THE REPUBLIC OF THE UNION OF MYANMAR
YANGON CITY DEVELOPMENT COMMITTEE (YCDC)

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR
THE IMPROVEMENT OF
WATER SUPPLY, SEWERAGE
AND DRAINAGE SYSTEM
IN YANGON CITY
IN
THE REPUBLIC OF THE UNION OF MYANMAR

VOLUME VI
SEWERAGE AND DRAINAGE SYSTEM
MASTER PLAN

< Advance Version >

MARCH 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

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THE PROJECT FOR
THE IMPROVEMENT OF
WATER SUPPLY, SEWERAGE AND DRAINAGE SYSTEM
IN YANGON CITY

FINAL REPORT

MARCH 2014

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Abbreviation

B/C	Benefit per Cost
BDS	Back Drainage Space
BOD	Biochemical Oxygen Demand
CBD	Central Business District
CIP	Cast-Iron Pipe
COD	Chemical Oxygen Demand
DDA	Department of Development Affair
DEWS	Department of Engineering (Water Supply Sanitation)
DIP	Ductile Iron Pipe
DMA	District Metered Area
EC	Electrical conductivity
E/N	Exchange of Notes
ECC	Environment Conservation Committee
F/S	Feasibility Study
FC	Foreign Currency
FY	Fiscal Year
GPCD	Gallons Per Capita per Day
HHWL	Highest High Water Level
HWL	High Water Level
IEE	Initial Environmental Examination
IUR	Inner Urban Ring
JICA	Japan International Cooperation Agency
JICA-HIS	JICA Household Interview Survey
Kyat	Myanmar Kyat
LPCD (or Lpcd)	Liters Per Capita per Day
LWL	Low Water Level
M&E	Mechanical & Electrical
M/P	Master Plan
METI	Ministry of Economy, Trade and Industry
MG	Million Gallons
MGD	Million Gallons per Day
MIP	Mingaladon Industrial Park
ML	Million Liters
MLD	Million Liters per Day
MOAI	Ministry of Agriculture and Irrigation
MOECAF	Ministry of Environment Conservation and Forestry
MOF	Ministry of Forestry
MOFA	Ministry of Foreign Affairs
MOU	Memorandum of Understanding
MWL	Mean Water Level
N/A	Not Available
NCEA	National Commission for Environmental Affairs
NewSZ	New Suburbs Zone

NRW	Non Revenue Water
NS	Northern Suburbs
O&M	Operation & Maintenance
OldSZ	Older Suburbs Zone
ORZ	Outer Ring Zone
P/S	Pumping Station
PPP	Public–Private Partnership
PVC	Polyvinyl Chloride
R.	Reservoir
RC	Reinforced Concrete
S/R	Service Reservoir
SCADA	Supervisory Control And Data Acquisition
SCBD	South of CBD
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SS	Suspended Solids
STP	Sewage Treatment Plant
TDS	Total Dissolved Solids
T-N	Total Nitrogen
T-P	Total Phosphorus
TS	Township
TS	Total Solids
US$、USD	United States Dollars
VAT	Value Added Tax
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant
YCDC	Yangon City Development Committee
YCDL	Yangon City Development Law

Abbreviation for the Relevant Studies

The Preparatory Study for Urban Development Programme in the Greater Yangon (JICA)	JICA Urban Plan Study, 2012
Household Interview Survey (JICA)	2012 JICA-HIS
Data Collection Survey on Water Resources Potential for Thilawa Special Economic Zone and Adjoining Areas (JICA)	JICA Thilawa Water Study
The Study on Improvement of Water Supply and Wastewater Treatment in Yangon (METI)	METI Water Supply and Sewerage Study
The Study on Improvement of Water Supply System in Yangon City	2002 JICA-M/P

Unit

1 Gallon (British Gallon) = 4.546 liter

1 Acre = 4,047 m^2

Foreign Exchange Rate

1 USD = 84.64 JPY (as of December 2012)

CHAPTER 1. INTRODUCTION

1.1 Background of the Study

Although the capital of Myanmar was moved to Naypyidaw in 2006, Yangon City is still the national center of economy, business and communication. Current population of Yangon City is approximately 5.1 million according to Yangon City Development Committee (YCDC). Water supply system in Yangon has a long history, the water supply services commenced in 1842. However, the service ratio is still as low as 38 %. Transmission and distribution pipes have not been rehabilitated properly resulting in large quantity of non-revenue water, i.e. 66 % of total daily supply of 520,000 m^3/day. Approximately, 90 % of water comes from reservoir, and two thirds of it is distributed directly without any treatment. In addition, water treatment at the water treatment plant is insufficient. Approximately, 70 % of connections are equipped with water meter, which is higher compared to other developing countries, but water charge is rather low, approximately 8 Yen/m^3 for metered houses and 180 to 300 Yen/month for houses without meter. It cannot be said that sufficient financial sources is secured for operation and maintenance of water supply system. Regarding technical capability of the undertaking, YCDC's capability is evaluated to be high, since they have been making efforts to design water supply facilities and to manufacture pipes by themselves. On the other hand, there remains much room for improvement in operation and maintenance of water treatment plant and in management of water quality. In the 6 townships located outside boundary of YCDC administrative area, water supply system, if it exists, is managed by the Yangon regional government.

Sewerage system in Yangon was constructed in the downtown in 1880's, which is located in the southern part of the city covering about 9 km^2 service area, and was expanded in 1929. A wastewater treatment plant was constructed in 2004 with a design capacity of 14,500 m^3/day. Currently sewerage service area is limited to 6 townships out of 33 townships. In the remaining 27 townships, wastewater is treated by on-site systems (septic tank etc.) and in such cases treatment efficiency is deemed to be low. Also, being located in monsoon region, Yangon City has suffered due to flooding in absence of appropriate wastewater collection networks. Under the circumstances mentioned above, efficient and timely development of water supply, sewerage and drainage systems in Yangon is the most urgent need to improve the level of services and living conditions.

Regarding water supply, JICA implemented a development study titled "The Study on Improvement of Water Supply System in Yangon City" in 2002, in which master plan was formulated and feasibility study was conducted to prepare development plan targeting year 2020. Estimation of future water demand, investigation of potential water resources, block distribution system, rehabilitation of pipe networks, construction of facilities such as new water treatment plant, transmission lines, and reservoirs, project cost estimation were included in the study. However, due to various reasons, most

of the projects proposed in the plan are yet to be implemented. Alternatively, measures to expand water supply coverage have been implemented to cope with the needs of development of new suburban areas; including 1 large water treatment plant for which raw water source is Ngamoeyeik reservoir and 4 small plants using ground water as sources of water. In addition, many service meters have been equipped.

After adoption of new liberal policies in Myanmar, JICA initiated discussing with the Yangon regional government on formulation of comprehensive development plan including water supply, sewerage, drainage, electricity, road, railways, ports etc. and the minutes were concluded concerning "the project for the strategic urban development plan of the greater Yangon" on May 1st 2012. Further minutes were concluded concerning water supply, sewerage and drainage, one of the umbrella projects on May 22nd 2012.

As a result, the following related projects are under progress through the Japanese assistance;

1) "Study on the Improvement of Water Supply and Wastewater Treatment in Yangon City" (Ministry of Economy, Trade and Industry (METI), Japan)
2) "Study on Development of Sewerage System in Myanmar, 2012" (Ministry of Land, Infrastructure, Transport and Tourism, Japan)
3) Project for the Strategic Urban Development Plan of the Greater Yangon (JICA)
4) "Study on Water Resource Potentialities for Thilawa SEZ and its environs" (JICA)

In addition, advisor for water supply has been dispatched from Fukuoka city, Japan, funded by JICA

1.2 Objectives of the Study

The objectives of this study are formulation of development plan for water supply, sewerage and drainage in greater Yangon and selection of priority projects in order to contribute to economic development and to improvement of living environment of the City.

1.3 Counterpart Organization

The main counterpart organization is Yangon City Development Committee (YCDC).

1.4 Study Area

The Study area is greater Yangon, covering YCDC area (33 townships) and parts of the surrounding 6 townships (Thanlyin, Kyauktan, Hmawbi, Hleagu, Htantapin and Twantay).

1.5 Target Year

Target year for master plan is set as 2040, same as that of the Project for the strategic urban development plan of the greater Yangon while that for feasibility study is set as 2025.

1.6 Study Schedule

This study started in August 2012 submitting Inception Report (IC/R). Then, a water vision and a master plan were prepared based on data of framework and household interview survey results obtained from "The Preparatory Study for Urban Development Programme in the Greater Yangon (JICA)" and interim report (IT/R) containing the water vision and the master plan (M/P) was submitted in March 2013. Furthermore, the revised interim report was submitted for disclosure to the public.

Of the project components in the master plan, priority projects were selected for a feasibility study (F/S) which started in February 2013. The feasibility study was completed in July 2013 and the contents were explained in the technology transfer seminar. Afterward, an additional survey was carried out according to change of the land for a service reservoir and the route of transmission pipeline to Thilawa SEZ, and the feasibility study was completed.

The draft final report (DF/R) containing Water Vision, Mater Plan and Feasibility Study was prepared and submitted herewith.

The final report (F/R) was prepared and finalized based on comments obtained from YCDC and submitted in March 2014.

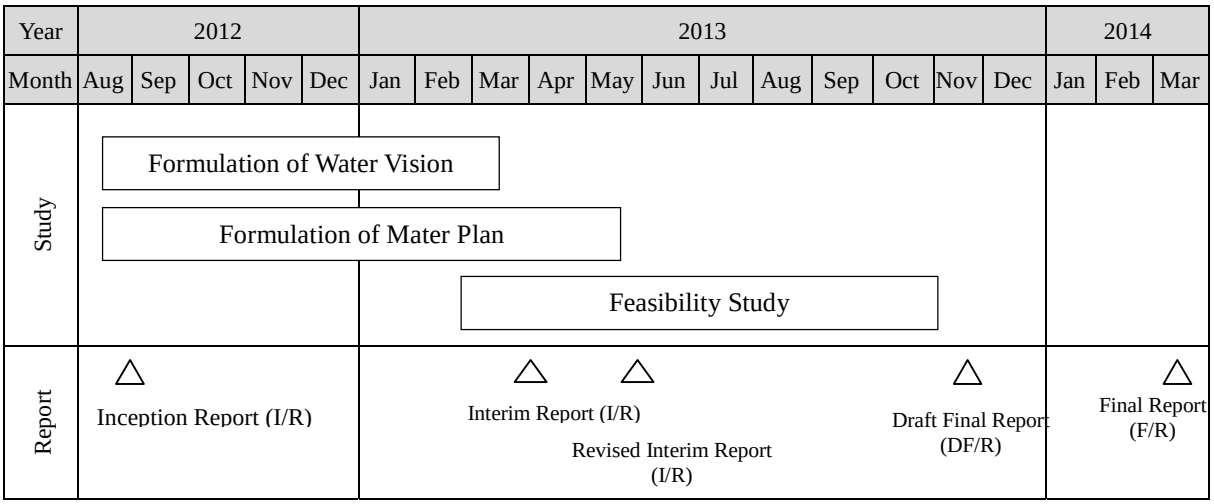


Figure 1.1 Study Schedule

CHAPTER 2. OUTLINE OF THE STUDY AREA

2.1 Socio-Economic Condition

2.1.1 Administrative Organization and Boundary of the Study Area

Administrative boundaries of YCDC has been gradually expanding, incorporating urbanizing townships in the peripheral area and, 33 townships are included in YCDC area as of 2012. In future, parts of other 6 townships in the Study Area might be incorporated with YCDC administrative area but at present it is under the administration of the Yangon regional government (see Figure 2.1). Thirty-three townships of YCDC are grouped into 7 categories, reflecting regional characteristics, according to the JICA urban development study (see Figure 2.2).

2.1.2 Present Land Use

(1) Urbanization Trend

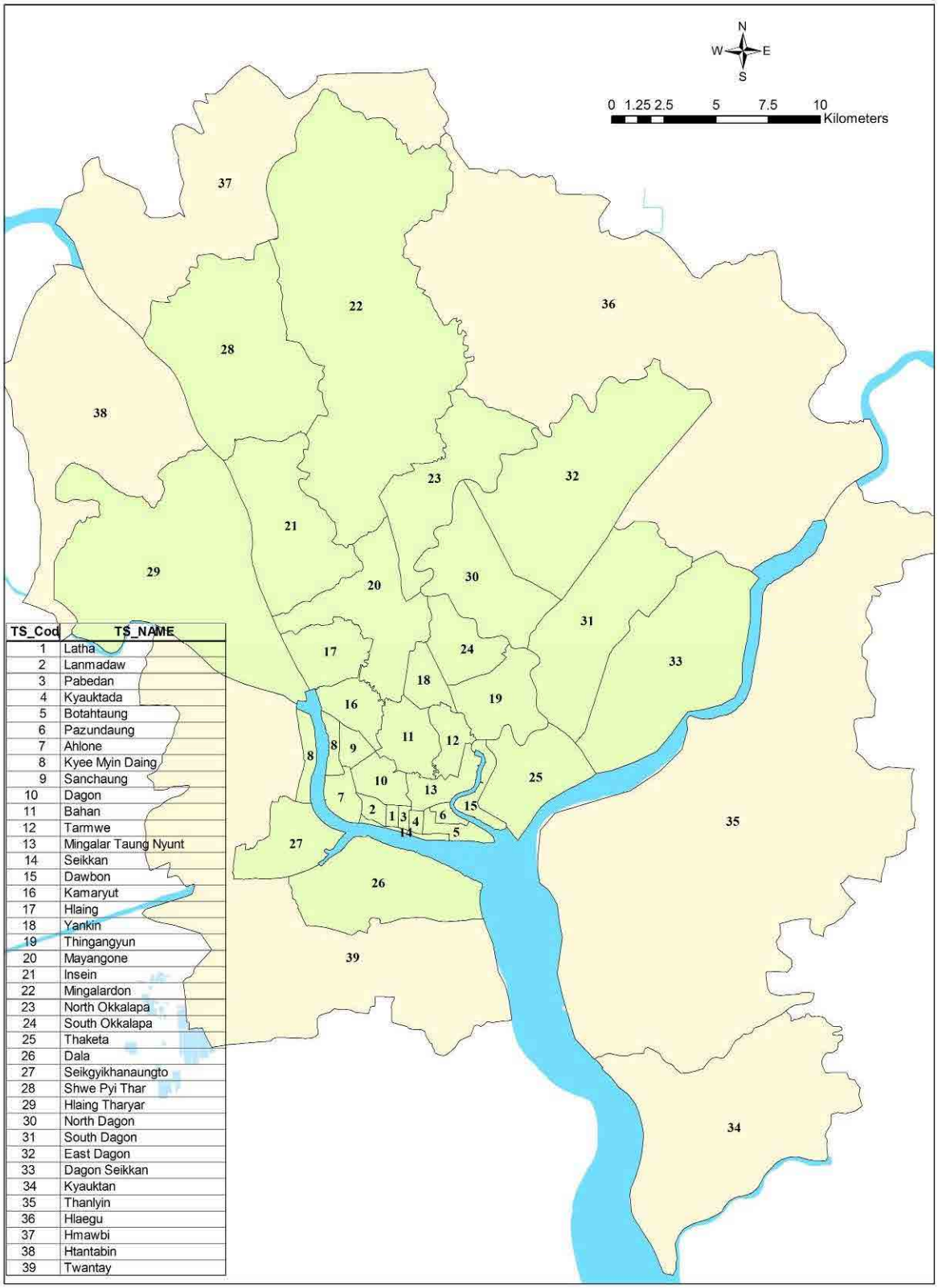
Present Yangon started its history from the current CBD (Central Business District) area, developed as the capital of lower Myanmar by Britain in 1885. Urbanization expanded northward during 1950's to accommodate redevelopment of houses after devastation of houses and mitigation of developed slums and illegal settlements after the 2nd world war. New urban areas are township groups of Inner Urban Ring, Outer Ring Zone and Northern Suburbs. After 1959, older suburbs were developed in the low-lying area. Total population in the above zones having area of 126.54 mile^2 is 3.28 million in 2011. So population density is about 100 per hectare. The above area is situated along the egg-shaped central hills between the Hlaing River and the Ngamoeyeik (or Pazuntaung) creek.

In late 1980's, egg-shaped hills area reached their saturation level in terms of population density (although this area still has potential of assimilating development according to the Japanese standard) and urbanization has shifted towards east and west crossing the above two rivers (creeks). They are called as "New suburbs". The population of new suburbs is estimated as 1.64 million in 2011 spread in an area of 174.02 mile^2 with population density of about 36 per hectare. Urbanization has not yet started in the south Yangon because of poor transportation access to the CBD.

(2) Present Land Use

The land use pattern prevailing in the Study Area in 2012 was developed in the JICA urban development study based on the analysis of satellite imagery. Looking at the land use in 2012, YCDC area is already developed or undergoing development while most of the area outside YCDC boundary

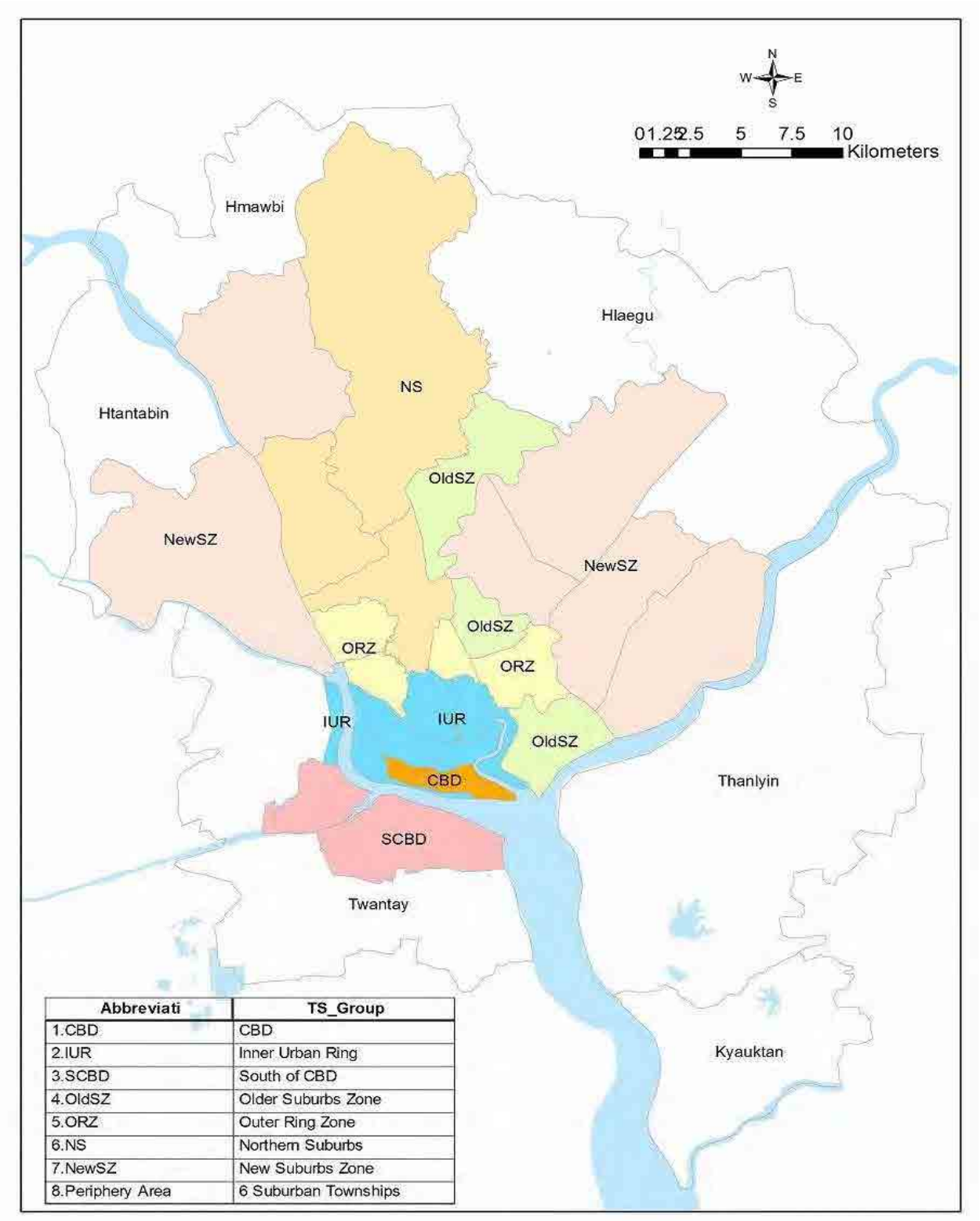
is agricultural land except parts of Thanlyin and Kyauktan which are situated on the hilly areas seemingly extending from the central hills of Yangon.



TS_Cod	TS_NAME
1	Latha
2	Lanmadaw
3	Pabedan
4	Kyauktada
5	Botahtaung
6	Pazundaung
7	Ahlone
8	Kyee Myin Daing
9	Sanchaung
10	Dagon
11	Bahan
12	Tarmwe
13	Mingalar Taung Nyunt
14	Seikkan
15	Dawbon
16	Kamaryut
17	Hlaing
18	Yankin
19	Thingangyun
20	Mayangone
21	Insein
22	Mingalardon
23	North Okkalapa
24	South Okkalapa
25	Thaketa
26	Dala
27	Seikgyikhanaungto
28	Shwe Pyi Thar
29	Hlaing Tharyar
30	North Dagon
31	South Dagon
32	East Dagon
33	Dagon Seikkan
34	Kyauktan
35	Thanlyin
36	Hlaegu
37	Hmawbi
38	Htantabin
39	Twantay

Source: JICA Study Team

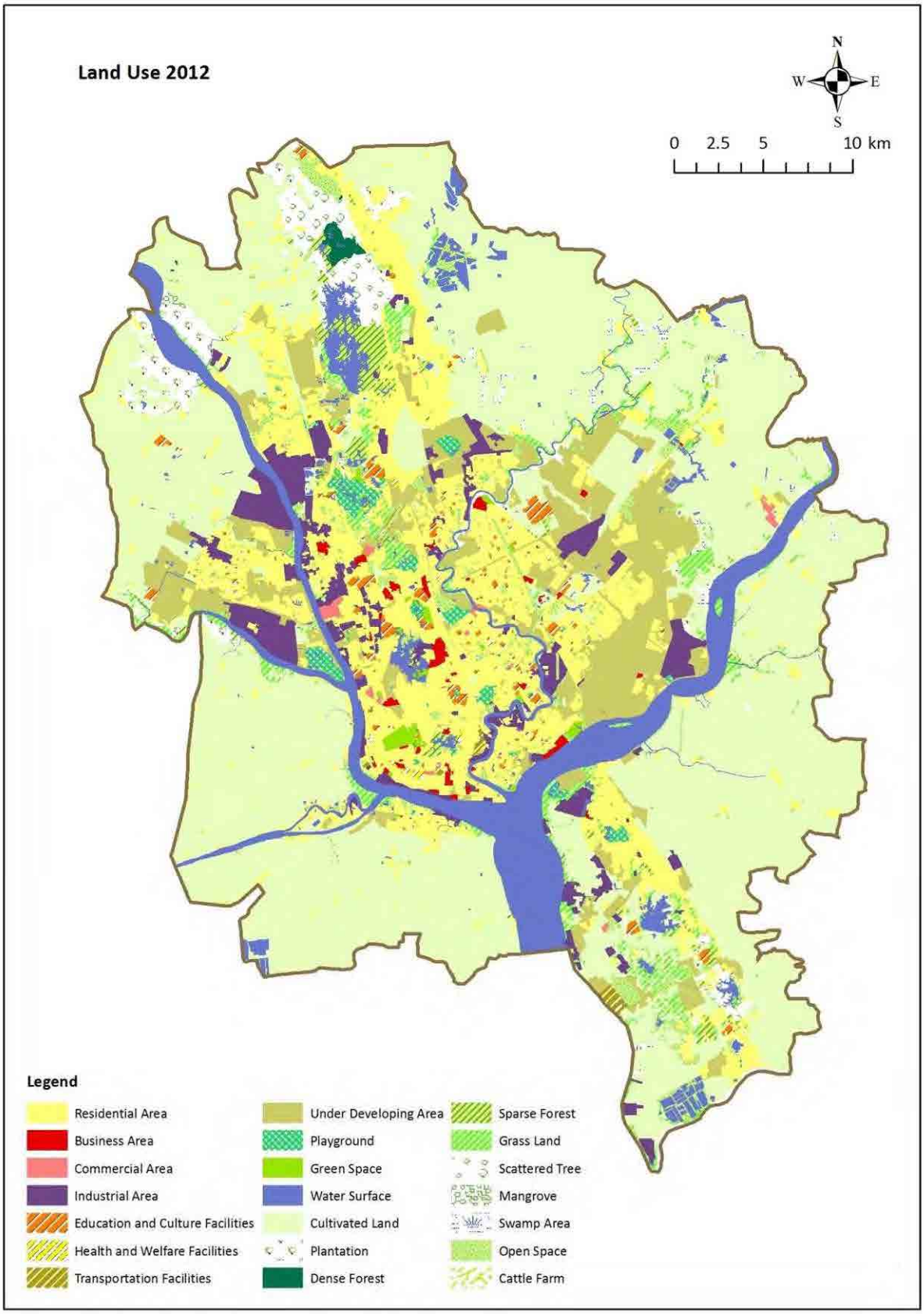
Figure 2.1 Study Area (33 Townships in Yangon City and the Part of Surrounding 6 Townships)



Abbreviati	TS_Group
1.CBD	CBD
2.IUR	Inner Urban Ring
3.SCBD	South of CBD
4.OldSZ	Older Suburbs Zone
5.ORZ	Outer Ring Zone
6.NS	Northern Suburbs
7.NewSZ	New Suburbs Zone
8.Periphery Area	6 Suburban Townships

Source: JICA Study Team

Figure 2.2 Grouping (33 Townships) and Surrounding Area of YCDC

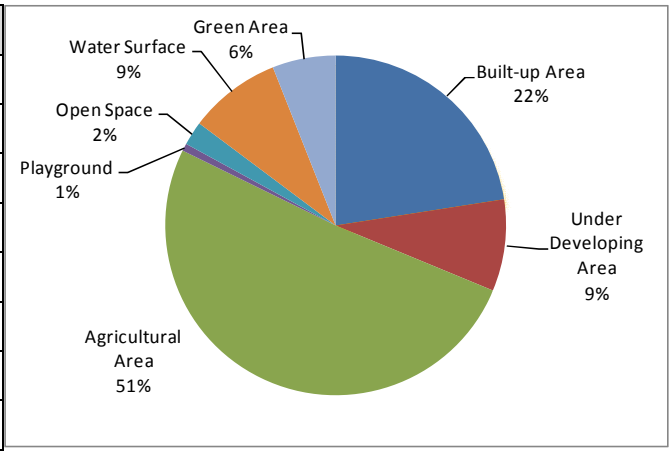


Source: JICA Urban Plan Study, 2012

Figure 2.3 Land Use in Greater Yangon (2012)

Table 2.1 The Composition of Land Use (2012)

Land Use	Are (sq.km)	%
Built-up Area	360.7	22%
Under Developing Area	139.7	9%
Agricultural Area	815.8	51%
Playground	11.5	1%
Open Space	36.4	2%
Water Surface	139.9	9%
Green Area	96.3	6%
Total	1,600.3	100%



Source: JICA Urban Plan Study, 2012

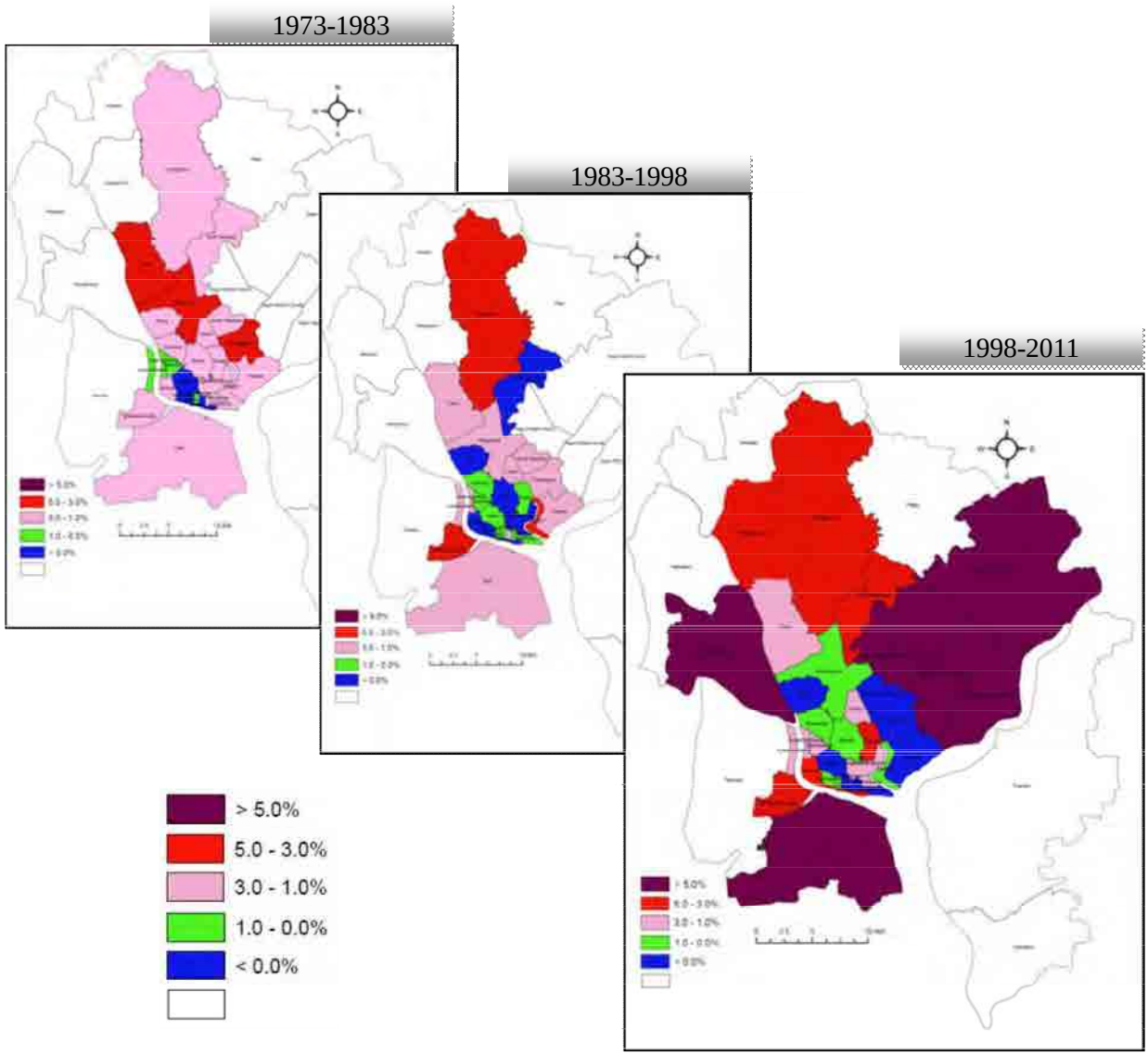
2.1.3 Population

Past populations together with the city area are shown in Table below. Population of 0.73 million in 1953 increased to 0.94 million (about 1 million) in 1963. Afterwards together with city area increase, population increased to 2 million in 1973, 3 million in 1993, 4 million in 2003 and 5.14 million in 2011. Average population growth rate has been about over 2%.

Table 2.2 Trend of Population in Yangon City

Year	Population (Mil.)	Average Population Growth (%)	Area (km^2)	Pop. Density (Person/km^2)	Remark
1953	0.73		123.3	5,925	
1963	0.94	2.5	164.2	5,725	
1973	2.01	7.9	221.4	9,077	Expansion of the City in 1965 and 1973
1983	2.51	2.2	346.0	7,254	Expansion of 1983
1993	3.09	2.1	603.5	5,120	Expansion of 1991
2003	4.10	2.8	794.3	5,161	Expansion of 2003
2011	5.14	2.9	794.3	6,471	

Source: YCDC



Source: JICA Urban Plan Study, 2012

Figure 2.4 Trend of Population Growth by Township

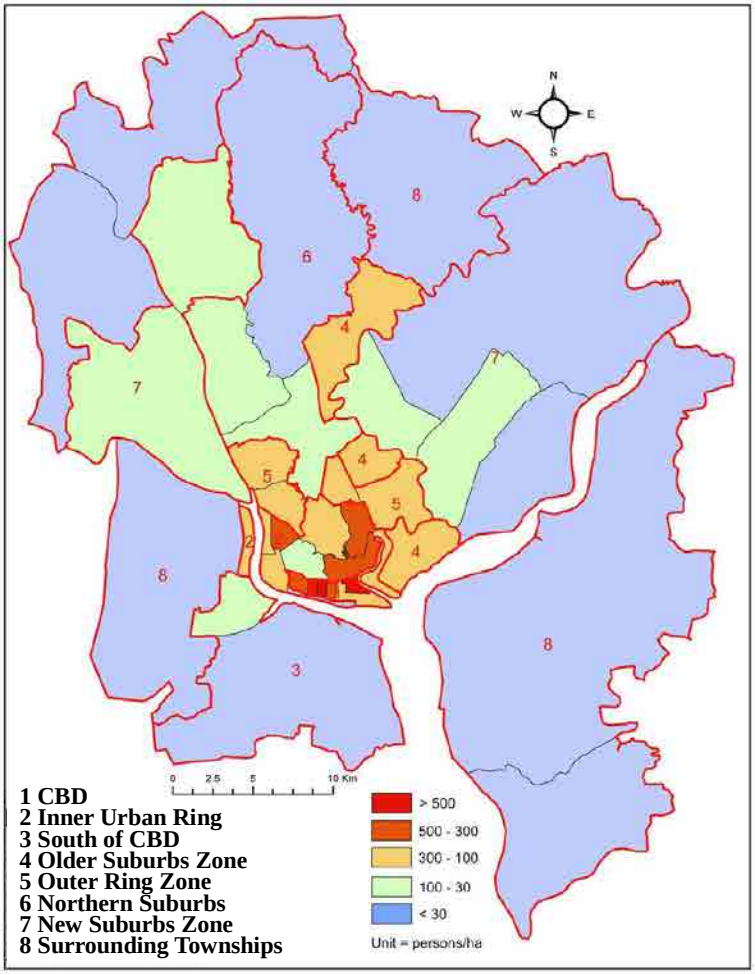
Urbanization rate in Myanmar is 29% in 2010, increased from 25% in 1983, which is lower than 50% of the average figure in the world. Henceforth, it is expected that urbanization will increase more rapidly in Myanmar.

Township-wise populations are shown in the Table below and township-wise population densities are shown in the Figure below. Population in the study area is 5.57 million consisting of 5.14 million in YCDC and 0.43 million in the peripheral area. Population density in the CBD zone is the highest, 365 persons per hectare and that in south of CBD is the lowest, 20 persons per hectare in YCDC. On the other hand, in the peripheral area, the population density is 6 persons per hectare. Population in the CBD has stopped growing recently while populations in the new suburbs and south of CBD have been growing at relatively higher rate of 4 to 15 % annually.

Table 2.3 Population, Population Growth and Population Density in Greater Yangon

No.	Township	TS Group	No. Ward	Area (m^2)	Population	Households No.	Pop. Growth (%)	Pop. Density (pop/ha)	Pop. Density by TS group (pop/ha)
				2011	2011	2011	1998-2011	2011	2011
1	Latha	CBD	10	604770.4	34125	5368	0.37%	564	
2	Lanmadaw	CBD	12	1310572	43137	7334	0.47%	329	
3	Pabedan	CBD	11	618984.4	37551	5366	-1.79%	607	
4	Kyauktada	CBD	9	701876.1	34797	6078	-1.80%	496	
5	Botahtaung	CBD	10	2601921.3	49134	8148	-0.53%	189	
6	Pazuntaung	CBD	9	1067498.3	53648	8258	2.61%	503	365
7	Ahlone	IUR	11	3380983.6	65510	9021	3.19%	194	
8	Kyeemyindaing	IUR	22	4570109.9	115841	20215	2.18%	253	
9	Sanchaung	IUR	18	2404655.5	105208	17242	2.25%	438	
10	Dagon	IUR	5	4894632.9	24492	3682	-3.70%	50	
11	Bahan	IUR	22	8474439.4	100695	16339	0.44%	119	
12	Tarmwe	IUR	20	4985869.1	191114	32505	3.10%	383	
13	Mingalar Taung Nyunt	IUR	20	4943031.6	155767	22732	2.73%	315	
14	Seikkan	IUR	3	1174224.5	2241	433	3.81%	19	
15	Dawbon	IUR	14	3111295	87284	13603	0.71%	281	224
16	Kamaryut	OR	10	6472492.7	87881	13663	0.45%	136	
17	Hlaing	OR	16	9820283	151014	25969	-0.81%	154	
18	Yankin	OR	16	4791565.1	125909	13921	1.25%	263	
19	Thingangyun	OR	39	13120302	231621	35335	-0.29%	177	174
20	Mayangone	NS	10	25834479	205403	33738	0.89%	80	
21	Insein	NS	21	31397616	311200	53324	2.00%	99	
22	Mingalardon	NS	32	127943855	288858	48896	4.12%	23	43
23	North Okkalapa	OldS	19	27755247	333484	57101	4.46%	120	
24	South Okkalapa	OldS	13	8217704.9	191388	33800	-1.07%	233	
25	Thaketa	OldS	19	13448713	253284	43076	-0.76%	188	157
26	Dala	SCBD	46	98400859	181087	31192	6.77%	18	
27	Seikgyikhanaungto	SCBD	9	12101872	38425	6804	3.18%	32	20
28	Shwe Pyi Thar	NewS	27	52706107	295993	38636	4.25%	56	
29	Hlaing Thar Yar	NewS	29	77614147	488768	73668	7.15%	63	
30	North Dagon	NewS	27	24177408	221200	36919	6.16%	91	
31	South Dagon	NewS	39	37506127	370403	58779	7.75%	99	
32	East Dagon	NewS	60	170871278	145505	22734	7.74%	9	
33	Dagon Seikkan	NewS	48	42035707	120161	21741	15.59%	29	41
	YCDC Total		676	829060625	5142128	825620		62	
34	Kyauktan	PA	13	76120987	48473	40552	-	6	
35	Thanlyin	PA	36	254846226	181959	135772	-	7	
36	Hlaegu	PA	14	101003839	50793	37996	-	5	
37	Hmawbi	PA	18	84228570	83719	133977	-	10	
38	Htantapin	PA	18	81770250	40234	88888	-	5	
39	Twantay	PA	10	107864054	24936	135958	-	2	
	Periphery Total		109	705833925	430114	252477		6	6
Greater Yangon Total			785	1.535E+09	5572242	825620		36	36

Source: JICA Urban Plan Study, 2012



Source: JICA Urban Plan Study, 2012

Figure 2.5 Population Density by Township Group (2011)

2.1.4 Economy

The industrial structure in Yangon Region (including whole 6 townships) is composed of processing and manufacturing sector (37%), trade sector (25%) and service sector (24%) in 2010/11. Agriculture, livestock, and fishery sectors accounted for only 8% of the total production value. Yangon is commercial and industrial city.

Table 2.4 Industrial Structure (GDB base)

	Commercial	Service	Construction	Electricity	Manufacture	Energy Mining	Agriculture, Forestry and Fisheries
Ratio (%)	25	24	5	1	37	0	8

Source: JICA Urban Plan Study, 2012

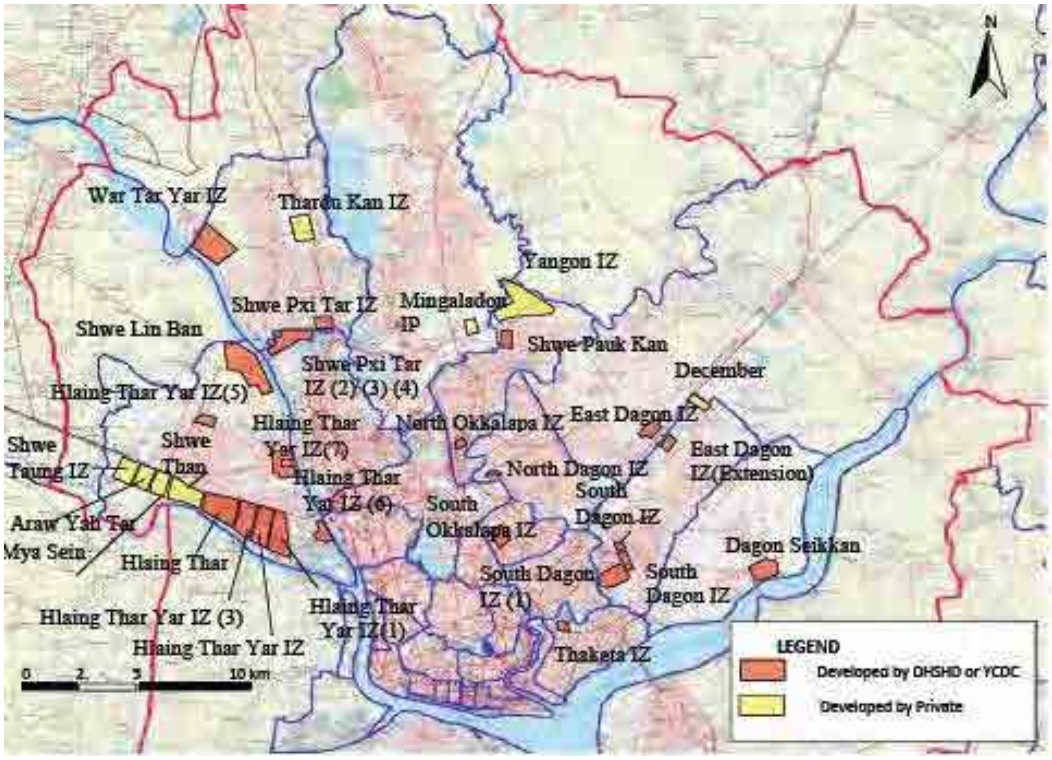
According to the data from Yangon regional office of Planning Department, Ministry of National Planning and Economic Development, there were a total of 15,089 factories or workshops in Yangon

Region in 2010/11. In the 39 townships of the Study Area, there were 13,582 factories or workshops. By zone, New Suburbs Zone is the most industrialized zone with 3,685 factories or workshops (27% of the 39 townships), followed by Inner Urban Ring Zone with 2,543 factories or workshops (19%), Older Suburbs Zone with 1,749 factories or workshops (13%), and Northern Suburbs Zone with 1,428 factories or workshops (11%). The area outside Yangon City has 1,679 factories or workshops (12%) but only a part of these factories or workshops are located in the Study Area.

There are 25 industrial zones in different stages of development with a total land area of 6,665 ha. They are mostly developed by Department of Human Settlement and Housing Development of Ministry of Construction in 1990's.

Existing condition of infrastructural facilities are investigated under the Yangon urban development study. According to the interim results, 80 % of establishments have backup power generation system to be used in case of frequent breaks of electricity supply. By establishments group, 100% modern commerce sector has backup power generation system while 84% of manufacturing sector has it.

As for water source, 55% traditional market sector and 54% services sector rely on water supply from YCDC. Among the manufacturing sector users, only 17% rely on YCDC water supply while 75% gets water from tube wells. Reliance on tube wells as a source of water is also high in case of other sectors; 45% of service sector and about 30% of traditional market and modern commerce sectors depend on tube wells for water.



Source: JICA Urban Plan Study, 2012

Figure 2.6 Locations of Industrial Zones

2.1.5 Health Status

The life expectancy of urban cities of Myanmar is 62.1 years for male and 66.2 years for female in 2003, but these figures have improved to 65.5 and 70.7 years respectively in 2009 (Statistical Yearbook 2010). According to WHO, in 2009 the median life expectancy for male and female of world is 69 and 75, for south-east Asian is 64 and 67 respectively. The life expectancy of Myanmar is little lower than the world median but higher in south-east Asian countries. The table below shows the birth rate, death rate, infant mortality rate, maternal mortality rate and under 5 mortality rate of Yangon Region from 2002 to 2011.

Table 2.5 Birth and Mortality Rate of Yangon Region

Sr. No	Impact Indicators	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	World median 2010
1	Crude Birth Rate (per 1,000 Population)	19.06	18.61	18.73	16.46	16.15	15.83	15.22	15.22	15.51	15.79	19.9
2	Crude Death Rate (per 1,000 Population)	8.11	7.72	7.97	7.72	7.76	8.01	8.09	7.35	7.24	6.76	8.2*
3	Infant Mortality Rate (per 1,000 live Births)	43.97	38.24	36.56	33.53	35.84	32.56	25.51	22.96	16.67	16.27	18
4	Maternal Mortality Rate (per 1,000 live Births)	0.39	0.52	1.22	1.30	0.93	1.15	0.86	0.94	1.07	1.05	0.66
5	Under 5 Mortality Rate (per 1,000 live Births)	57.27	51.04	47.10	45.18	45.11	45.13	33.80	28.76	22.15	21.78	20

Source: Yangon Regional Health Department, Ministry of Health
WHO for world median
* Data for 2009

The world median of each indicator is shown in the above table and it tells that the crude birth and death rate, and infant mortality rate are lower, than the world but maternal and under-five mortality rate is higher than the world in Yangon Region.

The table below shows the number of cases and deaths of epidemic diseases in Yangon region from 2007 to 2011.

Table 2.6 No. of Cases and Deaths by Epidemic Diseases

Diseases	2007		2008		2009		2010		2011	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Cholera	4	-	49	0	191	7	22	1	37	0
DHF (Dengue Hemorrhagic Fever)	4,759	54	3,604	31	3,333	38	3,162	21	552	4
Plague	0	0	0	0	0	0	0	0	0	0

Source: Yangon Regional Health Department, Ministry of Health

The world median number of cases of cholera in 2010 is 951 and plague in 2011 is 0. For the cholera, the situation of Yangon Region is better compared to the world.

The table below shows the number of cases and deaths by other diseases including water-borne diseases.

Table 2.7 No. of Case and Death by the Diseases

Sr. No	Name Of Disease	2007		2008		2009		2010		2011	
		Cases	Death	Cases	Death	Cases	Death	Cases	Death	Cases	Death
1	Diarrhea	17,344	7	17,462	9	13,166	10	11,851	2	10,969	4
2	Dysentery	8,507	0	9,489	-	6,135	0	6,361	0	4,436	0
3	Food Poisoning	244	7	259	3	435	7	255	0	395	0
4	Typhoid & Para Typhoid	103	1	71	1	55	0	98	0	47	0
5	Other Tetanus	2	1	3	1	6	1	4	0	5	0
6	Meningitis/ Encephalitis	32	5	24	2	1	4	9	4	10	2
7	ARI (Acute Respiratory Infections)	23,664	59	21,579	37	3	32	17,008	20	17,568	16
8	Viral Hepatitis	188	6	251	1	14	4	271	3	205	2
9	Rabies	17	17	14	14	10	8	8	8	8	8
10	Malaria	5,155	36	5,741	26	4,605	27	4,374	16	2,226	3
11	Snake Bite	486	62	446	57	401	45	479	45	569	64

Source: Yangon Regional Health Department, Ministry of Health

2.2 Natural Condition

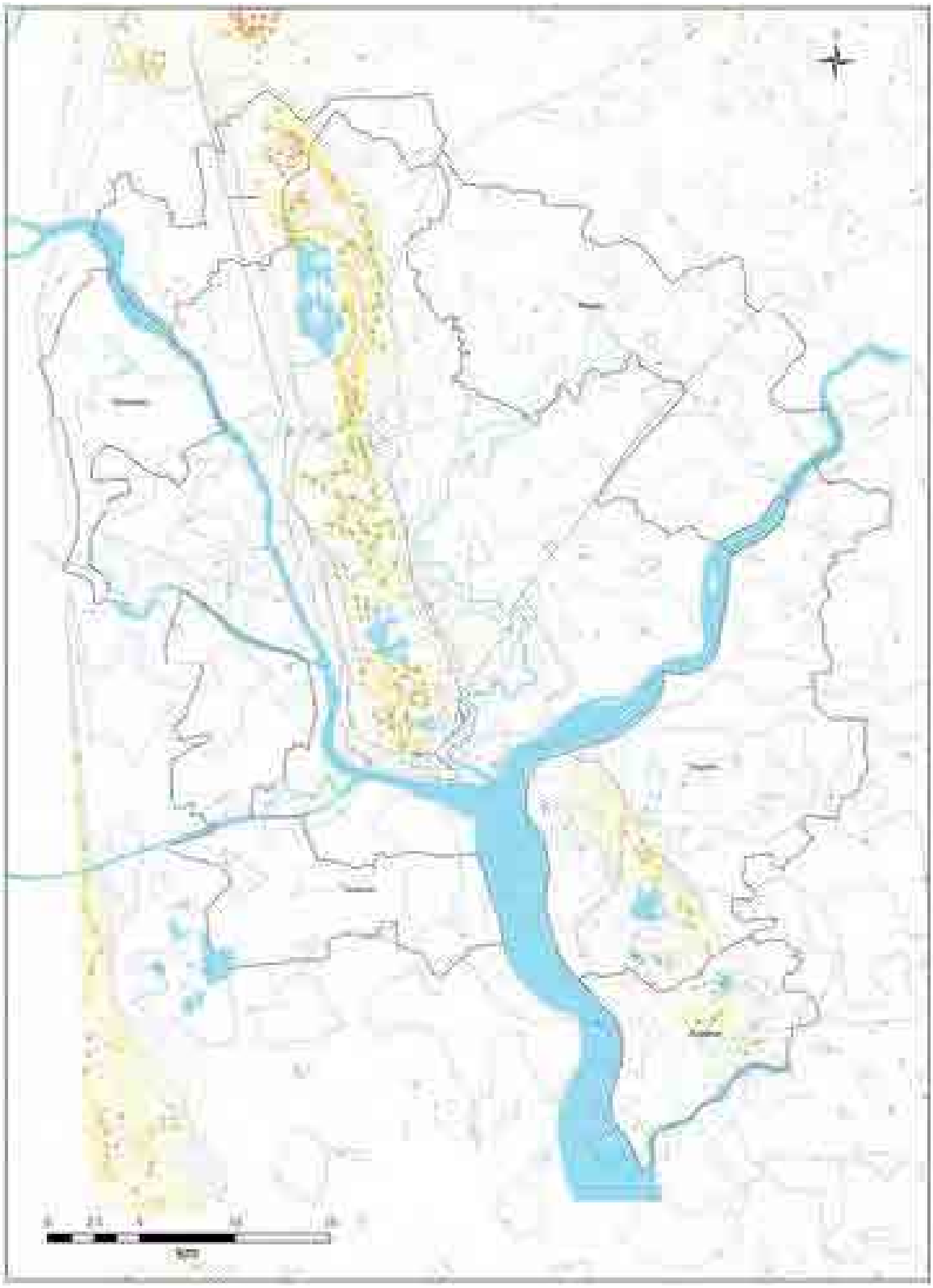
2.2.1 Topography

The study area is situated 34 km inland from the mouth of the Yangon River which traverses parts of the Ayeyarwadi delta.

Area in the center has lowland hills commonly known as the faulty zone ponds with artificial dam namely Kandawgyi Lake, Inya Lake, Hlawga R., Gyobyu R. and Phugyi R. which used to be or are main sources of YCDC water supply system. The three service reservoirs are also on the hills. This long and narrow spur of Pegu Yomas in the central area runs almost in N-S direction with an average height of 30m (100ft) and slopes gradually into flat plains towards east and west.

Flat plains are extensive and occur mostly in the eastern and western parts as wide flat bottoms along the rivers. These flat lands are formed by delta deposits, which are swampy and are almost occupied by paddy fields with elevation between about 3m (10ft) to 6m (20ft) above mean seat level.

The relief of the City varies from flat plains to lowland hills in the central part as shown in Figure 2.7.



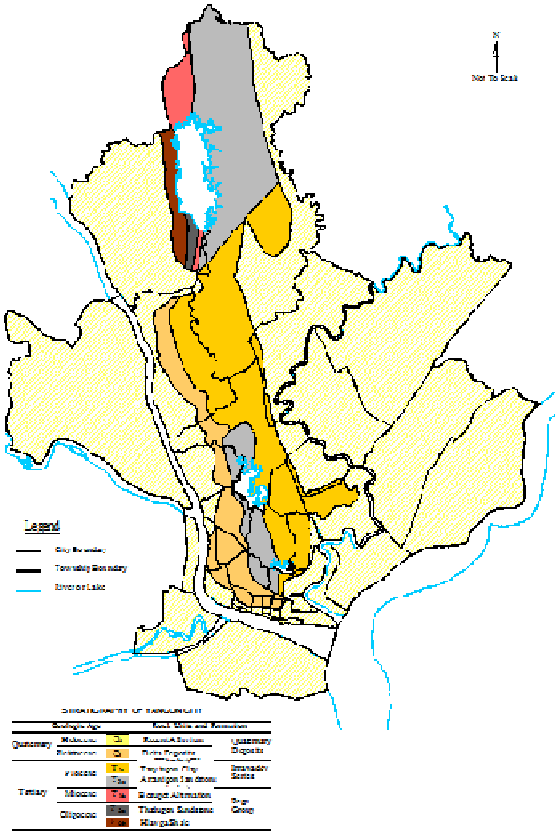
Source: JICA Study Team

Figure 2.7 Topography in Yangon Region

2.2.2 Geology

The geological structure of the city is attributed to moderate lowland hills. The rock formations in the city are classified into three main series/groups based on the geological ages. In terms of geological ages these are (from older to younger); (1) the Miocene and Older Systems-Pegu Group, (2) the Pliocene Series-Irrawaddy Series and (3) Pleisto-Holocene System-Quaternary Deposits, respectively.

Delta sediments consist of sands and gravels, remarkably free from clayey materials and lies upon the eroded surface of Irrawaddy Series. Recent alluvium consists of gravels, clay, silt and laterite. These deposits are widely distributed surrounding the main City area.



Source: 2002 JICA-M/P

Figure 2.8 Geology in Yangon City

2.2.3 Meteorology

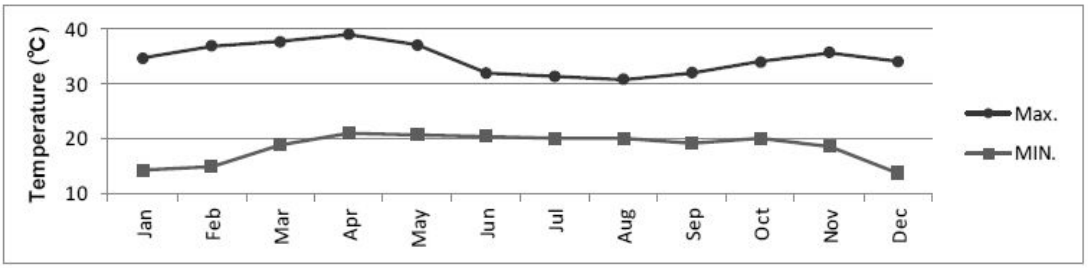
(1) Climate

Yangon has a tropical monsoon climate which consists of three seasons as listed below. It has an annual rainfall of 2700 mm/year, annual evaporation of 1347 mm/year, average temperature of 27.4 ^{o}C, maximum mean temperature of 33 ^{o}C, and minimum mean temperature of 21.8 ^{o}C.

Summer season: March–mid May
Rainy season: mid May–October
Dry season: October–February

(2) Temperature

Figure 2.9 shows the mean maximum and minimum temperature in Yangon City (1991-2008). The difference between the monthly maximum and monthly minimum temperatures is more than 20 ^{o}C from December through February and around 10 ^{o}C from June through August.

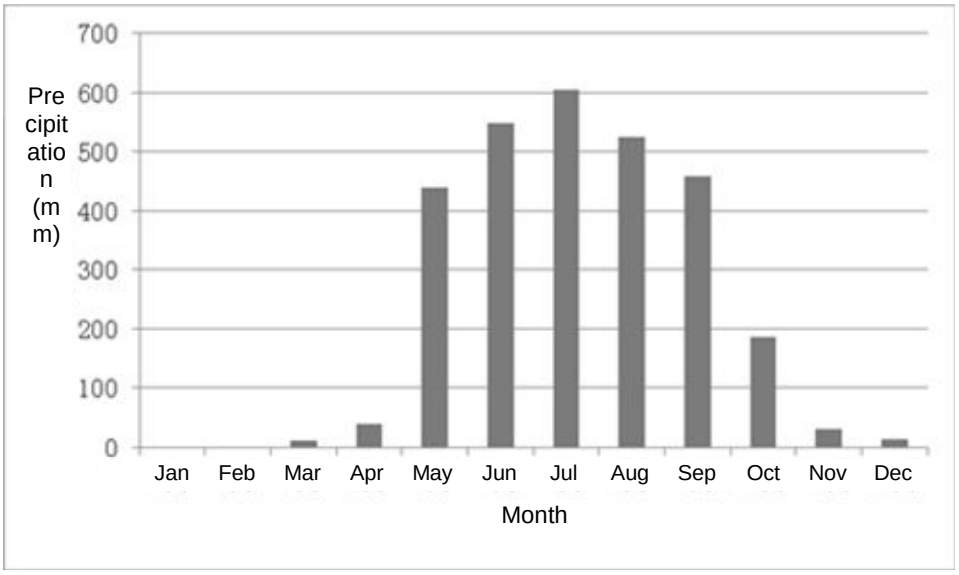


Source: JICA Study Team

Figure 2.9 Mean Maximum and Minimum Temperature in Yangon City (1991-2008)

(3) Rainfall

Figure 2.10 shows the mean monthly rainfall from 2001 to 2010 observed in Bago, Tharrawady, and Yangon (Kaba-Aye), respectively. From the graph, the annual mean rainfall is 2,700 mm. About 95% of the total rainfall throughout the year is accumulated during the rainy season period from May to October.



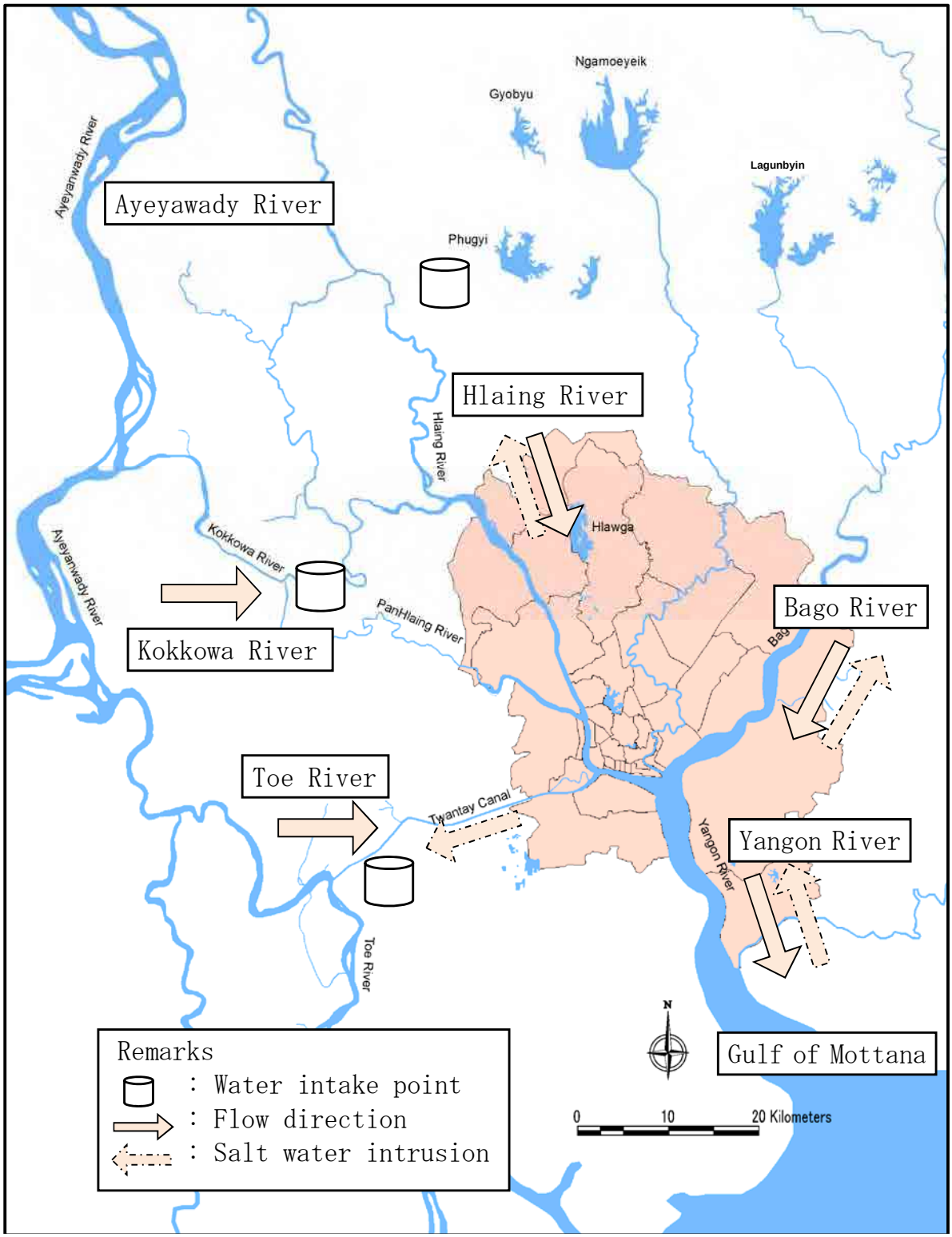
Source: JICA Study Team

Figure 2.10 Mean Monthly Rainfall (Yangon: Kaba-Aye, 1991-2008)

2.2.4 Hydrology

(1) River

Figure 2.11 shows a map which contains the rivers surrounding Yangon City. Yangon City lies at the confluence of the Bago River and Hlaing River. The two rivers meet at the confluence of the Yangon River, which is connected to the Gulf of Mottama. The Pan Hlaing River and Twantay Canal, which converge and run downstream the Yangon River, as well as the Kokkowa River which connects with the Hlaing River, all obtain its water from the Ayeyarwaddy River. These rivers are candidate water sources for the expansion of Yangon City's water demand expected to increase in the future. Pazuntaung Creek flows through the eastern part of the city CBD. The river upstream of this is called the Ngamoeyeik, where Ngamoeyeik Reservoir has been built as part of the water source in YCDC. There are no river flow data except for Bago River and Hlaing River in the available report.



Source: JICA Study Team

Figure 2.11 Map Showing the Rivers Surrounding Yangon

The rivers mentioned are all tidal rivers. During dry season periods when the river flow is low, salt water intrusion occurs. Therefore, it is necessary to consider salt water intrusion when developing

potential water source. As salt water intrusion is possible in the area of performance around Yangon, Figure 2.12 shows the salinity position having 1000 ppm concentration (circled in red) from 2009 to 2011.

Source: MOAI

Figure 2.12 Salt Water Intrusion in the Rivers Surrounding Yangon City

Table 2.8 shows available tidal information taken from the Myanmar Port Authority (MPA). From the Table, it is reflected that tidal observations have not been carried out since several years ago. The information is based on past observation records at Yangon Port (Sule Pagoda Wharf) and river mouth

of Yangon River (Elephant point). In Yangon Port, highest high water level (HHWL) including tidal condition is +6.74 m, and mean water level (MWL) is + 3.121 m. Ground elevation is normally assumed to MWL, and the difference between HHWL and MWL around Yangon port is approximately + 3.619 m (= HHWL + 6.74 – MWL + 3.121 m) on ground elevation basis.

Table 2.8 Tidal Information in Yangon Port

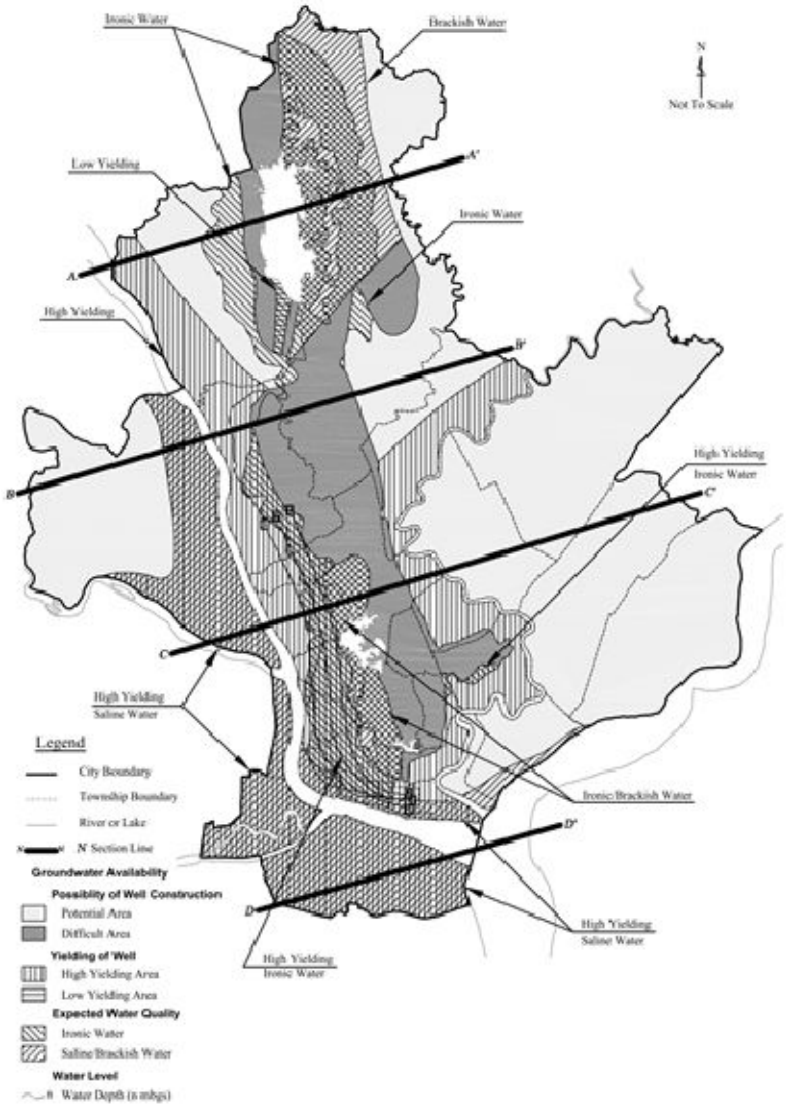
Items	Tidal Height (m)	Observed Dates
Highest High Water Level (HHWL)	+6.74	September 1899
Mean Water Level (MWL)	+3.121	Up to 1936
Lowest Low Water Level at Bo Aung Kyaw Street Wharf	-0.24	December 1902
Indian Spring Low Water Mark	+0.338	-

Source: MPA

(2) Hydrogeology

From the study on groundwater potential (refer to Figure below) in 2002 JICA-M/P, the followings are concluded;

- Groundwater potential is low in the central hilly areas.
- Iron contents might be high in groundwater in areas adjacent to hilly areas.
- Groundwater potential is high in the remaining low land areas.
- Groundwater potential is very high along the rivers.
- Salinity might be high in groundwater in CBD area.



