Part – G

GROUNDWATER RESOURCES DEVELOPMENT PLANNING

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ABBREVIATION

ADB	: Asian Development Bank
BWSA	: Barangay Waterworks & Sanitation Association
DB	: Database
DENR	: Department of Environment & Natural Resources
DILG	: Department of Interior & Local Government
DPWH	: Department of Public Works & Highways
DTI	: Department of Trade & Industry
E-Z	: Economic Zones
GIS	: Geographic Information Systems
GWRDP/s	: Groundwater Resources Development Plans
GW	: Groundwater
IBRD	: International Bank of Reconstruction & Development
JICA	: Japan International Cooperation Agency
L-I	: Level-I Water Supply Facilities
L-II	: Level-II Water Supply Systems
L-III	: Level-III Water Supply Systems
LGU/s	: Local Government Unit/s
LWUA	: Local Water Utilities Administration
MWSS	: Metropolitan Waterworks & Sewerage System
NCR	: National Capital Region
NIA	: National Irrigation Administration
NGO/s	: None Government Organization/s
NPC	: National Power Corporation
NSO	: National Statistics Office
NWRB	: National Water Resources Board
OECF	: Overseas Economical Cooperation Fund
PEZA	: Philippines Economic Zones Authority
PMO	: Project Management Office (DPWH)
PNSDW	: Philippines National Standard for Drinking Water
RWSA	: Rural Waterworks & Sanitation Association
SA	: Service Area (for Water Supply)
SW	: Surface Water
UNDP	: United Nations Development Program
WD/s	: Water District/s
WR/s	: Water Right/s
WSS/s	: Water Supply System/s

LIST OF UNITS

ha.	: 10,000 cubic meters
MCM/year	: million cubic meters per year
MCM/year.f	: million cubic meters per year facility
lpcd	: liter per capita day
lps	: liter per second

Part-G GROUNDWATER RESOURCES DEVELOPMENT PLANNING

G.1 General

G.1.1 Abstraction

The final aim of this study is to formulate a master plan for groundwater resources development (GWRD) on a nationwide scale up to the year of 2025, and is a part of the master plan study on water resources management.

This supporting report on the GWRDPs (groundwater resources development plans) is composed of two major sections. These are the groundwater development programs on a nationwide long and medium-term scheme and the urgent implementation plans for several major cities. For the nationwide groundwater development programs, sectoral future requirements were developed. For the urgent implementation plans, number of major cities where the municipal and industrial water supply demands were predicted to exceed the groundwater potential of their respective areas, presently or in the near future, were selected to be examined in terms of their possible future domestic water supply projects.

This study was carried out based on the available existing data, information, ongoing or future plans, etc., regarding groundwater utilization provided by the concerned government agencies with the assistance from the technical staff of the NWRB as their counterparts. In addition, this study was based on other study results regarding groundwater potential, demand forecasting, etc. These supporting reports were referred to in an effort to better understand and/or develop these GWRDPs.

The results of this study on GWRDPs, in terms of surface water requirements, were used for the task of the implementation/promotion of surface water resources development planning programs.

G.1.2 Work Schedule

The main work schedule for this study was composed of two stages. In the first stage, the relevant reports, data/information, plans and some opinions on groundwater utilization were gathered and evaluated for the tentative national GWRDPs. The finalized national GWRDPs were set up in consideration of the GDP rearrangement, the resources potential study and the water resources management concepts, etc. in the second stage. The urgent development plans for major cities were recommended as one of the major study results. The work stages were scheduled as shown in Figure G-01.

(1) First Field Work

The first field work in the Philippines began on 19 April and lasted until 1 August 1997 (105 days). The work contents of this period were to gather useful data/information to understand and evaluate the groundwater conditions until the year 2025 (study target year) and to prepare the Progress Report (1).

(2) First Homework

The first homework in Japan was started on 1 September and lasted until 18 September 1997

(18 days). The work contents of this period were to analyze the data/information and to present these findings and the tentative national GWRDPs in the Interim Report.

(3) Second Field Work

The second field work in the Philippines began on 16 November and ended on 30 November 1997 for the 1st period; the 2nd period started on 31 December 1997 and ended on 13 February 1998. These two periods totaled 60 days.

In November 1997, the preliminary national GWRDPs were confirmed by the Steering Committee Meeting. The steering committee consisted of the concerned government agencies of the Philippines, and their job was to select the major cities to be targeted in the urgent action plans, which had been tentatively established by this period. Hence, the Progress Report (2), which was composed of the final national GWRDPs and the preliminary urgent plans for nine major cities, was prepared and submitted. The Steering Committee Meeting was held again on February 1998.

(4) Second Homework

The second homework in Japan commenced on 14 February and continued until 18 March 1998 (33 days). The work contents of this period were to finalize the GWRDPs and the urgent action plans in the Draft Final Report.

G.1.3 Major Tasks and Activities

The study on GWRDPs was composed of the following two major tasks:

- to establish the National GWRDPs and
- to formulate the Urgent GWRDPs in the Major Cities

Based on the above study, the structures of the major tasks and activities for the each stage were illustrated in the workflow chart in Figure G-02 and Figure G-03, along with the other concerned tasks. As part of this study's tasks, the results from the Hydrogeological Study and the Water Demand Forecast were used as the bases for the establishment of the GWRDPs.

G.1.4 Planning Approach for Groundwater Development

The responsibilities of each line agency and organization related to water resource utilization are delineated at the national government administrative level. On the other hand, provincial or municipal users, such as the WDs and LGUs, etc., have more detailed and useful data/information regarding the groundwater extraction and development plans in their respective areas.

The other difficulties relating to the groundwater evaluation are the different time schedules for updating the current conditions and the interpretations of the necessary water usage data. This was because that some of the agency's managed data/information weren't updated at the same time and didn't mention water utilization at the same data level. On top of that, some contradictions or inconsistencies in the gathered data/information were observed between the national government agencies and between the central and regional offices.

For this study on the GWRDPs, collected data/information and its arrangement were mentioned as follows.

G.1.4.1 Availability of Data/Information for the National Plans

There are two kinds of groundwater indices to express the existing conditions. The first one is the water rights registered and granted by NWRB. The other one is the actual operation reports recorded by each responsible organization or user. However, both of these indices were lacking in terms of expressing the present groundwater conditions.

In addition, a matter that demanded special attention was the water rights registration system. A great number of facilities, mostly related to small WRs, were not registered and were not utilized until recently; this was especially true of wells for the L-I water supply facilities, which are privately owned facilities and systems primarily located in the southern part of the Philippines. These facilities might have capacities that are utilized at low rates. Also, there were still many abandoned facilities registered in the water rights database list. These matters created difficulties with the monitoring activities regarding the actual water usage of the existing water sources.

In the case of the actual operation reports, there were many lacking records, such as production amounts, facility structures (how and where they extracted groundwater, etc.) as well as the monitoring of static water levels and water quality. These matters are the biggest factor blocking progressive groundwater promotion by any level of governmental management (LGUs', regional, national, etc.).

The collected and available data/information referred to in this GWRDPs are summarized as below.

- From the NWRB
  Registered Grants for Water Rights (DB)
  Basic Data for Framework Plan; Land Use Map, Vegetation Map, etc.

- From the MWSS
  L-III Water Production & Wells Information
  Privately Owned Facilities & Its Production in the MWSS SA

- From the LWUA
  WSSs (population served, unit consumption, etc.)
  L-III Water Production (DB/1995 version)
  Progress & Status of the Foreign Assistance Projects

- From the WDs (by the field reconnaissance)
  L-III Water Production & Groundwater Information
  Future Expansion Plan for the WSSs
  Saline Water Intrusion Reports in several areas

- From the DPWH
  Constructed L-I Wells & Status Information

Status of L-II WSSs

- From the DILG
  Provincial WSSs/Facilities in Region I, II and III
  Future Construction Plan for L-I & II WSSs/Facilities

- From the PEZA (DTI)
  Existing E-Z's Information
  Planned & Studied E-Z's Information

- From the NIA/BSWM/DPWH
  Existing Irrigation Systems & Coverage (Irrigated Area)
  Future Construction Plan for GW Supply Systems/Facilities

The detailed data/information of the WDs' operation records for domestic water supply weren't collected from LWUA in Metro Manila. The purpose of the field reconnaissance in the first field work was to confirm the present conditions regarding groundwater shortage, usage and water supply systems, and to collect usable data and/or information from each government agency in Metro Manila concerned with groundwater utilization. The results of the field reconnaissance were used for verification of any groundwater shortages, present problems of groundwater usage, urgent action plans, etc. Therefore, for the field reconnaissance within this period, the major WDs were selected based on the scale of their WSSs. The prerequisites for inclusion in the field reconnaissance where those WDs which were fed more than four MCM/year for their source production and were fed mainly by groundwater sources.

The field reconnaissance was carried out at the ten WDs listed below by JICA experts and their NWRB counterparts. The other WDs' data/information were gathered by mailed questionnaire or from LWUA's Consultants.

- By JICA Expert with NWRB Counterpart (three WDs)
  Subic Water (Ex-Olongapo WD & Subic Base WSSs), Metro Cebu WD & Zamboanga City WDs

- By NWRB Counterpart (seven WDs)
  Balanga WD, Mariveles WD, Baliuag WD, Hagonoi WD, Damarines WD, Calamba WD & Laguna WD

- By Mailed Questionnaire (nine WDs)
  Ilocos Norte WD, Baguio City WD, Dagupan City WD, Legaspi City WD, Metro Naga WD, Metro Iloilo WD, Jolo Mainland WD, Misamis Occidental WD & Cotabato WD

- From LWUA's Consultants (four WDs; PCWSP-II, III & IV)
  Angeles City WD, Bacolod City WD, Cagayan de Oro City WD & Davao City WD

G.1.4.2 Basic Arrangement for Groundwater Development Planning

There were two major procedures for the GWRDPs. The first procedure was to formulate the present groundwater conditions in order to establish the future groundwater demand and to evaluate the groundwater balance between potential and demand. The other procedure was to estimate and formulate the projected groundwater shortage areas up to the target year (2025) in order to establish the urgent plans for several major cities. To carry out these tasks this study had the following basic arrangements:

(1) National GWRDPs

- to collect the existing data/information, plan and investigation, etc.,
- to formulate the present problems to be reflected in groundwater demand,
- to understand the present groundwater form and future development plan,
- to study the groundwater balance between the potential and demand,
- to consider recycled water use and the regulation for water resources conservation,
- to turn over the surface water requirements,
- to forecast the production capacity and life of the groundwater intake facilities,
- to estimate the program cost for future construction of the intake facilities and
- to recommend future actions in the regional GWRDPs.

(2) Urgent GWRDPs

- to consider the methodology for the selection of major cities,
- to collect the existing data/information, plan and investigation, etc.,
- to formulate the present problems to be reflected in groundwater demand,
- to understand the present groundwater form and future development plan(s),
- to study the groundwater balance between potential and demand,
- to turn over the surface water requirements,
- to recommend future actions in the GWRDPs.

G.2 Present Condition

The geologic and topographic features of the Philippine Islands are mainly caused by plate tectonics. Therefore, the water bearing formations and groundwater conditions of the Philippines, such as its hydrogeological and hydraulic characteristics, etc., have almost same form as in Japan.

G.2.1 Form of Groundwater Development

The present groundwater conditions, which were the bases of this study, were put in the following order:

G.2.1.1 Type of Facilities

The facilities for groundwater utilization are classified into two types: facilities with natural structures and facilities with artificial structures. A natural structure means a spring source; all others have artificial structures. However, spring sources have limited discharge (flow) and serviceability; in addition, spring flow is almost impossible to accelerate. Thus, spring development plans were evaluated by their constant rates and were not considered for the GRDP schemes.

The artificial structures have various were divided depending on their groundwater storage position and characteristics, utilization, the scale of facilities, their construction method, etc. These structures will be included in this GRDP report. The principal artificial structures are the wells (to extract from confined and unconfined porous aquifers) and the infiltration gallery (to extract from riverbeds), etc. However, the wells as the reasonable structures, which are distributed in more widely area than the infiltration gallery, were adopted and were concluded into this report.

G.2.1.2 Groundwater Usage

In a water rights registration form, there is a column for the water usage. This water usage is categorized as domestic, commercial, industrial, irrigation, power, livestock, recreation and fisheries. The water rights for hydropower use weren't considered for water consumption category within this study. This is due to the fact that they have been consuming water potential only to produce electricity as their purpose/business. The following definitions were used as expedients (in descending order) to describe water the categories:

- Municipal Water
  All domestic and commercial water, including industrial water provided by the public water supply systems
- Irrigation Water
  Agricultural use only
- Industrial Water
  Industrial water provided by privately owned facilities

- Other Usage Water (Livestock, Recreation and Fisheries Water)
  All other water usage

In addition, the existing water supply systems/facilities and service levels were projected by urban and rural area categories. For domestic use, water supply services were classified into three levels, namely L-I, -II and -III. Basically, water supply service in urban areas requires L-III systems. In rural areas, L-II or I systems/facilities suffice. The National Sector Plan demarcates the service level and system components of water supply systems/facilities as shown below.

(1) Water Supply Systems

a. Level-III Water Supply Systems
   Level-III systems (individual house connection systems) at the municipal level are usually established and operated by the Water Districts with the technical and financial assistance of LWUA. Metro Manila and its adjoining areas are covered by MWSS Level-III water supply systems. Some LGUs also implement and operate Level-III systems, commonly at the Barangay level.

b. Level-II Water Supply Systems
   Level-II systems (communal faucet systems) are designed to cater to Barangay level water supply with limited service coverage and supply capacities. Their systems have been implemented by different government agencies (the DPWH, LWUA, the DILG and the DENR). These agencies encourage(d) the use of spring sources. These systems are operated by LGUs, the RWSA or NGOs.

c. Level-I Water Supply Facilities
   Level-I facilities (point source) are common in rural barangays, the majority of which are privately owned. The major facilities of these systems are different types of well equipped with handpump or developed spring with transmission pipeline and one communal faucet.

