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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE SOCIALIST REPUBLIC OF VIET NAM
MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT

THE MASTER PLAN STUDY
ON
DONG NAI RIVER AND SURROUNDING BASINS
WATER RESOURCES DEVELOPMENT

FINAL REPORT

VOLUME VIII

APPENDIX VII DOMESTIC AND INDUSTRIAL
WATER SUPPLY

AUGUST 1996

NIPPON KOEI CO., LTD., TOKYO JAPAN

This Report consists of

Volume I	Executive Summary	
Volume II	Main Report	
Volume III	Appendix I	Socio-economy and Institution
Volume IV	Appendix II	Topography and Geology
	Appendix III	Meteorology and Hydrology
Volume V	Appendix IV	Natural Environment
Volume VI	Appendix V	Hydropower Generation
Volume VII	Appendix VI	Agricultural Development and Irrigation
Volume VIII	Appendix VII	Domestic and Industrial Water Supply
Volume IX	Appendix VIII	Flood Mitigation and Urban Drainage
	Appendix IX	Salinity Intrusion
Volume X	Appendix X	Formulation of Master Plan
Volume XI	Data Book	



The cost estimate was based on the December 1995 price level and expressed in US\$ according to the exchange rate of US\$ 1.00 = Vietnamese Dong 11,014 = Japanese Yen 101.53 as of December 15, 1995.

LIST OF ABBREVIATIONS

AFS	Agriculture and Forestry Service (PC)
CEMMA	Committee for Ethnic Minorities and Mountainous Areas
DCWSSS	Design Company for Water Supply and Sanitation System (HCMC-PC)
EA	Environment Assessment (Multi-lateral Lending Agencies)
ECSP	Evaluation Commission for State Projects
EIA	Environmental Impact Assessment
ENCO	Ho Chi Minh City Environmental Committee
EVN	<i>General Company of Electricity of Viet Nam (Abolished and renamed in November 1995 as Vietnamese Power Corporation)</i>
FIPI	Forest Inventory and Planning Institute (MOARD)
GCOP	Governmental Committee on Organization and Personnel
GDLA	General Department of Land Administration
GDMH	General Department of Meteorology & Hydrology
GOV	Government of Viet Nam
GSO	General Statistical Office
HCMC	Ho Chi Minh City
HEC	Ho Chi Minh Environment Committee (HCMC)
HIDC	Hydraulic Investigation and Design Company (MOARD)
HPC	Ho Chi Minh People's Committee (HCMC)
HSDC (or SDC)	Ho Chi Minh Sewerage and Drainage Company (HCMC)
HWSC (or WSC)	Ho Chi Minh Water Supply Company (HCMC)
IDD	Irrigation and Drainage Department (MOARD)
IEE	Initial Environmental Examination
IER	Institute for Economic Research (HCMC-PC)
IHPH	Institute of Hygiene and Public Health (MOPH)
IM	Institute of Mines (MOID)
INVESCO	Investment Company for the Development of Water Sector (HCMC-PC/TUPWS)
IOE	Institute of Energy (MOID)
IURP	Institute of Urban and Rural Planning (HCMC-PC/Construction Service)
IWRE	Institute of Water Resources Economics (MOARD)
IWRP	Institute of Water Resources Planning (MOARD)
IWRR	Institute of Water Resources Research (MOARD)
JICA	Japan International Cooperation Agency (Japan)

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IWRE	Institute of Water Resources Economics (MOARD)
IWRP	Institute of Water Resources Planning (MOARD)
IWRR	Institute of Water Resources Research (MOARD)
JICA	Japan International Cooperation Agency (Japan)

MOAFI	<i>Ministry of Agriculture and Food Industry (Abolished and integrated into the new MOARD)</i>
MOAP	Ministry of Aquatic Products
MOARD (New)	Ministry of Agriculture and Rural Development (Created in October 1995 by the merger of the former Ministry of Water Resources, Ministry of Agriculture and Food Industry and Ministry of Forestry)
MOC	Ministry of Construction
MOCI	Ministry of Culture and Information
MOD	Ministry of Defence
MOE	<i>Ministry of Energy (Abolished and integrated into the new MOID)</i>
MOET	Ministry of Education and Training
MOFI	Ministry of Finance
MOFO	<i>Ministry of Forestry (Abolished and integrated into the new MOARD)</i>
MOFA	Ministry of Foreign Affairs
MOHI	<i>Ministry of Heavy Industry (Abolished and integrated into the new MOID)</i>
MOID(New)	Ministry of Industry (Created in November 1995 by the merger of the former Ministries of Heavy Industry, Light Industry and Energy)
MOJ	Ministry of Justice
MOIT	Ministry of Interior
MOLI	<i>Ministry of Light Industry (Abolished and integrated into the new MOID)</i>
MOLWISA	Ministry of Labour, War Invalids and Social Affairs
MOPH	Ministry of Public Health
MOPI (New)	Ministry of Planning and Investment (Formed from a merger of the former SPC and SCCI)
MOSTE	Ministry of Science, Technology and Environment
MOTC	Ministry of Transport and Communications
MOT	Ministry of Trade
MOWR	<i>Ministry of Water Resources (Abolished and integrated into the new MOARD)</i>
MPAC	Ministrial Project Appraisal Committee
NEA	National Environment Agency
NGO	Non-Governmental Organization
NIAPP	National Institute for Agricultural Planning and Projection
NPAC	National Project Appraisal Committee
OECC	Overseas Environmental Cooperation Centre
OECF	Overseas Economic Cooperation Fund (Japan)
PC	People's Committee (executive arm of the People's Council)

PCC	Power Construction Company (VPC)
PIDC	Power Investigation and Design Company (VPC)
PPC	Provincial People's Committee (City People's Committee = CPC)
SBV	State Bank of Viet Nam
SCCI	<i>State Committee for Cooperation and Investment (Abolished and integrated into the new MOPI)</i>
SFEZ (or SFEA)	Southern Focal Economic Zone (or Southern Focal Economic Area)
SIWRP	Sub-Institute of Water Resources Planning (MOARD-IWRP)
SIWRR	Southern Institute of Water Resources Research (MOARD)
SPC	<i>State Planning Committee (Abolished and integrated into the new MOPI)</i>
SRV	Socialist Republic of Viet Nam
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Education Fund
UNIDO	United Nations Industrial Development Agency
VPC (New)	Vietnam Power Corporation (the former General Company of Electricity of Viet Nam = EVN)
WASECO	Water and Sewerage Construction Company (MOC)
WB	World Bank
WHO	World Health Organization
WPMI (IWRPM)	Water Planning and Management Institute (MOARD)
WRD(or WRS)	Water Resources Department or Water Resource Service (PC)
WSC	Water Supply Company (under Construction Services of the PC)

Note: Abbreviations in *Italics* are no more existent (already abolished and integrated in November 1995).

Measurements

Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer
ft	=	foot
yd	=	yard

Area

cm ²	=	square centimeter
m ²	=	square meter
ha	=	hectare
km ²	=	square kilometer

Volume

cm ³	=	cubic centimeter
l	=	litre
kl	=	kilolitre
m ³	=	cubic meter

Weight

g	=	gram
kg	=	kilogram
ton	=	metric ton

Time

s	=	second
min	=	minute
h	=	hour
d	=	day
y	=	year

Electric Measurements

V	=	Volt
A	=	Ampere
Hz	=	Hertz (cycle)
W	=	Watt
kW	=	kilowatt
MW	=	Megawatt
GW	=	Gigawatt

Other Measures

%	=	percent
PS	=	horsepower
°	=	degree
10 ³	=	thousand
10 ⁶	=	million
10 ⁹	=	billion

Derived Measures

m ³ /s	=	cubic meter per second
kWh	=	Kilowatt hour
MWh	=	Megawatt hour
GWh	=	Gigawatt hour
kVA	=	kilovolt ampere