Source: 2002 JICA-M/P

Figure 2.13 Groundwater Potential in Yangon City

2.3 Administrative Organization on Water, Sewerage and Drainage

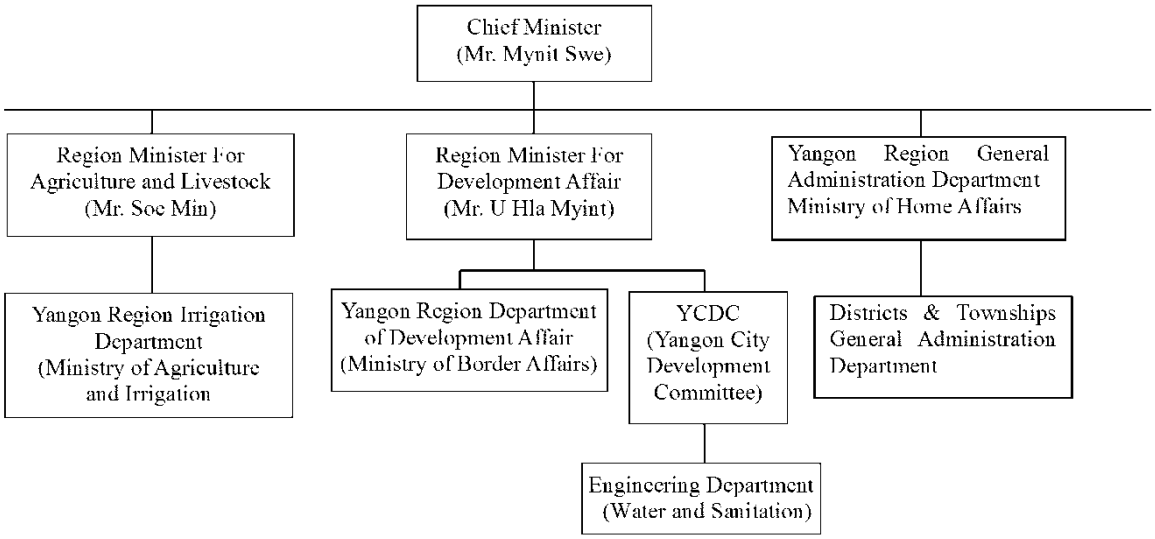
2.3.1 Yangon Region

Construction and operation/maintenance of irrigation canals and drainages are clearly defined in the Constitution as duties of the central and regional governments while the responsible agencies for construction of water supply, sewerage and urban drainage facilities is not explicitly defined under the Constitution. However, collection of water tax is defined as the regional government's responsibility. Department of Development Affairs in the regional government assumes the role of providing water supply systems. However, as a result of restructuring of the organizations in July 2012, responsible organization for water supply system has been transferred to the Department of Rural Development Affairs of the Ministry of Border Affairs. Then in 2013, the Department of Rural Development Affairs

is transferred to Ministry of Livestock, Fisheries, and Rural Development from Ministry of Border Affairs. So it is not clear to us that the regional government still assumes water supply sector in Yangon region.

Among the 6 peripheral townships, there exist small-sized water supply systems in Thanlyin and Kyauktan townships. In addition, there is one small-sized water supply system for Thilawa Special Economic Zone (SEZ). There is no sewerage system in 6 peripheral townships.

YCDC act clearly defines that YCDC has responsibility of construction and operation/maintenance of water supply and sewerage systems.



Source: JICA Study Team

Figure 2.14 Water-Related Organization in Yangon Regional Government

2.3.2 Yangon City Development Committee

(1) Yangon City Development Committee

YCDC was established based on the "City of Yangon Development Act" aiming to foster development project in Yangon city independently. The law defined that YCDC is authorized to implement their own project by using their own funding resources. However, YCDC is not appropriately able to exercise their authority under current procedure, for instance, 1) YCDC needs to apply for permissions related to implementation of projects to the central government, and 2) the funding sources of YCDC's activity are incorporated into the national budgetary system.

YCDC is responsible for water, sewerage and sanitation projects in 33 townships out of 45 townships

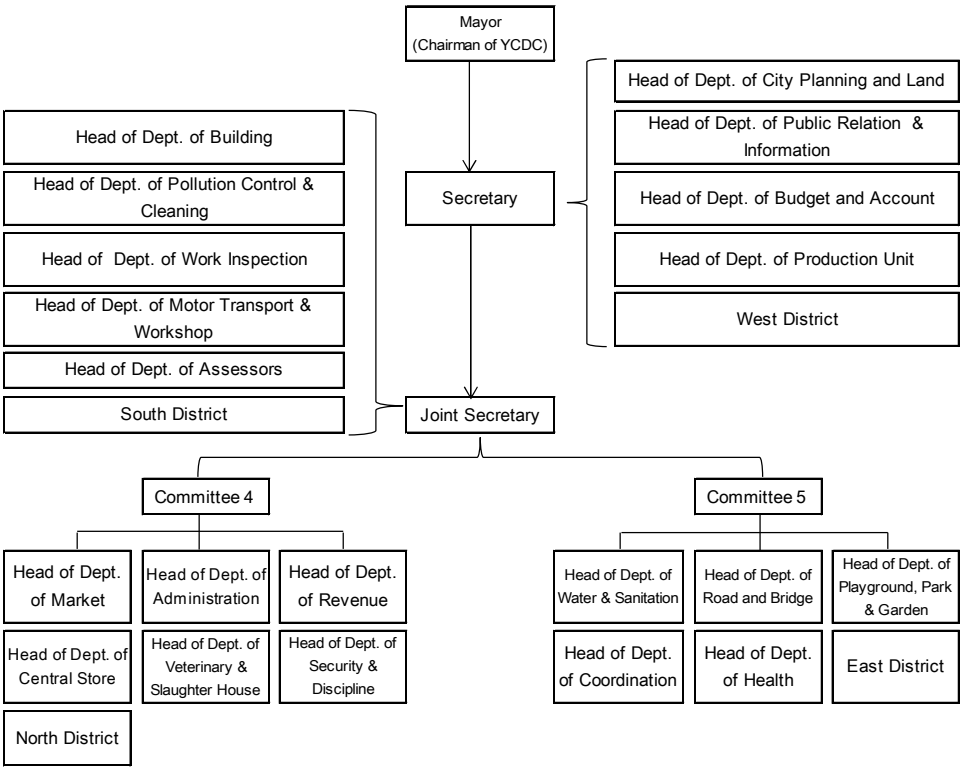
of Yangon division. The law defines the role and the responsibility to establish policies, and to manage and implement them.

YCDC is headed by the mayor, and supported by the secretary and the joint-secretary under the mayor. The committee members consist of mayor, secretary, joint-secretary, and other 2 members (committee 4 and 5). 20 departments in YCDC belong to these committees.

Department of Engineering (Water Supply and Sanitation) (DEWS) is a central section to encompass water, sewerage and sanitation services in Yangon city. Water supply projects to 6 townships out of Yangon city is handled by Department of Development Affairs (DDA), a part of regional government.

Meanwhile, storm water and drainage projects are under the responsibility of Department of Road and Bridge, water resource management for water supply and water quality test, and monitoring of quality test results are conducted by Department of Health and water quality monitoring section in Department of Engineering (Water Supply and Sanitation) respectively.

An organogram of overall YCDC is shown as follows.



Source：YCDC DEWS

Figure 2.15 Overall YCDC Organogram

(2) Department of Engineering (Water Supply and Sanitation)

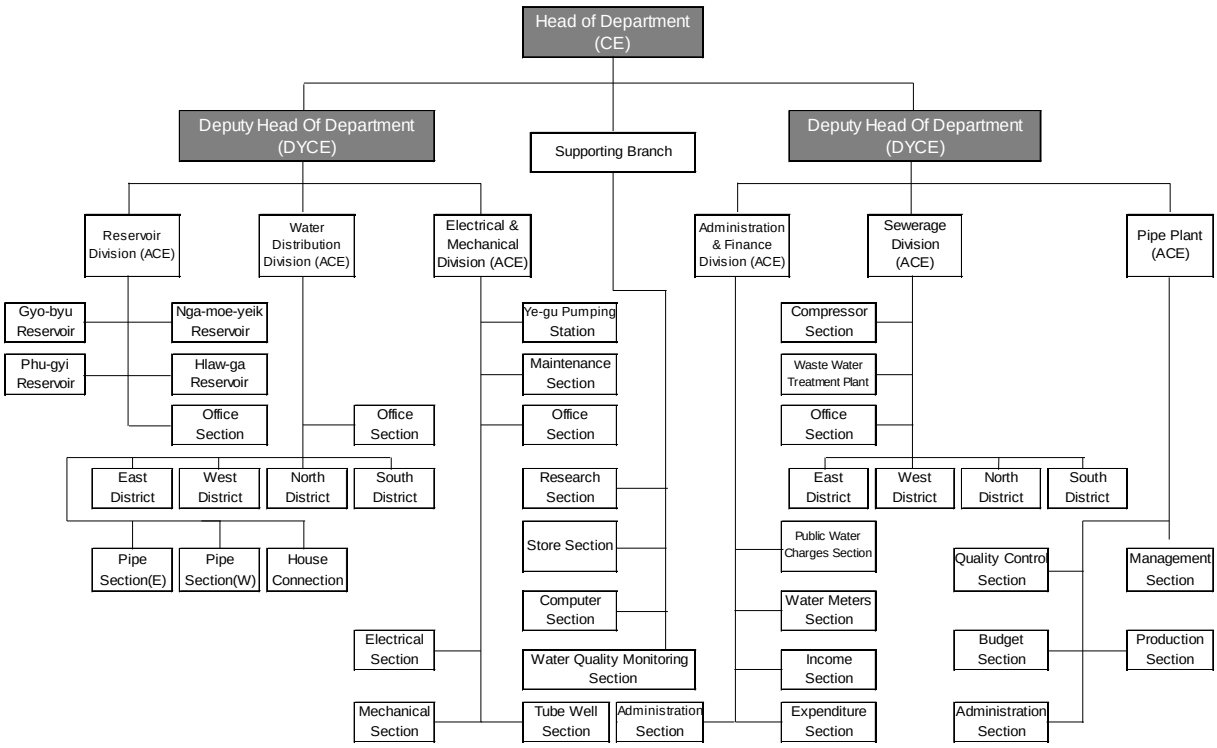
Engineering Department (Water Supply and Sanitation) consists of 6 divisions under the Head of Department and Deputy Head of Department : 1) Reservoir Division, 2) Water Distribution Division, 3) Electrical & Mechanical Division, 4) Finance & Administration Division, 5) Sanitary Division, 6) Pipe Plant Division.

Administrative support division including research section, store section, computer section, and water quality monitoring section is also organized. Total number of staff members is 2,171 as of January 2013.

The department is headed by Chief Engineer (CE), supported by two Deputy Chief Engineers (DYCE). In general Assistant Chief Engineers are allocated to the head of each division, and other officers such as Executive Engineers and Assistant Engineer (AE) exist. Those officers having a certain qualification, educational background, experiences take the central role of the organization.

Employment types are categorized into the following 5 types: (1) Officer, (2) Permanent, (3) Flat, (4) Daily Wages, (5) Work Authority. Most of engineers are allocated as officers. Employees of (1) – (3) who work full-time basis share 59% of the total number of employees and the rest approximately 40% of the employees are contract-based on irregular-base.

An organogram of DEWS is shown as follows



Source：YCDC DEWS

Figure 2.16 YCDC DEWS Organogram

The roles of each division and section of DEWS are listed below.

Table 2.9 Roles of Main Divisions/Sections of DEWS

Name of Division/ Section	Main Roles
Reservoir 485 employees (130 employees)	• Operation and management of the following four reservoirs and manufacturing and management of bottled water: - Gyobyu: Reservoir and pump station - Phugyi: Reservoir and pump station - Hlawga: Reservoir and pump station - Ngamoeyeik: Reservoir - Nyaunghnapin: WTP and P/S
Water Distribution Division 1,060 employees	• City of Yangon, including four districts of East, West, South, and North 32 township offices and the Head Office in the YCDC building - Receipt of applications for water supply construction/connection works - Collection of water charges - Repair of water leakage - Receipt of complaints from citizens
Electrical & Mechanical Division 86 employees	• Purification of ground water in South Dagon and Thaephyu and maintenance of water distribution facilities
Finance & Administrative Division 215 employees	• Management of revenue in terms of water charges and expenditure and payment of wages - Collection of charges (US$) from government organizations and management of funds from foreign investors - Collection of water meter rate - Payment of wages to employees of Engineering Department (Water & Sanitation) - Management of revenue in the form of water charges and expenditure
Sanitation Division 198 employees	• Maintenance and operation of sewer system in eight townships in the City of Yangon - Maintenance and management of public sewer pipes - Operation and management of sewage treatment plant - Operation and management of high pressure water distribution/discharge system (ejector station) - Operation and management of compressor station
Pipe Plant 136 employees	• Management of factory of pre-stressed concrete pipes - Manufacture and sale of concrete pipes of 16”, 24”, and 36” sizes (Sale route: Engineering Department (Water & Sanitation) of YCDC and Ministry of Agriculture and Irrigation)
Supporting Branch 13 employees	• Office that is directly controlled by the head of Engineering Department (Water & Sanitation) and supports operations of the above six divisions. - Cost analysis and drafting - Management of electronic data on pipe network, etc. - Water quality control - Storage of materials
Water Quality Monitoring Section	• Water quality monitoring for water supply service, particularly at the point of reservoir and water treatment plant. A laboratory for quality test is not owned. Water quality tests on 10 parameters are outsourced to the laboratory of Department of Health every month. The section monitors and manages the results of sampling test.

Source: JICA Study Team

(3) Department of Health

Department of Health was restructured and established in 1990. Main activity is prevention and control of infectious diseases. The details are: (1) Health education, (2) Disease Surveillance, (3) Prevention and Control measures, (4) Training, (5) Outbreak responses. Department of Health owns one laboratory for water quality test established by YCDC's funding sources in 1998. The Department has 225 employees, and approximately 15 employees out of them are working in the laboratory.

The laboratory conducted water quality tests of samples supplied by DEWS and private sectors such as restaurants and factories etc., amounted for 30-50 samples in monthly average. 17 parameters of WHO water quality standards can be tested in the laboratory.

Department of Health mentioned that the existing capacity of laboratory is not sufficient to respond quality test in the aspects of human resource and financial budget if the number of samples increases in future.

2.3.3 Related Organizations

(1) Ministry of Agriculture and Irrigation (MOAI)

MOAI was restructured in 1996, renamed from Ministry of Agriculture to MOAI. It is mainly responsible for irrigation and agriculture development including water resource management. Under the acknowledgement that to secure irrigation water is crucial to enhance agricultural production, the activities of MOAI is to focus on new construction of reservoirs and dams, rehabilitation for the reserved water amount, efficient utilization of groundwater, and so on. Their projects mainly including various purposes such as storm water management, hydropower development, irrigation, dam construction, water supply for township has been implemented.

Many water resource rights surrounding Yangon city, such as Ngamoeyeik dam and Lagunbyin dam, that are /or expected to be water resources of YCDC, are owned by MOAI. Current situation is that YCDC partially receives these water resources from MOAI and supplies the treated water.

The main roles of irrigation department are O&M of irrigation project, and construction of irrigation facilities, etc. Hydrological branch is responsible for monitoring of river stream flow and river level, and managing the monitoring data.

The activities of Water Resource Utilization Department (WRUD) focus on groundwater development by using machinery equipment like pump and supply water not only for irrigation but also for

domestic purpose as a part of the project.

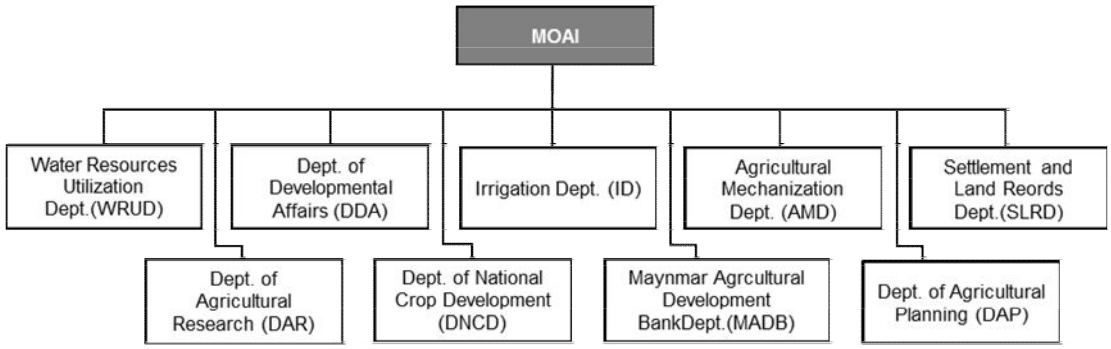
Activities of main departments of MOAI are shown in Table below.

Table 2.10 Main Department Activities of MOAI

Department		Main Activities
Irrigation Department (ID)	Activity : Section : No. of Employees :	O&M of irrigation project using surface water resources, new project for construction, research, design, and implementation. O&M of large scale facilities such as main dams, weirs, and main canals. (1) Head office, (2) Research Division, (3) Operation and Maintenance Division, (4) Mechanical Division, (5) Construction Division 20,367 persons
Water Resource Utilization Department (WRUD)	Activity : Section : No. of Employees :	Irrigation and rural development by groundwater and river sources using pumping machines, Development and promotion of sprinkler (1) Planning Division, (2) Groundwater Division, (3) Pump Division, (4) Gravity Flow and Civil Work Division, (5) Production and Procurement Division, (6) Administration Division 1,778 persons

Source: JICA Study Team

An organogram of MOAI is shown below.



Source：MOAI

Figure 2.17 MOAI Organogram

2.4 Legal System on Water, Sewerage and Drainage

2.4.1 Legal System in Myanmar

Myanmar was treated as a state of British India until 1932 and its legal system was based on the Burma Code, which derived from the English law. However some amendatory laws have been prepared progressively after transition of civilian government, because some of the constitution is not

in use under current environment.

The new Constitution of the Republic of the Union of Myanmar came into force in January 2011 and consists of 15 Chapters and 457 Articles. The constitution adopts a multi-party democracy under the presidential system and declares formal commitment to justice, freedom, equality, and the maintenance and development of peace and prosperity for the people. However, it also states that the military can play a leading role in politics.

It includes many notable provisions related to the protection of citizens' rights, such as those barring the nationalization of private companies and guaranteeing freedom of business and employment.
In addition, it establishes a system whereby the military can resume power in the state of emergency.

2.4.2 Laws Related to Water and Sewerage in the City of Yangon

(1) City of Yangon Development Law

"Chapter III Duties and Responsibilities of the Committee" of "the City of Yangon Development Law" clearly stipulates the businesses supervised by the YCDC including:

- Carrying out works for water supply;
- Construction of reservoirs and pipelines and maintenance thereof;
- Carrying out works for sanitation; and
- Carrying out works for public health.

On the other hand, Article 9 of Chapter IV "Powers of the Committee" sets forth the following provision that serves as grounds for exercise of autonomy by the YCDC:

- Demarcation and re-demarcation of the territorial limit;
- Right to operate works independently with funds owned by the Committee;
- Right to use foreign currency for development works; and
- Right to carry out works contributing to city development by making contracts with local and foreign organizations and with local and foreign individuals.

However, this study considers that most of Article 9 has lost its substance. The business activities of the YCDC shall be voluntarily performed pursuant to the City of Yangon Development Law; however, YCDC currently prepares plans and estimates for each business and applies to the provincial government for permission. Particularly with respect to the budget necessary for the performance of a business, YCDC actually seems to be forced to perform the business based on the permission of the provincial government under the budgetary system of the federal government as of April 2011.
Amendment and development of the legal system is considered to be urgently required in light of

future prospects, including consistency between the City of Yangon Development Law and the relevant legal system.

(2) Rules on Water Supply and Sanitation (Notification No.6/99)

The YCDC established the Rules on Water Supply and Sanitation, conferred by Section 33(a) of the "The City of Yangon Development Law", with the approval of the Chairperson of the State Peace and Development Council. The Rules for water and sanitation are proclaimed by the Notification No. 6/99. In the Rules, the YCDC's role and the responsibilities on water and sanitation are described. Main relevant chapter and clause are shown below.

Rules on Water Supply, conferred by Section 33 in "The City of Yangon Development Law"
（Notification No.6/99）

CHAPTER II WATERWORKS

3. The Committee shall manage to distribute sufficient drinking water to the inhabitants within the city limits.
4. The Committee may carry out the following works within the city and outside:-
    a) For the purpose of water distribution in the city, the Committee may build and establish necessary water tanks, artesian or tube- wells, pipelines or water works.
    For the purpose of water distribution, the Committee may purchase or lease land, equipment and machinery from its owners.
5. The Committee may acquire water resources, and carry out water works, by means of contract, auction or by tender, under prescribed rules.
11. The Committee:-
    a) Shall permit only licensed plumbers to work on water connections for the consumer.
    b) May check and examine any plumber who is carrying out water connection works.
13. The Committee may cut-off water connection, if the consumer fails to pay water tax, or fails to observe the directions of the committee
16. Whoever is desirous to do the following, shall apply to the Committee for permission.
    a) To make direct water connection, from the Committee's main water pipeline, into his own premises.
    b) To make extensions from the Committee's water pipeline.
    c) To get more water, by pumping from the Committee's water pipeline, by means of electricity or other power or energy, or by manual methods.
    To replace the original water and sanitary materials, with better ones or make extensions.
21. Before the Committee confirms and prescribes the national drinking water standard, it shall use the drinking water standard of the World Health Organization, as prescribed from time to time.
22. The Committee may:-
    a) Collect charges for water consumption from the consumers.
    b) Sell water at a certain price.

（Source：YCDC DEWS）

Rules on Sanitation, conferred by Section 33 in "The City of Yangon Development Law" (Notification No.6/1999)

24. The Committee may do the following, in or outside the city, in consultation with the government departments and organization respectively.
    a) Manage and operate sewerage system and sanitary work.
    b) Purchase or lease buildings, lands, or machinery, for the purpose of operating sewerage system.
    Give permission to others, to operate sewerage system, with prescribed terms and conditions.
25. The Committee may:-
    a) Give permission to the owner or the occupier, to construct his own sewerage system, after proper scrutinization.
    b) Manage and determine the sewerage system of the building, where more than 250 people are residing or the building, which is determined by the Committee, as a residential premise, in which a large number of people are occupying.
    Where there is no sewerage system, the Committee may determine only the treated sewage, to be disposed of in the specified canals, rivers, creeks, lakes, ponds, or tanks, indirectly.
    Determine the standard of the treated sewage.

    e) Allow whoever is desirous to dispose of treated sewage under sub-rule (c) to apply to the Committee. If the Committee considers it to be in conformity with the prescribed standards and conditions, permission may be given.
    Allow the sewage from the building to be disposed of, in the sewerage system of the Committee, on payment of service charges.
26. The Committee may collect prescribed fees or charges, from the owner, or occupier, of the building, situated within or outside the city, for the disposal of sewage.
28. The Committee may determine what sewerage system, and sewer pipe lines are to be used in different regions of the city.
32. The Committee may direct the owner or the occupier of the building to reconstruct, repair or change and amend the cesspool or cesspit or sewerage system, if it is not in conformity with the prescribed standards and conditions.

(Source : YCDC DEWS)

2.4.3 Comparison of Legal and Institutional System between Myanmar and Japan

Comparison of current legal and institutional system related to water supply and sewerage service between Myanmar and Japan is shown below. City water supply systems are limited to large urban cities such as Yangon and Mandalay so that the central government's role is limited to only budget allocation with no water related laws, regulations and technical guidance.

Japan	Myanmar
Local Public Enterprise Act The purpose is to set forth the organization and financial affairs of companies owned by local government (water utility, industrial water utility, electricity utility, and gas utility) and the treatment of employees engaged in such businesses, other fundamental management standards, and special provisions on procedures related to management of such companies, thereby contributing to the development of local autonomy. The principle is to always stress the economic nature of the company and enhance public welfare, which is the original purpose of the enterprise overall.	**No applicable law** ◆ To secure capital for water supply, review is required on the water utility as independent companies.
Ordinance for Enforcement of the Local Public Enterprise Act	**No applicable law**
Order for Enforcement of the Local Public Enterprise Act Stipulates detailed rules for implementation of the Local Public Enterprise Act.	**No applicable law**
Waterworks Act The purpose is to construct and properly manage water supply systems, develop them in a planned manner, protect and develop the water utility, and thereby supply abundant and inexpensive water and contribute to the improvement of public hygiene and the environment. The Act stipulates, depending on the type of water utilities and population supplied, definitions of water utility, small water utility, water wholesale, private water supply, and private water supply facilities, as well as requirements for a permit to operate each water utility.	**No applicable law** ◆ Consideration should be given to definition of waterworks, water utility and business, and responsibility of the establisher of water supply facility.
Chapter 1 General Provisions Article 1 Purpose of this Act Article 4 Water Quality Standards Article 5 Facility Standards Chapter 2 Water Utility Section 1 Permit, etc. for Business Article 6 Permit for Business and Management Body Article 8 Standards for Permit Article 12 Supervision of Construction Work by Engineer Article 13 Notification before Commencement of Supply and Inspection"	◆ Preparation of Myanmar's water quality standards is in progress. WHO standards are currently applied to the national standards. ◆ Similar law: Yangon City Development Law (YCDL)
Section 2 Inspection Article 14 Rules on Supply Article 15 Obligation to Supply Water Article 16 Structure and Materials of Water Supply Equipment Article 16-2 Work on Water Supply Equipment Article 17 Inspection of Water Supply Equipment	◆ Similar law: Rules for YCDL, Notification No.6/1999 ◆ Similar law: Rules for YCDL, Notification No.6/1999 ◆ Similar law: Rules for YCDL, Notification No.6/1999

Japan	Myanmar
Article 19 Technical Administrator of Waterworks Article 20 Water Quality Inspection	◆ Similar law: Rules for YCDL, Notification No.6/1999
Section 3 Designated Plumbing Contractor	◆ Similar law: Rules for YCDL, Notification No.6/1999
Article 25-2 Application for Designation Article 25-3 Standards of Designation Article 25-4 Designated Water Supply Installation Chief Engineer	◆ Similar law: Rules for YCDL, Notification No.6/1999
Chapter 3 Water Wholesale Article 26 Permit for Business Article 20 Standards for Permit	
Chapter 4 Private Water Supply Chapter 4-2 Private Water Supply Facilities Article 34-3 Obligation to Inspect	◆ When hotels and other large buildings install water supply facilities using their own water source (well), it is necessary to mandate the selection and allocation of engineers to monitor the independent water supply facility.
Order for Enforcement of the Waterworks Act	**No applicable law**
Ordinance for Enforcement of the Waterworks Act	**No applicable law**
Water Supply Ordinance of Municipal City Section 2 "Operations" of Chapter 2 of the Waterworks Act, which states that the water supplier must stipulate the water supply rules on charges, payment of the cost of water supply installation and other conditions of supply. Each city sets forth the detailed rules necessary at the time of water supply for persons in need of water supply in the relevant area.	**Similar law: Rules for YCDL, Notification No.6/1999** ◆ In order to supply safe water to citizens, consideration should be given to water charges and to construction method, rules on inspection and construction standards for contractors.
Sewerage Act The purpose is to set forth basic policies on the development of public and city sewerage systems, matters concerning allocation, structure, and performance of fundamental facilities, and quality standards for discharged water, and thereby contribute to public hygiene and maintain the quality of public water.	**No applicable law** ◆ Urgent consideration should be given to definition of sewerage business and the business operator, basic concept of sewerage, rules on the maintenance of public sewerage, establishment of preventing facilities for treatment obstacles, and rules on quality of sewage, etc.
Order for Enforcement of the Sewerage Act	**No applicable law**
Sewerage Ordinance of Each City With respect to drainage facilities connected with public sewers, each city sets forth definitions of terms, methods of connection with drainage facilities, designation of the contractor performing works on drainage facilities, rules on engineers performing work on drainage facilities, and collection of sewerage charges paid for the volume of sewage.	**No applicable law** ◆ It is necessary to develop laws concerning the collection of sewerage charges from drainage facilities established by citizens under the principle that the person who benefited must pay, notification associated with the installation of drainage facilities, method of treatment depending on classification of water such as

Japan	Myanmar
	rain, household wastewater, and sewage, and actual drainage facilities in the city center and the place of discharge.

Source: JICA Study Team

2.4.4 Public Private Participation (PPP) and Private Finance Initiative (PFI) Related Laws

(1) Development of Legal System for Implementation of PPP Business

In Myanmar, the PPP business sector will become more energized by the participation of private companies in the improvement of water and sewerage systems and the development of infrastructure directly affecting the people's livelihoods, but for the moment it seems that only temporary measures can be taken in response to the occurrence of problems, despite the existence of the Partnership Act of 1914.

In addition to the recent global financial crisis, the stability and reliability of the country's business environment does not measure up to other developing countries in Asia, and it is necessary to develop the economic and legal environment; this is especially so in regard to areas such as guarantees when foreign capital is provided and provision of support so as to enable international investors and financial institutions to finance long-term business as soon as possible.

Against this background, Myanmar revised the Foreign Investment Law in November 2012, assuming future investment from foreign countries. Further improvement is expected with respect to the situation of the Myanmar Investment Commission (MIC) that may considerably affect the foreign capital investment rate and the transparency of the decision-making process.

It is recognized that PPP in water and sewerage sector generate merits in the aspects of efficiency and profitability. Meanwhile, some challenges and failures of PPP projects are gradually emerged. The World Bank reported that there are no outstanding differences between private water supply service and public water supply service in the viewpoint of efficiency, in their review on PPP in water sector in the Asia region.

It is natural that private entities pursuit efficiency and profitability in their business in certain extent, it is pointed out from past lessons learnt that the original purpose which provides safe water to citizens with reasonable price is obscured if their activities exceed the level. Sufficient management capability to control such private provider's behavior is required for public side.

International Monetary Fund (IMF) suggested requisites for succeeding PPP in developing countries,

as shown below for reference.

- Project management capability of public side is sufficiently matured
- Regulatory and institutional environment on PPP is sufficiently developed
- Financial market for making funding sources is matured
- Beneficiary-pay environment is matured and widely penetrated
- Sufficient water resources for project exist

(2) Trend of PPP

1) PPP Trend in Water and Sewerage Sector in East and Southeast Asia, South Asia Regions

Only one PPP project as a management contract has been implemented in water and sewerage sector in low income countries according to the PPAIF database, so the number of projects is very limited. Meanwhile, PPP projects in water and sewerage sector in low-middle developing countries account for 33 projects. It can be seen that the number of PPP projects increase as the income level of countries goes up. Particularly, concession types of contract such as Build, Rehabilitation, Operate, Transfer (BROT) and Build, Operate, Transfer (BOT) are relatively dominant cases.

Main results of water and sewerage PPP projects in East Asia and Southeast Asia, and South Asia is shown in the following Table.

Table 2.11 Contractual Types for PPP and Matrix Table

Income level/ Region	Management Contract	Lease Contract	Concession Contract			BOT, BOO Concession		Asset Sales	Total
			BROT	ROT	RLT	BOT	BOO		
Low income countries									*1*
East/ Southeast Asia									0
South Asia	1								1
Low and Middle income countries									*33*
East/ Southeast Asia		1	10	3		5	1		20
South Asia	5		2	1	1	4			13
Total	6	1	12	4	1	9	1	0	34

Source：World Bank PPAIF Database
[Note] BROT –- Build, Rehabilitate, Operate and Transfer, ROT -- Rehabilitate, Operate and Transfer
RLT -- Rehabilitate, Lease and Transfer, BOT -- Build, Operate and Transfer
BOO -- Build, Own and Operate

2) Overall Trend of PPP Projects

In Myanmar, PPP projects can be seen in energy and transportation sectors; however the number of projects is limited and has low tone in overall. According to PPIAF database operated by the World

Bank, the first PPP project was launched in energy sector in 1995, 5 PPP projects up to 2012 accounted for 1,325 US$ were held. New construction projects such as BOT type contracts share all. Recently, one notification of the New Hanthawaddy airport development project for bidding was publicized by the central government.

Possibility of financing using the PPP framework and project implementation is expected to increase in general under the severe financial and budgetary circumstance of the central government in Myanmar. While, currently regulatory and institutional arrangement for PPP in Myanmar is not sufficiently established, thereby the attractive project merits and contents of the project contract could be crucial factors for private sector side. In addition, it is necessary for public sector to make regulatory and institutional environment mature through experiences learnt from trial and error of PPP projects.

2.5 Budgetary System for Water Supply, Sewerage and Drainage

2.5.1 Budgetary Situation on Water Supply, Sewerage and Drainage

All revenue income collected is credited to the account of regional government and the central government. All revenue income including waterworks sales used to be incorporated into the account of YCDC, however that system has been transformed to the current system since October 2011.

After YCDC prepares and applies the budget estimates for a new fiscal year, the actual expenditure against the approved amount is paid to YCDC through the regional government. Thus it seems to be a structural challenge for YCDC that YCDC has a very limited authority to determine how the revenue income is used flexibly.

2.5.2 Budgetary Situation of the Regional Government

The fiscal account for the period 1st April to 31st March is settled every year. Although the detail information on budgetary situation of the regional government is not yet obtained, it is confirmed by the JICA Study team for Strategic Urban Development Plan that the Yangon Region Government received an allocation of more than Kyat 15.6 billion from the Union Government to cover expenses in the second half of the 2011-2012 fiscal years under the Yangon Region Government and is thought to be running in deficits. Financial deficit situation of approximately 5 billion Kyat is reported. 20 out of 25 departments working under the Yangon Region Government were thought to be running in deficits.

2.5.3 Budgetary Situation of the Regional Government

(1) Budgetary Situation of YCDC and the Trend

The revenue income of YCDC is largely relied on the property tax consisting of general tax and environmental tax etc. The main financial source of the property tax are particularly the income from condominium, hotel, market, golf club, vehicle tax.

Meanwhile, 20 departments of YCDC including water and sanitation department are not authorized to determine by themselves how revenue income is used. Also they have no authority to decide the capital expenditure such as construction investment, it is necessary to get the approval from the executive committee.

(2) Budget Allocation of YCDC and Income Flow

The budgetary flow of YCDC from application to approval can be listed as follows: (1) 20 departments prepare budget estimates and submit to the mayor, (2) The Yangon city mayor submits the proposal application to the chief minister of the regional government. The chief minister of the regional government discussed with the regional offices of the Ministry of Finance and Revenue. A negotiation between the Yangon city mayor, 7 committee members, the department of budget and revenue is held, and the budget is determined and approved.

Revenue collection of water tariff is shown as follows: (1) In case of cash collection, water tariff is collected every day by meter readers and recorded in the record book by township officers, (2) then, the cash is transmitted to the account of the department of budget and accounting and is incorporated into the general account of the YCDC revenue, (3) the collected cash is transmitted to the account of the regional government, (4) in case of bank remittance, a remittance procedure of the collected amount is taken from township offices to YCDC, and from YCDC to the regional government.

2.6 Existing Environmental Framework

2.6.1 Policy, Laws and Regulations Related to Environmental and Social Considerations

Before the establishment of the Environment Conservation Law in April 2012, the country did not have a law, administrative organization and environmental standards concerning to environmental protection. Laws on environment protection have been established independently in each industrial sector and these laws were regarded to have functions of environmental protection law. However, these laws have been established separately and independently in each sector, they are not enough to

control environmental impacts taking whole picture of the impacts into consideration.
The recent formation of the Ministry of Environmental Conservation and Forestry demonstrates the government's commitment to improving the planning and management of natural resources and the environment. The 2012 Environment Conservation Law provides the legal basis for implementing a range of enhanced environmental management measures. Now drafting corresponding regulations to enact the Law including EIA law and pollution control standards such as air emission and water effluent is in progress.

The policies and major environment related laws are described below.

(1) National Environment Policy 1994

The Government of Myanmar adopted National Environment Policy in 1994 to establish sound environmental policies in the utilization of water, land, forests, mineral, marine resources and other natural resources in order to conserve the environment and prevent its degradation.

- "The wealth of a nation is its people, its cultural heritage, its environment and its natural resources. The objective of Myanmar's environment policy is aimed at achieving harmony and balance between these through the integration of environmental considerations into the development process to enhance the quality of the life of all its citizens. Every nation has the sovereign right to utilize its natural resources in accordance with its environmental policies; but great care must be taken not to exceed its jurisdiction or infringe upon the interest of other nations. It is the responsibility of the State and every citizen to preserve its natural resources in the interest of present and future generations. Environmental protection should always be the primary objective in seeking development".

(2) Myanmar Agenda 21

The development of the environmental policy was followed by the "Myanmar Agenda 21" in 1997, which follows a UN framework for a multi-pronged approach to sustainable development. Myanmar Agenda 21 calls for integrated management of natural resource and provides a blueprint for achieving sustainable development. Myanmar Agenda 21 seeks to achieve four main objectives:

- To provide a forum and context for the debate on sustainable development and the articulation of a collective vision for the future,
- To provide a framework for negotiation, mediation and consensus building in the country to achieve development with due regard to the environment, to focus the entire country on a common set of priority issues,
- To provide a strategy and implementation plans for the changing and strengthening of values, knowledge, technologies and institutions with respect to environmental protection and

development, and

- To provide the impetus and the framework for the development of organizational capacities and institutions required for sustainable development.

Myanmar Agenda 21 contains programs and activities that will promote environmental protection and prevent environmental degradation. These programs are social, economic, institutional and infrastructural strengthening programs as well as environmental protection and conservation programs that will put the country onto the sustainable development path.

(3) Constitution of the Republic of the Union of Myanmar (2008)

New Constitution of the Republic of the Union of Myanmar 2008 was ratified. Under the Constitution, "The Union shall protect and conserve the natural environment" (Chapter 1, Article 45). The Assembly of Union shall have the right to enact laws for the entire or any part of the Union related to matters pertaining to protection of the environment (Chapter 4, Article 96). In addition, every citizen has the duty to assist the Union in carrying out the preservation and safeguarding of cultural heritage, and environmental conservation. Regarding the land, the Union is the ultimate owner of all lands and all natural resources above and below the ground, above and beneath the water and in the atmosphere in the Union, and the Union shall permit citizens right of private property, right of inheritance, right of private initiative and patent in accord with the law (Chapter 1, Article 37).

(4) National Sustainable Development Strategy (NSDS) 2009

The National Sustainable Development Strategy (NSDS) is part of a broader program of the UN Sustainable Development Commission set up after the World Summit on Sustainable Development in 2002. There are three goals in NSDS including sustainable management of natural resources, integrated economic development and sustainable social development. Specific strategies are outlined under each goal. To achieve the goal of sustainable management of natural resources, strategies for forest resource management, sustainable energy production and consumption, biodiversity conservation, sustainable freshwater resources management, sustainable management of land resources, sustainable management for mineral resource utilization and others are proposed. As the NSDS was officially accepted by the Ministry of Planning, it is a guiding document for government ministries, departments and local authorities and international and local NGOs for sustainable development.

(5) Environment Conservation Law 2012

Environment Conservation Law of Union of Myanmar was promulgated on 30th March 2012. The

objectives of this Law are as follows:

- For implementation of Myanmar National Environment Policy,
- Adoption of basic principles and give guidelines so as to formulate systematic integration of environment conservation tasks for continuous development program,
- To develop good and clean environment for the benefit of present and future generations and conservation of nature and cultural heritage,
- To reveal and discover ecological systems which are starting to fall under oblivion,
- To take measures for prevention of decrease and loss of natural resources and making use of them beneficially and continuously,
- For implementation of propagating environment conservation consciousness and attracting more cooperation of the public, imperative education and teaching programs to be adopted,
- To increase international and country wide cooperation in environment conservation tasks,
- For achieving cooperation among government departments, international organizations, Non-governmental Organizations and private individuals.

This Law stipulates the establishment and roles of Environment Conservation Committee (ECC) and Ministry of Environment Conservation and Forestry (MOECAF). See more detail in chapter below. In this Law, descriptions related to system of environmental impact assessment (EIA) for development projects and strategic environmental assessment (SEA) is not included.

(6) Laws regarding Land

This British era act, Land Acquisition Act 1894 is still referred to at present due to the lack of any new legislation on the theme. The Act empowers the state to acquire land where it is needed for any public purpose. The Act provides for the relevant procedures, including the required notice to be given, procedures for objections to acquisition, the method of valuation of land, the process for taking possession of land, court processes and appeals, procedures for the temporary occupation of land and the acquisition of land for corporations. There are several laws related to the land, however it is not clear which law is still effective.

- The Land and Revenue Act (1879)
- The Transfer of Property Act (1882)
- The Rangoon Development Trust Act (1922)
- The Transfer of Immovable Property Restriction Act (1987)
- The Law Amending the Transfer of Immovable Property Restriction Act (2005)
- Procedures conferring the Right to Cultivate Land / The Right to Utilize Land (1991)

The classification of land type is made in the Guidance Note on Land Issues Myanmar published by

UN-HABITAT and UNHCR.

- Freehold Land
- Grand Land
- Agricultural Land
- Garden Land
- Grazing Land
- Cultivable Land, Fallow Land and Waste Land
- Forest Land
- Town Land
- Village Land
- Cantonments
- Monastery

The Farmland Law (No. 11/2012) is enacted in 2012 and the definitions about farmland, farmer and right to use the farmland are established. The contents cover the procedures to obtain the permission to use the farmland, right of the person who has the right to use the farmland, terms and conditions to be complied by the person who has the right to use the farmland, action for the failure to comply terms and conditions, settlement of dispute on the right to use the farmland and appeal, duties and powers of the administrative body of the farmland. In the case of the land confiscation for interests of the State or the public interests, it is stipulated that the compensation will be paid to the person who has the ownership right to use the farmland but no detail is provided about the compensation policy or compensation calculation method. Based on the Farmland Law, the Farmland Rules is enacted on 31 August 2012 and the detail procedures from the application of the right to use to approval, and transfer / inheritance are described.

(7) Other related laws

There are several other environmental related laws in Myanmar.

- Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law, 1994
- Protection and the Preservation of Cultural Heritage Region Law, 1998
- The Conservation of Water Resources and Rivers Law 2006
- Forestry Law 1992
- Public Health Law

2.6.2 Administrative Framework on Environmental and Social Considerations

(1) National Commission for Environmental Affairs (NCEA)

In 1990, NCEA was established to advise the government on environmental policy, to act as a focal point and as a coordinating body for environmental affairs and to promote environmentally sound and

sustainable development. Until 2005, the Minister of Foreign Affairs was the chair of NCEA which was a strong indication that the Myanmar Government created the NCEA merely as a tool to win international approval. In 2005, the NCEA was transferred under the Ministry of Forestry. The NCEA's main mission is to ensure sustainable use of environmental resources and to promote environmentally sound practices in industry and other economic activities, objectives and mandates.
The roles and function of NCEA are not defined in the Environment Conservation Law 2012 which is recently enacted and the functions of NCEA seem to be taken over by MOECAF and NCEA might be dissolved.

(2) Environment Conservation Committee (ECC)

The Environment Conservation Law tells the Union Government shall organize Environment Conservation Committee (ECC), assigning Union Minister for the Ministry of Union as the Chairman of the Committee which shall constitute suitable members. ECC shall hold the following authoritative rights:

- Make educative organizing activities and movements on environmental conservation,
- Give advice on making required amendments in school lessons on environmental conservation after making coordination with concerned governmental departments,
- Receive donation funds, cash support, materials and technical assistance and administer these funds, materials and technologies for applying in environmental tasks,
- Give appropriate advice on environmental conservation to concerned government departments and organization and exhort them in implementing the task,
- Request proposals and advice on promoting environmental conservation from concerned governmental departments and organizations,
- Forbid concerned government departments and organizations that could damage the environment and if necessary, submit the matter to the Union Government requesting its attitude and policy on the condition,
- Adopt Myanmar National Environment Policies and other related policies in conservation of environment with the approval of the Union government.

(3) Ministry of Environment Conservation and Forestry (MOECAF)

In the Environment Conservation Law 2012, the obligations and authoritative right of MOECAF are stipulated. The ministry has a broad responsibility:

- To implement the policies on environment conservation,
- To plan the environmental management both at the national and regional level,
- To plan, implement and monitor environmental conservation and promotion, and to prevent, control and reduce environmental pollution,
- To pave the way for sustainable development.

In order to do this, the Ministry has the power to create "guidelines for environmental administration,

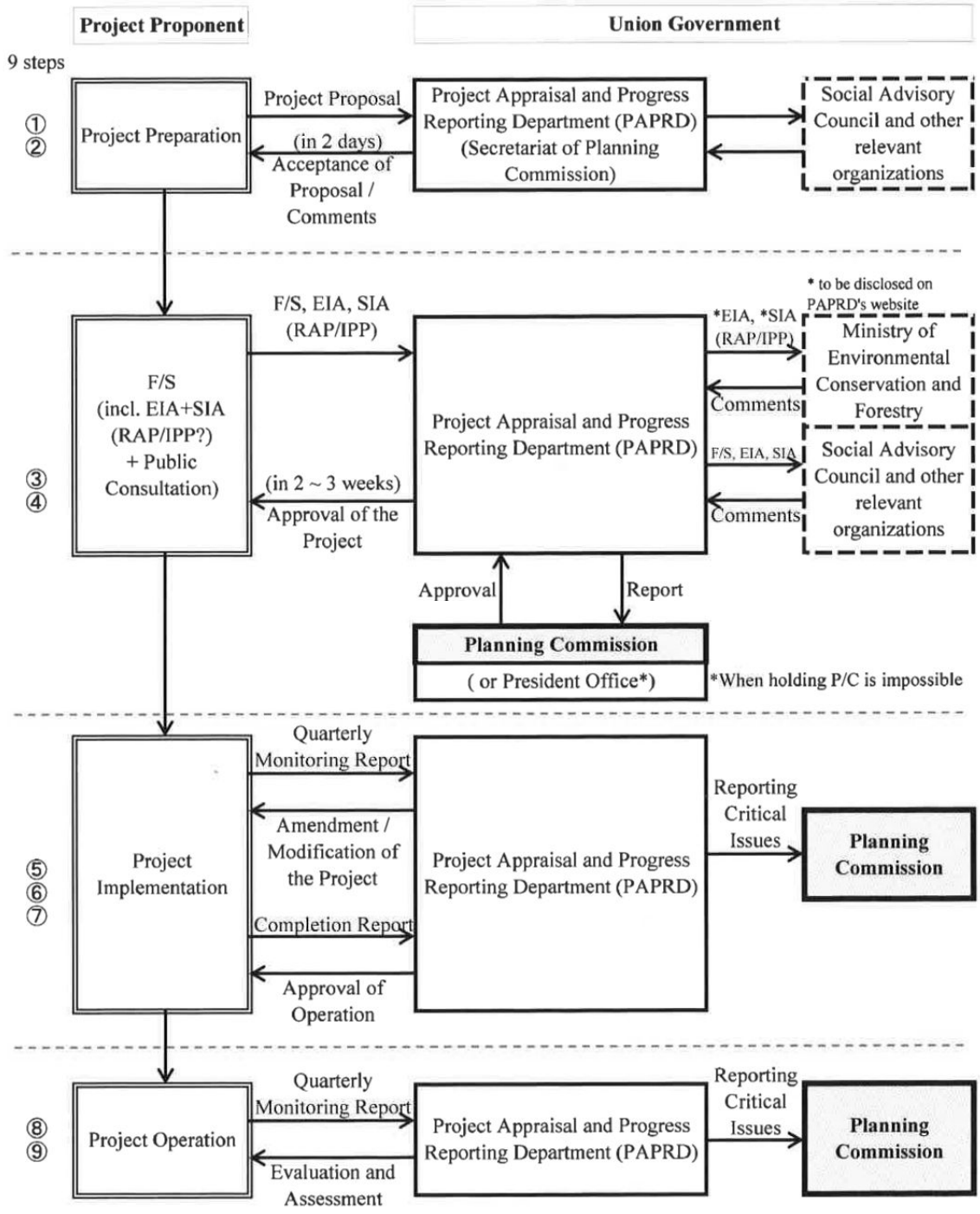
conservation and promotion in different sectors which include ozone layer protection, the conservation of biodiversity, marine coastal conservation, the effort to reduce and balance global warming and climate change, the fight against the increase of desert and waste management". In particular, the Ministry can:

- Set the rules for how much and what type of pollution is allowed, and what businesses and individuals have to do to reduce pollution,
- Set up a system to assess the environmental and social impacts of projects (both those carried out by the government and those done by the private sector),
- Set up a system to monitor pollution from agriculture, industry and mining,
- Decide which types of projects require permission to operate,
- Decide whether to grant the permission to individual projects,
- Require companies to pay for environmental conservation projects to make up for the damage caused by the companies,
- Oversee the system for judging and punishing environmental damage, and
- Negotiate regional and international environmental agreement.

The Ministry, the Committee and the national government share responsibilities for taking action when there is a natural disaster, including warning people about natural disasters.

2.6.3 Process of Environmental and Social Considerations

Based on the information obtained from JICA, the process of environmental and social considerations will be as follows.



Source: JICA

Figure 2.18 Process of Environmental and Social Considerations

It seems that the responsible organization will be Project Appraisal and Progress Reporting Department (PAPRD) under the Ministry of National Planning and Economic Development, and the MOECAF will issue the comments on EIA (SIA) reports. EIA and SIA are expected to be implemented in the F/S stage and the public consultation will be required during or after the F/S.

2.6.4 International Commitments

Myanmar has signed 31 international treaties related to the environment. It is unclear however, how the contents of those treaties have been incorporated into domestic law.

Table 2.12 International and Regional Treaties Concerning the Environment

No.	Name
1	Plant Protection Agreement for the Southeast Asia and Pacific Region
2	Treaty Banning Nuclear Weapons Test in the Atmosphere in Outer Space and Under Water
3	Outer Space Treaty: Treaty on Principles Governing the Activities of States in the Exploitation and Use of Outer Space including the Moon and other Celestial Bodies
4	Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea-bed and Ocean Floor and in the Subsoil there of (Seabed Treaty)
5	Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological and Toxin Weapons, and their Destruction
6	Vienna Convention for the Protection of the Ozone Layer
7	Montreal Protocol on Substances that Deplete the Ozone Layer
8	MARPOL: International Convention for the Prevention of Pollution from Ships
9	MAPROL: International Convention for the Prevention of Pollution from Ships as amended 1978
10	Agreement on the Networks of Aquaculture Centers in Asia and the Pacific Region
11	London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer
12	United Nations Framework Convention on Climate Change (UNFCCC)
13	Treaty on the Non-Proliferation of Nuclear Weapons
14	ICAO: ANNEX 16 Annex to the Convention on International Civil Aviation Environmental Protection Vol. I, II, Aircraft Noise
15	United Nations Convention to Combat Desertification
16	Vienna Convention for the Protection of Ozone Layer
17	Montreal Protocol on Substances that Deplete the Ozone Layer
18	London Amendment to the Montreal Protocol
19	Convention concerning the Protection of the World Cultural and Natural Heritage
20	Convention on Biological Diversity (CBD)
21	United Nations Convention on the Law of the Sea
22	International Tropical Timber Agreement (ITTA)
23	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
24	ASEAN Agreement on the Conservation of Nature and Natural Resources
25	Catagena Protocol on Biosafety
26	ASEAN Agreement on Transboundary Haze Pollution
27	Kyoto Protocol to the United Nations Framework Convention on Climate Change
28	Convention on the Prohibition of the Development, Production, and Stockpiling and Use of Chemical Weapons and on their Destruction
29	Stockholm Convention on Persistent Organic Pollutants
30	Ramsar Convention on Wetlands
31	Copenhagen Amendment to Montreal Protocol on Substances that deplete the Ozone Layer

Source: Burma's Environment, The Burma Environmental Working Group (BEWG)

2.6.5 Environmental Quality

Based on the Environment Conservation Law 2012, the new environmental quality standards are under preparation by MOECAF. The environmental quality will include:

- Surface water quality such as rivers, stream, canal, water spring, lake, pond marshy place, dam
- Water quality at sea coast lines and delta areas
- Underground water quality
- Ambient air quality
- Noise and vibration
- Fume emissions
- Liquid discharge quality
- Solid waste
- Other environment quality specifications prescribed by the Union of Government

If environment quality standards prescribed by government department concerned or by government organization are more stringent than that of MOECAF, they shall be applied as it is and if those standards are less stringent than that of MOECAF then the MOECAF standards shall be in force.

2.6.6 Environmental and Social Considerations for the Project

As mentioned in the above section, the system of environmental impact assessment is under preparation. Thus till the regulations related to EIA will be enacted, JICA's Guidelines for Environmental and Social Considerations (April 2010) (hereinafter referred as "JICA Guidelines") is applied to the Project.

According to JICA Guidelines, the IEE-level environmental and social considerations studies including analysis of alternatives including "without project" situations should be implemented in the full-scale study stage (Master Plan Study). In addition, it is said that JICA applies a Strategic Environmental Assessment (SEA) when conducting Master Plan Studies. Thus, in the Project, IEE-level environmental and social considerations which introduce the concept of SEA shall be implemented.

CHAPTER 3. ANALYSIS OF CURRENT SITUATION

3.1 Current Wastewater Treatment

3.1.1 Type of Wastewater Treatment

Wastewater treatment in Yangon is categorized into sewerage, septic tank, pour flush toilet, non-fly toilet, non-sanitary toilet and no toilet. Only a tiny portion of the population, as small as 5.8 % of total population enjoys sewerage services. Most of the middle and high class houses, public and commercial buildings are provided with mainly septic tanks, and low income houses in the peripheral areas are provided with various kinds of toilets without treatment. The existing sewerage system was originally constructed in 19th century which collects only toilet wastewater (black water), and gray water is discharged to the nearby drains without any treatment. The current situation of wastewater treatment not only brings forth deteriorated living conditions but also involves potential health risks. Wastewater treatment in Yangon in 1991 was reported as shown in Table 3.1. According to "Yangon Infrastructure and Environmental Services", population of Yangon in 1991 was 2.98 million.

Table 3.1 Wastewater Treatment in 1991

Treatment System	Population（%）
Sewerage	7.3
Septic Tank (communal)	4.2
Septic Tank (individual)	14.3
Pour Flush Toilet	27.6
Non-fly Toilet	18.4
Non-sanitary Toilet	27.9
No Toilet	0.3

Source: "Yangon Infrastructure and Environmental Services" Report

Current situation has been estimated based on the following assumptions due to lack of information. Results of the estimation are shown in Table 3.2.

Assumptions for estimation of the current situation

- Sewerage served population is estimated to be population in service area in 2011
- Population served with non-sanitary toilet or without toilet is same as that in 1991, which means that increment of the population has been provided with either septic tank, pour flush toilet, or non-fly toilet.
- In CBD and Inner Urban Ring areas, increased population has been provided with septic tank (communal or individual).

Table 3.2 Wastewater Treatment in 2011 (Estimates)

Treatment System	Population (%)
Sewerage	4.3
Septic Tank (communal)	4.0
Septic Tank (individual)	18.9
Pour Flush Toilet	31.5
Non-fly Toilet	25.3
Non-sanitary Toilet	15.8
No Toilet	0.2

Source: JICA Study Team

Population increment in Yangon from 1991 to 2011 was about 2.27 million, based on fact that the populations in respective years were 2.98 and 5.25 million. Population served with sewerage system were 0.218 million in 1991, and 0.226 million in 2011 which are almost same. People served with non-sanitary toilet or without toilets decreased significantly because of the assumptions. It is estimated that the number of pour flush toilets has experience maximum increase followed by septic tank (individual).

3.1.2 Results of Household Interview Survey

Results of the Household Interview Survey conducted in October and November 2012 are summarized as Tables 3.3 and 3.4. Table 3.3 shows type of toilet facility, and Table 3.4 shows treatment of toilet wastewater (black water) and sullage (gray water). Pour flush toilet is the most dominant type of toilet, which accounts for 82.4 %. This is similar to the estimation in the previous section, however, percentage is more than double. Non-sanitary toilet (pit latrine) accounts for 10.9 % which is less than the estimation. This reflects that since 1991, improvement has progressed at a faster pace than estimation.

On the other hand, interviewees answered that 9.3 % of black water and 13.5 % of gray water is treated by sewerage system. This might be misunderstanding of interviewees, since only flush toilet wastewater can be treated by sewerage system and current sewerage system collects only black water. Dominant answers are non-treatment both for black water and gray water, 47.2 % for black water and 59.2 % for gray water. Treatment by septic tank accounts for merely 43.1 %. These figures indicate unsanitary conditions of living environment, although the situation has improved since 1991.

Table 3.3 Type of Toilet, Results of Household Interview Survey

	Flush Toilet	Pour-flush Toilet	Pit Latrine	No Toilet	No Answer	Total
Number	580	8,278	1,098	58	31	10,045
(%)	5.8	82.4	10.9	0.6	0.3	100.0

Source: Strategic Urban Development Plan for the Greater Yangon

Table 3.4 Treatment of Black Water and Gray Water

Category		Sewerage System	Septic Tank	No Treatment	No Ansewer	Total
Black Water	Number	935	4,333	4,742	35	10,045
	(%)	9.3	43.1	47.2	0.3	100.0
Gray Water	Number	1,357	2,699	5,946	43	10,045
	(%)	13.5	26.9	59.2	0.4	100.0

Source: Strategic Urban Development Plan for the Greater Yangon

Comparing the estimation for 2011 and results of the Household Interview Survey (HIS), although terminology is slightly different (there is no non-fly toilet in HIS), the following main points can be said.

- Treatment of black water by septic tank accounts for 22.9% by the estimation and, accounts for 43.1% by HIS. This difference is caused by the fact that population served with non-sanitary toilet or without toilet is assumed to be the same as that in 1991. This means that not only increment of population but many people who had used non-sanitary toilet have installed septic tanks.
- In relation to the above, population that uses non-sanitary toilet which was estimated to account for 15.8% actually decreased to 10.9%.
- Population that can use sewerage system accounts for 5.8% by HIS instead of 4.3% by the estimation, which means that population increase in sewerage service area has been higher than that of the other areas.

The results of HIS are attached in the Appendix G.

3.2 Current Status of On-site System

3.2.1 Structure and Permission of Installation of Septic Tank

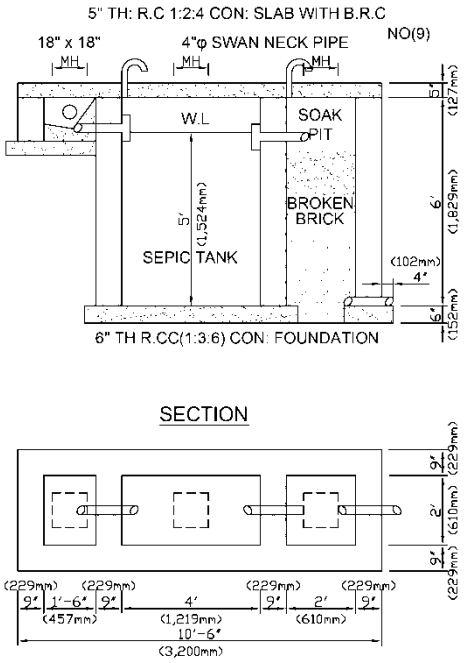
YCDC recommends septic tank system as wastewater treatment. Septic tank treat only toilet wastewater (black water), and gray water from kitchen, laundry and so on is discharged directly to storm water drains without treatment. Owner of a house or a building should submit an application to Sanitation Division, Department of Water Supply and Sanitation and needs to obtain its approval for wastewater treatment. YCDC has standard structure for septic tank. Figures 3.1 to 3.3 show standard structures of septic tanks for 10 persons, 100 persons and 200 persons, respectively. YCDC has authority to approve applications for up to 8 storied buildings. In case of high building with more than 9 story, approval from Committee for Quality Control of High-Rise Building, under Ministry of Construction is required. The Committee recommends septic tanks with up-flow filter. An example of structure approved by the Committee is shown in Figure 3.4. As shown in Figures, effluent from septic tank infiltrates underground and not being discharged to storm water drain.

Volume of the YCDC septic tank per person is compared with those of the neighboring countries. Neighboring countries include Vietnam, Thailand, and the Philippines. USA is added because septic tanks are commonly used in mainly suburban areas. Results are shown in Table 3.5. Volume per person of YCDC septic tank is almost equals to that of Thailand, however, approximately one fifth those of Vietnam, the Philippines and USA. This is due to the fact that in the Philippines and USA gray water is also treated in septic tanks. It is not clear whether gray water is treated in septic tanks in Vietnam, most provably gray water is included. Retention time in YCDC septic tank is significantly different in case of pour flush toilet and flush toilet. If septic tank is attached to flush toilet and per person wastewater is assumed to be 50 lpcd (l/cap/day), retention time is 2.9 days which is almost equal to those of Thailand, the Philippines and USA.

Table 3.5 Volume and Retention Time of Septic Tank

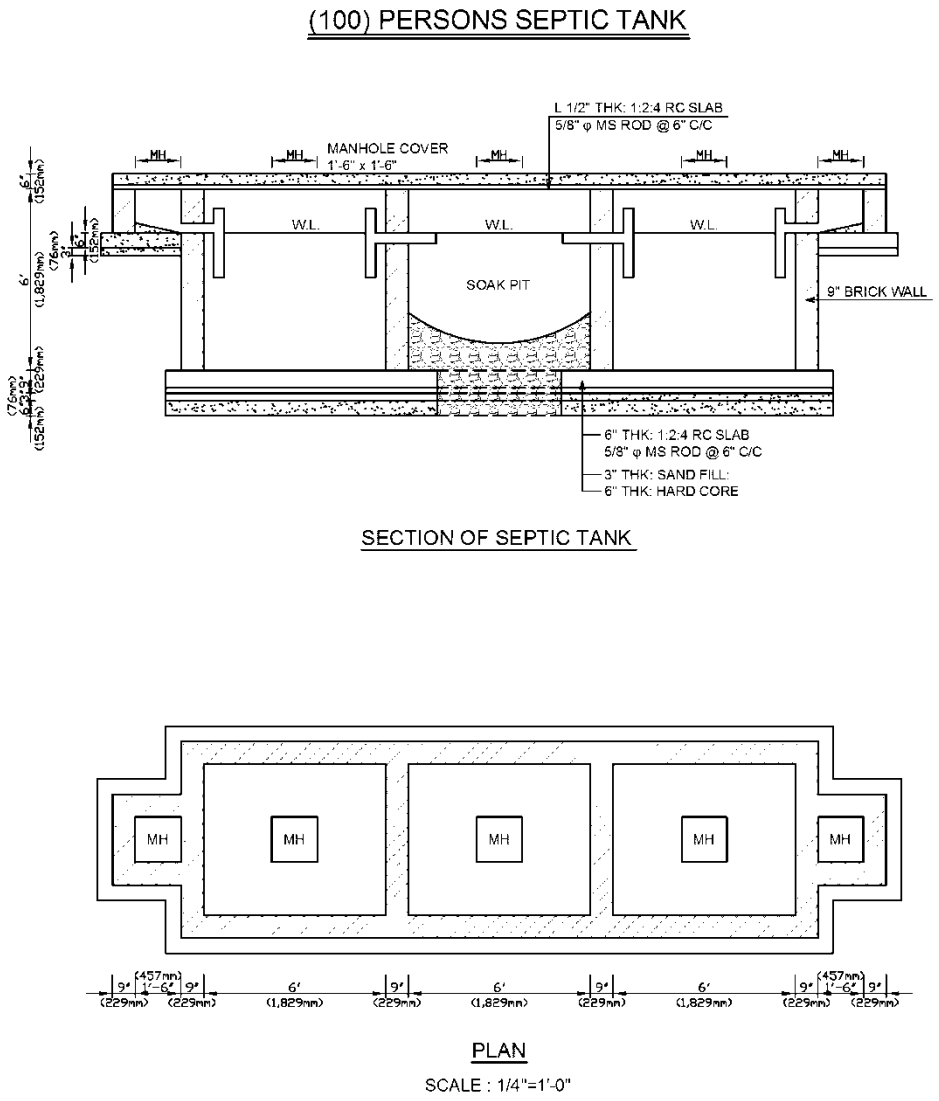
Country	Type of wastewater	Average Septic tank volume / Capita (m^3/capita)	Average Wastewater Flow (lpcd)	Average HRT (Day)
Vietnam	Black water (flush toilet)	0.70	50	13.8
Vietnam	Black water ＋Gray water	0.70	189	3.7
Thailand	Black water (flush toilet)	0.12	50	2.4
Philippine	Black water + Gray water	0.70	189	3.7
USA	Black water + Gray water	0.80	285	2.7
YCDC	Black water (flush toilet)	0.15	50	2.9
YCDC	Black water (pour-flush toilet)	0.15	3.1	47.3

Source: JICA Study Team



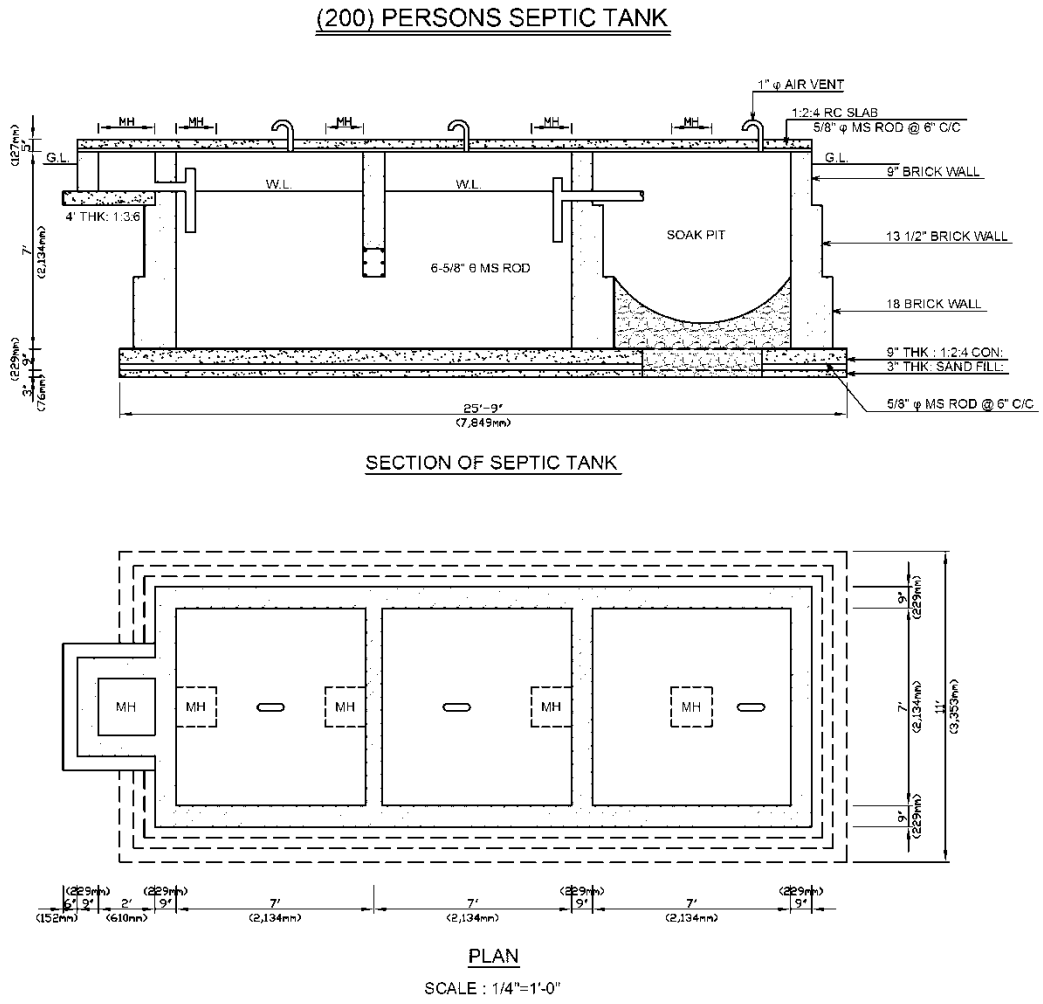
Source: YCDC

Figure 3.1 Septic Tank for 10 Persons



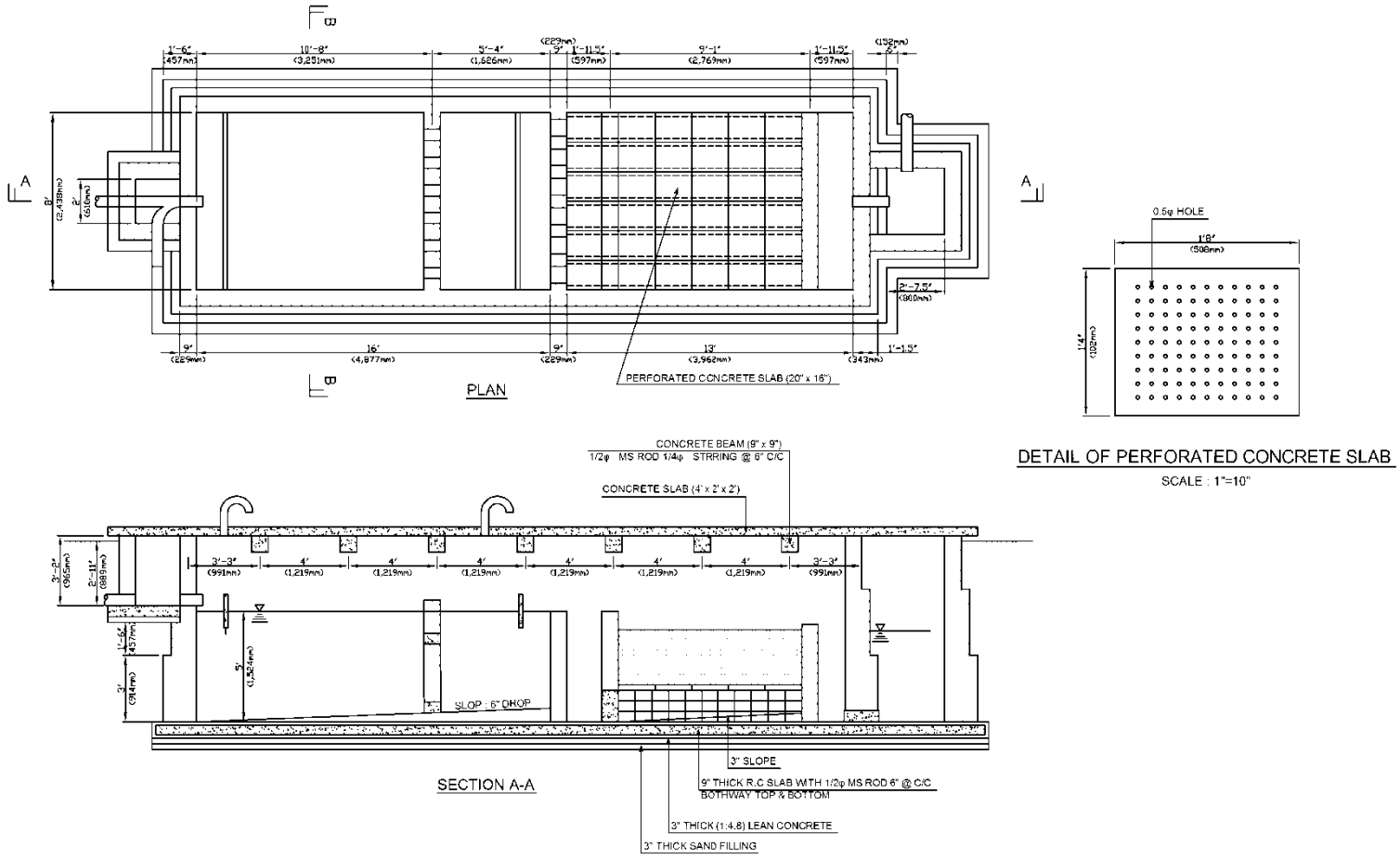
Source: YCDC

Figure 3.2 Septic Tank for 100 Persons



Source: YCDC

Figure 3.3 Septic Tank for 200 Persons

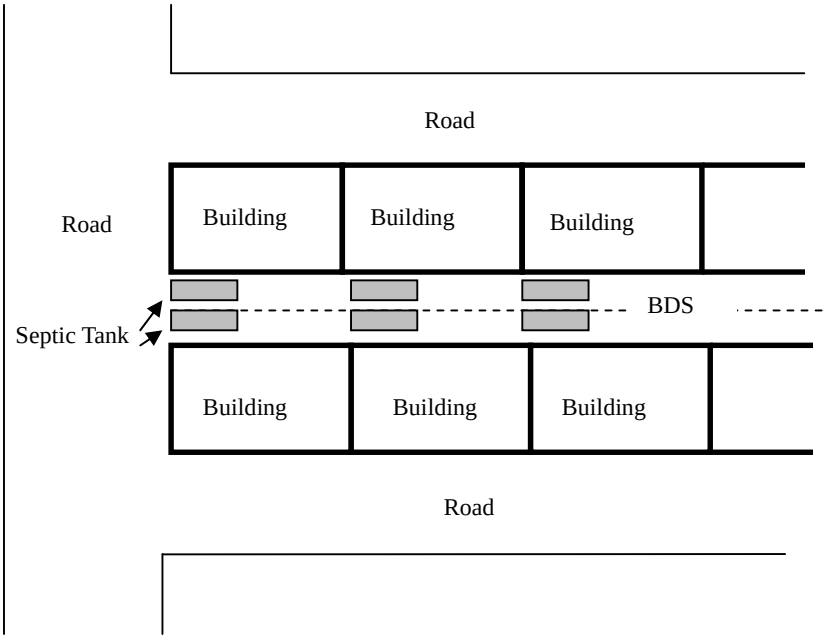


Source: YCDC

Figure 3.4 Septic Tank with Up-flow Filter

In CBD and Inner Urban Ring areas, Back Drainage Space (BDS) is provided in back yard of buildings. Width of BDS is usually 10 to 15 feet (3.0 to 4.5 m), and septic tanks for buildings at both sides are constructed in halves of the BDS. Typical arrangement of septic tanks in BDS is shown in Figure 3.5. Usually, storm water drains with width 1.0 to 1.5 ft. (30 to 45 cm) are provided on both sides of BDS into which storm water is discharged. BDS is owned by YCDC and building owner should pay annual rental fee. Construction cost of septic tank is born by building owner.

