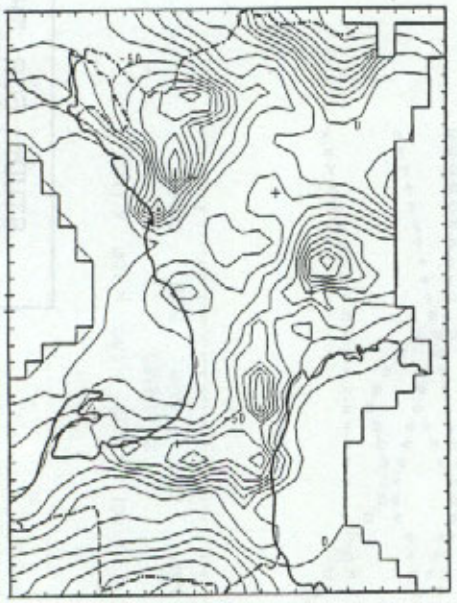

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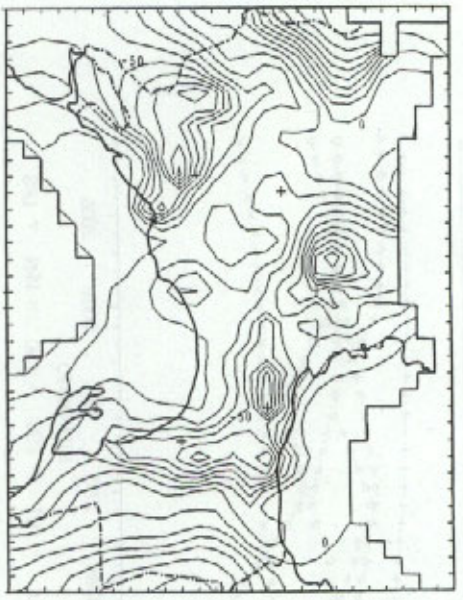

Plan(c)

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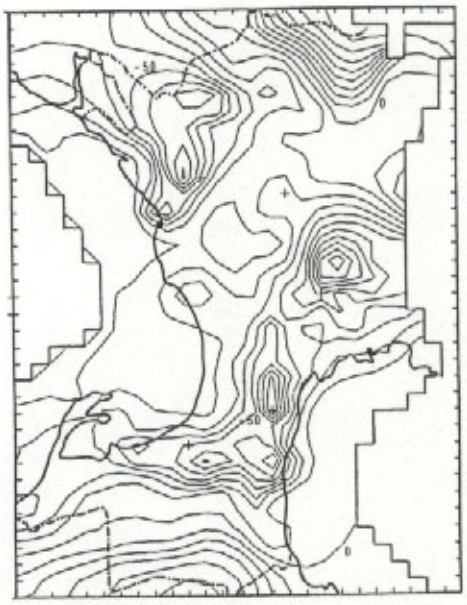
STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 9.4.8 SIMULATED PIEZOMETRIC HEADS IN 2010 IN FUTURE DISCHARGE PLAN (1)



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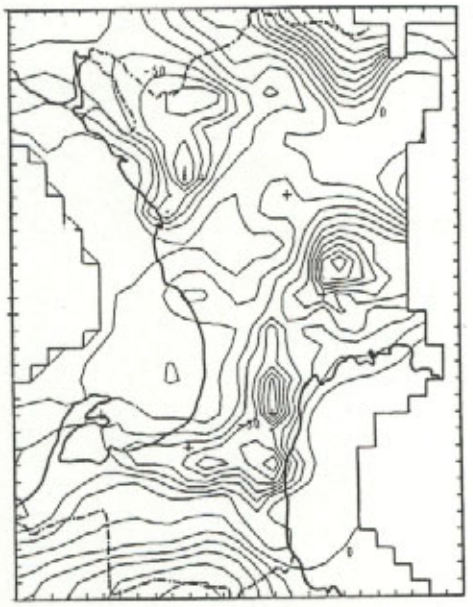