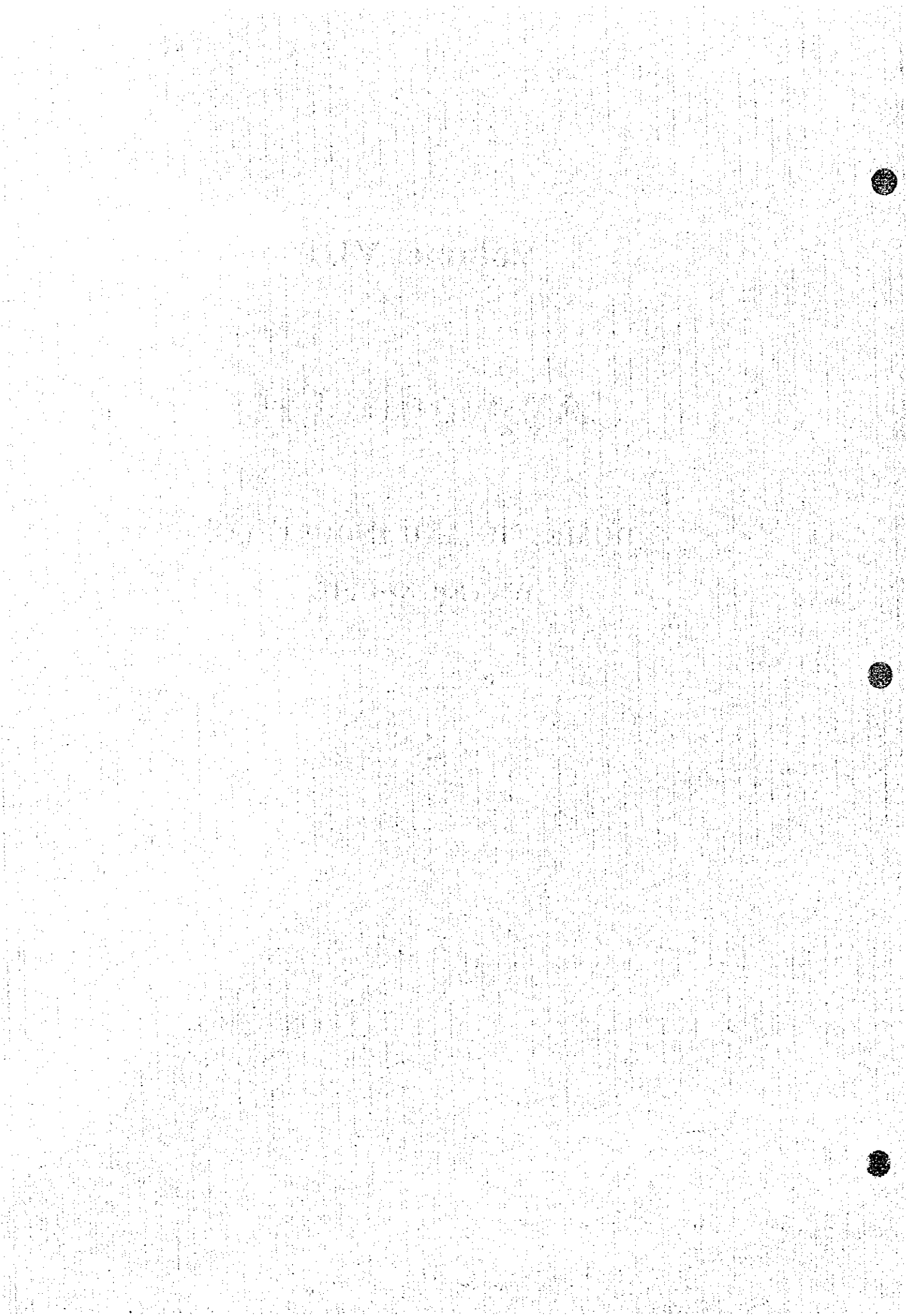
Currencies

US\$	=	US Dollar
VND	=	Vietnamese Dong

Volume VIII

Appendix VII

**DOMESTIC AND INDUSTRIAL
WATER SUPPLY**



APPENDIX VII
Domestic and Industrial
Water Supply

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1. INTRODUCTION

There are one city and nine provinces in the Study Area; Tay Ninh, Song Be, Dac Lac, Lam Dong, Ninh Thuan, Binh Thuan, Ba Ria-Vung Tau, Dong Nai, Ho Chi Minh City and Long An. A comprehensive inventory of existing water supply projects including on-going and planned ones has not well been compiled yet in the Study Area probably due to the fact that water supply projects are implemented on a local government level.

A survey based on hearings and distribution of questionnaires to each of the above nine provinces and one city was carried out in the field work of Phase I to prepare an inventory of water supply projects and to grasp the current water supply situation in the Study Area. In the field work of Phase II, a survey to visit water supply companies of each province in the Study Area was continued not only to confirm the collected information and data on water supply projects, but also to collect data and information necessary for water demand projection and future water balance studies.

As for Ho Chi Minh City, a master plan study on water supply is now being prepared (Draft Final in January 1996) by German Consultant, GKW, with a technical assistance of Asian Development Bank. Several meetings were held with them to make conformity between our study and their master plan. On the other hand, the data and information on the water supply project along National Highway No. 51, which supplies industrial and domestic water to the economic triangle zone, which is the economic development core of southern Viet Nam, were collected from National Corporation of General Construction Consultants (NAGECCO), Ministry of Construction.

As the results of study carried out through the periods of Phase I and II, the water supply project was selected as one of master plan projects as discussed in Appendix X. A further detailed discussion was devoted to this project through the work of Phase III.

As for rural water supply, which is another major work in this water supply study, data and information were collected from UNICEF and the Central Rural Water Supply Project Office in Hanoi. Furthermore, visits were made to the wells drilled with financial assistance of UNICEF. This Appendix VII deals with a development plan of domestic and industrial water supply in the Study Area toward the target year of 2015 including rural water supply on basis of the data and information collected through the field work of Phases I to III.

2. WATER SUPPLY CONDITION IN THE STUDY AREA

2.1 Institution and Service Criteria for Water Supply

The Ministry of Construction (MOC) is responsible for urban water supply and sanitation. Planning and design of water supply projects are managed by the companies such as Design Company for Water Supply and Sanitation Systems (DCWSS) established under the Ministry, whilst construction works of water supply projects is undertaken by its construction companies such as Water and Sewerage Construction Company No. 1 and 2 (WASECO 1 and 2). After the commission of water supply projects, management is in principle transferred to the water company established for each system, even if there is a case where a water company is established for managing a few systems.

A large administrative unit such as Ho Chi Minh City, which has enough capacity in terms of staff and funds, manages domestic and industrial water supply under its responsibility from planning to operation, even if close co-ordination with the Ministry of Construction is maintained.

According to the service criteria, urban water supply is defined as the project to supply domestic, commercial and industrial water to the areas with population more than 15,000, agriculture involvement ratio of less than 25 % in terms of the number of households and population density higher than 100 persons per hectare. On the other hand, water consumption per capita is set at 130 litre/day for domestic supply in the urban area. There is no standard for rural water supply in terms of unit consumption. Hygienic and chemical standard has been established for drinking water. Following the standard, chlorination is made for groundwater, whilst both of mechanical and chemical treatments are applied when raw water is drawn from surface water.

Other ministries related to water supply are the Ministry of Public Health (MOPH) to take care of potable water quality monitoring, the Ministry of Industry (MOID) in charge of groundwater allocation and the Ministry of Agriculture and Rural Development (MOARD) in dealing with the use of surface water for water supply as well as rural water supply.

2.2 Present Condition and Future Plans for Domestic and Industrial Water Supply

2.2.1 Tay Ninh Province

There are nine districts in the administrative area of Tay Ninh province, and present situation and future plans of water supply for those nine districts are summarized in Table 2.1. On the other hand, location of those nine district towns is referred to Figure 2.1.

The water supply and sewerage company established for Tay Ninh district has two water supply projects; one is the project to seek the water source to the Dau Tieng reservoir and the other is the exploitation of groundwater. The former, which supplies with a capacity of 4,000 m³/day, has an extension plan with a capacity of 5,000 m³/day. On the other hand, groundwater collected from eight wells has a supply capacity of 4,500 m³/day (390 m³/hour). Major shackles for the extension of the former are lack of fund sources, implying that extension of the plan will be implemented as soon as funds become available.

Hoa Thanh district has two existing wells with a capacity of 1,200 m³/day, planning an extension of 1,000 m³/day with two wells. Lying 5 km far from Tay Ninh town, Hoa Thanh is planned to be included in the system of Tay Ninh town by installing a connection pipe between two systems.

Trang Bang and Go Dau districts have two wells each with a supply capacity of 900 and 1,000 m³/day respectively, planning to exploit two wells with a supply capacity of 1,000 m³/day each for meeting future demands.

Ben Cau, Chau Thanh, Duong Minh Chau, Tan Bien and Tan Chau districts have no water supply at present, planning to exploit groundwater for domestic use; two wells for Ben Cau with a capacity of 1,000 m³/day, one well for Chau Thanh with a capacity of 500 m³/day, one well for Duong Minh Chau with a capacity of 500 m³/day, one well for Tan Bien with a capacity of 500 m³/day and two wells for Tan Chau with a capacity of 1,000 m³/day.

2.2.2 Song Be Province

There are nine districts in the administrative area of Song Be province (refer to Figure 2.1 for the identification of their district towns) and present situation and future plans of water supply for those nine districts are summarized in Table 2.1.

There exist two water supply companies in Song Be province; one is for Thu Dau Mot district and the other is for Thuan An district. The water supply system in Thu Dau Mot district has a

supply capacity of 12,500 m³/day from two sources. One is groundwater with a capacity of 5,000 m³/day and the other is the treatment of the Saigon River water with a capacity of 7,500 m³/day. After the implementation of the new treatment plant (Saigon River), the water company to manage the system fell in serious financial trouble, since costs to maintain the new plant such as electricity charge for pumping and procurement costs for chemicals increased, but incomes from beneficiaries did not increase due to a high distribution loss of 63 %. This high distribution loss is attributed to the old system built in the 19th Century by French colonial government. What is worse, all the documents to show the water supply distribution system were lost during the Viet Nam war. Taking into consideration the distribution loss mentioned above, the Thu Dau Mot water supply company launched a programme to reduce water loss from the current level of 63 % to 32 % by using an OECF loan.

Thu Dau Mot has two extension plans for the treatment of the Saigon River water; one is a development of 7,500 m³/day as the second stage of the existing plant for the town's use and the other is to exploit 25,000 m³/day for the industrial use in Thuan An town, lying in the southernmost part of the province, some 10 km south-east of Thu Dau Mot.

Water supply in Thuan An town is at present operated by four wells with a total capacity of 3,700 m³/day. For meeting future industrial water demands in Thuan An area, two plans are proposed; one is to receive a supply of 25,000 m³/day from the Thu Dau Mot system as mentioned above and the other is the construction of Tan Ba plant, which treats an amount of 20,000 m³/day by seeking a water source to the Dong Nai River. Since the water supply systems of Thu Dau Mot and Thuan An are connected with the construction of new plant with a capacity of 25,000 m³/day, those two systems are considered as one system. It is noted that the Thuan An area is promised to be developed as the industrial zone in Song Be province to share a part of the economic triangle zone in Southern Viet Nam as given in Figure 2.2.

Three districts, Ben Cat, Binh Long and Loc Ninh, have wells for domestic water supply with a capacity of 1,000 m³/day, 360 m³/day and 500 m³/day, respectively. Binh Long furthermore has an extension plan with a capacity of 5,000 m³/day.

Remaining four districts, Tan Uyen, Dong Phu, Phuoc Long and Bu Dang, have no water supply projects at present, however, a plan is proposed to have a water supply project with a capacity of 5,000 m³/day for Dong Phu, 5,000 m³/day for Phuoc Long and 3,000 m³/day for Bu Dang. It is noted that two towns of Dong Phu and Phuoc Long have rapidly been developed as the construction base camp of Thac Mo hydropower project.

2.2.3 Dac Lac Province

There are 17 districts in Dac Lac province, of which Dak Nong and Dak R'Lap districts are located in the Study Area (refer to Figure 2.1 for the identification of their district towns). Due to sparse population and mountainous terrain, there is a small scale water supply system with a capacity of 700 m³/day in Dak Nong district (refer to Table 2.1), but will be abandoned due to the fact that the stream source to draw water is polluted with sewerage from the precious stone processing factories. A new water source will therefore be sought to some 10 km far springs, which were once used as a water source of the US Army camp. The system will be built within a few years with a capacity of 1,000 m³/day. It is noted that Dak Nong will be the provincial town of the province to be formed by splitting parts of Dac Lac and Song Be provinces. No systematic water supply projects are planned for Dak R'Lap district.

2.2.4 Lam Dong Province

There are ten districts in the administrative area of Lam Dong province (refer to Figure 2.1 for the identification of their district towns), and present situation and future plans of water supply for those ten districts are summarized in Table 2.1.