For detached houses, gray water together with storm water is discharged through drains in the property (mostly open drain with brick structure, rarely pipes) to roadside drains.



Source: YCDC

Figure 3.5 Typical Arrangement of Septic Tanks in BDS

The following criteria are established and YCDC approves based on these criteria.

Criteria for capacity of septic tank

1) In case of BDS (relatively high density urban areas)
   2.25 ft^3/person (0.0605 m^3/person)
2) In case of no BDS (low density urban areas with detached houses)
   4.0 ft^3/person (0.108 m^3/person)

Number of persons per house is calculated based on the number of rooms and an assumption of 5 persons per room.

Number of approvals by YCDC for the last two years are 3,660 in 2010/11 and 5,444 in 2011/12 respectively as shown in Table 3.6.

Table 3.6 Number of Approvals by YCDC

Type	2010/11 FY	2011/12 FY
Connection to sewerage (CBD)	60	124
Septic tank (1 to 3 storeys)	3,081	4,685
Septic tank (4 to 8 storeys)	519	635
Total	3,660	5,444

Source: YCDC

3.2.2 Maintenance of Septic Tanks

Removal of sludge in septic tanks is carried out by Department of Motor Transport and Workshop, YCDC at the request of the house owner. The Department possesses 33 vacuum cars (1.8 m^3, 10 numbers and 5.4 m^3, 23 numbers). In some townships, private companies carry out this task, but details are not known to YCDC. The total dispatch of vacuum car by the Department in 2012 was 16,261.

Frequency of sludge removal obtained from Household Interview Survey is summarized in Table 3.7. Many households (33.8 %) remove sludge every 1 to 3 years followed by the households which remove once within 1 year (30.6 %). However, there are a number of households which do not remove sludge even for more than 5 years (6.7 %) or have never removed it (20.4 %). Black water from these households is assumed to be not treated properly.

Table 3.7 Frequency of Septic Tank Sludge Removal

	Less than 1 Year	1 to 3 Years	3 to 5 Years	More than 5	Never	No Ansewer	Total
Number	3,072	3,391	823	668	2,048	43	10,045
(%)	30.6	33.8	8.2	6.7	20.4	0.4	100.0

Source: Strategic Urban Development Plan

Sludge removal service is available in every township in Yangon Region except for Seikigyikhanaungto Township where access is very difficult. Fees for sludge removal are determined according to location of townships (distance) as shown in Table 3.8. Unit price of Diesel oil is reviewed on monthly basis. Unit price applied in November and December 2012 is 3,650 Kyat. Based on this unit price, fees are calculated as shown in Table 3.9. Least fee and highest fee for one time removal are 7,475 Kyat and 34,725 Kyat, respectively.

Total revenue for YCDC from this service amounted to be 51,486,490 Kyat in 2012 resulting in average fee for one time as 3,166 Kyat. This figure is quite low compared to fees calculated from the

formula. The reason for this is no collection from public entities.

On the other hand, an average fee of 19,021 Kyat for removal is obtained based on the data of Household Survey. Maximum fee is extraordinary as high as 2,200,000 Kyat resulting in higher average value. It is estimated that a few house households pay very high fee and the average fee become higher. Median obtained from the survey is 3,000 Kyat.

Table 3.8 Formula for Fees for Septic Tank Sludge Removal

Category of Township	1.8 m^3 Car	5.4 m^3 Car
1st (3TS)	5.0 gallon x unit price of Diesel oil + 3,500 Kyat	6.5 gallon x unit price of Diesel oil + 11,000 Kyat
2nd (6TS)	4.0 gallon x unit price of Diesel oil + 3,000 Kyat	5.0 gallon x unit price of Diesel oil + 8,500 Kyat
3rd (11TS)	2.5.0 gallon x unit price of Diesel oil + 2,500 Kyat	3.0 gallon x unit price of Diesel oil + 6,500 Kyat
4th (9TS)	2.0 gallon x unit price of Diesel oil + 2,000 Kyat	2.5 gallon x unit price of Diesel oil + 4,500 Kyat
5th (10TS)	1.5 gallon x unit price of Diesel oil + 2,000 Kyat	2.0 gallon x unit price of Diesel oil + 4,000 Kyat

Source: YCDC

Table 3.9 Fees for Septic Tank Sludge Removal (November 2012)

Township Category	1.8 m^3 Vacuum Car (Kyat)	5.4 m^3 Vacuum Car (Kyat)
1st	21,750	34,725
2nd	17,600	26,750
3rd	11,625	17,450
4th	9,300	13,625
5th	7,475	11,300

Source: Study Team

3.3 Sewerage System

3.3.1 Ejector System

Wastewater in YCDC is collected by ejector system which was constructed by British in 1890. This system has been utilized continuously with periodical modifications for approximately 120 years. Service area covers 8 townships in the Central Business District (CBD). Sewerage system adopted unique ejector system which consists of two compressor stations, a number of ejector stations and two force mains which run in east-west direction in the service area. Originally 40 ejector stations were constructed and 34 stations are in service at present (refer Figure 3.6).

Sewage (toilet wastewater only excluding gray water from kitchen, laundry and so on) collected by gravity to ejector stations is forced to be sent to the force main by compressed air distributed from compressor stations. Water level in an ejector reaches a certain level then valves of air pipe and discharge pipe are automatically opened to send wastewater (refer Figure 3.7).

The original sewerage system consisted of the following facilities.

Table 3.10 Sewerage System Facilities

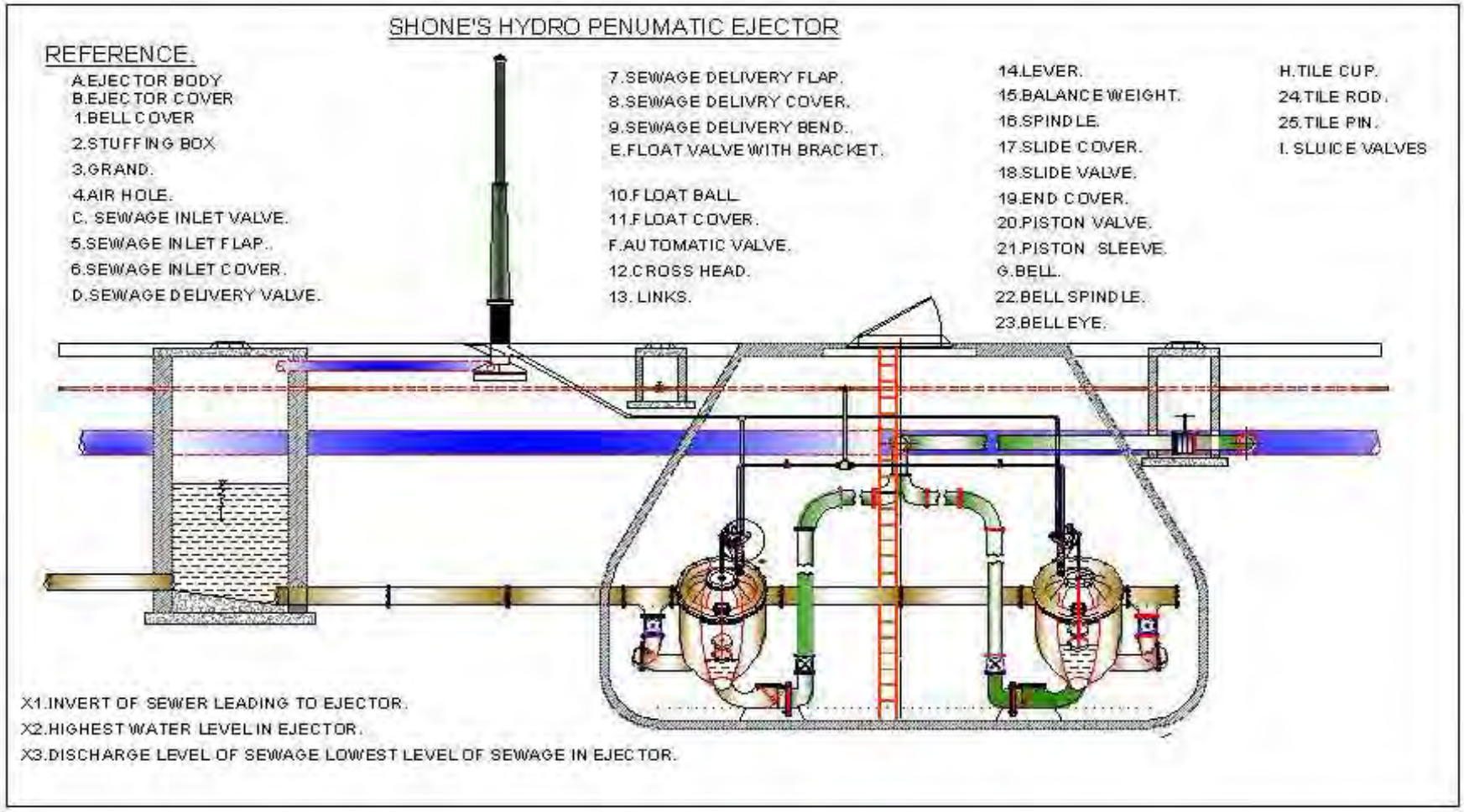
Item	Description
Start of construction	February 1888
Completion	March 1890
Planned population	40,000 persons
Planned service area	8 Townships Lanmadaw, Latha,, Panbedan, Kyauktada, Botadaung, Puzondaung (part), Dagon (part), Mingalataungnyunt (part)
Contractor	Huges & Lancaster
Manufacturer	Shone Hydro-Pneumatic Ejector
Construction cost	2.3 million Rupee (loan from Indian Government)
Length of force main	North 5.55 km, South 5.03 km, total 10.58km
Diameter of force main	North 300~1,200 mm, South 300~600 mm
Material of force main	Cast iron
Number of ejector station	40, out of which 34 currently in operation
Number of manholes	2,114

Source: JICA Study Team

In 2011, inspection of the interior of the force main from an inspection chamber was carried out and serious corrosion of years old pipes was observed. Also, clogging of inlet pipes to ejector stations by garbage became problem.

Figure 3.6 Sewerage System in Yangon City

Source: YCDC



Source: YCDC

Figure 3.7 Ejector Station

3.3.2 Wastewater Treatment Plant

Since construction of the sewerage system, collected wastewater had been discharged to the Yangon River without treatment. Wastewater has been treated since the completion of wastewater treatment plant in January, 2005. Design and construction of the wastewater treatment plant were carried out by YCDC. Construction cost was borne by several ministries including Ministry of Construction. Outline of the wastewater treatment plant is shown in Table 3.11.

Table 3.11 Outline of Wastewater Treatment Plant

Site area	2.25 ha (5.56 acres)
Start of construction	April, 2003
Completion	January, 2005
Design served population	300,000 persons
Design Capacity	14,775 m^3/day (3.25MGD)
Construction cost	1.96 million USD（2,065.7 M Kyat）
Characteristics of wastewater	BOD 600 mg/l, SS 700 mg/l (design)
Characteristics of treated effluent	BOD 60 mg/l, SS 40 mg/l (design)

Source: YCDC

Treatment process is extended aeration activated sludge process, and treatment flow of the wastewater is shown below. Mechanical type surface aerators are applied for aeration. Sludge is planned to be treated by aerobic digestion process and dewatered by belt-press, and these facilities were installed.

Wastewater treatment flow	Inlet → Grit chamber → Screen → Pump → Primary sedimentation tank → Aeration tank → Final sedimentation tank → Chlorine contact tank → Discharge
Sludge treatment flow	Mixing tank → Gravity thickener → Pump → Aerobic digestion tank → Pump → Belt-press → Disposal, Bypass from mixing tank to drying beds is provided and used at present

Source: JICA Study Team

The wastewater treatment plant is operated for two hours each in the morning and afternoon. Therefore, the plant is operated only 4 hours a day. The reason for this abnormal operation is assumed to be small quantity of wastewater inflow compared to design capacity. Inflow to the plant is not measured. However, it is reported by the manager of the plant that current inflow is estimated to be approximately 0.5 MGD (2,300 m^3/day). Capacity of the aeration tank was designed based on extended aeration process having 20 hours of retention time. Actually, current retention time is calculated to be:

20 hrs. x 14,775/2,300 = 128 hrs. (approximately 5.3 days)

This may be a reason for good treatment. However, automatic control device for pump operation was

broken down resulting in large quantity of wastewater flow in short period caused by operator's manual operation. Shock load is expected to be large, but this may be cancelled out by long retention time in the aeration tank. Proper operation is not carried out because of many reasons, such as break down of water level gauge and control device, absence of monitoring of characteristics of wastewater and water temperature, and lack of spare parts and chemicals. These problems should be solved for better operation.

Wastewater characteristics of inflow and treated effluent analyzed by Yangon Institute of Technology during June to August 2006 are shown in Table 3.12. As the results of 12 measurements, BOD and COD concentrations are considered to be low as black water. Average BOD and SS concentrations of inflow are 142 mg/l and 297 mg/l respectively, and those of treated effluent are 7.2 mg/l and 5.3 mg/l respectively. In other words, removal ratios of BOD and SS are 95 % and 98 % respectively indicating that treatment is very well conducted. Operation conditions during the period when monitoring was carried out were not known, it is obvious that normal treatment was conducted as far as wastewater characteristics are concerned. BOD concentration was 680 mg/l by Study Team's survey, and this indicates that different wastewater was analyzed. Therefore, effluent characteristics and treatment efficiency cannot be compared directly.

Sludge treatment facilities were constructed adopting aerobic digestion and mechanical dewatering as mentioned before, these facilities have never been operated since the completion of the plant. Bypass from mixing tank to sludge drying beds is constructed and sludge is treated on the drying beds. Reason for not using dewatering machinery is high price of polymer. Dried sludge cake is utilized as soil conditioner for parks.

If current served population is assumed to be 300,000, and each person produces 50 lpcd black water using flush toilet, total amount of black water is calculated to be 15,000 m^3/day. This figure is almost equal to the design capacity of the existing WWTP. However, current flow to the plant is only 2,300 m^3/day.

Table 3.12 Wastewater Characteristics of Inflow and Effluent

Item	8 Jun. 2006		15 Jun. 2006		20 Jun. 2006		22 Jun. 2006		27 Jun. 2006		4 Jul. 2006		11 Jul. 2006		13 Jul. 2006		20 Jul. 2006		8 Aug. 2006		17 Aug. 2006		Aug. 2006		Average	
	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.	Infl.	Effl.
BOD (mg/l)	144	21	175.2	7.8	60	3	86.4	4.5	188.4	13.8	97.2	1.8	39	4.8	66	3.6	64.2	4.92	594	4.68	86.4	11.4	98.4	5.22	142	7.2
DO (mg/l)	0.36	6.5	0	6.4	0.3	4.9	0	6.0	0	6.1	0	0	0	5.2	1.7	5.4	0.2	6.06	0	0	0	0	0	0	0.2	3.9
COD (mg/l)	560	48	640	25.6	192	38.4	432	13.44	736	124.8	240	19.2	272	38.9	340	32	192	48	275.2	16	64	28.8	968	16	409	37.4
pH	6.7	6.3	6.9	6.3	6.6	6.4	6.6	6.3	7.4	6.5	7.3	6.1	7.4	6.7	7.4	6.5	7.6	6.7	6.8	3.9	6.6	6.6	7.3	6.4	7.1	6.2
Total Solid (mg/l)	572	618	1,176	842	454	862	21,638	652	1,246	572	526	994	260	874	408	824	382	706	438	842	856	634	880	584	654	750
SS (mg/l)	450	5	775	0	40	0	450	0	300	0	340	0	50	0	20	25	60	20	240	5	460	0	375	8	297	5.3
Dissolved Solid (mg/l)	122	613	401	842	414	862	20,588	652	946	572	186	860	210	874	388	799	322	686	198	837	396	694	485	584	370	740
Conductivity (µ℧/cm)	960	1,150	1,095	790	1,225	730	1,345	775	1,250	775	860	860	900	740	950	765	850	695	1,045	850	1,195	760	1,080	795	1,063	807
NaCl (mg/l)	470	560	570	430	590	370	640	360	650	370	440	425	455	350	470	375	415	330	480	390	575	360	505	355	522	390
Turbidity (FTU)	450	5	1,225	35	100	15	600	0	550	13	336	40	120	18	130	25	110	38	219	12	500	15	365	15	392	19.3
Color (TCU)	100	3	100	0	140	45	150	50	50	0	48	0	60	0	65	0	63	0	125	0	95	0	80	0	89.7	8.2
Ammonia (mg/l)	-	-	-	-	-	-	-	-	-	-	5.75	0.45	5.5	0.21	1.8	0.23	1.38	0.28	1.5	0.13	1.41	1.25	1.38	0.98	2.7	0.5

Excluded from average calculation

Source: YCDC

Photo 3.1 Sign Board of WWTP

Photo 3.2 Receiving Well

Photo 3.3 Primary Sedimentation Tank

Photo 3.4 Aerator

Photo 3.5 Final Sedimentation Tank

Photo 3.6 Chlorine Contact Tank

3.4 Industrial Wastewater

3.4.1 Management of Department of Pollution Control and Cleansing

There are 24 industrial zones in YCDC, and 3,562 factories exist in these industrial zones. Industrial wastewater from these factories is under management of Department of Pollution Control and Cleansing, YCDC. YCDC's own discharging standards are used instead of Ministry of Industry's standards. YCDC's standards are shown in Table 3.13. Factories of the following industrial categories are mainly monitored, since monitoring of all factories is actually impossible.

- Chemical
- Brewery (alcohol)
- Battery manufacturing
- Sea food processing

In fiscal year 2012, 79 factories were monitored, and results are shown in Table 3.14. As shown in Table, out of 66 operating factories, treatment is needed for 24 factories. Samples were taken from these factories and analyzed by the laboratory under Ministry of Science. Eleven (11) factories satisfy the industrial wastewater standards, thirteen (13) factories do not. Request to provide treatment facility was issued to 13 factories and among them 12 factories installed treatment facilities, and only one (1) factory did not install. However, this factory would install treatment facility shortly. There is no standard for design of treatment facilities, and processes are determined by negotiation between YCDC and factory owner based on the result of water quality analysis. After installation, YCDC monitors effluent.

Standards for heavy metals are yet to be stipulated and monitoring is not carried out. Standards are now in the process of preparation and to be brought to effect in 2014. Standards of Laos and the Philippines are referred to in the preparation. When industrial wastewater is accepted in the sewerage system, water quality standards should be established and monitoring should be provided. For industrial wastewater that does not satisfy the standards, pretreatment by the factory is compulsory.

Table 3.13 YCDC's Industrial Wastewater Standards

Parameter	Permissible Limit	Unit	Notes
BOD_5	20 - 60	mg/l	Depending on geography of waste discharging point
Suspended Solids	200	mg/l	
pH	6 - 9.5		
COD	200	mg/l	
Total Solids	500	mg/l	

Source: Department of Pollution Control and Cleansing

Table 3.14 Results of Industrial Wastewater Analysis (FY 2011)

Total number of factories to be inspected	Total number of closed or non-operated factories	The number of factories inspected	The number of factories that do not purify wastes	The number of factories that need to purify wastes	The number of factories of which results were received	The number of factories that are consistent with standards	The number of factories that are not consistent with standards	The number of factories that built filtration tank	The number of factories that need to build filtration tank
79	13	66	42	24	24	11	13	12	1

Source: Department of Pollution Control and Cleansing, YCDC

3.4.2 Industrial Wastewater Management for Mingaladon Industrial Park

Mingaladon Industrial Park (MIP) is a joint enterprise of Myanmar government, Mitsui Corporation and a Singapore company. This joint enterprise developed the industrial park, re-leased land use right to the companies and manages utility services in the park. MIP has been recovering development and operation cost by lease fee (lump-sum payment) and monthly management, electricity and water supply and sewerage fees. MIP established standards to receive industrial wastewater to their sewerage system and obliged factories to construct pre-treatment facilities to meet the standards. Monitoring system with MIP and factories were also established jointly and structure of monitoring pit was determined. If a factory violates, MIP can stop supply of industrial water or receiving wastewater after three warnings. This very strict management of industrial wastewater is not practiced in any of the other industrial zones. Receiving standards is shown in Table 3.15. Layout plan of monitoring pit is shown in Figure 3.8.

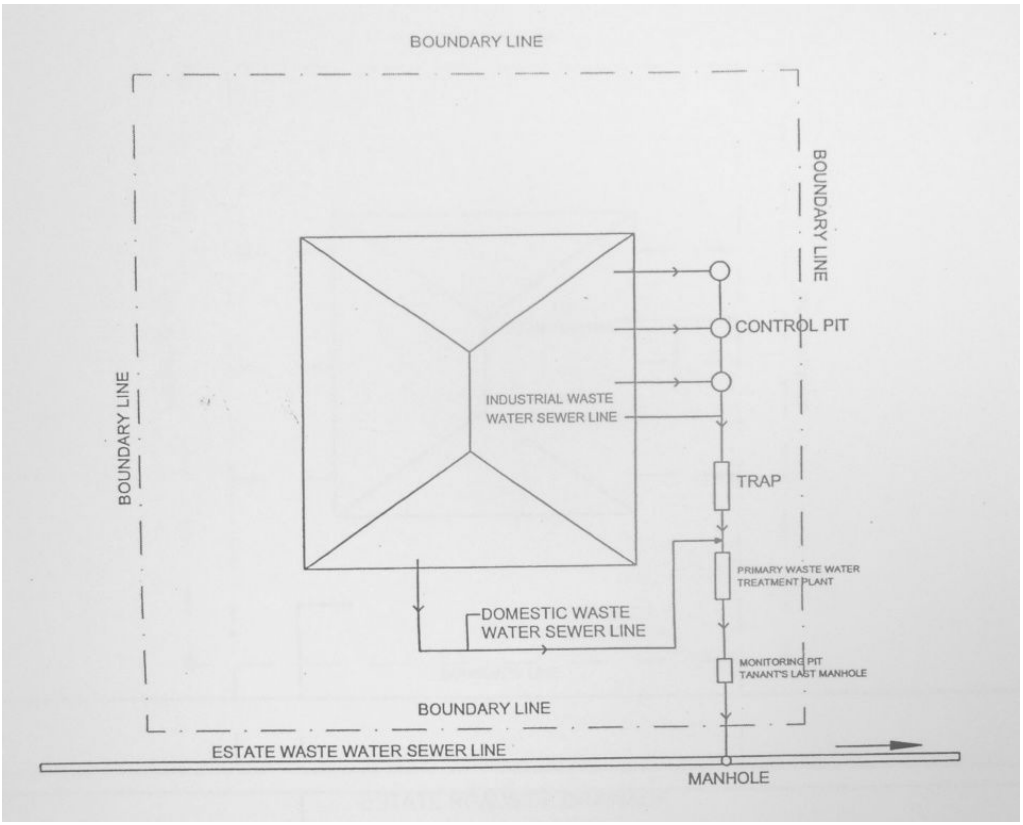
Receiving standards are self-established, a report is necessary annually. Analysis is entrusted to outside authorities. However, details are not known. It was informed that there is neither plating factories nor chemical factories.

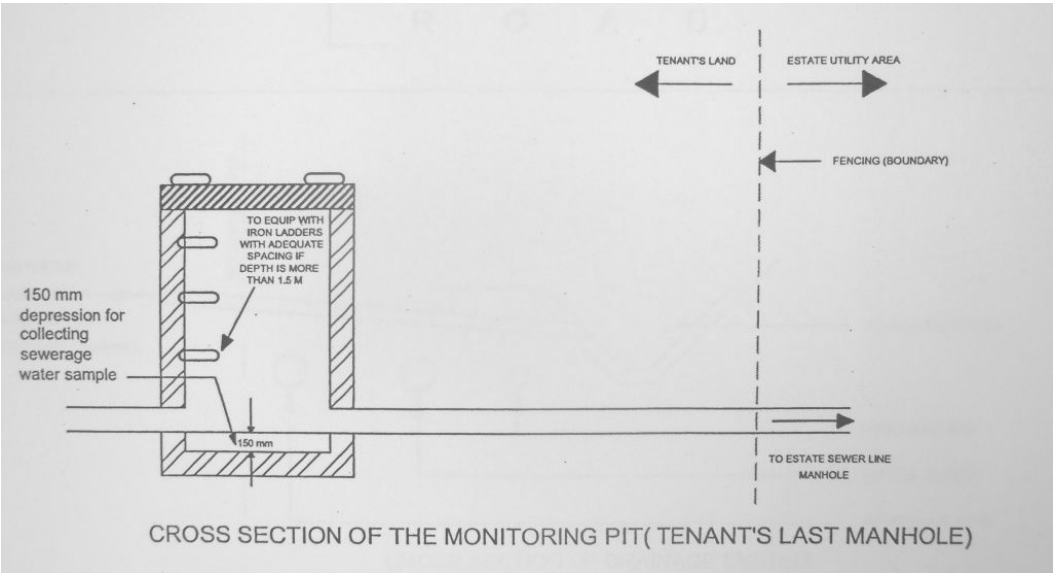
Table 3.15 Receiving Standards for Industrial Wastewater

Parameter		Unit	Maximum Permissible Limit
PHYSICAL			
Temperature		℃	35
Dissolved Solids		mg/l	1,000
Suspended Solids		mg/l	200
CHEMICAL			
pH		units	6-9
Iron	(Fe)	mg/l	5
Manganese	(Mn)	mg/l	0.5
Zinc	(Zn)	mg/l	5
Copper	(Cu)	mg/l	0.5
Chromium Hexav.	(Cr^6)	mg/l	0.1
Cadmium	(Cd)	mg/l	0.01
Total Mercury	(Hg)	mg/l	0.005
Boron	(B)	mg/l	1
Nickel	(Ni)	mg/l	0.1
Phosphate	(PO_4-P)	mg/l	1
PCB		mg/l	0.003
Lead	(Pb)	mg/l	0.1
Arsenic	(As)	mg/l	0.05
Selenium	(Se)	mg/l	0.01
Cyanide	(CN)	mg/l	0.02
Sulphur	(S)	mg/l	0.01
Fluorine	(F)	mg/l	1.5
Chlorine	(Cl_2)	mg/l	1
Chloride	(Cl)	mg/l	600
Sulphate	(SO_4)	mg/l	400
Free Ammonia	(NH_3-N)	mg/l	0.5
Nitrate	(NO_3-N)	mg/l	10
Nitrite	(NO_2-N)	mg/l	1
Oxygen Demand			
Biochemical	(BOD)	mg/l	240
Chemical	(COD)	mg/l	500
Blue Active Compound Methylene (Mixed Active Methyl Blue)		mg/l	0.5
Phenol		mg/l	0.002
Vegetable Oil & Fats		mg/l	30
Mineral Oil (Hydrocarbon)		mg/l	10
MBAS (Detergent)		mg/l	0.5
Radioactivity*			

Note: 1. Radioactivity* concentration follows the valid regulations.
2. No substances constituting an obstacle to the biological treatment process shall be included.

Source: MIP





Source: MIP

Figure 3.8 Layout Plan of Monitoring Pit

3.5 Water Quality Management

3.5.1 Existing Water Quality Management System

In this section, existing water quality management system for sewerage is described.

(1) WWTP

YCDC Water Supply and Sanitation Department monitors MLSS (aeration tank) and pH (effluent) periodically. Other monitoring, especially, periodical effluent monitoring of other water quality items is not done.

(2) Industrial wastewater and Drainage

Drainage

YCDC Environment and Cleansing Department manages water quality of drainage. However, the state of monitoring implementation is not clear.

Industrial wastewater

Industrial wastewater is managed by YCDC Department of Pollution control and Cleansing. Following Table describes wastewater discharge standard (issued by YCDC Department of Pollution control and Cleansing). For reference, Japanese wastewater discharge standard is shown.

Table 3.16 Wastewater Discharge Standard

Item	Limitation value (YCDC)	Wastewater discharge standard (Japan)
pH	6 – 9.5	5.8 – 8.6 (except sea area)
SS	200 mg/L	200 mg/L (Daily average 150 mg/L)
TS	500 mg/L	Not decided
BOD5	20 – 60 mg/L Depending on discharging point	200 mg/L (Daily average 120 mg/L)
COD	CODCr 200 mg/L	CODMn 160 mg/L (Daily average 120 mg/L)

Source: JICA Study Team

YCDC decides more stringent BOD5 value than Japanese standard. COD of YCDC standard is at same level or more stringent than Japanese standard considering the difference between CODCr and CODMn.

Table 3.17 shows existing analysis data of industrial wastewater in Yangon. Characteristics of industrial wastewater are as follows;

- pH: 3.9 – 9.1
- BOD5: average 2,008 mg/L
- CODCr: average 4,169 mg/L
- TS: average 6,552 mg/L
- SS: average 1,391 mg/L

Many industrial wastewater in Table 3.17 shows acidity. Moreover, BOD_5, COD_{Cr}, TS and SS exceed YCDC standard value.

Table 3.17 Water Quality of Industrial Wastewater

Parameter	F1	F2	F3	F4	F5	F6	F7	F8	F12	F13	F14	F15	F16	Average
pH	5.00	5.60	4.99	4.92	5.12	5.00	5.35	9.11	5.35	3.90	3.97	4.26	3.98	5.12
BOD	1,484	648	2,089	3,711	684	396	2,490	140	1,593	1,593	2,393	6,493	2,393	2,008
COD	2,053	2,023	2,023	2,490	2,156	562	1,225	468	200	7,200	4,600	20,800	8,400	4,169
TS	6,505	2,181	2,181	2,980	2,983	2,095	7,750	5,710	5,980	6,780	5,940	27,070	7,025	6,552
SS	1,915	391	391	658	658	515	300	1,210	300	1,280	3,140	6,710	610	1,391

Source: Department of Pollution Control and Cleansing

At first, acidic wastewater corrodes sewer. In addition, rapid change in organic pollutant load or inflow of harmful matter (e.g. heavy metal) damages wastewater treatment capability of WWTP.
Therefore, when sewerage accepts industrial wastewater, water quality standard for receiving industrial wastewater should be established to protect and maintain sewer and wastewater treatment function of WWTP.

In addition, establishment of monitoring and management scheme for industrial wastewater discharge is necessary to establish the standards for wastewater discharge effectively. For example, implementation scheme of industrial wastewater monitoring and administrative guidance, e.g. installation of on-site wastewater treatment facility should be considered.

3.5.2 Water Quality Investigation in This Study

Analytical items in this investigation and implementation body (including private company) are listed below;

Table 3.18 Analytical Item and Implementation Body

Analytical item	Implementation body
T-N, K-N, T-P	Water TEST (Private company, Thailand)
MLSS, Total coliforms, Fecal coliforms	MSTRD (Myanmar Scientific and Technological Research Department)
SS, COD, BOD, NH_4-N	ISO Tech (Private company, Myanmar)

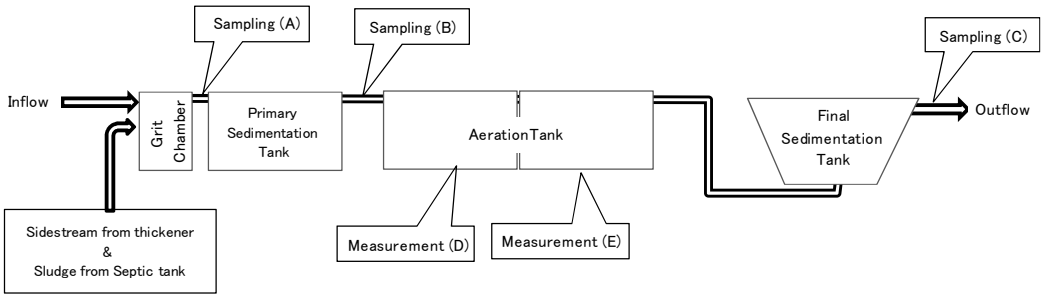
Source: JICA Study Team

(1) WWTP

WWTP of Yangon city is located at the south end of urban area, and stands on the bank of Yangon River. Treatment method is activated sludge method using surface aeration.

WWTP receives withdrawn sludge of septic tank, and this sludge is treated with wastewater influent.

In this investigation (rainy season), sampling points were inflow pit, effluent of primary sedimentation tank, aeration tank and effluent of final settling tank. Sampling was done 3 times i.e. morning, noon and afternoon. (Therefore, 4 × 3 = 12 samples were collected)



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Sampling (A) :	Sampling point of "Inflow"
Sampling (B) :	Sampling point of "Outflow of the Primary Sedimentation Tank"
Sampling (C) :	Sampling point of "Treated water"
Measurement (D) :	Measurement point of MLDO (A)
Measurement (E) :	Measurement point of MLDO (B) and Sampling point of "MLSS" and "SV"

Source: JICA Study Team

Figure 3.9 Sampling Point of WWTP

Summary of WWTP wastewater analysis is as follows;

Rainy season

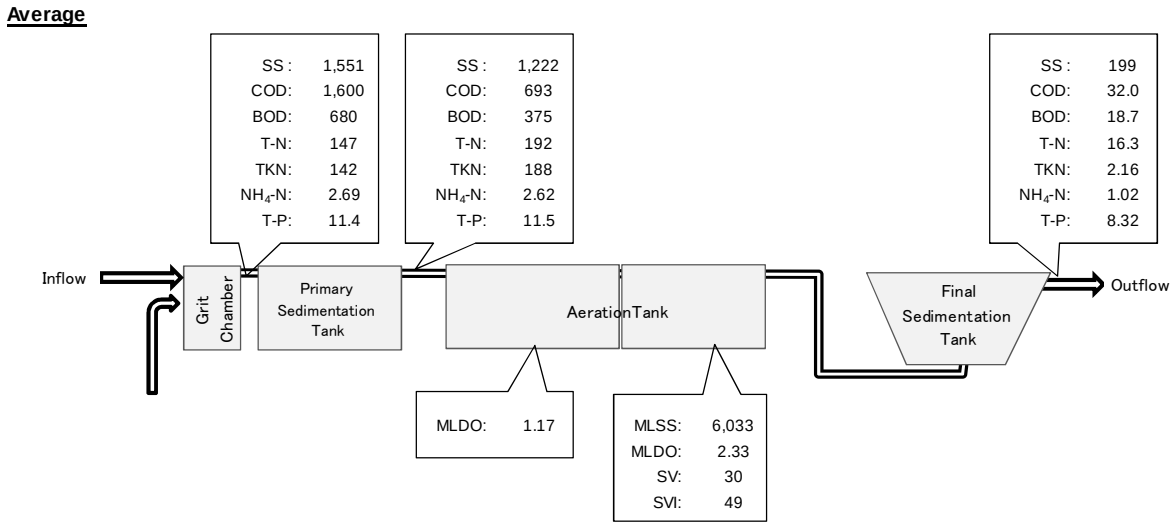
- Color of inflow wastewater is black. Average concentrations are: SS 1,551 mg/L, COD_{Cr} 1,600 mg/L, BOD_5 680 mg/L, T-N 147 mg/L and T-P 11.4 mg/L. Inflow wastewater contains withdrawn sludge of septic tank and side streams from sludge treatment facility.
- Mixed liquor dissolved oxygen (MLDO) is 1.2 mg/L (inflow side, average) and 2.3mg/L (outflow side, average). This is adequate MLDO value.
- Mixed liquor suspended solid (MLSS): 6,033 mg/L (average), settled sludge volume (SV30): 29.8 % and sludge volume index (SVI): 49.3.
- Effluent concentrations (average) are SS: 199 mg/L, CODCr: 32 mg/L, BOD5 19 mg/L, T-N: 16.3 mg/L, T-P: 8.32 mg/L. Average removal efficiencies are SS: 87%, CODCr: 98 %, BOD_5: 97%, T-N: 89 % and T-P: 27 %.

Dry season

- Similar to rainy season, color of inflow wastewater is black. Average concentrations are: SS 942 mg/L, COD_{Cr} 176 mg/L, BOD_5 79 mg/L, T-N 221 mg/L and T-P 7.97 mg/L. Inflow wastewater contains withdrawn sludge of septic tank and side streams from sludge treatment facility.

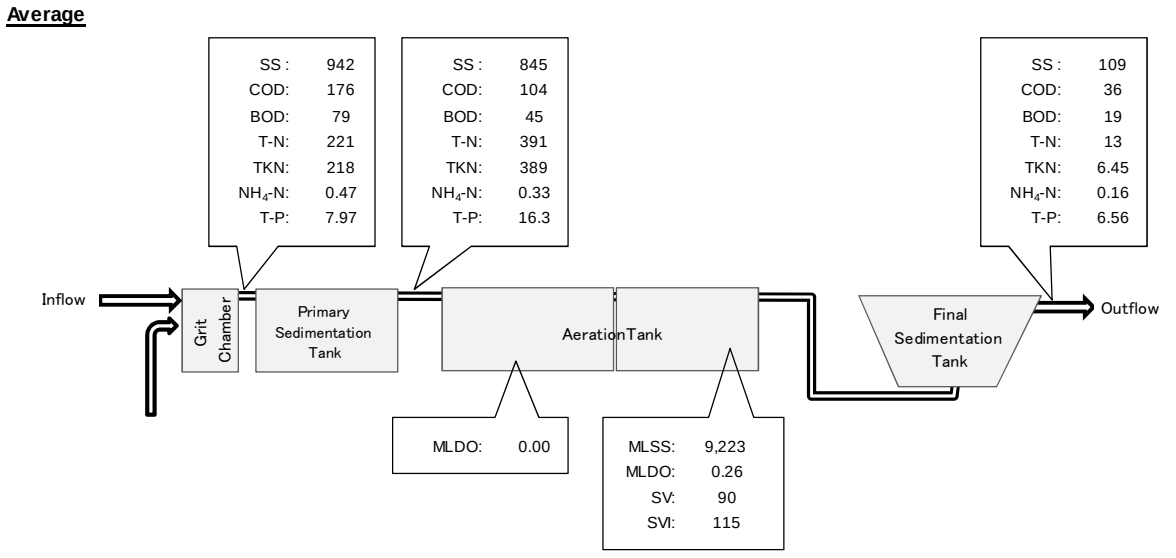
- Mixed liquor dissolved oxygen (MLDO) is 0.0 mg/L (inflow side, average) and 0.26 mg/L (outflow side, average). Therefore, aeration tank was in anoxic condition.
- Mixed liquor suspended solid (MLSS): 9,223 mg/L (average), settled sludge volume (SV30): 90 % and sludge volume index (SVI): 115.
- Effluent concentrations (average) are SS: 109 mg/L, CODCr: 36 mg/L, BOD5 19 mg/L, T-N: 13.4 mg/L, T-P: 6.56 mg/L. Average removal efficiencies are SS: 88%, COD_{Cr}: 80 %, BOD_5: 76%, T-N: 94 % and T-P: 18 %.

Considering water quality survey data of WWTP, removal efficiency is good, however, management of activated sludge condition have a serious problem.



Source: JICA Study Team

Figure 3.10 Wastewater Characteristics in WWTP (Average data, Rainy season)



Source: JICA Study Team

Figure 3.11 Wastewater Characteristics in WWTP (Average data, Dry season)

(2) Industrial wastewater and hospital wastewater

Industrial wastewater

Sampling was carried out at the following 3 factories.

Wastewater of Factory-A (Beverage) is discharged to the drain without treatment.

Factory-B (Pharmaceutical) has a wastewater treatment facility, and treated water is utilized for irrigation of green belt in the factory. Therefore, Factory-B doesn't discharge treated water to outside water body.

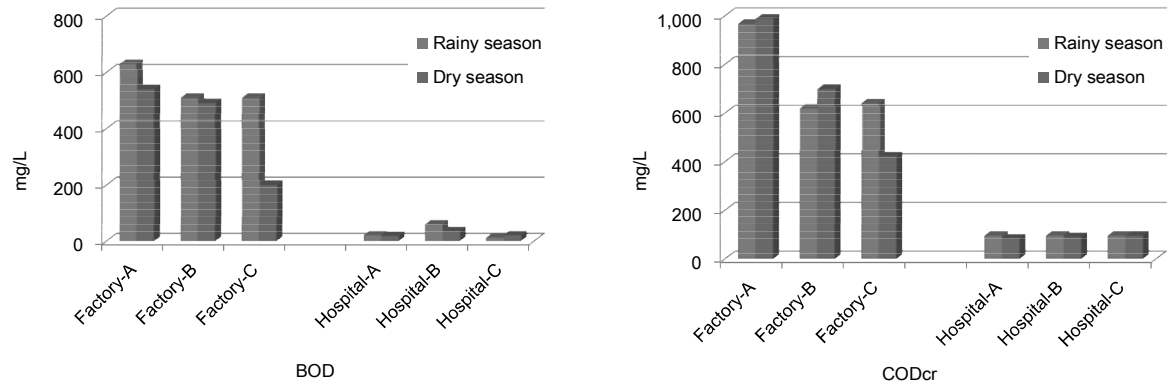
Factory-C (Bread making) didn't permit an access into site. Water sampling was done at the drainage near factory site. Wastewater from Factory-C is discharged to Hlaing River through drain.

Hospital wastewater

Sampling was done at the dominant hospital in Yangon city. Wastewater of 2 hospitals (Yangon General Hospital, Department of oral surgery, and Yangon General Hospital) is domestic wastewater of in-patients ward. Therefore, inclusion of medical wastewater is small.

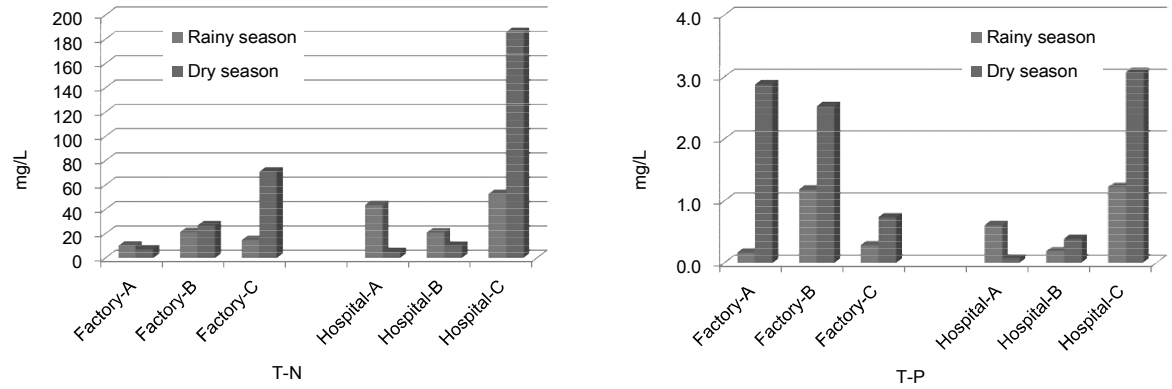
The other hospital (Yangon New General Hospital) is called as "Japan hospital". This hospital was constructed by Japanese aid, and on-site wastewater treatment facility was installed. However, this wastewater treatment facility is resting because of the obsolescence of treatment facility.

Characteristics of industrial and hospital wastewater are shown below.



Source: JICA Study Team

Figure 3.12 Characteristics of Industrial and Hospital Wastewater (BOD, COD)



Source: JICA Study Team

Figure 3.13 Characteristics of Industrial and Hospital Wastewater (T-N, T-P)

(3) Summary of industrial and hospital wastewater quality

- Average concentrations of industrial wastewater from 3 factories in Rainy season are: COD_{Cr}: 743 mg/L, BOD_5: 550 mg/L, T-N: 15.6 mg/L and T-P: 0.55 mg/L, In Dry season: COD_{Cr}: 704 mg/L, BOD_5: 411 mg/L, T-N: 35.2 mg/L and T-P: 2.05 mg/L.
- Average concentrations of wastewater of 3 hospitals in Rainy season are: COD_{Cr}: 96 mg/L, BOD_5: 31 mg/L, T-N: 39.2 mg/L and T-P: 0.68 mg/L, In Dry season: COD_{Cr}: 90 mg/L, BOD_5: 25 mg/L, T-N: 67.0 mg/L and T-P: 1.18 mg/L.
- Industrial wastewater has a higher organic pollution than hospital wastewater. BOD and COD concentration of industrial wastewater exceed permissible limit of the Department of Pollution Control and Cleansing.

3.5.3 Summary of Water Quality Investigation

(1) Condition of existing WWTP

Average removal efficiencies in rainy season are SS: 87%, COD_{Cr}: 98 %, BOD_5: 97%, T-N: 89 % and T-P: 27 %, and SS: 88%, and removal efficiencies in dry season are COD_{Cr}: 80 %, BOD_5: 76%, T-N: 94 % and T-P: 18 %.

However, MLDO in dry season was 0.0mg/L, i.e. anoxic condition, and settling property of activated sludge was not good. Therefore, WWTP has a serious problem about their operation.

(2) Industrial wastewater and hospital wastewater

Industrial wastewater has a higher organic pollution than hospital wastewater. BOD and COD concentration of industrial wastewater exceed permissible limit of the Department of Pollution Control and Cleansing.

On the other hand, hospital wastewater has similar property of domestic wastewater. However, when dialysis treatment and other high quality specialized medical treatment become popular in future,

attention should be paid to characteristics of hospital wastewater.

3.6 Water Quality of Public Water Body

3.6.1 Water Quality of Public Water Body

(1) Outline of this investigation

This investigation consists of 2 part of water quality investigation. This investigation is done 2 times, i.e. 1 time in rainy season and 1 time in dry season.

- Water quality of YCDC managed water body
  Investigate drains and major rivers that are affected by domestic wastewater discharge.
- Water quality of Kandawgyi Lake and its pollution source
  Investigate water quality of Kandawgyi Lake and its pollution source (restaurants and drains).

(2) Result of water quality investigation

Drains and Rivers

- Major drains in urban area are polluted by discharge of domestic wastewater. Moreover, drains are polluted by solid waste because the collection of solid waste is insufficient. From the view point of the improvement of living environment, water quality improvement of drains is necessary (See Photo 3.7 and Photo 3.8).
- River water in rainy season (Hlaing River, Yangon River and Bago River) is more polluted than drains. Especially, high concentration of BOD and COD was observed in rainy season.
- Water quality data is shown in the following Table. Both river and drain is highly polluted by organic pollutants.

Table 3.19 Water Quality of River and Drain in Rainy Season (CODCr and BOD5)

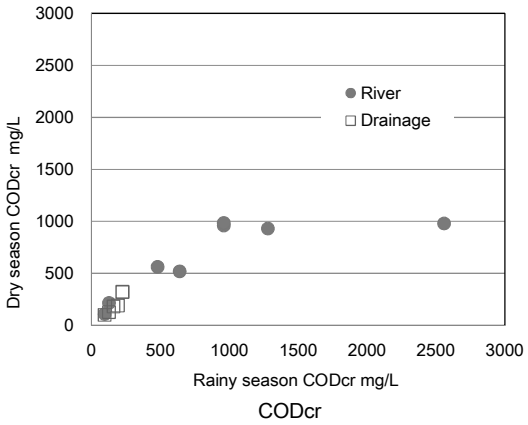
Sample	CODCr (mg/L)		BOD5 (mg/L)	
	Range	Average	Range	Average
River	96 - 2560	888	27 - 900	405
Drain	96 - 224	171	6 - 62	36

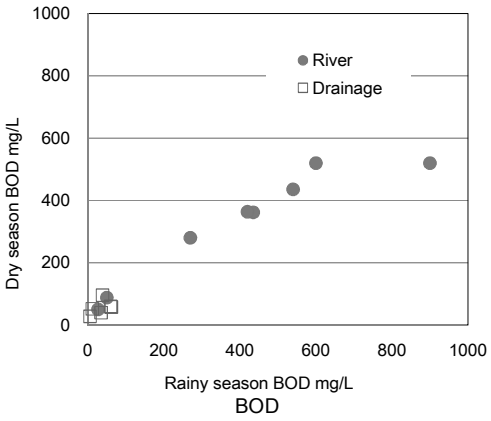
Source: JICA Study Team

Table 3.20 Water Quality of River and Drain in Dry Season (CODCr and BOD5)

Sample	CODCr (mg/L)		BOD5 (mg/L)	
	Range	Average	Range	Average
River	110 - 985	658	50 - 520	328
Drain	100 - 322	207	28 - 96	56

Source: JICA Study Team





Source: JICA Study Team

Figure 3.14 Water Quality of River and Drain (COD_{Cr} and BOD_5)

- Water quality data of T-N and T-P are shown in following Table and Figure. When the water quality of drainage channels and river are compared, the contamination of nitrogen and phosphorus in drainage channels are higher than that in river.
- This tendency is different from that of BOD and COD. The reason for this difference is probably due to the difference of degradation characteristic in water body.

Table 3.21 Water Quality of River and Drain in Rainy Season (T-N and T-P)

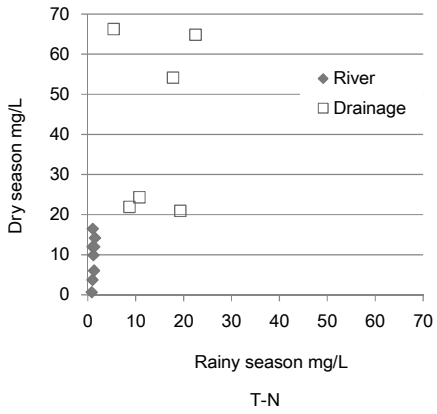
Sample	T-N (mg/L)		T-P (mg/L)	
	Range	Average	Range	Average
River	0.84 - 1.49	1.15	0.05 - 0.59	0.24
Drainage	5.42 - 22.5	14.09	0.30 - 1.78	1.05

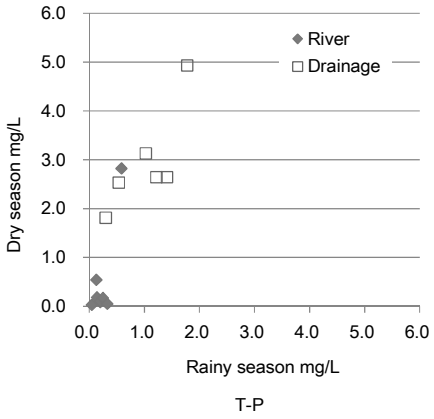
Source: JICA Study Team

Table 3.22 Water Quality of River and Drainage in Dry Season (T-N and T-P)

Sample	T-N (mg/L)		T-P (mg/L)	
	Range	Average	Range	Average
River	0.58 – 16.4	9.28	0.03 – 2.82	0.50
Drainage	20.9 – 66.2	42.03	1.81 – 4.93	2.95

Source: JICA Study Team





Source: JICA Study Team

Figure 3.15 Water Quality of River and Drain (T-N and T-P)

Photo 3.7 Condition of Drain (Nat Chaung)

Photo 3.8 Condition of Drain (Thamaing Chaung)

3.6.2 Water Quality of Kandawgyi Lake

(1) Outline of Kandawgyi Lake catchment area

Kandawgyi Lake is located in Bahan township in the south part of Yangon City. South bank of the lake is Mingalartaungnyunt township, east bank is Tamwe township. Surface area of the lake is 647,497 m^2, water depth is about 3 m (measurement date: Oct. 29, 2012, by JICA study team).

Kandawgyi Lake was developed as reservoir for Yangon city in 1879, and utilized as a drinking water source for 35,000 people. However, after Hlawga reservoir was developed (Phase 1: 1904, Phase 2: 1921 to 1924), the role of Kandawgyi reservoir was finished. At present, Kandawgyi Lake and surrounding area are developed as park.

Views of Kandawgyi Lake are shown in Photo 3.9 and 3.10. In the surrounding areas of Kandawgyi Lake, 12 restaurants (R1- R12) and one (1) hotel are carrying on business. All restaurants are located on the north bank of the lake. Photo 3.11 and 3.12 show the condition of water treatment facility of restaurants. All restaurants use simple treatment facility, e.g. grease trap and / or septic tank. Wastewaters from these facilities are discharged to Kandawgyi Lake.

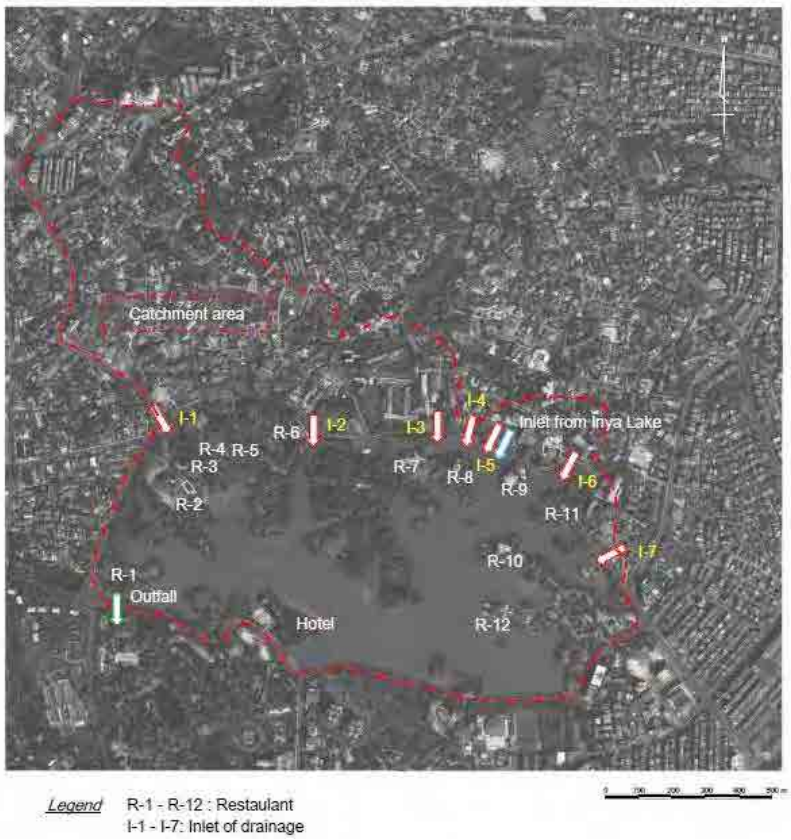
There are 7 drains on the north bank of Kandawgyi Lake. These drains collect domestic wastewater and storm water of Bo Cho (1) ward (Catchment area of Kandawgyi Lake, red dot-line in Figure 3.14). On the other hand, storm water drains and wastewater on the south bank area of Kandawgyi Lake are collected and discharged to Pazundaung creek.

Photo 3.13 and 3.14 show the outlet of drains. Many suspended matters (solid waste, oil, etc.,) are floating and accumulating around outlet. Moreover, inhabitation of Chironomid and gas babble are observed around drainage outlet. From these observations, it is considered that these drains are

polluted seriously by domestic wastewater, and this polluted discharging water affect the water quality of Kandawgyi Lake.

There is one (1) outfall on the south-west end of the lake, however, usually this gate is closed. Moreover, transmission pipeline from Inya Lake is not used usually (This transmission line is used only 15 days in a year during Thingyan).

Therefore, inflow to Kandawgyi Lake is wastewater and rainwater, and exchange of lake water doesn't occur. Therefore, it is said that pollutant is accumulated in this lake.



Source: JICA Study Team

Figure 3.16 Catchment Area of Kandawgyi Lake

Photo 3.9 Condition of Kandawgyi Lake (1)

Photo 3.10 Condition of Kandawgyi Lake (2)

Photo 3.11 Water Treatment Facility (grease trap) of Restaurant(R-6)

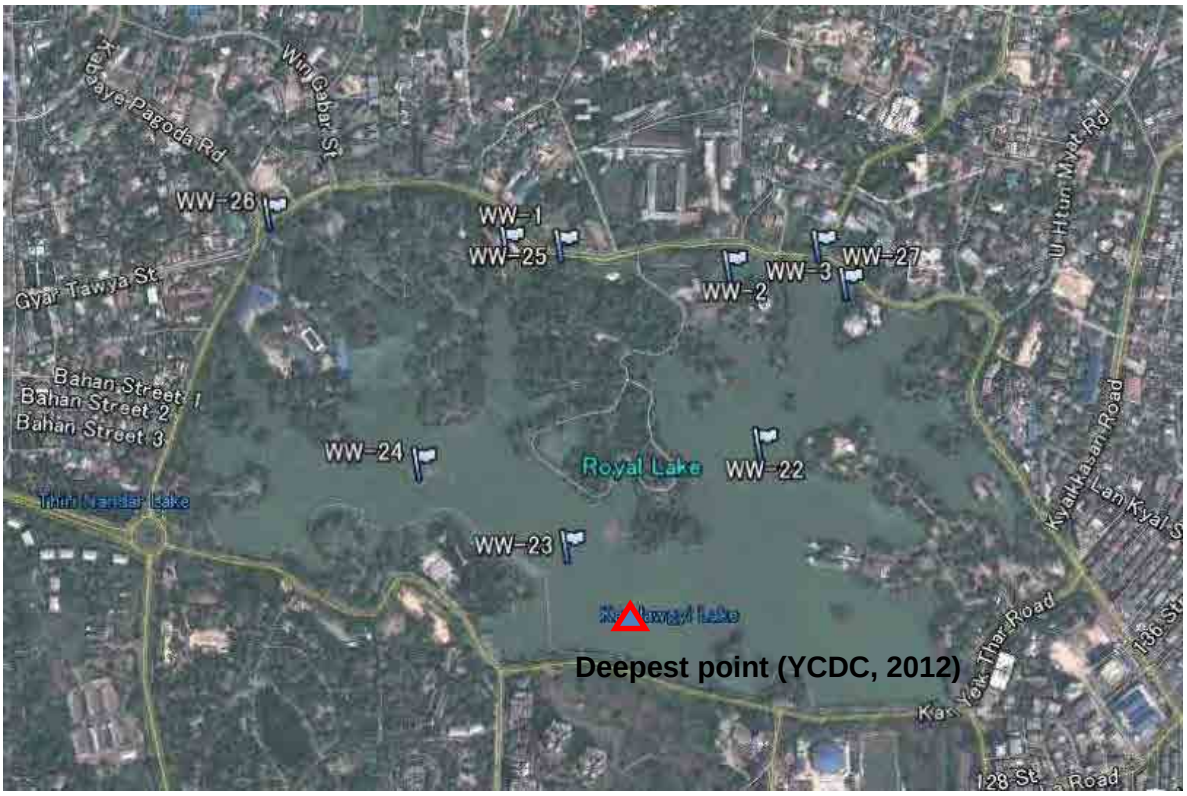
Photo 3.12 Effluent of Restaurant (R-6)

Photo 3.13 Outlet of Drain (I-2)

Photo 3.14 Outlet of Drain (I-5)

(2) Water quality of Kandawgyi Lake

Water quality investigation of Kandawgyi Lake was implemented in rainy season (September, 2012) and dry season (February, 2013). Sampling point is shown in Figure below.



Source: JICA Study Team

Figure 3.17 Sampling Point of Kandawgyi Lake

Water depth of Kandawgyi Lake was measured in parallel with water sampling. Measurement result is shown in Table below.

Table 3.23 Water Depth of Kandawgyi Lake

Point	Water Depth
WW-22	2.5m
WW-23	2.5m
WW-24	1.5m
Deepest point	3.0m

Source: JICA Study Team

Water quality in rainy season

Result of water quality survey in rainy season is shown in Table 3.24, and summarized as follows;

- Domestic wastewater of catchment area (Bo Cho (1) Ward) run into Kandawgyi Lake through drains.
- Restaurants around the lake discharge insufficiently treated wastewater (treated using grease trap or septic tank) into the lake.
- Outfall of Kandawgyi Lake is usually closed. Therefore, lake water is not exchanged.
- Water temperature exceeds 30ºC. This temperature condition accelerates the growth of blue-green algae.

- pH of lake water is 9.2 to 9.5. This high pH value is generated by the photosynthesis activity of algae.
- From the result of T-N and T-P analysis, Kandawgyi Lake is assessed to be eutrophied lake (considering OECD criteria, Kandawgyi Lake is classified as hypereutrophic).

Table 3.24 T-N and T-P of Kandawgyi Lake (Rainy season)

No.	Location	T-N (mg/L)	T-P (mg/L)
WW-22	Kandawgyi Lake-1 (East)	2.17	0.13
WW-23	Kandawgyi Lake-2 (Middle)	1.98	0.13
WW-24	Kandawgyi Lake-3 (West)	1.69	0.14

Source: JICA Study Team

Water quality in dry season

Result of water quality survey in dry season is shown in Table 3.25, and summarized as follows;

- pH of lake water is 10.9 to 11.1. Therefore, the photosynthesis activity of algae is more active than in rainy season.
- T-N and T-P in Kandawgyi Lake-1 (East) and Kandawgyi Lake-2 (Middle) are higher than those of rainy season. This result means the possibility of worsening of eutrophication.

