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JAPAN INTERNATIONAL COOPERATION AGENCY

YANGON CITY DEVELOPMENT COMMITTEE

THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FINAL REPORT
VOLUME I: SUMMARY REPORT

SEPTEMBER 2002

TOKYO ENGINEERING CONSULTANTS CO., LTD.
NJS CONSULTANTS CO., LTD.

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ON
IMPROVEMENT OF WATER SUPPLY SYSTEM
IN
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Foreign Exchange Rate:

Master Plan
US$ 1 = JPY 120
US$ 1 = Kyat 500
(As of December 2001)

Pre-Feasibility Study
US$ 1 = JPY 130
US$ 1 = Kyat 500
(As of March 2002)

THE STUDY

ON

IMPROVEMENT OF WATER SUPPLY SYSTEM

IN

YANGON CITY

IN THE UNION OF MYANMAR

FINAL REPORT

CONSTITUENT VOLUMES

VOLUME I	SUMMARY REPORT
VOLUME II	MAIN REPORT
VOLUME III	APPENDIX
VOLUME IV	DRAWINGS

PREFACE

In response to a request from the Government of Union of Myanmar, the Government of Japan decided to conduct The Study on Improvement of Water Supply System in Yangon City in the Union of Myanmar and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team to Yangon three times between May 2001 and May 2002. The study team is headed by Mr. Kazufumi Momose of Tokyo Engineering Consultants Co., Ltd. and associated with NJS Consultants Co., Ltd.

The team held discussions with the officials concerned of the Government of Myanmar and conducted field surveys at the study area. Based on the field surveys, the Study Team conducted further studies and prepared the final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Myanmar for their close cooperation extended to the Team.

September, 2002

川上隆朗

Takao KAWAKAMI
President
Japan International Cooperation Agency

Mr. Takao Kawakami
President
Japan International Cooperation Agency

September, 2002

LETTER OF TRANSMITTAL

Dear Sir,

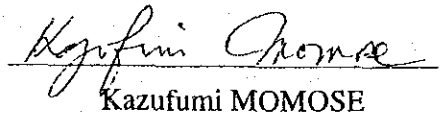
We are pleased to submit you the final report entitled "THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR". This report has been prepared by the Study Team in accordance with the contracts signed on 21 March 2001, between Japan International Cooperation Agency and Tokyo Engineering Consultants Co., Ltd. and NJS Consultants Co., Ltd.

The report examines the existing conditions concerning water supply system in Yangon City, and presents pre-feasibility study on a priority project selected from the master plan.

The report consists of the Summary Report, Main Report, Appendix and Drawings. The Summary Report summarize the results of all studies. The Main Report presents the results of whole study including background conditions, formulation of the master plan, selection of the priority project and the pre-feasibility study on the priority project. The Appendix describes in detail of the contents of the Main Report.

All the members of the Study Team wish to acknowledge gratefully to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Embassy of Japan in the Union of Myanmar, and also to the officials and individuals of the Government of Myanmar for their assistance extended to the improvement of water supply system in Yangon City in the Union of Myanmar.

Yours faithfully,



Kazufumi MOMOSE
Team Leader

1. OUTLINE OF THE PLANNING

Yangon City, the capital of the Union of Myanmar, is a highly urbanized economic center as well as the nation's center of administration, business and commerce. The study area (Yangon City) consists of 33 townships with 610 km^2 area and 3.88 million people. Yangon City is a metropolis.

Objectives of the study are follows,

1. To formulate a Master Plan for improvement of water supply system for the target year 2020.
2. To conduct a Pre-Feasibility Study(target year 2010) on the priority project(s) identified in the Master Plan.
3. To pursue technology transfer to counterpart personnel in the course of the Study.

The history of Yangon water supply is old and starts from 1842 with 30 wells near the center of city (159 years history). After that, reservoirs have been the main water source as the quality of reservoir water is considered to be better than that of river water. Given below is the short history of reservoir development.

1879 Kandawadyi Lake (In 1906 water supply had stopped due to the water contamination. This reservoir is located in near the center of city)
1884 Inya Lake (In 1906 supply of water had stopped.)
1904 Hlawga Reservoir (27km from city)
1940 Gyobyu Reservoir (50km from city)
1989 Phugi Reservoir (70km from city)

In spite of reservoir development, the growth of city, starting from 1950's, was rapid and resulted water shortage. Moreover, by the lack of own fund source of YCDC, major capital investment had not initiated since then. Consequently, the facilities are aging and chronic water shortage occurs. The Table 1 shows current (as of year 2000) service ratio.

Table 1 Service Ratio

YCDC WATER 46 %	
①Piped System	37 %
②Tube Well	2%
③Pond	7%
Non-YCDC WATRE 54%	
①Dug Well	1%
②Tube Well	52%
③Others	2%

As can be seen in the Table 1, YCDC's Pipe System covers a mere 37% and majority of citizens depend on own wells. This is the result of inadequate planning, development and implementation of surface water. The majority of people and enterprises want YCDC water supply. The 37% of service ratio is equivalent to 1.44 Million people, which is almost same as Yngon city population in the year of 1970. In this respect, the current water supply system is adequet only for the population of 30 years ago. Accordingly, in this Master Plan, large scale of water resource development and facility planning are essential.

(1) PLANNING FLAME

Table 2 shows Demand forecast in the study area.

Table 2 Demand Forecast

Year					2000	2005	2010	2015	2020
Total Population				(persons)	3,887,000	4,403,000	4,955,000	5,541,000	6,159,000
Service Ratio				(%)	37%	50%	60%	65%	70%
Served Population				(persons)	1,443,441	2,201,500	2,973,000	3,601,650	4,311,300
Daily Average Consumption	Domestic	percapita		(lpcd)	140	150	170	190	200
		Total	Consumption	(m3/day)	202,703	330,225	505,410	684,314	862,260
	Department	Total	Consumption	(m3/day)	46,480	63,838	76,101	88,624	101,080
	Commercial & Industry		Consumption	(m3/day)	7,123	56,138	85,920	116,333	146,584
		Industrial Zones	Consumption	(m3/day)	0	44,930	65,581	81,467	85,532
		Total	Consumption	(m3/day)	7,123	101,068	151,501	197,800	232,116
	Total			(m3/day)	256,306	495,131	733,012	970,738	1,195,456
Leakage	Ratio			(%)	50	45	40	35	25
	Amount			(m3/day)	256,306	405,107	488,675	522,705	398,485
Design Daily Average Demand				(m3/day)	512,612	900,238	1,221,687	1,493,443	1,593,941
Design Daily Average Demand per capita				(lpcd)	355	409	411	415	370
Design Daily Maximum Demand				(m3/day)	615,134	1,080,286	1,466,024	1,792,131	1,912,729
Design Daily Maximum Demand per capita				(lpcd)	426	491	493	498	444
Peak Factor					1.2	1.2	1.2	1.2	1.2

Target Year : 2020
Population : 6,159000 人
Swervice Ratio : 70%
Served Population : 4,311,300 人
Leakage Ratio : 25%
Per Capita Consumption : 200 lpcd
Design Daily Maximum Demand : 1,912,700 m3/day

(2) WATER SOURCE POTENTIAL

Water source is categorized into two; surface water and groundwater. Surface water is dived into river water (Hlaing River) and reservoir water. In the study, potential of water sources is

considered according to the following strategies.

Groundwater : The existing 217 wells in the left bank of Haing river (East Block, Central Block) are reduced into 75 regular wells. Instead surface water is developed so as to supply ample amount of water steadily. In the right bank of Hlaing river, it is expected that large amount of groundwater is available. And those areas are separated by rivers (remote area). Therefore, groundwater will be developed in those area(West Block).

Surface Water : Intake water from Ngamoeyeik Reservor and Hlaing river. Bago river (east of the city) water is considered, however amount of water is not sufficient in dry season. Also Lagunpyin Reservoir can supply water as much as about 45,000 m3/day from our calculation, however this water is not considered in M/P, because water right negotiation is needed between YCDC and ministry of irrigation.

2. FACILITY PLANNING

(1) ZONING SYSTEM

The study area is divided into 3 large Blocks as shown in Figure 1 (West Block, Central Block, East Block) . Then each block is divided into zones (total 11 Zone) in order to achieve easy maintenance and operation (3 Block 11 Zone System). Each zone has reservoir with 8 hours capacity.