(2) Classification of Urban and Rural Areas

The NSO classifies a barangay as urban when it satisfies any of the economic and social conditions outlined below. All areas not falling under the urban classification are defined as rural areas.

a. In their entirety, all municipal jurisdictions which, whether designed as chartered cities, provincial capital or not, have a population density of at least 1,000 persons per square kilometer.
b. Poblaciones or central districts of municipalities and cities, which have a population density of at least 500 persons per square kilometer.
c. Poblaciones or central districts, not included in above articles a. and b., regardless of population size which have the following:
   1. Street pattern, i.e., network of streets either at parallel or in right angle orientation;
   2. At least six establishments (commercial, manufacturing, recreational and/or personal services); and
   3. At least three of the following:
      - a town hall, church or chapel with religious services at least one month;
      - a public plaza, park or cemetery;

- a market place or building where trading activities are carried on at least once a week; and
- a public building like school, hospitals, culture and health center or library.

d. Barrios/Barangays having at least 1,000 inhabitants who meet the conditions set forth in article 3) above, and in which the occupation of inhabitants is predominantly non-farming/fishing.

G.2.1.3 Scheme for Public and Privately Owned Facilities

Municipal water is divided into the categories of domestic water and commercial water. Domestic water is composed of public and privately owned facilities. The water supply systems used in domestic water systems, namely Level-III, cover a part of the commercial, industrial and other usage water. These water uses for commercial, industrial and others are classified into two groups: those as served by public water supply systems and those served by privately owned water sources.

However, the above water utilization of public water supply systems occupies only a small portion of the total and such systems are also involved in domestic water service. Accordingly, privately owned water source usage is identified as their demarcated water. The allotment of is shown as under table for this study.

Category of Water supply	Public water supply		Privately owned
	Level-III	Level-II & I	
Domestic water	Municipal	Municipal	Municipal
Commercial water	Municipal	-none-	Municipal
Industrial water	Municipal	-none-	Industrial
Other usage water	Municipal	-none-	Other Usage
Irrigation water	-none-		Irrigation

G.2.1.4 Hybrid Water Resources Region

The existing WRRs are divided by river watershed boundaries. However, the groundwater basins have different shapes from the surface water (river) basins. The differences of these basins, in addition to various topographic factors, consist of hydrogeological characteristics such as static water levels, permeability and storage efficiency, etc. of each aquifer. Given these differences, it is evident that the time scales of the recharge cycles and the distributed forms of groundwater are quite different from surface water.

Some of the groundwater management uses a different form of boundary. For example, all the WDs were divided into eight (8) areas with LWUA's technical and financial assistance. Furthermore, groundwater utilization is managed and controlled within political boundaries. Therefore, any statistical information had to be first put in order based on the provincial data level.

In the same way, the NWRB has been using provincial units for water resources region boundaries when they register the address of a water right, it is also more convenient to study this master plans for groundwater management purposes. Accordingly, a hybrid WRR utilizing the same boundaries as the area of the NWRB database, is more useful and realistic for users as well.

G.2.1.5 Unit for the Groundwater Evaluation and Development Schedule

Usually, the unit of cubic meters per day (m^3/day) is used for measuring groundwater production, availability and inflow, etc. and liter per second/day (lps/lpd) is used for measuring well capacity or unit water consumption. For a more progressive understanding by the users, the unit of million cubic meters per year (MCM/year) was generally used for the GWRDPs annual volume in consideration of groundwater's seasonal variations and varying rainfall patterns.

The time frame for this development study used the year 2025 as a final study target and the intervening time was broken down into five (5) year intervals. The medium-term development schedule consists of the years 2000, 2005, 2010, 2015 and 2020; the final medium-term goal was the year 2025.

G.2.2 Existing Water Rights, Facilities and Production

Basically, the evaluation results of exist groundwater production was considered using a summation of the data and/or information provided from each of the concerned government agencies and/or the field investigation. However, the trends of water rights grants provided by the NWRB were representative of the existing status of water resources development. Accordingly, the general results of the water rights analysis were useable for reference materials to confirm the validity of other data to supplement areas lacking data/information. The water rights and sectoral groundwater utilization were summarized as shown below.

G.2.2.1 Registered Water Rights

Water rights are granted by the NWRB before applicants utilize a water source with their own facilities. Therefore, the form of water rights was only one information source to cover the state of the water resources nationwide. Each water right application was evaluated in terms of its propriety with the standard criteria and procedure shown below:

Water Use Sector	Standard Criterion or Procedure for Water Rights Grant
Domestic	0.0029 lps per capita
Commercial	The application shall be examined and approved by NWRB, while WD issues a clearance for processing water permit.
Industrial	The application shall be examined and approved by NWRB, while DENR issues a clearance for processing water permit.
Irrigation	1.5 lps per ha for paddy field (Other crops and plants have the different standard values.)
Livestock	0.00024 lps per head for cattle and swine, and 0.0000146 lps per head for poultry
Recreation	0.6 lps per ha for the planned golf course area
Fishery	3.15 and 6.30 lps per ha for prawns in freshwater and brackish water respectively, and 0.9259 lps per ha for other than prawns
Hydropower	The application shall be examined and approved by NWRB, while NPC issues a clearance for processing water permit.

The registration items of the water rights, which include WRR, Province, Type of Source, Usage and Granted Amount, were very helpful in understanding the present condition of groundwater water rights distribution. A brief summary is described below.

(1) **Types of Source**
The types of sources are categorized into surface water and groundwater. The facilities for groundwater utilization are classified as wells or springs. All sources for the water rights are put into the above three types (surface water, well or spring). Especially for wells, there are several types; namely, shallow and deep wells, dug and driven wells, infiltration wells and galleries and so on. Even though they have different structures, they all have the same purpose--groundwater extraction.

There are advantages for water rights applicants to develop surface water, if it is available and easily utilized in terms of its quality. Especially for mega-scale water supply purposes, such as municipal, industrial and irrigation water, surface water is a better source within limited areas than groundwater development. On the other hand, groundwater generally is has higher quality (potable) than surface water and is distributed more widely in populated areas. Also, in an area where there are topographical disadvantages, such as non-gravity surface water supply areas, groundwater (chiefly spring sources) have been developed in preference to surface sources.

Table G-01 indicates the number of registered water rights, the number of facilities and the average grant amount by WRR. Figure G-04 shows the ratio of each source amount. The features of the above water rights are as follows:

- Approximately 61,000 MCM/year of water resources is granted.
- The granted ratio of surface water and groundwater is 96.6 % versus 3.4 %.
- WRR-II, VIII and IX have a smaller ratio of groundwater grants.
- WRR VII has a smaller ratio of surface water grants.
- The amounts of grant in each WRR are usually linked by population and the GRDP.

(2) **Water Usage**
All usage for water rights application is put into the eight types mentioned above. Within this report, the registration data were analyzed statistically under the conditions shown below.

- Municipal water is composed of domestic and commercial water.
- Some of commercial/industrial water is included in domestic water (L-III).
- Unutilized surface water grants (i.e. MWSS, etc.) were excluded in terms of realistic usage.
- Water used for power generation isn't considered for water consumption usage.
- Other usage water is composed of livestock, recreation and fisheries water.

Therefore, there are four (4) categories: municipal, industrial, irrigation and other usage water. Table G-02 indicates the registered water rights in each usage category. Figure G-05 shows the granted amount ratio of each usage water right. The features of the above water rights are:

- The amount ratio of irrigation water is 91.8 % of the total grants.
- Municipal and industrial water forms only 6.7 % of the total grants.
- The proportion of municipal water is surface water 52.6 % and groundwater 47.4 %.
- The amount of municipal water grants is usually linked with the population density.
- WRR-III has a large amount of surface water grants; namely the Angat River for municipal water (utilized for formerly MWSS water supply systems whose service area are located

within WRR-IV).

- WRR-IV has a large amount of groundwater grants for municipal water (mainly utilized for the outskirts of Metro Manila).
- The NCR and its outskirts account for more than 40 % of the nation's municipal water.
- The majority source type for industrial water is surface water, which constitutes 85.3 % of the total industrial water grants.
- The amount of industrial water grants is usually linked with the GRDP ratio.
- WRR-VI, X, XI and XII have a larger proportion of surface water grants compared with the GRDP ratio for industrial water. Such water grants were utilized for mining (including refining), milling and manufacturing.
- The major source type for irrigation water is surface water, which forms 98.8 % of the total irrigation water grants.
- The amount of irrigation water grants is usually linked with arable land area.

(3) Distribution Trend of Granted Range of Groundwater Water Rights

Table G-03 indicates the amount of registered groundwater water rights and their facilities by each grant range and usage. Figure G-06 through Figure G-09 show the ratio of groundwater grants, etc. The features of above mentioned water rights are:

- Approximately 2,070 MCM/year of groundwater resources is granted.
- The ratio of wells and springs is 60.0 % versus 40.0 %.
- The proportion ratios of groundwater usage amount are municipal 49.9 %, industrial 13.5 %, and irrigation 33.8 %.
- The grants for spring sources for industrial use is smaller than any other usage.
- The average grants for wells are industrial 0.529 MCM/year, irrigation 0.399 MCM/year and municipal 0.198 MCM/year.
- The average grants for springs are industrial 2.395 MCM/year, irrigation 0.745 MCM/year and municipal 0.543 MCM/year.
- The amount of grants for wells is divided into three parts: MWSS 4.4 MCM/year (*actually, MWSS well production was estimated at 26.9 MCM/year in 1995), LWUA 378.7 MCM/year and the rest 237.7 MCM/year for privately owned grants.
- The amount of grants for springs is divided into two parts: LWUA 277.6 MCM/year and the rest 123.7 MCM/year for privately owned grants.

(4) Conclusion of Registered Water Rights Evaluation

The figures below are the estimated grant amount for groundwater in each WRR and by usage.

(Unit; MCM/year)

WRR	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Municipal	149.6	14.8	99.2	326.5	65.0	61.9	93.3	15.8	7.4	37.1	64.2	87.9	1,022.1
Industrial	3.7	0.4	41.9	98.5	1.2	27.8	45.1	12.0	0.7	36.5	8.0	3.4	279.0
Irrigation	59.8	23.3	203.0	84.4	23.1	66.2	65.1	10.2	5.1	20.9	41.1	96.9	699.4
Others	0.0	0.2	2.1	13.3	0.6	21.7	18.0	0.2	0.2	4.0	26.4	1.7	88.2
WRs	213.1	38.6	346.3	522.8	89.9	177.5	221.4	37.6	13.4	98.4	139.7	189.9	2,088.7

Finally, several percent of the irrigation water category are considered to be one of the factors related to the recharge of unconfined groundwater. On the hand, municipal and industrial drainage might be mostly discharged into the sea. Therefore, the criterion for irrigation water grants was considered beyond the present situation for future water resources management beyond that of the NWRB.

G.2.2.2 Municipal Groundwater

Municipal water is composed of domestic and commercial water. Additionally, some of the commercial and/or industrial water users were included as consumers of the L-III water supply systems. The other facilities for commercial and/or industrial water are privately owned. For the estimation of privately owned commercial water, this was the only way to estimate the present production of commercial groundwater by the water rights grants of the NWRB registration system, and was put at 15.0 MCM/year.

In addition, for the privately owned L-I water supply facilities, there was no available detailed data and/or information from the concerned government agencies. Therefore, the rest of the population from the previous study was summarized for the total domestic water consumption as detailed below.

(1) Level-III Water Supply Systems

The DPWH and the LGUs managed the L-III systems. The differential between them is their profitable operation or not. However, the L-III water supply systems managed by the LGUs are distributed out of populated areas and aren't viable organization. Therefore, their water supply systems, coverage and water sources production are so limited and a small scale. Hence, only the L-III water supply systems operated by the ex-MWSS and WDs were summarized in this study as follow.

The management of the viable L-III water supply systems is handled by two organizations: MWSS and LWUA, under the DPWH. The said independent organizations, formed from the previous agency NWASA, have different service areas. Metro Manila and its surround areas are under the aegis of MWSS and those areas outside of Metro Manila are LWUA's territories.

L-III water supply systems are supplied by groundwater and surface water sources but in this section, only the groundwater source production of 1995 was summed up as follows:

a. Ex-MWSS (turned over to Manila Water Co. and Maynilad Water Services Inc.)
   The ex-MWSS L-III water supply system has large surface water fed system that has three water rights for utilizing the intake facilities located at the Angat Dam in the province of Bulacan in WRR-III. Also, a large number of wells are located in the ex-MWSS service area. According to the operation records provided by the MWSS, there are 265 existing wells owned by the MWSS. The production amount and facility numbers of these wells decreased year by year. As of December 1995, 156 wells (58.9%) were abandoned due to saline water intrusion, lowered water levels, or the deterioration of the facilities.

   The records for groundwater production in 1995 provided by the MWSS are shown in Table G-04. The features of these operation records are as follows:

   - The majority of the groundwater in the ex-MWSS service areas was produced in the southern part of Manila, where the municipalities of Taguig, Paranaque, Las Pinas and Muntinlupa are located.