Table 3.25 T-N and T-P of Kandawgyi Lake (Dry season)

No.	Location	T-N (mg/L)	T-P (mg/L)
WW-22	Kandawgyi Lake-1 (East)	19.9	0.19
WW-23	Kandawgyi Lake-2 (Middle)	11.3	0.17
WW-24	Kandawgyi Lake-3 (West)	7.74	0.03

Source: JICA Study Team

Assessment criteria of eutrophication

Japan (Ministry of the Environment) T-N: 0.5 – 1.3 mg/L, T-P: > 0.02mg/L

OECD （1982） T-P: 0.035 – 0.1mg/L Eutrophic,

> 0.1 mg/L Hypereutrophic

3.7 Current Conditions of Finance in Sewerage Service

YCDC manages both water supply and sewerage service within the same organizational unit and furthermore, there is no separate sewerage tariff. The sewerage service area is limited within CBD areas and the treatment volume is limited to 500,000 gallon a day (2,300 m^3/day). Therefore, there is

no significant financial implication from the current sewerage operations. The sections related to sewerage service have a total of 139 staff members, which are comprised of 30 employees in the compressor section, 41 in the sewerage maintenance-west, 39 in the sewerage maintenance-east, and 29 in the wastewater treatment plant. The workforce involved in sewerage work constitutes 6% of the total workforce engaged in water supply and sewerage within YCDC.

Due to lack of accounting separation between water supply and sewerage, an estimated expenditure for sewerage operations is shown in Table 3.26 as below. The largest part of the budget is used for maintenance of sewers and treatment plant. The overall budget is estimated as 300 million Kyat, comprising 7% of the total budget for water and sewerage division. The relative share in the budget is still small. However, compared with the coverage of 5.8%, the burden of the cost is relatively large.

Table 3.26 Estimated Expenditure of Sewerage Operation

		Quantity	Unit	Cost (million Kyat)
Direct Cost				
	Manpower			
	Regular Staff	42	Persons	35
	Labor	97	Persons	58
	Power	511	MWh	18
	Maintenance		per year	192
	Others		-	11
Total Estimated Sum				314

Source: JICA Study Team

At present there is no sewerage charge levied directly to the consumer. Therefore, the only revenue source for YCDC is water related fee collection. The water tariff itself is set at one of the lowest levels in international standards. There are several reasons that make the prevailing low tariff possible. The current raw water source from an irrigation channel has low turbidities rendering low treatment costs. The intake is gravity-based requiring no electricity. Above all, the majority of operators are not official employees of YCDC but rather daily wage contract labors. A rule of thumb in measuring the labor productivity in water supply business is the ratio of workers to the number of service connections expressed as the number of workers to one thousand service connections. The ratio for YCDC is approximately 8 on this measure. In developed countries, the general target for this indicator is one to two. Thus the ratio is too large in the international standards. However, the proportion of labor cost comprises only 25% of the total cost. The largest cost item is electricity which comprises 40% of the total cost. YCDC follows a traditional government accounting. Therefore the depreciation cost is not included. Given the depreciation costs, the share of manpower cost should further decline. In this sense the priority target for cost rationalization is not the labor force itself.

Table 3.27 below shows the summary of the revenue and expenditures of the water supply and

sewerage section of the YCDC for the last five years. The operating surplus i.e., the balance of revenue after subtracting all the expenses for operation was 36% in 2007 but declined to 5% in 2011. This is due to the fact that the revenue increased marginally but the operating cost increased by 60% during same period. The main reason for the cost escalation is inflation. The inflation during the same period was 50%. Among the cost items, daily worker wages and maintenance cost rose the most rapidly. On the other hand the tariff for households remained at 13.2 Kyat/m^3 till 2011. The tariff was raised to 88 Kyat/m^3 and that for commercial customers was raised from 77 Kyat/m^3 in 2006 to 110 Kyat/m^3 in 2012. In simple tabulation, the revenue would more than double and the financial situation should improve to a large extent. Vigorous investment activities are reflected in finance. The investment amount more than doubled in 2011 compared to that in 2007.

Sewerage service is in general more costly in operation and maintenance for unit disposal and treatment. It would not be possible to cover the costs with the revenue from water alone. The tariff for sewerage will be required but the appropriate tariff will depend on the policy that defines the extent of the recovery of the capital cost by the tariff. The detailed analyses will be carried out in the financial analyses in Chapter 11 of Sewerage Plan.

Table 3.27 Water and Sewerage Budgets of YCDC 2007-2011

(Unit: million Kyat)

	2007	2008	2009	2010	2011
Revenue (A)	4,308	4,320	4,433	4,571	4,709
Recurrent Expenditure (B)	2,745	3,511	3,366	3,682	4,496
Capital Expenditure (C)	2,009	2,064	2,276	4,157	4,731
Operating Surplus (A)-(B)	1,563	809	1,067	889	213
Operating Surplus Ratio ((A)-(B))/(A)	36%	19%	24%	19%	5%
Investment Ratio (C)/(A)	47%	48%	51%	91%	100%

Source: JICA Study Team

3.8 Relevant Sewerage Development Plan

For Yangon City, the following four (4) Sewerage development plans have been carried out.

1) J.D & D.M Watson Report, July 1953
2) "Master Sewerage Plan for Rangoon", Metcalf and Eddy, April 1965, funded by USAID
3) "Yangon Infrastructure and Environmental Services", August 1993, UNCHS/UNDP
4) "Yangon Strategic Development Plan", Dec. 2006, YCDC and Economic Planning Unit, Prime Minister's Department, Malaysia

Among these plans, 3) "Yangon Infrastructure and Environmental Services' and 4) "Yangon Strategic Development Plan" are available, but 1) and 2) reports are not available. Proposals made under these two studies have not been realized mainly because of shortage of fund. However, conversion of steam engines to electric motors in the compressor station was done in 1962/64 with government fund. An ejector station was constructed in western part in 1964/67 to expand the service area. The existing wastewater treatment plant was constructed in 2003/05 as mentioned previously.

"Yangon Infrastructure and Environmental Services" is a report prepared based on the investigation on status of wastewater treatment and storm water runoff and other services at that time. No concrete sewerage development plan was presented in the report. Study area for "Yangon Strategic Development Plan" is YCDC consisting of 33 townships and target year is 2020. Based on the socio-economic analysis, productive sector studies and support infrastructure studies, policies and strategies were formulated and presented. Regarding sewerage system, development plan for 12 townships was proposed classifying 12 townships into three priority categories, short term (2005 to 2010), medium term (2010 to 2015) and long term (2015 to 2020). Capacity of WWTP is 300,000 population equivalent (P.E.) for each township and required site area for WWTP is 10 acres (4.05 ha). Therefore, it should be said that this plan is still at conceptual stage, rather than sewerage facility plan. Sewerage facility plan based on the plan has not been prepared yet.

Table 3.28 Sewerage Development Plan by Yangon Strategic Development Plan

Implementation Period	Township	Population Equivalent	Area for WWTP (acre)
Short Term (2005 - 2010)	Insein	300,000	10
	Thingangyun	300,000	10
	Hlaing Tharyar	300,000	10
	Shwe Pyi Thar	300,000	10
	South Okkalapa	300,000	10
	North Okkalapa	300,000	10
	Thaketa, No.1	300,000	10
Medium Tram (2010 - 2015)	South Dagon	300,000	10
	Mayangone	300,000	10
Long Term (2015 - 2020)	Mingalardon	300,000	10
	North Okkalapa	300,000	10
	Shwe Pyi Thar	300,000	10
	Thaketa, No.2	300,000	10
Total		3,900,000	130

Source : Yangon Strategic Development Plan

3.9 Issues Related to Wastewater Treatment and Disposal

3.9.1 Technical Aspects

Issues related to wastewater treatment and disposal from technical view point are summarized below.

(1) Wastewater treatment in general

① Sewerage coverage ratio in YCDC is as low as approximately 5 %.

② Water supply system coverage ratio is also low, i.e. 38 %. This is the reason for low demand and low coverage ratio of sewerage system.

③ Under the circumstances mentioned above, wastewater treatment should rely on on-site systems. Currently served population by septic tank which is the only applicable on-site treatment system is estimated to be 43% of the total population.

④ Septic tank can only treat black water and gray water is discharged to storm water drains without treatment. Treatment efficiency of septic tank is considered to be 50 % at the utmost, probably less than that if retention time in septic tank is low in case of flush toilet. Improvement of the existing septic tanks to receive gray water is very difficult because of their structures and locations.

⑤ Non-treatment population other than sewerage system and septic tanks is estimated to account for 52 % of the total population. Gray water together with black water from these households is discharged to the environment without treatment. As a result, storm water drains become actual open sewers, for which most of residents do not care. HIS conducted in 2012 reveals that very good, good and fair answers account for 67 % of the total, and bad and very bad answers account for 29 % about the condition of the storm water drain. Regarding odor problem very good, good and fair answers account for 74 % of the total compared to 26 % for bad and vary bad.

⑥ Currently residents' awareness is low, but concerns for odor and aesthetic matters will grow as peoples' living standards become high, and complaints from residents might increase.

⑦ Therefore, it is necessary to treat black water and gray water. The development of sewerage system takes longer time, and tentative measures need to be considered.

(2) Sewerage system

⑧ Discharging standards for effluent are not established.

⑨ Monitoring of flow and wastewater characteristics at WWTP is not carried out. Monitoring of these items is necessary for proper operation of the plant since these items fluctuate. This together with the following reasons results in improper operation of WWTP.

⑩ Current flow to the WWTP is estimated to be approximately 2,300 m^3/day compared to the design capacity of 14,775 m^3/day. This low flow may be caused by defects of ejector system.

However, true reason is not detected.

⑪ Sludge from septic tanks is dumped into the WWTP resulting in high concentrations.

⑫ It became difficult to obtain spare parts for ejector system which was introduced 120 years ago.

3.9.2 Organizational and Institutional Aspects

(1) Organizational aspect

Main duty of the sewerage section is O&M of existing small-scale sewerage facilities, thus their experiences on planning and design is limited. To accelerate sewerage development, the personnel responsible for the above mentioned tasks is not sufficient.
Similar to the case of water supply, there is no laboratory for quality tests, and water quality monitoring system is very weak.

(2) Institutional aspect

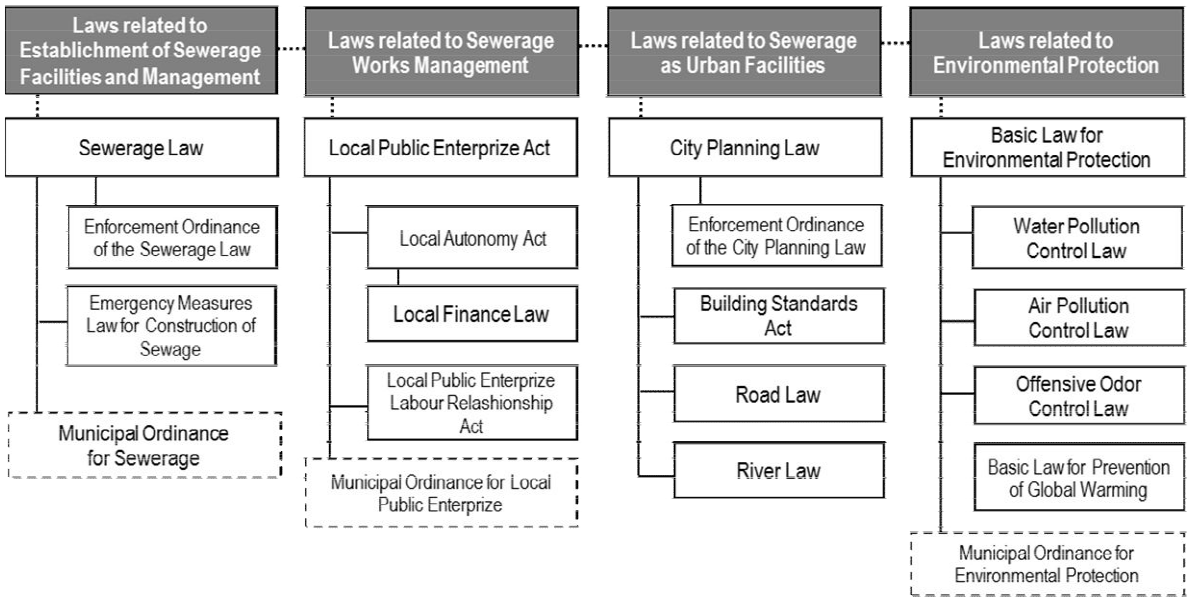
This section introduces the outline of legal framework on sewerage and drainage in Japan, and then indicates main institutional challenges of sewerage and drainage in Myanmar.

1) Legal framework on sewerage and drainage in Japan

The role of sewerage in Japan has been changing according to needs of time and age, and it may be summarized into the following three points: (1) mitigation of inundation damage by rain water, (2) improvement of living environment with the viewpoint of public sanitation, (3) Improvement of water quality of public water bodies. At the beginning of the sewerage history, the priority of sewerage was given to mitigation of inundation damage from rain water, while the importance of public sanitation and improvement of living environment have been acknowledged after outbreak of cholera since the end of nineteenth century. Afterwards the Sewerage Law was amended and the issue of water quality control of public water bodies was added among the role of sewerage responding to deterioration of water quality in rivers by rapid economic growth and concentration of urban population.

In order to enhance ensuring these roles of sewerage, laws and regulations such as “Sewerage Law” have a vital role from the aspects of regulatory system. It could be said that these laws and regulations are the basic framework to translate policies into practice. To develop the regulatory system is crucial to effectively enhance policies that enable to realize the mission of sewerage.

A regulatory framework of main laws and regulations related to sewerage and drainage are illustrated as follows.



"Sewerage Law" is a basic law as a fundamental platform to define construction and reconstruction, usage, and O&M of public sewerage system. The Sewerage Law indicates technical standards such as structure of public sewerage system, effluent water quality, O&M of terminal sewage treatment plant. Furthermore, it also classifies sewerage work as a service to be administered by local municipalities (i.e. city, town and village), and defines duty of establishment of drainage facilities in the drainage area where sewerage service have been started, an order for land owners who discharges severely deteriorated wastewater to construct pretreatment facilities, and the management system for public sewerage system. "Water Pollution Control Law" was legislated to set the effluent standards for wastewater and to define factories and plants as "specified facilities". After the enforcement of this law, the role of sewerage contributing to water quality control and the responsibility has been expanded.

Meanwhile, since sewerage facilities are recognized as necessary facilities for urban planning and for environmental protection, sewerage and drainage have become deeply interrelated to the laws and regulations relevant to urban planning and environmental protection. In case of Japan, the roles and responsibilities of sewerage has been expanding, which increases the importance of laws and regulations both on the "City Planning Law" which defines crucial urban facilities and the "basic law for environmental protection" as a fundamental law.

From the urban planning aspect, sewerage is defined as urban facilities in the framework of city planning law, and sewerage facilities in the city planning area is determined based on "City Planning Law". Also "Road Law" and "River Law" become associated to sewerage in the matter of occupancy required for the installation of sewers.

From the environmental protection aspect, sewerage issues are associated to the "Basic Law for

Environmental Protection" which defines environmental quality standards and environmental pollution control program, and "Water Pollution Control Law" which defines effluent control and total water pollutant emission regulation system. Some municipal governments impose more stringent prefectural standards by the municipal ordinance.

From the management and finance aspect, sewerage issues are related to "Local Public Enterprise Law", "Local Autonomy Act", and "Local Finance Law", because public sewerage works are operated by establishing their respective special account and by establishing local finance with local autonomy.

Outline of the sewerage law and other relevant laws and regulations are summarized in the following Table.

Category	Regulatory Name	Outline
Basic Law	Sewerage Law	• Main purposes is to contribute to sound urban development, enhancement of public sanitation and water quality protection of public water bodies • To define management of public sewerage system, river-basin sewerage system and urban drainage system (city, town, and village are responsible in principle) • To define the duty to establish discharge facilities • To define effluent water quality standards • To define the regulations against aggravated wastewater generators • To define burden of expense for sewerage service based on a beneficiaries-pay principle
City Development	City Planning Law	• To define sewerage as necessary facilities in urban planning and procedure for determination of urban planning and the project, construction, and design change.
	Emergency Measures Law for Construction of Sewerage	• A rationale law to define 7 years program for development of sewerage system
	River Law	• To define permission for occupancy of river, new construction facilities, etc., related to sewerage construction works
	Road Law	• To define permission for occupancy of road in case of installation of sewers related to sewerage construction works
	Road Traffic Act	• To define permission for road use in the construction works of sewerage facilities (Article 77)
Environmental Preservation	Basic Law for Environmental Protection	• To define basic concept of environmental preservation and the policies • To define environmental standards on air pollution, water pollution, soil pollution and noise
	Water Pollution Control Law	• To define the water quality of industrial effluents from factories and business facilities • To regulate effluent from treatment plants • To define liability for compensation of damage by wastewater and liquid waste from factories and business facilities if they are harmful to human health
	Air Pollution Control Law	• To define the regulation of emission of smoke and soot from boiler, drying furnaces and incinerator in wastewater treatment plant of a certain size or more

Category	Regulatory Name	Outline
	Offensive Odor Control Law	• To define the responsibility of manager to prevent offensive odor from facilities which receive wastewater
	Waste Management and Public Cleansing Law	• To define the regulation of collection, transportation and treatment of solid waste • As concerned with sewerage, to define the standard for transportation and treatment of sewerage sludge by the person who is not manager of sewage treatment facilities
Management and Finance	Local Public Enterprise Act	• To define basics of local public enterprise, management organization, finance and employee's working condition and treatment • All provisions or a part of that are applied for public sewerage projects
	Local Autonomy Act	• To define the collection of sewerage tariff concerning establishment, management, and usage of sewerage facilities as public facilities
	Local Finance Law	• To define development of local autonomy by establishing fundamental principles (financial autonomy, application of special account), local municipal bond
Others	Municipal Ordinance on Sewerage	• To define the necessary items for development of public sewerage and other management by local municipalities according to the Sewerage Law • Each municipal government defines the drainage facilities, connection methods, designation of construction companies for establishment of drainage facilities, and determination of engineers, selection of water quality manager, tariff rates of sewerage service and collection method, reduction etc.
	Johkaso Law (Private sewerage treatment tank)	• Main purposes are to promote appropriate treatment of domestic wastewater, to maintain good water quality in public water bodies and healthy living environment, and to improve public sanitation • To define establishment of Johkaso, maintenance and repair, cleaning and manufacturing • To develop qualification and registration systems, and a license system of Johkaso cleaning works

Source：MLIT homepage（http://www.mlit.go.jp/mizukokudo/sewerage/index.html）, Tokyo metropolitan government, Bureau of Sewerage http://www.gesui.metro.tokyo.jp/

2) Main challenges concerning legal framework on sewerage and drainage in Myanmar

The sewerage law and other relevant laws are not sufficiently developed in overall in Myanmar, and it is considered that the development is necessary. It could be crucial to develop laws and regulations on individual treatment system and monitor the progress of relevant development.

Main challenges of regulatory system are listed below:

① Lack of definition of basic concept on sewerage

There is no definition of sewerage service and sewerage operating utilities, no basic concepts of sewerage, no authorization system of project plan. In Yangon city, implementation of sewerage development plan is an urgent challenge, therefore development of the basic law and regulation as a fundamental framework which enable to clear the position of sewerage is

essential.

② Lack of rules for O&M of public sewerage system

There are no definition on management entity of O&M of sewerage facilities (sewer networks, treatment plant and pumping station), sewerage sludge treatment, and on engineers responsible for O&M works. To secure an appropriate O&M level and make these facilities sustainable, development of clear definition is desirable.

③ Necessity of establishment of quality standards of influent and effluent water

Regulatory framework on establishment of pretreatment facilities and quality of influent and effluent water is not developed. The awareness on that is also not well cultivated. Severely aggravate wastewater causes deterioration of sewer line and functional decline of final wastewater treatment plant, thus regulations are necessary to secure the wastewater characteristics processable. In addition, this regulatory framework will necessarily contribute to secure environmental preservation and public sanitation environment for citizens which tend to be left behind, in accordance with intensifying firm's economic activities.

④ Necessity of indicative laws and regulations on drainage facilities and the installation works, and beneficiaries-pay principle

A substantial legal framework is not developed concerning installation and connection methods of drainage facilities established by users, procedure of installation works of drainage facilities and registration of construction companies, definition of necessary technicians for the installation. In addition, sewerage tariff is currently not collected, so that it could be necessary to define tariff collection for sewerage based on the beneficiaries-pay principle from the viewpoint of sustainability.

⑤ Necessity of development of laws and regulations on individual treatment system (septic tank, private sewage treatment tank (Johkaso), etc.)

In the general residential area where public sewerage treatment system is not developed, human waste is treated by septic tanks. It may be necessary to develop laws and regulations on dissemination and enhancement of private sewage treatment tank for individual houses if the Johkaso is considered to be effective. Furthermore, it will take time to develop and expand sewerage system, thus it is likely thought that laws and regulations on sludge treatment and disposal, etc., needs to be developed.

3.9.3 Financial Aspect, Possibility of Application of PPP

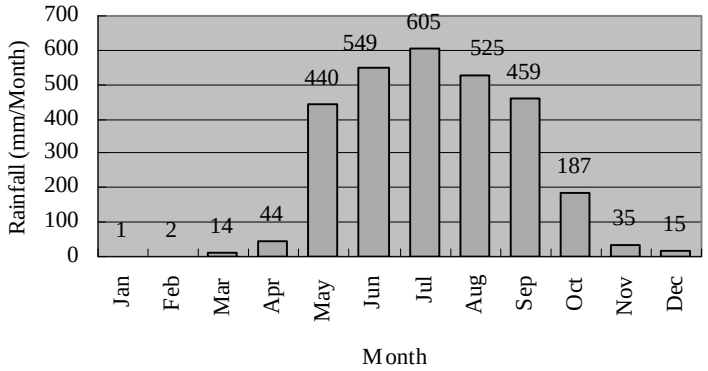
The above review of finance in water and sewerage sector in YCDC reveals that much of current tools in cost rationalization, i.e., de-regulating labor market, and use of outsourcing are already adopted in YCDC. The majority of labor force in YCDC water and sewerage sector is daily wage worker with a daily wage of 2,000 to 2,500 Kyat, less than three dollars a day. The implication of this outsourcing is significant in evaluating the possibility of PPP or BOT. One of the largest motives for adopting of PPP is to gain flexibility in employment practices and to reduce the labor costs by transferring operations to private entities. YCDC has achieved much of such possibilities already leaving less room for rationalization. However, the merit of PPP still exists in the cases of 1) BOT where a private sector would finance the investment upfront and provide operation for defined benefits; and 2) a service contract by a contractor with certain management skills and technologies that are capable of achieving higher productivities. A simple case of service contract offers only a limited prospect.

CHAPTER 4. CURRENT STATUS OF DRAINAGE

4.1 Natural Environment Related to Drainage

4.1.1 Rainfall

Figure 4.1 shows the monthly precipitation record in Yangon city. It exceeds 600 mm/month in July, at peak of the rainy season, and annual precipitation reaches about 3,000 mm, which is equivalent to 2 times the precipitation in Tokyo. The rainfall in Yangon is characterized by high intensity during short period.



Source: Kaba-aye Station (2001-2010), DMH

Figure 4.1 Monthly Precipitation in Yangon City

4.1.2 Tidal Level

Existing major drainages in Yangon city flow into the Yangon river, Hlaing river and Pazundaung creek. These rivers/creeks are also influenced by occurrence of tide. Table 4.1 shows tidal levels at Yangon port. Highest High Water Level (HHWL) indicates +3.619m (+6.74-3.121=3.619m) above mean sea level. In some parts of low land along the rivers, ground level is below HHWL.

Table 4.1 Tidal Levels at Yangon Port (Sule Pagoda Wharf)

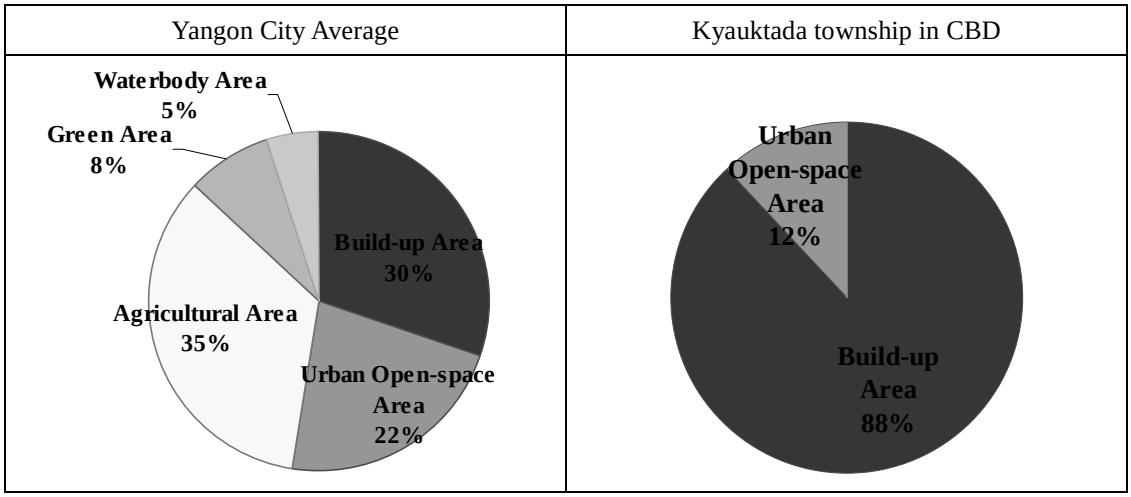
Items	Tide Level (m)	Remarks
Highest High Water Level (HHWL)	+6.74	Observed date: Sep. 1899
Mean Water Level (MWL)	+3.121	Observed date: Up to 1936
Lowest Low Water Level (LLWL)	-0.24	Observed date: Dec. 1902

Source: Record at Yangon Port (Sule Pagoda Wharf), MPA

4.1.3 Urbanization

Figure 4.2 shows the current condition of land use in Yangon city. Average ratio of urbanized area in whole Yangon city, which consists of build-up and urban open-space areas, is 52%. Meanwhile, Kyauktada township, which is a typical area in Central Business District (CBD), shows the

urbanization ratio at 100%. Though the amount of storm water runoff depends on the characteristic of each area, it is expected to increase in future with progress of urbanization in Yangon city.



Source: JICA Urban Plan Study, 2012

Figure 4.2 Land Use Condition in Yangon City

4.2 Existing Drainage Facilities

Photo 4.1 and Table 4.2 show existing main drainages in and around Yangon city. The runoff generated due to rainfall flows into the seven rivers/creeks/canal, i.e., Yangon river, Bago river, Hlaing river, Ngamoeyeik creek, Pazundaun creek, Pan Hlaing river, and Twantay canal, through about fifty open drains. The CBD area has fourteen main underground drains.

Hilly terrain with an elevation of 30 m lies along north-south direction in the central part of Yangon city, and it slopes down gently to low-lying areas in the east and the west.

Twenty two (No.1～22) main drainages in the central area of the city run out from the hilly terrain to Hlaing river and Pazundaung creek. Storm water runs off by gravity utilizing the topographical features.

A lot of existing open drains are in the form of natural channels without slope protection, and are polluted by wastewater incoming from surrounding area.

Table 4.2 Existing Main Drains in/around Yangon City

No.	Names	No.	Names
1	Ywa ma Chaung	23	Thaung gyi Chaung
2	Ka thwe Chaung	24	Sula kan Chaung
3	Pauk taw Chaung	25	Shwe lin ban Chaung
4	Yoe gyi Chaung	26	Ka sin Chaung
5	Tha maing Chaung	27	Htain hna pin Chaung
6	Aung theik di Chaung	28	Dun ta be Chaung

No.	Names	No.	Names
7	Pa dauk Chaung	29	Hmaw bi Chaung
8	Kamayut Chaung	30	Lat that Y Chaung
9	Kwin Chaung	31	Tagu gyan Chaung
10	Ywa thit Chaung	32	Ok po Chaung
11	Thebyu Chaung	33	Hte Tan Chaung
12	Aung mingalar myopat Chaung	34	To gyaung ga lay Chaung
13	Moemaka Chaung	35	Seik gyi Chaung
14	Nat Chaung	36	Pagan Daung Chaung
15	Kunitpinlain Chaung	37	Taw thun Chaung
16	Kyaikasan Chaung	38	Pa lan Chaung
17	Semyaung Chaung	39	Shwe byauk Chaung
18	Yeipauk-kyi Chaung	40	Ayun zok Chaung
19	Zwezon Chaung	41	Bo gyok Chaung
20	Shwehle Chaung	42	Tama ta kaw Chaung
21	Thunandar Chaung	43	Weta Chaung
22	Danityoe Chaung	44	Kon ywa Chaung
		45	Alat Chaung
		46	Ta ma aung Chaung
		47	Baw Chaung

Source: JICA Study Team based on the Interview of engineers of Dept. of Roads and Bridges

4.3 Current Flood Status

Photo 4.1 and Figure 4.4 show current status of inundation in Yangon city. Small inundation occurs frequently but there is no serious damage, e.g., inundation above floor level. Many residents have no fear of crisis due to inundation because depth of inundation is below their knee level and it ends within 3~4 hours. Causes of inundation are listed below.

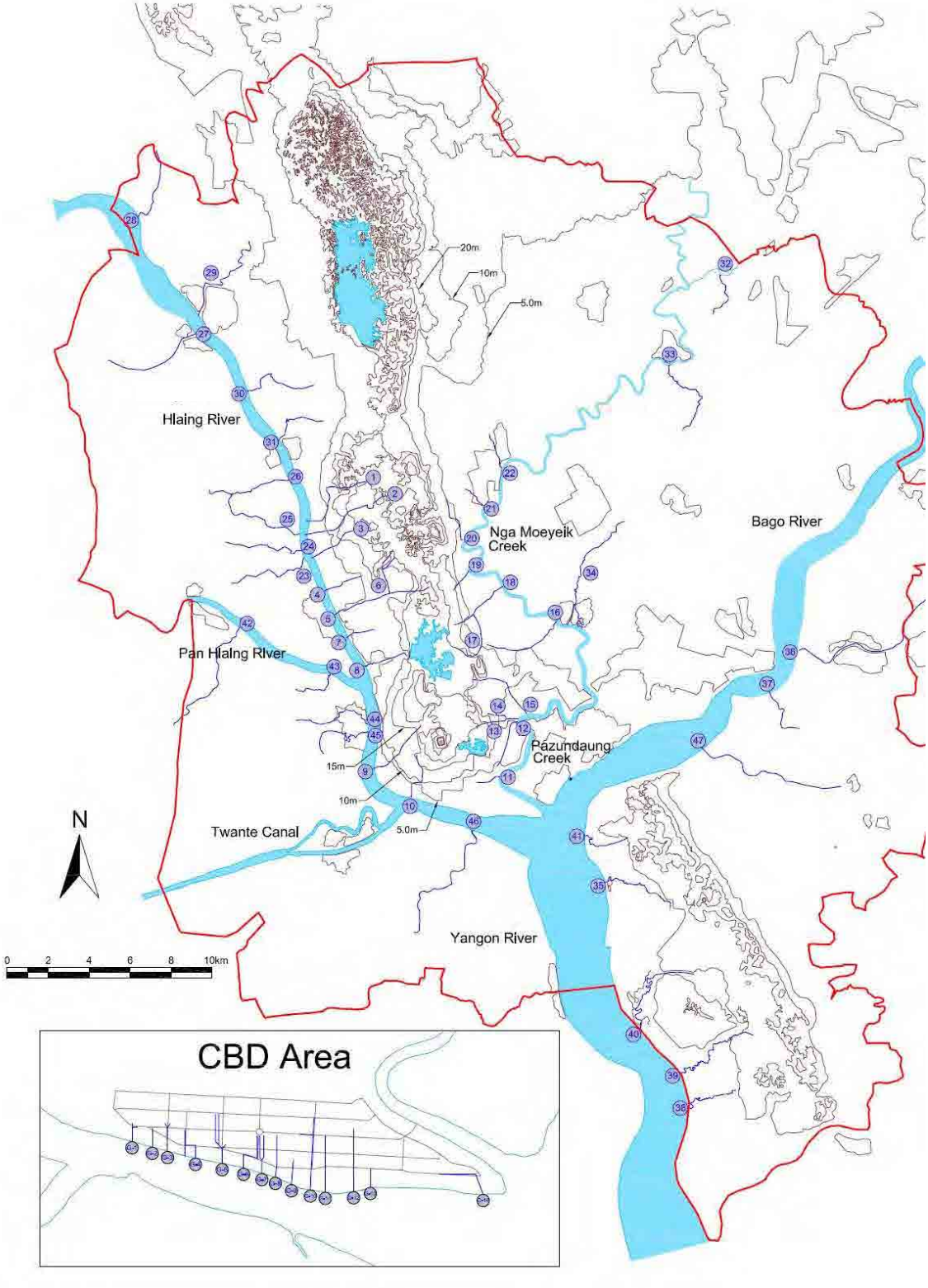
- Lack of drainage facility such as street gutter and storm sewer
- Lack of flow capacity of existing facilities, and decrease of flow capacity due to sediments and solid waste
- Poor drainage due to influence of tidal level
- No tide gates (Inundation by backwater)

Photo 4.1 Current Status of Inundation

Inundation on the roads

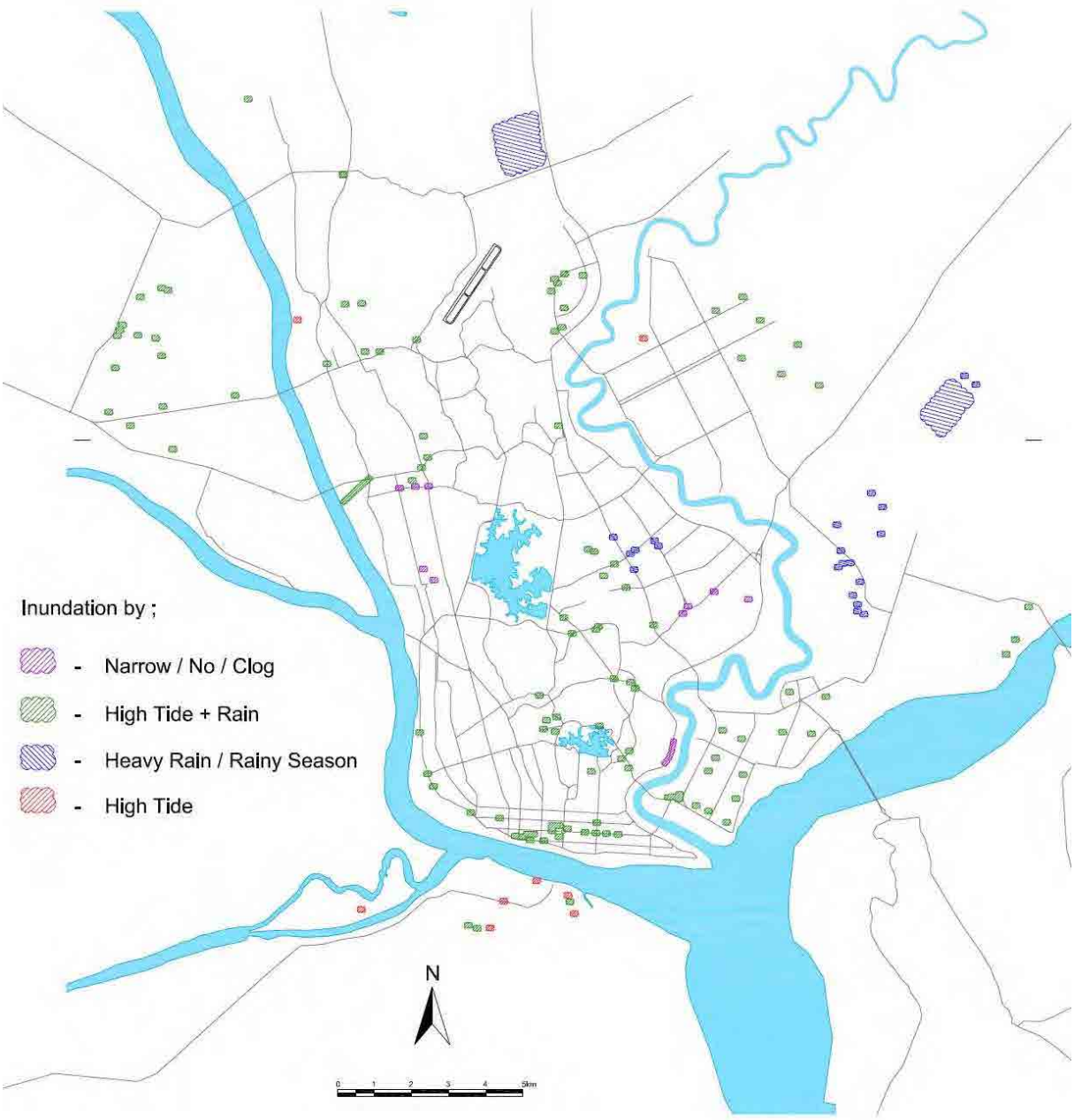
Sediments/solid waste in drain

Source: JICA Study Team



Source: JICA Study Team

Figure 4.3 Existing Main Drainage Channels in/around Yangon City



Source: JICA Study Team based on the data from YCDC Township Office and Interview of Residents

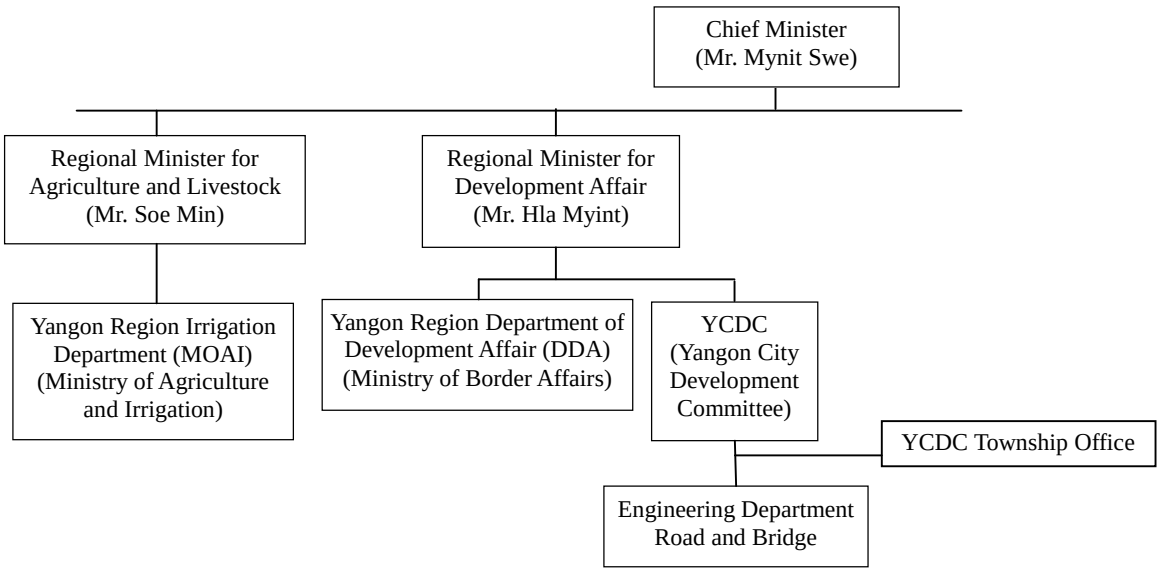
Figure 4.4 Present Status of Inundation in/around Yangon City

4.4 Operation & Maintenance (O&M)

Drainage facilities are managed based on "Yangon Municipal Act (1922)". Ministry of Agriculture and Irrigation (MOAI) manages the major seven rivers/creeks/canal (Yangon river, Bago river, Hlaing river, Ngamoeyeik creek, Pazundaun creek, Pan Hlaing river, Twantay canal) which receive storm water runoff coming from drainage channels.

Engineering Department of Road and Bridge in YCDC and its branches located in each township manage main drainage channels in Yangon city. Some drainage channels in new suburban townships are managed by Yangon Region Department of Development Affair (DDA).

Figure 4.5 shows relevant organizations for drainage management. Demarcation of drainage management is defined among relevant organizations but these organizations have no particular section for drainage management. Therefore, they cannot correct information about drainage facilities and main O&M work for drainage facilities is only cleaning of existing channels before rainy season.



Source: JICA Study Team

Figure 4.5 Relevant Organizations for Drainage Management

4.5 Financial Conditions

Engineering Department of Road and Bridge, YCDC is responsible for the development and maintenance of drainage facilities. However, there is no dedicated staff or special allocation of the budget for drainage. The budget for the cleaning of drainage channels along roads is suggested to be somewhere between 10 to 30 million Kyat but the total budget expenditure is not yet clear. The request for budget estimation for drainage related activities is still pending at YCDC. Since there is no especially dedicated facility for flood mitigation such as flood gates or pumping stations, drainage is constructed as ancillary facilities for road as side drainage channels or culverts at intersections. The maintenance is undertaken as part of road maintenance activities.

4.6 People's Awareness

The next Table 4.3 shows the analysis of public awareness on drainage by township based on the over 10,000 samples conducted by the Strategic Urban Development Plan of the Greater Yangon. Willingness-To-Pay (WTP) is inquired from the respondents by asking how much they are willing to pay each month for the reduction of flooding. The answers were selected from seven brackets of 1) Less than 500 Kyat, 2) 501 to 1,000 Kyat, 3) 1,001 to 2,000 Kyat, 4) 2,001 to 3,000 Kyat, 5) 3,001 to 5,000 Kyat, 6) 5,001 to 7,000 Kyat, 7) more than 7,000 Kyat. Since the top bracket has no ceiling, it is not possible to derive the average WTP. However, it is possible to derive the median value of the brackets.

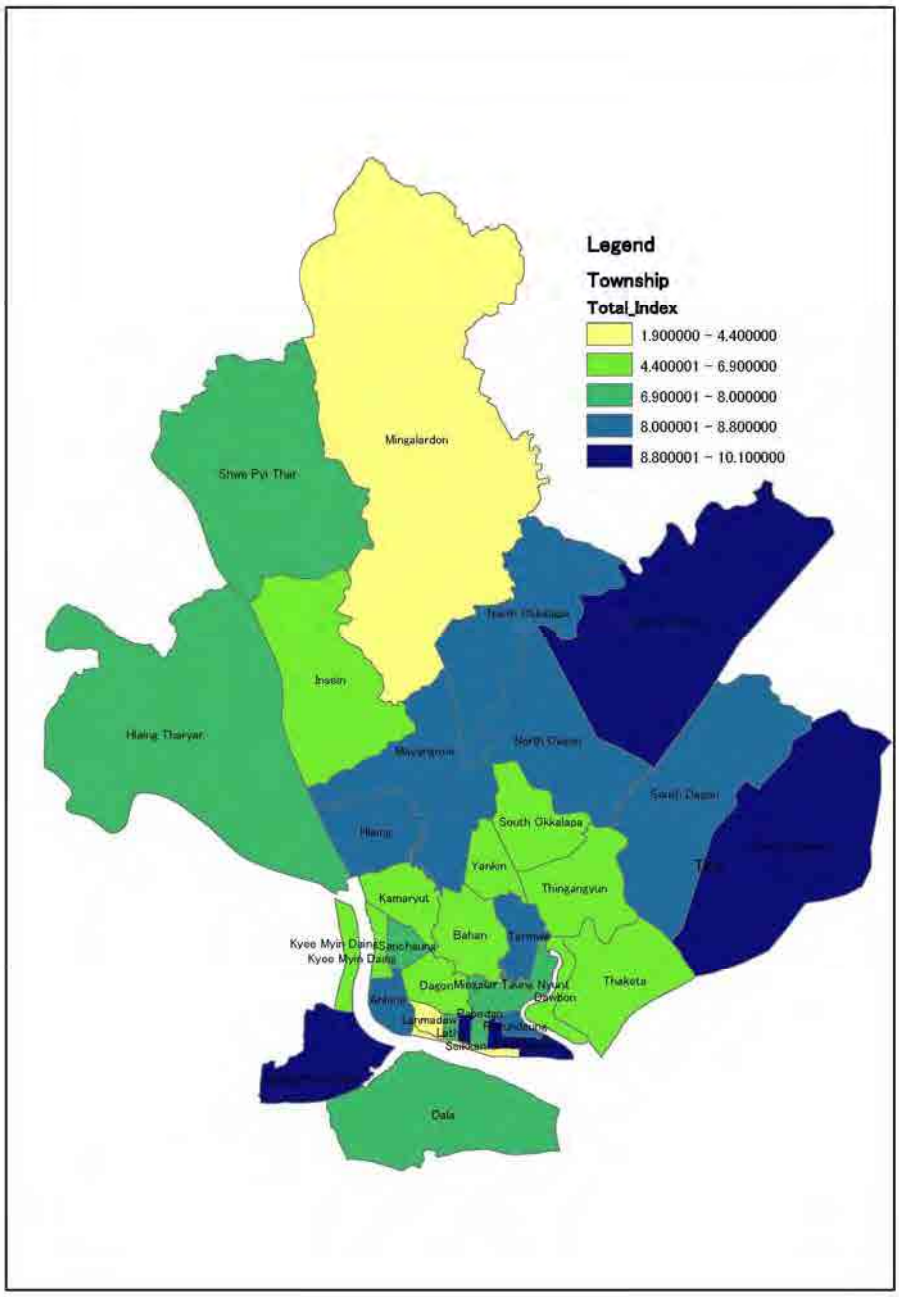
Table 4.5 shows the indexes by township for WTP, frequency of flooding, level of floods, and number of days by taking the deviation from the averages. The question on frequency of flooding had six brackets to choose from; 1) Every month, 2) Every year, 3) Every 2 years, 4) Every 10 years, 5) More than 10 years, 6) Never experienced. The question on flood levels has four brackets to choose from; 1) up to ankles, 2) up to knees, 3) up to waist, 4) more than waist. The question on the duration of days has five brackets to choose from; 1) less than half day, 2) half day- one day, 3) more than one to three days, 4) more than three to five days, 5) more than 6 days. Total Flooding Severity Index is the sum of all the indexes from WTP to flood duration. The Severity Index shows roughly the needs for flood mitigation by area.

Figure 4.6 shows the measurement of severity index classified into five levels by townships on the map. The severity is stronger at the peripheral areas along rivers rather than the central areas.

Table 4.3 Public Awareness Survey Results on Willingness-To-Pay for Flood Mitigation and Severity of Flooding

Township Code	Township	WTP	Flood Frequency	Water Level	Duration	Total Flooding Severity Index
01	Latha	3.35	1.72	2.29	0.63	8.0
02	Lanmadaw	1.92	0.87	0.79	0.49	4.1
03	Pabedan	3.46	2.89	3.06	0.70	10.1
04	Kyauktada	3.10	2.08	1.18	0.75	7.1
05	Botahtaung	3.36	2.51	2.45	0.74	9.1
06	Pazundaung	3.44	1.98	2.42	0.49	8.3
07	Ahlone	2.86	3.06	2.29	0.56	8.8
08	Kyee Myin Daing	2.18	0.61	3.07	0.79	6.7
09	Sanchaung	3.78	1.01	1.98	0.49	7.3
10	Dagon	2.86	0.59	2.29	0.49	6.2
11	Bahan	2.71	1.07	2.35	0.68	6.8
12	Tarmwe	3.59	2.38	1.92	0.51	8.4
13	Mingalar Taung Nyunt	2.88	2.10	2.20	0.66	7.8
14	Seikkan	1.58	0.56	-0.70	0.49	1.9
15	Dawbon	1.50	1.40	2.23	1.58	6.7
16	Kamaryut	2.98	0.90	1.40	0.49	5.8
17	Hlaing	2.85	2.79	1.84	0.74	8.2
18	Yankin	3.09	1.19	1.25	0.49	6.0
19	Thingangyun	2.67	2.18	1.29	0.76	6.9
20	Mayangone	2.68	2.26	2.54	0.74	8.2
21	Insein	1.78	1.53	2.08	0.94	6.3
22	Mingalardon	1.48	0.69	1.33	0.90	4.4
23	North Okkalapa	2.30	3.23	1.85	1.43	8.8
24	South Okkalapa	2.61	2.17	0.84	0.73	6.3
25	Thaketa	1.70	1.82	0.75	0.92	5.2
26	Dala	0.54	1.92	2.48	2.80	7.7
27	Seikgyikhanaungto	1.10	0.59	5.28	2.66	9.6
28	Shwe Pyi Thar	1.54	2.47	1.70	2.05	7.8
29	Hlaing Tharyar	1.50	2.09	1.82	2.52	7.9
30	North Dagon	2.48	3.15	1.40	1.59	8.6
31	South Dagon	2.20	2.69	1.82	1.82	8.5
32	East Dagon	1.53	2.87	2.21	2.51	9.1
33	Dagon Seikkan	2.46	2.60	2.34	1.84	9.2
34	Kyauktan	1.12	1.99	3.05	1.47	7.6
35	Thanlyin	0.62	0.22	3.17	1.64	5.6
36	Hlaegu	1.02	4.49	3.41	2.85	11.8
37	Hmawbi	0.43	0.50	2.47	1.95	5.3
38	Htantapin	0.37	3.04	3.92	3.94	11.3
39	Twantay	0.18	3.50	1.24	2.00	6.9

Source: JICA Study Team



Source: JICA Study Team

Figure 4.6 Public Awareness on Flooding Severity Classified by Levels

4.7 Relevant Studies

Recent studies relevant to urban drainage are listed below.

(1) Yangon Infrastructure and Environmental Services -Pre Feasibility Study, UNCHS/UNDP, August 1993

The city authority and the Government of Myanmar launched "Yangon City and Regional Development Project (MYA/85/016)" as a part of activities for "United Nations International Drinking Water Supply and sanitation Decade, 1981-1990". This Pre-feasibility Study was conducted as one of the activities under the Project, in which existing conditions of urban drainage system in Yangon city were surveyed.

(2) Study on Drainage System of Mingalar Taung Nyunt Area, Fukken Co., Ltd., November 2002

Fukken Co., Ltd. dispatched a study mission to YCDC in 1996 using the financial assistance from Engineering and Consulting Firms Association (ECFA) of Japan. The mission found that Mingalar Taung Nyunt Area of Yangon city is significantly affected by inundation. Fukken conducted a preliminary study to solve inundation problems in the area.

(3) Existing Drainage System of Yangon City, Mr. Aung Swe (ex-Technical Advisor in YCDC), January 2004

This report concluded conditions and issues of existing twenty two (22) main drainage channels in Yangon city. Mr. Aung Swe, the author of this report, was employed as an advisor for drainage works of the Department of Road and Bridges, YCDC for three and a half year.

(4) Yangon Strategic Development Plan, YCDC/Economic Planning Unit, Prime Minister's Dept., Malaysia, December 2006

This report includes proposals for infrastructure development in thirty three (33) townships in Yangon city. As regards urban drainage developments, installation of tide gates and improvement of twenty two (22) main drainage channels are recommended.

These reports have no specific plan for urban drainage developments. At present, YCDC conducts only stopgap measures against inundation problems such as dredging of channels, raising of roads, and installation of tide gates.

4.8 Major Issues of Urban Drainage

4.8.1 Technical/ O&M Issues

As mentioned in the previous sections, small inundation occurs frequently in Yangon city. Even though damages due to inundation are not serious at present, the economic damage caused by inundation is expected to increase in future because of urbanization of Yangon city. Fundamentally,

inundation is caused because of insufficient capacity of drainage facilities. Early development of drainage facility is required to solve inundation problems.

As regards operation and maintenance of facilities, YCDC has no particular section for management of drainage, and conducts limited works as stopgap and emergency measures. It is recommended that independent section for drainage management be established, and systematic O&M work for urban storm water drainage be conducted.

4.8.2 Organizational and Institutional Issues

The Department of Road and Bridge is responsible for drainage works, however the number of staffs responsible for drainage sector is very limited. The O&M works and the improvement works of existing drainage is often lagging behind. Organizational restructuring such as increase of relevant staff members may be required.

CHAPTER 5. TARGET OF IMPROVEMENT OF WASTEWATER TREATMENT AND SCENARIO

5.1 Development Policies Concerning Wastewater Treatment

5.1.1 Outline of Development Policies

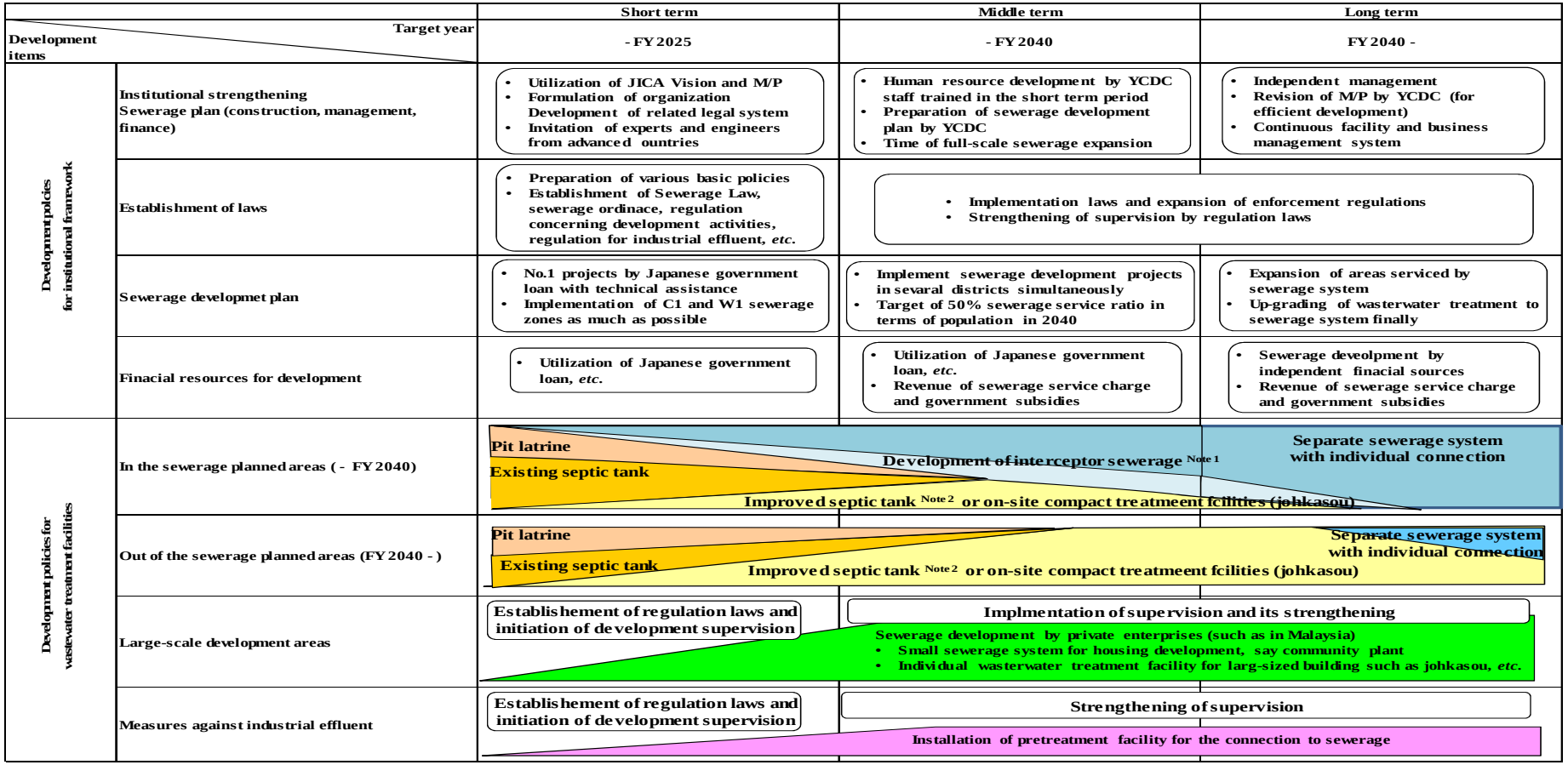
According to household questionnaire survey carried out by visiting interview by JICA from October to November in 2012, it was found out that percentage of population with toilet effluent treated by sewerage amounts to 5.8% and 43.1 % is treated by septic tank. In addition, no fewer than 59.2% of citizens actually discharge gray water without any treatment based on the visiting survey although a small portion of gray water is treated by septic tank. Judging from this situation, it has to be mentioned that the current development of wastewater treatment in Yangon City is at quite low level.

As for wastewater treatment including sewerage, YCDC is in the condition that management and operation organization is insufficient for full-scale development, legal system concerning wastewater treatment and water environment has not been developed properly, and accordingly a firm basis for development of finance has not been made evident. With these conditions into consideration, establishment of institutional framework towards full-scale development, staged efforts for the securement of financial resources, and basic policies for development with due concern to phased employment of and/or shift among various wastewater treatment techniques for realizing cost-effective treatment are indispensable for realizing efficient wastewater treatment development.

Based on the above, basic policies and a road map are articulately presented for each time phase, i.e. short term up to FY 2025, middle term up to FY 2040, and long term from FY 2040 onwards, and for each development items are listed below. Outline of development policies is illustrated in Figure 5.1.

Development items

- ◆ Development of institutional framework
  - Institutional strengthening, and sewerage plan (construction, management, and finance)
  - Establishment of laws
  - Sewerage development plan
  - Financial resources for development
- ◆ Development of wastewater treatment facilities
  - Wastewater treatment facilities inside sewerage planned areas (- FY 2040)
  - Wastewater treatment facilities outside sewerage planned areas (- FY 2040)
  - Wastewater treatment in large-scale development areas
  - Measures against industrial effluent



Note 1: For the time being, increase of sewerage service ratio is targeted by temporary sewerage development. In the case of focusing on the increase of wasterwater volume to be treated, the construction of wastewater treatment plant will be progressed with interceptor system. On the contrary in the case of focusing on the improvemnet of nearby living environment, the construction of sewer network will be the first priority, leaving wastewater treatment later. Anyway in both cases, enlightment acitivites to citizens' understanding concerning sewerage such as prevention of garbage dumping to sewer, and sewerage charge (service charge or tax as evironmental imrovement fee) are indispensible.

Note 2: Basically, sptic tanks to be newly installed are to be improved type capable of treating gray water as well as black water and improved type will be introduced at the time of rebuilding of buildings or redevelopment of the area for the existing buildings in exsting urbanized areas for which improved sptic tank cannot be installed right now technically.

Source: JICA Study Team

Figure 5.1 Basic Development Policies Concerning Wastewater Treatment

5.1.2 Development Policies in Short Term up to FY 2025

Considering the facts that 1) basically the development of water supply system takes first priority, 2) currently institutional framework based on which sewerage, etc., has to be developed efficiently has not been established, and 3) it is certain that there will be a great limitation for fund, the development at the beginning of the short term up to FY 2025 focuses on development and expansion of organizational structure and the development of laws, ordinances, an institutional systems concerning wastewater treatment and sewerage. Then, the development of sewerage districts with high priority, say C1 and W1, will be carried out. Along with the above, study and formulation of various standards and institutions in order to promote the change of current pit latrine and septic tanks to improved septic tank or on-site compact treatment facilities will be conducted as well as the promotion of enlightening and PR activities to citizens will be carried out.

(1) Development of institutional framework

◆ Institutional strengthening and sewerage plan (construction, management, and finance)

- By utilizing water vision and M/P prepared by JICA, strengthening of organization and development of legal systems concerning wastewater treatment is conducted.
- As for strengthening of organization, constituents of organization required for each development level are studied with due concern to required sections for planning, constructing, managing and operating sewerage and their responsibilities, number of staff for each section required, cooperation between YCDC and townships and their responsibility sharing based on M/P, and then substantial expansion of organization is implemented. Coupled with the above, institutional systems, ordinances, etc., of YCDC and townships required including service charge system and collection method are studied, developed and implemented.
- As for the establishment and expansion of organization, although this M/P can be referred to, detailed study is needed in actuality by referring to the examples of local governments in Japan as well as those in other countries. For this purpose, therefore, engineers are invited from advanced countries and establishment of organization and development or reform of institutional systems is implemented through their advice and joint cooperative efforts between engineers and YCDC. Through the above, capacity development of YCDC staff is carried out as well.

◆ Establishment of laws

- In order to implement planning, construction, operation, management and supervision of wastewater treatment facilities including sewerage properly and efficiently, organization of jurisdiction, authority, responsibility, facilities, required functions and performance, etc., are defined clearly by the development of laws.
- For this purpose, basic policies for the items specified above are formulated. As for the

formulation of basic policies, although the first draft is primarily prepared by YCDC, participation of and consultation with upper level governments are definitely needed especially in reflecting these basic policies in laws in actuality. Close cooperation of and consultation with national and regional governments from this stage is indispensable.

- In order to implement sewerage projects, the first thing required to do is the legislation of sewerage law specifying the development purpose, stations of jurisdiction, authority, responsibilities, facilities, required functions and performances and implementation procedures and sewerage ordinance complementing sewerage law to specify detailed rules which become necessary for responsible local government to implement development. Also, legislation of related laws and ordinances necessary for wastewater treatment facilities other than sewerage is conducted.
- Wastewater treatment such as sewerage is implemented for the ultimate purpose of conserving sound water environment of public water bodies such as rivers, lakes and marshes and oceans. For this purpose, therefore, study is carried out for ambient water quality standards for public water bodies to define the level of water quality to be maintained with due consideration to ways of using the water body and standards are set based thereupon. Since regulations of the quality of effluent directly discharged to public water bodies are necessary in order to achieve ambient standard, they are studied and set. Since water quality of a water body is dependent upon the situation of water basin, both allowable effluent water quality standards across the country set by national government as well as more stringent ones for individual water body set by regional or local government are necessary and provided in general.
- In case that development activity is implemented not appropriately, huge amount of wastewater flows into wastewater treatment and sharp increase of rainfall runoff is expected. Such a development activity has significant impacts on wastewater treatment facilities and nearby water environment. By dealing with the above problems at the time of development, on the other hand, the promotion of quite efficient spread of wastewater treatment service can be made possible. From this point of view, regulation of laws and ordinances for development activities are studied from the beginning of the short term and established.
- Factories producing certain products discharge effluents with extremely heavy pollutants and/or with trace hazardous substances such as heavy metals. Unlimited acceptance of these effluents poses excessive burden to wastewater treatment and there is a possibility to decrease treatment performance dramatically. Therefore, it is necessary to establish regulation of characteristics of effluent to be discharged to sewerage, *etc*. As preparation prior to the establishment of regulatory standards, water quality survey of industrial effluent and by products for various categories of factories is

implemented.

- At the time of implementing the development of sewerage, *etc.*, impacts on various environmental aspects surrounding wastewater treatment facilities are matter of concern. For the purpose of decreasing and limiting environmental impacts due to the development of treatment facilities, the development of laws and regulations related to environment such as water pollution prevention, solid waste treatment for generated sludge, air pollution prevention, noise regulation, vibration regulation, hazardous odor prevention is studied and laws and regulations possible to implement are legislated.
- Since the above legislation is considered to be basically legislated by national or regional government, close consultation with both governments is carried out for the realization of early legislation. It should be kept in mind that YCDC may need to prepare drafts of these laws and regulations and legislate them as ordinances before the legislation by upper level governments upon consultation with them, as the case may be.
- As for the development of laws, moreover, study and work with experts from advanced foreign countries are necessary since this is necessary to be done with full consideration to other countries' situation.

◆ Sewerage development plan and financial resources for development

- Basically, C1 sewerage zone (zone centered surrounding existing sewerage zone and WWTP) which has been given highest priority for development is developed first. Then, W1 sewerage zone (zone located in south-eastern part of the City adjoining Hlaing River and Yangon River) with the second highest priority is developed as much as possible during the short term.
- Although some legal procedure or measures may be necessary, such as city planning authorization based on City Planning Law in Japan, sites for WWTPs in sewerage planned area up to 2040 is basically secured.
- Since it is almost impossible for YCDC to implement the development of sewerage systems with its own financial source under the current economic situation and financial magnitude and YCDC's organization strength is not sufficient for the implementation, the development is implemented by utilizing Japanese government loan under technical assistance, *etc*. In the meantime during the implementation of sewerage development, capacity building of YCDC staff and human resource development are carried out at the same time for the preparation towards independent implementation during the middle term.

(2) Development of wastewater treatment facilities

◆ In the sewerage planned areas (- FY 2040)

- In the sewerage planned area up to FY 2040, the development of C1 and W1 sewerage zones is carried out during the short term. Since service coverage ratio in terms of

population will amount to only 7.8% with regard to 2040 population by the development of C1 and W1 sewerage zones even if the development is all completed, the effects of development in terms of improvement of water quality in rivers and ambient environment is not necessarily sufficient.

- Currently, majority of citizen in Yangon City treat wastewater (mainly black water) by pit latrine or septic tank. In order to increase the effects of development in water quality and ambient environment improvement even a little, shift from the current facility to and introduction of improved septic tank or on-site compact treatment facility are promoted. Basically the shift to improved septic tank is mainly promoted as first option from the economical point of view. However, the shift to on-site compact treatment facilities (Johkaso) which have higher treatment efficiency is also promoted where possible. In addition, PR activities are carried out through the institution of financial subsidiary system for the introduction of and modification to improved type, education to raise environmental awareness to citizens, *etc*.
- Although sewerage zones other than C1 and W1 zones are not constructed in the short term, the wastewater removal and treatment by interceptor method in other zones during the construction of C1 zone are studied and implemented for possible areas in order to increase the effects of water quality and ambient environment improvement.
- At this time, due to the facts that 1) wastewater is discharged almost without any treatment even at present, and 2) the construction of treatment facilities is not affordable financially, the method to collect both rainfall runoff and wastewater together and to discharge them without treatment is studied and the areas suitable for this method are examined. If there is appropriate site before discharge, the employment of temporary wastewater treatment to improve the effectiveness of water treatment such as simply dug planted lagoon to expect sedimentation and adsorption for example is studied. With this, the effects of improvement of living and ambient environment at least can be obtained.

◆ Out of the sewerage planned areas (- FY 2040)

- Because the areas will be developed after FY 2040, basically the shift of current septic tank and pit latrine to improved septic tank or on-site compact treatment facility (Johkaso) is promoted. As in sewerage planned areas, shift of treatment facilities as above is promoted by disseminating widely subsidiary system therefore and by conducting environmental education to citizens.
- Because the employment of on-site compact treatment facilities is difficult due to their expensiveness in spite of high treatment efficiency, the shift to improved septic tank is mainly promoted to citizens.

◆ Large-scale development areas

- Legislation of development regulation laws is speeded up and then guidance for development is implemented. As for development regulation, the way of regulation from the wastewater treatment point of view and measures against rainfall runoff is made articulated upon the study on magnitude of development subject to regulation laws with due concern to the trend of development and the perspective of wastewater treatment facility development in the future. By implementing guidance for development based on the above, impacts of the development on wastewater treatments and rainfall runoff disposal facilities, and on ambient environment are to be minimized.
- Although it depends on the magnitude and type of development, the installation of small-scale wastewater treatment facility, i.e. community plant, in the development area is basically guided for the development in the area in which connection to sewerage system is impossible.
- In the development of high rise building in addition, guidance to install treatment facility in the building and to reuse treated wastewater for toilet flushing in the building as much as possible is provided.
- Moreover, the procedure to monitor the management of the above facilities properly such as the requirement of monthly water quality record submission is studied and the infiltration of this procedural system is promoted.