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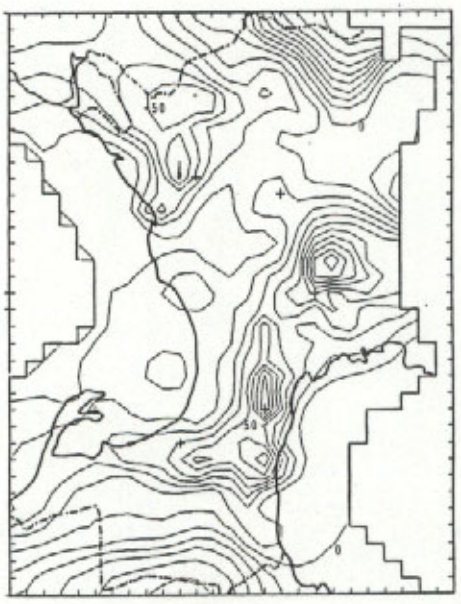

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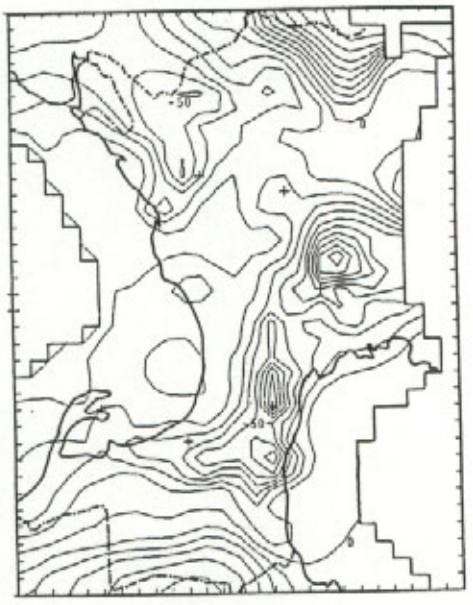
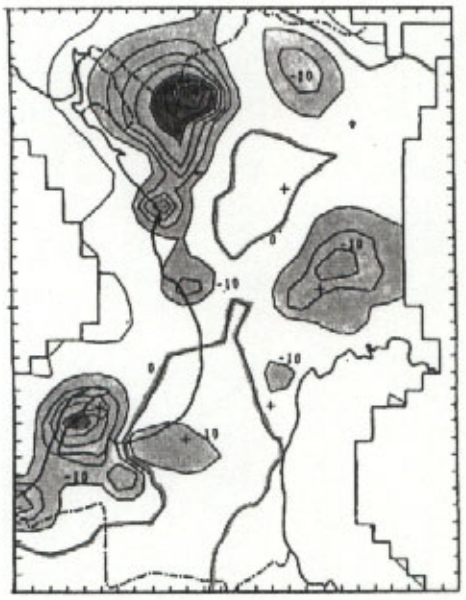


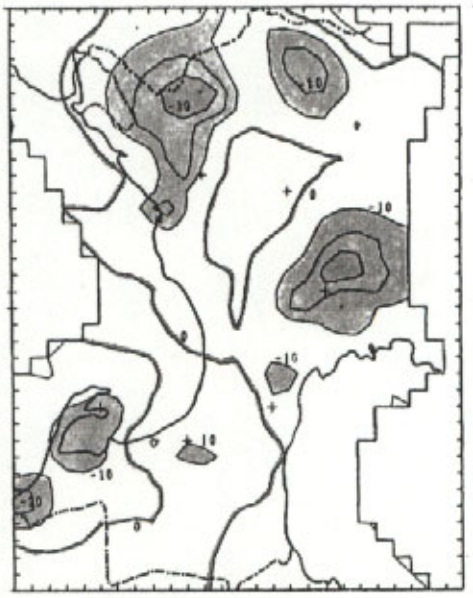
Plan(g)

(Contour Interval: 10m, Unit: masl)