- The capacities of these wells had a tendency to increase toward southern Manila.
- Within southern Manila, the ratio of abandoned wells was also higher.
- MWSS had 17 registered wells (1995)—down from 265 wells in 1991.
- The well depth in western Manila was deeper (maximum 300 m or 1,000 ft) than the eastern (Laguna) side, because a major aquifer (Guadalupe Formation) outcrops as a sedimentary face in the eastern part of the Marikina Valley.
- The average depth of the ex-MWSS wells located in Manila, Rizal and Cavite was 263 m, 156 m and 275 m respectively.
- The groundwater production of MWSS was 26.9 MCM/year in 1995.

b. LWUA (L-III operated by the WDs)

The production of each WD's facilities was summarized as shown in Table G-05. However, the data from the WDs doesn't mention the categorized sources' production. As reasonable approach, well production was estimated by taking the grant amount for spring and surface water from total production. This was because the number of grants and facilities for spring and surface water sources were probably almost the same quantity of their production, and usually their intake amount was larger than groundwater sources. Therefore, the WDs might have been granted such water rights.

The grant amount ratio is shown in Figure G-10. The groundwater production amount and unit consumption, based on production amount and service population, is shown in Figure G-11. The particulars of this information are shown below.

- In the Luzon region, groundwater development was utilized much more than surface water. In the Visaya and Mindanao regions, surface water development was mainly utilized because of the disparate groundwater availability.
- For L-III water supply systems, 85.9% of their sources were developed using groundwater (with wells and springs).
- Only the Metro Cebu WD's unit consumption was larger than the others'. The other WDs' unit water consumption was within 150 to 250 lpcd.
- The groundwater production of the WDs facilities was estimated at 560.1 MCM/year in 1995. The total figures for each WRR and source type are:

(Unit: MCM/year)

WRR	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Well	18.9	6.2	130.4	60.8	16.9	38.3	59.2	2.8	21.9	35.3	45.1	9.2	445.0
Spring	5.8	1.0	5.4	38.6	15.9	7.4	11.2	3.5	8.5	9.3	1.9	6.7	115.1
L-III	*24.7*	*7.2*	*135.8*	*99.4*	*32.8*	*45.7*	*70.4*	*6.3*	*30.4*	*44.6*	*47.0*	*15.8*	*560.1*

(2) Level-II Water Supply Systems

These systems have been implemented by different government agencies (the DPWH, LWUA, the DILG and the DENR), who encouraged the use of spring sources. LGUs, the RWSA or NGOs operated these systems. These Level-II water supply systems have an adequately served consumption rate of at least 60 lpcd. Therefore, the estimated production for Level-II systems is shown in Table G-06 and below.

(Unit: MCM/year)

WRR	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
L-II	*2.7*	*3.5*	*7.0*	*11.3*	*4.3*	*5.4*	*4.5*	*3.8*	*3.7*	*3.7*	*3.0*	*4.5*	*57.4*

(3) Level-I Water Supply Facilities

The DILG/DPWH Level-I water supply services cover parts of the rural areas and also those urban areas that are not covered by the Level-III systems. The DPWH was the leading implementing government agency until 1991, when the DPWH transferred the responsibilities for the rural water supply programs to the DILG/LGUs. Thereafter, the DILG had prepared the master plan for the provincial sectors such as water supply and sanitation. However, for implementing projects, the DILG/LGUs still need a great deal of the DPWH's assistance and technology.

The source for the L-I water supply systems is groundwater, and facilities are wells or spring intakes. In some limited areas, the DWPH or the LGUs have distributed rain collector facilities, but such facilities are unsafe sources for drinking water; hence, L-I facility weren't counted in such areas.

The DPWH provided well construction records until 1995 based on the inventory survey in 1987. These records include the annual Level-I well construction results. These records are shown in Table G-07 and Figure G-12. The DPWH estimated the operational Level-I wells and their production, which are shown in Figure G-13. It can be seen that, in general, L-I water supply facilities have an adequately served consumption rate of at least 20 lpcd.

Further data, based on the water consumption research under the provincial sectoral plans in some provinces of Luzon Island by the previous JICA study, was included in this study. The result of this investigation indicates that the unit water consumption of L-I water supply facilities was estimated at about 30 lpcd to 45 lpcd.

In consideration of the population density by province level, an additional unit water consumption figure, based on the said 20 lpcd, was adopted. Finally, the unit water rate for the L-I systems was modified to provide a more realistic analysis. The features of the above information are as follows:

- On average, more than 14,000 wells were constructed by the DPWH annually.
- The DPWH started L-I well construction in 1950.
- According to the investigation on L-I status in 1987, 75% of the constructed wells were still operational.
- The DPWH concentrated on the construction of L-I wells on the Central Luzon Plain.
- The groundwater production of L-I wells was estimated at 312.1 MCM/year in 1995; the production figures by each WRR are:

(Unit: MCM/yea)

WRR	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
L-I	*11.8*	*17.4*	*43.7*	*37.1*	*26.1*	*34.8*	*30.1*	*20.8*	*19.8*	*20.5*	*18.6*	*31.4*	*312.1*

(4) Privately Owned Level-I Facilities

To determine the L-I production figures, the population served and unit water consumption were estimated. The 1995 census and the service coverage were used to calculate the rest of the population. The unit water consumption was adopted from LWUA's standard L-I service level.

a. Remaining Population Served

The rest of the population served by the privately owned L-I facilities was calculated by the population served for the public water supply as mentioned before; the results are shown in the below table.

(Unit: capita)

WRR	Population	Level-III		Level-II	Level-I	
	Census 1995	Ex-MWSS	LWUA	DILG	DPWH	Private
I	2,362,180	0	440,160	122,931	1,723,168	75,921
II	3,054,225	0	128,920	159,788	1,421,892	1,343,625
III	9,111,124	0	1,865,560	321,529	5,807,796	1,116,239
IV	19,395,047	7,291,000	1,153,980	513,829	4,277,996	6,158,242
V	4,325,368	0	489,310	195,188	1,450,221	2,190,649
VI	5,777,016	0	695,740	245,158	1,698,509	3,137,609
VII	5,014,652	0	516,330	203,507	1,495,127	2,799,688
VIII	3,366,953	0	328,750	172,602	692,184	2,173,417
IX	3,581,617	0	488,270	170,136	727,951	2,195,260
X	3,954,742	0	716,550	170,737	629,759	2,437,696
XI	3,760,145	0	1,028,500	139,135	789,420	1,803,090
XII	4,909,195	0	251,540	205,770	1,109,693	3,342,192
Total	*68,612,264*	*7,291,000*	*8,103,610*	*2,620,310*	*21,823,716*	*28,773,628*

b. Estimation of Presumptive Production for Privately Owned Level-I

The L-I water supply facilities have an adequately served consumption rate of at least 20 lpcd. In consideration of the population density by province level, an additional unit water consumption, based on the said 20 lpcd, was adopted in the same manner as the public L-I water supply. Finally, the unit water rate for the L-I systems was modified for a more realistic result. Therefore, the estimated production for privately owned L-I systems is shown below.

(Unit: MCM/year)

WRR	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
P; L-I	*6.6*	*11.2*	*28.6*	*71.5*	*11.6*	*15.4*	*14.7*	*8.7*	*10.4*	*11.3*	*8.3*	*15.1*	*213.4*

(5) Privately Owned Commercial Water Facilities

A comparative examination of the registered wells in the MWSS service areas and the facilities owned by the WDs indicated that the non-registered well production was almost proportional to the registered wells. Therefore, in addition to the estimation of commercial groundwater source production, the well production amount was put at two times the granted amount. The estimated granted amount of groundwater water rights for commercial use is shown below.

(Unit: MCM/year)

WRR	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Comm'l	*0.2*	-	*0.4*	*8.9*	*0.0*	*2.4*	*0.5*	*0.6*	-	-	*0.3*	*1.7*	*15.0*

(6) Conclusion of Present Municipal Water Production

These production rates were adopted for further study of the GWRDPs. For example, municipal water demands, as well as the future additional demand, were forecasted based on these figures. It should be noted that the present groundwater production was estimated utilizing many conditional assumptions. For the future review of this master plan, a basic investigation into the actual conditions should be implemented by the concerned government agencies in the next census year.

The following figures are the aggregate of each sum of the municipal groundwater production at present (1995).

Present Production/Demand of Municipal Water

(Unit: MCM/year)

WRR	*Ex-MWSS*	*LWUA*	*Level-II*	*Level-I*	*Private*	*Comm'l*	*Total*
I	-	24.7	2.7	11.8	6.6	0.2	46.0
II	-	7.2	3.5	17.4	11.2	-	39.3
III	-	135.8	7.0	43.7	28.6	0.4	215.5
IV	26.9	99.4	11.3	37.1	71.5	8.9	255.1
V	-	32.8	4.3	26.1	11.6	0.0	74.8
VI	-	45.7	5.4	34.8	15.4	2.4	103.7
VII	-	70.4	4.5	30.1	14.7	0.5	120.2
VIII	-	6.3	3.8	20.8	8.7	0.6	40.2
IX	-	30.4	3.7	19.8	10.4	-	64.3
X	-	44.6	3.7	20.5	11.3	-	80.1
XI	-	47.0	3.0	18.6	8.3	0.3	77.2
XII	-	15.8	4.5	31.4	15.1	1.7	68.5
Total	26.9	560.1	57.4	312.1	213.4	15.0	1,184.8

G.2.2.3 Industrial Groundwater

Industrial groundwater consumers from the L-III domestic water supply systems were not included in the calculation of industrial groundwater as the other facilities for industrial water were privately owned. The only way to estimate the present production of industrial water was to use the grant amounts of the water rights registered by the NWRB database system. Also, for the industrial Economic-Zones' water supply systems, there was no available detailed data and/or information from the concerned government agencies such as PEZA or the DTI. Therefore, the detailed data and/or information from the water rights registration provided by the NWRB estimated the existing industrial groundwater.

Using the same procedures as for the L-III groundwater categories, the production of unregistered wells was counted as the same amount as the grants. The estimation of the groundwater water rights grants amount for industrial water is as follows.

(Unit: MCM/year)

WRR	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Indust.	*5.3*	*0.7*	*83.7*	*202.2*	*1.6*	*45.6*	*88.0*	*20.4*	*1.4*	*43.3*	*16.0*	*6.3*	*514.4*

G.2.2.4 Irrigation Groundwater

The facilities for irrigation water are primarily privately owned. The NIA, the DPWH and the BSMW provided the available data and/or information for irrigation groundwater. Only arable land areas and their coverage were included in this data/information. The only way to estimate the present production of irrigation water was by the capacity of the facilities, as estimated from water rights grants of the NWRB registration system.

Table G-08 shows the existing conditions of the cultivated land areas. The coverage of irrigated land was put at 43.6 % (approximately 1,362,000 ha) of total arable area (about 3,126,000 ha). Out of this amount, 99.8 % of the irrigated land was supplied by surface water.

According to the water rights registration records, 98.8 % of grants for irrigation water was surface water. The remaining 1.2 % consisted of groundwater grants and the amount from wells was estimated as the same value of spring source. From the number of facilities provided by the NIA, etc. and their capacities as estimated by the grants amount, the production amount for irrigation groundwater was estimated in Table G-09. These estimation results are shown in Figure G-14. The estimation result of the groundwater water rights for irrigation water is shown below.

(Unit: MCM/year)

WRR	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Irriga.	*64.0*	*29.2*	*120.1*	*46.1*	*25.6*	*110.6*	*64.0*	*9.4*	*19.9*	*40.6*	*41.1*	*125.1*	*695.6*

G.2.2.5 Present Production

Shown below is the aggregate of each usage sum for the present groundwater production.

Present Production/Demand of Groundwater

(Unit: MCM/year)

WRR	*Municipal*	*Industrial*	*Irrigation*	*Others*	*Total*
I	46.0	5.3	64.0	0.0	115.3
II	39.3	0.7	29.2	0.2	69.4
III	215.5	83.7	120.1	4.3	423.6
IV	255.1	202.2	46.1	20.1	523.5
V	74.8	1.6	25.6	0.6	102.6
VI	103.7	45.6	110.6	34.9	294.8
VII	120.2	88.0	64.0	29.5	301.7
VIII	40.2	20.4	9.4	0.2	70.2
IX	64.3	1.4	19.9	0.2	85.8
X	80.1	43.3	40.6	4.1	168.1
XI	77.2	16.0	41.1	26.5	160.8
XII	68.5	6.3	125.1	2.5	202.4
Nation	1,184.8	514.4	695.6	123.1	2,517.9

G.2.3 Relevant Projects

Information on the project status of on-going or future plans was gathered from the each concerned government agency.

G.2.3.1 Municipal Groundwater

The government of the Philippines has concentrated on the promotion of projects for domestic and public water supply systems and/or facilities. There was not a promotion program to assist the construction of commercial and privately owned facilities. The related line government agencies were MWSS and LWUA for L-III systems, and the DILG/LGUs (with technical assistance from the DPWH) for L-II and L-I systems. Their groundwater development programs are summarized as follows:

(1) MWSS

No concrete groundwater development projects in future.

(2) LWUA/WDs

a. Seventy-seven (77) major foreign-assisted projects were ongoing in the WDs--

mainly the PCWSP (Provincial Cities Water Supply Project, Phase II to V). These projects were expansion projects for water supply systems with the target years around 2005. The donors were the OECF, the ADB, Austrian Aid, DANIDA, French Assistance and German Aid. These foreign-assisted projects are shown in Table G-10.

b. LWUA has been implementing a water resource master plan at two (2) cities, namely Iloilo and Naga, and a groundwater development plan for thirty (30) major provincial cities, financially assisted by the UNDP. This study has a 2025 target year. Only the master plan for Metro Iloilo has been completed (December 1997).

(3) DILG/DPWH

The Rural Water Supply Projects for L-I and L-II systems until the year 2002; based on the PW4SP (Provincial Water Supply, Sewerage and Sanitation Sector Plan) on Luzon Island were requested from the OECF and the ADB.