◆ Measures against industrial effluent

- Upon establishing regulations of effluent water quality for industrial wastewater and pretreatment water quality standards for receiving effluent from factories to sewerage, regulation and supervision based thereon is initiated.
- For the establishment of the above standards, survey for volume and characteristics of wastewater from main factories for each category in terms of their products are carried out, investigation on regulation methods and level of standards in advanced countries are studied, and finally standards are set. As for the setting of regulation values, the consideration of the provision of temporary loose regulation with a time limit, *etc.* may be necessary for the purpose of not hindering the industrial growth seriously.
- As for industrial effluent as well, the procedure to monitor it properly such as the requirement of monthly water quality record submission is studied and the implementation of this procedural system is promoted.

5.1.3 Development Policies in Middle Term up to FY 2040

(1) Development of institutional framework

◆ Institutional strengthening and sewerage plan (construction, management, and finance)

- By YCDC staff trained through the joint development implementation with experts and

engineers from advanced countries up to FY 2025, the education for human development to wide range of YCDC staff is implemented to secure staff required for full-scale development of sewerage systems in the middle term.

- 12 years have passed since JICA M/P was first prepared. Adequacy of M/P is reviewed and the updating thereof is implemented as OJT of YCDC staff as well. Based on this, sewerage development plan for middle term is prepared by YCDC staff as main planner.
- Towards the financially sound management of sewerage services, financing method, the review of service charge system, and method of managing assets with due consideration to the introduction of corporate accounting are studied.
- By development of 4 sewerage zones, C2＋E1, W2, N1, and E3, full-scale expansion of sewerage systems is carried out.

◆ Establishment of laws

- In addition to enforcing laws and ordinances established by FY 2025 all the way, the development and the expansion of enforcement regulations, *etc.*, are carried out based on the accomplishment during the short term.
- By reviewing systematically various regulation laws studied and targeted to be legislated by FY 2025, making them strict and rigid is implemented, supervision and control based thereon is reinforced, and enforcement of laws with practical effects is realized. As for regulation standards to which temporary loose standards are provided in the initial stage of sewerage development up to FY 2025, in addition, the return thereof to the normal more stringent standards is carried out in order to improve environmental quality including aquatic one dramatically.

◆ Sewerage development plan and financial resources for development

- Development of several sewerage zones, i.e. 4 zones of C2＋E1, W2, N1, and E3, is implemented and the effects of developing sewerage systems are to be increased dramatically. C2＋E1 sewerage zone (located in the central part of Yangon City in the north of C1 zone), W2 zone (located in the north of W1 district along Hlaing River), N1 zone (located in the northern area adjoining W2 district), and E3 zone（located in the western area adjoining C1, C2, and E3 zones） planned to be constructed up to FY 2040 in M/P are developed as much as possible.
- By developing these sewerage zones sewerage service ratio of 50% (49.4% to be precise) in terms of 2040 population is targeted.
- Although economic condition is expected to have improved dramatically, the implementation of the sewerage development by own independent financial resource is still impossible, the development is basically carried out by the use of Japanese government loan, *etc.* However, since the service ratio is almost amounting to 50% at

the end of the middle term, thus an income of service charge can be secured and system of subsidy by national government for the development of sewerage systems may be fully established, these financial resources are also used as the costs for construction, management and O & M.

(2) Development of wastewater treatment facilities

◆ In the sewerage planned areas (- FY 2040)

- As a target, the development up to FY2025（C1 and W1 zones）is expected to be completed. However, if there are still facilities and areas not completed, they are constructed continuously.
- Four sewerage zones to be newly developed are constructed one after another. If there are areas for which wastewater treatment facilities were developed with temporary treatment or interceptor method by FY 2025, they are provided with regular sewerage facilities one after another.
- Though the development of 4 sewerage zones with sewerage systems is expected to be completed by FY 2040 as targeted, the development with temporary treatment facilities for the districts or parts of them where possible at the early stage of the middle term is taken into consideration if all the development is judged to be difficult because of financial and other reasons.
- As for houses which still use pit latrine or existing septic tank, all of them are basically changed to improved septic tanks by FY 2030 or so. Since they are expected to connect sewerage system sooner or later, change to expensive on-site compact facility unit is not actively promoted. For this purpose, enlightening activities and PR to citizens are proceeded further. For areas and houses which are supposed to be connected to sewerage soon after the modification to the improved type according to the construction schedule of the sewerage, it is considered that the existing septic tank may be left as it is.

◆ Out of the sewerage planned areas (- FY 2040)

- Since the development of sewerage is implemented during the long term from FY 2040 on, the change of the existing septic tanks and pit latrines to improved septic tanks or on-site compact facility units is promoted further.
- The shift to either improved septic tanks or on-site compact treatment units is promoted in this area. However, since 1) individual income is expected to have greatly increased by this time, and 2) treatment facilities to be constructed can be utilized for relatively long time according to construction schedule for sewerage development, the employment of on-site compact treatment units with high treatment efficiency is actively promoted.
- Though it is not clearly specified in Figure 5.1, the employment of temporary treatment

technique, such as interceptor method with simplified treatment facility, is studied and implemented where possible, if necessary.

◆ Large-scale development areas

- Thoroughgoing development guidance is implemented and supervision and enforcement is strengthened.
- As for large-scale development in an area without sewerage system, the installation of small-scale wastewater treatment facility, community plant in other word, in the area is made prerequisite for the approval for development. This is expected to control the discharge of excessive pollution load due to development.
- As for development of high rise building, the installation of treatment facility in the building is made prerequisite for the approval for development. Moreover, the guidance to implement reuse of treated wastewater in the building as toilet flush is strengthened. From the point of view of securing valuable water source in the city, the establishment of incentive system to promote reuse of treated wastewater is studied and implemented.

◆ Measures against industrial effluent

- Enforcement of regulation for factory effluent discharge to public water bodies and to sewerage system is strengthened.
- Temporary loose regulation for factory effluent with a time limit for application established in the short term is abolished one after another at least in areas already served by sewerage system and normal regulation and standards, stricter than before generally, are newly applied. For this purpose, regulation and standards concerning factory effluent are reviewed and classified systematically and the revision thereof is studied and implemented.
- Since sewerage development has been advanced, it is expected that the number of connection of factory effluent to sewerage have been increasing. In some large factories, quite large amount of service charge is required to pay by connecting to sewerage system. Thus, the case that some factories like to treat wastewater generated from their own factories by themselves may come up. There is a chance that the above case may influence the scale of treatment facilities in a wastewater treatment plant very much depending upon the size of factories which decide to treat wastewater by themselves. Therefore, whether they have intention to connect to sewerage or not is to be made clear for large-scale factories in order to avoid excessive capacity of sewerage system.

5.1.4 Development Policies in Long Term beyond FY 2040

(1) Development of institutional framework

◆ Institutional strengthening and sewerage plan (construction, management, and finance)

- Since sewerage service ratio exceeds 50% and sufficient knowledge and experiences have been accumulated in YCDC, YCDC basically manage and operate sewerage service by themselves
- Although M/P prepared by JICA was updated in the middle term, 30 years have already passed from the beginning of the sewerage development based on JICA M/P. M/P is required to be revised by the full-scale review of basic parameters and values in order to realize the most efficient M/P at the beginning of 2040s. YCDC implement the revision of M/P by themselves with due concern to the status of sewerage development.
- Since 30 years have passed since the beginning of the sewerage development, some of facilities are aged. By referring to the results of study on facility management method carried out in the middle term, continuous and efficient management of sound sewerage service by the use of asset management technique, *etc.* is studied and the establishment of sewerage management system is advanced.
- Construction of facilities and areas not completed in the middle term is continued and completed. Sewerage systems for other districts are constructed one after another.

◆ Establishment of laws

- Basically, what was done in the middle term is continuously implemented.
- Laws and ordinances, regulation and standards are revised and/or strengthened when necessary according to the trend of times.

◆ Sewerage development plan and financial resources for development

- Development of sewerage in areas which is expected to be completed at this time but not completed is continuously implemented one after another. It should be noted that the development is implemented based on the revised M/P mentioned above. First priority for constructing sewerage is placed on the above areas or districts, if any. With this, 50% of sewerage service ratio is targeted to be achieved by the time earliest possible.
- Since economic situation is expected to improve dramatically by this time, the management and operation of sewerage services are fully carried out by YCDC. Sewerage services are implemented and operated by YCDC's own finance along with the use of revenue by service charge and various subsidiaries such as national subsidy. For the development of sewerage from now on, moreover, the management and operation of sewerage services by private enterprise, whether all or in part, may be possible. Thus this is studied and may be implemented if and where possible.

(2) Development of wastewater treatment facilities

◆ In the sewerage planned areas (- FY 2040)

- The development of sewerage for zones or areas to be completed by FY 2040 is

completed with highest priority if there is any area where construction of sewerage facilities is not completed.

- Zones or areas where development of sewerage system was carried out by temporary treatment or interceptor method, in which ordinary sewerage system is not completed, is developed with ordinary system as soon as possible.
- Construction of all the sewerage zones originally developed by FY 2040 is completed and all zones are sewered as earliest possible.

◆ Out of the sewerage planned areas (- FY 2040)

- For zones to be developed in the long term, the concrete construction schedule is not detailed. The development of sewerage systems in these zones is carried out one after another by studying their priorities with due concern to population density, financial condition, citizens' opinions, *etc.*
- Since it is assumed to take long time to develop sewerage system in this area, the change of the existing septic tanks and pit latrines to improved septic tanks or on-site compact treatment units is further promoted as principle.
- Shifting to either improved septic tanks or on-site compact treatment units is promoted in this area. The employment of on-site compact treatment units with high treatment efficiency is actively promoted as in the middle term.
- As in middle term, the employment of temporary treatment technique, such as interceptor method with simplified treatment facility, is studied and implemented where possible, if necessary.

◆ Large-scale development areas

- Thoroughgoing development guidance is implemented and supervision and enforcement is strengthened.
- As for large-scale development in the area without sewerage, the same regulatory approaches such as those in the middle term are actively carried out further.
- Also, for the development of high rise building, the same regulatory approaches such as those in the middle term are actively strengthened and carried out further.

◆ Measures against industrial effluent

- Enforcement of regulation for factory effluent discharge to public water bodies and to sewerage system is strengthened.
- Approaches and efforts carried out in the middle term are strengthened and continuously implemented.

5.1.5 Priorities of Tasks to be Implemented by YCDC for The Time Being

YCDC is supposed to go ahead with the development of wastewater treatment systems and facilities based on the above-mentioned development policies with the cooperation and support of JICA, etc. In order to realize quick development and early commencement of the operation of wastewater treatment systems and facilities, however, various tasks are to be implemented efficiently prior to the 1st stage construction of treatment system. For the reference to YCDC, these required tasks are articulately listed hereinafter and the outline about how these tasks should be carried out in order is presented as shown in the following table:

Table 5.1 List of Tasks to be Implemented by YCDC for the Time Being and Their Priorities

Tasks to be implemented by YCDC for the time being	Priority (High ◢ Low)					Remarks
1. Land acquisition or its outlook	●					
2. Preparation of policies on sewerage service operation						
a. Study on management organization for sewerage service (Administration, planning, and operation and maintenance)	●					
b. Role sharing for sewerage services between YCDC and townships	●					
c. Study on the method of securing financial sources for construction upon consultation with national and regional governments	●					
d. Study on service charge system for sewerage		●				
e. Enactment of local ordinance for sewerage charge			●			
3. Basic policies on related laws and coordination with national government						
a. Study on existing related laws and regulations		●				
b. Drafting of legal systems for environment and wastewater treatment and consultation with national government		●				
c. Basic policies of laws and regulation concerning environment and wastewater treatment and consultation with national government		●				
4. Drafting of sewerage-related laws and regulations and consultation with national government						
a. Study on framework of Sewerage Law		●				
b. Drafting of Sewerage Law and consultation with national government		●				
c. Request to national government for the enactment of Sewerage Law		●				
d. Drafting of Sewerage Ordinances by YCDC and townships and consultation among them			●			
e. Enactment of Sewerage Ordinances			●			
5. Study on environmental and effluent standards and consultation with national government						
a. Drafting of ambient water quality standards			●			
b. Study on laws and regulation concerning solid waste treatment related to sludge treatment			●			
c. Consultation with national and regional governments, academics, and entrepreneurs			●			
d. Drafting of uniform effluent standards and request to national government for enactment				●		
e. Drafting of more stringent local effluent standards by YCDC and its enactment				●		
6. Study on law and regulation for other wastewater treatment facilities and establishment of subsidizing system						
a. Study on methods for improving septic tanks	●					
b. Study on laws and regulations for Johkaso and septic tanks (Structural standards) and consultation with national government	●					
c. Study on subsidizing system for septic tank improvement and Johkaso installation		●				
7. Basic policies concerning laws and regulations for development activities and consultation with national government						
a. Study on regulation required and items to be requested for cooperation to developers		●				
b. Coordination with City Planning Act concerning regulation and consultation with national government		●				
c. Study on regulation ordinance for developing activities concerning sewerage and its enactment			●			
8. Enactment of ordinance concerning the receipt of industrial effluent to sewerage system						
a. Water quality survey for industrial effluent for types of industries		●				
b. Consultation with interested parties such as national and regional governments, other departments of YCDC, and entrepreneurs			●			
c. Enactment of ordinance for the receipt of industrial effluent to sewerage system				●		
9. PR to citizens concerning sewerage and wastewater treatment						
a. Preparation of general enlightening materials, introduction of various related systems			●			
b. Holding of explanation meeting for citizens				●		
10. Procedures towards system commencement and project advancement						
a. Procedures and preparation of sewerage ledgers, daily and monthly reports for operation					●	
b. Preparation of water quality management plan					●	

Source: JICA Study Team

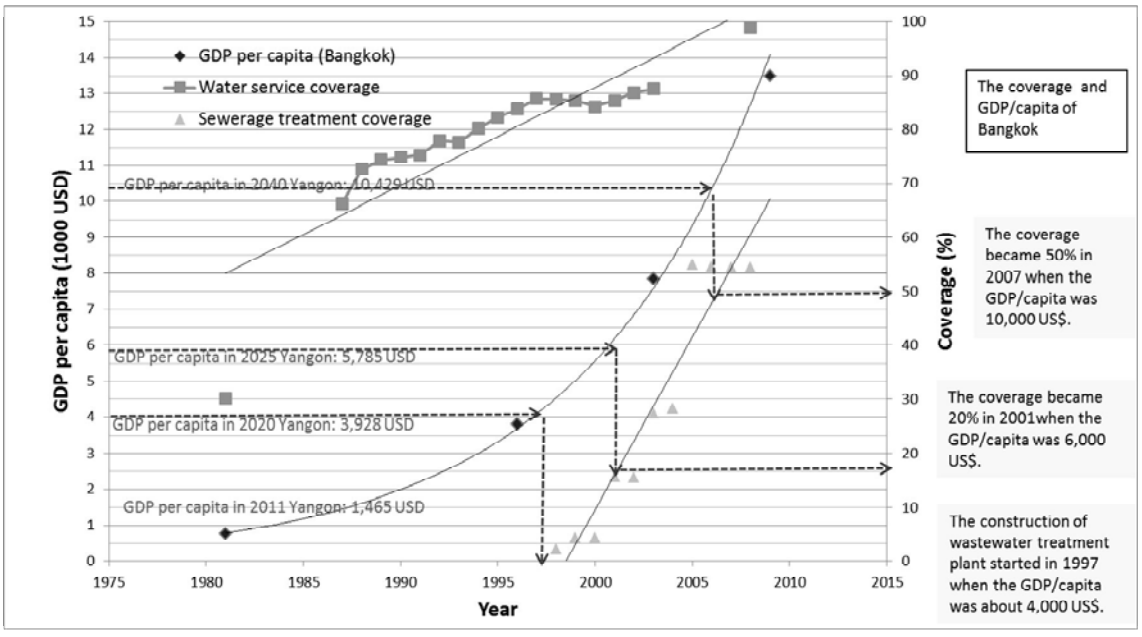
5.2 Case Study of Neighboring Countries

5.2.1 Case of Bangkok Metropolitan Area

The city similar to Yangon is Bangkok in Thailand because the scale of the population is similar and Yangon may follow Bangkok in terms of economic development and other infrastructure development. Therefore, the relationship between the trends of population growth and economic development and progress of sewerage system coverage in case of Bangkok after introduction of sewerage system in 1980's are studied and used for establishment of future sewerage target of Yangon.

The relationship between the coverage of water supply and sewerage system and GDP per capita of Bangkok is shown in the following Figure. The sewerage system with wastewater treatment plant was first introduced in Bangkok in 1994. The introduced sewerage system in Bangkok was not conventional but interceptor sewerage system. The sewerage development started in full swing since around 1997 when per capita GDP of Bangkok was 4,000US$. Then the sewerage coverage became around 20 % when the GDP per capita became 6,000US$. Furthermore, the coverage surpasses 50 % when the GDP per capita was around 10,000 US$ in 2007. The time span between the introduction of sewerage system and 50 % of the coverage is as short as 13 years.

During this period, the investment in the sewerage system totaled 19,871million Baht (equivalent to about 483 million US$ based on the exchange rate at the investment time) for the target population of about 3 million. Thus, the cost incurred per capita was 162 US$ which is rather low compared to conventional sewerage system development. Rapid increase in the sewerage coverage and corresponding low investment value may be attributed to the introduction of interceptor sewerage system.



Source: JICA Study Team

Figure 5.2 Relationship between GDP per Capita and Water Supply and Sewerage Coverage

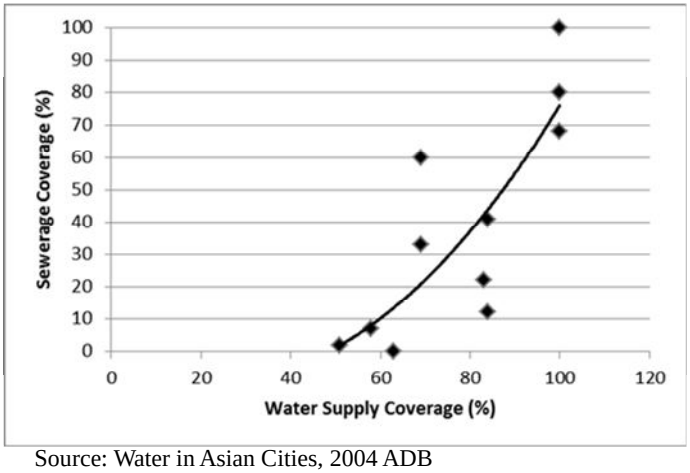
Table 5.2 Estimated GDP per Capita of Greater Yangon and the Years When Bangkok Achieved the Same Level of GDP per Capita and Sewerage Coverage in These Years

Year	Greater Yangon	Bangkok Metropolitan Area	
	GDP per capita estimation	The years when Bangkok achieved the same level of GDP per capita of Yangon	Sewerage coverage in these years
2011	1,465 US$	1987	0%
2020	3,928 US$	1997	The construction of major wastewater treatment plant started.
2025	5,785 US$	2001	About 18%
2040	10,429 US$	2007	About 50%

Note 1: The contents of this table are taken from "Figure 5.2 Relationship between GDP per capita and Water Supply and Sewerage Coverage."
Note 2：The estimation of the GDP per capita are referred from JICA Yangon Urban Development Study.
Source: JICA Study Team

5.2.2 Water Supply and Sewerage Coverage of Major Cities in Neighboring Asian Countries

The coverage of water supply and sewerage of major cities in neighboring Asian countries is shown in Table below and the relationship between both coverages is shown in the following Figure based on the same data.



Source: Water in Asian Cities, 2004 ADB

Figure 5.3 Relationship between Water Supply and Sewerage Coverage

As shown in this Figure, the sewerage is introduced when the water supply coverage reach around 50 % and it becomes 20~40% when the water supply coverage reach around 80 %. Eventually, the sewerage coverage reaches almost 70 % when the water supply coverage becomes 100 %.

Initially, when the water supply coverage is at the lower level, the focus of development of infrastructure is on water supply system and not on sewerage system. The Figure shows that the development of sewerage system starts when the water supply coverage surpasses around 50 %. Furthermore, sewerage development would be accelerated when the authorities afford to invest in sewerage system after investment in water supply system is saturated and the people realize that living environment is deteriorated due to increased water use and consequent increase in discharge of wastewater without treatment.

Table 5.3 Water Supply and Sewerage Coverage of Major Cities in Neighboring Asian Countries

Item	Colombo	Ho Chi Minh	Hong Kong	Jakarta	Kuala Lumpur	Manila	Phnom Penh	Vientiane	Delhi	Kathmandu	Shanghai
Water supply coverage (%)	69	84	100	51	100	58	84	63	69	83	100
Sewerage coverage (%)	33	12	100	2	80	7	41	0	60	22	68

Data source: Water in Asian Cities, 2004 ADB
Note 1: The year of data is 2001.
Note 2: The sewerage coverage means sewerage access which does not necessarily mean wastewater treatment coverage. For example, the sewerage coverage of Phnom Penh is 41% but the wastewater treatment coverage is 0 %.

As stated above, the development of water supply system is prioritized over sewerage system with the limited investment fund although it is ideal to develop both water supply and sewerage systems simultaneously. This is true of Yangon city. Based on the Figure above, the introduction of sewerage system shall start in full swing when the water supply coverage become 50% and the sewerage coverage target in 2040 may be around 40 % when the water supply coverage becomes 80 % in Yangon in 2040.

5.3 Establishment of Target

Target of water supply M/P of which target year is 2040 is established as follows.

Target year:	2040
Water supply coverage ratio (24 hrs.):	80 % of total YCDC population
Net per capita consumption:	150 to 200 lpcd, (178 lpcd on average)
Non-revenue water:	15 % (including 10 % leakage)

The following correlation between per capita GDP and sewerage coverage ratio is deduced from that of Bangkok described in the previous section. Future per capita GDP projection is based on JICA Urban Plan Study, 2012.

Start of sewerage system provision:	Per capita GDP USD 4,000, year 2020 for Yangon
Coverage ratio 10 %:	Per capita GDP USD 6,000, year 2025 for Yangon
Coverage ratio 50 %:	Per capita GDP USD 10,000, year 2040 for Yangon

Target of coverage ratio for Yangon in 2040 is determined to be 50 % taking into account the correlation between per capita GDP and sewerage coverage ratio in Bangkok. Sewerage facilities will be planned to realize this target and project cost will be estimated. Then feasibility of the sewerage projects will be evaluated, and scope of the project will be adjusted as necessary.

5.4 Improvement of Wastewater Treatment Facilities and Pollution Load Reduction Effect

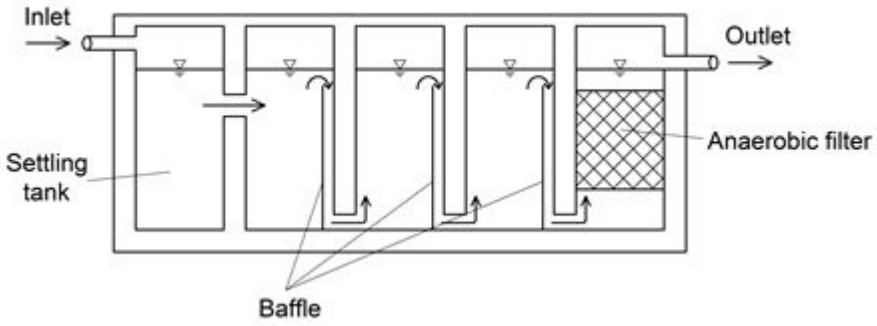
5.4.1 Improvement of Septic Tank

Taking into account the current situation and target of sewerage coverage ratio in 2040, i.e. 50 %, wastewater outside of the service area will be discharged without treatment for long time until the time when sewerage system is provided. Also in 2040 if the target is achieved, still a half of the population cannot enjoy sewerage service. In order to improve living conditions and water pollution in water bodies, application of other systems are also studied.

Firstly, possibility of treatment of gray water together with black water in septic tank is studied since septic tank is only applicable system in Yangon. Treatment of gray water together with black water in septic tank is widely applied in USA for mainly suburban and rural areas. Design criteria for the capacity of septic tank is so stipulated that the retention time is 1.7 to 6.7 days, 2 days on an average, for 284 lpcd per capita wastewater flow. This capacity can be converted to 0.5 to 1.9 m^3/day per capita capacity which is 5 to 10 times that of septic tanks in Yangon i.e. 0.12 to 0.17 m^3/day. If per capita wastewater flow is 3.1 lpcd (including pour-flush water), retention time is calculated to be 40 to 55 days. If gray water is added and per capita wastewater is 178 lpcd, retention time reduced to 0.7 to 0.9 days resulting in almost no treatment. Capacity of septic tank should be at least 5 times the current capacity to accommodate gray water. It is, therefore, very difficult to convert the existing septic tanks.

Secondly, methods to improve treatment efficiency of septic tank without substantial remodeling of the existing ones are studied. A method developed by a group of Hanoi University is referred to in this section.[1] This study was conducted to search an innovative method to increase reduction efficiency of septic tank. In this system, up flow is generated in the compartments by baffles installed inside a septic tank and anaerobic filter is added. Recommended system consists of a settling, more than 3 compartments of septic tanks with baffles and anaerobic filter. A sample is shown in Figure 5.4.

[1] "IMPROVED SEPTIC TANK WITH CONSTRUCTED WETLAND, A PROMISING DECENTRALIZED WASTEWATER TREATMENT ALTERNATIVE IN VIETNAM" Anh Viet Ngyuyen, Nga Thuy Pham, Thang Huu Nguyen, Antoine Moral and Karin Tonderski, Paper XI-RCS-07-30 NOWRA 16th Annual Technical Education Conference & Exposition (Baltimore, Maryland, March 2007)

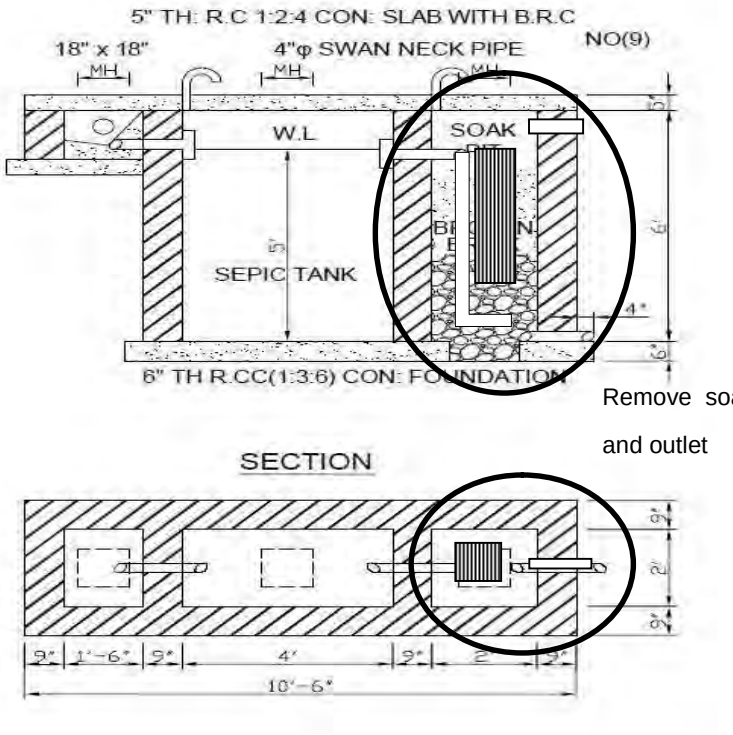


Source: JICA Study Team

Figure 5.4 Septic Tank with Baffles and Anaerobic Filter

Retention time is recommended to be 2 days. Reduction of COD and SS can be expected to be 80 to 90 %. Settled sludge should be removed once per 2 years to maintain reduction efficiency.

A sample of remodeling of the existing septic tank (10 persons) is illustrated in Figure 5.5. Improvement of reduction efficiency can be expected.



Source: JICA Study Team

Figure 5.5 Sample of Remodeling of Septic Tank (10 persons)

Same remodeling can be applied to septic tanks for 100 and 200 persons. YCDC is recommended to investigate the results of research conducted by Hanoi University, and to conduct bench scale and pilot scale experiments with Yangon Institute of Technology. Once effectiveness of the system is confirmed,

improvement of the existing septic tanks can be implemented and design criteria for new systems which will be installed in suburban areas should be established.

5.4.2 Systems for Collection and Treatment of Black Water Together with Gray Water

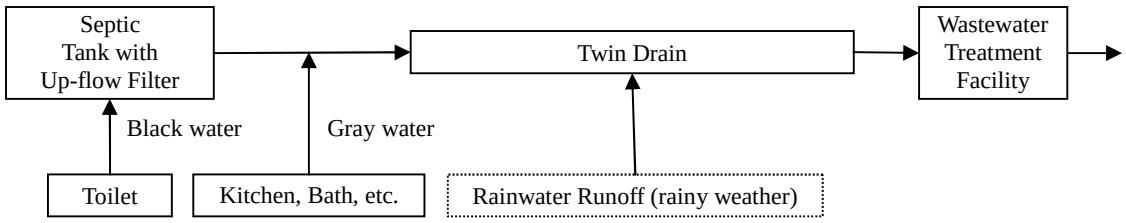
Finally, systems to collect and treat black water and gray water together are studied. The following two systems are considered.

Systems to collect and treat septic tank effluent and gray water

1 Twin drain system (India, Tamil Nadu)
2 Interceptor sewerage system (Manila, the Philippines)

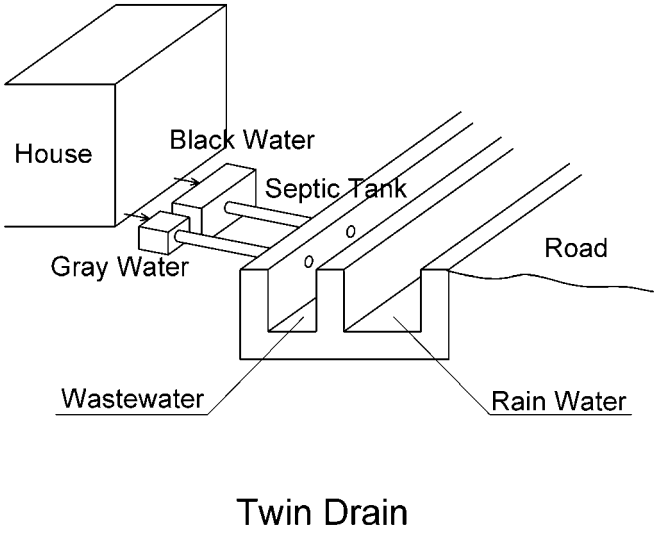
(1) Twin drain system

This system was constructed in Tamil Nadu, India with houses for refugees of Tsunami in 2004. Twin drains were constructed along with roads, in which the drain on house side is used for wastewater, and the drain on road side is used for storm water runoff. Wastewater is conveyed to a treatment plant. Outline and concept of the system are shown in Figures 5.6 and 5.7 respectively.



Source: JICA Study Team

Figure 5.6 Diagram of Twin Drain System



Source: JICA Study Team

Figure 5.7 Concept of Twin Drain

Converting the existing drains in the existing urban areas to twin drain system is very difficult because of limitation of space and difficulty to change house connections. On the other hand, it is possible to adopt the system outside of sewerage service area or in newly developed areas, on condition that site for low cost treatment plant such as oxidation pond, is secured near discharging point.

(2) Interceptor sewerage system

This system is planned in Manila, the Philippines to reduce initial construction cost by omitting provision of lateral sewers and house connections at initial stage which require huge amount of investment. Interceptors and a wastewater treatment plant are constructed at initial stage to reduce pollutant loads. Wastewater is collected by interceptors and conveyed to a treatment plant. Lateral sewers and house connections are provided later and the system converted to conventional separate system finally. Therefore, wastewater intercepted is equal to dry weather flow (1 Q). Description of the system, advantages and disadvantages, is given later in Section 6.2.3. Interceptor sewerage system utilize the existing storm water drains as branch sewers which require high construction cost, construction of branch sewers can be postponed. This system should be considered as one of the options of sewerage system implementation.

5.4.3 Reduction of Pollutant Load by Sewerage System and Other Systems

Evaluation of pollutant load reduction in case of with or without sewerage project is conducted. Other reduction systems such as Johkaso and community plant other than septic tank are also evaluated in terms of pollution load reduction. Reduction rate of septic tank is explained in Section 6.2.1, and those of Johkaso are explained in Section 6.2.2.

For the evaluation, the following simple assumptions are made to estimate BOD load discharged from the origins to the basin. Current population in YCDC, i.e. 5.14 million is classified into three groups based on the results of Household Interview Survey.

1) Sewerage service population (black water only), (5 %, 0.26 million)
2) Black water by septic tank, gray water no treatment population (43 %, 2.21 million)
3) Black water and gray water no treatment population (52 %, 2.67 million)

The following three cases are assumed based on the assumption above.

Case-1: No sewerage project, increment of the population will be provided with septic tanks
Case-2: Sewerage project is implemented as planned, increment of population which is not served with sewerage system is provided with septic tanks
Case-3: Sewerage project is the same as in Case-2, increment of population which is not served with sewerage system is served with Johkaso or community plants

BOD load and its reduction are calculated based on the following conditions.

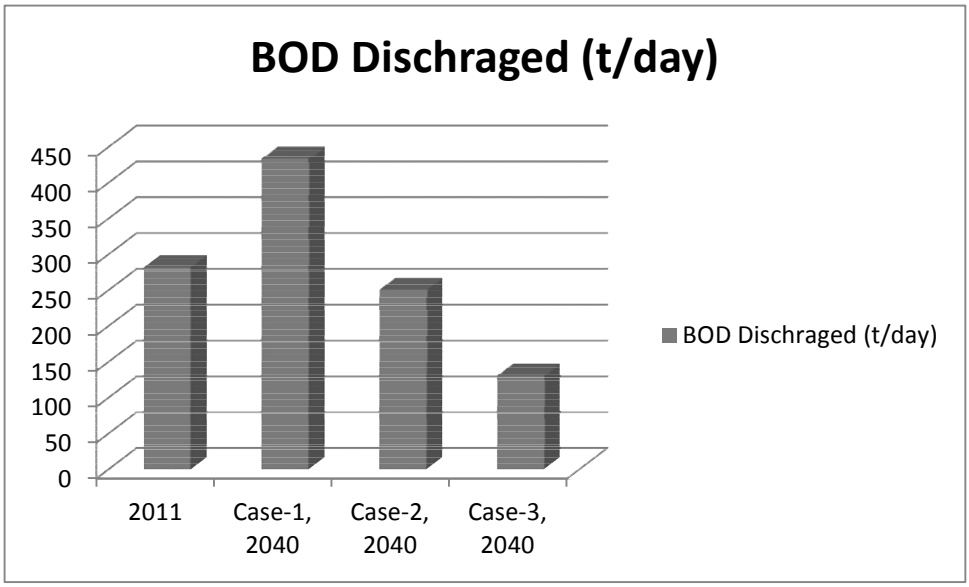
Per capita BOD load: 40 gcpd (black water 13 gcpd and gray water 27 gcpd)
Reduction rate by septic tank: 50 % for black water
Reduction rate by sewerage system, Johkaso and community plant: 90 %

Results are shown in Table 5.4 and Figure 5.8.

Table 5.4 BOD Load Discharged

	BOD Dischraged (t/day)
2011	282
Case-1, 2040	434
Case-2, 2040	251
Case-3, 2040	131

Source: JICA Study Team



Source: JICA Study Team

Figure 5.8 BOD Load Discharged

Pollutant load will increase by 50 % if sewerage system is not provided and wastewater treatment is fully relied on septic tank resulting in worsening of water pollution in rivers. On the other hand, if sewerage project is implemented as planned, pollution load will decrease less than the current figure instead of population growth. If increased population outside of the sewerage service area is provided with Johkaso or community plant whose pollution load reduction efficiency is equal to that of sewerage system, pollution load is reduced to less than half of the current figure, and improvement in the control of water pollution can be expected. Significant improvement in water pollution control cannot be expected only by provision of sewerage system. Therefore, appropriate measures need to be considered for approximately half of the total population who cannot be provided with sewerage services.

CHAPTER 6. PLANNING CONSIDERATIONS AND BASIC POLICY

6.1 Planning Frame

6.1.1 Population Projection

Population projection by township estimated under "JICA Urban Plan Study, 2012" is used which is the same projection as for water demand estimation. Population projection is shown in Table 6.1. Population of YCDC, which was 5.14 million in 2011, is estimated to increase to 6.46 and 8.52 million in 2025 and 2040, respectively. Total population of 39 townships which was 5.57 million in 2011 is estimated to increase to 7.98 and 11.73 million in 2025 and 2040, respectively.

Table 6.1 Population Projection by Township

Code	Township Group	Township	Population (persons)						
			2011	2018	2020	2025	2030	2035	2040
1	CBD	Latha	34,125	34,125	34,125	34,125	34,125	34,125	34,125
2	CBD	Lanmadaw	43,137	43,137	43,137	43,137	43,137	43,137	43,137
3	CBD	Pabedan	37,551	37,551	37,551	37,551	37,551	37,551	37,551
4	CBD	Kyauktada	34,797	34,797	34,797	34,797	34,797	34,797	34,797
5	CBD	Botahtaung	49,134	49,134	49,134	49,134	49,134	49,134	49,134
6	CBD	Pazundaung	53,648	54,182	54,353	54,822	55,354	55,959	56,647
7	IUR	Ahlone	65,510	66,044	66,215	66,684	67,216	67,821	68,509
8	IUR	Kyee Myin Daing	115,841	121,718	123,600	128,751	134,607	141,265	148,835
9	IUR	Sanchaung	105,208	105,742	105,913	106,382	106,914	107,519	108,207
10	IUR	Dagon	24,492	28,766	30,135	33,881	38,140	42,982	48,488
11	IUR	Bahan	100,695	102,298	102,811	104,216	105,813	107,629	109,693
12	IUR	Tarmwe	191,114	192,182	192,525	193,461	194,526	195,737	197,113
13	IUR	Mingalar Taung Nyunt	155,767	157,370	157,883	159,288	160,885	162,701	164,765
14	IUR	Seikkan	2,241	2,241	2,241	2,241	2,241	2,241	2,241
15	IUR	Dawbon	87,284	87,818	87,989	88,458	88,990	89,595	90,283
16	ORZ	Kamaryut	87,881	90,552	91,408	93,749	96,411	99,437	102,878
17	ORZ	Hlaing	151,014	153,151	153,835	155,708	157,838	160,259	163,012
18	ORZ	Yankin	125,909	125,909	125,909	125,909	125,909	125,909	125,909
19	ORZ	Thingangyun	231,621	233,758	234,442	236,315	238,445	240,866	243,619
20	NS	Mayangone	205,403	216,622	220,215	230,049	241,229	253,940	268,392
21	NS	Insein	311,200	322,953	326,718	337,019	348,732	362,048	377,188
22	NS	Mingalardon	288,858	398,909	434,158	530,621	640,293	764,983	906,748
23	OldSZ	North Okkalapa	333,484	349,511	354,644	368,692	384,664	402,823	423,468
24	OldSZ	South Okkalapa	191,388	192,456	192,799	193,735	194,800	196,011	197,387
25	OldSZ	Thaketa	253,284	258,092	259,632	263,846	268,638	274,086	280,279
26	SCBD	Dala	181,087	236,112	253,737	301,968	356,804	419,150	490,032
27	SCBD	Seikgyikhanaungto	38,425	44,836	46,889	52,508	58,897	66,160	74,419
28	NewSZ	Shwe Pyi Thar	295,993	334,992	347,483	381,666	420,531	464,717	514,954
29	NewSZ	Hlaing Tharyar	488,768	533,109	547,311	586,177	630,366	680,605	737,724
30	NewSZ	North Dagon	221,200	232,953	236,718	247,019	258,732	272,048	287,188
31	NewSZ	South Dagon	370,403	402,457	412,724	440,819	472,763	509,080	550,371
32	NewSZ	East Dagon	145,505	330,348	389,553	551,573	735,779	945,210	1,183,320
33	NewSZ	Dagon Seikkan	120,161	169,844	185,758	229,306	278,818	335,111	399,111
	YCDC Su-total		5,142,128	5,743,669	5,936,343	6,463,609	7,063,078	7,744,637	8,519,527
34	Out of YCDC	Kyauktan	48,473	67,171	73,160	89,549	108,183	129,368	153,454
35	Out of YCDC	Thanlyin	181,959	371,076	431,650	597,416	785,881	1,000,154	1,243,770
36	Out of YCDC	Hlaegu	50,793	136,804	164,353	239,744	325,458	422,910	533,707
37	Out of YCDC	Hmawbi	83,719	167,059	193,752	266,802	349,854	444,280	551,636
38	Out of YCDC	Htantapin	40,234	103,807	124,170	179,893	243,247	315,277	397,170
39	Out of YCDC	Twantay	24,936	79,427	96,881	144,644	198,947	260,687	330,882
	Out of YCDC Sub-total		430,114	925,344	1,083,966	1,518,048	2,011,570	2,572,676	3,210,619
	Total		5,572,242	6,669,013	7,020,309	7,981,657	9,074,648	10,317,313	11,730,146

Source: JICA Urban Plan Study, 2012

6.1.2 Wastewater Generation

Wastewater generated is estimated based on quantity of water distributed by water supply system. Wastewater is water consumed by houses, public and commercial establishments plus infiltration. Water consumed equals to water distributed minus leakage. Industrial wastewater produced by large scale factories which have their own water resources is not counted as wastewater. These factories should treat their wastewater by themselves to comply with discharge water quality standards.

Three kinds of wastewater generation are estimated, i.e. daily average, daily maximum and hourly maximum. Daily average is calculated by dividing annual total wastewater by 365, and this is used for calculation of sewerage fee revenue. Daily maximum is the largest one day wastewater generation, and this is used for design of WWTP. Hourly maximum is one hour peak flow at daily maximum flow, and this is used for design of pipe networks, pumps and conduits and pipes in WWTP. Daily maximum is 1.1 times daily average, and hourly maximum is 1.5 times daily maximum. These ratios are the same as in case of water supply master plan.

Data or design criteria for infiltration are not available, thus 10 m^3/ha/day which is adopted for Bangkok is adopted because of the similar characteristics of the both cities. However, amount of infiltration sometimes shows extremely high figures, since the amount is calculated based on the area. New development areas which are to be developed in the future are most likely to have huge vacant areas. Amount of infiltration in these areas tends to be excessively high. Therefore for these areas maximum infiltration is assumed to be 30 % of wastewater. Wastewater generation up to 2040 is shown in Table 6.2 below. Infiltration is constant even for daily maximum and hourly maximum.

Table 6.2 Wastewater Generation (Daily Average)

Code	Township	2011			2025			2040		
		Wastewater	Infiltration	Total	Wastewater	Infiltration	Total	Wastewater	Infiltration	Total
1	Latha	13,373	600	13,973	15,513	600	16,113	15,167	600	15,767
2	Lanmadaw	17,938	1,310	19,248	19,609	1,310	20,919	19,171	1,310	20,481
3	Pabedan	20,076	610	20,686	17,069	610	17,679	16,689	610	17,299
4	Kyauktada	17,276	670	17,946	15,818	670	16,488	15,464	670	16,134
5	Botahtaung	11,776	2,580	14,356	15,633	2,580	18,213	21,837	2,580	24,417
6	Pazundaung	15,324	1,040	16,364	24,918	1,040	25,958	25,176	1,040	26,216
7	Ahlone	7,405	3,290	10,695	9,095	3,290	12,385	18,269	3,290	21,559
8	Kyee Myin Daing	3,703	4,520	8,223	17,558	4,520	22,078	39,689	4,520	44,209
9	Sanchaung	10,492	2,390	12,882	14,505	2,390	16,895	28,856	2,390	31,246
10	Dagon	6,438	4,640	11,078	10,782	4,640	15,422	21,551	4,640	26,191
11	Bahan	31,414	7,670	39,084	33,160	7,670	40,830	48,753	7,670	56,423
12	Tarmwe	58,662	4,990	63,652	79,142	4,990	84,132	87,607	4,990	92,597
13	Mingalar Taung Nyunt	26,459	600	27,059	50,682	600	51,282	73,229	4,780	78,009
14	Seikkan	0	0	0	305	92	397	597	134	731
15	Dawbon	2,289	610	2,899	12,064	610	12,674	24,076	2,950	27,026
16	Kamaryut	6,724	2,017	8,741	12,785	3,836	16,621	27,433	6,173	33,606
17	Hlaing	12,614	2,580	15,194	21,233	2,580	23,813	43,469	9,250	52,719
18	Yankin	27,724	1,040	28,764	28,615	1,040	29,655	44,767	4,780	49,547
19	Thingangyun	20,873	3,290	24,163	53,709	3,290	56,999	86,620	12,090	98,710
20	Mayangone	29,870	8,961	38,831	52,285	15,686	67,971	95,429	21,472	116,901
21	Insein	26,441	7,932	34,373	45,958	13,787	59,745	100,584	22,631	123,215
22	Mingalardon	14,751	4,425	19,176	72,358	21,707	94,065	241,800	54,405	296,205
23	North Okkalapa	51,073	7,670	58,743	117,313	7,670	124,983	188,209	26,460	214,669
24	South Okkalapa	25,473	7,960	33,433	44,031	7,960	51,991	70,183	7,960	78,143
25	Thaketa	6,454	12,600	19,054	35,978	12,600	48,578	74,743	12,600	87,343
26	Dala	1,176	353	1,529	27,451	8,235	35,686	98,007	22,052	120,059
27	Seikgyikhanaungto	4,108	1,232	5,340	11,140	3,342	14,482	24,807	5,582	30,389
28	Shwe Pyi Thar	3,751	1,125	4,876	34,696	10,409	45,105	102,991	23,173	126,164
29	Hlaing Thar yar	2,432	730	3,162	53,287	15,986	69,273	147,544	33,197	180,741
30	North Dagon	14,149	4,245	18,394	37,427	11,228	48,655	76,584	17,231	93,815
31	South Dagon	8,716	2,615	11,331	40,076	12,023	52,099	110,073	24,767	134,840
32	East Dagon	2,851	855	3,706	50,142	15,043	65,185	236,664	53,249	289,913
33	Dagon Seikkan	0	0	0	20,845	6,254	27,099	79,823	17,960	97,783
YCDC Sub-total		501,805	105,151	606,956	1,095,182	208,287	1,303,469	2,305,861	417,206	2,723,067
34	Kyauktan	0	0	0	1,493	448	1,941	15,345	4,604	19,949
35	Thanlyin	0	0	0	9,957	2,987	12,944	124,377	37,313	161,690
36	Hlaegu	0	0	0	3,995	1,199	5,194	53,370	16,011	69,381
37	Hmawbi	0	0	0	4,447	1,334	5,781	55,163	16,549	71,712
38	Htantapin	0	0	0	2,998	899	3,897	39,717	11,915	51,632
39	Twantay	0	0	0	2,410	723	3,133	33,088	9,926	43,014
Out of YCDC Sub-total		0	0	0	25,300	7,590	32,890	321,060	96,318	417,378
Total		501,805	105,151	606,956	1,120,482	215,877	1,336,359	2,626,921	513,524	3,140,445

Source: JICA Study Team

6.2 Wastewater Treatment Other Than Sewerage System

6.2.1 Possibility to Reduce Pollution Load by Septic Tank and Its Improvement

Installation of septic tank which treats toilet wastewater is compulsory when houses and buildings are constructed (refer to Section 3.2). Pour-flush toilet is the only sanitary toilet system for households which receive insufficient water supply, and suitable treatment system may be limited to septic tank. Therefore, while water supply is insufficiently provided, installation of septic tank will be continued in the future. However, septic tank system is said to be incomplete treatment system in view of water pollution control because of the reasons mentioned below.

Pollutant load generated from households can be divided into two categories, viz. black water (toilet) and gray water (kitchen, bathroom etc.). BOD load generated from black water and gray water accounts for 30 % and 70 % respectively (refer to Table 6.3). This kind of data is not available in Myanmar, reduction of pollutant load by septic tank is discussed here referring to Japanese samples.

BOD reduction rate in a septic tank is assumed to be 50 % taking into consideration reduction in anaerobic digester since the same reaction occurs in both processes. Thus, reduction rate of black water pollution is only 15.5 % as shown in Table 6.4 (refer to Figure 6.1). In case black water and gray water are treated together, reduction rate becomes 50% as shown in Table 6.5 (refer to Figure 6.2).

On the other hand, overall reduction rate reaches 90 % in case of sewerage system. Therefore septic tank is said to be an insufficient treatment system from the view point of reduction of pollutant load.

Table 6.3 Breakdown of Domestic Pollutant Load

Parameter	Average (g/cap/day)	Standard Deviation (g/cap/day)	Number of Data	Average (g/pc/day)	
				Excreta	Gray Water
BOD	58	17	169	18	40
COD	27	9	153	10	17
SS	45	16	169	20	25
T-N	11	3	29	9	2
T-P	1.3	0.4	25	0.9	0.4

Source: Design and Planning Manual of Sewerage System, Japan Sewerage Works Association

Table 6.4 Reduction of Pollution Load (BOD) by Septic Tank and Sewerage System (Black water)

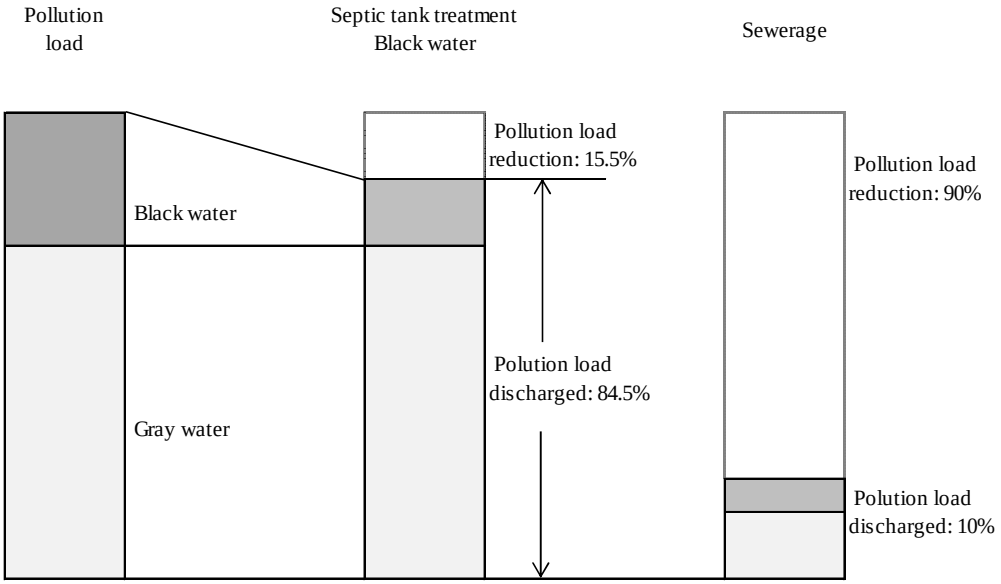
Pollution Source	Load (g/cap/day)	Treatment Efficiency (%)	Effluent Load (g/cap/day)	Removal Rate (%)	Sewerage System
Excreta	18	50	9	－	Removal Rate 90%
Gray Water	40	0	40	－	
Total	58	－	49	15.5	

Source: JICA Study Team

Table 6.5 Reduction of Pollution Load (BOD) by Septic Tank and Sewerage System (Black water + Gray water)

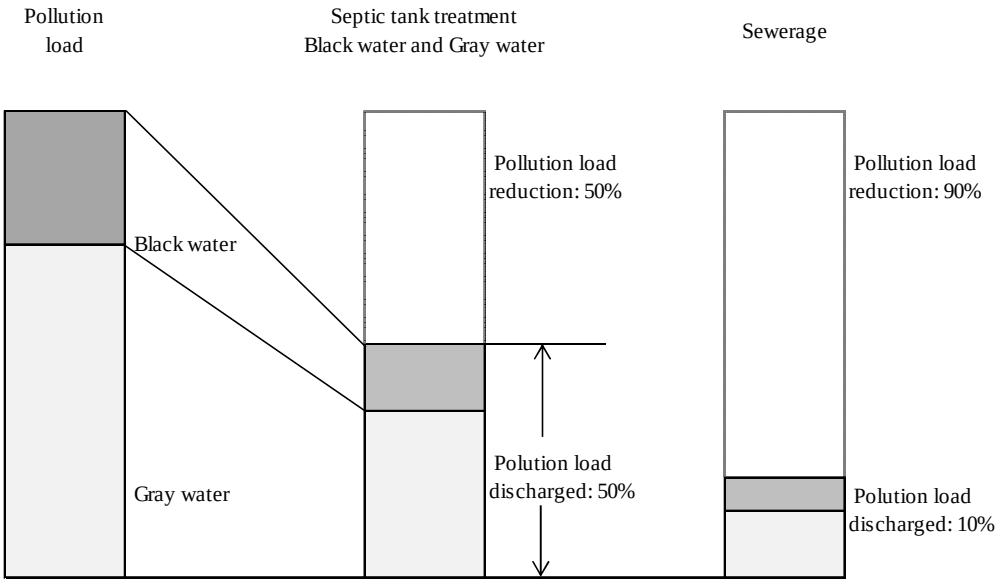
Pollution Source	Load (g/cap/day)	Treatment Efficiency (%)	Effluent Load (g/cap/day)	Removal Rate (%)	Sewerage System
Excreta	18	50	9	－	Removal Rate 90%
Gray Water	40	50	20	－	
Total	58	－	29	50.0	

Source: JICA Study Team



Source: JICA Study Team

Figure 6.1 Efficiency of Septic Tank (Black water)



Source: JICA Study Team

Figure 6.2 Efficiency of Septic Tank (Black water + Gray water)

Actual improvement measures of septic tanks in YCDC will be clarified by studies mentioned in the previous Section 5.4.1.

6.2.2 Community Plant and Johkaso

While septic tank can treat only toilet wastewater, there is a method to treat both excreta and gray water together, which is called "Johkaso". Johkaso is manufactured in a factory and easily installed at the site. Removal rate can be expected to be 90 % which is equal to that of sewerage system. Johkaso can be considered to have the same efficiency as sewerage system. However, there is a certain limitation in terms of the capacity of the Johkaso since it is manufactured in a factory and should be transported to the site. Approximately 100 m^3/day is the limit. This capacity is equivalent to 1,000 persons assuming per capita water consumption of 100 lpcd. Therefore, Johkaso can be applied to households and to commercial or public buildings. Example of a small size Johkaso for a household is illustrated in Figure 6.3.

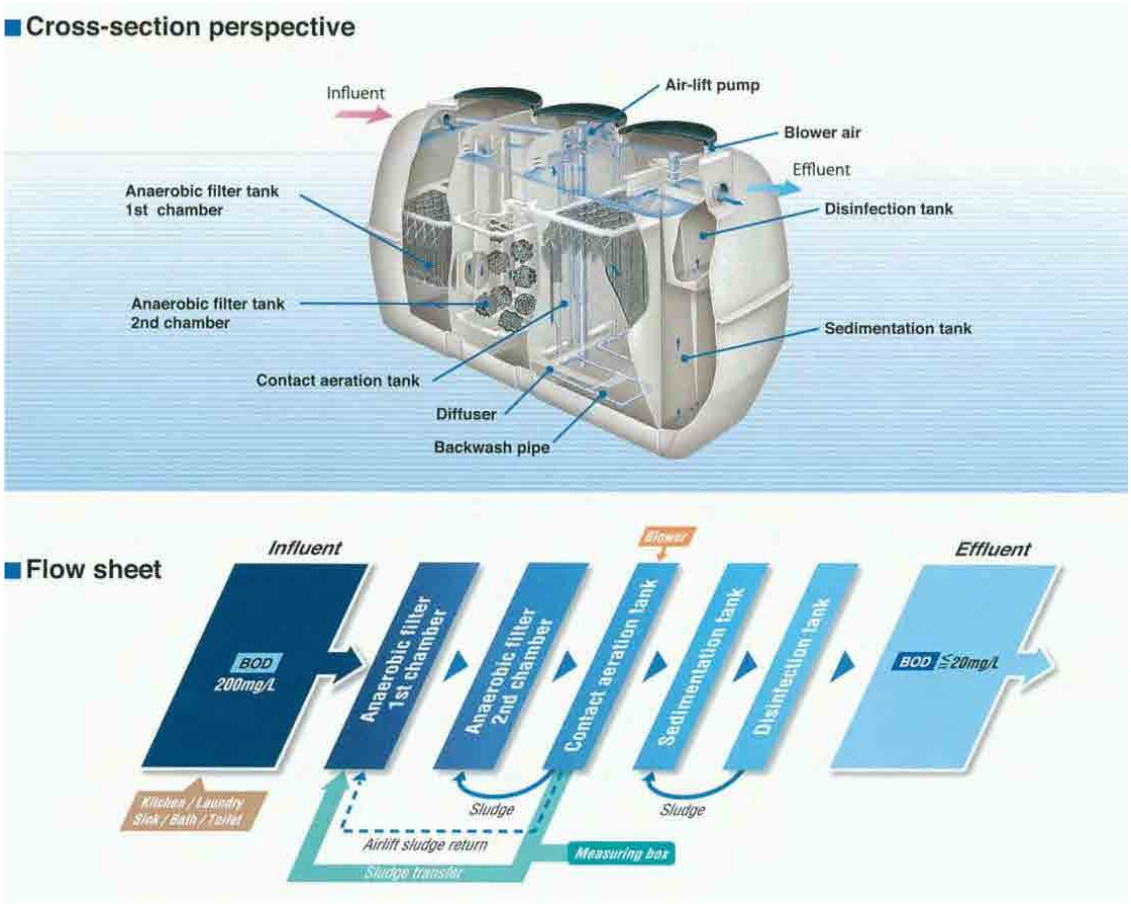
In Southeast Asian countries, Johkaso treats wastewater more efficiently than in Japan because of higher temperature. However, construction cost is in general 3 to 4 times that of septic tank and electricity is required for operation. Johkaso can be applied only to high income residents or commercial establishment such as restaurants in Yangon.

In case of large scale housing development, a small scale sewerage system can be constructed by the developer. This system is sewerage system itself which treats black water and gray water, and is generally called as community plant in Japan. Activated sludge process such as conventional, extended aeration or sequential batch reactor is most commonly used for community plant. In addition, oxidation ditch and contact oxidation can be applied. Therefore, the same removal efficiency as WWTP can be expected. Community plant can be applied both in and out of sewerage planning area. In case that a community plant is constructed in a sewerage planning area, sewer networks can be utilized as they are and connected to the public sewerage system and treatment plant is to be closed when the public sewerage system starts operation. Concept of converting community plant and Johkaso which are constructed in sewerage planning area to sewerage system is shown in Figure 6.4.

In other countries, community plant is not only improperly operated and treatment not carried out efficiently, but this situation also hinders intention to connect to the sewerage system. Installation of community plant is to be institutionalized, control including penalty rules by authority concerned should also be introduced to carry out proper operation and maintenance.

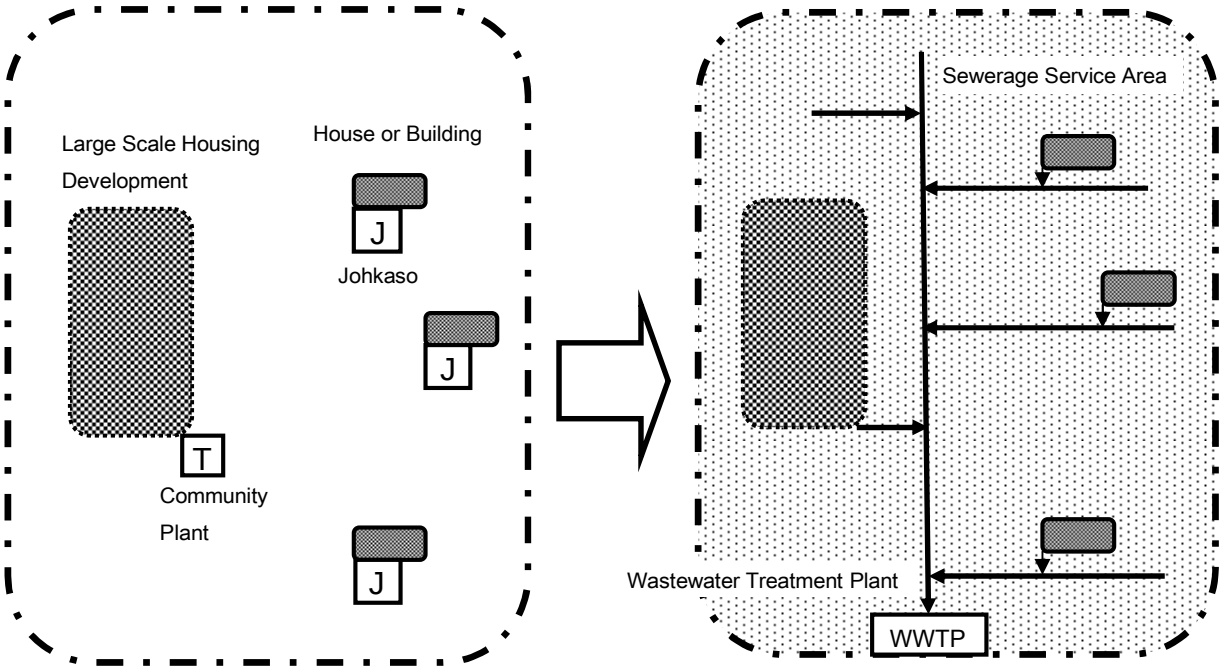
Periodical operation and maintenance is required for Johkaso and community plant. Department of Water Supply and Sanitation, YCD may provisionally be engaged in operation and maintenance of community plant which is constructed by public authority since the system is actually small scale sewerage system. Community plant which is constructed by private undertaking and Johkaso may be operated and maintained by concerned department of YCDC, however, private companies should be

nurtured and it is better that these private companies are engaged in operation and maintenance of the facilities. In future, operation and maintenance of community plants under responsibility of YCDC should also be transferred to private companies.



Source: Japanese Manufacturer

Figure 6.3 An Example of Johkaso



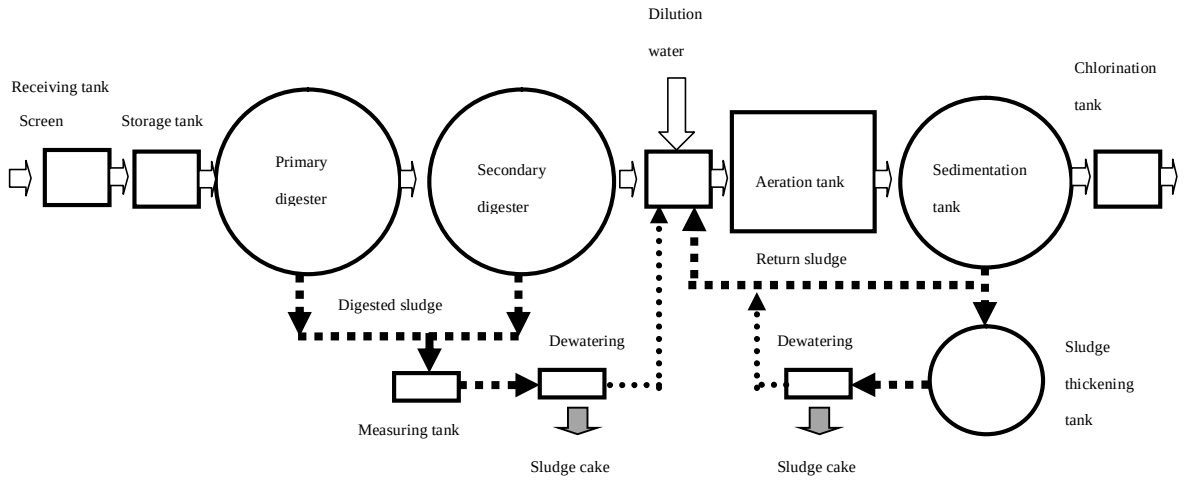
Source: JICA Study Team

Figure 6.4 Conversion of Community Plant and Johkaso to Sewerage System

6.2.3 Treatment of Septic Tank Sludge

Currently, septic tank sludge is transported to the existing wastewater treatment for treatment and disposal. This operation results in high BOD and COD concentrations of inflow to wastewater treatment. Therefore, construction of treatment plant to treat septic tank sludge is recommended. In Japan, several treatment processes are used for human excreta treatment. Among them, combination of anaerobic process and aerobic process is considered to be appropriate since organic matters concentration is expected to be high considering current characteristics of inflow to the treatment facility. An example of the combination of processes is shown in Figure 6.5. Two stage anaerobic digestion is adopted followed by activated sludge process. Dilution water (20 times sludge) is added before activated process. Target effluent water quality is as follows.

Target water quality	BOD	30 mg/l
	SS	70 mg/l
	E-coli	3,000 nos./cm^3



Source: JICA Study Team

Figure 6.5 Example of Septic Tank Sludge Treatment

Quantity of current septic tank sludge in YCDC is estimated to be 100 to 140 m^3/day on daily average basis based on the operation records of vacuum cars. Therefore, construction of two treatment plants each having 100 m^3/day capacity at proposed solid waste disposal sites is recommended.

6.3 Considerations for Sewerage System Planning

6.3.1 Sewerage System

Sewerage system is in general divided into two categories, viz. separate system and combined system. Separate system collects wastewater and storm water runoff separately, and combined system collects both of them in the same pipe. Separate system is adopted for Yangon City for the reasons mentioned below. There is no YCDC regulation regarding sewerage system.

1 Existing sewerage system is separate system
2 Rainfall intensity is very high resulting in excessively large diameter of combined pipes
3 Rainfall runoff is easily collected and discharged to nearby rivers and creeks
4 Reduction of pollutant load is larger than that of combined system, and this is an advantage for water pollution control

(1) Service area of the existing sewerage system is very limited and the system only collects toilet wastewater (black water). It is said to be as incomplete sewerage system, however it is considered to be a kind of separate system, since rainfall runoff is collected separately by drains. Moreover, it is much more economical to newly construct separate sewer pipes and improve the existing house connections than to newly construct combined sewer pipes when the existing system is to

be improved.

(2) Rainfall intensity in Yangon based on 5-year return period is approximately 63 mm/hour. Assuming a residential area with 4,000 persons in 20 ha, sewage flow and storm water runoff (peak flow) are calculated to be 0.0177 m^3/sec and 3.463 m^3/sec respectively. Storm water runoff is about 200 times sewage flow. This ratio decreases as catchment area increases. However, storm water runoff is far larger than sewage flow. Because of this, storm overflow chambers are provided in the catchment to discharge excessive flow to the nearby drains or rivers. Interceptors after storm overflow chambers collect 3 to 5 times sewage flow. In any case, obviously diameter of combined sewer becomes much larger than that of separate sewer.

(3) Central part and old urbanized areas in Yangon are surrounded by Pazundaung Creek (upstream is called as Ngamoeyeik Creek) in the east, Yangon River in the south and Hlaing River in the west, and its configuration is long in north-south direction. The maximum width between Pazundaung Creek and Hlaing River is 15 km. Gently-sloping with 30 m elevation runs through the center of the area in north-south direction. Thus, storm water runoff in the central part and old urbanized areas can be discharged to the rivers in a short period. Currently urbanization has proceeded beyond Pazundaung Creek and Hlaing River. Areas east to Pazundaung Creek and west to Hlaing River are very flat and low-lying. Situation of storm water runoff in these areas is quite different from that in the central part and old urbanized areas.