Da Lat, which is the largest town in hill area of the Study Area, has a water supply project with a capacity of 27,000 m³/day relying on the Suoi Vang reservoir water. This project has an extension plan to exploit another 42,000 m³/day for meeting the future growing demands by the year 2005. Besides the Suoi Vang reservoir, there were two stand-by reservoirs for water supply, Xuan Huong reservoir and Than Tho reservoir but were abandoned for use due to pollution. Thus, the water source for the Thien Huong treatment plant with a capacity of 6,000 m³/day and for the Than Tho treatment plant with a capacity of 4,000 m³/day was changed to the Suoi Vang reservoir.

Distribution loss in the water supply system of Da Lat was as high as 41 % in the year 1991 mainly due to broken pipes, stolen water and improper management and billing system. A notable improvement of 28 % was recorded in distribution loss of water supply in the year 1994 by carrying out the following measures.

To detect broken pipes, venture meters were placed on main and branch distribution pipes. As countermeasures for stolen water, water meters were installed to each user. Furthermore, not only the new installation of water meters, which are reliable in metering, improved bad management in water bill collection, but also the billing system by meter reading encouraged the necessity of saving water to users.

The improvement of distribution loss of water supply from 41 % in the year 1991 to 28 % in the year 1994 is equivalent to the new development of 3,250 m³/day (25,000 m³/day x (0.41-0.28)). This implies that considerable amounts of costs required for the development of drinking water can be saved, even if patient work is necessary for the management body in reducing distribution loss.

Water quality at the outlet of treatment plant maintains the international standard. Due to broken pipes, water from sewers and toilets contaminates in the distribution system of water supply, resulting in the deterioration of drinking water in quality at the consumers' end.

The improvement of distribution system of water supply is thus important in terms of both of quality and quantity. The challenge to improve distribution loss in the water supply system by Da Lat Water Supply Company will encourage other water supply companies, which now suffer from high distribution loss, falling in financial difficulties.

Four districts, Bao Lam, Di Linh, Duc Trong and Lac Duong, have a water supply system, relying on groundwater for the first three and springs for the last. Bao Lam and Duc Trong have an existing supply with a capacity of 3,020 m³/day and 1,040 m³/day, and furthermore an extension plan with a capacity of 7,000 m³/day and 2,160 m³/day, respectively. Remaining five districts, Cat Tien, Da Teh, Da Huoi, Don Duong and Lam Ha, in the province have no water supply project, but Lam Ha is expected to implement a new project with a capacity of 1,000 m³/day.

2.2.5 Ninh Thuan Province

There are four districts in the administrative area of Ninh Thuan province (refer to Figure 2.1 for the identification of their district towns), and present situation and future plans of water supply for those four districts are summarized in Table 2.1.

Of four districts, only Phan Rang-Thap Cham district has water supply projects with a total capacity of 2,000 m³/day; 1,200 m³/day from groundwater and 800 m³/day from Thap Cham plant. To meet the future growing demand, construction of the new Thap Cham plant is under way with a development capacity of 12,000 m³/day and with a future extension of 12,000 m³/day. The operation of existing wells and Thap Cham plant was planned to be stopped after the completion of first phase of new Thap Cham plant, but is to be continued with a rehabilitation programme.

Ninh Chu, which is the administrative and tourist centre in Ninh Hai district, and Dong Hai in Phan Rang - Thap Cham district will be included in the Phan Rang-Thap Cham water supply system after the completion of the first phase of new Thap Cham plant. Remaining two

districts, Ninh Son and Ninh Phuoc, have neither existing nor planned water supply projects at the moment.

2.2.6 Binh Thuan Province

There are nine districts in the administrative area of Binh Thuan province (refer to Figure 2.1 for the identification of their district towns), and present situation and future plans of water supply for those nine districts are summarized in Table 2.1.

Drinking water of Phan Thiet district, where groundwater is poor in quantity and quality due to brackish water, is supplied after treatment for water drawn from the Phu Hoi reservoir. Present supply capacity from the reservoir is 15,000 m³/day with flow decrease in the dry season. Thus, the district has a plan to augment the flow decrease for water supply especially in the dry season by drawing water from the Quao reservoir, which is built for irrigation. In fact, water is drawn from the Quao reservoir for treatment by using the irrigation canal through the dry season of the year 1995 with no rainfall days continued for three months. For the permanent use, facilities such as pipeline, treatment plant and primary pumping station will be constructed with a capacity of 12,000 m³/day.

Ham Tan district has a water supply project with a capacity of 1,500 m³/day, which will be raised to a level of 5,000 m³/day to meet future growing demands by splitting into two phases; 500 m³/day in the first phase and 3,000 m³/day in the second phase. Bac Binh, which supplies domestic water with a capacity of 800 m³/day, has an extension plan with two phases; 1,600 m³/day in the first phase and 2,600 m³/day in the second phase.

In Tuy Phong district, there are two major towns; Phan Ri Cua, the second largest town in Binh Thuan province, and Lien Huong, district town. Lien Huong town has domestic water supply with a capacity of 600 m³/day, whilst Phan Ri Cua has abandoned the wells with a capacity of 450 m³/day due to salinity intrusion, resulting in the system connection with Bac Binh. An 8 km long pipeline is under construction to link two supply systems. Expected amount to be sent to Phan Ri Cua is 800 m³/day, a half of Bac Binh Extension (1).

Remaining five districts, Ham Thuan Nam, Thanh Linh, Duc Linh, Ham Thuan Bac and Phu Quy, have no systematic water supply projects at present, but first four districts except for Phu Quy will supply domestic water to their urban areas by the year 2000.

2.2.7 Ba Ria-Vung Tau Province

There are five districts in the administrative area of Ba Ria-Vung Tau province (refer to Figure 2.1 for the identification of their district towns), and present situation and future plans of water supply for those five districts are summarized in Table 2.1.

The water supply system for Ba Ria-Vung Tau district has a supply capacity of 33,000 m³/day at present; 20,000 m³/day from the Dinh River and 13,000 m³/day from groundwater. As future plans, there is an extension plan of the Dinh River with a capacity of 10,000 m³/day and has a new development plan of Da Den reservoir with a total capacity of 100,000 m³/day. This extension plan is proposed to meet not only domestic demands including the Phuoc Tinh and Long Hai tourist zones but also industrial demands in the Long Huong, Long Son, Ben Dinh and Phuoc Thang zones (refer to Figure 2.2). Furthermore, when the Dinh River treatment plant is extended, Long Dien, district town of Long Dat district, and two other towns in Long Dat, Dat Do and Phuoc Hai, will be included in the Ba Ria - Vung Tau water supply system.

Phuoc Buu, district town of Xuyen Moc district, has no water supply project at present, but will develop a capacity of 3,000 m³/day by the year 2000 by seeking two water sources; 1,000 m³/day for groundwater and 2,000 m³/day for Phuoc Buu weir. Another 2,000 m³/day will be developed by extending the Phuoc Buu weir by the year 2010.

Phu My, district town of Tan Thanh, has an existing water supply with a capacity of 600 m³/day. To meet growing future demands especially for industry, the town will exploit groundwater with a capacity of 15,000 m³/day by the year of 1997. The system will raise the total capacity level to 240,000 m³/day by the year 2010 especially for securing cooling water of Phu My thermal plant. One of the most promising water sources for meeting such large demand (240,000 m³/day) will be the Dong Nai River by drawing water from Thien Tau with a long pipeline along with the Song Ray reservoir, which is discussed in more detail in subsequent Section 4.2. On the other hand, a steel company has a plan to exploit an amount of 20,000 m³/day for its exclusive use by seeking water sources to two local rivers, the Chau Pha and Sao rivers. The construction works for the project is expected to commence in the year 1996. It is noted that Phu My electric power plant will be built by two phases; the first phase selects gas turbine and the second phase chooses coal-fired plant requiring much cooling water.

Ngai Giao, district town of Chau Duc district, has no water supply project at present, but plans to exploit a capacity of 2,000 m³/day by seeking a water source to springs by the year 2000.

2.2.8 Dong Nai Province

There are nine districts in the administrative area of Dong Nai province (refer to Figure 2.1 for the identification of their district towns), and present situation and future plans of water supply for those nine districts are summarized in Table 2.1. It is noted that Long Khanh is a new district born by dividing Xuan Loc into two, whilst Nhon Trach is divided from Long Thanh.

Domestic water in Bien Hoa district is supplied from the Thien Tan treatment plant with a capacity of 36,000 m³/day and groundwater with a capacity of 480 m³/day. To meet the growing demand, the extension of Thien Tan plant with a capacity of 100,000 m³/day is under construction with the expected commission year of 1997. Industrial development in the Bien Hoa area is expected to spur with the commission of the new Thien Tan water plant, but will require further development of water for its full scale achievement as a further development of 300,000 m³/day is planned. Tam Phuoc is a new town to be born with the development progress of Tam Phuoc industrial zone (refer to Figure 2.2). Future water demands will be supplied from the Dong Nai River as the extension of Bien Hoa water supply system.

Four districts, Long Thanh, Xuan Loc, Vinh Cuu and Tan Phu, have only a small scale water supply system with a capacity of some hundreds m³/day, although Xuan Loc has a plan to newly construct a treatment plant with a capacity of 2,400 m³/day. Long Khanh has a supply capacity of 5,000 m³/day, planning to develop another 5,000 m³/day. Remaining three districts, Nhon Trach, Thong Nhat and Dinh Quan, have no water supply project at the moment, but Nhon Trach, which is a real new-born town, is promised to be developed as the centre of Nhon Trach industrial estate.

2.2.9 Ho Chi Minh City

There are 18 districts in the administrative area of Ho Chi Minh City (refer to Figure 2.1 for the identification of their district towns), and present situation and future plans of water supply for those 18 districts are summarized in Table 2.1.

Water supply for 12 urban districts, Thu Duc district, and parts of Binh Chanh and Nha Be districts, is at present managed by two water supply companies; Ho Chi Minh City Water Supply Company and Saigon Water Company. The latter company supplies potable water to two districts, District 6 and District 8. The former handles the water supply of remaining 13 districts. Furthermore, the service area of the former company includes the industrial zone in Bien Hoa (Dong Nai province) with a capacity of 30,000 m³/day.