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



Scenario 1



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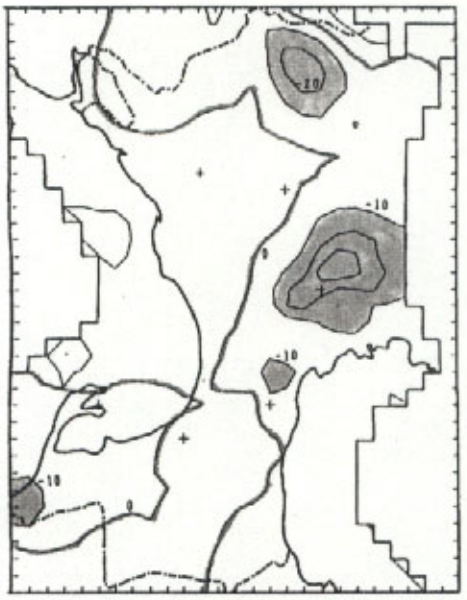
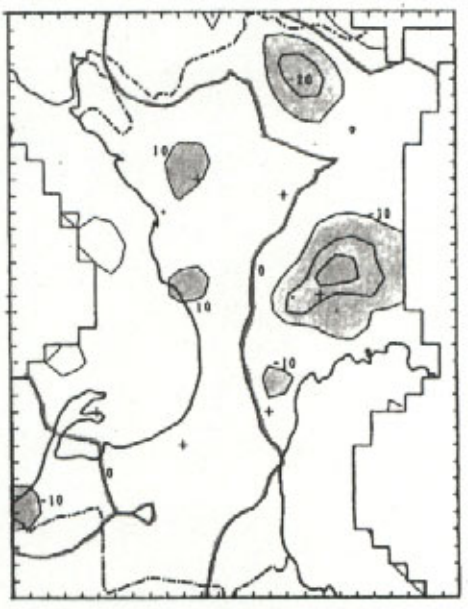


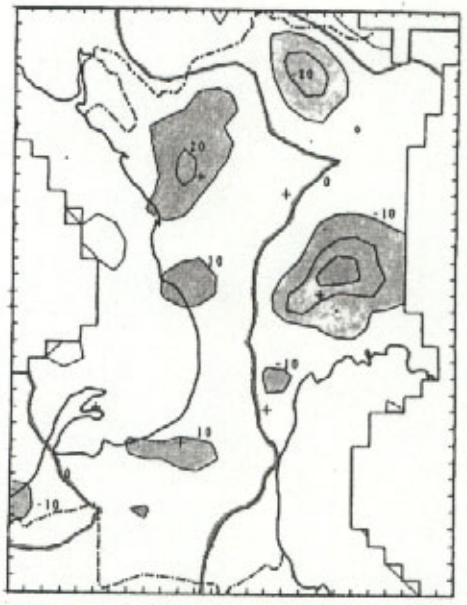
Plan(b)



Plan(c)

(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA	FIGURE 9.4.10 SIMULATED PIEZOMETRIC CHANGES FROM 1991-2010 IN FUTURE DISCHARGE PLAN (1)
JAPAN INTERNATIONAL COOPERATION AGENCY	



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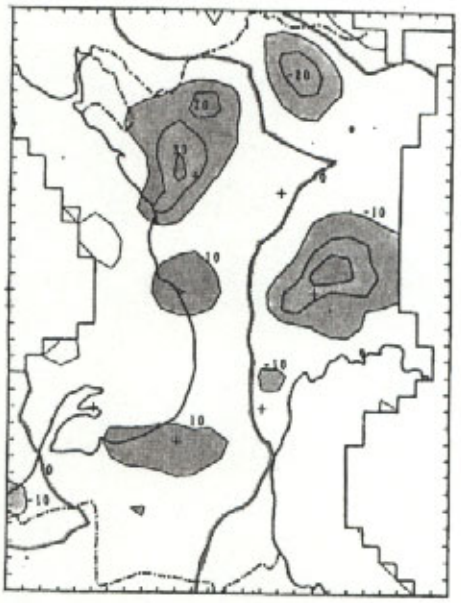

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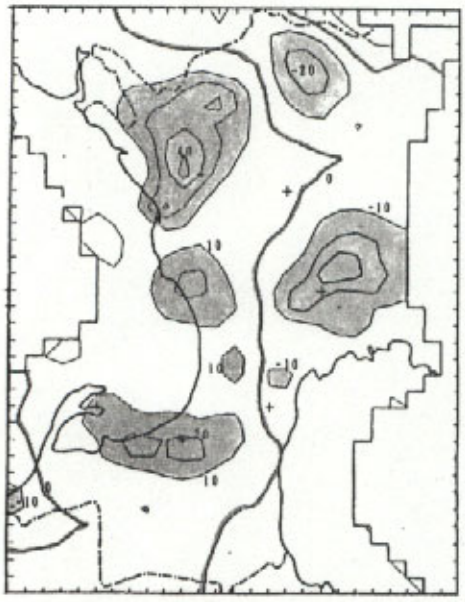