G.2.3.2 Industrial Groundwater

PEZA established planned and studied the construction of Economic Zones in various provinces. Their information is listed in Table G-11.

G.2.3.3 Irrigation Groundwater

NIA has planned projects, mostly nationwide, with various schemes. Their information is listed in **Table G-12**.

G.2.4 Present Problems

The problems associated with groundwater are sorted into physical and administrative problems. In this study, the problems outlined below were observed and should be followed up in near future by the DENR.

G.2.4.1 Physical Problems

(1) Saline Water Intrusion

Saline water intrusion can be observed along any seashore. The main reason for this phenomenon stems from an insufficient and/or declining groundwater recharge rate, geological conditions, and the difference of density between saline and fresh water coming from both sides (sea and inland). This problem usually has been induced by the over exploitation of groundwater.

The DENR has a white paper (1995) on the Philippines Environment. However, there is no mention of groundwater environmental problems. Accordingly, based on our experience, the available data/information and hydrogeological information, the majority of areas where intruded by saline water were presumed. In particular, Metro Manila and Cebu City have serious saline water intrusion problems.

(2) Groundwater Pollution and Subsidence

All areas, including those located in areas with available groundwater or those outside of areas where groundwater extraction is difficult have the possibility of being polluted by human activities. Therefore, the monitoring reports on groundwater pollution and subsidence should necessarily describe/identify/delineate the areas susceptible to or vulnerable to groundwater contamination. There are no such nationwide reports on groundwater quality problems in any governmental agency.

The situation of ground subsidence is similar to the saline water intrusion problems mentioned above. The DENR's white paper (1995) doesn't deal with groundwater environmental problems caused by groundwater over exploitation, such as pollution and ground subsidence. In consideration of the situation in the Philippines, the major pollutants might be sewage, factory wastes and agricultural chemicals (fertilizer). Accordingly, all populated, industrial and agricultural areas have the possibility of groundwater pollution.

Ground subsidence on a not-so-serious scale is observed mainly in the wide plain areas. The main reason for ground subsidence originates in the drainage of groundwater from clayey sediments. Artificial subsidence means that groundwater has been extracted by artificial structures such as wells and other apparatuses. However, large populated areas (Metro Manila, Cebu City, Davao City, etc.) are located on consolidated sediments or on thin unconsolidated sediments. Therefore, ground subsidence as an environmental problem hasn't been reported to the DENR as yet.

G.2.4.2 Administrative Problems

The NWRB is the responsible agency for water resources management in the Philippines. For more effective and realistic water management, the NWRB should coordinate with line agencies to a greater extent. The most important matter is the interrelationship or communication between the relevant government agencies. The following are necessary action matters for the NWRB to undertake:

(1) General

Early government level decision on a scheme for water resources management should be followed by the NWRB, and then this promotion should be implemented using more effective coordinated organization and communication systems between the line agencies built up by the NWRB.

(2) Pre-exploitation of Water Resources

The NWRB should research and act regarding the approach stage for water resource development such as planning and/or study, and provide assistance/suggestions to each line agency regarding progressive development planning.

(3) Water Rights Registration

The NWRB should improve or add the items of application forms for the establishment of standard criteria to evaluate the appropriate water right grant amount. In addition, the NWRB should build up countermeasures for unregistered utilities and re-applications for abandoned facilities.

(4) Monitoring Systems

The NWRB has to assist and strengthen the monitoring activities in consideration of:

- build up of the systems for obligatory annual reports from each line agency,
- update of current (annual) water resources utilities,
- complete management of water resources information systems,
- promotion of analytical technology for water resources management and
- the build up of nationwide monitoring systems.

G.3 National Planning for Groundwater Development

The demand forecasting previously projected each categorized water resource necessary for development. In this section, the study results on water resources availability and demand control was reflected in each resource demand.

G.3.1 Analysis for Groundwater Development Potential

The GWRDPs are sectoral and/or sub-sectoral and are composed of groundwater development schemes, preliminary designs (capacity/life forecasting and intake facility design), medium-term plans and program cost estimations by each WRR.

For this purpose, there are two major procedures for the GWRDPs. The first procedure is to evaluate the balance of the groundwater resources between potential and demand in an urbanized area by province. This means that groundwater balance should be studied in areas where large amounts of municipal (Level-III water supply systems) and industrial groundwater will be extracted. The urban areas are studied because other service levels of municipal and irrigation groundwater demand and development fields are distributed in mostly in rural areas.

The other procedure is to estimate and formulate the projected surface water requirements for municipal and industrial (M/I) use until the target year 2025 by WRR and MRB (major river basin). Therefore, this section has the following basic arrangements for the M/I GWRDPs.

- to study the groundwater balance between potential and demand of Level-III and industrial water,
- to consider industrial water management (including water recycling) in areas with difficulties in terms of groundwater needs; study possibility of conversion to surface water development,
- to reconfirm the BOT bulk water supply schemes to reflect the surface water demand,
- to estimate the required surface water development and
- to recommend future requirements in the GWRDPs.

G.3.1.1 Criteria of Future Water Sources Development

Each water source development scheme was projected with consideration of the criteria for demand forecasting by other tasks.

(1) Municipal Water Development

Presently, only the L-III water supply systems utilize groundwater and surface water. There were 404 L-III water supply systems operated by the WDs and the ex-MWSS areas. Out of this number, 36 WDs (8.9 %) have surface water intake facilities. For other domestic water service levels (L-I & II), as well as privately owned Level-I and commercial water sources, water sources will be developed using groundwater in the same manner as the present conditions.

The future development schemes for L-III water supply systems were set up using the criterion of the type of present sources. Only the demand in the WDs, which have sufficient groundwater sources in their service areas, will be developed using groundwater. The other WDs will develop surface water for their future demand as shown below.

Type	Present Water Source	Source to be Developed
A	Groundwater only	GW
B	surface water only	SW
C	Groundwater is larger than surface water	SW
D	surface water is larger than groundwater	SW

(2) Industrial Water Development
The industrial water demand projection was considered using sub-sectoral gross regional domestic products (GRDP) growth scenarios, which were classified into four groups. These grouped water uses were: 1) mining and quarrying, 2) manufacturing, 3) construction and 4) electricity, gas & water, as mentioned in "Socio-Economy" and "M/I Water Demand".

According to the NWRB water rights database as of March 1997, registered surface water rights for industrial use numbered 225 applications, accounting for 1,719.09 MCM/year. This amounted to 62.6 % for total industry use. Out of these registrations, the majority of surface water rights were applied for the purpose of mining and quarrying and manufacturing. The amount of surface water for mining use, mainly registered around 1980 or before, formed more than 80 % of the total surface water use for industry. Therefore, additional water demand in future for industrial use will be developed by groundwater sources, preferentially up to the sources' limited potential.

(3) Irrigation Water Development
The groundwater development for irrigation purposes was projected by the present plans of the NIA.

G.3.1.2 Groundwater Balance, Water Recycle and BOT Scheme

The M/I demand forecast was based upon the consideration of groundwater balancing and demands controls (industrial water recycling) for the finalized water resources demand.

(1) General Background and Concept
The natural groundwater cycle is in balance when there is no artificial removal of groundwater. Therefore, even when small-scale groundwater development takes place in a limited area or is concentrated in an area, the groundwater cycle has been altered. This concept is fundamental in understanding how groundwater imbalances can be permitted in a given aquifer by human beneficiaries.

The amount of sustainable groundwater development can be referred to as the balance between potential and extraction in an aquifer (groundwater demand or development). Properly managed, groundwater can serve for the M/I use as a suitable source in terms of quality and quantity. However, if groundwater is extracted in excess of an aquifer's potential, then a variety of problems can be experienced.

The groundwater cycle is much longer than that of surface water. Therefore, if groundwater extraction is concentrated within a limited area, the balance between potential and extraction (the groundwater cycle) will be disturbed. Even if the groundwater potential is larger than its demand over a wide area, groundwater levels will decline in an area with concentrated groundwater development. These problems induce ground subsidence, saline water intrusion, etc., because the groundwater storage will be decreased and the water level will be lowered. Therefore, it is necessary to examine the balance of groundwater potential and demand of the populated and/or economically developed areas and to formulate a plan for future source development.

(2) Methodology

The groundwater balance was studied on the basis of the above groundwater development concept. Finally, the necessary demand conversion amount, which would be transferred from groundwater to surface water by groundwater balancing, was estimated. The following procedures were taken into account for this predictable and realistic conversion of groundwater sources.

a. L-III and Industrial Water Demand to be studied by Groundwater Balance

Areas prone to future groundwater resource shortages could have trends such as urbanization and/or could be populated wherein large-scale groundwater demand is forecasted. The majority of groundwater demand in urbanized areas is composed of Level-III water supply and industrial use. In this study, the medium-term provincial amount of the above two classified demands was compared with the (limited) groundwater potential with the following formula.

Urban GW Demand (UGWD) = L-III GW Demand + Industrial GW Demand

b. Groundwater Potential Limitation

The groundwater recharge was calculated using 5 % of the overall rainfall amount and other information sources, such as the hydrogeological study. The groundwater availability was studied based on a previous study (NWRC, 1976) and additional groundwater information from that time on such items as deeper aquifers and saline water intrusion, etc. The product of the recharge and groundwater availability land ratio was used to estimate the provincial groundwater potential.

The total provincial of groundwater potential was allocated to Level-III and industrial use, as the groundwater potential limitation (GPL), with the following formula, for use in proportion to the present share of regional demand.

GPL = GW Potential x (UGWD/Total GW Demand)

c. Case 1; Objective groundwater demand will be exceeded the GPL.

The excess amount of Level-III and industrial groundwater demand over the GPL will be transferred to Level-III surface water demand from industrial groundwater demand. Subsequently, an additional amount of Level-III and industrial water demand will be supplied by Level-III systems.

d. Case 2; Objective groundwater demand was already exceeded the GPL.

The excess amount of present Level-III and industrial groundwater demand exceed the GPL; industrial groundwater demand is to be transferred to municipal water until the groundwater demand is within the GPL by the year 2010.

e. Regulation of Groundwater Exploitation
Accordingly, groundwater development by privately owned facilities for industrial use will be regulated by the NWRB's water rights registration. Water resource development for Level-III water supply (domestic use) should have higher priority in order to secure this source and should have bear the responsibility of supplying water to industrial water users.

f. Source Development for Public Water Supply
The type of the water source previously demarcated the Level-III water demand. An amount of converted demand, from industrial water into municipal water, as in case 1 and 2, will be developed by surface water.

g. Case 3; Public water demand exceeds the GPL.
An amount of surplus Level-III and industrial water demand will be transferred to municipal surface water until the groundwater demand is within the GPL by the year 2010. Thereafter, the groundwater development amount should be stabilized.

h. Projected Unit Area (WRR and MRB)
The above groundwater balancing was analyzed and adjusted on a provincial basis. These results were then adjusted to the WRRs and MRBs.

For the MRB unit allotment of municipal water, WD databases were adopted for the L-III GW/SW demand; provincial area data was adopted for the GW demand of other level of water supply systems or facilities. The special case of L-III SW additional demand converted from the groundwater sources of L-III and industrial systems. The original allotment ratio was adopted to add the same value as the surface water demand.

For the MRB unit allotment of industrial water, provincial area data was adopted for GW and the Water Rights database (NWRB, March 1997) was adopted for the surface water demand.

i. BOT On-going Plan Consideration (L-III/WDs private water supply scheme)
According to LWUA's project management office (PMO), there might be more than fifty (50) BOT schemes large scale of L-III water supply systems which were planned or are on-going for. However, most of the said BOT schemes were basically confidential projects.

The amount and schedule of several BOT schemes, which were already published, were considered for the future L-III SW demand. The reflected BOT schemes were Baguio City, Cagayan de Oro City and Davao City, and others.

j. M/I Demand Management
Some industrial water demand will be converted to municipal water demand, because of groundwater potential limitation mentioned above. However, when surface water demands reach their development potential, demand control (such as

increasing the water recycle ratio) conversion to other industrial sub-sectors (i.e. heavy industry to high technology), etc. should be required. Industrial water demand should be strictly controlled in the Metro Manila area and in Cebu City.

At present, the administration of central government level related water resources utilization is divided in a complex manner. Therefore, there is a need for friendlier interrelationships to be established. Improvements in the institutional/constitutional arenas in terms of communications and adjustments between the various governmental entities' future water resources development plans. Additionally, in an urbanized area or major city as mentioned above in "M/I Demand Management", the NWRB's regulations in regards to the gap between development needs and groundwater preservation has not been implemented effectively.

Demand adjustment, such as the conversion from groundwater to surface water and/or from industrial water into municipal water, should be required of the concerned agencies by the NWRB as part of the water resources management aspect of the national master plan. The existing and future groundwater problems will not be improved unless effective countermeasures for groundwater preservation are enthusiastically promoted by the central government, the NWRB and/or LGUs within the near future.

On the other hand, the process of decentralization is ongoing in the water-related administrative areas. For example, the recently empowered LGUs have coordinated their actions regarding infrastructure developments, wherein the LGUs have the power to implement the necessary programs. However, the LGUs' institutional systems are not organized enough yet to smoothly carry out the said development.

Therefore, effective plans for the DILG's and other related agency's institutional development and/or improvement should be consolidated more effectively in order to formulate an adequate plan for the LGUs. The major considerations are:

a. Responsibility Demarcation between LGUs & Central Government agencies
The activities previously under the DILG, DPWH, DTI and other agencies concerned, (which were the implementing agencies for the said M/I sectors) including technical assistance, should be formulated and modified.

b. NWRB's Faculty for Management Agency to carry out the LGU's Sectoral Projects
Presently, the LGUs have no direct relation to central government agencies without coordination by the DILG and other agencies. Therefore, it is necessary that NWRB shall receive and adjust the planned programs requested by each of the LGUs through the DILG. The NWRB should also negotiate directly with other agencies in relation to these matters and it should also proceed to develop, maintain and follow procedures to approach such related agencies.