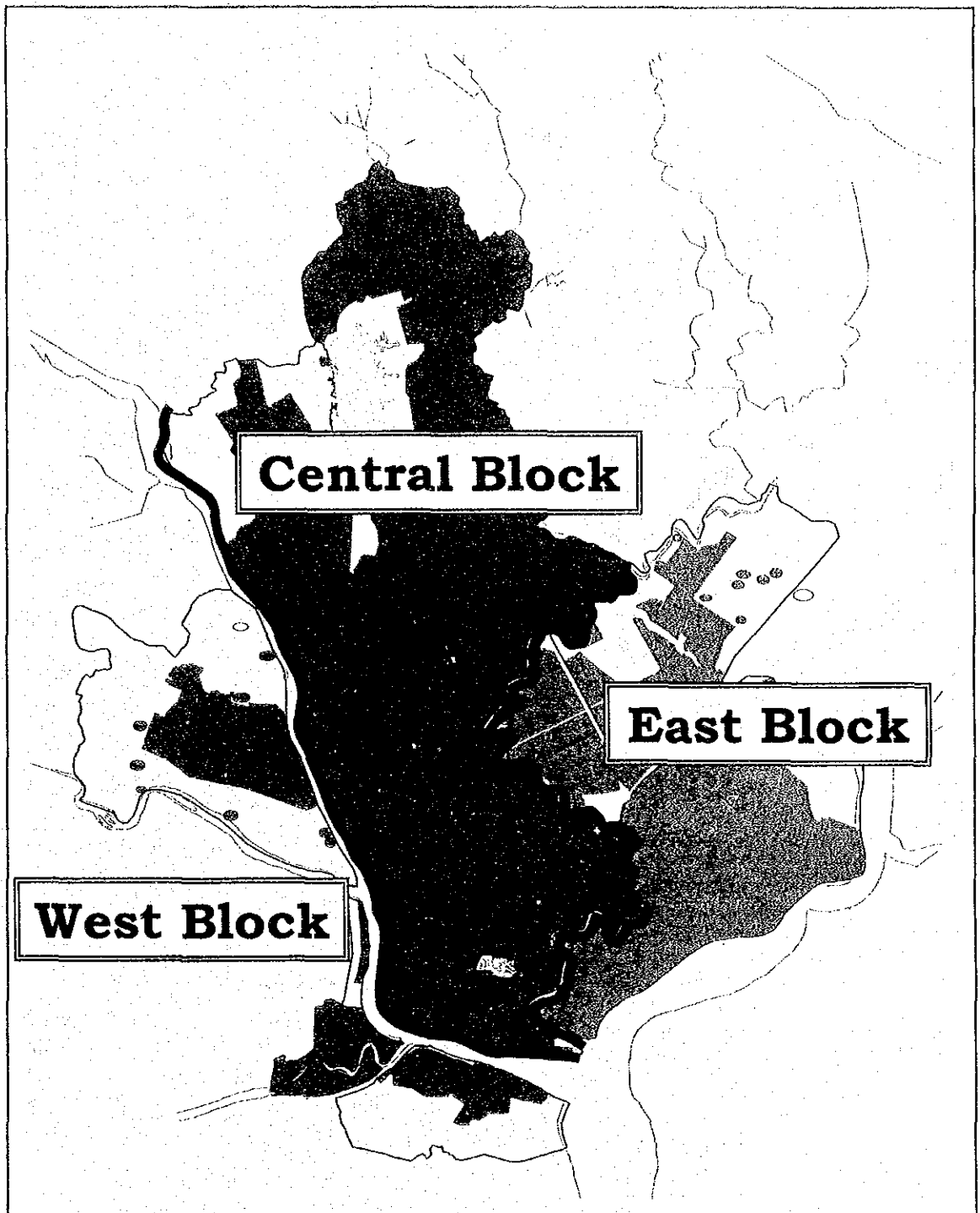
Figure 1 shows 3 Blocks, Figure 2 shows 11 Zones and Figure 3 shows proposed facilities.

(2) PROPOSED FACILITIES

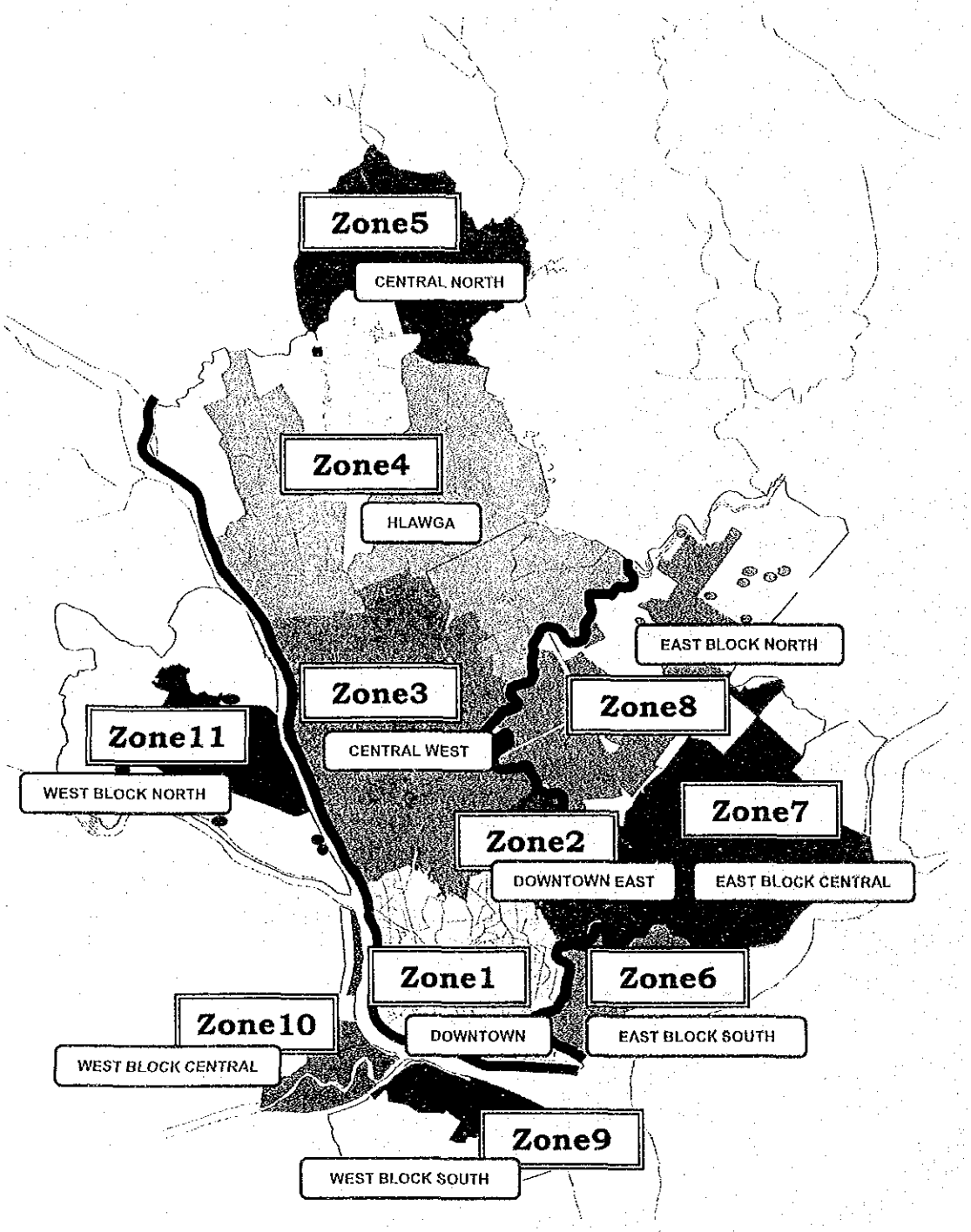
The main proposed facilities and rehabilitation programs are listed below. Phase 1 (2004～2010) is the period for Pre-F/S and the period of Phase2 is form 2010 to 2020.

① Rehabilitation of aged pipe(350 km approximately) (Phase1)
② New Hlaing WTP
Design Capacity :940,000 m3/day、 Intake water from Hlaing river
(Phase1: 1/2 capacity, Phase2: 1/2 capacity)
③ New Hlawga WTP
Design Capacity:820,000 m3/day, all reservoirs water is treated.
(Phase2)
④ Ngamoeyeik reservoir system: Raw water main and puping station
Capacity is 90 MGD : Million Gallon per Day＝409,100 m3/day
(Phase1)
⑤ Construction of Service Reservoirs (total number is 11)
(Phase1 : 6 Phase2 : 5)

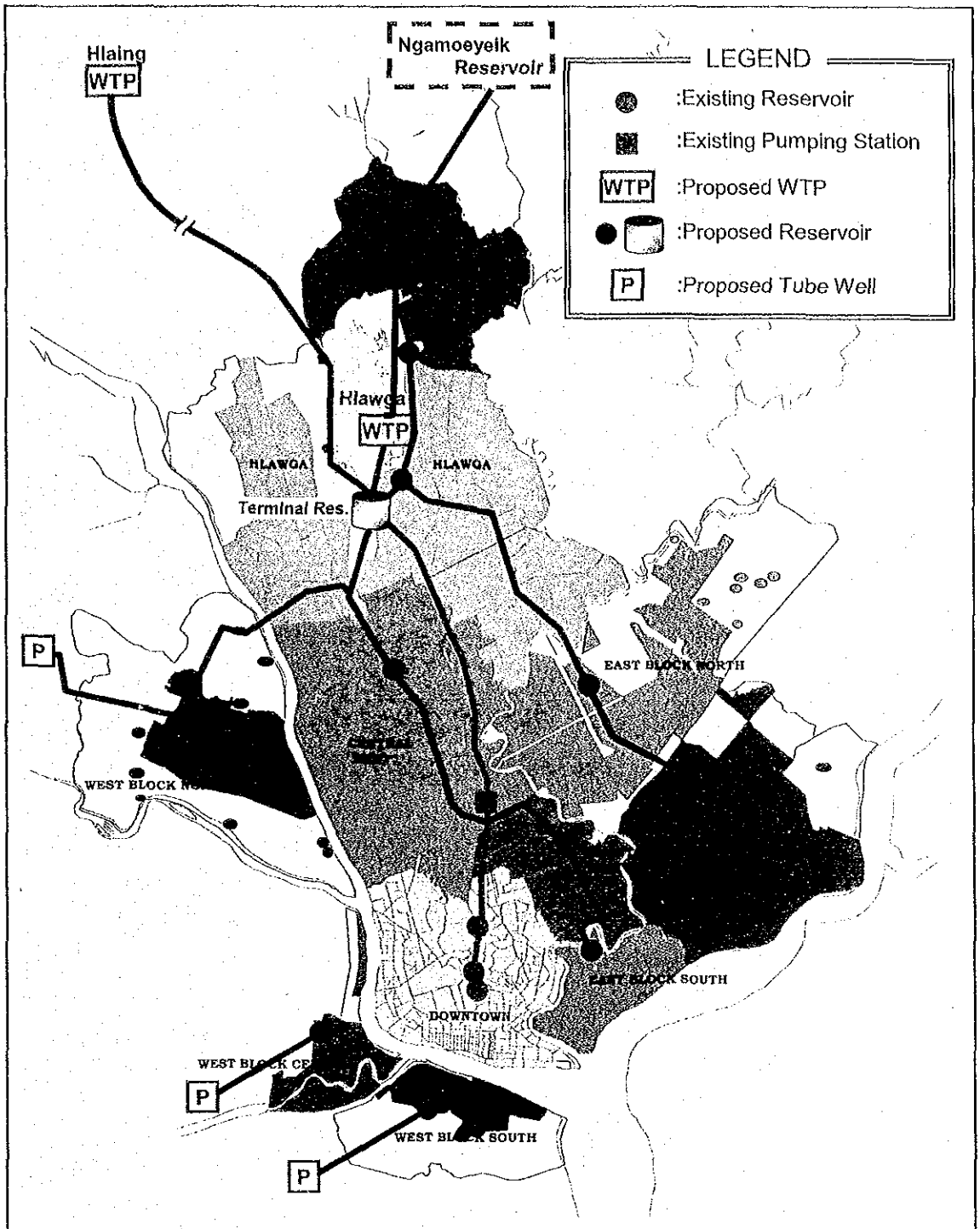
⑥ Rehabilitation of existing Wells(217): also reduce the number to 75 (Phase 1)
⑦ Groundwater development :West Block North(Phase1), WB Central(Phase2), WB South(Phase2)
⑧ Transmission, distribution and pumping stations for each zone(11 Zone) (Phase1 &Phase2)
⑨ Exisitng Gyobyu Pumping station: replace 3 pumps (Phase1)
⑩ Existing Pyugyi Pumping station: add 1 pump (Phase1)