Present water supply capacity for the management area of the said companies is 680,000 m³/day; Dong Nai River water treatment of 650,000 m³/day and groundwater of

30,000 m³/day. There are three plans to extend the supply capacity for meeting the growing water demand; one is the extension of Hoa An intake, in which 100,000 m³/day is developed by the year 1997 as urgent work, and further developments of 350,000 m³/day and 400,000 m³/day will be sought by the year 2000 and 2010, respectively. Another is the new construction of treatment plant at Phu Cuong by drawing the Saigon River water with a capacity of 300,000 m³/day in the first phase, and the final development target of the plant will be 900,000 m³/day by the year 2010.

The other is the Binh An project, which draws the Dong Nai River water for treatment with a development capacity of 100,000 m³/day by the year 1997 and another 50,000 m³/day development by the year 2000. This Binh An is promoted as a solicited BOT (Build-Operate-Transfer) project by a Malaysian private company.

Drinking water for Hoc Mon district, of which water company is independent of that of Ho Chi Minh City, is supplied with groundwater. Supply capacity stays at a level of 20,000 m³/day at present and will increase to a level of 100,000 m³/day by the year 2000. Cu Chi district has three wells with a capacity of 2,880 m³/day for domestic supply. For future demand growth, drilling of two other wells is expected with a capacity of 2,400 m³/day. Domestic water for Can Gio district, where no systematic supply exists at present, is supplied with shallow wells, drills, roof catchment and so on depending on the local condition.

The water supply system in Ho Chi Minh City will extend from the present supply area to the entire area of 17 districts including Can Gio district distant from the system centre and excluding Cu Chi district. Water for Cu Chi district will be supplied from the east canal of the Dau Tieng irrigation project, whilst Can Gio district, where fresh water is scarcely available due to the location lying near the estuary of the Dong Nai River, is included in the system with public stands.

2.2.10 Long An Province

There are 14 districts in the administrative area of Long An province. Of them, all or some part of nine districts is included in the Study Area. Since seven district towns, Can Duoc, Tan Tru, Can Giuoc, Ben Luc, Duc Hoa, Duc Hue and Thu Thua, of those nine districts (refer to Figure 2.1) lie in the east bank of the West Vam Co River, discussion of water supply is thus made for those seven districts in this study. Tan An district, which has the administration office of the province, lies out of the Study Area.

The seven districts in the Study Area have a small scale water supply system with a capacity of hundreds to one thousand m³/day mostly relying on groundwater as summarized in Table 2.1. Long An province has a plan to drill wells with a capacity of 1,000 m³/day within a few years

besides the existing wells for such districts as Tan Tru, Can Giuoc, Duc Hue and Thu Thua with rather small supply capacity except for Duc Hoa where private wells are well developed for local use. In Duc Hoa district, there are, in fact, three major urban areas, Duc Hoa, Hiep Hoa and Huu Nghia, of which Duc Hoa and Huu Nghia have water supply with a capacity of 200 and 300 m³/day, respectively.

2.3 Future Balance for Domestic and Industrial Water Supply

Present water supply conditions of nine provinces and one city in the Study Area were discussed in preceding Section 2.2, and were concluded that water supply in the Study Area stays at a primary stage in development. In making future development plans of water supply projects, future balance between water supply capacity and demand shall be calculated for all the areas to be defined as urban in the district and major towns of the Study Area.

Population growth rates and water consumption rates, which are the base to predict water demands in future by urban centre, mainly district town, were estimated through the field work of Phase II. Table 2.2 summarizes the estimate of population growth rates for nine provinces and one city. For Tay Ninh province, annual growth rates of population are estimated by relying on population data in the year 1989 and 1994. Two districts, Tan Bien and Tan Chau, which have no areas to be defined as urban in the year 1989, are predicted by taking the average value of four districts in the province with 1989 and 1994 population data.

In Song Be province, Thu Dau Mot, which is the only town to have urban population in both the year 1989 and 1994, shows a high annual growth rate of 5.01 % due to the rapid introduction of industry, which induces the migration of people seeking jobs from others areas, called mechanical increase. Thuan An, which is promised to be developed as another industrial centre in Song Be province and is composed of Di An and Lai Thieu urban areas, is assumed to have the same population growth rate of 5.01 % a year as that of Thu Dau Mot. Since the population growth rate in the province is estimated to be in a range of 1.6 % to 2.0 %, a rate of 2.0 % is applied for two districts, Tan Uyen and Ben Cat, lying near Thu Dau Mot, whilst a lower rate of 1.6 % for three districts, Binh Long, Loc Ninh and Bu Dang, lying in the remote areas. Dong Phu and Phuoc Long are rapidly being developed as the construction base camp of Thac Mo hydropower project. Relying on the information that Dong Phu will reach 25,000 people in the year 2000, a rate of 8.89 % is applied for both towns.

In Dac Lac province, Gia Nghia of Dak Nong district, which will be the provincial town of the new province, is estimated to reach a population of 8,302 in the year 2000, of which a total of 5,302 is induced from natural increase by applying an annual population growth rate of 2.68 % and that another 3,000 people migrate as the employees of the provincial government.

The number of 3,000 is estimated from the number of public servants in Buon Ma Thuot, provincial town of Dac Lac, which would have the same scale as a provincial town. The population in the year 2001 onwards is estimated on basis of the predicted growth rate of 2.44 % per year and the number of 8,302 in the year 2000. On the other hand, Dak R'Lap is estimated to have no urban population.

Annual growth rates of population in Lam Dong province are estimated by using 1989 and 1992 population data. Lac Duong is estimated to have no urban population. In Ninh Thuan province, population growth rates are projected by the data mentioning that the population of Phan Rang-Thap Cham urban area will reach 95,122 in the year 2000 from 71,111 in the year 1989. Future populations in Binh Thuan province are projected by relying on the current growth rate inferred at 2.68 %, since population data to estimate the future population growth rate are not available.

Major towns and cities except for Phuoc Buu and Ngai Giao, district towns of Xuyen Moc and Chau Duc districts respectively, in Ba Ria-Vung Tau province are developing with the progress of industrial zones to be developed along National Highway No. 51 and tourist zones to be developed along the Vung Tau coast area. This implies that future populations in these areas should not be projected from the past trend, but from the development plan of industrial zones (refer to Table 2.3 and Figure 2.2). Populations of major towns in Ba Ria-Vung Tau province are in fact projected in the year 2000 and 2010 based on the development plan of industrial zones as given in Table 2.2. In the Vung Tau tourist zone, the number of tourists to come is also projected in the years 2000 and 2010 by splitting into domestic and foreign tourists. It is noted population growth rates given in the parentheses are estimated based on 1989 and 2000 population data as a reference.

Four towns, Bien Hoa, Tam Phuoc, Long Thanh and Nhon Trach, in Dong Nai province are developing as the residential areas of industrial zones to be developed along National Highway No. 51 (refer to Table 2.3 and Figure 2.2). As did in the major towns and cities of Ba Ria-Vung Tau province along National Highway No. 51, future populations of these four towns in the year 2000 and 2010 are projected based on the development plan of industrial zones. For other six district towns, population growth rates are estimated based on the projected 1995 and 2000 data. It is noted that population growth rates given in parentheses are estimated based on the 1989 and 1995 population data as did in Ba Ria-Vung Tau province.

Of 18 districts, 17 districts except for Cu Chi are treated as one area for water supply in Ho Chi Minh City, since its water supply system plans to cover the entire area of those 17 districts. A rate of 2.46 %, which is officially approved, is applied for the estimate of future population, even if population data in the year 1989 and 1995 show a higher rate of 3.16 %. It is noted that unregistered population, estimated in the range of 200,000 to 270,000, is not included for the estimate of population growth rate due to the fact that water consumption by unregistered

people is minimal. A rate of 2.47 %, gained by using the 1989 and 1995 population data, is applied as the population growth rate of Cu Chi district.

Urban population growth rates of three districts, Ben Luc, Duc Hoa and Thu Thua, in Long An province are estimated based on the 1989 and 1994 population data. In Duc Hoa district, three towns, Huu Nghia, Hiep Hoa and Duc Hoa, are treated as one urban area for the estimate of population growth rate. For the remaining districts, Can Duoc, Tan Tru, Can Giuoc and Duc Hue, where 1989 population data are not available or negative population growth rates are observed, an average population growth rate of the above three districts is applied.

Based on the population growth rates so estimated for the urban areas of nine provinces and one city in the Study Area as given in Table 2.2, future populations of those areas are projected for both years of 2000 and 2015 as summarized in Table 2.4. It is noted that population in the year 2015 for three towns, Bien Hoa, Long Thanh and Nhon Trach, in Dong Nai province is estimated with an annual increase rate obtained by relying on the 2000 and 2010 projected population data.

Necessary conditions for water demand projection by urban area other than population data, i.e. water consumption rates, aerial service rates, other uses and loss rates, are estimated based on the results obtained through hearings to each water supply company as shown in Table 2.5. The aerial service rate is defined as the rate of the number of beneficiaries to receive water supply to total people in the urban area.

Other uses include industrial, commercial and public uses, which show as the rate to domestic use. Industrial use covers both of small and concentrated industrial consumption. However, industrial water demand for Thuan An in Song Be province, Tan Thanh in Ba Ria - Vung Tau province, Bien Hoa and Nhon Trach in Dong Nai province and Cu Chi in Ho Chi Minh City is estimated based on the development plan of industrial estates shown in Table 2.3. Meanwhile, tourist demand for Vung Tau in Ba Ria - Vung Tau province is projected separately from commercial use. When no figure is given for public use, such demand is included in commercial use.

Future water demand for the urban areas of nine provinces and one city in the Study Area is estimated in the year 2000 and 2015 as summarized in Table 2.6 based on the projected population given in Table 2.4 and the conditions necessary for water demand projection shown in Table 2.5, reaching a level of 1.6 million m³/day in the year 2000 and 4.3 million m³/day in the year 2015 as the total of the Study Area. As for HCMC, the demand will grow to a level of 1.0 million m³/day in the year 2000 and 2.1 million m³/day in the year 2015. The industrial development area along National Highway No. 51 including such towns as Bien Hoa, Tam Phuoc, Long Thanh and Nhon Trach in Dong Nai province and Vung Tau, Ba Ria, Long Son, Long Hai, Phuoc Tinh, Long Dien, Dat Do, Phuoc Hai and Phu My in Ba Ria - Vung Tau

province will need to develop domestic and industrial water with an amount of 0.4 million m³/day by the year 2000 and 1.7 million m³/day by the year 2015 as summarized below:

Province	District and Major Towns	Water Demand, m ³ /day	
		2000	2015
Dong Nai	Bien Hoa	158,000	353,487
	Tam Phuoc	20,895	243,938
	Long Thanh	3,803	15,103
Ba Ria-Vung Tau	Nhon Trach	55,440	368,776
	Vung Tau	65,122	270,275
	Ba Ria	11,393	61,383
	Long Son	3,675	14,871
	Long Hai	4,594	15,215
	Phuoc Tinh	3,675	10,897
	Long Dien	5,145	14,990
	Dat Do	5,145	14,990
	Phuoc Hai	2,756	9,785
	Phu My	83,950	330,704
	Total	423,593	1,724,414

For future water demand predicted as given Table 2.6, present water supply capacity including future plans for extension is summarized as given in Table 2.1. The balance between them is computed as deficit to be developed as given in Table 2.7, requiring an amount of 0.22 million m³/day by the year 2000 and 1.13 million m³/day by the year 2015 as the sum of the Study Area.