G.3.1.3 Required Surface Water Development

(1) Trend of Conversion Amount into Municipal Surface Water Development

In order to reflect the uncertainties associated with predicting economic trends, the industrial water demand was divided into two scenarios; high and low GRDP. Table G-13 shows the parameters for M/I water demand by WRR under high GRDP conditions while Table G-14 does the same under low GRDP conditions. The difference between the two scenarios is significant. The total industrial demand in the year 2025 is 4,997.6 MCM/year under high-growth economic conditions and 3,310.1 MCM/year under low-growth economic conditions. Tables G-15 and G-16 mirror the above two tables but their data is for the parameters by MRB.

The conversion amounts into municipal surface water demand from M/I groundwater demand were shifted based on the previous M/I's GW/SW development plan. These were grouped into two GDP scenarios and by WRR and MRB.

The growth ratio of balanced Level-III demand was indicated at 4.3 times the present and the year 2025 under high-GRDP conditions while it was shown at 3.7 times under low-GRDP conditions. In comparison, index was 3.4 times the unbalanced growth ratio. This is because some groundwater demand for the industrial use was converted into municipal surface demand.

On the other hand, the growth ratio of balanced industrial demand was estimated at 1.3 times the present in the year 2025 under high-GRDP conditions while it was 1.1 times under low-GRDP conditions. The index was 2.2 and 1.5 times the pre-balanced under the two GRDP growth ratios.

The amount of M/I groundwater demand was finally summed up at 4,756.0 MCM/year under the high GRDP scenario and 4,312.4 MCM/year under the low GRDP scenario. However, the total demand of M/I water was still estimated at the same amount. The conclusions of the final groundwater demand are shown by WRR and MRB in Table G-17 through G-20. The conversion amounts by province, WRR and MRB by each scenario are shown in Table G-21 through G-26, respectively. The major differentials between pre- and post-balancing are:

a. Conversion; Industrial GW Demand into Municipal SW Demand

i) Province (Table G-21 and G-22)

Present M/I groundwater demand (developed) was already exceeded the GPL in three provinces namely Metro Manila*[1], Laguna and Bataan. Especially in Bataan, the groundwater availability area is belongs to a narrow seashore belt and a small riverbed only.

There will be large amount of industrial demand conversion into municipal demand in Metro Manila and its surrounding provinces in both GRDP scenarios. Even if industrial groundwater demand will be stabilized within the groundwater potential limitation, its groundwater extraction is too concentrated in some industrial zones in the western and southern parts of Manila. It is recommended that the NWRB control the industrial groundwater rights registration through careful study of the groundwater level monitoring. In addition, the promotion of industrial water recycling as a form of demand management should be required by the NWRB to the concerned agencies.

In the high-growth scenario pattern, the necessity conversion amount will appear in Cebu Province in the year 2020 (that means after the year 2015). In the Metropolitan Cebu area, industrial water recycling should be a necessity, much the same as Metro Manila. In the target year 2025, the over-exploitation of groundwater for industrial use will occur in 13 provinces (about 17 % of the total 77 provinces) if drastic countermeasures for groundwater preservation are not promoted.

Remarks *[1]; It is noted that NCR and ex-MWSS service area have different boundary forms. Therefore, the ex-MWSS groundwater source amount was divided into the Metro Manila, Rizal and Cavite provinces.

ii) WRR (Table G-23 and G-24)

Even in both the high and low GRDP scenarios, there are serious industrial groundwater shortages in WRR-III and IV, because of the rapid urbanization of Metro Manila. Figure G-18 and G-19 shows that the conversion amount in WRR-III and IV will be conspicuous by the year 2025. In the high scenario, in 2025, WRR-III, IV and VII (as shown in Figure G-20) will occupy 99 % of the conversion amount.

From a nationwide viewpoint, approximately 2,000 MCM/year (40 %) out of the 5,000 MCM/year projected industrial demand under the high-growth scenario should be supplied by the Level-III water supply systems in the year 2025. Under the low-growth scenario, the conversion amount was 750 MCM/year (23 %) of the 3,300 MCM/year industrial demand.

iii) MRB (Table G-25 and G-26)

The above I-M conversion groundwater by WRR was broken down into each MRB. Figure G-18 and G-19 indicates that there will be an industrial groundwater shortage only in the Pampanga River Basin (WRR-III) and the Pasig-Laguna River Basin (WRR-IV). In the high-growth scenario, in 2025, almost 100 % of the conversion amount will be occupied by the said above two MRBs as shown in Figure G-20. The total amount was more than 1,200 MCM/year in 2025.

b. Conversion; Municipal GW Demand into Municipal SW Demand

i) Province (Table G-21 and G-22)

Presently, even municipal groundwater demand exceeds the GPL in the province of Bataan. This is because, as mentioned before, groundwater availability is so limited. That is why Bataan's main aquifer (at the seashore side and located near populated areas) is nearly completely intruded by saline water, even given its small scale.

The municipal water demand is projected mainly by population. According to the projected population growth ratio between the present year and 2025 (by political region), Region-III was forecasted to increase 1.539 times the current population while the national average was 1.631. The minimum growth ratio was 1.417, in the NCR, and the maximum ratio was in Region-IV, with 2.010.

Up until the master plan study target year (2025), there will be a large amount of municipal groundwater needs which will be over the provincial GPL; especially in the provinces of Pampanga and Batangas. Also, in WRR-X and XII, municipal groundwater shortages will occur by the year 2015 or 2020 in the provinces of Misamis Occidental, Lanao del Norte and Sur. In 2025, groundwater over-exploitation for municipal water use will occur in seven (7) provinces (about 9 %) out of the total 77 provinces.

ii) WRR (Table G-23 and G-24)
At the moment, new surface water development is required in WRR-III. Regarding water sources for the ex-MWSS water supply systems, surface water development in WRR-III is ongoing; mainly for use in Metro Manila. Metro Manila and its surrounding provinces have the highest demand indicators, followed by other areas, which are experiencing increasing urbanization/economic growth. In nearly every WRR, there are WDs that have ratios indicating potential groundwater shortages. The primary influencing factor in the high economic growth scenario is groundwater consumption.

The trend of this study indicates that sustainable domestic water sources should be (by necessity) secured and maintained for WRR-III. Figure G-21 shows the regional conversion amount of groundwater into surface water for domestic purpose. In 2025, WRR-III, XII, IV and X will require 56 %, 29 %, 11 % and 4 %, respectively, as shown in Figure G-23.

iii) MRB (Table G-25 and G-26)
Even for the M-M conversion groundwater, as compared with same I-M groundwater, the said needs in the Pampanga River Basin (WRR-III) will be conspicuous, as will the Agus River Basin (WRR-XII) until year 2025.

Sustainable domestic water sources should (by necessity) secured and maintained for the said two MRBs. Figure G-22 shows the MRB's conversion amount into surface water for domestic purposes. In 2025, Pampanga, Agus, Mindanao and Pasig-Laguna will account for 55 %, 39 %, 4 % and 2 %, respectively as shown in Figure G-24.

c. Industrial Water Demand Control by Water Source Limitation

i) Metro Manila and its outskirts area
Within the ex-MWSS service area, M/I groundwater demand will be exceeded in 2010. Even when the water recycle ratio for industrial water use (which is set to increase from 5 % in 2000 to 30 % in 2025) is considered, the industrial groundwater demand planned to be converted into surface water (extracted from the Pasig-Laguna River Basin) dramatically affects the said surface water potential.

Therefore, the industrial water recycle ratio should be drastically increased until about it nears 70 % (under the high GDP scenario). This ratio is the same level as Japan. It will be impossible to supply industrial water using Level-III water supply systems unless the said demand control is actualized.

ii) Metropolitan Cebu
Much the same as Metro Manila; industrial water should be managed through water recycling, and the ratio of such recycling should be increased to 75 % by 2025 in Metropolitan Cebu.

(2) Conclusion

Based on the projected M/I demand forecast, each categorized water demand was divided into two types of water resources; groundwater and surface water. These categorized groundwater demands were considered as the probable required development amount in urbanized and/or populated areas prone to future groundwater shortages.

Also within some major river basins, namely the Pasig-Laguna and of WRR-VII, the conversion amount of industrial groundwater into municipal surface water drastically affects the basin's limited surface water potential. Therefore, even if industrial water recycling management was to be introduced into the demand forecast, further industrial water recycling would be required in Metro Manila and Metropolitan Cebu.

The M/I water demand, divided into GW/SW resources by the two scenarios, are summarized below.

Summary of M/I Demand until Target Year 2025

(Unit MCM/year)

Year	High GDP Scenario				Low GDP Scenario			
	Municipal Water		Industrial Water		Municipal Water		Industrial Water	
	GW	SW	GW	SW	GW	SW	GW	SW
1995	1,185	1,000	514	1,720	1,185	1,000	514	1,720
2010	2,200	2,480	730	1,720	2,200	2,445	615	1,720
2025	3,475	4,830	1,280	1,720	3,475	4,330	840	1,720

Table G-27 and G-28 show the final M/I water demand under the two scenarios by WRR while Table G-29 and G-30 mirror the same form of the above but their data is for the parameters by MRB. The nationwide M/I's GW/SW demand and its WRR-wise growth are illustrated in Figure G-25 through G-27 under the high-growth economic scenario while the same graphs are shown in Figure G-28 through G-30 reflect the low-growth economic scenario.

G.3.2 Future Requirements in Groundwater Development

The future requirements for groundwater supply in the Philippines were undertaken in this section. According to the analysis conducted herein, the number of deepwell projected to be necessary and the costs associated with the groundwater development requirements have been calculated. Both the well number and the program costs are mainly borne by the rural groundwater development schemes for domestic water supply purposes. In the case of the high GDP growth scenario in the year 2025, the ratio of this share in rural areas is only 97.7 % of the total well numbers and is 69.2 % of the total development costs. A summary of the investment amount for the GWRDPs is shown in the below table.

GWRD (Well Construction) Program Cost

(Unit: Billion Peso/5-year)

Year	2000	2005	2010	2015	2020	2025
High	47.5	54.1	49.9	57.0	46.0	51.7
Low	47.3	53.4	48.9	55.5	44.2	48.9

The bases for the above table was arrived at through the processes outlined below.

G.3.2.1 Groundwater Development Scheme

(1) Sectoral and Sub-Sectoral Plans

The groundwater development scheme was based on a number of factors in order to come up with a workable program. These factors are shown below.

a. Water Supply Categories

In order to analyze the available groundwater for a development scheme, the categories of water utilization are broken down into three utilization types, namely municipal, industrial and irrigation.

b. Municipal Water Classification

Municipal water is divided into the domestic and commercial water. Domestic water is composed of public and privately owned facilities. Presently, there are some of the concerned government agencies have responsibilities for each level of public water supply. Finally, five classes of the municipal water exist. These are as follows:

i) Public Water Supply
- Level-III water supply systems
- Level-II water supply systems
- Level-I water supply facilities

ii) Privately Owned Water Supply
- Level-I water supply facilities
- Commercial water supply facilities

(2) Industrial Demand by High and Low GDP

In order to take into account the possibility of the uncertainties relating to economic growth, two scenarios were used: high GDP and low GDP. The disparate impacts of these scenarios on the groundwater demand were taken into account.

(3) GWRDPs by the Hybrid WRR

The groundwater basins have different shapes from surface water (river) basins. The differences of these basins, in addition to topographic factors, consist of hydrogeological characteristics such as permeability and storage efficiency, etc. The other data and management functions relating to water supply is done based on political boundaries. Therefore, hybrid WRRs, utilizing the same boundaries as the NWRB database areas, was used.

In such a hybrid water resources region, the provincial boundaries are overlaid on the groundwater basins and the percentage of a groundwater basin's area within each province is calculated. Using such groundwater supply figures, demand estimates can be ascertained and are used to calculate the overall groundwater development requirements.

(4) Medium-Term Development Program

The time frame for this development study uses 2025 as a target year and the intervening time was broken down into five-year intervals. The medium-term development schedule consisted of the years 2000, 2005, 2010, 2015 and 2020; the final medium-term goal was the year 2025.

(5) Deepwell Development for Future Groundwater Demand

Groundwater resources are classified into two types, namely wells and springs. As previously stated, spring sources are limited and unable to be artificially enhanced. The necessary groundwater development (the gap between demand and production) was covered by well development.

G.3.2.2 Design Criteria of Groundwater Intake Facilities

The amount of groundwater exploitation should meet the medium-term demand. Each water intake facility is aged and this will be reduce its performance year by year within its particular life span. Hence, the development needs were larger than the gap amounts between previous and next the medium-term demand. Different structures and production needs are required for various safety, economy and sustenance purposes for each groundwater usage, and these characteristics are also dictated by the existing hydrogeological conditions. The following design criteria were adopted for the study on GWRDPs.

(1) Performance Reduction and Life of Facilities

One of the factors that had to be considered in the estimation of the water supply development potential was the affect that the existing and projected water supply facilities would have. Based on the available data and on the Consultant's experience in the Philippines and elsewhere, an analysis was conducted.

In Table G-31, the life of the facilities employed by the various water supply systems were categorized into Case 1, Case 2 and Case 3; the characteristics of each case was determined. For example, five-year old Case 1 facilities were calculated to comprise 15.3 % of the total deepwell number. Each of these categories has the same deviation of 10 years for their service life to represent a different average life; with Case 1 the lowest (20 years) and Case 3 the highest (35 years).