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG. 1
	Three (3) Blocks	



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG. 2
	Eleven (11) Zones	



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG. 3
	Proposed Facilities	

3. COST

The construction period (M/P) is from 2004 to 2020 (17 years). Considering project priority, implementation capability and supply-demand planning, whole 17 years period is divided into 2 Phases. Thus, the highly priority projects is planned in Phase 1 (Pre-F/S period).

Phase	Year
Phase-1	2004 – 2010
Phase-2	2011 – 2020

Total project cost for M/P is below.

Phase	Cost (Million US$)
Total	1,473
Phase-1	830
Phase-2	653

Note) Exchange rate 1US$=120 JPYen (M/P)

The Phase 1 (7 years) is divided into 2 stages considering priority, implementation capability, and supply-demand planning. The target year of Pre-F/S (Phase 1) is 2010. The projects in Stage-1 have high priority.

Stage	Year
Phase-1	2004 – 2010
Stage-1	2004 – 2006
Stage-2	2007 – 2010

The following projects are planned in Stage-1.

① Rehabilitation of Aged pipes
② Ngamoeyeik System (pumping station and raw water main : 400,000 m3/day is newly supplied to the City)
③ Disuse and rehabilitation of existing Wells (Regular Well number become 75)
④ Rehabilitation of existing Gyobyu pumps (3 pumps: increase supply)
⑤ Installation 1 additional pump at Phugyi pumping station (1 pump: increase supply)

The next table shows total project cost. (Shaded portions are high priority activities.)

No.	Facility	Phase 1								Total Cost
		Stage 1				Stage 2				
		2003	2004	2005	2006	2007	2008	2009	2010	
1	Rehabilitation of Aged Pipeline		2,302	2,302	3,944	3,947	3,949	1,650	1,650	19,744
2	Development of Reservoir System		29,183	28,015	37,153	15,235				109,586
3	Hlaing River System						92,226	94,286	135,768	322,280
4	Terminal System			2,304	53,488	8,007	0	3,528	20,100	87,427
5	Transmission and Distribution System		2,365	3,018	39,683	64,664	81,043	32,239	14,365	237,377
6	Connections							4,696		4,696
7	Groundwater Management			94	1	1	3	3	3	105
	Grand Total	0	33,850	35,733	134,269	91,854	177,221	136,402	171,886	781,215
	Subtotal of Priority Works		31,485	30,411	41,098					
	Total of Priority Works				102,994					

Note) unit = Thousand US$

The following is cost , EIRR, and FIRR for Pre-F/S.

Phase	Cost (Million US$)
Total	781
EIRR	5．43%
FIRR	8．53%

Note) Exchange Rtae 1US$=130 JPYen (Pre-F/S)

Also new water tariff is proposed from the year of 2005. The new tariff structure is suggested after considering willingness to pay, affordability and soundness of financial status. Table 3 shows the proposed tariff .

Table 3 Proposed Tariff

Water Price to be applied (US cents/m3)

Sector	2005	2010	2015	2020	Share Rate
Domestic Sector	8.47	12.65	15.62	17.92	70 %
Public Sector	5.65	8.43	10.41	11.95	10 %
Industrial/Commercial Sectos	38.11	56.93	70.29	80.65	20 %

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PART 1
MASTER PLAN

SUMMARY

1. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Yangon city, a highly urbanized city, is the capital of the Union of Myanmar as well as the designated economical center. Yangon City is a part of Yangon Division. The city is the nation's center of administration, business and communication.

Water supply system in Yangon City has become old (started in 1842), overloaded and inadequate to meet the increasing water demand of the city. The water supply system in Yangon City is facing various problems. The city needs to expand its water supply capacity so that it will be able to meet increasing water demand of the city in the future.

In August 2000, a project formulation mission from the Government of Japan (GOJ) visited Yangon City to identify and confirm necessity and urgency of Japan's cooperation in water supply sector of the city. As a result, the Government of the Union of Myanmar (hereinafter referred to as "GOM") requested the GOJ to conduct the Study on Improvement of Water Supply System in Yangon City in the Union of Myanmar (hereinafter referred to as "the Study").

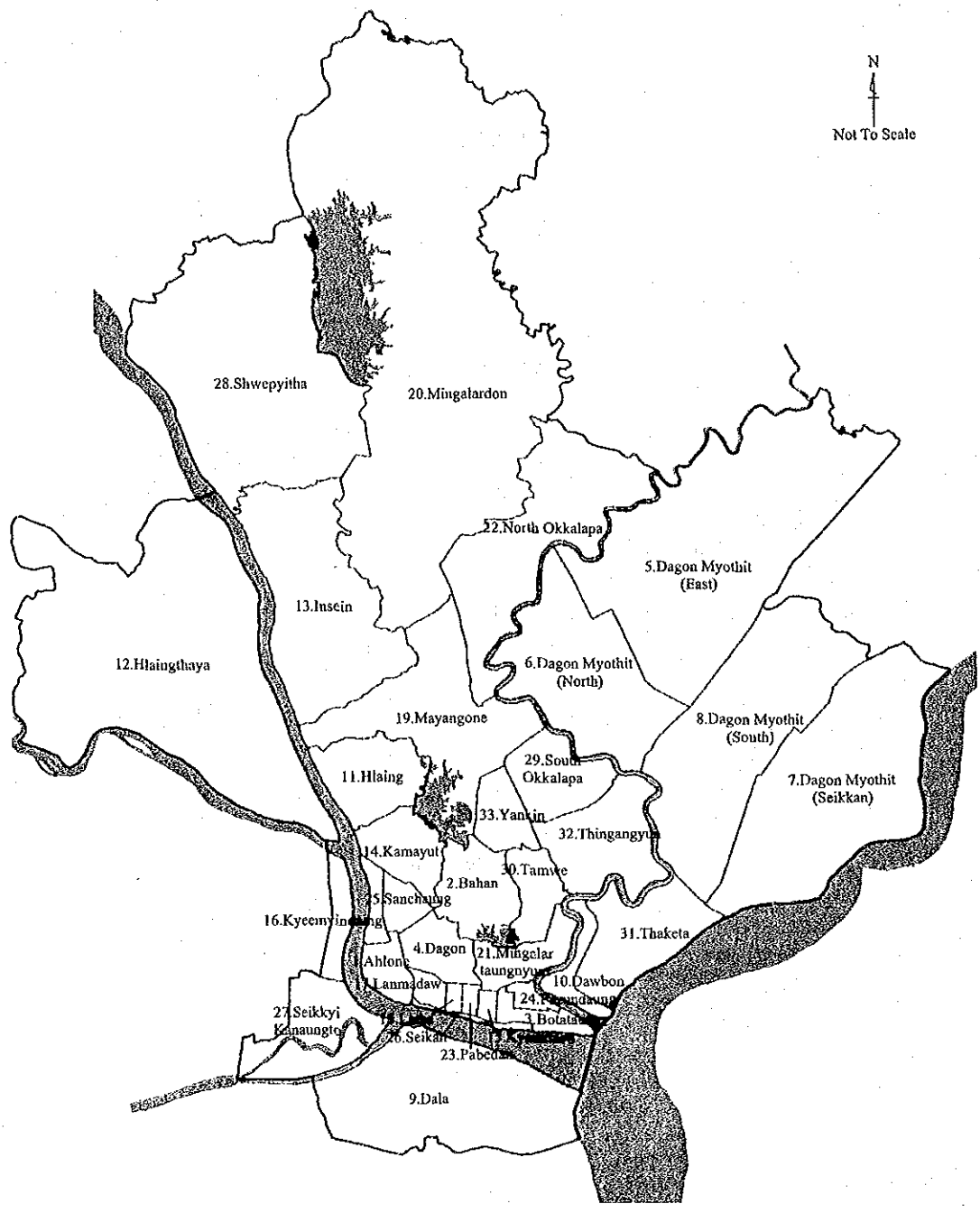
In response to the request from the GOM, Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of the GOJ dispatched the Preparatory Study Team. After discussions with GOM, JICA agreed on the Scope of Work and Minutes of Meetings for the Study on November 17, 2000.

Accordingly, JICA decided to undertake the Study in close cooperation with the authorities concerned of GOM. Tokyo Engineering Consultants Co., Ltd. in association with NJS Consultants Co., Ltd. was selected in March, 2001 by JICA to conduct the Study.

1.2 STUDY AREA

The Study Area covers the administrative area of Yangon City Development Committee (YCDC) (610 km^2), which consists of 33 townships. The Study Area map with 33 townships' name is shown in Fig. 1.1

The central City is located 34 km inland from the mouth of Yangon River. The City is physically divided into five (5) blocks by the rivers, namely ; (a) Pazundaung Creek, (b) Hlaing River (c) Pan Hlaing River and (d) Thunday Canal.