In this water balance study, a few to several towns in a province are treated as one water supply system as follows:

Province	Towns in a System
Tay Ninh	Tay Ninh and Hoa Thanh
Song Be	Thu Dau Mot, Di An and Lai Thien
Ninh Thuan	Phan Rang, Thap Cham, Ninh Chu and Dong Hai
Binh Thuan	Bac Binh and Phan Ri Cua
Ba Ria - Vung Tau	Vung Tau, Ba Ria, Long Son, Long Hai, Phuoc Tinh, Long Dien, Dat Do and Phuoc Hai
Dong Nai	Bien Hoa and Tam Phuoc

It is noted that the towns and cities developed along Natural Highway No. 51 would seek a water source to the Dong Nai River along with water sources available in and around the area as a system.

In HCMC, there are several proposed projects to develop domestic and industrial water as listed in Table 2.1. If all the projects listed are developed, the supply capacity will far exceed the demand. Taking into consideration this situation, following schemes are assumed to be developed to meet water demand in HCMC by the year 2000 and 2015:

Development Year	Project	Development Amount, m ³ /day
by 2000	Hoa An Rehabilitation	100,000
	Hoa An Extension	150,000
	Bin An Under-construction	50,000
	Phu Cuong Under-construction	300,000
	Hoc Mon Groundwater	20,000
	Total	620,000
by 2015	Hoa An Extension	600,000
	Bin An Extension	100,000
	Total	700,000

The last interest on the domestic and industrial water development in the Study Area is to estimate the construction cost to be invested by the year 2000 and 2015. Table 2.8 summarizes the cost to be invested for the domestic and industrial water development in the Study Area, requiring an amount of US\$ 337 million by the year 2000 and US\$ 683 million between the year 2000 and 2015. HCMC will need an investment of US\$ 160 million by the year 2000 and US\$ 190 million by the year 2015, whilst US\$ 99 million by the year 2000 and US\$ 353 million by the year 2015 for the towns and cities along National Highway No. 51 from Bien Hoa to Vung Tau as summarized below:

Province	District and Major Towns	Investment Cost, million US\$	
		2000	2015
Dong Nai	Bien Hoa and Tam Phuoc	35.6	115.3
	Long Thanh	0.8	3.6
	Nhon Trach	14.0	92.3
Ba Ria-Vung Tau	Ba Ria, Vung Tau and others ¹⁾	27.5	67.5
	Phu My	20.8	74.0
	Total	98.7	352.7

Note: ¹⁾ Others include Long Son, Long Hai, Phuoc Tinh, Long Dien, Dat Do and Phuoc Hai.

The cost estimated in this computation includes not only for the investment for the planned projects, but also for the projects to be developed for meeting deficit as defined as development amount in Table 2.8. The selection of water source, i.e. surface water or groundwater, is based on the information given in Table 2.1. Unit price for surface water development is assumed at US\$ 250/m³, in which cost for the development of distribution system is not included. For groundwater development, unit price varies in a range of US\$ 500/m³ to US\$ 1,000/m³ relying on availability of groundwater; that is, US\$ 500/m³ in the low-lying area where ample groundwater is available, whilst US\$ 1,000/m³ in high land area where rich aquifer is less available (refer to Appendix II). Some cost for the distribution system is included in this groundwater development, since the development of small water supply system relying on groundwater inevitably needs to involve the development of distribution system.

3. WATER SUPPLY FOR THE ECONOMIC TRIANGLE ZONE

3.1 Sources for Water Supply

An area, which includes HCMC and the corridor between Bien Hoa and Vung Tau along with the southern part of Song Be province, i.e. Thu Dau Mot and Thuan An, is emerged as a locomotive to propel economic development of the nation, called the economic triangle zone. Future water demands of the area in the year 2015 are projected by district or town as given in Table 2.6, reaching a level of 3.8 million m³/day as summarized below:

Area	Water Demand in 2015, m ³ /day
<u>Song Be Province</u>	
1. Thu Dau Mot-Thuan An	90,000
<u>Ba Ria-Vung Tau Province</u>	
2. Ba Ria Vung Tau including nearby towns	410,000
3. Go Dau-Phu My-Thi Vai	330,000
<u>Dong Nai Province</u>	
4. Bien Hoa-Ho Nai	350,000
5. Tam Phuoc-An Phuoc	240,000
6. Nhon Trach-Long Thanh	380,000
<u>Ho Chi Minh City</u>	
7. 17 Districts	2,000,000
Total	3,800,000

Sources for the water supply systems of the above towns and cities are mainly sought to the Dong Nai River and the Saigon River, even if there are alternative sources such as groundwater and local rivers.

Table 3.1 shows a summary of development requirement to seek water sources to the Dong Nai River and the Saigon River to meet the above mentioned demand in the said area in the year 2015 under the condition that the existing and planned projects given in Table 2.1 are under operation. It indicates that an amount of 3,187,000 m³/day equivalent to 36.8 m³/sec is sought to the Dong Nai River, whilst 940,000 m³/day (10.9 m³/sec) for the Saigon River.

As discussed in preceding Section 2.3, an amount of 300,000 m³/day is sought to be developed at Phu Cuong of the Saigon River as a water source of the HCMC water supply. On the other hand, water intake sites in the Dong Nai River are congested around the Hoa An area. That is to say that another intake site, Bin An, for the HCMC water supply lies just downstream of Hoa An and that the intake site for the water supply project along National Highway No. 51 including Bien Hoa, Thien Tan, is located some 30 km upstream of Hoa An in the Dong Nai River. To avoid such congestion, diversification of water sources is strongly sought to the water supply projects of HCMC. In this context, it is suggested that another

600,000 m³/day development at Phu Cuong of the Saigon River, i.e. 900,000 m³/day in total, be secured as a water right (refer to Table 2.1). On the other hand, there are the Song Ray and other reservoirs besides the Dong Nai River as alternative sources of water supply to the major towns along National Highway No. 51 in Ba Ria-Vung Tau province (refer to subsequent Section 4.3), but those are also suggested to be excluded in computing water amount to be secured (water right) to the Dong Nai River as a source of water supply projects. Taking into account the above facts, following amount is given as the boundary condition of the Dong Nai and Saigon rivers at Hoa An and Phu Cuong respectively for the optimal water allocation study of the Dong Nai River as discussed in Appendix X:

River	Site	Requirement, m ³ /sec
Dong Nai	Hoa An	36.8
Saigon	Phu Cuong	10.9

That is to say that water supply projects for HCMC and the corridor towns along National Highway No. 51 are proposed as the candidates of master plan projects to be selected in the optimal water allocation study. Taking into consideration the fact that drinking water is one of crucial elements in daily life, supply of domestic and industrial water to these two areas is treated as the condition to absolutely meet in the water allocation, i.e. boundary condition in the water allocation model, but this does not necessarily imply that all the amount of 36.8 m³/sec for the Dong Nai River and 10.9 m³/sec for the Saigon River is developed for the two areas without fail; that is, the amount is secured as the right for the two areas.

It is true that the Dong Nai River has ample flow. However, there might be a chance that the requirement of 36.8 m³/sec for the Dong Nai River as mentioned above could not be met, if any water is not released from the Tri An and Thac Mo reservoirs in the operation of hydropower generation. Thus, it would be an urgent task to establish a rule for the release of water from the reservoirs among the ministries concerned. Further discussions of the management system for the water resources development of the Dong Nai River basin are given in Appendix X.

As discussed in preceding Chapter 2, water supply projects of district and major towns in the Study Area stay at a level relying on groundwater as a water source even if demands are growing rapidly. This results in excluding those water supply projects from the candidates of the optimal water allocation study; that is, those are not candidates for the master plan projects.

3.2 Water Intake and Salinity Intrusion

A comprehensive study to investigate salinity intrusion in the Dong Nai, Saigon and Vam Co rivers is undertaken as discussed in Appendix IX to secure maintenance flow, which can keep the salinity concentration lower than the standard stipulated in the code of drinking water. According to the Vietnamese standard, the salinity concentration of drinking water is stipulated to be lower than 0.25 g/l.

The study of salinity intrusion recommends to secure a maintenance flow of 100 m³/sec at Hoa An of the Dong Nai River and 25 m³/sec at Thu Dau Mot (Phu Cuong) of the Saigon River. With these flows, salinity concentration is kept at 0.25 g/l or less for both the Dong Nai River and the Saigon River. Thus, in terms of salinity concentration, suitable raw water for drinking can be secured at the existing and proposed intake sites of the Dong Nai and Saigon rivers.

3.3 Waste Water and Sewerage

As summarized in preceding Section 3.1, water demands in HCMC and the corridor area between Bien Hoa and Vung Tau along with the southern part of Song Be province will reach a level of 3.8 million m³/day in the year 2015. Domestic and industrial water is not substantially consumed through use, since those water is mainly used for bathing, cloth washing, industrial processing and so on. This implies that water with an amount of more or less 3.8 million m³/day used for domestic and industrial purposes is returned to the rivers with degraded quality, thus being required treatment.

Appendix VIII discusses the present situation of sewerage works in HCMC, telling the city has combined sewer systems with a total length of 661.6 km, but most of domestic sewage and waste water is released to the rivers without any treatment. If the present condition, i.e. no treatment for waste water, continues even with increase of domestic water demands in future, it is quite easy to expect that riverine and estuarine environment deteriorates tremendously, causing menace to the healthy life of human being as well as to the eco-system in the lower reaches of the Dong Nai River.

It is not realistic to recommend to build extensive sewer systems with sewage treatment judging from the present situation in HCMC. However, based on the argument that such systems are necessary to protect natural environment as well as to keep social amenities as basic human needs, a proposal here is to install waste water treatment plants to the industrial development zones where release of waste water is concentrated with the lower quality than that of domestic sewage. It is moreover proposed that installation of the sewage system with treatment be

carried out simultaneously when the water supply project is implemented for industrial zones as one package project.