Each type of water supply (Level-III, Commercial, etc.) was assigned Case 1 through 3 characteristics based from well structures, water quality and production capacity of their facilities, which would change over time as old facilities were constructed.

The reduction in the production capacity of a facility was adopted, with the final production capacity of all the facilities averaging around 55 % for more economical performance. The reduction in the production capacity for each of the three cases is graphically illustrated in Figure G-31. Each case is applied for each deepwell characteristic. After the year 2010, each well characteristic should feature improved service life due to increasing technology levels.

In Table G-32 the breakdown of the properties of Case 1, Case 2 and Case 3 facilities is shown. It in the table can be seen that a Case 1 facility would have only 17.6 % of its original production capacity after 30 years of service, while for Case 3 facilities the ratio is still 49.1 %.

It is important to note that in the analyses in this section were based on the principle of maximized production and minimized development. In other words, the present facilities were considered to represent the maximum production capacity, thereby minimizing development because spring sources were limited in their capacities.

(2) Deepwell Structures

The deepwells, which was required for groundwater development in each area, have different structures based on the conditions prevalent in their respective areas. In Table G-33, the different characteristics of the deepwells in each WRR are allocated reflecting the different hydrogeologic conditions in each WRR. In this table, the groundwater availability was based on the GIS (Geograhyic Information System) average depth in meters for deepwells in the different formations. The typical deepwell structures are illustrated in Figure G-32 based on referenced Table G-33.

The calculations for the typical depth of the deepwells in the categorized municipal columns were modified based on the standards and/or characteristics of the respective classification. For example, a Level-III system is considered to have a depth equal to three (3) times of the average S/D-dep and the Dp-dep. This was because a Level-III systems must provide a sustainable and safely water source for a large number of people; hence they're greater depths. The deepwell depths for each type of water supply were designed with consideration of following preferential order.

a. Municipal Water; Safely water should be required for drinking purpose.

i) Level-III Systems
semi-permanent life>sustained production>economic operation cost>construction cost

ii) Level-II Systems
sustained production>semi-permanent life>economic operation cost>construction cost

iii) Level-I Facilities
sustained production>economic operation cost>semi-permanent life>construction cost

iv) Private Level-I
sustained production>construction cost>economic operation cost>semi-permanent life

v) Commercial
construction cost>sustained production>economic operation cost>semi-permanent life

b. Industrial Water
sustained production>semi-permanent life>economic operation cost>construction cost

c. Irrigation Water
sustained production>economic operation cost>construction cost>semi-permanent life

(3) Deepwell Production Capacity

The production capacity of the deepwells in each WRR are shown in Table G-34 based on the data obtained from WDs, the LWUA water supply standard and water rights sources. The production capacity of the deepwells for the various categories were modified based on their typical characteristics. Regional well production capacity is illustrated in Figure G-33.

For Level-III water supply systems, the production capacity of deepwells was the regional average of WDs' operation records, as of 1995.

For public Level-I & II, and private Level-I water supply systems or facilities, the production amount was estimated by it the applicable domestic service figures, because Level-I or Level-II production might be smaller than the deepwell capacity. The water consumption rate was adopted at 30 liters per capita day in line with LWUA's water supply standard. The population served per deepwell was estimated by the average population of an urban barangay's poblacion (300 persons), rural barangay (150 persons) and the population of ten households (50 persons) for each Level-I or Level-II deepwell, respectively.

For the production of privately owned deepwells serving commercial, industrial and irrigation purposes, the regional average of water rights was adopted.

G.3.2.3 Construction Needs to Meet the Groundwater Demand

Based on the results of each demand (Figure G-34 and G-35) and source capacity forecasting, additional groundwater development needs by the categorized and classified water uses within a medium-term period were studied.

The deepwell development needs are shown in Table G-35 through G-42 while Table G-43 through G-50 indicate the deepwell construction needs until year 2025. Figures G-36 to G-42 illustrate the medium-term development values. The following are the features of the deepwell construction needs:

(1) Municipal Water

a. Level-III Urban Water Supply Systems

It can be seen that WRR-III and WRR-IV will require the greatest amount of development in the coming years. In the whole view of trend, two times the present expansion progress will be required in 2025.

b. Level-II & I Rural Water Supply Systems/Facilities

The total demand indicates that the coverage of Level-II systems in urban areas will be reduced (these areas would be covered by Level-III systems) while the Level-I systems in rural areas will be sustained. Therefore, the necessary groundwater development will be reduced accordingly.

Level-I public groundwater facilities cover a much wider area than the Level-II systems in the Philippines. Therefore, the scale of the development is also much larger.

For the governmental groundwater development scheme, the rural Level-I water supply program should be considered as sustained public welfare. Through the evaluation of the Level-I conditions, this scheme will become a serious condition around the target years 2010 and 2015. However, if the Philippine Government implements this program, following our demand forecast, this scheme would become sustainable by the target year 2025.

c. Privately Owned Level-I and Commercial Water Supply Facilities
The number of wells called for amounts to 91,000 in the year 2025. This growth ratio trend becomes quite large after the year 2025.

(2) Industrial Water
The tremendous difference in the demand projections was readily apparent through the comparison of the two graphs. The projected development requirements in the year 2025 are about two times as large under the high GDP scenario as the low GDP scenario.

(3) Irrigation Water
The development program of the NIA and the other concerned agencies will peak in 2005 (7.7 thousand wells) and the groundwater development program will thereafter be lowered. The figures for the year 2025 are 3.0 thousand wells. Irrigation groundwater demand shows that while production capacity will top out after 2006, further production capacity development will be necessary to make up for the decline in the capacity of the previously built systems.

G.3.2.4 Program Cost Estimation for Groundwater Development

(1) Structures of Program Cost
The program cost is composed of construction and O/M cost as below. All construction prices were adjusted 1995 price levels, which were changed into US $ using a rate of 25.7144 (Average Cross Rates of the Peso, 1995) for the future review of the GWRDPs.

The construction cost of groundwater development facilities, along with their essential water supply components were estimated in accordance with the scope of cost estimation as shown in Table G-51. At the minimum, a deepwell and its pump as an intake facility were included in all groundwater development. If an intake facility was not functioning due to the lack of a water supply system, then the necessary components were added. A typical domestic water supply systems to be estimated for this study is illustrated in Figure G-43.

There is no necessity to equip the water treatment systems of groundwater development for domestic purpose, because groundwater quality is generally classified into "Class AA" DENR water quality criteria (refer to Table G-52). Only the disinfection (usually a chlorination facility is provided) is required in order to meet the Philippine National Standard for Drinking Water (PNSDW).

Indirect Cost, the ratio of direct cost or Profit and VAT, referred the standard prices of DPWH/LWUA (1995) and were added to each type of groundwater development system or facility.

(2) Construction Cost

a. Intake Facility (Deepwell & Pump)
The construction costs for deepwell of different sizes and depths were shown in Table G-53. The direct and indirect costs were estimated together for each well to

be constructed.

Table G-54 shows the cost of pump, which composed items were pump house, pump, platform control panel and delivery plumbing. Electrical pumps (submersible or self-priming) were estimated by the water power needs.

b. Transmission (Table G-55)
Pipeline length was measured by the expansion service area, which was calculated by deepwell capacity, unit water consumption and population density. Pipe diameter was adopted from the deepwell discharge figures, with the suitable materials for each service level.

c. Treatment (Chlorination)
A gas chlorination system was adopted for L-III water supply systems. It costs forty thousand pesos (₱40,000.-), including a chemical plunger pump with a switch box and cylinder. A drip chlorinator was adopted for L-II and I water supply systems. It costs one thousand pesos (₱1,000), including a drip instrument with plastic tank.

d. Distribution (Reservoir)
The storage ratios of L-III water supply systems varied around 10 % to 20 % of total day demand when their water sources had a performance capacity up to the maximum day demand (about 1.25 times of average day demand). Basically, new water sources will be fed through existing reservoirs. Otherwise, one steel 250 m^3 elevated reservoir (₱1,100,000.-) will be constructed for each 1,750 m^3/day supply. Its storage ratio was estimated to be 14.3 % of average day demand value. The standard reservoir size is 8 m in diameter and 6 m in height, with an elevation of 15 m. This assumption was adopted for industrial use also.

A new L-II water supply system will be constructed in the Barangay poblacion area. One concrete elevated reservoir, which has a storage of 5 m^3 (₱350,000.-), will be planned for each deepwell source.

e. Unit Construction Cost
Unit construction costs were summarized in Table G-56.

(3) Program Cost Estimation

a. Municipal Water (Table G-57)

i) Level-III Water Supply Systems
The public groundwater development plan for L-III systems was based on the figures for deepwell cost and production. In Table G-58, the costs associated from the number of deepwell required were depicted for each medium-term. It can be seen from this table, that WRR-III and WRR-IV will require the greatest amount of funding in the coming years.

ii) Level-II & I Rural Water Supply Systems or Facilities
The costs for Level-II and I rural water supply systems were computed in the same manner as in Table G-59. The costs associated with these systems were much

higher than the Level-III systems. Most of construction cost for this scheme is shared by L-I rural water supply.

iii) Privately Owned Level-I & Commercial Water Supply Facilities

The costs for Level-I private water supply and commercial facilities were computed in the same manner in Table G-60. The cost is ₱20.3 billion in the year 2025. This scheme will be comprised of Level-III water supply systems in the future.

b. Industrial Water

The results of cost estimation by each GDP growth scenario were shown in Table G-61 and G-62. The differential between both scenarios varies significantly, starting from the year 2005.

i) High GDP Scenario

The year 2025 figures are 1,010 wells to be built at a cost of ₱4.8 billion. The disparity between the figures illustrates effectively the impact that high economic growth will have on the demand for groundwater resources in the Philippines.

ii) Low GDP Scenario

After the year 2005, the necessity of groundwater development will be stabilized. The year 2025 figures are 380 wells to be built at a cost of ₱1.9 billion.

c. Irrigation Water

In Table G-63, it can be seen that the development program of the NIA and the other concerned agencies will peak in 2006 (7.7 thousand wells at ₱3.5 billion) and the groundwater development program will thereafter lower. The figures for the year 2025 are 3.0 thousand wells at a cost of ₱1.4 billion.

(4) Operation and Maintenance (O/M) Cost

The O/M cost for public water supply was applied to L-III systems only. Other level of public water supply systems/facilities were shared by RWSA for L-II and BWSA for L-I.

a. Level-III

The necessary O&M cost for the groundwater development is shared by the WDs. Table G-64 indicates regional water rates. According to the PW4SP's financial indicators, in Luzon, 85.9 % of the water price was occupied by the O&M cost for L-III water supply systems. Therefore, the O&M cost for each supplied groundwater shall be considered after completion of the groundwater expansion programs.

The analysis results (Table G-64) indicate that the water rates were ranked by the type of water sources. Cheapest water rates were supplied by the source of spring while the most expensive one was by deepwell and surface water sources. The cause of this was probably due to the history of water source development since its establishment. In general, the preferred water source was groundwater. When the groundwater development cost became higher or extraction more difficult, the WDs constructed surface water intake facilities with a treatment plant.

The escalation of water rates, estimated by the said previous table and household population in 1990 census, is shown in Figure G-44. This trend of water tariff escalation means that the water sources developed by the wells and surface water were limited within their service areas. Therefore, the water rate extracted by the facilities of wells and surface water had higher escalation rates than the others. Also the water rate over 20 m^3/month.household shows a higher curve. It means that water consumption over 125 lpcd becomes expensive.

Hence, the descriptions of well rehabilitation with a facility's renovation and for recruiting for pump operators were recommended as part of the future groundwater source development expansion programs, as shown below.

i) Deepwell Rehabilitation (Maintenance)
Groundwater is extracted through deepwells using the pressure differential between the inside of the well and the aquifer. Hence, an artificial negative pressure is applied in deepwells. Under these conditions, the minerals dissolved in groundwater will adhere to well screen in the form of an incrustation. Also, soil corpuscles will clog or plug gravel filters. Therefore, physical and chemical rehabilitation is required when well efficiency becomes less than 70 % of original capacity.

ii) Deepwell Operation
A maintenance crew (at least one person) usually stays at each pump station for pump and chlorinator operation, daily recording of operation, discharge quantity/pressure and any other consumables, etc.

b. Level-II & I
Instead of the O&M cost for L-II and L-I (RWSA & BWSA), the cost for community development and training per barangay (12 % of construction cost; DILG's past experience in RWSA or BWSA formation was the basis for this figure) shall be considered in the case of a newly developed facility.

G.3.2.5 Regional Groundwater Resources Development

Major indexes of the GWRDPs for the M/I and irrigation groundwater demands were described by WRR as below.

Those indicated tables are composed of the groundwater development requirements for (a) the additional needs, (b) the additional wells and (c) the program cost, respectively. Each table's line of the medium-term period mentions groundwater programs to be implemented within five (5) years.

The features of the regional GWRDPs against other regions are described before the said tables.

(1) WRR-I

For public water supply systems/facilities, the program cost of the L-III systems will be increased while those of the L-I will peak in 2010. The L-III program cost in 2025 is increases three times the present acceleration. The L-I scheme has medium-scale programs and is larger than the L-III until 2020.