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 1.1
	Study Area (33 Townships)	

1.3 OBJECTIVES OF THE STUDY

The Objectives of the Study are:

- To formulate a Master Plan for improvement of water supply system in Yangon City for the Target year 2020.
- To conduct a Pre-Feasibility Study on the priority project(s) identified in the Master Plan.
- To pursue technology transfer to counterpart personnel in the course of the Study.

1.4 ORGANIZATION OF THE STUDY

The Study was carried out by the JICA Study Team, which comprises members of the Tokyo Engineering Consultants (TEC) and NJS Consultants (NJS), under the guidance of JICA Advisory Committee and in cooperation with the Myanmar counterparts (YCDC). The organization for the Study is shown in Fig.1.2.

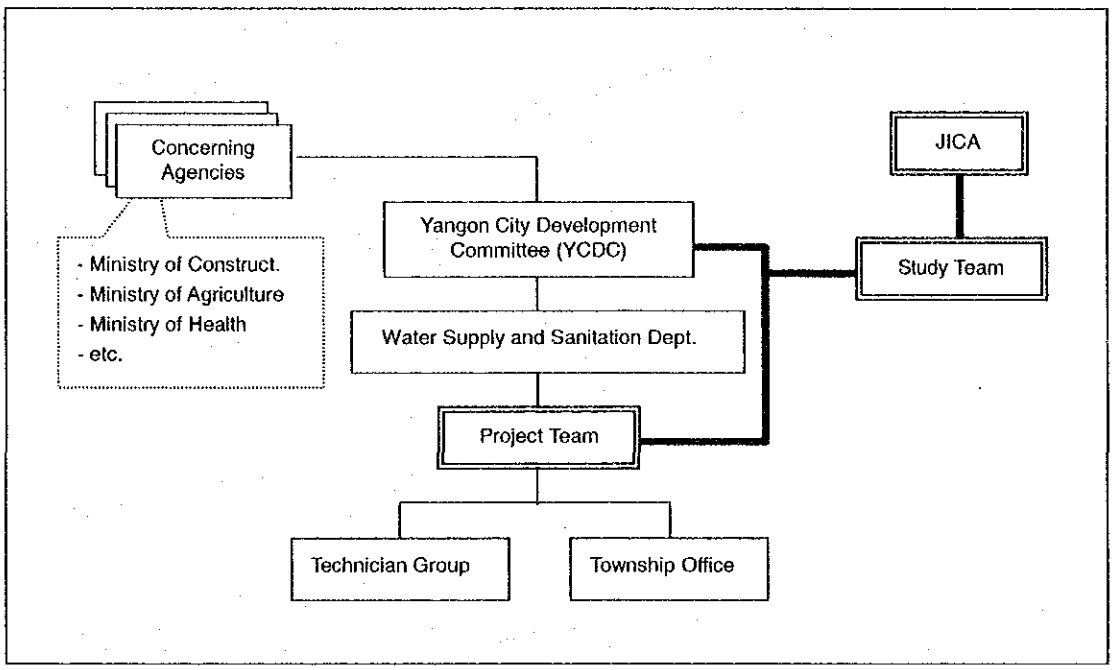


Figure 1.2 Study Organization

2. DESCRIPTION OF STUDY AREA

The Study Area is the Yangon City Development Committee (YCDC) area comprising of 33 Towships.

2.1 POLITICAL ATMOSPHERE AND THE GOVERNMENT

The Union of Myanmar is governed by the Myanmar Armed Forces since 1988. The State Peace and Development Council (SPDC) is the present governing body in the country.

For the purpose of administration, the Union is divided into 7 Divisions and 7 States. Each Division/State has its own districts, townships, wards and villages/ village tracts. The townships are the smallest administrative units of which there are 595 wards and 30 villages in total.

In the study area, the coordination of all development efforts is undertaken by the Yangon Division Peace and Development Council, 43 TPDCs and several WPDCs. These Councils are accountable to the SPDC for the implementation of law and order and to provide leadership in all development activities while they are accountable to the General Administrative Department (GAD) of the Ministry of Home Affairs for the purpose of administration of the area under their charge.

The administration of the City is entrusted to the Yangon City Development Committee (YCDC). The social, economic, commercial, recreation, environmental and cultural activities within the study area is administered by the YCDC. For this purpose, the Committee has deployed staff at 33 townships spread through out the study area. The government ministries and departments of the Union within the study area have only a limited function having to undertake specific tasks related to the roles and responsibilities of the relevant Ministry.

2.2 ECONOMY

The economy of the Union is based mainly on agriculture. Its contribution to the national Gross Domestic Product (GDP) is about 50%. The GDP attributable to the production of goods (of which agricultural goods are dominant) is about three times larger than the services. The per capita GDP was about Kyats (Ks.) 1800 in 2000 at 1999 constant prices. The mean annual rate of increase of the GDP during the past 10 years has been 3.83%.

The main industries of the Union are cement, pharmaceutical products, alcohol and cigarettes. Expenditure has exceeded the revenue for the past 10 years.bThe two main financial sources are the tax revenue contributing to 46% and the revenue from state enterprises making up 41% of the government revenue. Other sources make up the balance of 13%.

2.3 SOCIO-CULTURAL CHARACTERISTICS

People in Myanmar are friendly, hospitable and entertaining. The culture is characterized by diversity in races, food preparations and costumes, religion, and life styles which are different across the country. Ceremonies and festivals occupy an important place in the lifestyles of the people with several of them celebrated in the City.

2.3.1 Ethnicity

People in Myanmar belong to about 135 ethnic groups of which two races namely, Bamar making up 69% and indegenous races (25.7%) contribute to over 90% of the population. The others include Indian and Pakistan races (1.3%), Chinese (0.7%), and European and other races making up the remaining 3.3%. The Barma race in the country being the largest ethnic group made the British rulers to name the Union as Burma.

2.3.2 Religious Affiliations

According to the 1983 census, the population comprised of 5 main religions as follows,

Buddist	: 89.4%
Christians	: 4.9%,
Muslims	: 3.9%
Animist	: 1.2%
Hindu	: 0.5%

The prominent religious group in Yangon is Buddhists. Accordingly, Pagodas and Buddhist temples occupy a significant position of the landscape in the study area. The other important religious groups in Yangon are Christians, Hindus and Muslims.

2.3.3 Education and Literacy

Approximately 86% of household members are educated in the Union as a whole. The relevant figure for Yangon Division was about 90% with a slightly higher figure of 94% for the study area. The mean literacy rate as stated in the Statistical Yearbook 2000 was 66.5%.

2.3.4 Household Composition

Households are characterized by extended system of family living where several families closely-related to each other reside in the same house. The extended system of family living is common both in the country as well as in the study area.

The mean household size in the Union was 5.25 while this was 5.22 in Yangon Division. The relevant figure for the study area was 5.16 (Household Income & Expenditure Survey, 1997).

2.3.5 Status of Health

The mean life expectancy at birth in the country is low with only 60 years for men and 63.9 years for women in 1993. However, the life expectancy has grown to 61 years for men and 65.1 for

women in 1999. Other important health statistics are the crude birth rate at 24.3 per thousand (1000) in 1996 declining to 18.1 per in 1998. The death rates during the same period were 7.9 and 9.3 per thousand of population respectively.

The data on the incidence of water-borne diseases indicate that the prevalence of water-borne diseases is high in the study area suggesting the importance of water supply improvement in the City.

The main death factors in urban areas are intestinal infections contributing to 38.3 deaths per 100,000 population, Malaria with 29.5 deaths per 100,000 and Bronchitis making up 13 deaths per 100,000 population. The above death causing factors indicate the below average status of domestic water use and housing in urban areas in general.

2.3.6 Spread of Mass Media

About 25% of urban household members of the age group 35-49 years read newspapers in the Union. National newspaper readership of household members of the age group 15-59 was 79%. There was hardly a difference in newspaper readership between the Union and Yangon City. This characteristic has an important bearing on the education of water customers within the City.

2.3.7 Employment and Household Income

The mean employment rate for the Union was 2.38 employed persons per household. This came down to 1.90 persons per household in the City. The mean monthly income per household was Ks.16,660 in Yangon Division while the figure for Yangon City was Ks. 18,997 per household.

2.4 ADMINISTRATION OF THE STUDY AREA

The responsibility for administration of law and order in the study area is vested in the General Administration Department (GAD) of the Ministry of Home Affairs and the YCDC. The focus of the former is general administration such as law and order, resolution of social conflicts, registration of deaths, births and migration and the collection of other basic statistics. The activities of YCDC on the other hand, are the provision of social, economic and recreation facilities, utility services such as water, housing, markets, cleansing and discipline.

2.4.1 Administrative Units

For the purpose of City administration, the YCDC area is divided in to 33 townships and 595 wards. Some townships have villages in addition to wards. Altogether there are 30 villages included within 33 townships. The service administration is centered on the township office where YCDC officials responsible for implementation of various tasks are based.

The geographical area under each township depends mainly on the size of the resident population, whether it includes any satellite towns or the year in which the township was established. The

townships newly added to the YCDC area comprising the satellite townships for instance have relatively larger areas under their command. Most of the satellite townships are yet to be fully developed and populated. It is these areas where the exodus of inhabitants from the densely populated City would be settled in future.

2.5 NATURAL CONDITION OF THE STUDY AREA

Area on the center has lowland hills commonly known as the fault ponds with artificial dam namely Kan Daw Gyi Lake, Inya Lake and Hlawga Lake. This long and narrow spur of Pegu Yomas in the central area runs almost N-S direction with an average height of 30m and degenerates gradually into levelled plains in eastwards and westwards.