The industrial waste water, which requires treatment in HCMC and the corridor area along with the southern part of the Song Be province, is read to be 0.7 million m³/day in the year 2000 and 1.7 million m³/day in the year 2015 from Table 2.6 under the condition that water is not consumed through use, and is summarized as follows:

City/Province	District and Major Towns	Treatment Demand of Industrial Waste, m ³ /day	
		2000	2015
HCMC	17 districts	420,200	842,600
Dong Nai	Bien Hoa	90,500	157,000
	Tam Phuoc	18,900	130,100
	Long Thanh	900	3,500
	Nhon Trach	39,800	185,100
Ba Ria-Vung Tau	Vung Tau	31,800	126,600
	Ba Ria	6,700	36,300
	Long Son	2,200	8,800
	Long Hai	2,700	9,000
	Phuoc Tinh	2,200	6,400
	Long Dien	3,000	8,900
	Dat Do	3,000	8,900
	Phuoc Hai	1,600	5,800
	Phu My	64,500	143,700
Total		688,000	1,672,700

If the unit price for constructing a waste water treatment plant is assumed at US\$ 1,500 per m³, an amount of US\$ 1,030 million and US\$ 2,510 million shall be invested for waste water treatment by the year 2000 and 2015 respectively.

4 WATER SUPPLY MASTER PLAN PROJECT

4.1 Strategies for Water Source Development

As discussed in Appendix X, the water supply project along National Highway No. 51 is selected as one of master plan projects out of two water supply candidates, i.e. HCMC water supply project together with this project (refer to Section 3.1), since the master plan study for the former is now being carried out by using the funds of the Asian Development Bank. The project along National Highway No. 51 covers an area stretching between Bien Hoa and Vung Tau with a distance of some 85 km. This Chapter deals with the water supply project along National Highway No. 51 in more detail.

Water demand centres in this area are divided into five based on the industrial development plan. Following show the five demand centres (refer to Figure 4.1) with their water demands in the year 2000 and 2015 respectively (refer to Section 2.3):

Name of demand centre	Industrial areas included in the demand centre	Water demand in the centre, m ³ /day	
		2000	2015
1. Bien Hoa	Bien Hoa and Ho Nai	158,000	354,000
2. Tam Phuoc	Tam Phuoc and An Phuoc	21,000	244,000
3. Nhon Trach	Nhon Trach and Long Thanh	59,000	384,000
4. Phu My	Go Dau, Phu My and Thi Vai	84,000	331,000
5. Vung Tau	Ba Ria, Vung Tau and nearby towns	102,000	412,000
	Total	424,000	1,725,000

The first task to prepare a concrete development plan for the project is to list up development alternatives made by combining several water sources available in the vicinities so as to meet the water demands of each centre for the time horizon up to the year 2015. The second task is to select the optimal alternative from among the development alternatives as the development plan of the water supply project along National Highway No. 51. Following discuss the water sources available for the project as well as the selection of the development plan from among the alternatives conceived.

4.2 Water Sources

4.2.1 Groundwater

QII-III, Q1 and N2 aquifers are estimated to be promising as a groundwater source along National Highway No. 51 with support of ample rainfall of more or less 2,000 mm/year on an

average as discussed in Appendix II. It is considered to be possible to abstract an amount of more or less 10,000 m³/day from one groundwater potential site as a measure to meet immediate demand or a "make-up" measure.

Development potential of groundwater in the area is estimated by demand centre as follows:

Name of demand centre	Development potential of groundwater, m ³ /day
1. Bien Hoa	-
2. Tam Phuoc	25,000 to 35,000
3. Nhon Trach	55,000
4. Phu My	25,000
5. Vung Tau	35,000 (including 20,000 m ³ /day already exploited)

4.2.2 Reservoir Projects

There are several rivers with a catchment area of tens to hundreds km² in the project area such as the La Buong, Ca, Phuoc Thai, Da Den and Ray rivers as shown in Figure 4.2. For each of those rivers, reservoir projects are proposed for irrigation and water supply as summarized in Table 4.1, and their location is referred to Figure 4.2.

La Buong reservoir

La Buong reservoir, the development stage of which is under the master plan level, to be built in the La Buong River will be used as a water source of the Tam Phuoc demand centre. The development capacity of the La Buong reservoir for water supply is estimated at 220,000 m³/day by simulating a 10-year drought runoff for the proposed Full Supply Level (FSL) of E1. 50.0 m and Minimum Operation Level (MOL) of E1. 48.0 m, which are determined based on the available 1 to 50,000 scale topographic map. A preliminary geological study for the proposed dam suggests insufficient bearing strength and high permeability from the foundation, thus recommending the construction of earth-fill type dam (refer to Appendix II). A preliminary development plan of the La Buong reservoir is given in Figure 4.3.

Song Ca-1 and Song Ca-2 reservoirs

Two reservoirs, Song Ca-1 and Song Ca-2, both of which are under the master plan level, to be built in the Ca River will supply water to the domestic and industrial use of Nhon Trach demand centre. The joint operation of both reservoirs makes it possible to develop an amount of 270,000 m³/day. For this estimate, FSL and MOL for Song Ca-1 are set at E1. 80.0 m and E1. 61.0 m respectively, whilst E1. 60.0 m and E1. 52.0 m for FSL and MOL of Song Ca-2 respectively based on the 1 to 50,000 scale topographic map. On the other hand, a 10-year drought runoff is used for simulation. A preliminary geological study points out the problem that there is a high possibility of leakage from the reservoir through the basaltic rocks with

horizontally continuous open cracks and underlying old river deposit consisting of unconsolidated permeable sand and gravel. Judging from the topographic and geological condition at the site, an earth-fill type dam is recommended. Figure 4.4 depicts a preliminary development plan of Song Ca-1 and Song Ca-2 reservoirs.

Phuoc Thai reservoir

Phuoc Thai reservoir, the development stage of which is under the master plan level, is proposed to be built with a catchment area of 90 km² in the Phuoc Thai River. Due to the small catchment, development capacity of water to be conveyed to Phu My demand centre is limited to an amount of 120,000 m³/day. For the simulation, FSL and MOL of the Phuoc Thai reservoir are set at El. 20.0 m and El. 16.0 m respectively based on the 1 to 50,000 scale topographic map, whilst a 10-year drought runoff is used as hydrological data. A preliminary geological study discusses that the riverbed at the damsite is covered with alluvial deposits of mainly sand with layers of clay or gravel, suggesting possibilities of leakage from the reservoir. This situation would only allow the construction of earth-fill type dam at the proposed damsite. A preliminary development plan of the Phuoc Thai reservoir is shown in Figure 4.5.

Da Den reservoir

The feasibility study of the Da Den reservoir was carried out by a local company, proposing a development of 100,000 m³/day for the domestic and industrial use in the Ba Ria-Vung Tau area. In this study, FSL and MOL of the Da Den reservoir are set at El. 40.0 m and El. 27.0 m respectively based on the available 1 to 50,000 scale topographic map. By simulating a 10-year drought runoff for FSL and MOL so set, it is found that it is possible to develop an amount of 250,000 m³/day for domestic and industrial use in Ba Ria-Vung Tau area. Taking into consideration the fact that water demand in the Ba Ria-Vung Tau including the Phu My area grows rapidly, the development scale of Da Den reservoir would be desired to be as large as possible. A preliminary geological survey confirmed that there exists exposure of siltstone at and around the damsite, recommending the construction of a rock-fill type dam. A preliminary development plan of the Da Den reservoir is shown in Figure 4.6.

Song Ray reservoir

The Song Ray reservoir project under the pre-feasibility study level is expected to supply water to the Ba Ria-Vung Tau area. A simulation study to use a 10-year drought runoff is carried out in this study by setting FSL and MOL at El. 70.0 m and El. 48.0 m respectively based on the available 1 to 50,000 scale topographic map, showing a development capacity of 1,400,000 m³/day which warrants to meet the water demand of Ba Ria-Vung Tau including the Phu My area far beyond the target year 2015. A preliminary geological survey confirmed both banks

are covered with basalt at the damsite, recommending the construction of rock-fill type dam. A preliminary development plan of the Song Ray reservoir is shown in Figure 4.7.

Discharge data predicted for 30 years by applying Tank Model at An Vien Gauging Station (catchment area; 264 km² and basin average rainfall; 2,114.2 mm/year) in the La Buong River are used for the estimate of runoff at the respective reservoir sites (refer to Appendix III). Multipliers to shift discharge data from the An Vien site to the respective reservoir sites are estimated as the ratio of catchment area and basin average rainfall as follows:

Reservoir project	Catchment area km ²	Basin average rainfall, mm/year	Multiplier to An Vien discharge
La Buong	246	2,114.2	0.93
Song Ca-1	56	2,100	0.21
Song Ca-2	49	2,100	0.18
Phuoc Thai	90	2,000	0.32
Da Den	127	1,950	0.44
Song Ray	750	2,100	1.72 (2.82)

The estimate of basin average rainfall for the respective reservoir projects is based on the isohyetal map (refer to Appendix III) prepared in this study, whilst predicted hydrological data of the year 1978 to 1979 are used as a 10-year drought runoff. As for Song Ray, a multiplier of 2.82 is gained based on the procedure mentioned above. Taking into consideration the fact that there is one discharge station 1.5 km upstream of the proposed Song Ray dam with available data of four years between the year 1979 and 1982, showing an average value of 19.3 m³/sec, the multiplier is adjusted to 1.72. Irrigation requirements shown in Table 4.2 are given as the condition to meet in estimating development capacity of domestic and industrial use. MOL is estimated by assuming a denudation rate of 1.0 mm/year/km² for a project life of 50 years.

Construction costs for the proposed six reservoir projects are estimated based on the preliminary design as given in Table 4.3.

4.2.3 Dong Nai River Water

The Dong Nai River water is one of the most promising water sources for the water supply project along National Highway No. 51 in terms of quality and quantity; that is, ample water is available to meet the water demand of the area (1.7 million m³/day) in the year 2015.

Intake: The proposed intake site is located at Thien Tan (refer to Figure 4.2). The advantages to place the intake site at Thien Tan are as follows:

- (1) The pipeline to Vung Tau becomes shortest when the intake is placed in the upstream reaches of Hoa An/Bien Hoa.
- (2) Due to the fact that running water can be abstracted as well as that there are no large towns to release sewage water in the upstream reaches of the intake, water quality is good, resulting in easy treatment.
- (3) No new land acquisition is necessary, since the new intake will be constructed within the intake site area under construction at the moment.