For privately owned municipal water facilities, the program cost is almost sustained until the target year. Industrial water development cost will be increased in the high GDP scenario. The irrigation groundwater development program is medium-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm'l	GDP	GDP	
2000	12.1	0.3	4.9	0.7	0.0	4.6	3.6	86.9
2005	16.1	0.4	5.6	0.7	0.0	4.6	4.2	104.6
2010	21.4	0.4	6.1	0.3	0.0	7.0	4.7	38.8
2015	26.7	0.4	5.7	0.4	0.0	9.8	5.4	39.8
2020	32.7	0.3	4.3	0.4	0.0	14.0	6.1	39.8
2025	36.0	0.2	2.5	0.2	0.0	19.7	5.9	40.7

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	68	95	2,984	1,365	0	17	14	1,140
2005	90	108	3,398	1,264	0	17	16	1,372
2010	120	119	3,738	481	0	26	18	509
2015	150	110	3,460	744	0	37	20	523
2020	183	84	2,636	764	0	52	23	522
2025	202	49	1,521	453	0	74	22	534

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	264	139	862	257	0	66	55	386
2005	350	158	982	238	0	66	62	465
2010	457	174	1,080	90	0	101	70	173
2015	583	161	1,000	140	0	144	78	177
2020	711	123	762	144	0	203	90	177
2025	784	72	440	85	0	289	86	181

(2) WRR-II

For public water supply systems/facilities, the program costs of the L-III will increase while those of the L-I will peak in 2010. The L-III program cost in 2025 increases four times the present acceleration. The L-I scheme has medium-scale programs and is larger than the L-III until 2025.

For privately owned municipal water facilities, the program cost decreases and will be not necessity in the target year. Industrial water development cost will increase in the high GDP scenario. The irrigation groundwater development program is large-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	7.8	0.5	8.3	1.2	0.0	1.7	1.2	416.9
2005	11.4	0.6	9.8	1.3	0.0	1.3	1.4	502.0
2010	15.9	0.7	11.4	0.6	0.0	1.7	1.2	184.2
2015	20.1	0.7	11.5	0.6	0.0	2.3	1.3	189.1
2020	24.8	0.6	9.9	0.7	0.0	3.3	1.4	188.9
2025	28.5	0.5	8.4	0.0	0.0	4.6	1.4	194.2

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	60	161	5,057	2,128	0	10	7	2,281
2005	88	190	5,962	2,376	0	7	8	2,746
2010	123	221	6,920	1,149	0	10	7	1,008
2015	155	223	6,986	1,179	0	13	7	1,034
2020	191	193	6,039	1,193	0	19	8	1,033
2025	220	164	5,132	0	0	26	8	1,062

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	268	272	1,760	460	0	39	27	912
2005	393	321	2,075	513	0	27	31	1,098
2010	549	373	2,408	248	0	39	27	403
2015	691	376	2,431	255	0	51	27	414
2020	853	326	2,102	258	0	74	31	413
2025	982	277	1,786	0	0	102	31	425

(3) WRR-III

For public water supply systems/facilities, the program cost of the L-III will be increased while of the L-I will peak in 2005. The L-III program cost after 2010 is two times the present acceleration and will be sustained. The L-I scheme has large-scale programs and is larger than the L-III until 2015.

For privately owned municipal water facilities, the program cost is decreased. Industrial water development costs peak in 2005 and 2020 under both economic scenarios. The irrigation groundwater development program is large-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	77.2	1.0	15.9	3.8	0.1	23.2	17.4	320.7
2005	103.0	1.1	17.4	2.8	0.1	44.8	38.0	384.7
2010	130.8	1.1	16.7	2.7	0.1	0.0	0.0	155.7
2015	151.2	0.8	13.0	2.3	0.1	17.4	0.0	159.9
2020	144.4	0.5	7.7	1.3	0.1	70.3	34.4	159.6
2025	150.1	0.0	0.0	0.6	0.1	61.5	26.9	156.3

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	200	308	9,660	6,935	1	34	25	773
2005	266	339	10,624	5,046	1	65	55	927
2010	338	324	10,159	5,000	1	0	0	375
2015	391	253	7,925	4,240	2	25	0	385
2020	373	149	4,684	2,422	1	102	50	385
2025	388	0	0	1,117	1	90	39	377

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	1,130	488	3,352	1,498	0	218	160	451
2005	1,502	538	3,687	1,090	0	417	353	541
2010	1,909	514	3,525	1,080	0	0	0	219
2015	2,209	401	2,750	916	1	160	0	225
2020	2,107	236	1,625	523	0	654	321	225
2025	2,192	0	0	241	0	577	250	220

(4) WRR-VI

For public water supply systems/facilities, the program cost of the L-III will be sustained while of the L-I will peak at a high level in 2015. The L-III program cost in 2025 will decrease until it is half of the present acceleration. The L-I scheme has large-scale programs and is larger than the L-III until 2025.

For privately owned municipal water facilities, the program cost is increased drastically after 2025. Industrial water development cost will peak in 2015 in both economic scenarios. The irrigation groundwater development program is medium-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	43.3	1.1	16.6	5.6	1.7	0.0	0.0	87.8
2005	43.5	1.2	19.1	8.3	1.9	23.7	12.6	105.5
2010	51.3	1.3	20.2	0.7	2.0	19.2	25.3	41.3
2015	53.1	3.0	47.4	0.0	2.1	95.4	79.5	42.3
2020	52.8	1.5	24.2	4.4	2.1	16.9	23.5	42.3
2025	24.7	1.2	19.1	45.8	1.4	27.3	20.2	42.1

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	243	322	10,088	10,148	12	0	0	243
2005	244	370	11,599	15,121	14	56	30	292
2010	288	392	12,271	1,300	15	46	60	114
2015	298	920	28,837	0	15	227	189	117
2020	296	470	14,712	8,044	15	40	56	117
2025	139	371	11,623	83,585	10	65	48	116

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	1,018	524	3,652	2,273	4	0	0	124
2005	1,022	602	4,199	3,387	4	284	152	149
2010	1,206	638	4,442	291	5	233	304	58
2015	1,248	1,498	10,439	0	5	1,151	958	60
2020	1,240	765	5,326	1,802	5	203	284	60
2025	582	604	4,208	18,723	3	330	243	59

(5) WRR-V

For public water supply systems/facilities, the program cost of the L-III will be increased while of the L-I will peak in 2005. The L-III program cost in 2025 is increased 2.5 times the present acceleration. The L-I scheme has medium-scale programs and is larger than the L-III until 2025.

For privately owned municipal water facilities, the program cost is decreased until the target year. Industrial water development costs will slightly increase in the high GDP. The irrigation groundwater development program is medium-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	20.1	0.5	8.5	2.0	0.0	4.2	2.5	94.7
2005	20.4	0.8	12.9	0.6	0.0	2.2	3.0	113.9
2010	31.1	0.8	12.8	0.8	0.0	3.2	2.0	43.3
2015	38.4	0.8	12.7	0.8	0.0	4.3	2.2	44.5
2020	47.0	0.7	10.3	0.9	0.0	5.9	2.4	44.4
2025	50.1	0.5	8.1	0.4	0.0	8.5	2.5	44.8

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	74	164	5,145	3,692	0	31	18	417
2005	75	252	7,884	1,017	0	17	22	501
2010	114	248	7,769	1,489	0	23	15	191
2015	141	247	7,745	1,425	0	31	16	196
2020	172	201	6,300	1,724	0	44	18	196
2025	183	157	4,921	804	0	63	19	197

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	370	264	1,790	797	0	127	74	189
2005	374	406	2,744	220	0	70	90	227
2010	569	400	2,704	322	0	94	61	87
2015	703	398	2,695	308	0	127	66	89
2020	859	324	2,192	372	0	180	74	89
2025	913	253	1,713	174	0	258	78	89

(6) WRR-VI

For public water supply systems/facilities, the program costs of the L-III will be increased while of the L-I will peak in 2005. The L-III program cost in 2025 is increased 3.5 times the present acceleration. The L-I scheme has medium to small-scale programs and is larger than the L-III until 2015.

For privately owned municipal water facilities, the program cost is decreased until the target year. Industrial water development cost will peak in 2005 year in the high GDP. The irrigation groundwater development program is medium-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	38.0	0.7	11.4	3.2	0.1	6.1	4.4	109.7
2005	53.5	0.8	12.7	1.6	0.1	23.0	5.7	130.7
2010	73.2	0.8	12.6	1.2	0.1	16.0	5.4	61.8
2015	91.8	0.7	11.2	0.8	0.1	16.4	6.2	63.5
2020	112.8	0.4	6.7	1.1	0.1	17.6	7.4	63.3
2025	130.5	0.1	1.4	0.3	0.1	13.1	2.7	57.6

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	86	221	6,917	5,803	1	11	8	120
2005	122	247	7,731	2,981	1	40	10	143
2010	166	245	7,662	2,198	1	28	9	68
2015	209	217	6,801	1,530	1	28	11	70
2020	256	130	4,059	2,046	1	31	13	69
2025	296	26	830	630	1	23	5	63

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	488	349	2,345	1,230	0	64	47	82
2005	690	390	2,621	632	0	233	58	98
2010	940	387	2,597	466	0	163	52	47
2015	1,183	343	2,306	324	0	163	64	48
2020	1,450	205	1,376	434	0	181	76	47
2025	1,675	41	281	134	0	134	29	43

(7) WRR-VII

For public water supply systems/facilities, the program cost of the L-III will be increased while of the L-I will peak in 2005. The L-III program cost in 2025 will increase two times the present acceleration. The L-I scheme has medium to small-scale programs and is larger than the L-III until 2020.

For privately owned municipal water facilities, the program cost will decrease until the target year. Industrial water development costs will peak in 2005 and 2015 in the high GDP. The irrigation groundwater development program is small-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High GDP	Low GDP	
	L-III	L-II	L-I	L-I	Comm.			
2000	21.8	0.6	9.7	2.2	0.0	12.9	10.1	10.7
2005	26.4	0.7	10.8	1.6	0.0	80.6	67.8	12.8
2010	32.6	0.7	10.5	1.1	0.0	38.6	20.2	5.4
2015	37.7	0.6	8.8	0.7	0.0	95.4	55.5	5.5
2020	43.6	0.3	4.4	1.0	0.0	39.5	60.3	5.5
2025	38.2	0.0	0.0	0.2	0.0	23.9	51.7	5.3

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High GDP	Low GDP	
	L-III	L-II	L-I	L-I	Comm.			
2000	14	188	5,875	3,929	0	8	7	41
2005	17	211	6,597	2,865	0	53	44	49
2010	21	204	6,399	1,955	0	25	13	21
2015	24	171	5,360	1,335	1	62	36	21
2020	28	85	2,653	1,736	0	26	39	21
2025	24	0	0	289	0	16	34	20

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High GDP	Low GDP	
	L-III	L-II	L-I	L-I	Comm.			
2000	130	294	1,974	829	0	65	57	19
2005	158	330	2,217	605	0	432	358	23
2010	195	319	2,150	413	0	204	106	10
2015	224	267	1,801	282	0	505	293	10
2020	260	133	891	366	0	212	318	10
2025	225	0	0	61	0	130	277	9

(8) WRR-VIII

For public water supply systems/facilities, the program costs of the L-III will increase while the cost of the L-I will peak in 2010. The L-III program cost in 2025 is increased five times the present acceleration. The L-I scheme has medium-scale programs and is larger than the L-III until 2020.

For privately owned municipal water facilities, the program cost is slightly decreased until the target year. Industrial water development cost will be increased in the high GDP scenario. The irrigation groundwater development program is small-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	4.4	0.5	7.4	1.1	0.1	20.8	16.5	18.4
2005	6.7	0.6	8.6	1.1	0.1	17.7	16.4	22.2
2010	9.5	0.6	10.0	0.4	0.1	25.7	17.2	8.3
2015	12.6	0.6	9.4	0.9	0.1	35.6	19.8	8.5
2020	16.2	0.5	7.6	0.7	0.1	50.3	22.0	8.5
2025	24.1	0.2	3.1	0.4	0.1	68.7	20.5	8.7

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	28	145	4,532	2,082	0	25	20	75
2005	43	168	5,266	1,972	0	21	20	90
2010	61	193	6,058	800	0	31	21	34
2015	81	183	5,724	1,592	1	43	24	35
2020	104	148	4,622	1,334	0	60	26	35
2025	155	60	1,891	804	0	82	24	35

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	137	240	1,609	458	0	162	130	38
2005	211	278	1,869	434	0	136	130	45
2010	298	320	2,151	176	0	201	136	17
2015	396	303	2,032	350	0	279	156	18
2020	508	245	1,641	293	0	390	169	18
2025	757	99	671	177	0	533	156	18

(9) WRR-IX

For public water supply systems/facilities, the program cost of the L-III will be increased while of the L-I will peaked in 2010. The L-III program cost in 2025 is increased three times the present acceleration. The L-I scheme has medium to small-scale programs and is larger than the L-III until 2020.

For privately owned municipal water facilities, the program cost is decreased until the target year. Industrial water development cost will increase in the high GDP scenario. The irrigation groundwater development program is small-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	13.2	0.4	6.6	2.1	0.0	8.2	8.2	25.5
2005	18.4	0.5	7.7	1.5	0.0	13.2	11.1	30.5
2010	25.3	0.5	8.1	0.6	0.0	10.0	6.6	13.4
2015	32.0	0.4	6.3	0.8	0.0	13.3	7.2	13.7
2020	39.9	0.2	3.1	0.6	0.0	19.7	8.6	13.7
2025	39.4	0.1	1.1	0.2	0.0	28.7	9.3	12.9

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	17	128	4,007	3,857	0	94	94	67
2005	23	150	4,711	2,722	0	150	126	80
2010	32	157	4,905	1,125	0	114	75	35
2015	41	122	3,811	1,480	0	152	82	36
2020	51	60	1,883	1,090	0	224	98	36
2025	50	21	673	430	0	326	106	34

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	120	193	1,230	760	0	360	360	33
2005	163	226	1,446	536	0	575	483	39
2010	226	237	1,506	222	0	437	287	17
2015	289	184	1,170	292	0	582	314	17
2020	359	90	578	215	0	858	375	17
2025	353	32	207	85	0	1,249	406	17

(10) WRR-X

For public water supply systems/facilities, the program cost of the L-III will be increased while of the L-I will peak in 2010. The L-III program cost in 2025 increases three times the present acceleration. The L-I scheme has medium scale programs and is larger than the L-III until 2020.