Level plains are extensive and are found mostly in the eastern and western parts as broad level bottoms along the rivers. These levelled lands are formed by delta deposits, areas of which are swampy and are almost occupied by paddy fields with elevation between about 3m (10ft) to 6m (20ft) above sea level.

2.6 METEOROLOGY

Yangon City has a type of tropical monsoon climate with three distinct seasons under the coronas classification, such seasons are namely summer, rainy and cool. The summer season covers the period from March till mid-May, the rainy season from mid-May till October and the cool season from October till February.

2.7 HYDROLOGY

Reservoirs and the rivers are the two important surface water sources in the study area.

2.7.1 Rivers

The Hlaing River, also known as Myitmakha River has its source near Paunk Kaung. It flows from north to south approximately parallel to the Ayeyawady River, first joining the Bawle River in Taikkyi township, and then the Kotekowa River in Hmawbi township and finally the Penhlaing River near Hsinmalaik. When it reaches Yangon it continues to flow into the sea as Yangon River.

The Bago River has its source near Thikkyi in the Bago Yoma. It flows down the east-facing slope of the Bago Yoma from north to south approximately parallel to the Sittang River. When it reaches Bago it turns to the southwest and flows into the sea as Yangon River.

2.7.2 Reservoirs

The present surface water sources for supply of water to the Yangon City are consisted of Gyobyu Reservoir, Phugyi Reservoir and Hlawga Reservoir. Ngamoyeik Resevoir constructed by Irriga-

tion Department, Ministry of Agriculture and Irrigation is not yet utilized as drinking water source but it will be able to supply the water for Yangon City.

2.8 HYDROGEOLOGY

Topographic peaks in the central city are ranging north and south through east side of the Hlawga Lake and west sides of the Inya Lake and the Kan Daw Gyi Lake. Trend of groundwater flow is probably toward east and west following to gradient of ground surface. The trend of groundwater flow seems to be eastward at western side of topographic peaks in an area between Kan Daw Gyi Lake and Inya Lake. Because of dipping Irrawaddy Series eastward and unconformity overlaying to Pegu Group (Besupet Alternation), surface geological boundary of lower Irrawaddy Series may be same as watershed boundary of groundwater flow.

Among the water quality problems of the city, ironic groundwater is serious with a high percentage of affected existing tube wells. The problem is extended to most of the central city. Origin of ironic groundwater was reported because of lateritised members distributing lenticular in Irrawaddy Series. High chloride content in groundwater was also reported in inland and coastal areas, which is believed as the cause of brackish water and/or saline water intrusion.

2.9 POPULATION

2.9.1 Past Population Trend (1836 – 1998)

Table 2.1 shows the collected Yangon City population data from 1836 to 1998. The City population reached about 100,000 in 1872. By 1931, population was more than 400,000 (4 times than that of 1872). In 1800's (1836 – 1872), the growth rate was 3.35 %, in 1900's (1872 – 1973), that was 3.04 %, and recent years (1973-1998), the rate was 2.43 %. The growth rate has been gradually decreasing.

Table 2.1 Past Population and Growth Rate

YEAR	POPULATION (Persons)	ANNUAL GROWTH RATE (%)	
1836	30,000	(1836-1855) 1.26	(1836-1872) 3.35%
1855	38,055	(1855-1856) 20.88	
1856	46,000	(1856-1860) 7.56	
1860	61,570	(1860-1865) 2.56	
1865	69,866	(1865-1872) 4.97	
1872	98,138	(1872-1921) 2.58	(1872-1973) 3.04%
1921	341,962	(1921-1931) 1.59	
1931	400,415	(1931-1953) 2.81	
1953	737,079	(1953-1973) 5.19	
1973	2,027,256	(1973-1983) 2.00	(1973-1998) 2.43%
1983	2,472,176	(1983-1998) 2.71	
1998	3,691,941		

2.9.2 Recent Population In Yangon City

Table 2.2 shows the recent population data.

Table 2.2 Population Distribution

No.	Township	Population (persons)		
		1973	1983	1998
1.	Ahlone	46,547	51,849	43,569
2.	Bahan	85,757	102,112	95,114
3.	Botataung	44,057	49,168	52,653
4.	Dagon	35,746	35,541	39,967
5.	Dagon Myothit (East)	-	-	55,192
6.	Dagon Myothit (North)	-	-	101,673
7.	Dagon Myothit (Seikkan)	-	-	18,279
8.	Dagon Myothit (South)	-	-	140,387
9.	Dala	43,503	54,167	77,236
10.	Dawbon	37,439	49,967	79,582
11.	Hlaing	131,587	171,687	167,881
12.	Hlaingthaya	-	-	199,190
13.	Insein	143,625	196,809	240,704
14.	Kamayut	67,309	75,177	82,943
15.	Kyauktada	37,772	37,634	44,076
16.	Kyeemyindaing	64,145	69,866	87,491
17.	Lanmadaw	42,691	41,663	40,597
18.	Latha	31,646	31,061	32,535
19.	Mayangone	108,749	152,616	183,024
20.	Mingalardon	80,867	108,303	170,950
21.	Mingalartaungnyunt	96,287	110,435	109,796
22.	North Okkalapa	155,259	190,905	289,068
23.	Pabedan	40,718	41,913	47,461
24.	Pazundaung	34,763	38,806	38,363
25.	Sanchaung	66,593	68,867	78,788
26.	Seikan	7,732	5,285	1,379
27.	Seikkyi Kanaungto	12,458	15,393	25,586
28.	Shwepyitha	-	-	172,377
29.	South Okkalapa	149,409	183,264	220,214
30.	Tamwe	106,682	119,914	128,455
31.	Thaketa	145,888	193,028	279,799
32.	Thingangyun	141,209	194,100	240,417
33.	Yankin	68,818	82,646	107,195
	TOTAL	2,027,256	2,472,176	3,691,941

The growth rates (1983 to 1998) by each township are different and summarized below.

(1) Population has decreased (3 townships): Seikan, Ahlone, Lanmadaw
(2) Growth rate is less than 1 % (steady: 12 townships): Latha, Pazundaung, Bahan, Dagon, Mingalartaungnyunt, Pabedan, Kyauktada, Sanchaung, Botataung, Tamwe, Kamayut, Hlaing
(3) Growth rate is more than 1 % (13 townships 46 %): The others.

Twenty five (about 88%) townships out of 28 have recorded an increase in population and half of the townships has more than 1 % growth rate.

2.9.3 Population Projection

Since the population is growing and we cannot set the saturation population, the logistic curve cannot be applied here for population forecast. Table 2.3 shows projection methods.

Table 2.3 Population Projection Method

Method		Data
By Annual Growth Rate	Growth rate :3.02%	1836-1998
	Growth rate :2.43%	1973-1998
	Growth rate :2.18%	1998-2000 (estimated by ManPower & Immigration Department)
By Linear line	Annual increase :67,750 people	1973- 1998
By Power Curve		1973 – 1998

The results are shown in Figure 2.1. The highest population at the target year 2020 is 7,097,412 with 3.02 % annual growth rate. This is too high estimation obviously. On the other hand, the lowest estimation is 5,124,302 with linear estimation, this is low and R^2 value is low.

A 2.43 % GR estimation has little bit high R^2 value compared with the one of GR of 2.18% estimation. R^2 value for power curve estimation is 1 because it needs 3 data point to estimate, thus this R^2 value is not comparable with other R^2 values. A 2.43 % GR estimation and Power curve estimation are almost same, however the characteristic of the power curve (annual growth rate becomes smaller, see Figure 2.1) makes it more likely. Thus Power curve estimation will be used for the forecast.

2.10 LAND USE

The current land use in the project area is as follows:

Resendensial : 37%
Government : 19%
Commercial and industrial : 5%

Farm : 22
Other : 17

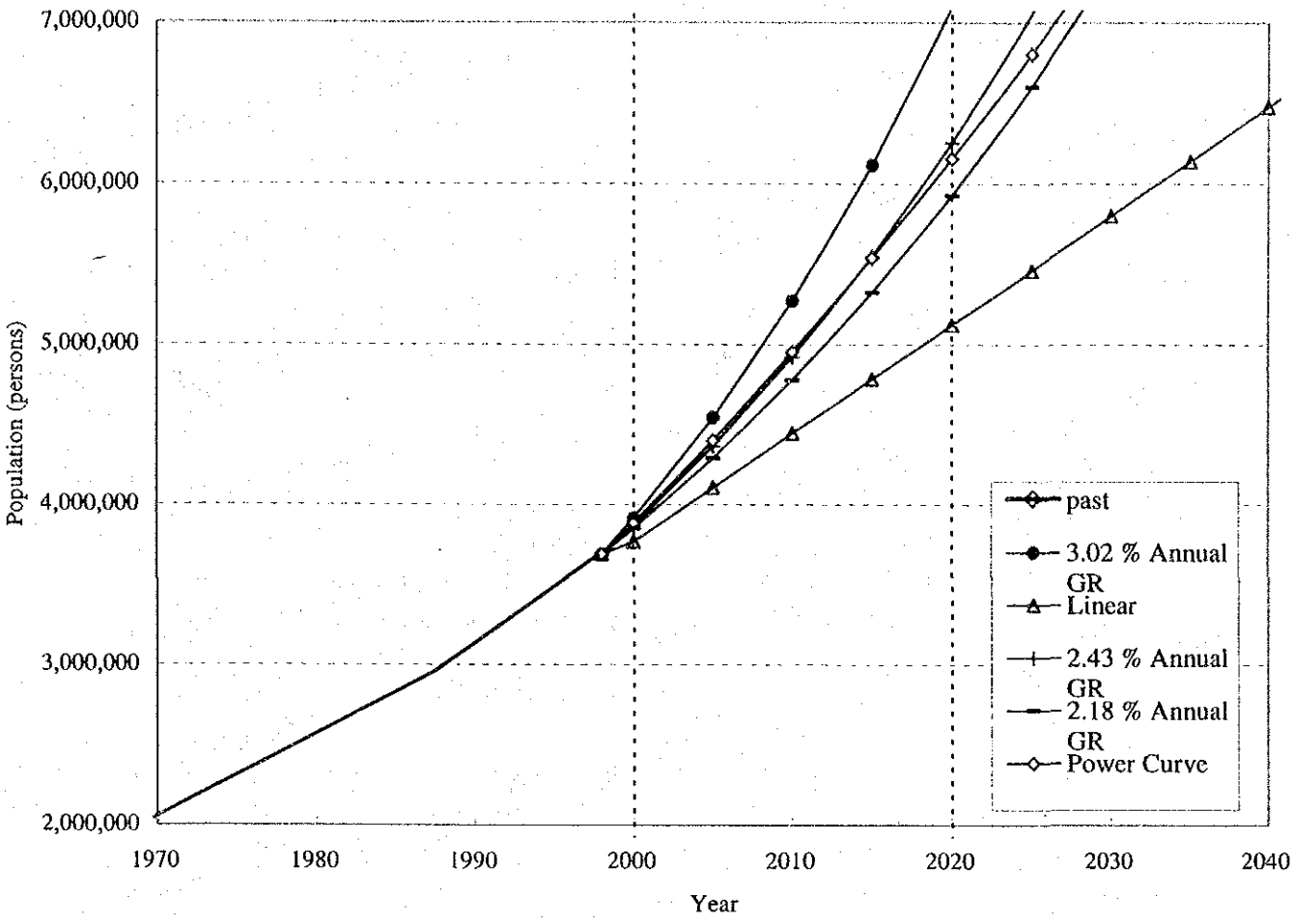


Fig. 2.1 Population Estimation

2.11 STATUS OF WATER SUPPLY

2.11.1 Water Sources

The three main sources of water utilized to a varying degree are surface, groundwater and rain water. The main surface water source in the study area comes from three reservoirs namely, Gyobyu, Pugyi and Hlawga. The groundwater comes both from shallow and deep underground aquifers. It is used either individually or supplemented to piped-water supply system.

(1) Surface Water Ponds

A unique characteristic of the study area is the presence of several lakes and ponds scattered over the landscape. Two of these lakes namely, Kandawgyi and Inya were the only source for City water until the construction of Hlawga Reservoir (1904). Since then many lakes particularly those in the central area of the City have subsequently been used mainly for recreation and aesthetic purposes. However, people in 12 townships within the study area draw their domestic water from several lakes and ponds.

(2) Undergroundwater

The two types of undergroundwater utilized in the study area come from shallow aquifers and deep aquifers.

(3) Rain Water

Rain water is the main source of water for utilized by almost all people in Seikky Kanantungy township during the rainy season. Being an area across the river and without any reliable drinking water source, rain water is the only source of potable water for the people. However, any systematic method of collecting it nor the use of improved techniques that have proven to be more efficient in other Asian countries is yet to be introduced to the Study Area.

2.11.2 Water Supply Institutions and Organizations

Yangon City Development Committee is the only institution which has an overall responsibility for water supply within the study area. However, because of the complex nature of the Study Area itself including its expansion into several new areas around the former City frontier, and various other constraints, a host of other institutions and organizations has evolved out and are actively involved in the supply of water to the City dweller and for other activities. This includes a large number of private entrepreneurs who have developed and managed their own supply systems to suit their domestic as well as industry water demands. The above suggests that no single institution has been able to meet the demand for water within the study area at present. The organizations involved with the water supply system in one or other ways are are:

1) Government Ministries including the Yangon City Development Committee
2) Private entrepreneurs and organizations
3) Other state institutions
4) Community Based Organizations
5) Non Governmental Organizations

3. CURRENT WATER SUPPLY SYSTEM

3.1 WATER SOURCES

The production rate of the existing water sources is estimated as 439,440 m^3/day as of 2000 and come from both surface water and groundwater.

Surface water (Reservoirs)	: 395,550 m^3/day
Groundwater	: 43,890 m^3/day
Total	: 439,440 m^3/day

3.1.1 SURFACE WATER

A total amount of 395,550 m^3/day of surface (reservoir) water is developed from three reservoirs as follows.

(1) Gyobyu Reservoir

Gyobyu has dependable yield of 93,300 m^3/day and was completed in 1940. It is located at about 64km (40 miles) north of Yangon.

(2) Phugyi Reservoir

Phugyi Reservoir was completed in 1992 and has a dependable yield of 245,700 m^3/day.

(3) Hlawga Reservoir

It has a dependable yield of 75,000 m^3/day and was completed in 1906.

(4) Ngamoyeik Reservoir (reservoir exists but water is not utilized yet)

It can supply the up to 409,500 m^3/d of water to Yangon City.

3.1.2 Groundwater

Groundwater extraction facilities in the city were divided into two categories; YCDC tube well and None YCDC dug/tube wells. The YCDC has 217 tube wells located in 22 Townships as of July 2001 with three levels of water supply service. Table 3.1 shows such categorized database for the YCDC tube wells. A total of 16.02 MCM/year of water is produced from these YCDC tube wells in 2000. Average pump operation hours was from 3.1 to 12.0 hrs per day. There are 21 service reservoirs existing in the main system at present to serve the ground water.

The ground water sources have qualitative problems especially; saline water intrusion, brackish water and high iron/manganese concentration.

Figure 3.1 shows the schematic diagram of current water supply system.

Table 3.1 Tube Well Parameters of YCDC Database

Category & Parameter		Description		
		Valid No.	Range	Remarks
Location	Township	217 wells	-	22 Townships
	Ward			
	Street			
	Numbering			
Struc-tures	Diameter	217 wells	50-300 mm	22 Townships
	Depth	217 wells	24-146 m	
	Year Completed	45 wells	1965-2001	5 Townships
Perform-ance	Water Quality	16 wells	pH, Fe, Cl	10 Townships
	Discharge	217 wells	50-2,270 lpm	Av. 744m^3/day
	Pump	100 wells 117 wells	50-250 mm 100-300 mm	Air-lifting Submersible
Utility	Level-I	74 wells	74 facilities	6 Townships
	Level-II GW	5 wells	2 systems	2 Townships
	Level-III GW	31 wells	16 systems	6 Townships
	Level-III SW/GW	104 wells	1 system	15 Townships
	Hydrant	3 wells	200 mm	3 Townships
Operation	Monthly Q Jan/98-Dec/00	199 wells	2,128-620,529 m^3/month	3 wells: Hydrant 2 wells: Standby 13 wells: No Records

Remarks; GW=Groundwater, SW=Surface Water, Q=Discharge
Sources; YCDC Township Office, as of July 2001

3.2 CLASSIFICATION OF EXISTING WATER SUPPLY

3.2.1 Service Level

The existing service is divided into "Individual" and three "Service Levels" according to the accessibility to water.

Individual : There is water source without pipeline network supply, only house owner can access to the water source facility.

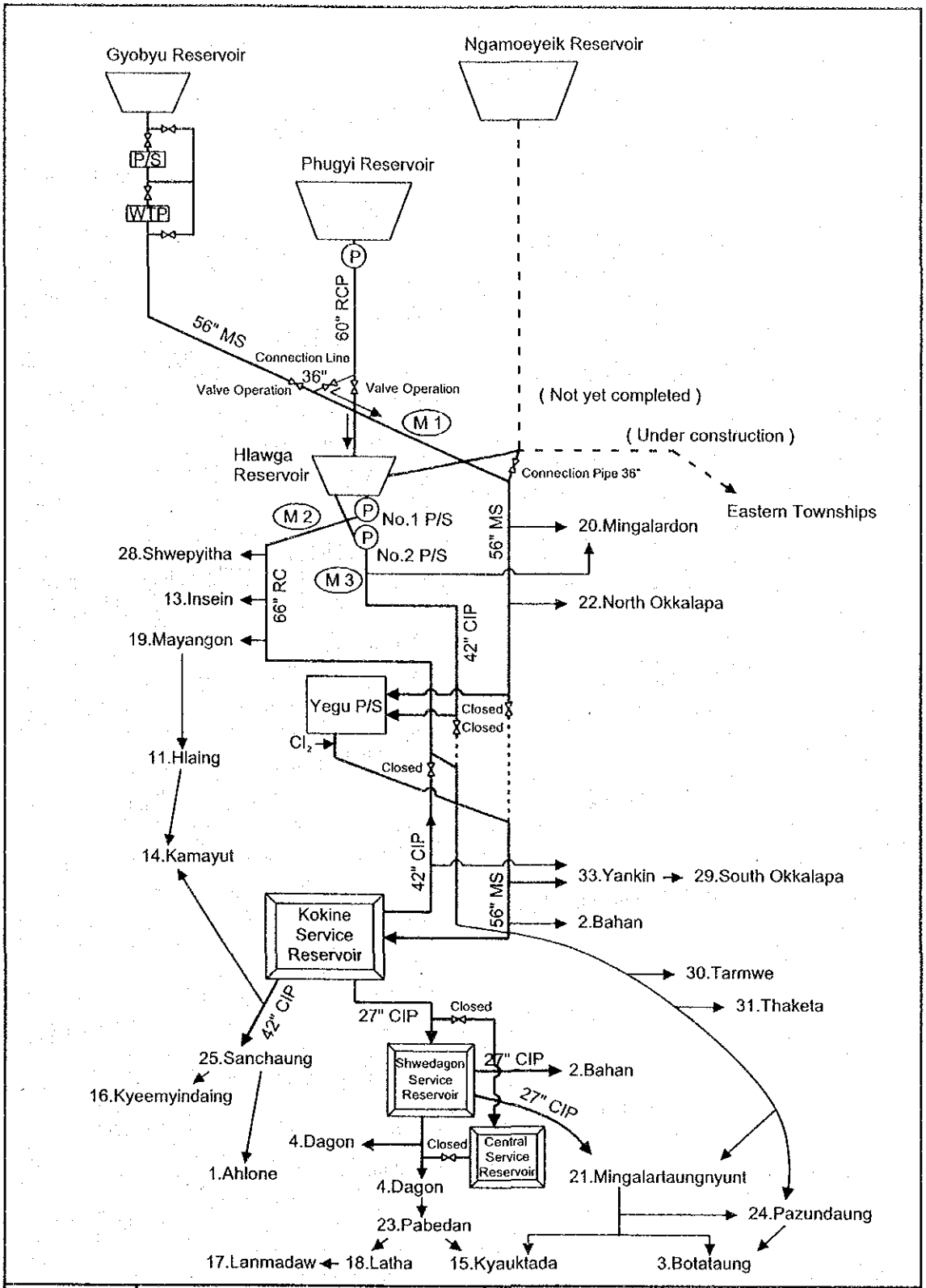
Level I : There is water source without pipeline network supply, beneficiaries access to the water source facility.