(4) In case of combined system, wastewater is discharged to receiving water bodies in wet weather because wastewater and storm water runoff is collected in the same sewer. Storm water runoff is far larger in quantity than wastewater flow as mentioned earlier, and entire flow cannot be conveyed to WWTP. Excess amount of flow which exceeds 3 to 5 times wastewater flow is discharged to the nearby drains or rivers. Pollutant load which is discharged to the receiving water bodies by combined system reaches almost double compared to separate system. This is significant disadvantage of the combined system from water quality control view point. In a study conducted for Matsudo City in Chiba Prefecture which is located next to Tokyo, annual pollutant load (BOD) into the sewerage system which is estimated to be 694.8 t/year can be reduced to 73.3 t/year (reduction 89.5 %) by separate system, comparing to 129.6 t/year (81.3 %) by combined system.

It should be noted that connection to the sewerage system is not progressed in some existing urban area in case of separate system.

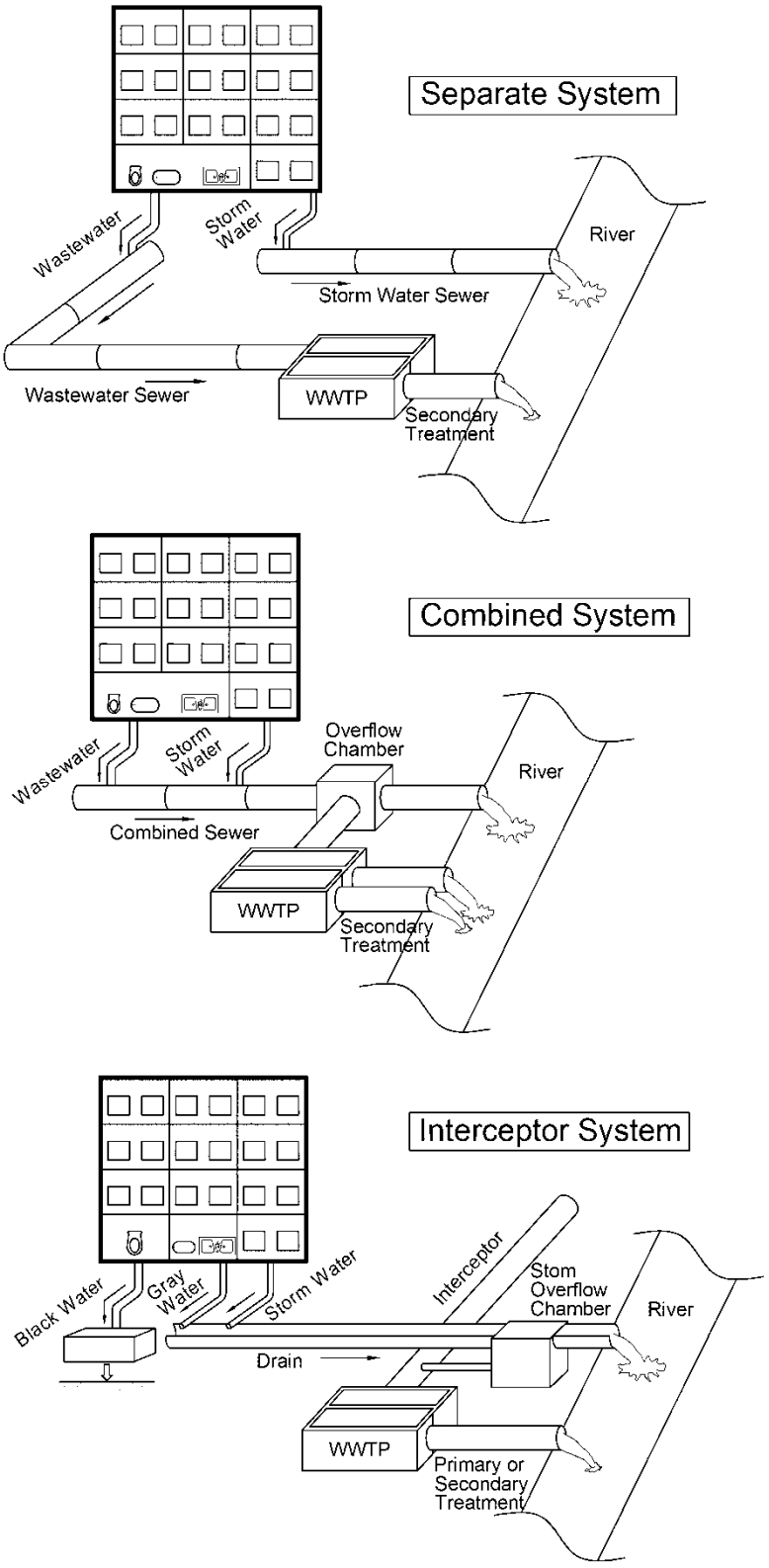
In addition to separate and combined systems, interceptor sewerage system can be considered as temporary system. Interceptor sewerage system is finally converted to conventional systems. This system consists of storm water overflow chambers and interceptors. The former intercepts dry weather flow to the existing drains immediately before rivers and overflows excessive storm water runoff. The latter collects wastewater from storm water overflow chambers and convey it to the treatment plant.

Construction of lateral sewers and house connection which require huge amount of investment can be avoided at initial stage resulting in earlier improvement of water pollution in water bodies. However mixed wastewater and storm water is discharged from storm water overflow chambers when it rains because both of them flow in the existing drains. Therefore, reduction of pollutant load is less than that of separate system.

Intercepting flow is 5 times dry weather flow (5Q) in Bangkok and 1Q in Manila. In Bangkok, 2Q is preliminary treated (screen and grit chamber), 2Q is primary treated and the remaining 1Q is secondary treated at the WWTP. Efficiency of reduction of pollutant load is almost equal to that of combined sewerage system. On the other hand, in case of Manila, interceptor sewerage system is to be converted to separate system finally and interceptors are used as trunk mains, therefore, 1Q, i.e. dry weather flow, is intercepted. From pollution load reduction view point, this system is inferior to separate system and 5Q collecting system.

For Yangon, interceptor sewerage system which collects 1Q as planned for Manila can be applied since provision of separate system is final target.

Three types of sewerage system are illustrated in the following Figure 6.6.



Source: JICA Study Team

Figure 6.6 Three Types of Sewerage System

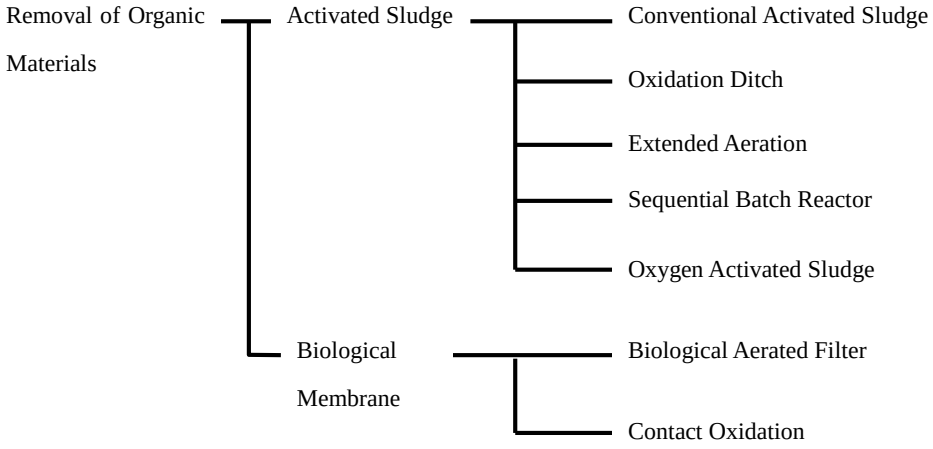
6.3.2 Characteristics of Wastewater

In order to estimate future wastewater characteristics, per capita BOD load is assumed to be 40 g taking into account examples in neighboring countries. BOD concentration is calculated to be 173 mg/l based on average per capita wastewater flow in 2040, i.e. 221 lpcd (consumption 187 l + infiltration 43 l). For planning purposes, BOD concentration is determined to be 200 mg/l. SS concentrations is determined to be 180 mg/l taking into account BOD and SS ratio monitored in treatment plants in Japan, i.e. 1.125: 1.

6.3.3 Wastewater Treatment and Disposal

Secondary treatment by biological processes is selected taking into account water pollution control in water bodies, reuse of treated effluent and sludge in the future. Biological treatment has a significant advantage that the process requires less energy compared to other processes. Biological process can be said to be the most suitable process to treat organic materials which are main pollutant of domestic wastewater. Biological secondary treatment is applied for wastewater treatment all over the world. Treatment process adopted for the existing WWTP in Yangon is also activated sludge process (extended aeration).

Biological treatment process which reduces organic materials are classified and described below.



Other treatment processes such as oxidation pond and aerated lagoon are applied for wastewater treatment. However, these processes require huge land space and cannot be applied in such a densely urbanized area as Yangon although these processes have advantages of less mechanical equipment and less energy requirement. Oxidation ditch and contact oxidation processes are applied to relatively small plants because of ease of operation and maintenance. These processes may be applied to small scale WWTP in suburbs of YCDC.

Among the biological treatment processes mentioned above, conventional activated sludge process which is oldest and most commonly used is selected at the stage of master planning. Stable treatment can be expected for conventional activated sludge process. Other modified activated sludge processes will be considered according to the specific conditions of the possible site for construction of WWTP.
Water quality standards for treated effluent are yet to be stipulated in Myanmar. Therefore the following limits commonly used for treated effluent by activated sludge process are adopted.

Table 6.6 Effluent Standards

Parameter	Limit
BOD	20 mg/l
SS	30 mg/l

Source: JICA Study Team

Treated effluent should be discharged either to Pazundaung Creek or to Hlaing River. Sections of these rivers in YCDC are influenced by tide. Reuse of treated effluent for beautification or industrial purposes will be considered in the future.

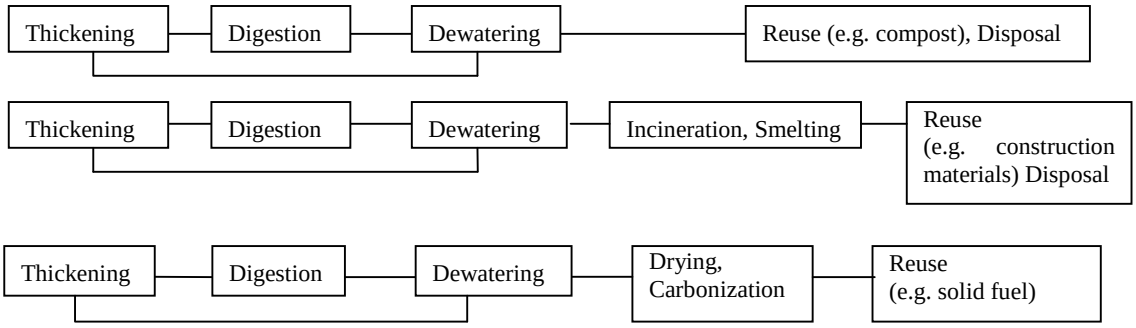
6.3.4 Sludge Treatment and Disposal

Sludge generated in the existing WWTP is small in quantity because it receives only limited amount of wastewater. Dried sludge is reused as manure or soil conditioner for parks. However, its quantity is not recorded. Large quantity of sludge will be produced as sewerage system will be developed. Reduction of sludge volume or effective reuse of sludge will become important issue in the future. Realization of recycle society and countermeasures against global warming has become global issues, and it is important to convert the current system to a new system which can reuse sludge as natural or energy resource.

Sludge treatment is a combination of unit processes which comprises mostly reduction of volume and stabilization of sludge. For each purpose, the following unit processes are considered.

Reduction of volume: Thickening, Dewatering and Drying
Reduction of solid materials: Digestion, Incineration and Smelting
Stabilization: Anaerobic digestion, Composting, Incineration, Carbonization and Converting to fuel

Optimum combination of the processes is dependent on final disposal. The following shows representative examples of the combination. Digestion in the following Figure can be omitted and direct connection from thickening to dewatering is possible.



Taking into account current land use and electric power supply conditions in Yangon, reuse of sludge as compost to green and agriculture lands is recommended. Therefore, combination of thickening and dewatering is adopted as sludge treatment process. In case additional land space is available, digestion is to be considered.

For reuse of sludge, concentration of heavy metals in sludge becomes problem in advanced countries in terms of sewerage system. It is very important that control of industrial wastewater should be carried out to satisfy standards. In order to receive industrial wastewater into the sewerage system, it is important for each factory to strictly maintain the effluent discharge standards.

6.3.5 Design Criteria for Sewerage Facilities

Design criteria are determined as described below referring to the Japanese standards since there are no design criteria in Myanmar.

Minimum diameter of pipe

Basically minimum diameter of pipe is 200 mm.

Flow friction formula

Manning formula shown below is used.

$$v = \frac{1}{n} R^{\frac{2}{3}} I^{\frac{1}{2}}$$

Where

v：velocity（m/s）
n：Manning’s friction factor
R：hydraulic radius (m)
I：pipe gradient (-)

Manning’s friction factor n is taken as 0.013 assuming that all pipes are concrete pipe.

Minimum and maximum velocity

Generally flow in a sewer is gravity flow. Minimum velocity is determined not to accumulate sediments in pipes. Maximum velocity is determined to prevent erosions of pipes and manholes by excessively high velocity. Proper diameter and gradient should be determined considering minimum and maximum velocities. For preliminary design, minimum and maximum velocities are determined as follows.

Minimum velocity = 0.6 m/s, Maximum velocity = 3.0 m/s

Minimum covering depth and minimum clearance to the existing structure

Minimum covering depth and minimum clearance are determined as follows.

- Minimum covering depth at upstream end manhole = 1.0 m
- Under-crossing of drainage channel = 2.0 m
- Minimum covering depth under heavy traffic road = 2.0 m

Arrangement and interval of manholes

Manholes are necessary for workers to go into a sewer for inspection, cleaning and repair and maintenance works. Manholes are provided at the following points.

- Starting point
- Meeting point of sewers
- Changing point of diameter, gradient and direction

Manholes should be provided for maintenance works at other points than those mentioned above if necessary. Maximum intervals of manholes are shown in Table 6.7.

Table 6.7 Maximum Intervals of Manholes

Pipe Diameter（mm）	Maximum Interval（m）
D<600	75
600≦D< 1,000	100
1,000≦D ≦1,500	150
1,650≦D	200

Source: JICA Study Team

Other design criteria

- Gradient of pipes between manholes should be constant.
- Level of crown of outlet pipe should be same as that of the lowest inlet pipes in a manhole
- Diameter of the downstream pipe should be same as or larger than that of upstream pipe.

CHAPTER 7. SEWERAGE SYSTEM PLANNING

7.1 Wastewater Treatment Plan

7.1.1 Sewerage System Planning Area and Site for WWTP

In order to determine sewerage planning area in 2040, population and population density of each township in 2011 and 2040 were analyzed since these can be considered as indicators of urbanization. Results of the analysis are shown in Table 7.1. Townships in which population densities in 2011 were over 100 persons/ha are twenty (20) including all CBD townships. Population densities in CBD townships were as high as 189 to 606 persons/ha. All twenty townships are considered to be highly urbanized, and most appropriate measure to control pollution in this area is to provide sewerage system including wastewater treatment facilities. All of the twenty townships are to be included in the sewerage system planning area.

Townships in which population density in 2011 was below 100 persons/ha, but is expected to exceed this level in 2040 are four. Population densities of these four townships in 2011 were 79 to 99 persons/ha which are close to 100 persons/ha. Therefore, these four townships are also to be included in the sewerage system planning area. Population densities in Dagon Township are rather low, 50 persons/ha in 2011 and 99 persons/ha in 2040 respectively. The reason for this low population density is that huge area is occupied by Swe Dagon Pagoda and People's Park. Surrounding area of these religious and public facilities has been highly developed as commercial and tourist areas. Therefore, this township should be included in the sewerage system planning area. On the other hand, although Seikkan Township is included in Inner Urban Ring, its population density is as low as 19 persons/ha. The reason for this low population density is the fact that most of the township is occupied by port facilities and related equipment. Therefore, this township is excluded from the planning area. If there is any facility which produce wastewater in the township, its wastewater is to be conveyed to the neighboring sewerage zone.

As a result of the above mentioned analysis, a total of 25 townships constitute sewerage system planning area. Populations in the area in 2011 and 2040 are 3.58 million persons (70 % of total Yangon) and 4.21 million persons (49 %) respectively.

Table 7.1 Current and Future Population and Population Density by Township

Code	Township	Township Grooup	Area (ha)	Population		Population Density		Core Area
				2011	2040	2011	2040	
1	Latha	CBD	60	34,125	34,125	569	569	✔
2	Lanmadaw	CBD	131	43,137	43,137	329	329	✔
3	Pabedan	CBD	62	37,551	37,551	606	606	✔
4	Kyauktada	CBD	70	34,797	34,797	497	497	✔
5	Botahtaung	CBD	260	49,134	49,134	189	189	✔
6	Pazundaung	CBD	107	53,648	56,647	501	529	✔
7	Ahlone	Inner Urban Ring	338	65,510	68,509	194	203	✔
8	Kyee Myin Daing	Inner Urban Ring	457	115,841	148,835	253	326	✔
9	Sanchaung	Inner Urban Ring	240	105,208	108,207	438	451	✔
10	Dagon	Inner Urban Ring	489	24,492	48,488	50	99	✔
11	Bahan	Inner Urban Ring	847	100,695	109,693	119	130	✔
12	Tarmwe	Inner Urban Ring	499	191,114	197,113	383	395	✔
13	Mingalar Taung Nyunt	Inner Urban Ring	494	155,767	164,765	315	334	✔
14	Seikkan	Inner Urban Ring	117	2,241	2,241	19	19	
15	Dawbon	Inner Urban Ring	311	87,284	90,283	281	290	✔
16	Kamaryut	Outer Ring	647	87,881	102,878	136	159	✔
17	Hlaing	Outer Ring	984	151,014	163,012	153	166	✔
18	Yankin	Outer Ring	479	125,909	125,909	263	263	✔
19	Thingangyun	Outer Ring	1,312	231,621	243,619	177	186	✔
20	Mayangone	Northern Suburbs	2,588	205,403	268,392	79	104	✔
21	Insein	Northern Suburbs	3,163	311,200	377,188	98	119	✔
22	Mingalardon	Northern Suburbs	12,783	288,858	906,748	23	71	
23	North Okkalapa	Older Suburbs	2,766	333,484	423,468	121	153	✔
24	South Okkalapa	Older Suburbs	822	191,388	197,387	233	240	✔
25	Thaketa	Older Suburbs	1,356	253,284	280,279	187	207	✔
26	Dala	South of CBD	9,840	181,087	490,032	18	50	
27	Seikgyikhanaungto	South of CBD	1,210	38,425	74,419	32	62	
28	Shwe Pyi Thar	New Suburbs	5,271	295,993	514,954	56	98	
29	Hlaing Tharyar	New Suburbs	7,761	488,768	737,724	63	95	
30	North Dagon	New Suburbs	2,418	221,200	287,188	91	119	✔
31	South Dagon	New Suburbs	3,751	370,403	550,371	99	147	✔
32	East Dagon	New Suburbs	17,064	145,505	1,183,320	9	69	
33	Dagon Seikkan	New Suburbs	4,204	120,161	399,111	29	95	
YCDC Sub-total			82,901	5,142,128	8,519,524	62	103	
34	Kyauktan	Periphery Area	7,612	48,473	153,454	6	20	
35	Thanlyin	Periphery Area	25,485	181,959	1,243,770	7	49	
36	Hlaegu	Periphery Area	10,100	50,793	533,707	5	53	
37	Hmawbi	Periphery Area	8,423	83,719	551,636	10	65	
38	Htantapin	Periphery Area	8,175	40,234	397,170	5	49	
39	Twantay	Periphery Area	10,786	24,936	330,882	2	31	
Out of YCDC Sub-total			70,581	430,114	3,210,619	6	45	
Total			153,482	5,572,242	11,730,143	36	76	

Source: JICA Study Team

Sewerage zones have been formulated dividing the sewerage system planning area which consists of 25 townships. Total area of 25 townships exceeds 24,000 ha, and the distances of the area in north-south and east-west directions reach 20 km. It is very difficult from technical view point and is also significantly uneconomical to make this huge area as one sewerage zone. Therefore, sewerage zones have been defined combining townships which are in the similar urbanization situation. Further, taking into account topographic conditions and discharging water bodies, some townships have been divided into several sewerage zones in case township boundaries are not appropriate as sewerage zone boundary. As a result, 15 sewerage zones have been formulated. Core area for which sewerage system planning in 2040 will be carried out consists of 8 sewerage zones. All 25 townships identified in the previous section are included in these 8 sewerage zones.

It has been tried to find sites for construction of WWTP in these 8 sewerage zones. A few possible sites have been selected on the aerial photo of each sewerage zone, and YCDC was requested to assure possibility of land acquisition. It became evident that there is no possible site with appropriate space available in C2 sewerage zone. It was not possible to locate a proper site for WWTP even after rearrangement of townships in C2 and neighboring E1 sewerage zones due to another development plan in E1 sewerage zone.

Therefore, in order to get enough land space for WWTP, Sewerage Zones E1 and C2 are again combined. However, C2 and E1 remain as Sewerage Sub-Zones, because the area is very huge and status of urbanization is significantly different. Priority of sewerage project is to be evaluated separately for these Sub-Zones. Townships were originally divided into 15 sewerage zones and finally re-organized into 13 sewerage zones as shown in Table 7.2.

These 13 sewerage zones are also shown in Figure 7.1. Area, planned population and wastewater flow for each sewerage zone are shown in Table 7.3. Area, planned population and wastewater generation in townships which formulate sewerage zones are shown in tables in Appendix F also. In addition required site area for each WWTP calculated by the following formula is shown in Table 7.3. This formula is presented in Japanese “Guidelines for Comprehensive Basin-wide Planning of Sewerage Systems”.

$A = 4.59 * Q \wedge 0.62$

Where

A: Area (1,000 m^2)

Q: Daily maximum wastewater flow (1,000 m^3/day)

Sewerage systems are to be constructed as separate system finally, however, adoption of interceptor system described in Section 6.3.1 is considered as temporary provision. Adoption of interceptor

system aims at reduction of initial investment for construction of sewerage system. Construction cost of branch and lateral sewers and connection facility can be reduced because wastewater is collected from existing storm drains. In addition, two cases of wastewater treatment, viz. primary treatment and secondary treatment are considered to evaluate effects of construction cost reduction.

Adoption of interceptor system is considered for the following sewerage zones. Interceptor system cannot be applied for the existing sewerage service area (including entire C1 sewerage zone and a part of W1 sewerage zone) because the area is highly urbanized and septic tanks are not provided with buildings. Similarly, the remaining area of W1 and a part of C2 sewerage zone is also highly urbanized, and sewerage system should be provided from the beginning as separate system. Thus, interceptor system is to be considered for the remaining sewerage zones. For these sewerage zones, adoption of interceptor system should be studied at the feasibility study stage.

- Sewerage zones where separate system should be adopted:
  C1, W1 and a part of C2 (four townships viz. Bahan, Tarmwe, Mingalar Taung Nyunt and Yankin)
- Sewerage zones where adoption of interceptor system should be studied
  A part of C2 (three townships viz. Thingangyun, Mayangone, South Okkalapa), W2, N1, E1 and E3

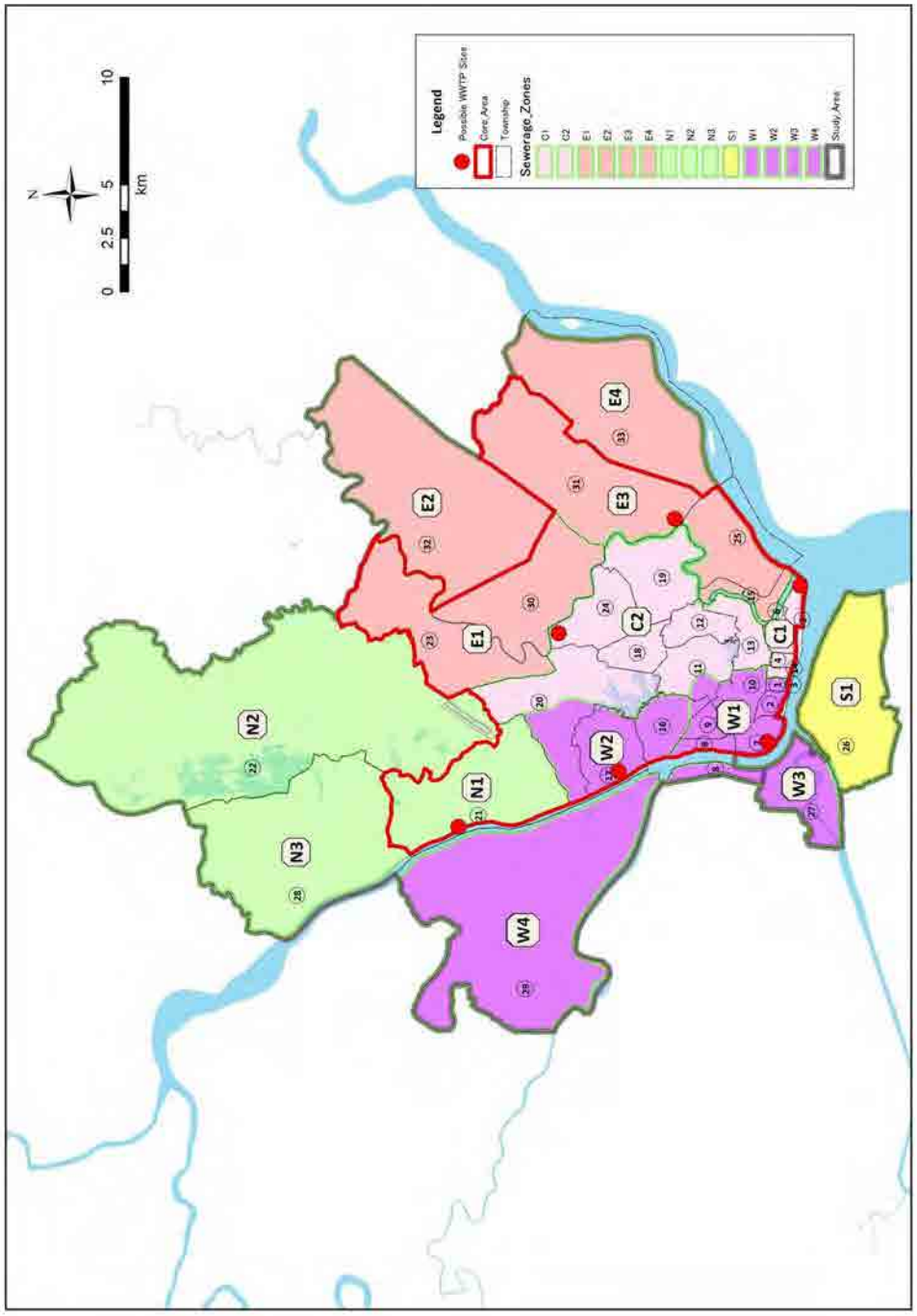
Table 7.2 Townships and Sewerage Zones (Original and Final Plans)

Township		Sewerage Zone																			
		C1	C2		W1	W2	W3	W4	N1	N2	N3	E1		E2	E3		E4		E5		S1
			Ori.	Last								Ori.	Last		Ori.	Last	Ori.	Last	Ori.	Last	
Code	Name																				
1	Latha				■																
2	Lanmadaw				■																
3	Pabedan	■																			
4	Kyauktada	■																			
5	Botahtaung	■																			
6	Pazundaung	■																			
7	Ahlone				■																
8	Kyee Myin Daing				■		■														
9	Sanchaung				■																
10	Dagon				■																
11	Bahan		■	■	■																
12	Tarmwe		■	■																	
13	Mingalar Taung Nyunt		■	■																	
14	Seikkan																				
15	Dawbon															■	■				
16	Kamaryut				■	■															
17	Hlaing					■															
18	Yankin		■	■																	
19	Thingangyun		■	■																	
20	Mayangone			■		■						■									
21	Insein								■												
22	Mingalardon									■											
23	North Okkalapa											■	■								
24	South Okkalapa			■								■									
25	Thaketa															■	■				
26	Dala																				■
27	Seikgyikhanaungto						■														
28	Shwe Pyi Thar										■										
29	Hlaing Tharyar							■													
30	North Dagon											■	■								
31	South Dagon														■	■					
32	East Dagon													■							
33	Dagon Seikkan																	■	■		

Note: ■ Original Plan ■ Final Plan

Source: JICA Study Team

YCDC has been negotiating with land owners or concerned authorities about acquisition of necessary land space for construction of WWTP. However, at the time of submission of Draft Final Report, Study Team was notified that modification of location and land space for some WWTPs has become necessary. Details of modification are described in Appendix K. Changes of location and/or land space for WWTP requires modification of sewerage system planning which result in reexamination of cost estimation, financial analysis, and so on. Therefore, for sewerage zones of which WWTP location was changed, sewerage system planning is to be reconsidered at the time of FS preparation.



Source: JICA Study Team

Figure 7.1 Sewerage Zones (Final Plan)

Table 7.3 Population, Wastewater Flow and Area by Sewerage Zone

Sewerage Zone	Population (person)	W. Flow (m^3/day)		Area (ha)	WWTP Area (ha)	Township
		Daily Ave.	Daily Max.			
C 1	178,127	64,276	70,213	499	6.4	Pazundaung, Botahtaung, Kyauktada, Pabedan
C 2	1,191,499	452,548	492,264	6,102	21.4	a part of Bahan, Mingalar Taung Nyunt, Tamwe, South Okkalapa, Thingangyun, Yankin, a part of Mayangone
W 1	483,058	169,214	184,247	1,654	11.7	Lanmadaw, Latha, Dagon, a part of Bahan, a part of Kyee Myin Daing, Ahlone, Sanchaung, a part of Kamaryut
W 2	349,512	116,999	126,410	2,356	9.2	Hlaing, a part of Kamaryut, a part of Mayangon
W 3	74,419	14,512	15,628	1,485	2.5	A part of Kyee Myin Daing, Seikgyikhanaungto
W 4	737,724	191,809	206,563	7,761	12.5	Hlaing Tharyar
N 1	377,188	129,633	139,691	3,163	9.8	Insein
N 2	906,748	294,693	317,362	12,783	16.3	Mingaladon
N 3	514,954	100,416	108,140	5,271	8.4	Shwe Pyi Thar
E1	710,656	232,953	252,094	5,184	14.2	North Okkalapa, North Dagon
E 2	1,183,320	269,207	289,915	17,064	15.4	East Dagon
E 3	920,933	243,849	263,583	5,418	14.5	Dawbon, Taketa, South Dagon
E4	399,111	77,827	83,814	4,202	7.1	Dagon Seikkan
S 1	490,032	127,409	137,210	9,840	9.7	Dala
Out of SZ	2,241	971	1,046	117		Seikkan
Total	8,519,522	2,486,316	2,688,180	82,899	159.2	

Note: Shaded sewerage zones are core area. C2 and E1 are combined.
Source: JICA Study Team

7.1.2 Site Areas Required for WWTPs Outside of Sewerage Planning Area

Sewerage system planning area is limited to 6 sewerage zones in the core area. However, sewerage system should be provided in the remaining sewerage zones also in future beyond 2040. Population densities in these sewerage zones in 2040 will be still low, urbanization is likely to progress by mainly large scale housing development instead of spontaneous sprawl. Installation of Johkaso or construction of community plant is recommended for large scale development. Conversion of these systems to sewerage system is envisaged at the final stage. Therefore, required area for construction of WWTP is presented here based on the wastewater flow in 2040. Required area is calculated using the formula mentioned earlier.

Required areas for WWTPs in 6 townships outside of YCDC are also calculated and presented in the same Table.

Table 7.4 Required Site Areas for WWTPs for Future Sewerage System Planning Area

Sewerage Zone	Population (person)	Daily Max. (m^3/day)	Area (ha)	WWTP Area (ha)	Township
W 3	74,419	15,628	1,485	2.5	East Dagon
W 4	737,724	206,563	7,761	12.5	Dagon Seikkan
N 2	906,748	317,362	12,783	16.3	A part of Kyimyindaing, Seikkyikhanaungto
N 3	514,954	108,140	5,271	8.4	Hlaingtharyar
E 2	1,183,320	289,915	17,064	15.4	Mingaladon
E4	399,111	83,814	4,204	7.1	Shwepyithar
S 1	490,032	137,210	9,840	9.7	Dala
YCDC Total	4,306,308	1,158,632	58,408	72.0	
Kyauktan	153,454	21,483	7,612	3.1	
Thanlyin	1,243,770	174,128	25,485	11.2	
Hlaegu	533,707	74,718	10,100	6.7	
Hmawbi	551,636	77,228	8,423	6.8	
Htantapin	397,170	55,604	8,177	5.5	
Twantay	330,882	46,323	10,786	5.0	
Out of YCDC	3,210,619	449,484	70,583	38.3	
Total	7,516,927	1,608,116	128,991	110.3	

Source: JICA Study Team

7.1.3 Receiving of Industrial Wastewater

Industrial wastewater is under control of Department of Pollution Control and Cleansing, YCDC as mentioned in Section 3.4. Parameters monitored are limited to BOD, SS, pH, COD and TSS. Limits of the parameters are determined assuming that industrial wastewater is discharged directly to a water body. If wastewater satisfies the standards, it can be received into the sewerage system without any problem. However, standards do not include poisonous and hazardous materials. Thus Department of Water Supply and Sanitation must stipulate its standards which include these materials. A sample of standards stipulated in Enforcement Regulations of Sewerage Act, Japan is shown in Table 7.5. In addition to it, each city can stipulate more stringent standards.

Some industrial wastewater includes hazardous materials such as high organic material concentration or heavy metals. High organic material concentration poses excessive load to wastewater treatment, and hinders proper treatment resulting in violation of discharge standards. Heavy metals cannot be removed by biological treatment in principal, and these are discharged from WWTP. Thus, WWTP becomes a pollution source. It is important not to receive these materials into the sewerage system in order to avoid these situations. Therefore, it is important to make factories strictly maintain the effluent standards. Removal of these materials should be conducted at the place of origin from Polluter-Pay-Principal view point.

It is also very important to monitor and enforce each factory to adhere to the standards once they are established. Periodical report, inspection and sample taking by the Department at the site at any time

should be agreed on with factories. In case of violation, penalties including stopping of water supply or rejection of wastewater should be stipulated. Analysis of wastewater should be entrusted to public laboratory, it is desirable for the Department to analyze general items such as BOD and SS by itself. It is also desirable for the Department to analyze heavy metals by themselves in the future.

Table 7.5 Standards for Receiving Industrial Wastewater

Parameter	Permissible Limit (mg/l)
Anmonia, Nitrite, & Nitrate Nitrogen	380 (125)
pH (no unit)	5 - 9 (5.7 - 8.7)
BOD	600 (300)
SS	600 (300)
Mineral oil	5
Animal and plant oil	30
Nitrogen	240 (150)
Phosphrus	32 (20)
Phenol	5
Copper and its compounds	30
Zinc and its compounds	2
Iron and its compounds (soluble)	10
Manganese and its compounds (soluble)	10
Chromium and its compounds	2
Fluorine compounds	15

Note: Figures in parenthesis are daily average basis
Source: JICA Study Team

7.2 Proposed Sewerage Facility Plan by Sewerage Zones

Sewerage facility plans in each of 6 sewerage zones established in the previous Section are described below.

7.2.1 C1 Sewerage Zone

C1 Sewerage Zone is the existing sewerage service area. However, the existing collection system has been used far beyond the useful life and the pipes have been significantly deteriorated. Moreover, this system collects only toilet wastewater (black water). As mentioned in Section 6.2.1, pollution load caused by gray water is higher than that caused by black water. Therefore goal of water pollution control cannot be achieved sufficiently unless gray water is treated. Also current collection system is considered to have defect since only 15 % of currently estimated wastewater flow (black water) is

flowing into the WWTP as mentioned in Section 3.3.2. Taking into consideration current situation, conversion of the system to conventional sewerage system is urgent requirement. Outline of the sewer networks including improvement of the existing pipeline is shown in Table 7.6. Trunk sewer system is shown in Figure 7.2.

Extended aeration process currently adopted should be converted to conventional activated sludge process, and the plant is to be expanded to accommodate design flow in 2040. Outline of the wastewater treatment plant is enumerated in Table 7.7. Layout plan and location of the WWTP are shown in Figures 7.3 and 7.4, respectively.

Table 7.6 Outline of Sewer Network in C1 Sewerage Zone

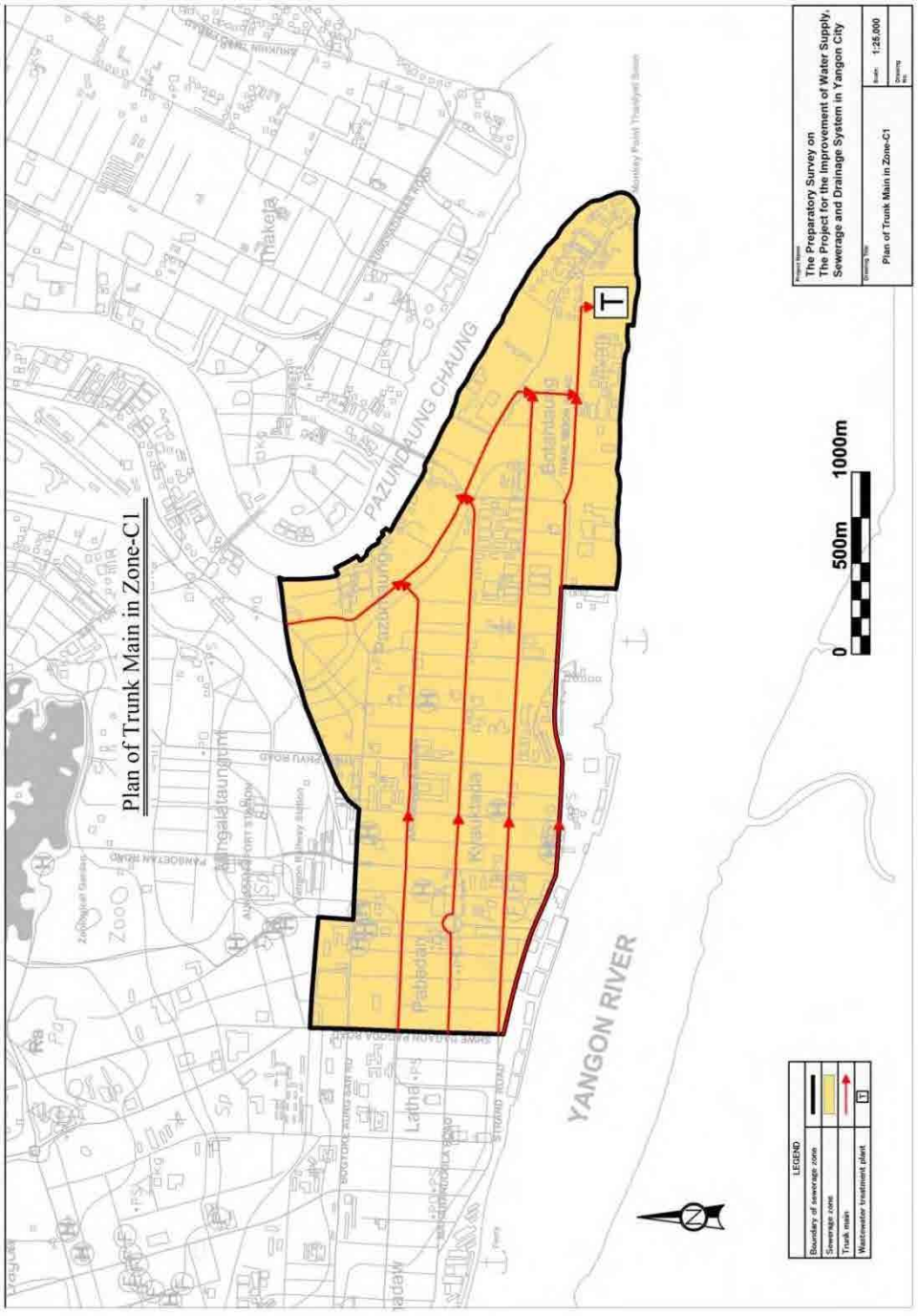
C1 Sewerage Zone		
Trunk Sewer		
Dia. (mm)	Length (m)	Construction Method
500	1,100	Small diameter pipe jacking
600	1,900	Small diameter pipe jacking
700	5,400	Small diameter pipe jacking
800	2,400	Pipe jacking
900	600	Pipe jacking
1,100	720	Pipe jacking
1,350	240	Pipe jacking
1,500	550	Pipe jacking
Branch Sewer		
<500	47,600	Open cut
House connection		
100	6,376 Nos.	Open cut

Source: JICA Study Team

Table 7.7 Outline of WWTP for C1 Sewerage Zone

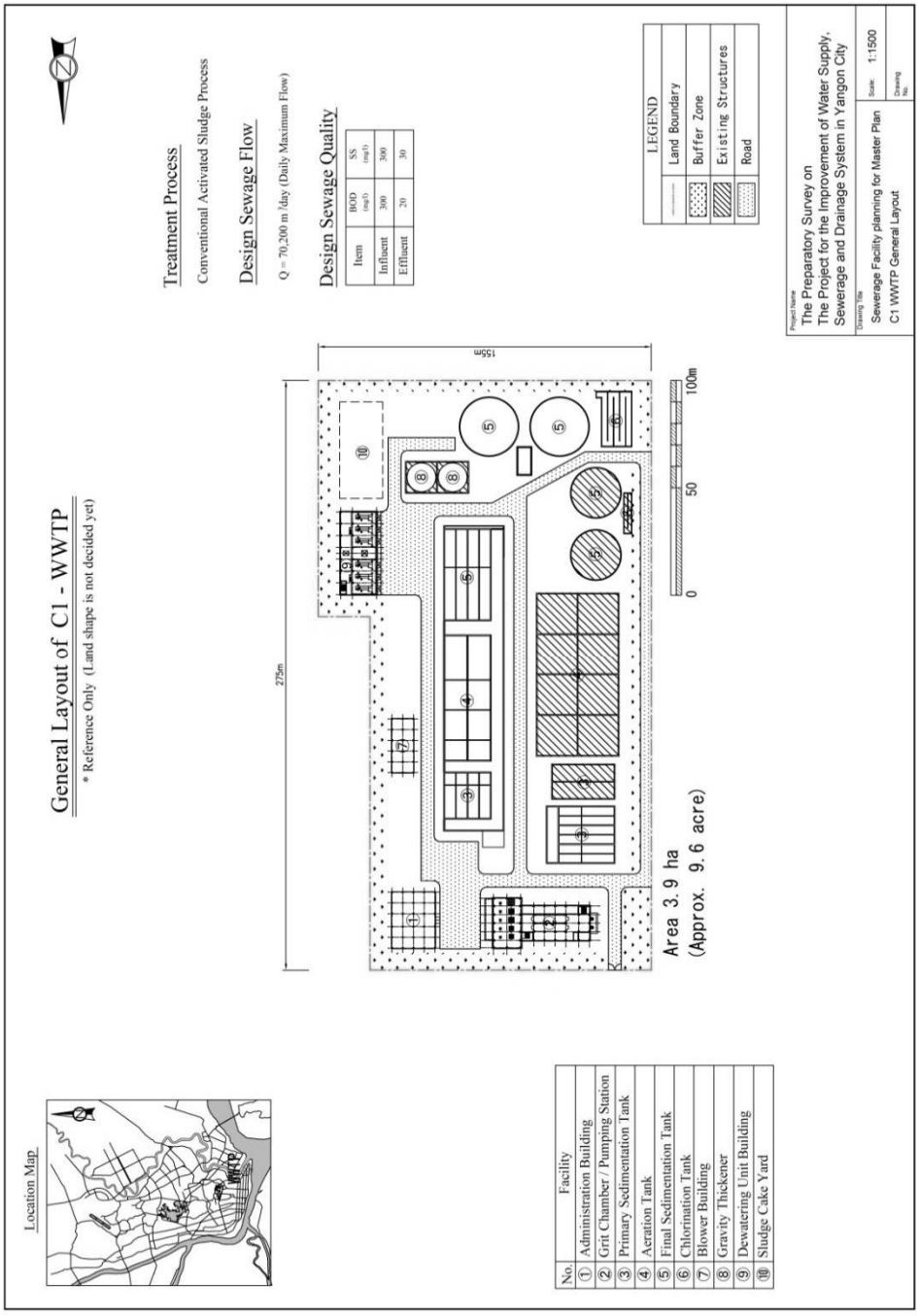
C1 WWTP		
Served Population in 2040 (persons)		178,127
Per Capita Wastewater daily ave. (lpcd)		333
Design Capacity (m^3/day)		70,200
BOD and SS Concentrations (mg/l)	BOD in	200
	SS in	180
	BOD out	20
	SS out	30

Source: JICA Study Team



Source: JICA Study Team

Figure 7.2 Layout Plan of Trunk Main, C1 Sewerage Zone



Source: JICA Study Team

Figure 7.3 General Layout Plan, C1 WWTP

Source: JICA Study Team

Figure 7.4 Location of C1 WWTP

7.2.2 C2+E1 Sewerage Zone

C2+E1 Sewerage Zone is the integration of old C2 and E1 Sewerage Zones because site for WWTP cannot be obtained in old C2 Sewerage Zone, and further modification was made integrating E1 Sewerage Zone again because there is no possible site for WWTP in E1 Sewerage Zone. Therefore, C2+E1 became a huge sewerage zone, its area is 11,286 ha which is more than 2 times that of the other sewerage zones. In addition characteristics and status of urbanization of the townships included in these Sewerage Zones differ significantly. Therefore, in order to evaluate priority of sewerage system provision appropriately, this Sewerage Zone is divided into two Sub-zones.

All sewerage facilities in the Sewerage Zone should be newly constructed. Outline of the sewer networks is shown in Table 7.8. Trunk sewer system is shown in Figures 7.5. Outline of the wastewater treatment plant is enumerated in Table 7.9. Layout plan and location of the WWTP are shown in Figures 7.6 and 7.7, respectively.

Adoption of interceptor sewerage system should be considered at feasibility stage for three townships in C2 sewerage zone, i.e. Thingangyun, Mayangone, and South Okkarapa and entire E1 sewerage zone in order to reduce initial investment.

Table 7.8 Outline of Sewer Network in C2+E1 Sewerage Zone

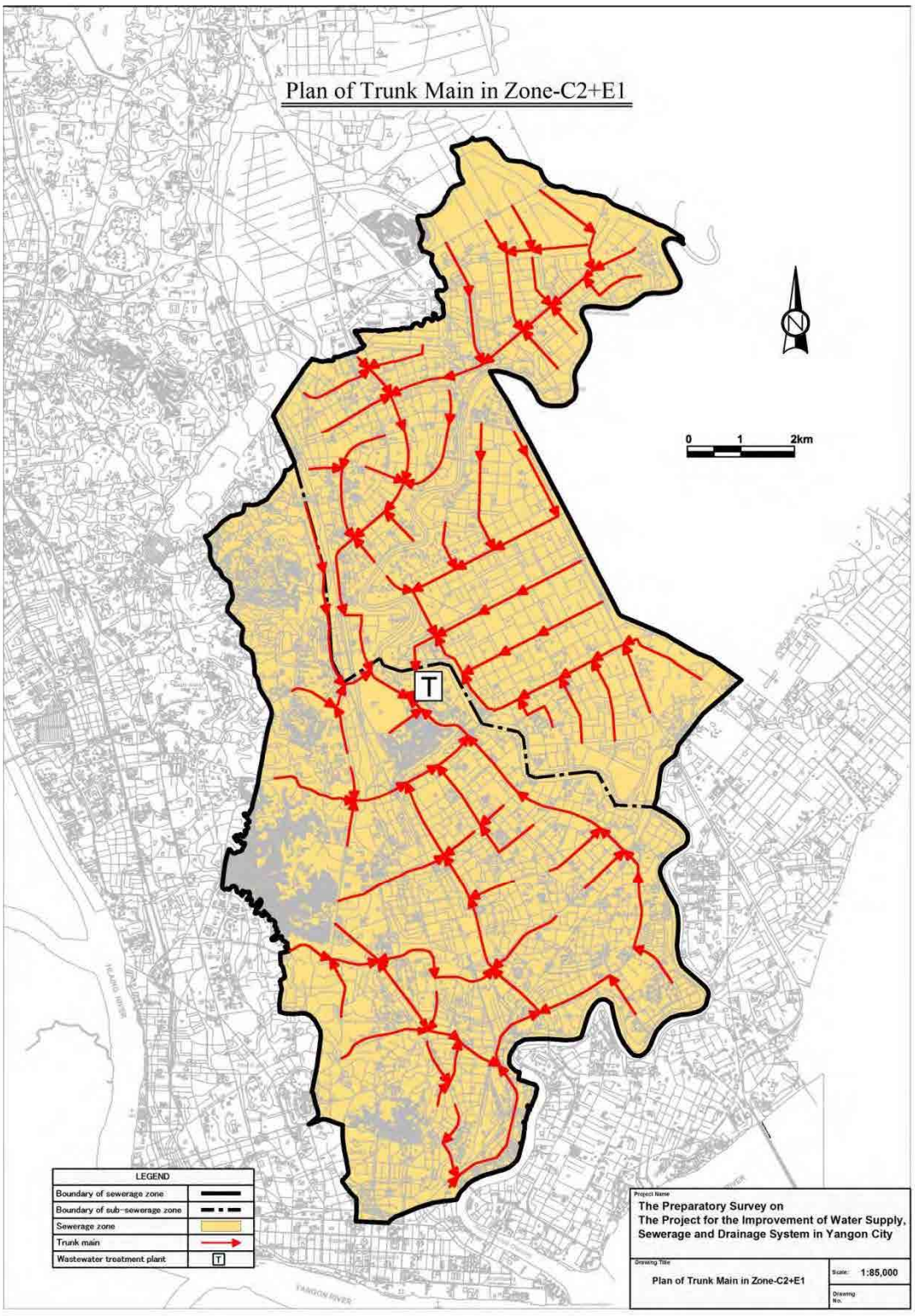
C2+E1 Sewerage Zone		
Trunk Sewer		
Dia. (mm)	Length (m)	Construction Method
500	780	Small diameter pipe jacking
600	25,000	Small diameter pipe jacking
700	26,400	Small diameter pipe jacking
800	7,500	Pipe jacking
900	6,800	Pipe jacking
1,000	4,000	Pipe jacking
1,100	6,000	Pipe jacking
1,200	4,700	Pipe jacking
1,350	7,500	Pipe jacking
1,500	4,600	Pipe jacking
1,650	6,800	Pipe jacking
1,800	5,800	Shield
2,200	3,200	Shield
2,400	2,200	Shield
2,600	810	Shield
2,800	1,400	Shield
3,200	150	Shield
Branch Sewer		
<500	863,000	Open cut
House connection		
100	252,789 Nos.	Open cut

Source: JICA Study Team

Table 7.9 Outline of WWTP for C2+E1 Sewerage Zone

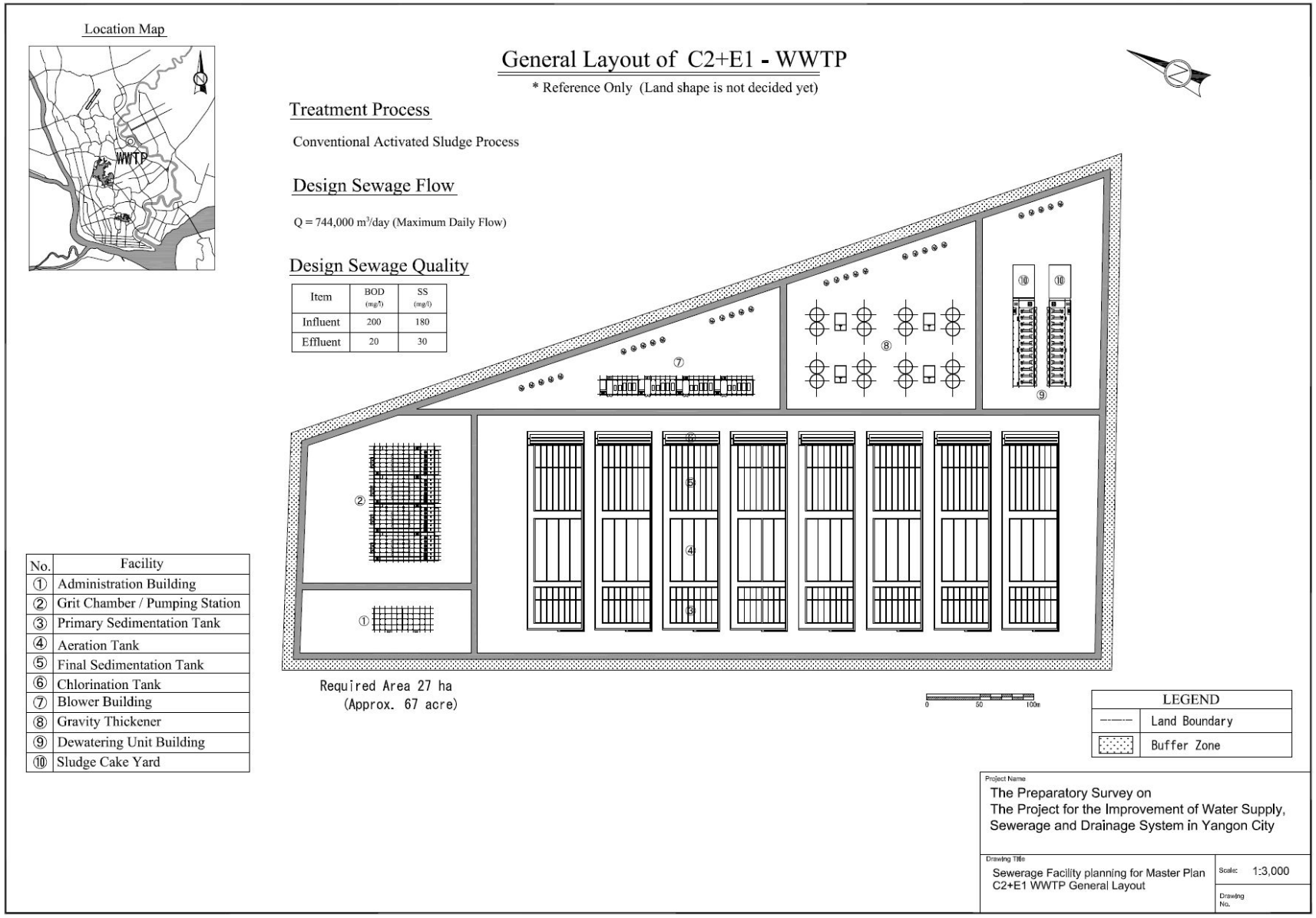
C2+E1 WWTP		
Served Population in 2040 (persons)		1,902,155
Per Capita Wastewater daily ave. (lpcd)		333, 269
Design Capacity (m^3/day)		744,400
BOD and SS Concentrations (mg/l)	BOD in	200
	SS in	180
	BOD out	20
	SS out	30

Source: JICA Study Team



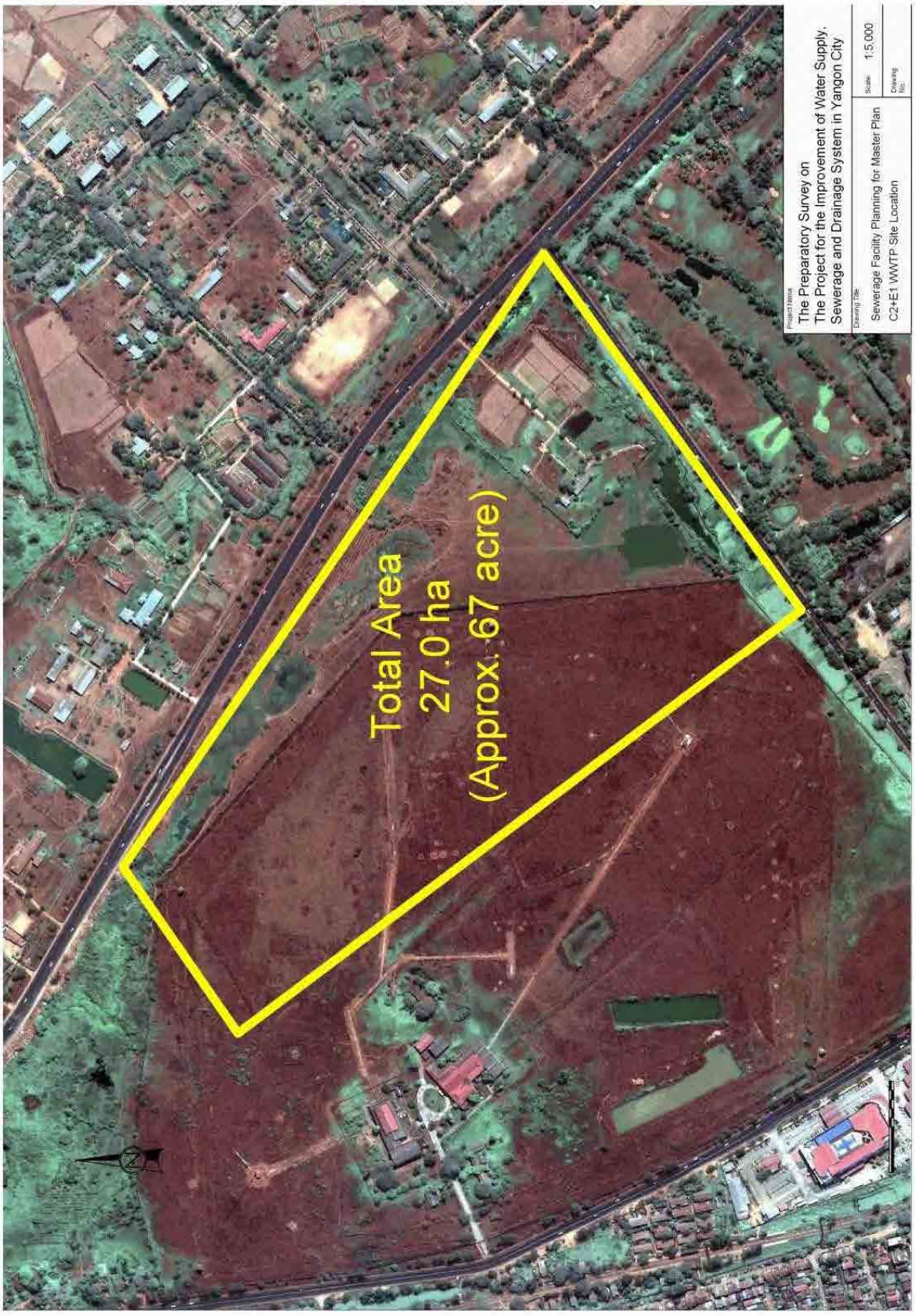
Source: JICA Study Team

Figure 7.5 Layout Plan of Trunk Main, C2+E1 Sewerage Zone



Source: JICA Study Team

Figure 7.6 General Layout Plan, C2+E1 WWTP



Source: JICA Study Team

Figure 7.7 Location of C2+E1 WWTP

7.2.3 W1 Sewerage Zone

W1 Sewerage Zone includes a part of the existing sewerage service area. The existing sewerage system in the area should remain as it is and wastewater should be conveyed to C1 WWTP temporarily until the completion of W1 WWTP and be treated. Once W1 WWTP is put into operation, the existing system should be converted to conventional sewerage system which collects black water together with gray water. Conventional activated sludge process with double deck sedimentation tanks and deep aeration is adopted for this sewerage zone because site for construction of WWTP is limited to 4.5 ha (11.1acve). Outline of the sewer networks is shown in Table 7.10. Trunk sewer system is shown in Figure 7.8. Outline of the wastewater treatment plant is enumerated in Table 7.11. Layout plan and location of the WWTP are shown in Figures 7.9 and 7.10, respectively.

Table 7.10 Outline of Sewer Network in W1 Sewerage Zone

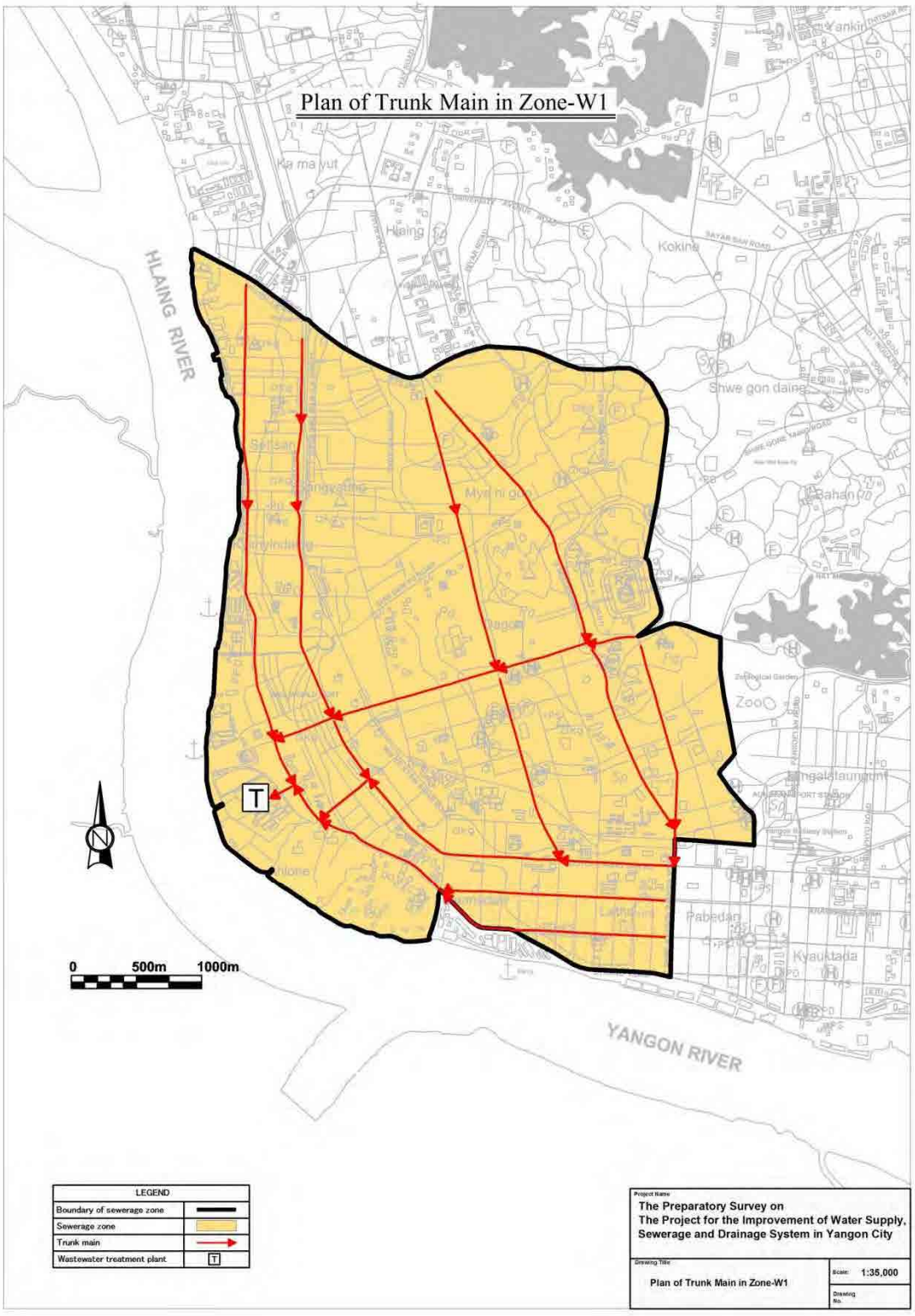
W1 Sewerage Zone		
Trunk Sewer		
Dia. (mm)	Length (m)	Construction Method
500	1,500	Small diameter pipe jacking
600	5,100	Small diameter pipe jacking
700	5,900	Small diameter pipe jacking
800	2,800	Pipe jacking
900	1,100	Pipe jacking
1,000	3,200	Pipe jacking
1,100	2,400	Pipe jacking
1,200	1,700	Pipe jacking
1,350	1,800	Pipe jacking
1,500	340	Pipe jacking
1,650	860	Pipe jacking
2,000	220	Shield
Branch Sewer		
<500	122,000	Open cut
House connection		
100	32,363 Nos.	Open cut

Source: JICA Study Team

Table 7.11 Outline of WWTP for W1 Sewerage Zone

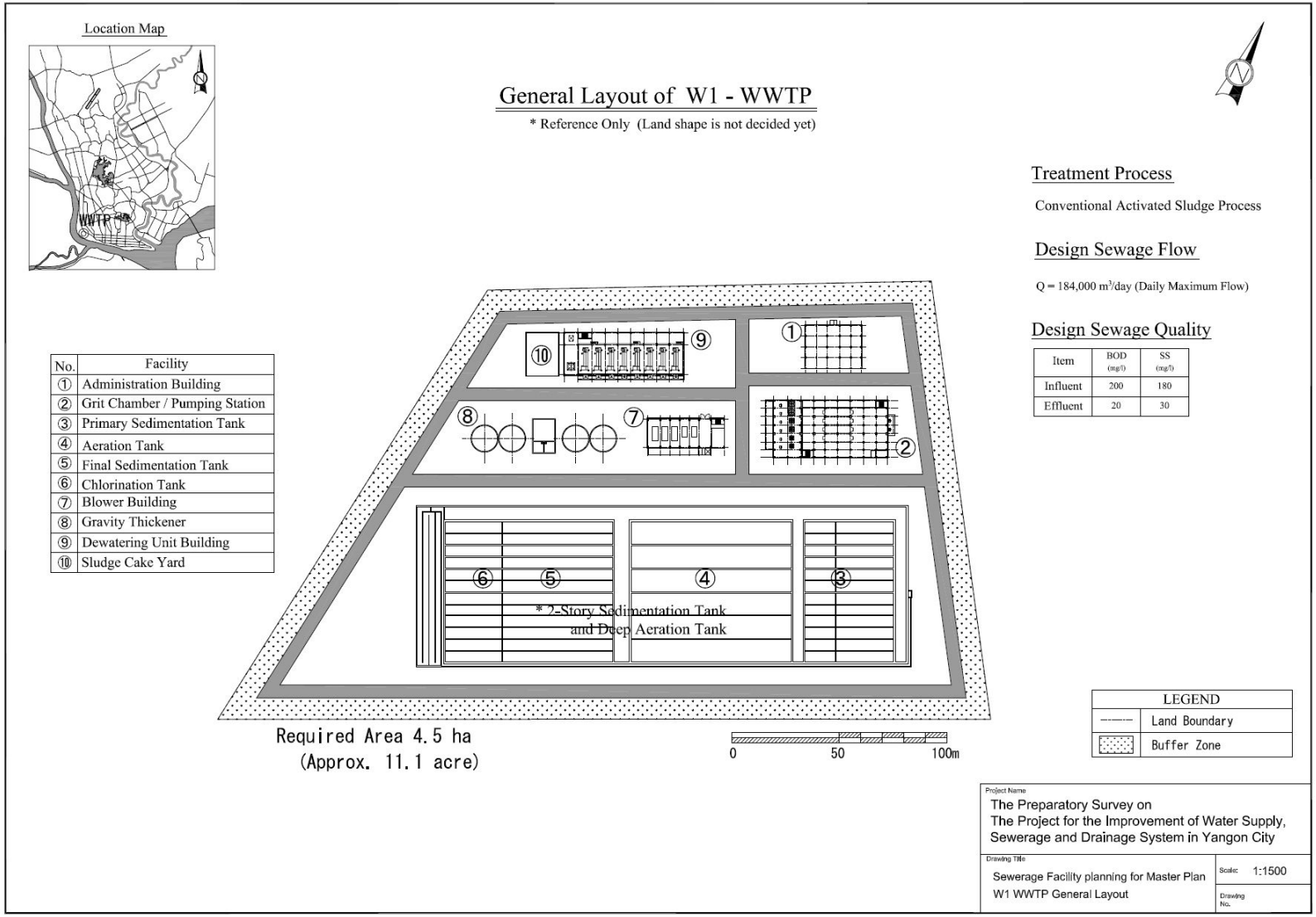
W1 WWTP		
Served Population in 2040 (persons)		483,058
Per Capita Wastewater daily ave. (lpcd)		311
Design Capacity (m^3/day)		184,200
BOD and SS Concentrations (mg/l)	BOD in	200
	SS in	180
	BOD out	20
	SS out	30

Source: JICA Study Team



Source: JICA Study Team

Figure 7.8 Location of W1 WWTPW1 Sewerage Zone



Source: JICA Study Team

Figure 7.9 General Layout Plan, W1 WWTP

Source: JICA Study Team

Figure 7.10 Location of W1 WWTP

7.2.4 W2 Sewerage Zone

All sewerage facilities in this Sewerage Zone should be newly constructed. Outline of the sewer networks is shown in Table 7.12. Trunk sewer system is shown in Figure 7.11. Outline of the wastewater treatment plant is shown in Table 7.13. Layout plan and location of the WWTP are shown in Figures 7.12 and 7.13, respectively.