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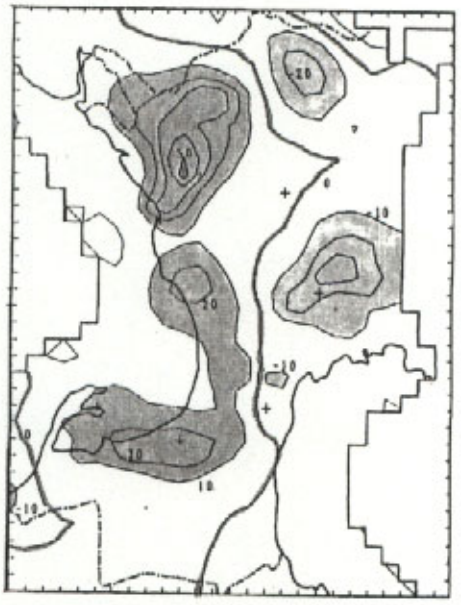
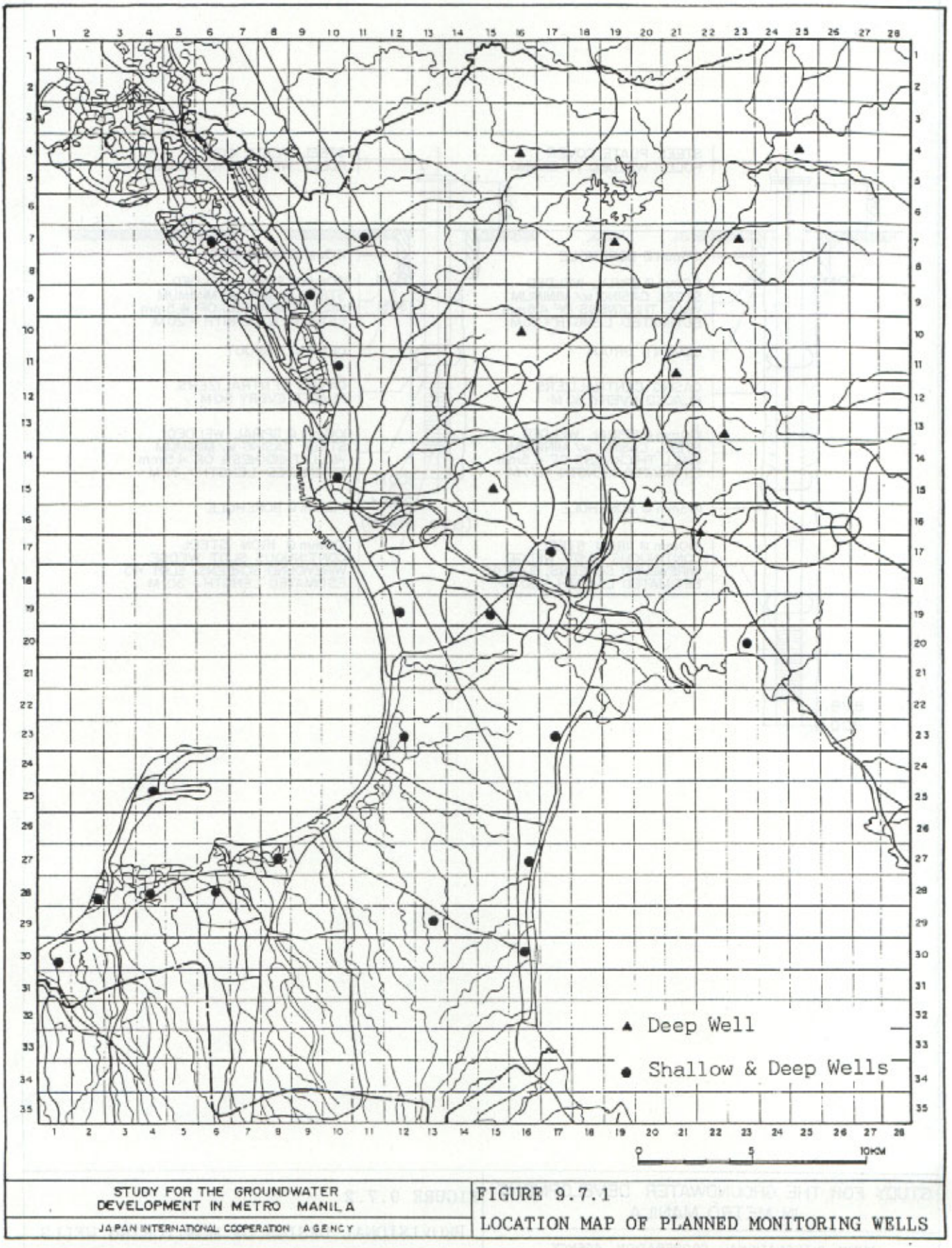