Level II : There is/are water source(s) with pipeline network supply, however beneficiaries access the communal/public faucets.

Level III : There is/are water source(s) with pipeline network supply, beneficiaries can utilize the water from the in-house faucet(house connection).

Table 3.2 shows the study results of service level and coverage ratio by Township. In short, the data in the table indicates:

- YCDC piped supply (SW, GW) is 37 % of total population
- YCDC Tube well Level I is 2 %
- YCDC Pond and Boat Supply is 7 %
- Total of YCDC supply is about 46 % (piped supply is only 36%)
- Non YCDC supply is 54%



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 3.1
	Current Water Supply Scheme	

Table 3.2 Categorized Database for Tube Well and Service Level Coverage

Township Name	Pop.	YCDC Owened Facilities									Privately Owned Facilities									Total
		Pipe-SW		Pipe-SW/GW		Pipe-GW		T/W	Boat	Pond	Dug/Driven Well			Tube Well				Pond	Rain	
		L-II	L-III	L-II	L-III	L-II	L-III	L-I	L-I	L-I	Indiv.	L-I	L-II	Indiv.	L-I	L-II	L-III	L-I	Indiv.	
01. Ahlone	45,870	0%	0%	0%	26%	0%	0%	0%	0%	0%	0%	0%	0%	13%	1%	0%	60%	0%	0%	100%
02. Bahan	100,139	0%	91%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	1%	0%	0%	100%
03. Botataung	55,434	0%	76%	0%	12%	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%	0%	0%	0%	100%
04. Dagon	42,079	0%	0%	0%	97%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	100%
05. Dagon Myothit East	58,108	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	39%	46%	0%	0%	0%	0%	100%
06. Dagon Myothit North	107,045	0%	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	0%	42%	43%	0%	4%	0%	0%	100%
07. Dagon Myothit Seikkan	19,245	0%	0%	0%	0%	0%	0%	0%	0%	53%	0%	0%	0%	1%	22%	0%	23%	0%	0%	100%
08. Dagon Myothit South	147,804	0%	0%	0%	0%	0%	0%	6%	0%	6%	0%	0%	0%	15%	66%	0%	2%	0%	6%	100%
09. Dala	81,317	0%	0%	0%	0%	5%	8%	0%	0%	88%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
10. Dawbon	83,787	0%	2%	0%	0%	0%	0%	14%	0%	70%	0%	0%	0%	12%	1%	0%	0%	0%	0%	100%
11. Hlaing	176,751	0%	10%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	39%	32%	0%	13%	0%	0%	100%
12. Hlaingthaya	209,714	0%	0%	0%	0%	0%	0%	4%	0%	10%	0%	0%	0%	15%	71%	0%	1%	0%	0%	100%
13. Insein	253,421	0%	10%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	13%	76%	0%	0%	0%	0%	100%
14. Kamayut	87,325	0%	0%	0%	24%	0%	23%	0%	0%	0%	0%	0%	0%	53%	0%	0%	0%	0%	0%	100%
15. Kyauktada	46,405	0%	0%	11%	89%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
16. Kyeemyindaing	92,113	0%	0%	0%	20%	0%	0%	0%	17%	0%	0%	0%	0%	33%	4%	0%	9%	0%	17%	100%
17. Lanmadaw	42,742	0%	9%	0%	87%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	100%
18. Latha	34,254	0%	24%	0%	76%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
19. Mayangone	192,694	0%	67%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	100%
20. Mingalardon	179,982	0%	19%	0%	0%	0%	0%	3%	0%	0%	3%	0%	0%	40%	34%	0%	0%	0%	0%	100%
21. Mingalartaungnyunt	115,597	0%	99%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	100%
22. North Okkalapa	304,339	34%	25%	4%	3%	0%	0%	6%	0%	6%	2%	4%	0%	4%	11%	0%	0%	0%	0%	100%
23. Pabedan	49,969	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
24. Pazundaung	40,390	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
25. Sanchaung	82,951	0%	0%	0%	40%	0%	0%	0%	0%	0%	0%	0%	0%	38%	19%	0%	3%	0%	0%	100%
26. Seikan Port	1,452	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	40%	40%	0%	0%	0%	0%	100%
27. Seikkyi Kanaungto	26,938	0%	0%	0%	0%	0%	0%	0%	43%	57%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
28. Shwepyitha	181,484	0%	0%	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	64%	32%	0%	0%	0%	0%	100%
29. South Okkalapa	231,849	0%	54%	0%	13%	0%	1%	0%	0%	0%	0%	0%	0%	22%	11%	0%	0%	0%	0%	100%
30. Tamwe	135,242	0%	92%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	100%
31. Thaketa	294,582	5%	2%	6%	2%	0%	0%	0%	0%	17%	0%	0%	0%	54%	15%	0%	0%	0%	0%	100%
32. Thingangyun	253,119	0%	0%	0%	0%	1%	6%	3%	0%	1%	0%	0%	0%	20%	38%	0%	30%	0%	0%	100%
33. Yankin	112,859	0%	59%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	41%	0%	0%	0%	0%	0%	100%
City Total	3,887,000	3.1%	23.3%	0.9%	8.5%	0.2%	1.2%	1.7%	0.7%	7.1%	0.8%	0.3%	0.0%	24.2%	23.4%	0.0%	4.0%	0.0%	0.6%	100%

Individual: There is water source without pipeline network supply. Only house owner can access to the water source facility for fetching water.
Service Level-I: There is water source without pipeline network supply. Beneficiaries access to the water source facility for fetching water.
Level-II: There is/are water source(s) with pipeline network supply. However, beneficiaries access to the communal/public faucets for fetching water.
Level-III: There is/are water source(s) with pipeline network supply. Beneficiaries can utilize the water fron the in-house faucet (house connection).

3.2.2 Communal Tanks

YCDC and its predecessors have initiated a system of water supply to poor communities via communal tanks. In this case, a masonry tank is built and is connected to the YCDC supply network. The capacity of existing tanks ranges from 400 gallons to 20,000 gallons. The customers collect water through taps fixed to the tank.

Households benefiting from communal tanks	19,890
Total households in study area	540,378
Households depending on communal tanks	3.7%

The communal tanks are in 13 townships. The majority of communal tank users do not pay for water. However, users in two townships are reported to be paying 3.25% of their property tax as water charges. The share of water charge comes to about Ks.11 per quarter. This system of water supply is particularly suitable for economically disadvantaged communities.

3.2.3 Standpipes

Standpipes have been provided for the use of pedestrians in the past. For example, the Myanmar General Consultants (1993) report the presence of 2,500 standpipes in 1980 which had later declined to 825 in 1993. The current policy appears to be to get rid of them gradually.

3.2.4 Lakes and Ponds

Lakes and ponds are the main water supply source for people in 12 townships. Of the 261 lakes and ponds in the 12 townships, only 118 are used as a source of drinking water. The other lakes/ponds serve several functions among which providing water for other domestic purposes (non-drinking), fire control and runoff storage are of significant importance.

3.2.5 Other Arrangements

Still there is a practice of water delivery to Seikky Kanantungy township via a tanker. Water is collected from a borehole in Ahlone to be shipped away to the township across the river. The township is a water deficit area especially in the dry season. The well water is salty which is unfit for consumption. At present, 4,480,000 gallons are provided to the people in this township over a period of 3 months beginning March, 2001.

Figure 3.2 shows existing service area covered by YCDC.

3.3 WATER SUPPLY SERVICE CONDITION

3.3.1 Water Connection

(1) Types of Connections: domestic (93%), commercial (6%), government (1%), foreign (0.03%) and free (% not available)

(2) Connection policy

Water connections are granted provided the premises where water connection is re-

quested is located in an area where there is already a network and water is adequate for the existing customers.