Pipeline Route: Figure 4.2 shows a pipeline route temporarily proposed between the Thien Tan intake site and Ba Ria. Further details of the pipeline route are as follows:

- (1) The pipeline from the Thien Tan intake to Ho Nai through the Thien Tan treatment plant runs along the pipeline under construction at the moment.
- (2) The pipeline between Ho Nai (near the junction of National Highway No. 1 and No. 51) and Ba Ria runs along the new express way constructed parallel to existing National Highway No. 51.

The new express way is planned to be constructed as a toll road with financial supports of private sectors, i.e. BOT project. The pre-feasibility study of the project has been completed by the Ministry of Transport and Communications (MOTC), and the feasibility study of the project is expected to be carried out by the private investors including environmental impact assessment (EIA). The completion of the project is expected at early 2000's.

Since the pipeline is planned to run along the new express way, it is desired to carry out the land acquisition at the same time for both of road and water supply projects. In this context, the Ministry of Construction is requested to cooperate with the Ministry of Transport and Communications, when the land acquisition is implemented for the express way project.

4.3 Development Alternatives

Following three are conceivable development alternatives prepared by combining three water sources discussed above, groundwater, reservoir projects and the Dong Nai River water:

Alternative 1:

Demand centre	Development stage		
	Stage I	Stage II	Stage III
1. Bien Hoa	Thien Tan	Thien Tan	Thien Tan
2. Tam Phuoc	groundwater	Thien Tan	Thien Tan
3. Nhon Trach	groundwater	Thien Tan	Thien Tan
4. Phu My	groundwater	Da Den	Song Ray
5. Vung Tau	groundwater	Da Den	Song Ray

Alternative 2:

Demand centre	Development stage		
	Stage I	Stage II	Stage III
1. Bien Hoa	Thien Tan	Thien Tan	Thien Tan
2. Tam Phuoc	groundwater	Thien Tan	Thien Tan
3. Nhon Trach	groundwater	Thien Tan	Thien Tan
4. Phu My	groundwater	Da Den	Thien Tan
5. Vung Tau	groundwater	Da Den	Thien Tan

Alternative 3:

Demand centre	Development stage		
	Stage I	Stage II	Stage III
1. Bien Hoa	Thien Tan	Thien Tan	Thien Tan
2. Tam Phuoc	groundwater	Thien Tan	Thien Tan
3. Nhon Trach	groundwater	Song Ca 1 & 2	La Buong
4. Phu My	groundwater	Da Den	Song Ray
5. Vung Tau	groundwater	Da Den	Song Ray

Stage I is the project to be implemented urgently to meet immediate water demand, whilst Stage II is the project to be developed by early 2000's and Stage III is the project to be implemented for meeting the water demand in the year 2015.

The basic idea of Alternative 1 is to rely on the Dong Nai River water as a water source for the demand centres in the Dong Nai province, whilst local rivers for the demand centres in the Ba Ria-Vung Tau province, i.e. Da Den and Song Ray reservoirs. Alternative 2 basically intends to supply the Dong Nai River water up to the farthest Vung Tau demand centre, although water demand of Stage II in the Phu My and Vung Tau demand centres is required to be met with the Da Den reservoir due to the time period necessary for the construction of pipeline. Alternative 3 is the plan to seek water sources to the local rivers as much as possible.

An attempt to select the optimal alternative from among the above three alternatives is made to determine the entire development plan of the water supply project along National Highway No. 51. Table 4.4 shows the installation timing and development scale of each water source to be developed for meeting future water demand of the five demand centres in Alternative 1, whilst Tables 4.5 and 4.6 are for Alternatives 2 and 3, respectively.

Following are in particular noted for the water sources to be developed in each Alternative:

- a) In Alternatives 1, 2 and 3, the Da Den reservoir is developed for the Phu My and Vung Tau demand centers with a capacity of 250,000 m³/day, half of which is to supply to Phu My, whilst Vung Tau for the other half.
- b) In Alternatives 1 and 2, a pipeline with a conveyance capacity of 300,000 m³/day is developed in the year 2002 for the Tam Phuoc and Nhon Trach demand centres. In the year 2009, another pipeline with the same capacity is to be placed for those two demand centres.
- c) In Alternative 2, a pipeline with a conveyance capacity of 450,000 m³/day is placed for Phu My and Vung Tau in the year 2006; 200,000 m³/day for the former and 250,000 m³/day for the latter.
- d) In Alternative 3, a pipeline with a conveyance capacity of 250,000 m³/day is placed for Tam Phuoc in the year 2002. Thus, the second stage development, i.e. Tien Tan II, is only the construction of treatment plant.
- e) In Alternatives 1 and 3, the Song Ray reservoir is developed in the year 2006 by setting FSL at El. 70.0 m. Doing so, it is possible to abstract an amount of 1.4 million m³/day far beyond the requirement of 450,000 m³/day for Song Ray. Taking into account the assumption in the economic evaluation that water demand will not increase in the year 2015 onwards as discussed below, one-third of the cost necessary for building the Song Ray reservoir (= 450,000/1,400,000) is treated as the project cost of the Song Ray project.
- f) In Alternatives 1, 2 and 3, a pipeline with a conveyance capacity of 300,000 m³/day is developed in the year 2002 for the Bien Hoa demand centre. Thus, the second stage development, i.e. Thien Tan II, is only the construction of treatment plan.
- g) In Alternatives 1 and 3, a pipeline from the Da Den reservoir bifurcates into two; one is for the Vung Tau demand centre with a capacity of 125,000 m³/day and the other is for the Phu My demand centre with the same development capacity. After the completion of Song Ray, the pipeline placed for Vung Tau from the Da Den is used to convey water to Phu My with a capacity of 75,000 m³/day.

Tables 4.7, 4.8 and 4.9 summarize the cost required for the construction of respective projects given in Alternatives 1, 2 and 3. Following are assumptions applied for the cost estimate of respective alternatives:

- a) Estimate of dam costs is based on work quantities calculated for respective work items and their unit prices (refer to Table 4.3);
- b) Pipeline costs are estimated by assuming a unit rate of US\$ 170/m³/sec/m;

- c) Costs of treatment plant are estimated by applying a unit rate of US\$ 200/m³; and
- d) Water source development cost of groundwater is estimated at US\$ 250/m³ by taking into account the availability of aquifer in the area.

Economic evaluation to select the optimal alternative from among the proposed three alternatives is based on the present worth and EIRR (economic internal rate of return) methods. Following are assumed for the economic evaluation to select the optimal alternative:

- a) Benefits are derived from selling water projected as future demands up to the year 2015 as summarized in Section 4.1.
- b) Unit benefit is set at US\$ 0.15/m³, which is the average water tariff derived from the revenue of the HCMC water supply system.
- c) Economic cost is 85 % of construction costs.
- d) The construction time period is one year for groundwater, whilst three years for the pipeline and dam project with a cost disbursement of 0.2, 0.5 and 0.3.
- e) Annual operation and maintenance cost is 3.0 % for the economic cost.
- f) An evaluation period to compute the present value is 50 years between the year 1996 and 2045.
- g) Water demand, which is the base to estimate the benefit, is constant after the year 2015 with the same value as that year.
- h) A prime discount rate to compute the present value is 10 %.

Table 4.10 shows the presumed benefits to be gained by applying the above assumptions; a) and b), whilst the disbursed costs of respective projects to be developed in each alternative are given in Tables 4.11 to 4.13, which show the cash flows, by applying the above assumptions, c) to e).

Economic comparison among three alternatives is made based on the cash flow so prepared as well as the assumptions of f) to h), demonstrating the highest net benefit of US\$ 63.5 million and an EIRR of 12.9 % in Alternative 1 as summarized below:

	Alternatives		
	1	2	3
Benefits, million US\$	303.3	303.3	303.3
Costs, million US\$	239.8	241.4	275.5
Net benefit, million US\$	63.5	61.9	27.8
EIRR, %	12.9	12.8	11.1

Furthermore, all the water supply plans for five demand centres proposed in Alternative 1 demonstrate economic viability by showing the EIRR higher than 10 % as summarized below:

Demand Centre	Economic Index	
	Net Benefit, million US\$	EIRR, %
1. Bien Hoa	9.4	13.2
2. Tam Phuoc	13.2	14.5
3. Nhon Trach	22.2	14.4
4. Phu My	7.1	11.3
5. Vung Tau	11.6	12.0

Owing to the fact that Alternative 1 shows the highest net benefit among three alternatives as well as the fact that the water supply projects proposed for the respective demand centres are economically sound, Alternative 1, the basic idea of which is to seek the water source to the Dong Nai River for the demand centres in Dong Nai province, whilst Da Den and Song Ray reservoirs for the demand centres in Ba Ria-Vung Tau province, is selected as the development plan for the water supply project along National Highway No. 51. It is herein recommended to reinforce the meteo-hydrological measurement systems in the project area, since such data are most crucial to determine the development scale of the reservoir projects accurately.

A tentative time schedule to implement the water supply projects proposed for the five demand centres in Alternative 1 is prepared based on Table 4.4 as given in Figure 4.8. Further discussions for the selected master plan project such as fund management, administrative management system and selection of priority projects are given in Appendix X. In fact, this water supply project along National Highway No. 51 is selected as one of the priority projects to proceed to the feasibility study stage, and therefore Terms of Reference (TOR) for the feasibility study is prepared as attached in Appendix X.

5. RURAL WATER SUPPLY

5.1 Present Condition of Rural Water Supply

As discussed in the preceding Section 2.2, domestic water supply in the Study Area is in an incipient stage except for large cities and towns such as Ho Chi Minh City and Bien Hoa. This fact implies that any systematic water supply projects have rarely been established in the rural areas of the Study Area. In fact, people living in the rural areas rely on small wells privately dug, sand filtration system, rain water tanks (roof catchment) and so forth as a drinking water source.

Small wells manually dug in the rural areas are normally shallow with a depth of 20 m to 30 m, showing less reliability on supply in the dry season probably due to the fact that water level in the well rapidly draws down in coincidence with rapid falling of river water level starting from the beginning of dry season. Dry-up of wells in the dry season makes local people have no alternatives but to buy for getting drinking water. In particular, the long lasting dry season in the year 1995 made most of shallow wells drilled on the rural area dried up, resulting in serious shortage of drinking water as reported for example that hundreds of patients and the staff of the Health Care Centre of Bu Dang district, Song Be province, have to share a well, which only had a supply capacity of 1 m³/day. Even if wells are barely available for use, there is a hygienic problem, since there are high chances that the release of water used for daily life including toilet water to the ground would contaminate the well.