Plan(g)

(Contour Interval: 10m, Unit: m)

STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA JAPAN INTERNATIONAL COOPERATION AGENCY	FIGURE 9.4.11 SIMULATED PIEZOMETRIC CHANGES FROM 1991-2010 IN FUTURE DISCHARGE PLAN (2)

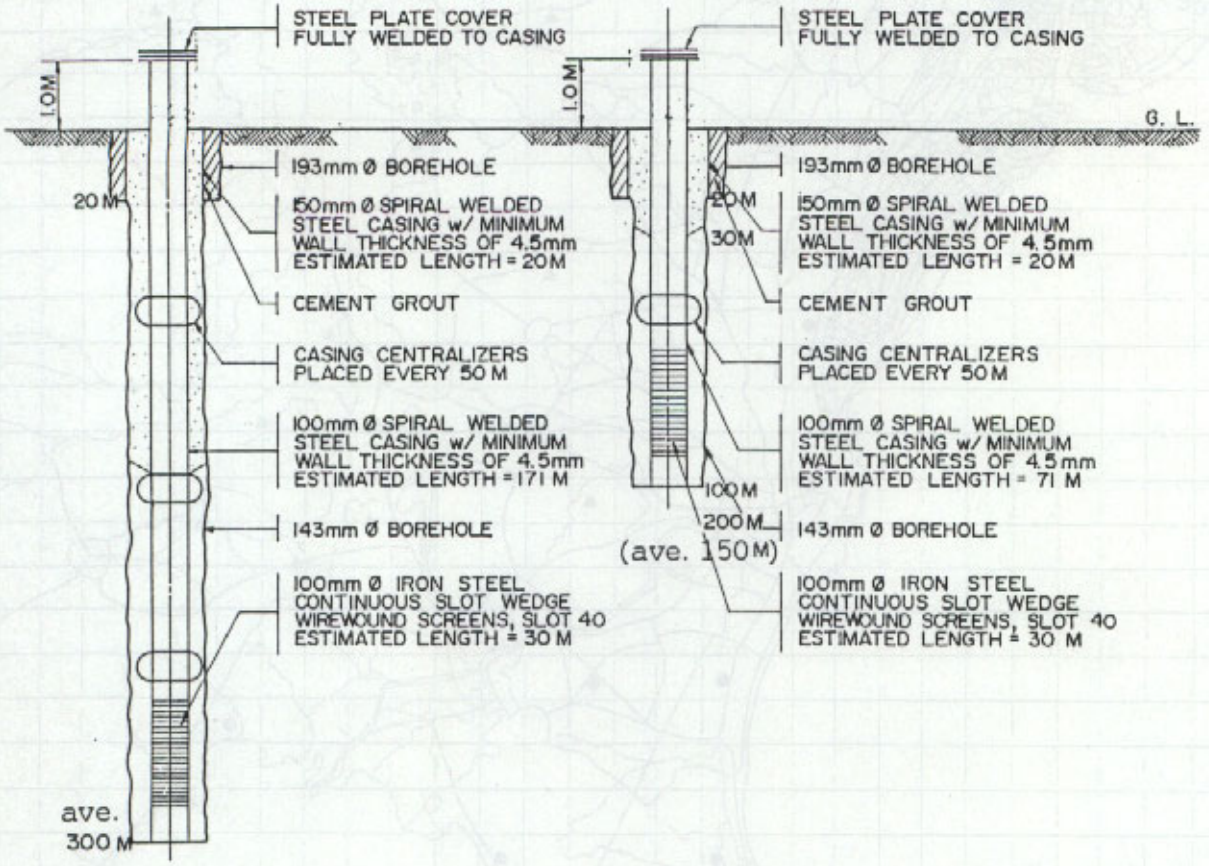


STUDY FOR THE GROUNDWATER DEVELOPMENT IN METRO MANILA

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 invento-

ry, 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 al-

ready 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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