For privately owned municipal water facilities, the program cost is decreased until the target year. Industrial water development cost will be increased after 2015 in both GDP scenarios. The irrigation groundwater development program is medium-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High GDP	Low GDP	
	L-III	L-II	L-I	L-I	Comm.			
2000	27.7	0.4	6.4	2.4	0.0	0.7	0.5	88.3
2005	41.3	0.5	7.9	1.5	0.0	9.4	2.5	106.1
2010	57.4	0.5	8.3	0.9	0.0	6.0	2.4	41.7
2015	73.8	0.5	7.2	0.8	0.0	25.4	12.9	42.8
2020	86.5	0.30	4.8	0.8	0.0	37.7	14.6	42.7
2025	85.4	0.2	2.7	0.3	0.0	48.6	15.6	42.4

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High GDP	Low GDP	
	L-III	L-II	L-I	L-I	Comm.			
2000	38	125	3,902	4,371	0	2	2	236
2005	56	154	4,823	2,752	0	34	9	284
2010	78	160	5,024	1,615	0	22	9	112
2015	100	140	4,386	1,385	0	93	47	115
2020	118	94	2,948	1,375	0	138	54	114
2025	116	52	1,620	562	0	178	57	114

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High GDP	Low GDP	
	L-III	L-II	L-I	L-I	Comm.			
2000	292	200	1,295	909	0	9	9	121
2005	433	246	1,601	572	0	156	41	145
2010	602	255	1,668	336	0	101	41	57
2015	773	223	1,456	288	0	428	216	59
2020	910	150	979	286	0	635	248	58
2025	896	83	538	117	0	819	262	58

(11) WRR-XI

For public water supply systems/facilities, the program cost of the L-III will be increased slightly while of the L-I will peak in 2010. The L-III program cost in 2025 is increased two times the present acceleration. The L-I scheme has medium-scale programs and is larger than the L-III until the target year (2025).

For privately owned municipal water facilities, the program cost is almost sustained until the target year. For industrial water development, costs will be increased after 2010 in the high GDP scenario. The irrigation groundwater development program is small-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High GDP	Low GDP	
	L-III	L-II	L-I	L-I	Comm.			
2000	8.4	0.5	8.3	2.1	0.0	2.0	1.8	23.6
2005	9.5	0.6	9.2	0.9	0.0	5.0	3.4	28.4
2010	11.7	0.7	10.7	0.2	0.0	10.0	6.8	11.1
2015	13.8	0.7	10.8	1.0	0.0	13.3	7.6	11.4
2020	16.5	0.6	9.7	0.7	0.0	17.7	8.1	11.4
2025	12.0	0.5	8.0	0.7	0.0	22.6	6.2	11.3

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High GDP	Low GDP	
	L-III	L-II	L-I	L-I	Comm.			
2000	9	161	5,033	3,793	0	3	3	43
2005	11	179	5,596	1,650	0	7	5	51
2010	13	208	6,519	444	0	15	10	20
2015	16	209	6,554	1,795	0	20	11	21
2020	19	189	5,936	1,277	0	27	12	21
2025	14	155	4,850	1,318	0	34	9	20

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	*Municipal*					*Industrial*		*Irrigation*
	Public			Private		High GDP	Low GDP	
	L-III	L-II	L-I	L-I	Comm.			
2000	79	268	1,802	838	0	18	18	24
2005	96	298	2,003	365	0	41	30	29
2010	113	347	2,334	98	0	89	59	11
2015	139	348	2,346	397	0	118	65	12
2020	165	315	2,125	282	0	160	71	12
2025	122	258	1,736	291	0	201	53	11

(12) WRR-XII

For public water supply systems/facilities, the program cost of the L-III will be increased while of the L-I will peak in 2010. The L-III program cost in 2025 is increased three times the present acceleration. The L-I scheme has medium to small-scale programs and is larger than the L-III until 2025.

For privately owned municipal water facilities, the program cost is decreased until the target year. Industrial water development costs will be greater in the high GDP scenario. The irrigation groundwater development program is large-scale.

a. Additional Groundwater Development Needs

(Unit: MCM/year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	27.2	0.7	10.9	2.4	0.0	1.3	0.7	275.4
2005	45.3	0.9	14.0	2.2	0.0	2.1	1.8	331.0
2010	59.4	1.0	15.4	0.8	0.0	3.7	2.5	127.8
2015	77.9	0.8	12.9	1.2	0.0	4.9	2.7	131.1
2020	80.6	0.6	8.7	0.8	0.0	5.5	2.2	131.0
2025	89.8	0.2	3.7	0.5	0.0	8.2	2.2	131.3

b. Additional Deepwell Construction Needs

(Unit: well/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	93	211	6,607	4,435	0	5	3	1,006
2005	154	272	8,535	3,961	0	9	8	1,209
2010	202	299	9,355	1,488	0	15	10	467
2015	265	250	7,829	2,222	0	20	11	479
2020	274	169	5,280	1,536	0	22	9	478
2025	305	72	2,243	944	0	33	9	479

c. Groundwater Development Program Cost (M.Pesos/5-year)

Year	Municipal					Industrial		Irrigation
	Public			Private		High	Low	
	L-III	L-II	L-I	L-I	Comm.	GDP	GDP	
2000	509	334	2,180	922	0	24	14	520
2005	843	431	2,817	824	0	43	38	625
2010	1,105	473	3,087	310	0	72	48	241
2015	1,450	396	2,584	462	0	96	53	248
2020	1,499	268	1,742	319	0	105	43	247
2025	1,669	114	740	196	0	158	43	248

G.3.3 Groundwater Shortage Forecasting

Groundwater balance can be referred to as the balance between the rates of recharge and extraction in an aquifer. Properly managed, groundwater can serve as a sustainable resource in terms of quality and quantity. However, if groundwater is extracted in excess of an aquifer's recharge rate, then a variety of problems will be experienced. Thus, the nationwide groundwater shortage investigation shall be studied.

The groundwater cycle is much longer than that of surface water. Therefore, if groundwater extraction is concentrated within a limited area, the balance between recharge and extraction (the groundwater cycle) will be disturbed. Even if groundwater recharge is larger than its demand over a wide area, groundwater levels will decline in the area with concentrated groundwater development.

These problems induce ground subsidence, saline water intrusion, etc. because the groundwater level will be lowered. Therefore, it is important that the relative groundwater capacity of the populated and economically developed areas versus demand will be analyzed. The following sections deal with this process.

G.3.3.1 Provincial Groundwater Balancing

The natural groundwater cycle is in balance when there is no artificial removal of groundwater (i.e. no groundwater development). Therefore, even when small-scale groundwater development takes place, the groundwater cycle has been altered. This concept is fundamental in understanding how many groundwater imbalances can be permitted in a given aquifer.

In order to form a basis for the estimate regarding any predicted forecast for a shortage of groundwater, the pressures placed on the groundwater resources of the provinces should be performed. Several factors used form the basis of this forecast are shown below:

a. Population
   One of the key elements in calculating the groundwater extraction demand is population. It follows that the pressures placed on the water resources of any given area will be greatest in those areas with the highest population/population densities. In this case, Metro Manila clearly has the highest population/population density of all the provinces.

b. Level-III Groundwater
   Stemming from the above population figures, the Level-III population served is calculated. Again, Metro Manila far outstrips the other provinces in terms of sheer numbers. Based on the data/information from LWUA and MWSS, the Level-III groundwater demand is determined.

c. Industrial Groundwater
   As a final portion of the projected groundwater demand, the expected demand for industrial groundwater was projected. To take into account the uncertain nature of economic growth in the future, two (2) scenarios were utilized: one of high economic growth (tentatively provided by NEDA on March 1997) and one for low economic growth (prepared by the Study Team with reference of the Asian trend).

(1) Analysis

Presently, the groundwater shortage is forecast in Table G-65. This table takes into consideration the type of water source(s) used by the various WDs. The water districts are classified as follows:

Type	Water Source	Points	Source to be Developed
A	groundwater only	1	GW
B	surface water only	4	SW
C	Groundwater is larger than surface water	2	SW
D	surface water is larger than groundwater	3	SW

Note: the points are indicating for level of development potential/requirements for surface water.

Also in Table G-65, indicators show that which provinces have saline water intrusion problems as well as which provinces are currently experiencing water shortages. The shadowed provinces show those provinces which have a high point "product of 2"; this means that the province could require further surface water development.

It should be noted that these projected groundwater shortages are only relevant to those portions of the provinces, which are urbanized (i.e. where there is a high level of groundwater extraction).

Based on the above trend, a groundwater shortage would be predicted by the groundwater consumption rate as a direct index and by population or consumers as an indirect index. The following factors are the conditions of groundwater forecasting.

Table G-66 shows the industrial and Level-III groundwater demand for the low economic growth scenario. Based on these figures, Table G-67 illustrates the ratio of groundwater consumption (demand/recharge) for the low economic scenario. The darker shaded portions of this table indicate ratios of 10 % or more; the lighter shaded portions are those of 5 % or more. Tables G-68 and Table G-69 are the same as the above, but for the high economic growth scenario. It can be seen that economic growth has a direct affect on water demand. In any case, the number of areas with ratios of greater than 10 % should be noted.

The following three tables deal with population. Table G-70 shows the projected urban population, Table G-71 the population density and Table G-72 the Level-III population served in each of the respective provinces. In each of these tables, the shaded portions illustrate those provinces, which have over the selected number noted on the bottom portion of the tables. Such shading helps to draw attention to those provinces, which would likely have high water, demand ratios.

A nationwide view of the above data can be seen in Figures G-45 through G-49. It can be seen that Metro Manila and its surrounding provinces have the highest demand indicators, followed by other areas which are experiencing increasing urbanization and/or economic growth. Figures G-50 to G-61 feature the details of the individual WRRs. In nearly every WRR, there are WDs that have ratios indicating potential groundwater shortages.

(2) Refinement

In an effort to refine the data set for the purposes of preparing a master plan, a large square deviation ratio was used to rank the provinces from lowest to highest in terms of municipal population (Table G-73), municipal population density (Table G-74), groundwater source size in MCM/year (Table G-75). The scatter diagrams of each of these tables are shown in Figures G-62 and G-63.

(3) Summary

Based on these trends, the provinces' groundwater shortage factors over time are shown along with the countermeasures that should be taken. The factors contributing to groundwater shortages are shown along with the time frame in which they are projected to occur. The key in this table is the next "Recommendation", which indicates the probable countermeasure (including time frame) that will need to be taken. The primary influencing factor is the high economic growth scenario's groundwater consumption.

G.3.3.2 Recommendation of National and Regional Medium-Term Action

(1) National Medium-Term Action

The summation of the projected provincial groundwater shortages and the recommended countermeasures (including probable time frames) are shown in Tables G-76 and G-77. The countermeasures are broken down as follows:

- surface water development
- improvement of groundwater resources development
- surface water development and/or improvement of groundwater resources development

Finally, Table G-78 presents the Level-III water supply systems, which are recommended for surface water development, within the groundwater shortage provinces. These analyzed groundwater shortage provinces are:

a. Metro Manila and its surrounding area,
b. Central Luzon Plain area and
c. Large-scale (groundwater supply for L-III & industry) provincial cities.

(2) Regional Medium-Term Action

After collecting and analyzing the data above, an effort was made to break down the information by WRR and MRB. The results of these analyses are shown below.

Table G-79 shows the groundwater demand and consumption by WRR while Table G-80 illustrates groundwater demand and consumption by MRB as groundwater development programs are allocated by WRR while surface water development programs are allocated by MRB. Figures G-64 and G-65 offer a comparative illustration of groundwater demand by WRR and usage under the low economic growth scenario. Until target year 2025, the consumption ratios between groundwater potential and demand by WRR and MRB will not reach one hundred percent (100 %). Therefore, according to the results of this study, further groundwater development by the public scheme is still possible with the consideration of the groundwater balancing study.

In Figure G-64 and G-65 the increase in the groundwater demand can be directly traced to the promotion of irrigation projects by the NIA which will put an additional 2 million ha of land under irrigation by the year 2006. As shown in the same figures, WRR-II, WRR-III, and WRR-XII are most affected by these programs. In Figure G-65, the effects of increased industrial growth under the high scenario are shown by the increased groundwater demands in WRR-III, WRR-IV and WRR-VII.

Figure G-66 illustrates the effects of low economic growth on groundwater demand in terms of usage. The industrial water growth rates for the low scenario is 3.09 while the high scenario is 6.37. The WRR base growth rate for the low scenario has a minimum of 0.91

and a maximum of 25.37; the high scenario has a minimum of 1.88 and a maximum of 52.27. The affects of the NIA's irrigation programs are clearly seen in Figure G-66.

The rise in irrigation water usage rises until the completion of the NIA's programs in 2006 and then declines thereafter. The different growth development against the groundwater demand in populated areas (Level-III and Industrial Groundwater) for the two scenarios are as follows:

(Unit: MCM/year)

Scenario	1995	2000	2005	2010	2015	2020	2025
Low Growth	46.0	32.8	30.3	36.0	41.6	47.0	51.6
High Growth	46.0	33.1	30.8	37.5	44.7	52.1	59.2

Figures G-67 and G-68 show the groundwater consumption ratios for the WRRs. It can be seen that the high economic growth scenario in Figure G-68 dramatically affects the groundwater consumption ratio, with WRR-III reaching nearly 90 % by the year 2025. For WRR-III, WRR-IV, WRR-VI, WRR-VII and for WRR-XII, the groundwater development should be effectively improved and more widely implemented.