Adoption of interceptor sewerage system should be considered at feasibility stage for W2 sewerage zone in order to reduce initial investment.

Table 7.12 Outline of Sewer Network in W2 Sewerage Zone

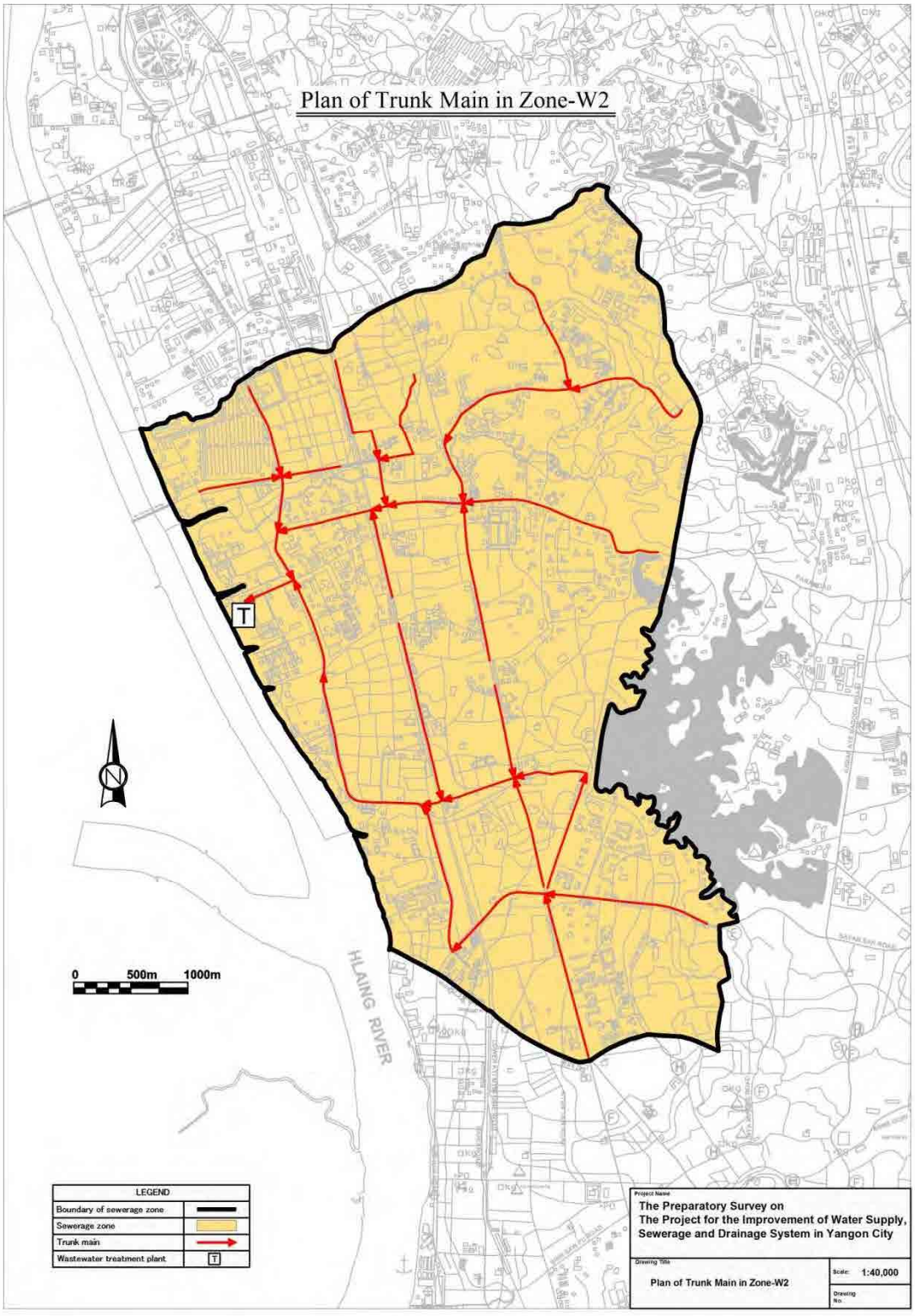
W2 Sewerage Zone		
Trunk Sewer		
Dia. (mm)	Length (m)	Construction Method
500	4,400	Small diameter pipe jacking
600	2,900	Small diameter pipe jacking
700	6,300	Small diameter pipe jacking
800	660	Pipe jacking
900	1,000	Pipe jacking
1,000	1,300	Pipe jacking
1,100	2,300	Pipe jacking
1,350	2,800	Pipe jacking
1,500	1,700	Pipe jacking
1,650	470	Pipe jacking
1,800	470	Shield
Branch Sewer		
<500	207,000	Open cut
House connection		
100	37,787 Nos.	Open cut

Source: JICA Study Team

Table 7.13 Outline of WWTP for W2 Sewerage Zone

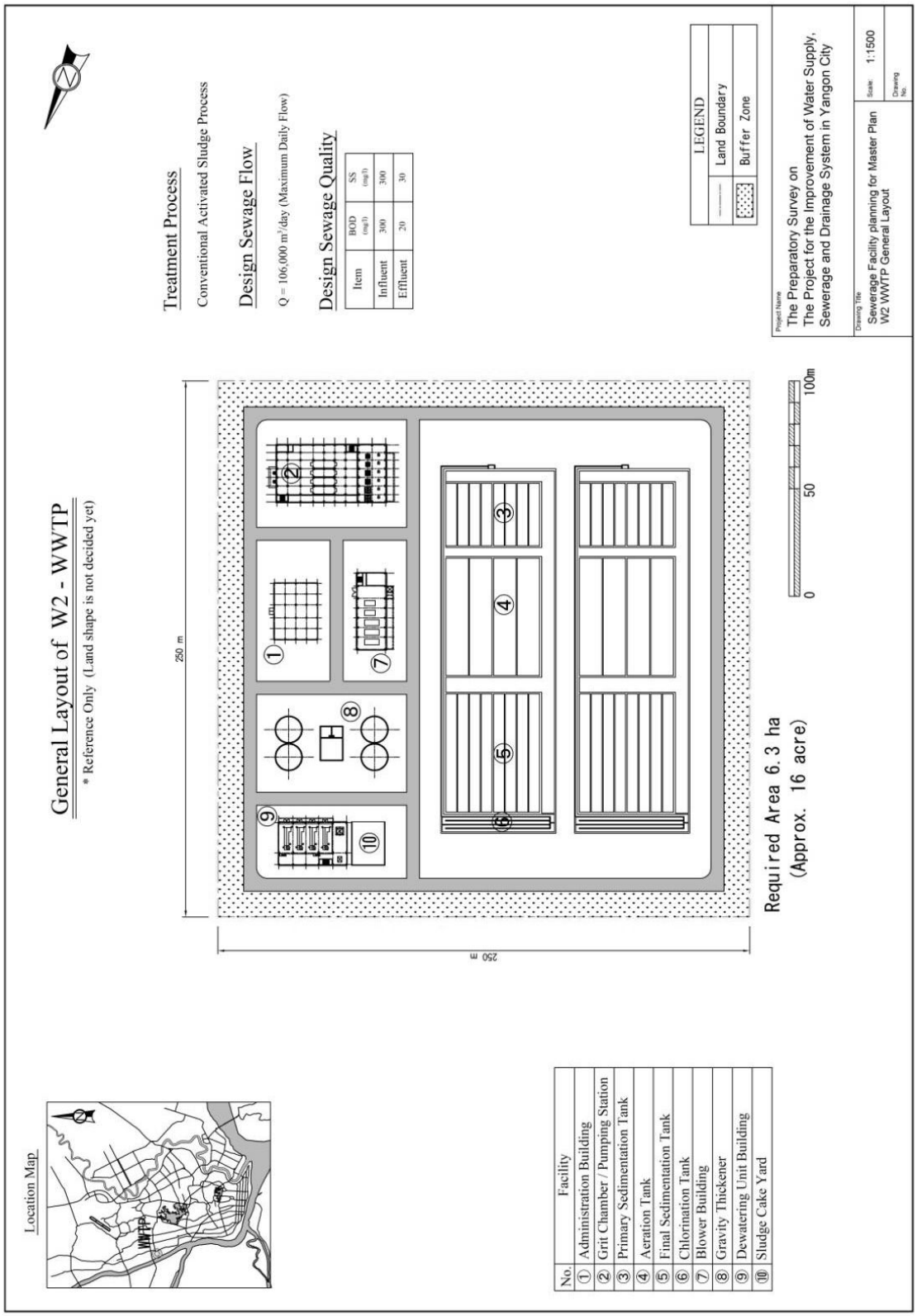
W2 WWTP		
Served Population in 2040 (persons)		349,512
Per Capita Wastewater daily ave. (lpcd)		269
Design Capacity (m^3/day)		126,400
BOD and SS Concentrations (mg/l)	BOD in	200
	SS in	180
	BOD out	20
	SS out	30

Source: JICA Study Team



Source: JICA Study Team

Figure 7.11 Layout Plan of Trunk Main, W2 Sewerage Zone



Source: JICA Study Team

Figure 7.12 General Layout Plan, W2 WWTP

Source: JICA Study Team

Figure 7.13 Location of W2 WWTP

7.2.5 N1 Sewerage Zone

All sewerage facilities in this Sewerage Zone should be newly constructed. Outline of the sewer networks is shown in Table 7.14. Trunk sewer system is shown in Figure 7.14. Outline of the wastewater treatment plant is enumerated in Table 7.15. Layout plan and location of the WWTP are shown in Figures 7.15 and 7.16, respectively.

Adoption of interceptor sewerage system should be considered at feasibility stage for N1 sewerage zone in order to reduce initial investment.

Table 7.14 Outline of Sewer Network in N1 Sewerage Zone

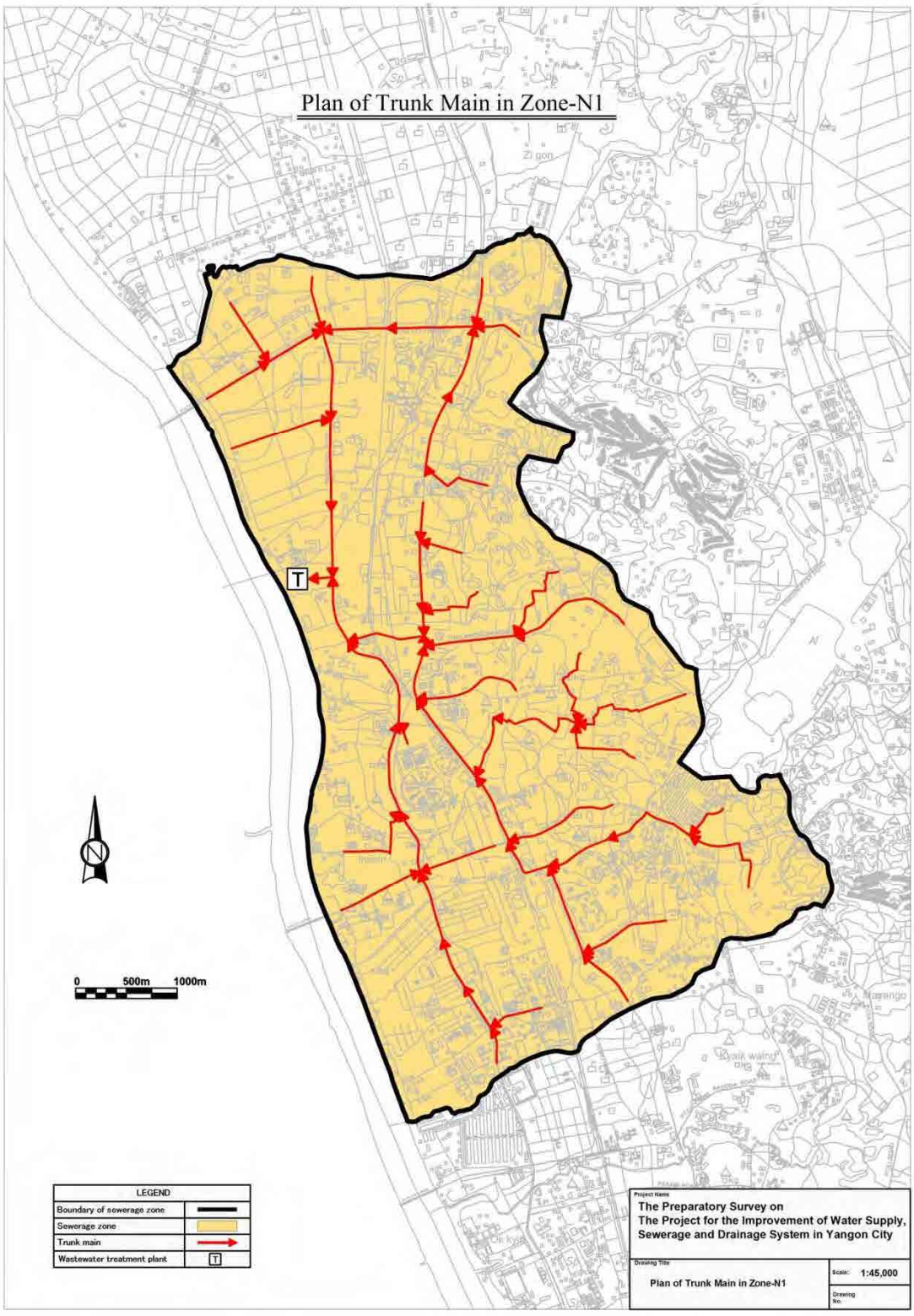
N1 Sewerage Zone		
Trunk Sewer		
Dia. (mm)	Length (m)	Construction Method
500	1,000	Small diameter pipe jacking
600	1,400	Small diameter pipe jacking
700	4,200	Small diameter pipe jacking
800	930	Pipe jacking
900	1,300	Pipe jacking
1,100	12,300	Pipe jacking
1,200	100	Pipe jacking
1,350	770	Pipe jacking
1,650	900	Pipe jacking
Branch Sewer		
<500	269,000	Open cut
House connection		
100	58,863 Nos.	Open cut

Source: JICA Study Team

Table 7.15 Outline of WWTP for N1 Sewerage Zone

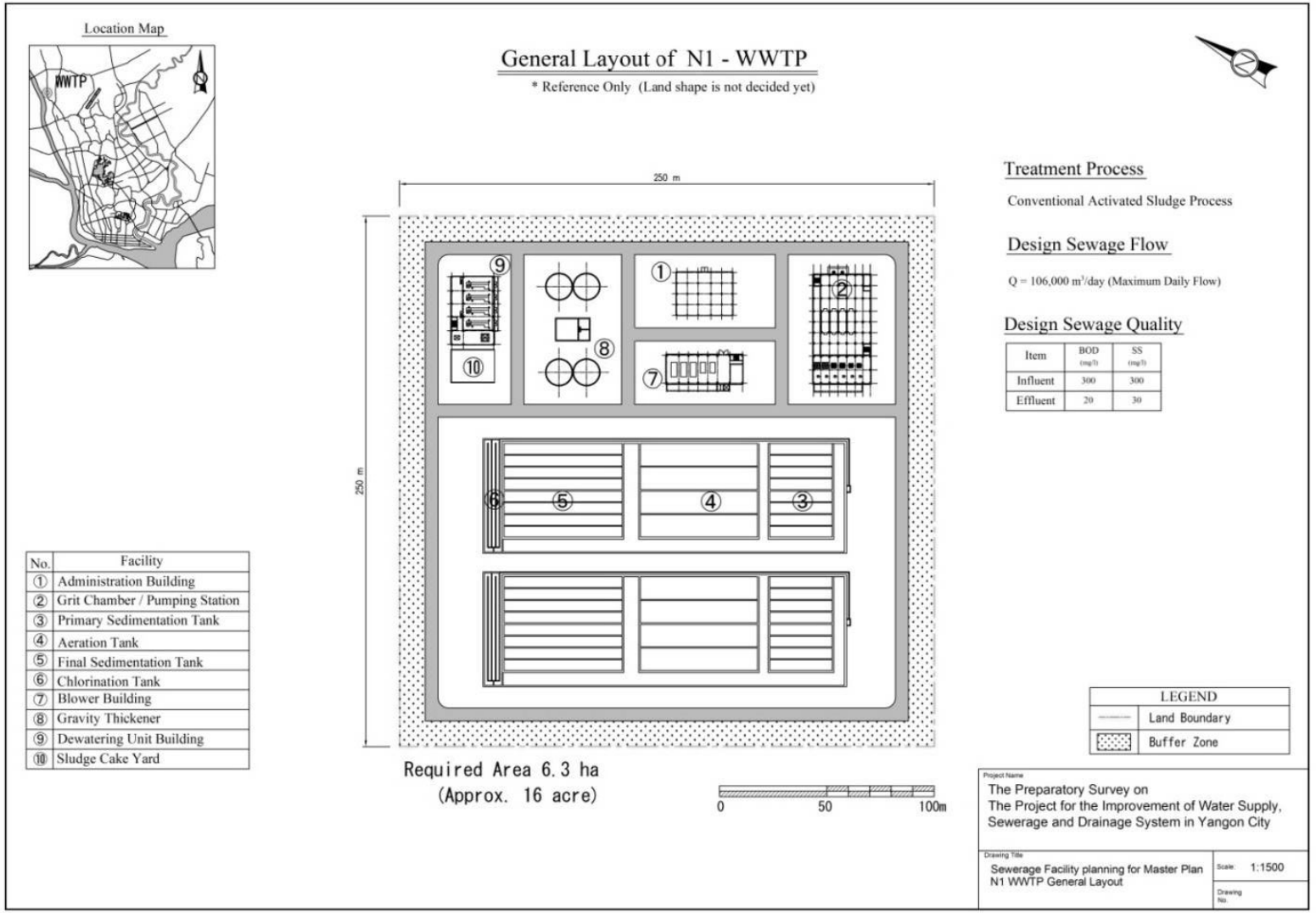
N1 WWTP		
Served Population in 2040 (persons)		377,188
Per Capita Wastewater daily ave. (lpcd)		234
Design Capacity (m^3/day)		140,000
BOD and SS Concentrations (mg/l)	BOD in	200
	SS in	180
	BOD out	20
	SS out	30

Source: JICA Study Team



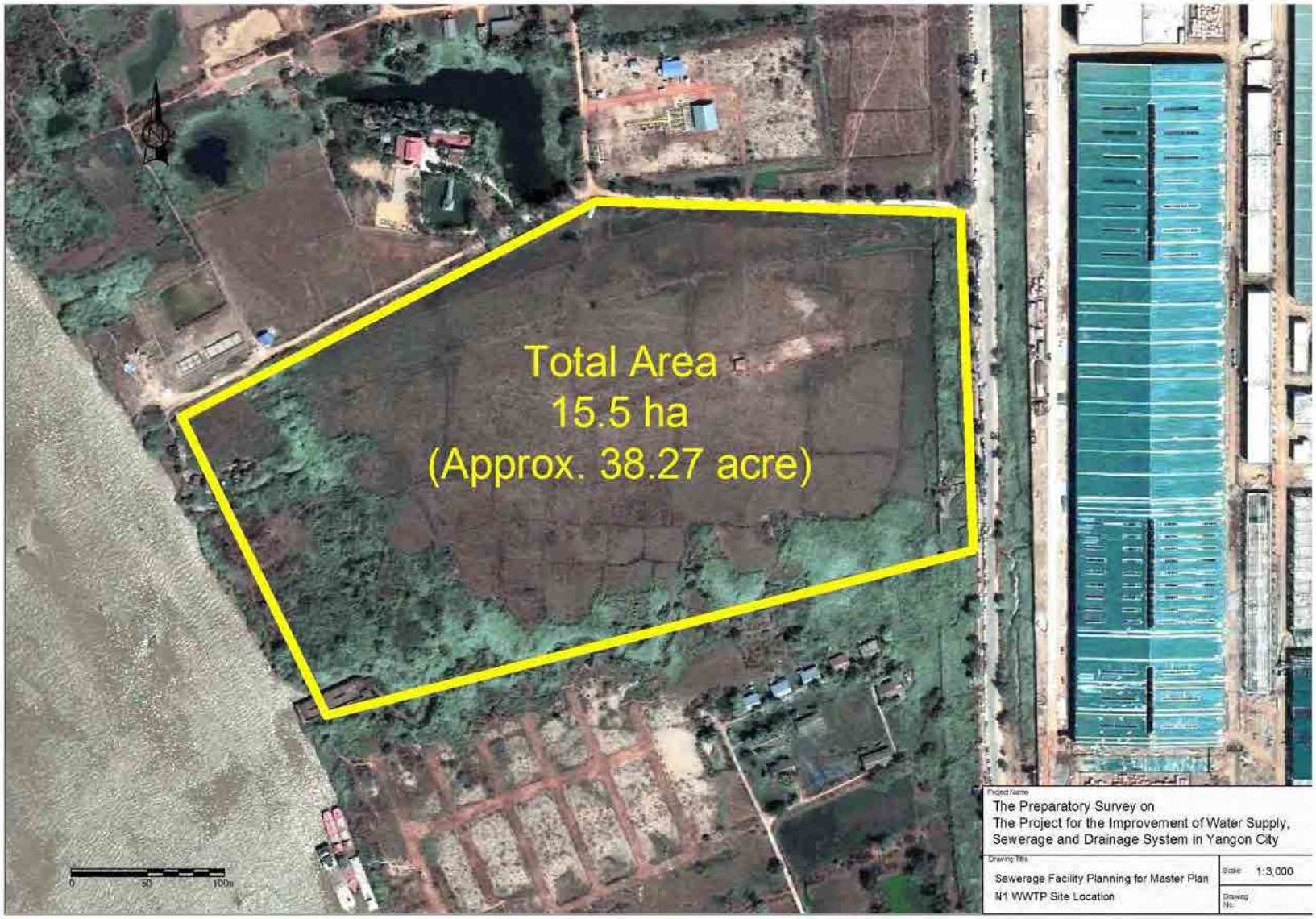
Source: JICA Study Team

Figure 7.14 Layout Plan of Trunk Main, N1 Sewerage Zone



Source: JICA Study Team

Figure 7.15 General Layout Plan, N1 WWTP



Source: JICA Study Team

Figure 7.16 Location of N1 WWTP

7.2.6 E3 Sewerage Zone

All sewerage facilities in this Sewerage Zone should be newly constructed. Conventional activated sludge process with double deck sedimentation tanks and deep aeration tanks adopted for this Sewerage Zone because site for construction of WWTP is limited to 8.1 ha (20 acres). Outline of the sewer networks is enumerated in Table 7.16. Trunk sewer system is shown in Figure 7.17. Outline of the wastewater treatment plant is enumerated in Table 7.17. Layout plan and location of the WWTP are shown in Figures 7.18 and 7.19, respectively.

Adoption of interceptor sewerage system should be considered at feasibility stage for E3 sewerage zone in order to reduce initial investment.

Table 7.16 Outline of Sewer Network in E3 Sewerage Zone

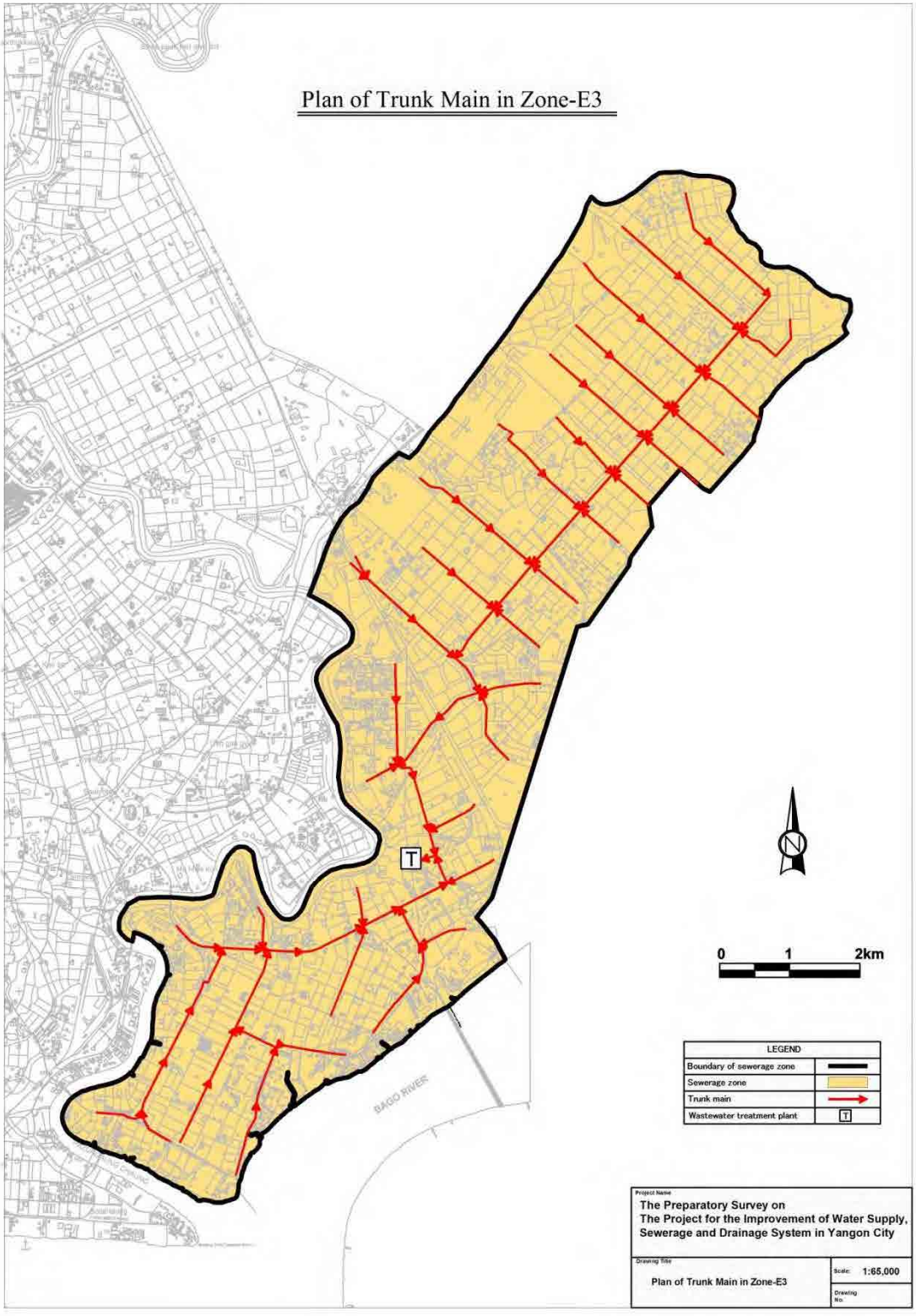
E3 Sewerage Zone		
Trunk Sewer		
Dia. (mm)	Length (m)	Construction Method
500	5,100	Small diameter pipe jacking
600	10,600	Small diameter pipe jacking
700	14,600	Small diameter pipe jacking
800	1,600	Pipe jacking
1,000	2,900	Pipe jacking
1,100	1,700	Pipe jacking
1,200	690	Pipe jacking
1,350	2,000	Pipe jacking
1,500	1,300	Pipe jacking
1,650	3,800	Pipe jacking
1,800	1,500	Shield
2,000	3,100	Shield
2,400	220	Shield
Branch Sewer		
<500	462,000	Open cut
House connection		
100	143,838 Nos.	Open cut

Source: JICA Study Team

Table 7.17 Outline of WWTP for E3 Sewerage Zone

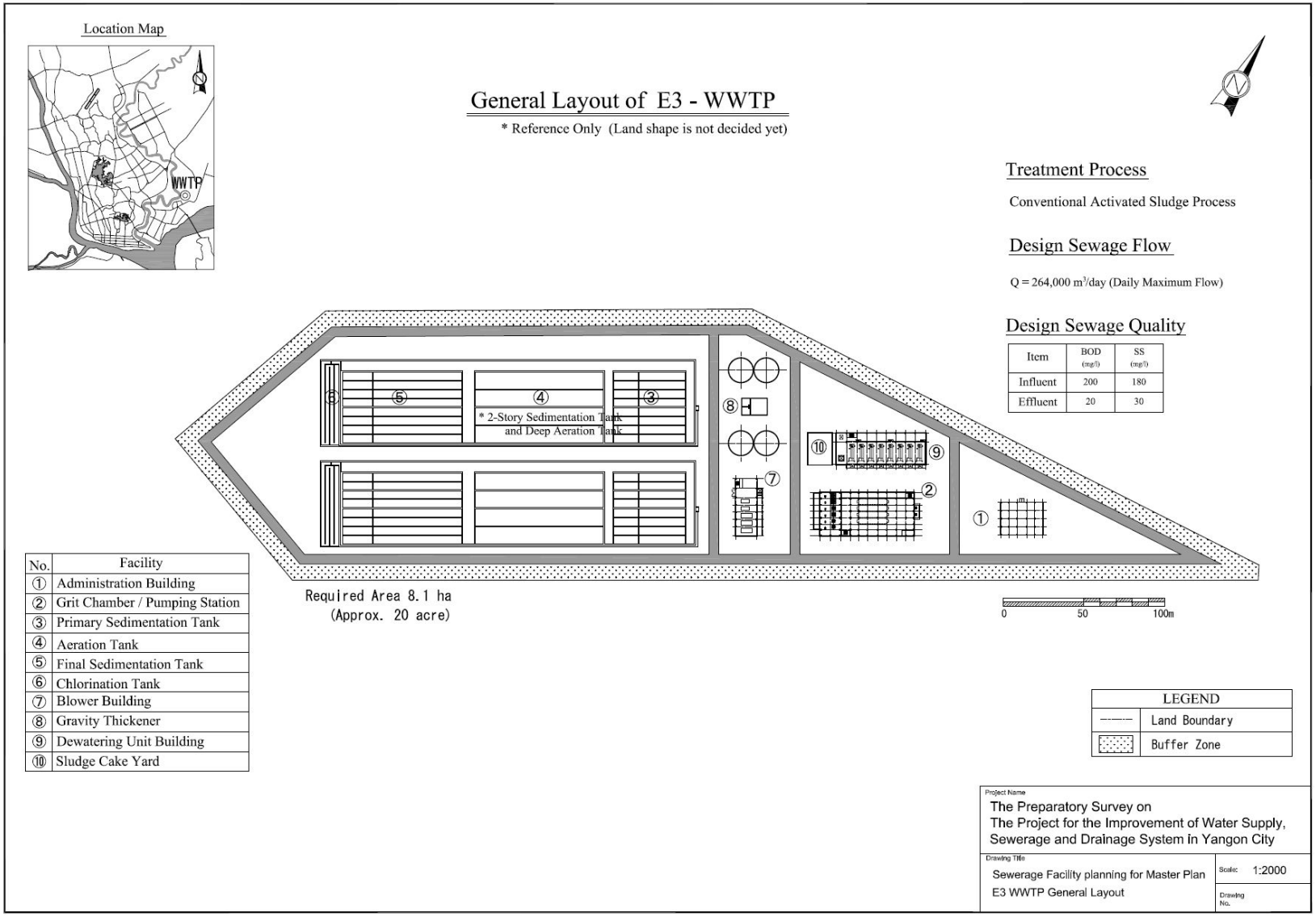
E3 WWTP		
Served Population in 2040 (persons)		920,933
Per Capita Wastewater daily ave. (lpcd)		214
Design Capacity (m^3/day)		264,000
BOD and SS Concentrations (mg/l)	BOD in	200
	SS in	180
	BOD out	20
	SS out	30

Source: JICA Study Team



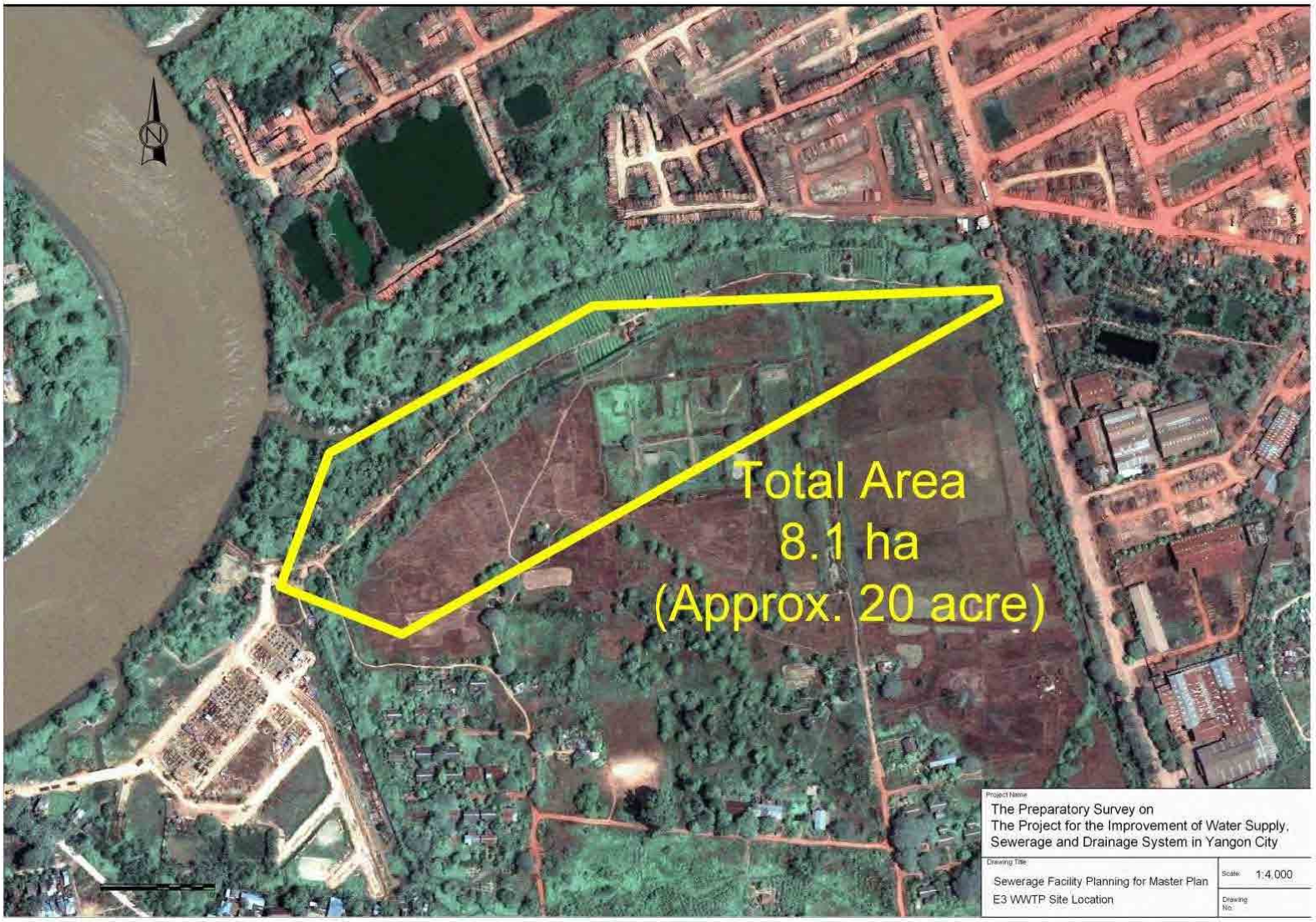
Source: JICA Study Team

Figure 7.17 Layout Plan of Trunk Main, E3 Sewerage Zone



Source: JICA Study Team

Figure 7.18 General Layout Plan, E3 WWTP



Source: JICA Study Team

Figure 7.19 Location of E3 WWTP

7.3 Priority of Sewerage Zones

In order to prepare implementation program for sewerage system development, priority of each of 7 sewerage zones (sub-zones of C2 and E1 are treated as independent zone) has been evaluated. Outline of the 7 sewerage zones, such as area, population, wastewater flow (daily average), location of WWTP sites and receiving water bodies for treated effluent is shown in Table 7.18. Receiving water bodies for treated effluent are Yangon River, Ngamoeyeik Creek, and Hlaing River, and all discharging points are located within river sections which are affected by tide. Inya Lake and Kandawgyi Lake are included in C2 sewerage zone. The existing sewerage service area is divided into C1 and W1 sewerage zones. Entire C1 sewerage zone lies in the existing sewerage service area, however, only a part of W1 sewerage zone is currently served by the existing sewerage system.

Selection criteria to determine order of sewerage system development are established. Three categories are selected for evaluation of priority, viz. status of urbanization, physical characteristics of sewerage zone, and contribution to water pollution control. Several indicators are also selected for these categories. These are population densities (2011 and 2040) for status of urbanization, size of zone and road length in sewerage zone for physical characteristics of sewerage zone and reduction of pollutant load for water pollution control. Reasons for the selection are described below.

Sewerage system is the most appropriate wastewater treatment system for urbanized area and becomes more economical as population density increases. Population density is the most suitable indicator to evaluate urbanization. Therefore, current (2011) and future (2040) population densities are considered as a parameter. The higher the population density, the higher is given priority.

Area of sewerage zone and length of road are selected as indicators for physical characteristics of sewerage zones. The smaller the area of sewerage zone and the shorter the length of road, development of the sewerage system is easier. The last category for selection of priority is contribution to water pollution control. If there is important water usage such as intake of water supply exist in the receiving water body, high priority should be given in such case. However, all of the discharging points are located in tidal sections of the rivers and such important water usage as water supply does not exist. Therefore, there is no difference among sewerage zones in this regard. There are small lakes, viz. Inya Lake and Kandawgyi Lake which provide the citizen with places of recreation and relaxation in the sewerage planning area. However, these lakes are located in relatively high elevation area, and catchments are very limited due to their topography. Therefore effect of provision of sewerage system on improvement of water pollution is also limited. Taking into account these considerations, a simple indicator which is reduction of pollution load (BOD) by wastewater treatment is taken into consideration.
Results of the evaluation are shown in Table 7.19.

Table 7.18 Outline of Seven Sewerage Zones

Sewerage Zone	Area (ha)	Population in 2040 (persons)	Daily Average Flow (m^3/day)	Location of WWTP (Township)	Receiving Water Body	Remarks
C 1	499	178,127	64,276	Botahtaung	Yangon River	Existing sewerage service area
C 2	6,102	1,191,499	452,548	South Okkalapa	Ngamoeyeik Creek	Inya Lake and Kandawgyi Lake are included
W 1	1,654	483,058	169,214	Ahlone	Yangon River	A part of the existing sewerage service area
W 2	2,356	349,512	116,999	Hlaing	Hlaing River	
N 1	3,163	377,188	129,633	Insein	Hlaing River	
E1	5,184	710,656	232,952	South Okkalapa	Ngamoeyeik Creek	WWTP in C2
E 3	5,418	920,933	243,849	South Dagon	Ngamoeyeik Creek	

Note: C2 and E1 are Sewerage Sub-Zones which formulate C2+E1 Sewerage Zone
Source: JICA Study Team

Table 7.19 Evaluation of Priority of Sewerage Zone

Sewerage Zone	Urbanization				Size and Road Length				Pollution Control		Total Points	Priority Order
	Population Density in 2012		Population Density in 2040		Area		Road Length		BOD Reduction			
	(persons/ha)	Point	(persons/ha)	Point	(ha)	Point	(km)	Point	(kg/day)	Point		
C 1	351	1	357	1	499	1	47	1	17,997	7	11	1
C 2	182	3	195	3	6,102	7	476	7	116,832	1	21	3
W 1	252	2	292	2	1,654	2	122	2	37,784	4	12	2
W 2	128	5	148	5	2,356	3	206	3	27,603	5	21	3
N 1	98	7	119	7	3,163	4	268	4	27,459	6	28	7
E1	107	6	137	6	5,184	5	386	5	67,840	2	24	6
E 3	131	4	170	4	5,418	6	462	6	55,156	3	23	5

Note: C2 and E1 are Sewerage Sub-Zones which formulate C2+E1 Sewerage Zone
Source: JICA Study Team

CHAPTER 8. WATER QUALITY IMPROVEMENT OF KANDAWGYI LAKE

8.1 Water Quality Management

On the north bank of Kandawgyi Lake, there are 12 restaurants and 7 drain outlets of urban drainage. These facilities discharge partially treated (sedimentation or grease trap) or untreated wastewater into Kandawgyi Lake. Kandawgyi Lake has 1 outlet (small movable weir) on the south west bank, however this weir is usually closed. Therefore, Kandawgyi Lake becomes closed water body, and pollutants are accumulated in the lake. Actual condition of Kandawgyi Lake is shown below. Lake water is already eutrophied, and blue - green alga is growing.

Photo 8.1 Actual Condition of Kandawgyi Lake

Kandawgyi Lake and its surrounding area are developed as water park, and one of famous tourist spot in Yangon City. Therefore, improvement in condition of eutrophied lake, and improvement of landscape of the lake is an urgent issue.

Possible eutrophication control measures for Kandawgyi Lake are shown in Table below.

Table 8.1 Possible Eutrophication Control Measures for Kandawgyi Lake

No.	Method	Aspect	Applicability
1	Application of algaecide ($CuSO_4$)	Quick impact measure Remains of water-broom become deposit Influence to other aquatic life	Not applicable Influence to other aquatic life
2	Removal of blue-green algae	Quick impact measure Influence to other aquatic life is very limited Various methods have been tried and implemented	Applicable Employ as urgent countermeasures
3	Air lift tube	Applied in deep lake / pond (depth >10m)	Not applicable Depth of Kandowgyi Lake is about 3m
4	Dredging	Removal of nutrient in sediment	Applicable
5	Water transmission from Inya	Feed rate from Inya Lake is very small (due to the capacity of existing transmission pipeline from Inya Lake).	Not applicable

No.	Method	Aspect	Applicability
	Lake	Long time is necessary to exchange Kandawgyi Lake water. Therefore, effect of this measure is low.	
6	Improvement of interceptor sewer	Quick impact measure Prevent nutrient inflow	Applicable
7	Improvement of sewer	Mid / Long- term measure High construction cost. Long time is necessary to complete.	Applicable
8	Household wastewater treatment tank	Establishment of law and regulation about management and dissemination of this wastewater treatment system Training of specified engineer is necessary.	Applicable

Source: JICA Study Team

8.2 Water Quality Improvement Project

8.2.1 Urgent Measure

"Blue-green algae removal" is the most probable measure, because this measure is expected to have quick impact, and influence to other aquatic life is very limited.

Demonstration experiment of blue-green algae removal was implemented from May to June, 2013. Summary of this experiment is shown below.

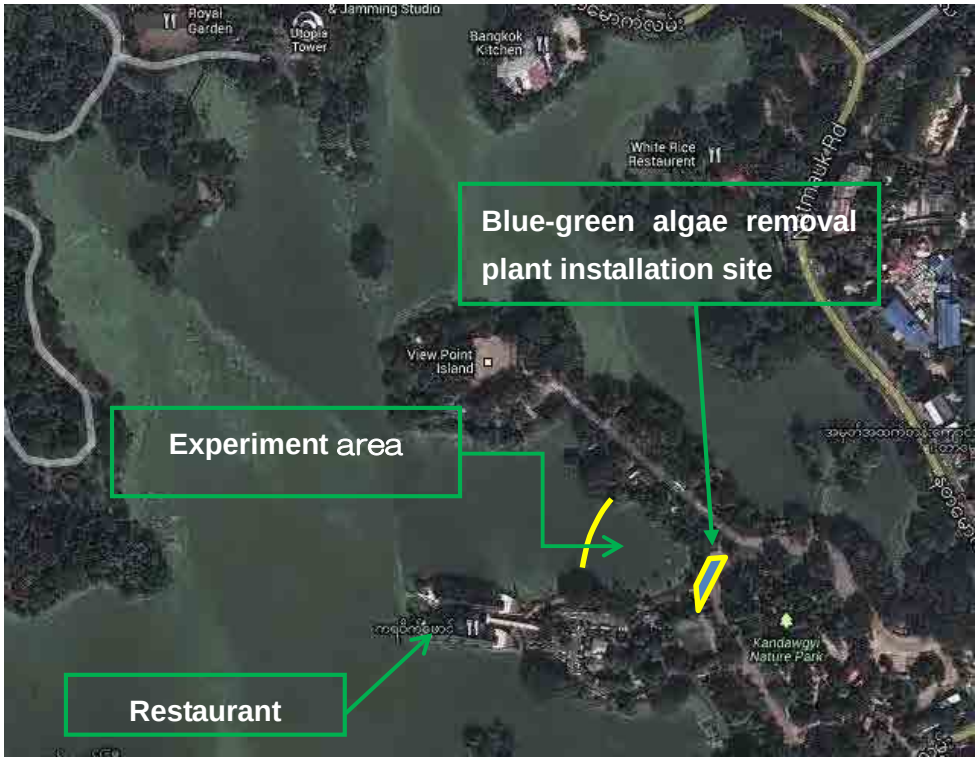
(1) Summary of experiment

Experiment period: May 23 to June 21, 2013.

Location: Experiment was done in the small inlet of Kandawgyi Lake. (See figure below)

Source: JICA Study Team

Figure 8.1 Location of Experiment Site (in the yellow dotted circle)

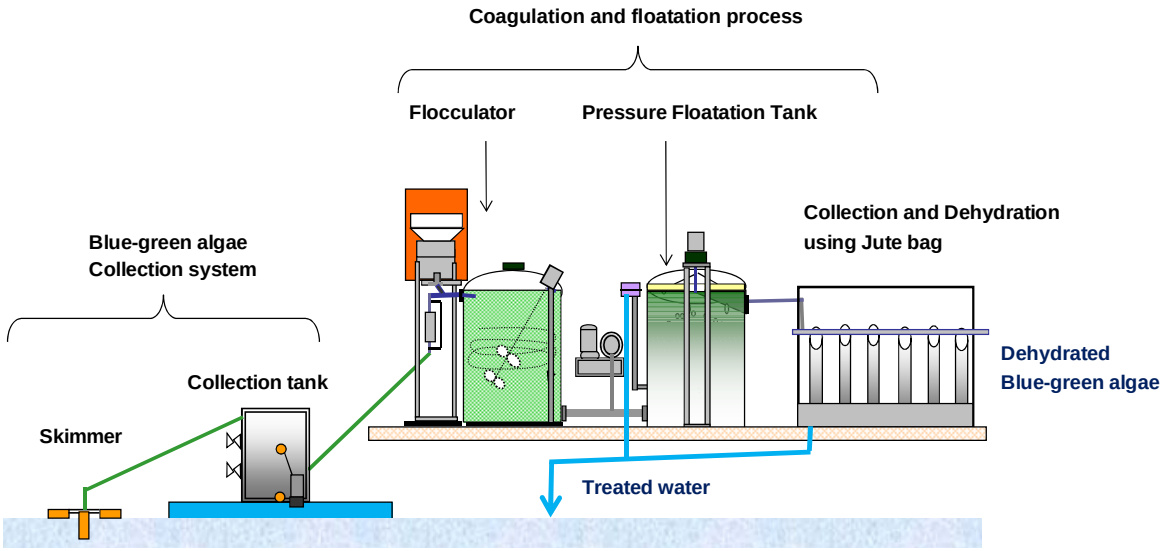


Source: JICA Study Team

Figure 8.2 Location of Experiment Site (detailed)

Blue-green algae removal plant

Scheme of blue-green algae removal plant is shown below;



Source: JICA Study Team

Figure 8.3 Scheme of Blue-Green Algae Removal Plant

Process of this blue-green algae treatment plant is as follows;

Collection of blue-green algae and lake water → Aggregation → Floatation using micro bubble → Collection and dehydration of aggregated blue-green algae → Disposal

Collected blue-green algae and lake water are pumped to treatment plant. In the treatment plant, coagulation and floatation technique is employed to separate blue-green algae. At the same time, SS, organic pollutant (CODcr), T-N and T-P are removed in coagulation process.
Treated water is returned to Kandawgyi Lake, and collected blue-green algae are disposed after dehydration.

(2) Result of experiment

Capacity of treatment plant

Capacity of blue-green algae removal plant in this experiment is as follows;

- Capacity of lake water treatment: 67m^3/day
- Capacity of blue-green algae removal: 48kg (dry weight) / day
- Capacity of pollutant removal: SS 85%, CODcr 80%, T-N 98% and T-P 91%

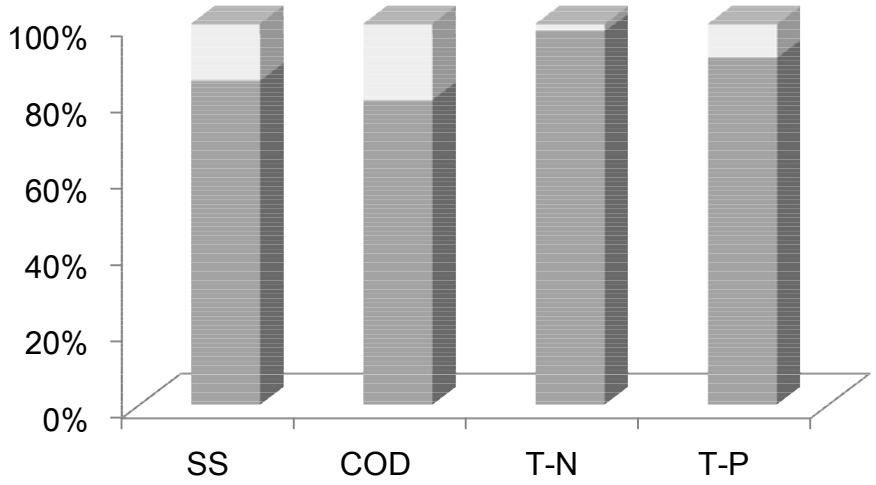
Following photos show difference of raw water (blue-green algae and lake water) and treated water.
During this experiment period (24 days), on 19 days rain occurred because of the rainy season. Thus, during this experiment period, blue-green algae were dispersed by rainfall. Therefore, experimental condition for blue-green algae collection was not appropriate.
However, in this experiment, blue-green algae in lake water were removed, and treated water became clear.

Left: Raw water (Before treatment)
Right: Treated water

Coagulated blue-green algae

Photo 8.2 Treated Water and Collected Blue-Green Algae

Removal ratio of SS, CODcr, T-N and T-P are shown in following figure.



Source: JICA Study Team

Figure 8.4 Removal Ratio of Pollutants in Treated Water

Through these experimental results, it was shown that this blue-green algae removal plant was effective not only in algae removal, but also resulted into improvement of water quality through removal of other pollutants.

(3) Estimation of construction period or capacity of treatment plant for processing entire Kandawgyi Lake

Based on the experiment result, required construction period and capacity of treatment plant are estimated.

Quantity of lake water and blue-green algae to be treated

Quantity of lake water to be treated is calculated as follows;

Surface area of Kandawgyi Lake: 647,497 m^2
Thickness of water layer to be treated (Blue-green algae are existing.): 0.5m

i.e. Quantity of lake water to be treated: 647,497 m^2 × 0.5m = 323,749 m^3

Quantity of blue-green algae is estimated based on the SS of Kandawgyi Lake.

i.e. Quantity of blue green algae
= 323,749 m^3 (Lake water) × 121.3 mg/L (average SS of Kandawgyi Lake)
= 39,271 kg

Estimation of required construction period

Here, obtained capacity of blue-green algae removal: 48kg (dry weight) / day was a result of 8 hours operation / day.
However, an actual operation hour / day is estimated 6 hours. Therefore, net capacity of blue green algae removal is estimated 36 kg/day.

Therefore, when this treatment plant is used for Kandawgyi Lake blue-green algae removal, required operation period is;

39,271 (kg) / 36 (kg/day) = 1,091 days

Estimation of required capacity of treatment plant

By the way, appropriate period for blue-green removal may be dry season.
Net operating period of dry season is estimated;

5 months × 20 days (operation period / months) = 100 days

Therefore, required capacity of treatment plant is estimated as follows;

39,271 kg / 100days = 393 kg/day

That is, if the capacity of treatment plant is enhanced 12-folds (i.e. 4 treatment plants of 3-fold treatment capacity is installed), blue-green algae removal of Kandawgyi Lake can be completed within 1 dry season.

8.2.2 Short Term and Mid / Long - Term Measures

The fundamental measures to reduce blue-green algae are removal of nutrient in sediment and prevention of nutrient inflow. Specific measures are as follows;

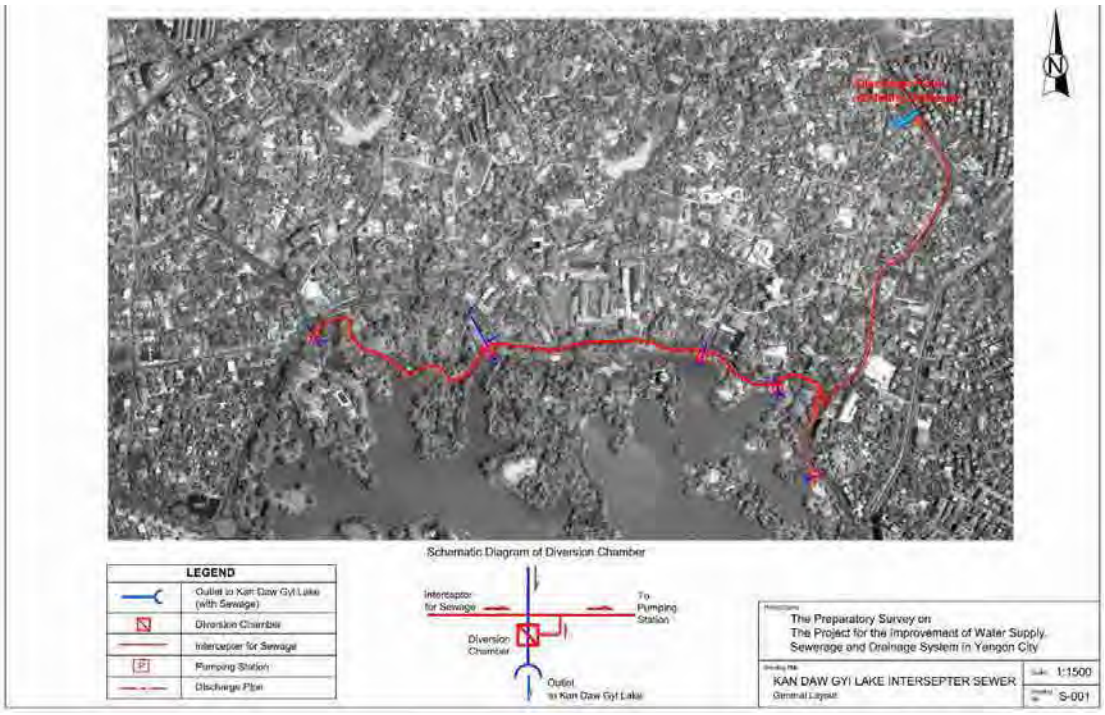
- Removal of nutrient by dredging of sediment

In order to prevent nutrient from inflowing to Kandawgyi Lake, there are three measures on domestic human wastewater as shown below.

- Installation of interceptor sewer connecting outlet points of drainage system (Figure 8.5)
- Installation of household wastewater treatment tank in the restaurants around the lake (12 restaurants)

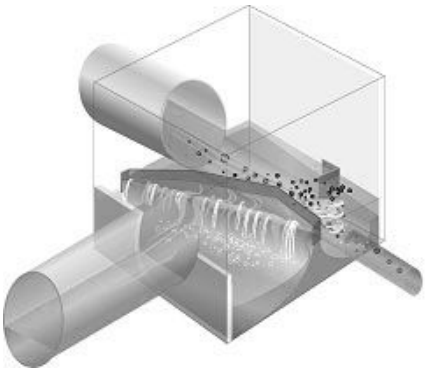
- Development of sewerage system

Figure shown below is a possible route of interceptor sewer (Figure 8.5). Interceptor sewer is to be connected with storm outfall (Figure 8.6) installed on existing drainage. Intercepted wastewater is collected and discharged into existing drain.



Source: JICA Study Team

Figure 8.5 Possible Route of Interceptor Sewer



Source: JICA Study Team

Figure 8.6 Example of Storm Outfall

Dredging and construction of interceptor sewer can be implemented easily, therefore, these measures are considered as short-term measure. On the other hand, installation of household wastewater treatment tank and sewer improvement need long term to generate the effect. Therefore, these measures are considered as mid / long-term measure.

Time schedule of short-term measure (dredging and interceptor sewer construction) is shown below.

Dredging is implemented after interceptor sewer construction is finished.

Detailed construction plan is to be considered in F/S.

Measure	Year					
	1	2	3	4	5	---
Dredging	▬▬▬	Implement ad libitum				
Interceptor sewer	▪▪▪▪▪▪▪ Construction	▬▬▬	Operation			Utilize in sewer improvement

Source: JICA Study Team

Figure 8.7 Schedule of Short-Term Measure Implementation

CHAPTER 9. INSTITUTIONAL DEVELOPMENT FOR OPERATION AND MAINTENANCE AND CAPACITY BUILDING

9.1 Institutional Development for Operation and Maintenance

Currently operation and maintenance of ejector system and WWTP, and approval for application of septic tank is under responsibility of Sanitary Division. Institutional system should be strengthened substantially as sewerage system is developed. Organization which will be required in 2040 when sewerage system is developed as proposed in the previous Chapters is studied. Proposed organization is described in Figure 9.1. Main points of the proposal are as follows.

- An additional Deputy Head should be appointed in addition to the current two Deputy Heads, and he should be exclusively responsible for sewerage works.
- Under new Deputy Head, Office Section, Finance Section, Database & Tariff Section, Laboratory, Planning and Monitoring Section, Research and Development Section, Construction Section, Development Coordination Section, Customer Care and Public Relation Section, Industrial Wastewater Section and Laboratory which report to the Deputy directly should be established.
- Pipe Network and On-site Treatment Division which is responsible for operation and maintenance of pipe networks and on-site treatment facilities should be established. Under the Division, 4 District Offices are placed.
- WWTP Division which controls 6 WWTPs should be established.
- Drainage Division should be established for operation and maintenance of drainage facilities and to control township or district offices once transfer of responsibility is agreed upon.

  (Note: Underlined Section or Division are new establishments)

Responsibility of new Sections and Divisions are as follows.

Finance Section

Control all revenue and expenditure of the Department.

Database & Tariff Section

Preparation and maintenance of inventory of sewerage system using GIS. Accounting although tariff collection is entrusted to Water Supply Department.

Planning and Monitoring Section

Negotiation with outside authorities. Preparation of sewerage development plan.

Research and Development Section

Research and experiment on sewerage system and on-site treatment system. Preparation of design criteria.

Construction Section

Design and construction supervision of sewer network and WWTP

Development Coordination Section

Direction of large scale development, installation of new septic tank

Customer Care and Public Relation Section

Public relation activities with citizens including sewerage fee collection and house connection

Industrial Wastewater Section

Preparation and definition of discharge standards, and monitoring of industrial wastewater

Laboratory

Analysis of water samples taken from WWTPs and other related facilities.

Pipe Network and On-site Treatment Division

Maintenance of pipe networks including house connections. Operation and maintenance of Johkaso and community plants.

WWTP Division

Control of WWTPs

Drainage Division

Control of township offices or district offices which directly carry out operation and maintenance work. Refer to Drainage Part for details.

It is desirable to establish Database & Tariff Section, Laboratory, and Planning and Monitoring Section which report to the Deputy Head directly as soon as possible. Responsibilities of other new Sections will be assumed by Office Section and/or Planning and Monitoring Section at first and new Sections will be established as activities increase. Pipe Network Division and WWTP Division will be enlarged as sewerage system is developed. Total number of staff excluding Drainage Division is estimated to be approximately 600 persons depending on the extent of outsourcing to private sector. Currently operation and maintenance work is carried out by YCDC staff. It is considered necessary that outsourcing of operation and maintenance work to private sector be promoted for more efficient operation of the sewerage system. A total of 600 persons are estimated based on the assumption that substantial part of the work at WWTP and maintenance of sewer network is outsourced.

For operation and maintenance of WWTP, organization shown in Figure 9.2 is proposed. Three sections, i.e. Operation & Control Section, Electrical and Computer Section and Mechanical & Vehicle Section should be established for each WWTP. Responsibility of Section is as follows.

Operation & Control Section

Operation and maintenance of all facilities except for electrical and mechanical facilities. Sampling of wastewater for analysis. Monitoring of industrial wastewater. Minor repair work of facilities.

Electrical and Computer Section

Operation and maintenance of all electrical and instrumental equipment including transformer.

Preparation and maintenance of operation records.

Mechanical & Vehicle Section

Operation and maintenance of all mechanical equipment and vehicles possessed with WWTP.

Required staff number depends on capacity of WWTP and 30 to 60 persons might be required for 6 WWTPs which are in operation in 2040.

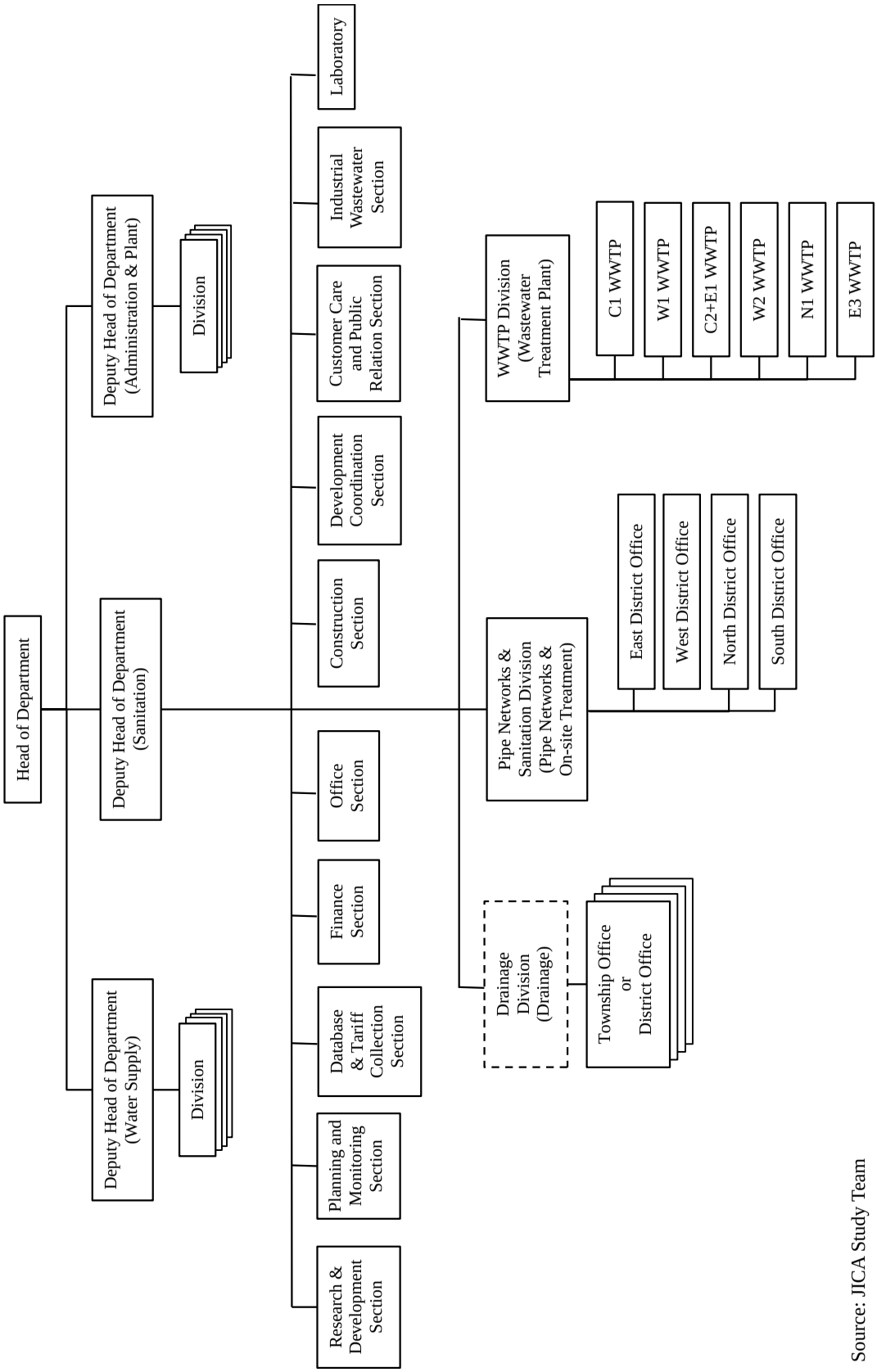
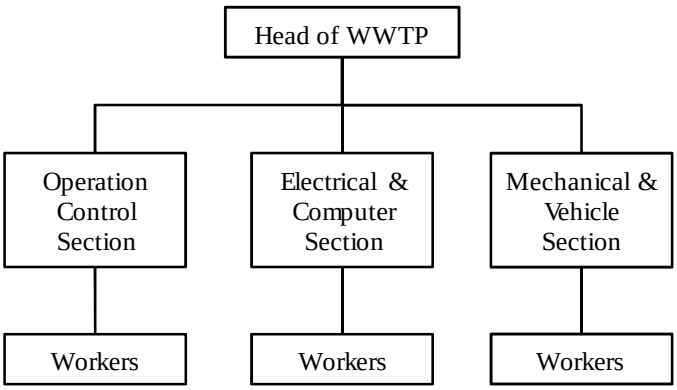


Figure 9.1 Organization Chart of Sewerage Department

Source: JICA Study Team



Source: JICA Study Team

Figure 9.2 Organization Chart for O&M of WWTP

9.2 Technical Capacity Building

WWTP consists of civil and architectural structures, mechanical and electrical and instrumental equipment. In addition, wastewater treatment adopts biological processes. Thus, knowledge covering civil, architectural, electrical, chemical and biological fields is required for operation and maintenance of WWTP. On-the-job training (OJT) using actual facilities are most desirable for staff's technical capacity development. However, OJT is difficult currently because there is only one WWTP and normal operation of it is not expected because current wastewater flow is only 15 % of the design flow and many gauging devices are broken down.