It can be said that the life of people, who have wells even if those are not good in quality, is rather easy compared with those who do not have wells. They have to collect drinking water from the nearby river or canal no matter how water quality is, or to buy it. In case of buying drinking water, local people have to buy it with the price 10 to 100 times higher than that of tap water.

Based on the rural water supply situation in Viet Nam mentioned above, UNICEF (United Nations Children's Fund) with the assistance of Central Rural Water Supply Project, Ministry of Labour, War-invalids & Social Affairs, which was in charge of rural water supply projects in the Vietnamese Government at that time, commenced in the year 1980 their assistance to improve the rural water supply in Viet Nam in aiming to protect children's life by raising hygienic level in the rural area. Its assistance spurred based on the proclamation of the International Drinking Water and Sanitation Decade (the year 1981 to 1990) by the United Nations (UN). It is noted that the office of Central Rural Water Supply Project, which belonged to the Ministry of Labour, War-invalids & Social Affairs, administratively shifted to the Ministry of Agriculture and Food Industry on August 1st, 1995, which is the Ministry of Agriculture and Rural Development at present. Basic rules established and achievements

undertaken by UNICEF in the Study Area are summarized below as the indication of more systematic dissemination programmes of rural water supply in future:

- a) Poor and remote areas, in particular highland area where minority groups live, are placed as a high priority area to receive funds for drilling wells.
- b) Main water sources are wells, but roof catchment and surface water are included as alternative sources.
- c) Wells are drilled by manual method for the soil layer and by mechanical method for the rocky layer with a drilling depth of 45 to 80 m (Dong Nai, Song Be, Lam Dong, Dac Lac and Ba Ria-Vung Tau provinces).
- d) For drilling wells, UNICEF supplies drilling machines, construction materials of cement, pipe and so on along with technical assistance, whilst local People's Committee provides local materials such as sands and stones along with labour forces from beneficiaries. Taking into consideration the idea of self-help by local people, UNICEF shares 40 % of total construction cost of drilling wells by supplying materials, whilst the local government and local people bear 30 % of its total cost, respectively.
- e) Shallow wells are normally drilled with a spatial interval of 50 to 100 m, even if changed depending on locality. Water is collected with a hand pump, but there are cases with a small distribution system. The expected number of beneficiaries for one shallow well falls in a range of 120 to 150 persons.
- f) Deep wells, which can supply ample drinking water with high quality through the year, are drilled by mechanical method and are distributed with a spatial interval of 200 to 300 m. Although the placement of deep wells, which are possible to provide the distribution system with beneficiaries of 1,500 to 2,000 people, is preferable, the number of deep wells so far drilled is limited due to high drilling cost as well as high operation cost.
- g) In case where surface water is sought as a water source, simple treatment is applied with slow sand filtration.
- h) Rural water supply programmes in the Study Area by UNICEF were commenced for Long An province in the year 1982, followed by Binh Thuan and Ninh Thuan provinces and Ho Chi Minh City in the year 1987, and Lam Dong, Song Be, Dong Nai, Tay Ninh, Dac Lac and Ba Ria-Vung Tau provinces in the year 1990, as the joint work with the provincial People's Committee and the Central Rural Water Supply Project, Ministry of Agriculture and Rural Development.

As at the end of the year 1994, UNICEF has developed 15,448 water sources for rural water supply in the Study Area; 3,949 for Ho Chi Minh City, 3,410 for Binh Thuan, 1,959 for Ninh Thuan, 655 for Ba Ria-Vung Tau, 336 for Dong Nai, 493 for Song Be, 598 for Tay Ninh, 564 for Lam Dong, 20 for Dac Lac and 3,464 for Long An as summarized in Table 5.1. It is noted that rural water supply projects in Dac Lac and Long An provinces show the performance of two and seven districts respectively lying in the Study Area.

As at the end of the year 1994, only a fraction of 27.6 % of people living in the rural part of the Study Area is computed to receive the benefit of rural water supply projects compared with the national average of 35 % under the condition that the number of beneficiaries is 120 persons for a water source and that annual increase rate of population is 2.68 % between the year 1989 and 1994. By province, Tay Ninh, Song Be, Dac Lac and Dong Nai lie in the area with the poorest performance rate of lower than 10 %.

Two provinces, Lam Dong and Ba Ria-Vung Tau, show a slightly higher performance rate of 14 % to 18 %, whilst three provinces, Ninh Thuan, Binh Thuan and Long An, performed rural water supply projects with a higher rate of more than 60 % due to the following facts:

- a) These three provinces can provide enough counter-budget for the UNICEF's programme;
- b) UNICEF mainly provided drilling machines suitable for drilling the Quaternary-Neogene deposit layer extending in the lower-plain area; and
- c) Rural water supply projects started from the areas where shallow aquifers are available.

A total of 3,949 rural water supply projects, which are largest in number compared with other nine provinces in the Study Area, were implemented by the end of the year 1994 in Ho Chi Minh City including the zones defined to be an urban area. The above result gives an impression that rather poor provinces are left behind in terms of improvement of amenities indispensable for daily life, although the poorest provinces, Ninh Thuan and Binh Thuan provinces, have a rather good performance rate in rural water supply.

5.2 Future Plan for Rural Water Supply

The Vietnamese Government launched a programme to increase the water supply rate in rural areas to 80 % by the year 2000 for improving social amenity as well as for narrowing down the economic disparity existing between urban and rural areas. In the Study Area, six provinces, Tay Ninh, Song Be, Dac Lac, Dong Nai, Lam Dong and Ba Ria-Vung Tau, are far distant from the target of the government, requiring an intensive programme to disseminate rural water supply projects especially in those six provinces.

The funds of UNICEF, which is the sole overseas donor to promote the systematic rural water supply programmes in Viet Nam at the moment including the counter budget of the Vietnamese Government, fall short of sufficiency. Thus, fund sources from other international agencies and developed countries are strongly sought to spur the implementation of rural water supply projects in the Study Area. Furthermore, people living in the rural areas still have a big burden to collect drinking water even in the completion of UNICEF's programme, since the UNICEF's programme mainly drills shallow wells with a hand pump, requiring local people to come to the well and to collect water by hand - pumping. Furthermore, the areas where shallow aquifers are available are limited in the Quaternary - Neogene deposit layer extending in the lower-plain area. It is therefore deemed urgent to introduce a new rural water supply programme with a small supply system; that is, local people receive potable water from public stands installed every 50 m for instance, whilst taps are equipped for such public facilities as hospitals, schools and government offices to access to drinking water. In fact, the number of this sort of programme performed in the Study Area is only limited to 34; two in Lam Dong, four in Ninh Thuan, four in Binh Thuan, one in Dong Nai and 23 in Long An, compared with the total water source number of 15,448 performed by the end of the year 1994.

Identification of the communes, which are the smallest administrative unit lying under the district, urgently requiring rural water supply projects with a small distribution system, is made by distributing a questionnaire from the office of Central Water Supply Project to each provincial office in charge of rural water supply projects except for Ho Chi Minh City, where piped water is expected to be supplied in most of its administrative area. Based on the distribution of questionnaire to the provincial offices of rural water supply projects, a list of communes to require a rural water supply project urgently is prepared as summarized in Table 5.2; nine communes in Tay Ninh province, 11 communes in Song Be province, 19 communes in Dac Lac province, 29 communes in Lam Dong, nine communes in Ninh Thuan province, 25 communes in Binh Thuan province, 20 communes in Ba Ria-Vung Tau province, 18 communes in Dong Nai province and 30 communes in Long An province.

The number of rural water supply projects with a small distribution system required for the above communes is estimated under the following conditions:

- a) Annual population increase rates in the remote rural areas are assumed at 2.5 % between the year 1994 and 2000, 2.0 % between the year 2001 and 2010 and 1.8 % in the year 2011 onwards.
- b) The number of beneficiaries for the rural water supply projects carried out by UNICEF's programme is 120 persons per water source except for 200 persons/water source for Long An province.

- c) The number of beneficiaries for the rural water supply projects with a small distribution proposed in this study is 1,500 persons/project.

Based on the above conditions, a total of 1,207 rural water supply projects with a small distribution system are estimated to be implemented by the year 2015 as summarized in Table 5.2. This implies that 60 rural water supply projects should be implemented every year in the Study Area, if the project implementation is evenly made for the coming twenty years by the year 2015. As dealt with in Appendix X, a plan to implement 1,207 rural water supply projects is selected as one of master plan projects of this study based on the recognition that it is important to improve social amenities of the area where economic development is left behind without any large-scale water resources development project.

As for the discussions to determine the implementation order among the selected communes to have rural water supply projects, following are mainly taken into consideration:

- Poverty and remoteness,
- Less availability of aquifer,
- Afflicted area by less rainfall, salinity intrusion and acid water,
- Large water demand, and
- Administration support.

Ninh Thuan and Binh Thuan provinces lie in the lowest income category in the nation (refer to Appendix I) along with less availability of aquifer and small rainfall. This fact would suggest that Ninh Thuan and Binh Thuan provinces be the first provinces to implement rural water supply projects (refer to Appendix X), even with a higher performance rate of UNICEF's programme.

Taking into consideration the importance to enhance the living condition in the rural area, the rural water supply project is furthermore selected as one of priority projects in the study to proceed to the feasibility study stage. Thus, the Terms of Reference (TOR) to implement the proposed rural water supply project is prepared as attached in Appendix X.

According to the information from the Central Rural Water Supply Project office, costs necessary to build a rural water supply project with the beneficiary number of 1,500 to 2,000, even if costs vary site by site, are estimated at more or less US\$ 60,000 on an average, of which US\$ 10,000 is for survey and design, US\$ 18,000 is for water exploitation and US\$ 32,000 is for procurement of materials including labour and transportation. It will require to invest an amount of US\$ 72.42 million for the implementation of 1,207 rural water supply projects within the coming 20 years, if the above unit rate is applied. If even investment is made for the coming 20 years, the amount to be prepared every year is US\$ 3.6 million, which

is such heavy burden for the Vietnamese government that assistance from foreign countries is strongly sought particularly to protect children's life by raising hygienic level in the rural area.