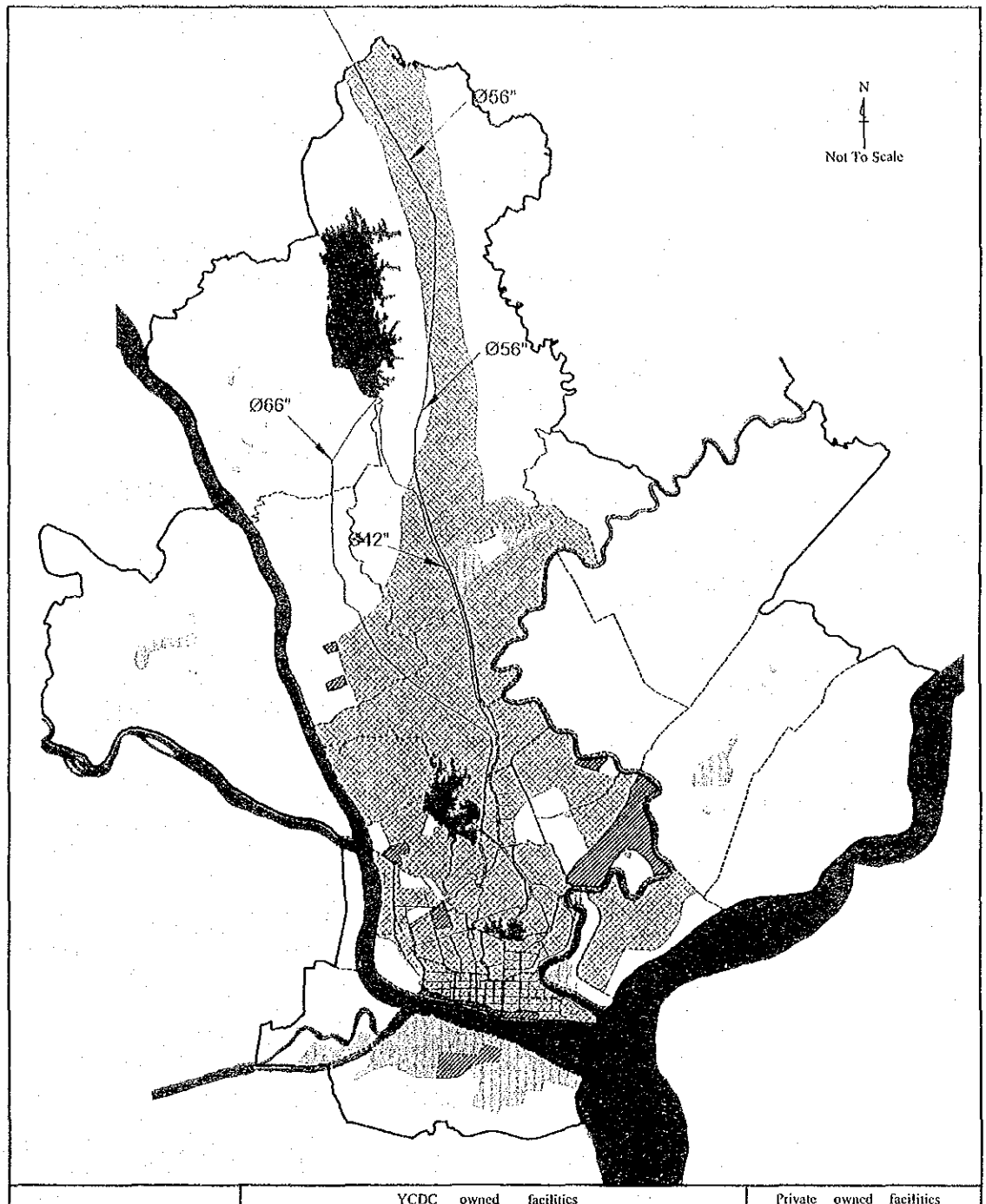
3.3.2 Duration Of Supply

In general, the townships located near the main distribution line get 24-hours water supply while those far away from the distribution line may have their supply lasting only for a short duration. 8 townships have 24-hours of water supply. The supply duration for many other townships including some of those in the CBD is very low as shown in Table 3.3. The dwellers in the CBD have adapted themselves to low-supply duration by installing water pumps.

Table 3.3 Water Supply Duration Status in Different Townships

Township	Supply Duration (Hours per day)	Number of Wards with Water Supply to Total Wards Number
Ahlone	10	10:11
Bahan	15	21:22
Botataung	24-10	10:10
Dagon	8	5:5
Dagon Myothit (East)	No pipe water supply system	0:54
Dagon Myothit (North)	No pipe water supply system	0:25
Dagon Myothit (Seikan)	No pipe water supply system	0:39
Dagon Myothit (South)	6	5:33
Dala	6	3:23
Dawbon	24-16	3:14
Hlaing	24	12:16
Hlaingthayar	4	7:29
Insein	24-2	4:21
Kamayut	12	10:10
Kyauktada	24	9:9
Kyeemyindaing	6	18:21
Lanmadaw	24	11:12
Latha	24	10:10
Mayangone	24-14	8:10
Mingalardon	24	18:31
Mingalartaungnyunt	24	20:20
North Okklapa	24-8	18:19
Pabedan	24-15	11:11
Pazundaung	24	10:10
Sanchaung	5-1	18:18
Seikkan (Port)	No pipe water supply system	0:3
Seikkyi Kanaungto	No pipe water supply system	0:8
Shwepyitha	4	13:21
South Okklapa	24-10	13:13
Tamwe	24	17:20
Thaketa	24-8	17:19
Thinganchaung	24-8	24:38
Yankin	24-18	15:16

Source: JICA Study Team



Legend	YCDC owned facilities			Private owned facilities
City Boundary	Piped System: Pipe SW / Pipe SW/GW	Non piped System: Tube Well, Boat, Pond		Dug/Driven well, Tube well, Pond, Rain collector
Township Boundary	Piped System: GW with independent network			
River or Lake				
Primary Mains				

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THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FIG 3.2

Existing Service Area by YCDC

3.3.3 Water Pressure

The relatively high-pressure areas are Bahan, Hlaing, Insein, Mayangone, Tamwe and Yankin. The north of Bahan areas have reasonable pressure, especially near transmission main. Yegu P/S and near Shwe Dagon Service Reservoir areas have relatively high pressure (1.0,1.5, 3.0 kg/cm^2). The other areas such as Ahlone, Botataung, Dagon, Dawbon, Kamayut, Kyauktada, Kyeemyindaing, Lanmadaw, Latha, Mingalartaungnyunt, North Okkalapa, Pazundaung, Sanchaung, South Okkalapa, and Thingangyun have low pressure. Typical minimum service levels in many countries are 2 kg/cm^2 and almost all the Yangon Supply area is below this pressure.

3.4 WATER QUALITY

3.4.1General

Periodical water sampling was conducted to examine the current status of the existing water sources. Water sampling was carried out every month starting from May 2001 to March 2002. Based on the results of water quality analysis, which was continued almost a year, water treatment method was proposed by water source wise.

3.4.2 Examination Parameters

Water quality examination parameters were selected to improve the water quality in the system and to determine the proposed water treatment process. The followings are the selected parameters;

Bacteriological	BOD, Dissolved Oxygen,
Physical	Temperature, Color, Turbidity,
Chemical	Hardness, Alkalinity, pH, COD, Arsenic, Cadmium,
Cations	Calcium, Magnesium, Potassium, Sodium,
Anions	Chloride, Sulfide, Cyanide, Nitrate, Nitrogen-Ammonia,
Trace Elements	Iron, Manganese, Zinc, Copper, Lead,

3.4.3 Sampling Points

Forty sampling points were selected as shown in the table below;

Table 3.4 Sampling Points and Sampling Number

Sampling Points		Sampling Number	Remarks
Existing Reservoirs	Gyobyu Reservoir	1	
	Phugyi Reservoir	1	
	Hlawga Reservoir	1	
Planned Reservoirs	Ngamoeyeik Reservoir	1	
	La Gun Pyin Reservoir	1	
Rivers	Hlaing River	12	High and low tide, 2 points 3 depth (upper, middle, lower)
	Bago River	12	Ditto
Tube Wells		11	
	Total	40	

3.4.4 Saline Water Intrusion Survey

Saline water intrusion survey was conducted at Bago and Hlaing River during rainy season and as to Hlaing River, survey was performed again in dry season. Survey was conducted to determine the appropriate river water intake point. Starting from Wataya, located 15 km downstream of Gwedanshe, the proposed intake point in Hlaing River, electric conductivity was measured in several points including Yangon Port. Interview to the villagers was also carried out to grasp the saline water influence. EC value at Wataya was 258 μS/cm and it was determined as "fresh water" and thus, Gwedanshe was adopted as proposed intake point of Hlaing River.

3.4.5 Examination on Analysis Results

The following table shows the summary of water quality analysis on 1) Reservoir, 2) Hlaing River and 3) Groundwater;

Table 3.5 River and Reservoir Water Quality Analysis Results

Parameters	Unit	Myanmar Standard	Reservoir	Hlaing River
Turbidity	NTU	20	N.D. to 3	237 to 800
Color	TCU	5 – 50	N.D. to 7.5	17.5 to 575
pH		6.5 – 9.2	6.7 to 7.8	7.2 to 8.1
Alkalinity	$CaCO_3$ mg/L	-	40 to 58	40 to 125

As shown in the table, water quality in reservoir is satisfactory but proper turbidity removal facility is needed on Hlaing River water for drinking use. Appropriate disinfection shall also be conducted in full time scale for these water sources.

Table 3.6 Groundwater Quality Analysis Results

Parameters	Unit	Myanmar Standard	Groundwater
Turbidity	NTU	20	2 to 48
Color	TCU	5 – 50	15 to 50
pH		6.5 – 9.2	7.0 to 8.7
Iron	ppm	0.5 – 1.5	0.3 to 3.6
Manganese	ppm	0.3	N.D. to 0.7
Electric Conductivity	μS/cm	1,500	340 to 23,200

Above table shows the water quality analysis results on groundwater taken from existing YCDC tube wells. As shown in the table, values higher than the standard was detected in some parameters. Along with this water quality analysis, EC was measured on 217 YCDC tube wells and high EC value indicating high contents of dissolved matters was recognized especially in eastern and northern area of the City. Consequently, it was suggested that "groundwater use in the fol-

lowing T/S shall transfer to surface water in future".

- Dagon South T/S
- North Okkalapa T/S
- Thaketa T/S

3.5 ORGANIZATIONAL STRUCTURE AND HUMAN RESOURCES

- Staff of only 13 out of 33 townships had training opportunities during the past year
- Out of the 456 staff numbers attached to townships, only 78 staff (17%) have had the opportunity of training during the whole year
- Training is predominantly biased on administrative aspects of training
- Tthe current engineering management course of training is more administrative than technical.

3.6 OPERATION & MAINTENANCE AND REPAIRS

The current responsibility for operation and maintenance (O&M) of the water supply facility is vested mainly with WSS while the customer is responsible for his supply line and all internal connection work. The department is responsible for the O&M and repairs of reservoirs, transmission and distribution lines, other facilities, water pumps and other fitouts. The customer is responsible for any repairs or leaks from the service connection supplying water to him/her.