OJT is also difficult for pipe networks, because only operation and maintenance of ejector system is carried out by the Division. Under these circumstances, capacity building program for operation and maintenance of sewerage facilities should be developed and implemented by steps mentioned below.

- Conduct training assessment for responsible divisions of department of YCDC (Pipe Network and On-site Treatment Division, WWTP Division)
- Prepare training program
- Implement OJT, workshop and lecture by professionals and outside authorities (universities or foreign institutions).
- Monitor and evaluate implementation of the program

Firstly training program should be implemented in cooperation with outside authorities such as universities and retired senior persons of the Department and developed gradually to be permanent training programs. Dissemination of developed training programs to other cities in Myanmar should be considered. Training program offered by overseas financing agencies and educational institutions should be utilized positively. Samples of training program are shown in Tables 9.1 and 9.2.

Table 9.1 A Sample of Capacity Building Program Related to Sewerage System (Technical)

Field	Course
Mechanical Equipment	O & M of pumps
	Safety control of chlorine dosing equipment
	O & M of mechanical gauging equipment
	O & M of valves
	O & M of sedimentation tank equipment
	O & M of aeration equipment
Electrical and Instrumental Equipment	O & M of electrical equipment
	Fundamentals for design of electrical equipment
	O & M of instrumental equipment
	Information management system（SCADA）
	Single wiring diagram
Sewer Network	Design of sewer network
	O & M of sewer network
	House connections
Water Quality Analysis	Characteristics of wastewater
	Chemical analysis of wastewater
	Biochemical analysis of wastewater
	Microscopic test
Wastewater Treatment in General	

Source: JICA Study Team

Table 9.2 A Sample of Capacity Building Program Related to Sewerage System (General)

Field	Component
General/management of project	- Project management - Finance, accounting, budget, IT application , and capacity building - Preparation of handbooks/manuals for project management
Legal system	- Sewerage Act, Regulations, and Standards (discharging effluent, receiving of industrial wastewater, etc.)
Database/GIS	- Preparation of database using GIS - Utilization of database
Environmental management	- Preparation of environmental management program - Implementation of environmental management
Public Relation/Public Hearing	- Training for public relation (distribution of pamphlet, holding of meeting, etc.) - Training for public hearing (holding of hearing, etc.)

Source: JICA Study Team

9.3 Institutional and Organizational Development Plan

The following policies in the short-term that form the three pillars of an organization to be incorporated, out of 3 stages of short-term (- 2025), medium-term (- 2040) and long-term (after 2040), have been proposed under the framework of organizational development and the roadmap for setting the foundation for strengthening the organization:

a) Clearly defining the policies of the DEWS

b) Restructuring of the DEWS and township offices
c) Strengthening the organization of the DEWS and township office

The policies are as given below.

(1) Policy 1: Clearly defining policies of the DEWS

Formulation of high level policies and plans for organization

- Once an organization has policies to aim for that are not limited to water supply and sewerage works, it can start making plans, strategies, business plans and set comprehensive targets. It is extremely important to clearly define the high level policies of the DEWS and to establish the direction to proceed so as to make the water supply and sewerage works sustainable. The vision prepared in the Master Plan will become a part of the policies. Then the Sewerage Division should formulate its short-, medium- and long-term development plans according to such high level policies and plans in gradual stages henceforth.

Setting up the planning and monitoring section

- Section (for instance: planning and monitoring section) should be set up for preparing high level policies and plans, strategies, business plans and so on, and for continually monitoring and updating the same. The aforementioned section should be under the Deputy Head, may not be a large department, but it should overlook the entire organization including the roles and duties of existing sections from the management viewpoint, and should have the role of proposing improvements in addition to planning and monitoring.

Utilizing performance indicators (PIs)

- Performance indicators for sewerage services should be effectively utilized in the business operation of the Sewerage Division. PIs are an effective tool for evaluation of performance quantitatively. It enables to compare the utility's performance of the past, present and future periodically, and also to set up quantitative targets for future improvement. The state of existing business operation and target achievement status of sewerage service should be always monitored. It makes current management situation and achievement visible. Although performance indicators are not being used by YCDC currently, such actions will clarify issues and improvement points to be undertaken and prove to be effective.

- The category of performance indicators of IBNET for sewerage and wastewater service and a part of that are shown in the following table.

Table 9.3 Category and Main Performance Indicators for Sewerage and Wastewater Service

Service Coverage	Billing an d Revenue Collection
Pipeline System Performance	Financial Performance
Cost and Staff Allocation	Willingness to pay for Services
Service Quality	Process Indicators

Code	Performance Indictor	Unit	Definition
2.1	Sewerage Coverage	%	Population with sewerage services (direct service connection)as a percentage of the total population under utility's notional responsibility
10.1	Sewer System Blockages	blockages/km/yr.	Total number of blockages per year expressed per km of sewers
11.6	Unit Operational Cost – Wastewater	US$/WW pop served	Annual wastewater operational expenses/ Population served
12.2	Staff Wastewater/'000 Wastewater connections	#/'000 WW conn	Total number of staff expressed as per thousand connections
12.6	Staff Wastewater/'000 Wastewater pop served	#/'000 WW pop served	Total number of staff expressed as per thousand people served
13.1	Labor Costs vs. Operational Costs	%	Total annual labor costs (including benefits) expressed as a percentage of total annual operational costs.
13.2	Electrical Energy Costs as percentage of Operational Costs	%	Annual electrical energy costs expressed as a percentage of total annual operational costs
17.1	Wastewater – at least primary treatment	%	Proportion of collected sewage that receives at least primary treatment, i.e. involving settlement with the intention of removing solids, but not biological treatment. Both lagoon and mechanical treatment can be included, where appropriate.
16.1	Complaints about W&WW services	% of W&WW conn	Total number of W&WW complaints per year expressed as a percentage of the total number of W&WW connections
18.5	Revenue Split - % wastewater	%	Percentage split of total revenue into wastewater
18.10	Wastewater revenue per person served	US$/person served	Operating revenues (WW only) expressed per person served
23.2	Collection ratio	%	Cash income / Billed revenue as %
27.3	Gross Fixed Assets – wastewater	US$/WW pop served	Total gross fixed assets per population served, separately for wastewater (WW)

Source: IBNET

Setting Targets for Sewerage Division

- Performance targets and achievement standards of Sewerage Division should be clearly established. Sewerage Division should set up the key performance indicators and the achievement targets, and do their best for achievement of these targets. Then they need to review the performance results. The establishment of targets using performance indicators as far as possible are able to make the results visible.

(2) Policy 2: Reconstruction of the Department of Engineering (Water Supply and Sanitation) (DEWS) and township offices

Services based on customer needs

- Sewerage and sanitation service is a public service for the citizens. The organization should change itself such that it is aware of customers and services are offered based on customer needs.

Change to an organization with business awareness

- The DEWS is a part of the local government. It is important that this department changes to a service provider with business awareness as a part of its organizational culture rather than change to an administrative organization with technical specialization. The first step for this change could be started from the change of employee's mind and awareness at the individual level. In order to do that, strong leadership needs to be taken by the upper management class. The Sewerage Division is not the exception. YCDC needs to pay more attention to the cost recovery of sewerage service for their sustainability.

Clear division of labor and delegation of authority

- Division of labor and delegation of responsibility should be clearly established in each department. Authority should be delegated to departments lower in the hierarchy. Self-awareness and self-reliance of employees should be encouraged more than ever before.

Establishment of water quality laboratory

- A water quality laboratory should be created at WWTP and a regular monitoring system be established as soon as possible. Although water quality test is currently not conducted, it is necessary to install water quality equipment and facilities for chemical and biochemical quality analysis, and to recruit new employees having such specialized knowledge.

Creating the Customer Services and Public Relations Section

- A section in charge of customer services and public relations should be set up in the DEWS to reinforce the functions of IEC activities and public health education. A customer service and public relation section will be also created particularly in every township office on the frontline. This section concurrently serves as water and sewerage services without any separation. This M/P recommends the shift from the current facility to introduction of improved septic tank or on-site compact treatment facilities (Johkaso). Thus, promotion activities assisted by institutionalizing a financial subsidiary system for the introduction of and modification to improved type and IEC activities raising environmental awareness of citizens are essential. Since the dissemination and the public awareness-raising by IEC activities will take time, it is important to urgently create the section in the DEWS specialized in planning and implementation of IEC activities. This section will shift their focus to improvement of customer service and increase of customer satisfaction in order to

enhance the quality of service.

(3) Policy 3: Strengthening the organization of the DEWS and township office

Formulating plans for human resource development plan

- Plans should be formulated to develop human resources, and skills of personnel be upgraded periodically and continuously. With the expansion in facilities, the efficiency and quality of the water supply and sewerage services need to be enhanced. For this purpose, human resources should be developed on priority basis and skills of the employees enhanced, recognizing that humans are the most important of all resources. Up to the period of launching particularly full-scaled development since 2025, public health education and public awareness-raising through IEC activities to the citizens are necessary. In addition, technical and management foundations for sewerage and wastewater services need to be developed. Thus YCDC is required to understand such urgent needs and reflect them on establishment of human resource development plan in short- and medium-term.

Building up the human resource management system

- Human resources must be understood at all times and should be efficiently utilized and assigned properly by developing the human resource management system at the Head Office. In addition, evaluation standards must be set and information systems developed so as to evaluate the performance of the employees. The Sewerage Division as a part of DEWS needs to be systemized as well.

Making work more efficient by installing computers

- Managing work by handwritten documents should be reduced as far as possible so as to aim for more efficient work. Use of computers should be encouraged in townships and in the Head Office. In the initial stage, the information on status of IEC activities and dissemination of septic tanks to the citizens are managed by using computers. It should be utilized for efficient management works. It is also applied to management works of customer information and revenue collection after starting sewerage service. On the occasion, sewerage charge collection work will be integrated into water charge collection work by using same database of DEWS.

Enhancement of public health education and public awareness-raising through IEC activities

- Customer Care and Public Relation Division in DEWS will develop IEC materials in cooperation with outside institutions and experts and establish a plan for IEC activity programs. It also proactively promotes education and awareness-raising by using media and publications. The intensive training for human resource development to township offices needs to be carried out to implement the programs appropriately. On the other hands,

township staffs needs to learn how to raise NGOs who will be partners of field activities subcontracting public health education, public awareness-raising, training and monitoring, and to utilize its capability. It will be necessary to deploy education and awareness-raising activities institutionally.

(4) Main organizational functions of the Sewerage Division

The assumed main functions of the Sewerage Division under the institutional development are summarized in the following table.

Section	Main functions
Planning and Monitoring section	□ Target setting □ Strategic planning □ Performance management by PIs □ Evaluation and monitoring of PIs □ Sewerage development plan, Demand management plan for short-, medium- and long-term □ Asset management plan, renewal and rehabilitation plan
Research and Development Section	□ Implementation of project study, implementation support □ Technical study activity □ Study and experiment on sewerage and on-site treatment □ Development of design criteria
Customer Care and Public Relations Section	□ Enhancement of customer communication □ Customer window, customer care and customer management □ Customer claim □ Customer satisfaction survey □ Marketing □ Education and awareness-raising through IEC activity □ Publication, information service □ Periodical publication □ Press release
Finance Section	□ Management of service financial balance □ Budget preparation and application
Database and Tariff Section	□ Development and management of inventory of sewerage system □ Issuance of sewerage bill □ Accounting processing □ Revenue collection management
Construction Section	□ Facility planning and design □ Procurement of construction works by outsourcing contract □ Construction work under direct management □ Supervision work, quality management, approval □ Payment for construction work, financial management
Development Coordination Section	□ Coordination and guidance of development project □ Management of development project
WWTP Division	□ O&M of WWTP □ Sludge management, appropriate disposal of treated

Section	Main functions
	wastewater and sludge
Industrial Wastewater Section	□ Receiving standards of factory effluent, water quality management of factory effluent
Pipe Network and On-site Treatment Division	□ O&M of sewers □ O&M of community treatment plant

Source: JICA Study Team

9.4 Arrangement of Legal Framework

Up to the middle term of FY2040, M/P proposes that the coverage of sewerage services which treats both black and gray water should be 50 %, and in other area, the improvement of septic tank and construction of Johkaso and community plant are proposed.

Particularly until increasing coverage areas, not sewerage system but sanitation facilities including community plant and improved septic tank need to be promoted and disseminated. By doing so, the arrangement of legal framework is an urgent challenge. In accordance with the development of sewerage system, it is required to develop the basis of legal framework on wastewater treatment including sewerage system and water environmental preservation.

A roadmap of arrangement of legal framework on wastewater treatment including sewerage system is shown as below.

Table 9.4 Roadmap on Arrangement of Legal Framework

Year	2014	2015			2020							2025
Necessary legislation												
1. Legislation on Johkaso and septic tank												
2. Legislation on environment and wastewater treatment												
3. Legislation related to sewerage system development （Sewerage Act、Sewerage Ordinance）												
4. Legislation and regulations on land development related to wastewater collection and treatment												
5. Municipal ordinance on receiving industrial wastewater												
6. Ambient standards and effluent standards												
Development of sewerage facilities												
1. Construction of C1 zone												
2. Construction of W1 zone												

Source: JICA Study Team

With regard to the necessary each laws and legislations, the significance, the necessity and the main items to be defined are summarized in the following table.

9.4.1 Legislation on On-site Compact Treatment Facility (Johkaso)

Name :	Legislation on On-site Compact Treatment Facilities (Johkaso)
Significance and necessity :	• Discharge of black and grey water without any treatment is assumed to causes deterioration of living environment and public health. This legislation enhances appropriate treatment by septic tank and onsite compact treatment facility. • Increase of sewerage system takes long-term period. It is necessary to legally define the construction of these facilities in order to enhance the improvement of water quality and effectiveness of environmental improvement until sewerage system is developed.. • The treatment efficiency of current septic tank and pit latrine is outstandingly low, therefore the shift to improved septic tank or on-site compact treatment facilities should be further promoted.
Items to be defined:	• Definition • Necessity of treatment of night soil (black water) and miscellaneous drainage (grey water) by improved septic tank and on-site compact treatment facilities • Design standards such as structural standards and capacity standards • Construction standards • Approval of type of construction and registration methods • Report on installation, modification, admonition, change of facilities • Duties of supervisory entities • Maintenance and inspection of on-site compact treatment facilities and repair • Registration and permission of construction companies and cleansing vender and maintenance vender. • Water quality standards and quality test methods of treated wastewater • Admonition and order of regular inspection • Fines for violation • Fund subsidy system, etc.

9.4.2 Legislation Related to Environmental Conservation and Wastewater Treatment

Name :	Legislation related Environmental Conservation and Wastewater Treatment
Significance and necessity :	• It is necessary to consider development of legislations related to environmental conservation and to formulate practicable legislations before development of sewerage system to avoid the possible negative impacts to the environment surrounding the wastewater treatment etc. • For instance, the formulation of legislations on water pollution control, solid waste management, air pollution prevention, noise regulation, vibration regulation, odour prevention etc. aiming to mitigate and regulate environmental impacts on sewerage system may be assumed.
Items to be defined:	• Water pollution control • Solid waste management (sludge) • Air pollution prevention • Noise regulation • Vibration regulation • Odour prevention, etc.

9.4.3 Legislation Related to Sewerage System

Name :	Legislation related to Sewerage System
Significance and necessity :	• Formulation of a basic law defining roles and functions of sewerage system is necessary, which is expected to be a legal basis for development of sewerage system • Development of sewerage system in the interceptor treatment blocks expected to be defined by sewerage laws or sewerage ordinance preliminarily until final separate sewerage system is constructed.
Items to be defined:	• Definition of sewerage works management and operating entities • Authorities, duties, responsibilities and facilities • Requirement for development planning, structural standards • Development, use and O&M of sewerage facilities • Installation and inspection of discharge facilities • Limitation of wastewater exclusion from specified facilities • Installation and registration of specified facilities • Duty for water quality measurement • Beneficiaries pay principles • Fine and indemnity liability • Development of interceptor-type sewerage system (interceptor treatment block) − Construction of sewer main and treatment facilities by YCDC first until an establishment of separate-type sewerage system − Mitigation of pollution load by using exiting rain drainage channel as interceptor branch channel − Development of branch sewers and connection pipe will be developed afterwards, etc.

9.4.4 Legislation on Wastewater Treatment Related to Development Activities

Name :	Legislations on Wastewater Treatment related to Development Activities
Significance and necessity :	• In case that development activity is implemented not appropriately, huge amount of wastewater flows into wastewater treatment and sharp increase of rainfall runoff is expected. In order to mitigate such significant impacts on wastewater treatment facilities and nearby water environment, an arrangement of regal framework is important. • For instance, “City Planning Act” aims to prevent from inappropriate urbanization and to enhance regulating of urban development by appropriate planning.
Items to be defined:	• Permission system for development activities more than a certain scale of development • Regulation of development area and block • Limitation of □architecture construction • Installation of wastewater treatment facilities and drainage facilities • Allocation of facilities, structure and inspection etc.

Land development should be controlled by government instructions and regulations to reduce the storm water runoff by appropriate land use.

9.4.5 Regulation on Discharge Effluents from Industry

Name :	Regulation on Discharge Effluents from Industry
Significance and necessity :	• Factories producing certain products discharge effluents with extremely heavy pollutants and/or with trace hazardous substances such as heavy metals. Unlimited acceptance of these effluents poses excessive burden to wastewater treatment and there is a possibility to decrease treatment performance dramatically. Therefore it is necessary to establish regulation of characteristics of effluents to be discharged to sewerage. • It is also necessary to prevent water quality degradation beforehand.
Items to be defined:	Exclusion criteria of discharge effluents for sewerage system • Municipal Ordinance/ Standards on acceptance discharge effluents from factories and specified organization/company to sewerage in specified water quality parameters Regulation on effluent quality standards • Permissible level of water quality on hazardous substances

9.4.6 Development of Ambient Water Quality Standards/ Effluents Standards

Name :	Development of Ambient Water Quality Standards/ Effluents Standards
Significance and necessity :	• In order to conserve sound environment of public bodies, it is necessary to define the level of water quality to be maintained. • For achieving this purpose, regulations of the quality of effluents discharge to directly public water bodies are necessary. • Allowable effluent water quality standards across the country set by national government and more stringent ones for individual water body set by regional or local government are necessary.
Items to be defined:	• Environmental standards on water quality control • Water quality standards on human health • Water quality standards on living environment (river, lake, sea)

9.5 Public Awareness Activity

In Yangon City, only 5.8 % of the population is connected to sewerage facilities and treatment of only black water is carried out. About 43 % of population has septic tank to treat black water and the remaining population discharges all wastewater into the drains and rivers without treatment. The sewerage facilities and septic tank treat only black water and the gray water is discharged directly into the drains. This situation leads to deterioration of the water quality in lakes and rivers.

By 2040, it is proposed that the coverage of sewerage services which treats both black and gray water should be 50 %, and in other area, the improvement of septic tank and construction of Johkaso and community plant are proposed. For the necessary action such as connection to the sewers, payment of charges, improvement of septic tank, construction of Johkaso and community plant, the understanding and actions of the citizens are inevitable and the public awareness activities to enhance the understanding and cooperation are required. In addition to the awareness activities, the establishment

of laws and regulations such as obligation of using septic tank, is also required. The necessary laws and regulations will be discussed in the further study.

9.5.1 Activities of YCDC

Several departments of YCDC are working for the public awareness and public relations.

- Department of Public Relations and Information
  As public relations activities, the department publishes City News daily and own City-FM to provide citizens with necessary information such as cuts in water supply due to the pipe accidents. These tools would be very effective for the future activities.
- Department of Health
  The department implements public education program mainly focusing on hygiene education and preventive measures of infectious diseases by mosquito. Their activities are mainly in schools, and through visit to the community and residents.
- Department of Pollution Control and Cleansing.
  Their main activities are to focus on the schools.
- Department of Engineering, Water and Sanitation
  In cooperation with other department's activities, the district engineer visits the areas where the main water source is pond and creek, to explain about the safe water. Their activities are not undertaken on regular basis.

9.5.2 Public Awareness Activities

The public awareness activities should mainly focus on the following objectives.

- Understanding impacts of untreated wastewater on health, living environment and natural environment,
- Understanding necessity of wastewater treatment, polluter-pays principle,
- Understanding the impacts of disposal of solid waste into the drains and rivers to enhance change in citizen's attitudes of disposing the solid waste into drains and rivers,
- Publicizing the citizen's obligation of wastewater treatment as best as one can (after establishment of laws and regulations),
- Understanding obligation to connect to sewer, effects and payment of the charges,
- Understanding necessity of septic tank' improvement and construction,
- Understanding importance of septic tanks' operation and maintenance,
- Publicizing the construction of Johkaso and community plant to developers of housing and commercial complex as best as one can.

The sewerage facilities will be constructed in a stepwise approach, the priorities of the area should be

established. Most importantly, considering the level of people's awareness, the topics should be upgraded from the familiar issues such as health and sanitation, then community problem, city level problem and environmental issues.

9.5.3 Approaches

There are many kinds of approaches for public awareness and each approach has its advantage and disadvantage. Based on the situation, appropriate approach should be selected and combined. The Table below shows the advantage and disadvantage of the various approaches.

Table 9.5 Advantage / Disadvantage of Approaches

Approach	Contents	Advantage / Disadvantage
Publications	• Publications with slogan message and drawings • Leaflet, magazines, pamphlet, brochure, flier, poster, etc.	• Good keeping • High information transmissibility • Long time required for preparation • Attempt is necessary to make people read carefully
Mass media	• Public relations through TV, radio and newspaper, etc.	• Large unspecified number of residence can be communicated • High advantage in rapid communication • YCDC owns radio and newspaper so that the activities can be started without initial investment • People can understand easily with words, visions, and music • Need to repeat to fully understand the message.
Event	• Direct contact with the public. Mutual communication tool, • Event and set up a booth on the sewerage week, water day, or environmental day, display the explanation panel, quiz rally, water quality test, etc. • Open the sewerage facilities to the public visit • Sewerage class at school • Drawing and photo contest	• Direct communication will make deeper understanding. • The needs of the public can be identified through direct contact, • Participants are limited comparing with the expenditure, it is often said that the cost-effectiveness is low.
Seminar, Workshop	• Explanation seminar to the developers or factories about the effluent regulations and related laws about wastewater treatment. • Mutual communication, opinion exchanges	• It is difficult to organize frequently • Participants are limited • Outcome is high
School activities	• Publish the topics related to water and environment in the text in cooperation with Min. of Education • Hold the sewerage class in school • Experience based class such as water quality test, • Activities and contest related to the water in the school	• Spread effect from children to the family members, • Sustainability is high, • Time is needed for the coordination with various organizations
Religious activities	• Involvement of influential religious leaders into the activities • The improvement of water use behaviors in	• Time is needed for the coordination with various organizations

Approach	Contents	Advantage / Disadvantage
	the religious activities	
Explanatory meeting at community	• In the area of sewerage services, explanatory meeting to explain the necessity of the facilities, effects, obligation to connect to the sewer, payment, etc.	• Participants are limited but outcome is high

Source: JICA Study Team

CHAPTER 10. PROJECT IMPLEMENTATION PLAN AND COST ESTIMATION OF IMPROVEMENT OF SEWERAGE

10.1 Phased Implementation Program

As a result of evaluation, highest priority is given to C1 sewerage zone. This is because of high population density and compact size of the sewerage zone. In addition, C1 sewerage zone is the current sewerage service area and the current system collects only toilet wastewater (black water) and has been operated for long time exceeding useful lifetime of the system, requiring immediate improvement. It is obvious that C1 sewerage zone has high priority from various view points at any rate.

Second highest priority has been given to W2 sewerage zone. This is because of the fact that W2 includes a part of the existing sewerage service area and urbanization has been highly progressed second to C1 sewerage zone. Therefore, W2 sewerage zone is considered to have the same high priority as C1. Following these two sewerage zones although with some gap, C2 and W2 sewerage zones have high priority. There are, as mentioned previously, Inya Lake and Kandawgyi Lake in C2 sewerage zone.

Based on the result of the evaluation of priority, phased implementation program up to 2040 has been worked out as shown in Table 10.1. Table 10.1 shows the case that interceptor sewerage system is adopted. In case all sewerage zones are provided with separate system, total population is covered by separate system. Phased program is also illustrated in Figure 10.1.

Table 10.1 Phased Implementation Program up to 2040

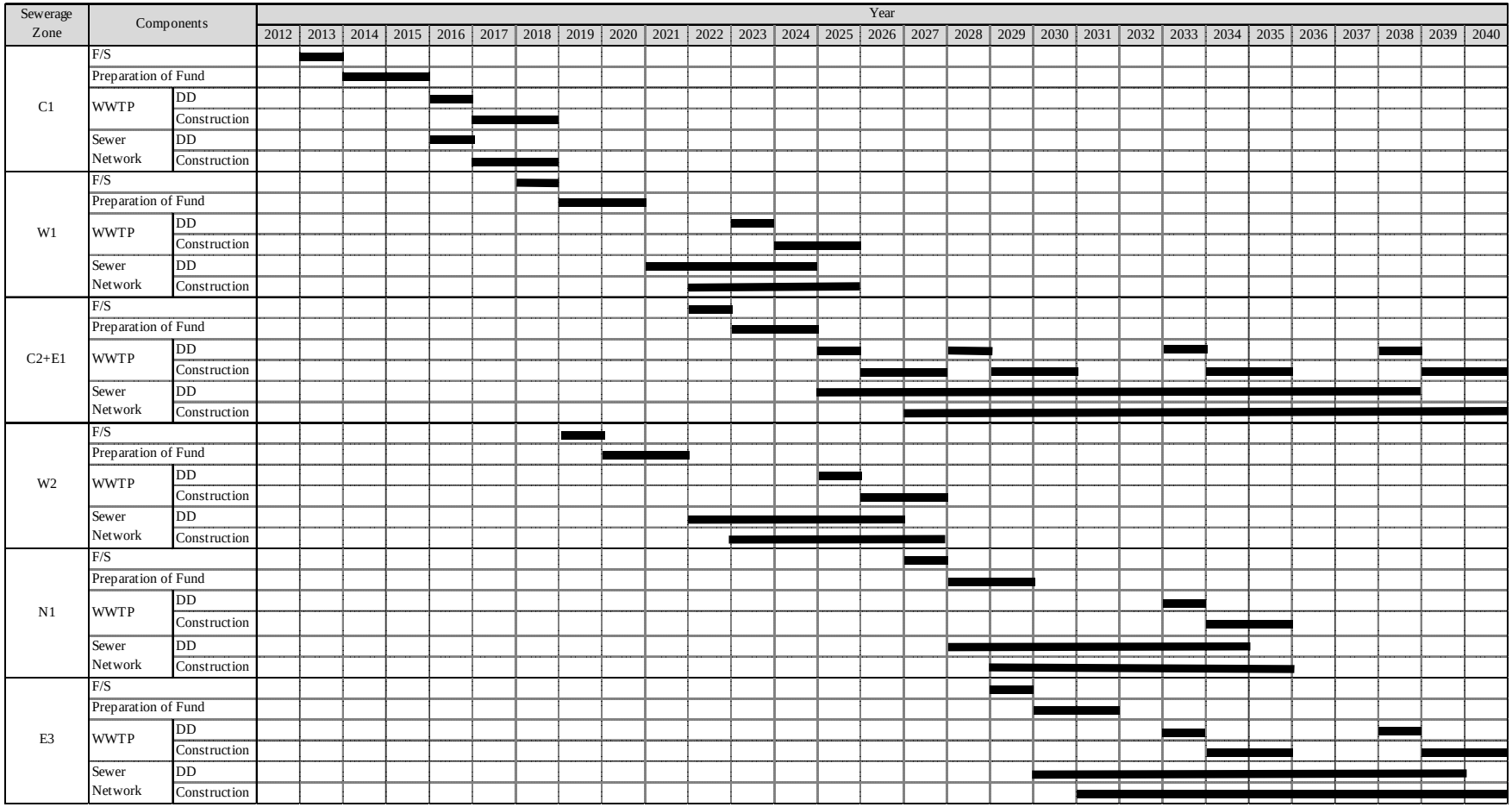
Priority	Sewerage Zone	Target Year	Type of Sewerage System	Population in 2040 (persons)	Accumulated Population in 2040 (persons)	Coverage Ratio (%)
1st	C1	2020	Separate System	178,127	178,127	3.0
			Interceptor System	0	0	
			Total	178,127	178,127	
1st	W1	2025	Separate System	483,058	661,185	10.2
			Interceptor System	0	0	
			Total	483,058	661,185	
2nd & 3rd	C2, W2, N1, E1, E3	2040	Separate System	577,171	1,238,356	49.4
			Interceptor System	2,972,617	2,972,617	
			Total	3,549,788	4,210,973	

Source: JICA Study Team

Implementation schedule up to 2040 is shown in Table 10.2. Feasibility study (FS), preparation of project funding, and detailed design (DD) are necessary to commence the construction. Period required for these activities are assumed to be 1 year, 2 years, and 1 year respectively. There is no sewerage development plan, such as 5 year plan, therefore, 2 years are considered to be necessary for preparation of funding because funds from bilateral or multilateral funding institution might be necessary for projects which should be commenced earlier. Sewerage development plan which covers medium or long term period is established and funding is secured in the future, this activity can be neglected.

Construction period is estimated based on scale of sewerage facility. C2+E1 Sewerage Zone has different priorities, C2 is 2nd and E1 is 3rd. Therefore, sewerage facilities in C2 should be completed by 2030 and E1 by 2040. In addition, WWTP for C2+E1 Sewerage Zone has large design capacity. Thus the WWTP should be constructed in 4 phases, 1st phase by 2030 and the last 4th phase by 2040. WWTP for E3 Sewerage Zone should also be constructed in 2 phases, 1st by 2035 and 2nd by 2040.

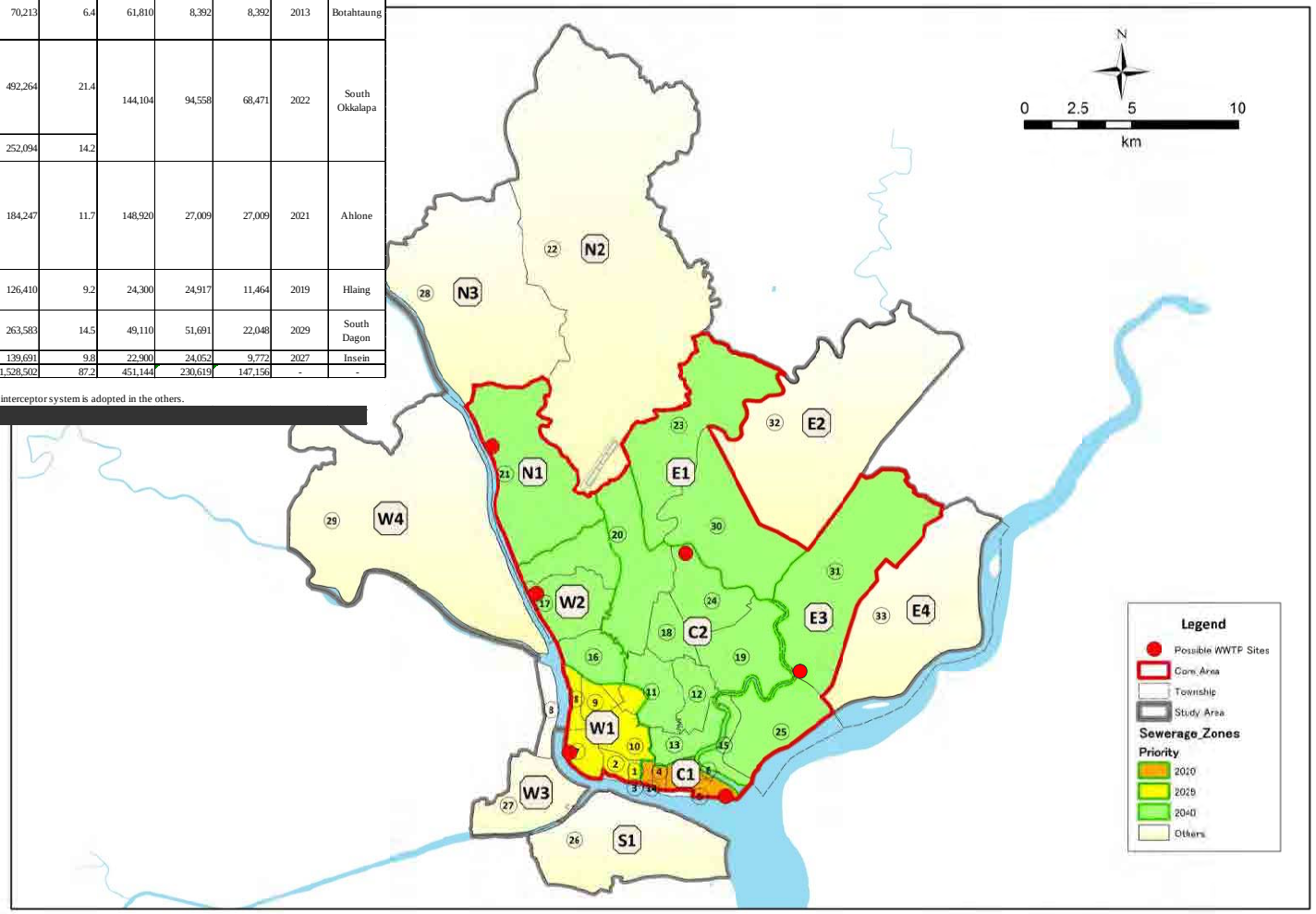
Table 10.2 Implementation Plan of Sewerage Works



Source: Study Team

Sewerage Zone	Population in 2040	Target township and its area		Capacity of WWTP	WWTP area	Total length of trunk main	Project cost (Mil. JPY)		Commencement date	Location of WWTP
	Persons	Township	ha	m3/d	ha	m	1	2		
C1	178,127	Pabedan	62	70,213	6.4	61,810	8,392	8,392	2013	Botahtaung
		Kyauktada	70							
		Botahtaung	260							
		Pazundaung	107							
C2	1,191,499	Bahan	705	492,264	21.4	144,104	94,558	68,471	2022	South Okkalapa
		Tamwe	499							
		Mingalar Taung Nyunt	494							
		Yankin	479							
		Thingangyun	1312							
		Mayangone	1791							
		South Okkalapa	822							
E1	710,656	North Okkalapa	2766	252,094	14.2					
		North Dagon	2418							
W1	483,058	Bahan	142	184,247	11.7	148,920	27,009	27,009	2021	Ahlone
		Latha	60							
		Lanmadaw	131							
		Ahlone	338							
		Kyee Myin Daing	182							
		Sanchaung	240							
		Dagon	489							
		Kamaryut	72							
W2	349,512	Mayangone	797	126,410	9.2	24,300	24,917	11,464	2019	Hlaing
		Kamaryut	575							
		Hlaing	984							
E3	920,933	Dawbon	311	263,583	14.5	49,110	51,691	22,048	2029	South Dagon
		Thaketa	1356							
		South Dagon	3751							
N1	377,188	Insein	3163	139,691	9.8	22,900	24,052	9,772	2027	Insein
Total	4,210,973		24,376	1,528,502	87.2	451,144	230,619	147,156	-	-

1: Case that separate system is adopted in all sewerage zone
2: Case that separate system is adopted in C1, W1 and a part of C2, and interceptor system is adopted in the others.



Source: Study Team

Figure 10.1 Phased Implementation Program up to 2040

10.2 Policy and Condition of Cost Estimation

The price level and exchange rate are defined as shown below.

Price level: Average in December 2012

Exchange rate: 1USD=84.64JPY

Considering the condition listed below, the construction cost is calculated.

- It is possible to procure civil and building material, labor and construction machine within the country and the procurement in local country is set as basic policy for project cost estimation.
- The mechanical and electrical equipment is basically procured from overseas including third country; such as European Union (EU), etc. The equipment will be procured with consideration of quality, performance, economic efficiency and O&M, etc.
- The local contractors have enough experiences and ability for normal civil engineering work. On the other hand, they are not experienced in the specialized project regarding water supply and sewerage. However, Japanese experts and foreign experts are staffed in implementation system of the Project and construction is conducted by the local contractor.
- The local contractors are not experienced in the construction methods of pipe jacking and shield. The unit cost of these construction methods is collected from Thailand where many contractors have relevant experiences.
- The installation unit cost of house connection for sewerage is estimated by YCDC, based on the standard section drawings for pipe installation.
- The construction plan is established with the considerations of local natural condition (topographic aspects, geotechnical condition and meteorological condition) and legislation/custom.
- In case interceptor system is adopted, the project cost of primary or secondary treatment and sludge treatment in WWTP are calculated.
- In case interceptor system is adopted, operation and maintenance cost for primary or secondary treatment and sludge treatment is calculated.

10.3 Project Cost Estimation

10.3.1 Capital Cost

Non-disclosure Information

Non-disclosure Information

Table 10.3 Result of Cost Estimation of Sewerage Project (As of 2040)

Non-disclosure Information

10.3.2 Operation and Maintenance Cost

The required operation and maintenance cost for sewerage works is shown below. In the field of sewerage works, in case separate system is adopted in all sewerage zones, the annual total cost of operation and maintenance is approximately 1,903 million JPY. On the other hand, in the case that separate system is adopted in C1, W1 and a part of C2, and interceptor system with primary treatment is adopted in the others and interceptor system with secondary treatment is adopted, the annual total cost of operation and maintenance is approximately 1,152 million JPY and 1,840 million JPY, respectively. The detail O&M cost estimation is shown in Appendix E.

Table 10.4 Annual Operation and Maintenance Cost for Sewerage Works

(Unit: Million JPY/Year)

Category	Operation and Maintenance Cost		
	Case that separate system is adopted in all sewerage zone	Case that separate system is adopted in C1, W1 and a part of C2,	
		Interceptor system is adopted in the others. (Primary treatment)	Interceptor system is adopted in the others. (Secondary treatment)
Labour cost	32.9 (0.4)	31.0 (0.4)	31.0 (0.4)
Electricity cost	535.5 (6.3)	331.0 (3.9)	535.5 (6.3)
Spare parts cost	431.1 (5.1)	224.1 (2.6)	431.1 (5.1)
Sludge disposal cost	165.4 (2.0)	115.3 (1.4)	165.4 (2.0)
Chemical cost	621.8 (7.3)	409.5 (4.8)	621.8 (7.3)
Sewer maintenance cost	80.3 (0.9)	19.2 (0.2)	19.2 (0.2)
Others	35.8 (0.4)	22.7 (0.3)	22.7 (0.4)
Total Cost	1,902.8 (22.5)	1,152.4 (13.6)	1,839.8 (21.7)

Source: JICA Study Team, ( ): Million USD

CHAPTER 11. PROJECT FINANCING PLAN

11.1 Sewerage Tariff Policy

Normally sewerage tariff is calculated according to the volume of piped water consumption. It is partly due to administrative expediency in collecting user fees for sewerage. It is also rational as the treatment volume of sewage is almost equal to the consumption of water. According to economic theory, water supply and sewerage are complementary goods, i.e. the consumption of one service necessitates the other. Simultaneous provision of both services will allow the goal of providing lifeline with water supply while maintaining public sanitation through sewerage service.

There are three core issues to be taken into account in determining tariff for water and sanitation.

1) Majority of residents can afford the user charges.
2) The provider is capable of sustaining a long-term operation with the tariff revenue.
3) The service accomplishes public health and environmental protection.

As the third factor is analyzed later, initially the first two goals are discussed.

11.1.1 Social Equity and Efficiency

The first point above is related to the issue of social equity while the second point is related to economic efficiency. These two goals have a tradeoff relationship where the maximization of one goal will lead to the negation of the other. If the tariff is set at a level where low income class feels no problem to meet the payment for the water and sewerage, the operation of water and sewerage service will not be sustainable without subsidy from the government. On the other hand, given the nature of local monopoly, it is possible to set an arbitrarily high tariff to earn a high profit, making easy the financial management of the operation. Such a high tariff will definitely impose economic difficulties on low-income households who have no option but to purchase water that is vital for sustaining life. Tariff policy must balance the two goals of social equity and operational efficiency without causing the extreme tradeoffs.

11.1.2 Appropriate Tariff Level and Discriminatory Pricing

The goal of balancing social equity and economic efficiency can be more easily achieved if the service operator can charge lower tariff to low income classes while charging higher tariff to higher income classes. This differential tariff system is called discriminatory pricing in economic theory. However, its implementation is not as perfect as the theory goes. The first biggest problem is how to distinguish low income and high-income households. In California US, the utilities accept tariff reduction applications from low-income households and after approval, levy reduced tariffs. However, there is a setback that

the administration incurs additional costs and there is a chance of malpractices.

Normally implemented is a system of progressive tariff as pseudo-discriminatory pricing. Under a progressive tariff, usually the tariff is divided into several levels according to the volume of monthly consumption. The first level has a fairly low unit charge, the second has a mid-level user charge, a third has a level much higher than the supply cost and so on. The system is based on presumption on consumer behavior that low-income households will only use a minimum requirement while high-income households will use more abundantly. This tariff system is most pragmatic in terms of administrative costs. The current YCDC water tariff has a uniform fee per volume. It is important to introduce progressive tariff system at a future juncture for tariff revision.

11.1.3 Implementation Program of Progressive Tariff

There are two potential issues to be noted for the introduction of progressive tariff system.

Public Awareness Campaign

First, the public needs to be fully informed of the change. Under a progressive tariff system, profligate use of water will lead to a drastic increase in the user fee payment. The customer may feel deprived of fair treatment with sudden increases. Under such a case, the operator may face a flood of complaints from the user. To avoid such incidents, there should be a well-planned public awareness program to inform the public of the changes.

Introduction of Customer Resource Management System

In terms of operation, the tabulation of the user charge according to progressive tariff will be more complex. There will be a higher chance of miscalculations under the present manual tabulation. The errors on the part of the operator may lead to more resistance to the introduction of a new tariff system. The introduction of a billing management information system simultaneously at the time of tariff reform may be a nice strategy to make the reform more acceptable institutionally. The shift to IT based-billing will enable to reduce mistakes and also to achieve improvements in operation efficiency.

At present, YCDC has a few PCs in the headquarter which are used for bill collection records. Other operations related to customer issues rely on manual paper-based procedure for meter reading, bill issuance, revenue collection at branch offices. Introduction of IT based system will not only enhance the efficiency of all the documentation operations but will also make it possible to generate management information for strategic planning and operation. For instance, the first step in reducing UFW is to undertake water auditing for defined district metered areas (DMA). The introduction of customer resource management system will facilitate the generation of water consumption data by DMA or more detailed areas or other attributes. Thereby, it becomes possible to compile the information on water consumption data or other customer data that are closely related to the data requirement for strategic operation planning.

11.1.4 Sewerage Tariff and Environmental Protection

The goal of sewerage business is environmental protection. The goal must be reflected in tariff policy as well. The basic rule in environmental protection is the Principle of Polluter-Pay. This principle must be applied to producers such as factories in a rigorous manner. However, if the principle is applied to general households, it may not be conducive to achieving the goal of environmental protection. For water supply, a higher tariff may encourage more water saving lifestyle and is accepted as rational policy. On the other hand, sewerage tariff should not be too high lest it should discourage the customer from connecting to the system.

The aim of environmental protection through sewerage system is achieved by having all the potential polluters connected to the system as a society. However, from each customer's view, one's free disposal without proper sewer connection will only marginally pollute the environment while paying no sewerage charges if everyone else is properly connected to the sewerage system. This incentive for cheating deteriorates the framework for all inclusive connections. If very few are connected, again, there is no incentive for connection because it will not change the environment either. It is a so-called free rider problem in the enforcement of sewer connection. The preventive strategy is to lower the cost of compliance, i.e. connection cost and charges while increasing the penalty of violation financially and socially. Lower sewer charges will induce more connection rate and will expedite the achievement of environmental goal. The consumer psychology backed by game theoretic foundation provides a rationale for a higher water tariff and lower sewer tariff.

There are cases where people may not have sewer connections immediately even if there is a sewer main in front of their premises. In such a case, the citizen is foregoing her/his obligation to contribute to the projection of environment. A general levy of sewerage facility fee to the established areas of sewer network is acceptable policy in terms of environmental protection.

It may prove more prudent to offer a sewerage tariff lower than that for water supply, e.g. around 80% of water tariff, in order to achieve more perfect environmental protection. Another option is to set a low connection fee for sewerage and charge a higher user volumetric charge later to encourage initial connections.

11.2 Tariff Setting Evaluation

11.2.1 Willingness-To-Pay Analysis

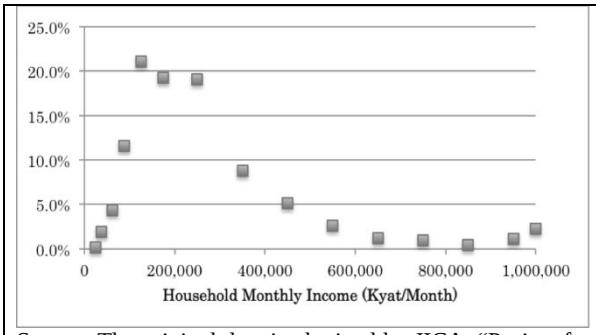
A 10,000 sample survey on citizens undertaken by JICA, "Project for the Strategic Urban Development Plan of the Greater Yangon"**,** has a few questions concerning willingness-to-pay (WTP) for improved and expanded water supply and sewerage services. The question on WTP had provided seven potential tariff slots of; 1) Less than 500 Kyat, 2) 501 to 1,000 Kyat, 3) 1,001 to 2,000 Kyat, 4) 2,001 to 3,000 Kyat, 5) 3,001 to 5,000 Kyat, 6) 5,001 to 7,000 Kyat, 7) more than 7,000 Kyat. It is not

possible to derive the average WTP due to the open-ended last tariff slot which attracted a large percentage of responses. In other words, the tariff levels were set on a lower side. However, it is possible to derive the medians. Since the same questions at the same tariff brackets were addressed both for sewerage and water supply services, it is also possible to make comparative analyses. The median WTPs for water supply falls in the bracket 3, 1001 to 2000 Kyats and that for sewerage falls in the bracket 2, the section between 501 to 1000 Kyats. The townships that exhibit the WTP median at the bracket 3 are Botahtaung, Pazundaung, Sanchaung and Tarmwe. These towns have exhibited needs for drainage improvements. Since most of sewage is discharged into roadside drains, flooding and lack of sewerage system combined may be causing severe sanitation problems thus need to be further investigated.

11.2.2 Sewerage Tariff Affordability

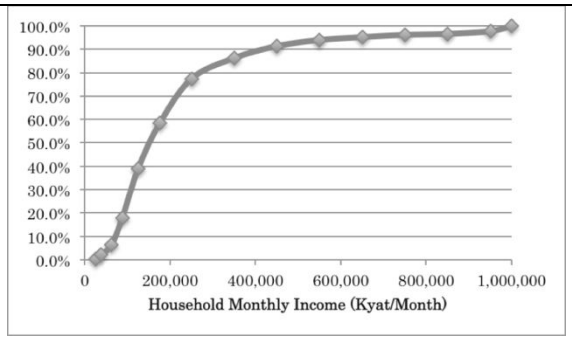
Another important aspect in tariff policy is to make certain the user charges are within the range of the payment capacity by the residents. So-called affordability to pay must be verified. Generally the maximum level of user tariff for water and sewerage services is 3-5% of income.

The next two graphs show the distribution and cumulative distribution of monthly household income in Yangon included in the aforementioned Household Interview Survey. The average income derived was 371,853 Kyat per month per household.



Source: The original data is obtained by JICA, "Project for the Strategic Urban Development Plan of the Greater Yangon", subcomponent, Household Interview Survey

Figure 11.1 Yangon Household Monthly Income Distribution



Source: The original data is obtained by JICA, "Project for the Strategic Urban Development Plan of the Greater Yangon", subcomponent, Household Interview Survey

Figure 11.2 Yangon Household Monthly Income Cumulative Distribution

The distribution indicates a large lump at the bottom of income distribution at around 200 thousand Kyats per month with another small hump at the tail end of the bracket of beyond one million Kyats per month. One yardstick for affordability is to target at 80% of population instead of the average citizen in measuring the affordability. In this case, the maximum affordable tariff needs to be linked to the income of the bottom 20% of the cumulative income distribution. Estimated income at the 20% cumulative level is 105,000 Kyats per month per household. The household income would grow in

tandem with economic development. Assuming the annual growth rate of 5%, the household income would grow by the multiple of 3.7 by 2040. The 20% benchmark income would grow to 392,000 Kyats per month. Further assuming expending 4% of income on water and sewerage service is within the bounds of affordability, the limitation is 16,000 Kyats per month. Assuming the consumption of 200 liters of water per person per day with the average size of household of 5 in 2040, the maximum allowable expenditure for water and sewerage is 560 Kyats per m^3. By dividing this water and sanitation budget in the ratio of 1 to 0.8 between water and sewerage, the maximum tariff for sewerage service would be 240 Kyats per m^3. This is equivalent to 0.28 dollars per m^3.

11.3 Financial Analysis

11.3.1 Macro Framework for Funding

It is a difficult task to discuss appropriate level of infrastructure development toward the distant future of 2040. There will be many changes in international economic environment, regional economic competition and integration, internal economic structure reforms and development, too many elements to forecast the financial situation accurately. A broad guideline may be to set a target that is somewhat optimistic so as not to pose obstacles to economic development but at the same time not to cause any debt overhang.

According to the latest World Economic Outlook database of IMF, per capita GDP of Myanmar grew at the rate of 10% during the period of 1999 and 2007 but the pace slowed down considerably to 1.5% in 2008, and then sustaining around 3% annual growth rate during 2009 to 2011. This database's outlook sets 4% annual growth for the period up to 2017. An optimistic projection based on the IMF projection would be 5% per annum. Under this assumption, an estimated current per capita GDP in Yangon of around USD 1500 could grow to reach USD 5600 by the year 2040. It is also assumed that most of large scale infrastructure development funding needs to be financed by external funding from international development banks. Though it is difficult to argue for an acceptable level of external debt, a rule of thumb could be around 50% of the GDP. When this yardstick is applied, the ceiling for the external debt for a citizen of Yangon becomes USD 2800. The Japanese experience indicates around water supply and sewerage sector each comprises 10% of the total infrastructure stock while the road sector comprises 50%. Therefore one rough ceiling target recommended would be around USD 280 investment per capita. Given the projected population of approximately 8 million in 2040, the investment framework of sewerage infrastructure is [redacted]

11.3.2 Financial Simulation Model

The JICA Study Team has created a Sewerage Financial Simulation Model specially catered to the financial analyses of investments, service connections, operation and maintenance encompassing all

the proposed projects up to the year 2040 and additional 40 years of operation, maintenance and replacement investments up to the year 2080. The model is equipped with the variables that can be instantly modified: sewerage tariff and its annual increase, interest rate on the capital, percentage of subsidy to investment, increase in fixed costs to determine the impacts on financial projects funding mechanism. Other model parameters concerning costs, volume, the size of family, sewerage coverage, water consumption, and sewage infiltration can be modified if so required. The notable assumptions are as follows:

Project Coverage and Phases: The financial simulation covers the projects for the zones of C1, W1, C2&E1, W2, E3, and N1. C2&E1 are divided into four stages which are termed as C2-south, C2-north, E1-west and E1-east. E3 is divided into two stages, namely E3-west and E3-east. The major parameters of each project are summarized in Table 11.1 Project Parameter Summary.

Alternative Sewerage Systems: There will be two systems of sewer collection, i.e. conventional separate sewer and interceptor. The separate sewer system is planned with full treatment of sewage including biological treatment. The interceptor collector system will have two options of conducting only primary settlement and conducting up to secondary treatment. The interceptor system will utilize existing side drains during the project period for collecting sewage but later be replaced by pipe collectors. Given the level of urban development, the central areas of C1, W1, and C2-south will have full sewage treatment systems with separate sewers. However, other zones will be simulated for different options of separate collection system and interceptor system.

Project Period: The project period is between 2013 and 2040 for the construction of all the above projects. The period between 2041 till 2080 is the operation period for all the projects to be operated to collect the revenues.

Simulation Control Variables: The simulation is constructed in MS-Excel so that the simulation is easily operated by anyone. The control variables that can be changed immediately are tariff, tariff annual increase rate, interest rate, capital subsidy rate, and annual increase rate in fixed cost.

Simulation Results: The overall financial results for each year are presented in the column for the Operating Cash Flow. The overall performance may be examined by the net present values of the Operating Cash Flow or Debt Balance at the end of the project period.

Investment: For separate system, the sewer network would require investments for trunk and branch lines as well as service connections while the interceptor system would only require the investment for the interceptor trunk mains. The treatment system up to secondary treatment would require additional investments on secondary treatment as well as primary treatment capacity.

Tariff Assumptions: The basic tariff is set at 80% of water tariff in 2013. The Sewerage Financial Simulation Model can accept the changes in the annual tariff increase rate. In the base case, the annual increase rate was set at 3%.

Treatment Volume: The treatment volume is in accordance with the volume assumed in the basic planning for each sewerage treatment zone which collects the disposed volume equal to water consumption with additional infiltrating water by each township. The volume is matched to the

addition of service connections assumed in the phasing plan of sewers after the commissioning.

Service Connection: Firstly the number of households is tabulated for each township on an annual basis based on the population and service coverage projections. In most cases, major service connections are expected to take place within the three years after the commissioning of the WWTP. Therefore each year one third of the target year (the last year of the three) household number is added as the consumer. Since for each year, the average functioning connection for the disposal of wastewater is half the number of the service connection achieved at the year end. Therefore the disposal volume added or water consumption volume added is 1/6 for the first year, 1/2 for the second year and 5/6 for the third year of the target year.

The unit connection cost is assumed at USD 290 for the sewerage zones of C1 and C2 and USD 550 for the remaining zones for the separate sewer system. In the case of the interceptor collector system, there is no service connection cost as wastewater is collected from roadside drains.

Revenue: The revenue is the user water charge derived by multiplying the tariff to the water consumption volume. It is assumed that the sewerage charge is collected together with water charge for the sake of collection efficiency. This is also an international common practice. The increment in the first three years follows 1/6, 1/2, and 5/6 rule as explained above.

Fixed Operation and Maintenance Cost: Fixed cost is comprised of salaries and wages for the three categories of personnel requirements for each wastewater treatment plant, the maintenance cost tabulated according to the length of sewers, and spare parts required every year for each wastewater treatment plant. It is assumed that the costs excluding the spare parts are assumed to escalate 5% every year up to 2040.

Variable Operation and Maintenance Cost: Electricity, chemicals, sludge cake disposal are calculated by deriving the unit requirement per volume and multiplying the unit prices of inputs. The average unit price of the combined inputs per treatment volume has come to USD 0.012 per m^3 for primary sewerage treatment system and USD 0.03 per m^3 for conventional full sewage treatment up to secondary treatment. The increment in the treatment volume in the first three years follows 1/6, 1/2, and 5/6 rule as explained above.

Replacement Investment: 5% of the original investment in electro-mechanical equipment is assumed to require replacement investment every year starting 10^{th} year after the commissioning of the WWTP.

Net Operating Cash Inflow: Net operating cash inflow is defined as the revenue minus operation and maintenance costs minus service connection costs.

Table 11.1 Financial Simulation Assumptions and Project Parameters

Project	C1	W1	C2 south	C2 north	E1 west	E1 east	W2	E3 south	E3 north	N1
Sewer System	Separate	Separate	Separate	Optional	Optional	Optional	Optional	Optional	Optional	Optional
Capacity (MLD)	70,200	172,000	226,200	226,200	150,800	75,400	133,000	198,000	66,000	106,000
Construction Start Year	2016	2021	2025	2028	2033	2038	2024	2033	2038	2033
Period (Years)	3	3	3	3	3	3	3	3	3	3
Service Start Year	2019	2026	2028	2031	2036	2041	2027	2036	2041	2036
Sewer Length Main (km)	14	27	34	34	23	11	24	17	6	49
Sewer Length Branch (km)	48	122	259	259	173	86	207	347	116	269
Sewer Total (km)	62	149	293	293	195	98	231	364	121	318
Sewer Construction Start Year	2016	2016	2025	2028	2033	2038	2021	2030	2036	2028
Sewer Construction Period (Years)	3	5	3	5	5	3	6	6	5	8

Source: JICA Study Team

Table 11.2 shows the output produced by the Sewerage Simulation Model created for the study. In this case of separate sewer system with secondary treatment assuming the sewerage tariff to be set at 80% of the current water tariff for sewerage treatment starting at USD 0.08 per m^3 in 2013 with an annual increase of 3%, the operation in sewerage service will generate constant operation surplus of USD 34 million per year. However, the cumulative debt balance in the year 2080 is approximately USD 10.4 billion. In other words, the entire scope requires additional financial improvement measures to attain financial sustainability.

Table 11.2 Financial Simulation: Full Separate /Tariff at 3% annual increase

Non-disclosure Information

Table 11. 2 Financial Simulation: Full Separate /Tariff at 3% annual increase

Non-disclosure Information

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Non-disclosure Information

11.3.3 Funding Plan

Financing planning for sewerage system development needs to be based on short-term and long-term financial projections. In principle, sewerage service is a capital-intensive operation. It would be difficult to cover the total funding needs by the user charges collected from its beneficiaries due to still low-income levels of most of the users in contrast to high capital costs.

A basic financing option is that the government of Myanmar would borrow low interest loans from bilateral sources such as the Japanese government and multilateral sources and re-lend the loan to the YCDC. YCDC would repay a part or all of the loans from the surplus left after meeting expenditure for operation and maintenance. As discussed in Tariff Policy, sewerage service is aimed at preserving a public good of environment in addition to providing convenience to the customer. If the overall service of sewerage is considered as partly serving to public good, it is not necessary to pay for the cost entirely by the beneficiary charges. It is acceptable for the government to provide a subsidy for a part of the capital costs.

The Sewerage Financial Simulation Model is utilized to examine the relationship between contributions between the customer (tariff) and government (subsidy).

Premises: The interest rate is assumed as 3% on the average. The Yen loan interest would be less than 1% depending on other terms of the loan. IDA and ADB have similar interest rates presumably. However, it is not certain if all the funding can be sourced as low interest loans. There may be cases where it is necessary to utilize loans with market rate interests. Taking account of these uncertainties as Myanmar is progressing toward middle income country by 2040, a chance of incurring higher interests is more likely. Thus the interest is set at 3% on the average.

11.3.4 Financial Simulation Results

The results of financial simulation are shown in Table 11.3.

Table 11.3 Results of Financial Simulation According to Capital Subsidy and Type of Sewerage System

Capital Subsidy Ratio	Separate/Secondary	Interceptor/Secondary	Interceptor/Primary
80%	3.9%/Year= $ 0.22 /m^3 In 2040	2.7%/Year= $ 0.16/m^3 In 2040	1.7%/Year= $ 0.13/m^3 In 2040
60%	5.0%/Year= $ 0.30 /m^3 In 2040	3.9%/Year= $ 0.22/m^3 In 2040	3.0%/Year= $ 0.18/m^3 In 2040
40%	5.9%/Year= $ 0.38/m^3 In 2040	4.9%/Year= $ 0.29/m^3 In 2040	4.0%/Year= $ 0.23/m^3 In 2040
0%	7.3%/Year= $ 0.53/m^3 In 2040	6.3%/Year= $ 0.41/m^3 In 2040	5.4%/Year= $ 0.33/m^3 In 2040

Source: JICA Study Team

Case-80% Capital Subsidy:

- For the option of adopting separate sewers and up to secondary treatment, the tariff needs to be increased by 3.9% from USD 0.08/m^3 in 2013 to USD 0.22/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.1 of Appendix C).
- For the option of adopting interceptor and up to secondary treatment, the tariff needs to be increased by 2.7% from USD 0.08/m^3 in 2013 to USD 0.16/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.2 of Appendix C).
- For the option of adopting interceptor and up to primary treatment, the tariff needs to be increased by 1.7% from USD 0.08/m^3 in 2013 to USD 0.13/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.3 of Appendix C).

Case-60% Capital Subsidy:

- For the option of adopting separate sewers and up to secondary treatment, the tariff needs to be increased by 5.0% from USD 0.08/m^3 in 2013 to USD 0.30/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.4 of Appendix C).
- For the option of adopting interceptor and up to secondary treatment, the tariff needs to be increased by 3.9% from USD 0.08/m^3 in 2013 to USD 0.22/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.5 of Appendix C).
- For the option of adopting interceptor and up to primary treatment, the tariff needs to be increased by 3.0% from USD 0.08/m^3 in 2013 to USD 0.18/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.6 of Appendix C).

Case-40% Capital Subsidy:

- For the option of adopting separate sewers and up to secondary treatment, the tariff needs to be increased by 5.9% from USD 0.08/m^3 in 2013 to USD 0.38/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.7 of Appendix C).
- For the option of adopting interceptor and up to secondary treatment, the tariff needs to be increased by 4.9% from USD 0.08/m^3 in 2013 to USD 0.29/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.8 of Appendix C).

- For the option of adopting interceptor and up to primary treatment, the tariff needs to be increased by 4.0% from USD 0.08/m^3 in 2013 to USD 0.23/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.9 of Appendix C).

Case-0% Capital Subsidy:

- For the option of adopting separate sewers and up to secondary treatment, the tariff needs to be increased by 7.3% from USD 0.08/m^3 in 2013 to USD 0.53/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.10 of Appendix C).
- For the option of adopting interceptor and up to secondary treatment, the tariff needs to be increased by 6.3% from USD 0.08/m^3 in 2013 to USD 0.41/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.11 of Appendix C).
- For the option of adopting interceptor and up to primary treatment, the tariff needs to be increased by 5.4% from USD 0.08/m^3 in 2013 to USD 0.33/m^3 in 2040 and constant thereafter in order to repay the interests and principals of the borrowings for the investment by the year 2080 (Table C.12 of Appendix C).

The above results show that depending on the level of capital subsidy, the consequent required tariff vary quite drastically.

11.3.5 Evaluation of Possible Financial Sources

The macro framework for long-term investment in sewerage infrastructure is estimated at [redacted] [redacted] The interceptor sewer systems with either primary or secondary treatment facilities do basically fulfill the macro guideline. On the other hand, full separate sewer and secondary treatment system will exceed the limitation. However, it is important to resort to micro-based evaluation beyond this rule of thumb. Financial simulation makes it possible to investigate the ability to repay the loans based on tariff and annual increases as described in the preceding sections. Furthermore, the exact limitations of financing through tariff using the maximum affordable level of USD 0.28/m^3 are examined as follows:

1) Separate Sewer/Secondary Treatment: capital subsidy of no less than 65%,
2) Interceptor/Secondary Treatment: capital subsidy of no less than 42%, and
3) Interceptor/Primary Treatment: capital subsidy of no less than 20%.

The results show that the choice of the system will depend on the level of the capital subsidy which is the manifestation of public consensus to publicly finance the maintenance of urban sanitation and

environment. The interceptor sewer system with only primary treatment will offer the most economical financing option with the possibility of financing the entire development with tariff revenue and low capital subsidies. As the above affordability to pay analysis indicates, the income distribution of the city of Yangon is skewed to low income levels. Expenditure for water and sanitation has much larger economic impacts on low income households. The situation is quite likely to invite political intervention. It is necessary to further investigate the affordability of tariff and more detailed household income distribution. If a simple tariff is not affordable to a large proportion of low income households, it would be necessary to provide some mitigation measures such as a proposed progressive tariff system. It would be necessary to make financial investigation to weigh the needs for reducing expenditure for the poor against the needs to sustain adequate revenue for proper operation and maintenance.

There are two points of caution. It should be clearly noted that the assumed annual increase in tariff is purely real base increase without including inflation. With an ongoing inflation, the actual tariff increase required would be the sum of inflation plus real increases. It is clear that continuous incremental tariff increases are vital to sound financial management. It will avoid political intervention to normal tariff revision adjusting to the cost escalation due to inflation. With due consideration to uncertainties involved in the future, it is necessary to revise the master plan periodically to adjust itself to changes in prevailing economic conditions.

11.3.6 Financing Plan for Decentralized Sewage Treatment System

The development of sewerage system will require large investment money over a long period of time. The proposed systems if all developed still only cover 50% of the total population of the city of Yangon. The disposal of household wastewater into drainages without treatment may cause serious pollution and sanitation problems. Since 1990s, the Japanese government has a policy to support decentralized sewerage system, namely Johkaso for areas outside the coverage of centralized sewerage systems. In principle, the Johkaso system requires that the individual households and collective housing purchase and operate mini-sewage treatment tanks. The government is providing 40% of the investment cost to promote the adoption of the system. The rate of subsidy is commensurate with the subsidy that the government provides to local governments for the development of larger scale sewerage systems. As analyzed in the previous section, it is not practical to develop sewerage system by solely relaying on the revenue from tariffs. Similarly, if the promotion of a decentralized sewerage system is left to the market mechanism, a large initial investment cost may inhibit widespread adoption of the system as was the case in Japan prior to 1990, causing much of water pollution. From social equity standpoint, the same level of capital subsidy should be provided to either system of large-scale centralized sewerage or decentralized sewerage system.

There are two important elements in promoting decentralized sewerage system as follows;

1) Clear demarcation of centralized sewerage system areas within urban planning scheme, and
2) Allocation of the same level of capital subsidy to decentralized sewerage system as for centralized system.

For implementing the above policy, it may require the establishment of a legal framework.

CHAPTER 12. INITIAL ENVIRONMENTAL EXAMINATION (WITH SEA CONCEPT)

12.1 Necessity of Environmental and Social Considerations

The implementation of the project and operation of the constructed facilities by the project might cause adverse impacts on the environment such as air, water, soil, ecosystem, flora, and fauna, as well as the social impacts including involuntary resettlement, land use, water right and so on. These impacts should be avoided, minimized or mitigated as much as possible. The environmental and social consideration is the process of identifying, predicting, evaluating and mitigating the environmental and social impacts of development projects prior to major decisions being taken and commitments made. The environmental and social considerations studies include baseline surveys, predicting and evaluating the adverse impacts and likely impacts that projects may have on the environment and on local society, and mitigation measures to avoid and minimize these impacts.

The environmental and social considerations have various levels of the considerations. The level depends on the stages of the projects.

SEA (strategic environmental assessment) is systematic decision support process, aiming to ensure that environmental and possibly other sustainability aspects are considered effectively in policy, plan and program making. IEE (initial environmental examination) and EIA (environmental impact assessment) is applied to the projects to evaluate the environmental and social impact that projects are to have. Those studies include the analysis of alternative plans, the prediction and assessment of environmental impacts, and the preparation of mitigation measures and monitoring plans. IEE study is a study based on easily available information including existing data and simple field surveys and EIA study based on the detailed field surveys.

12.2 Level of Environmental and Social Considerations in the Master Plan

As mentioned in the above section, the system of environmental impact assessment is under preparation in Myanmar. Thus till the regulations related to EIA will be enacted, JICA's Guidelines for Environmental and Social Considerations (April 2010) (hereinafter referred as "JICA Guidelines") is applied to the Project.

According to JICA Guidelines, the IEE-level environmental and social considerations studies including analysis of alternatives including "without project" situations should be implemented in the full-scale study stage (Master Plan Study). In addition, it is said that JICA applies a Strategic Environmental Assessment (SEA) when conducting Master Plan Studies. Thus, in the Project,

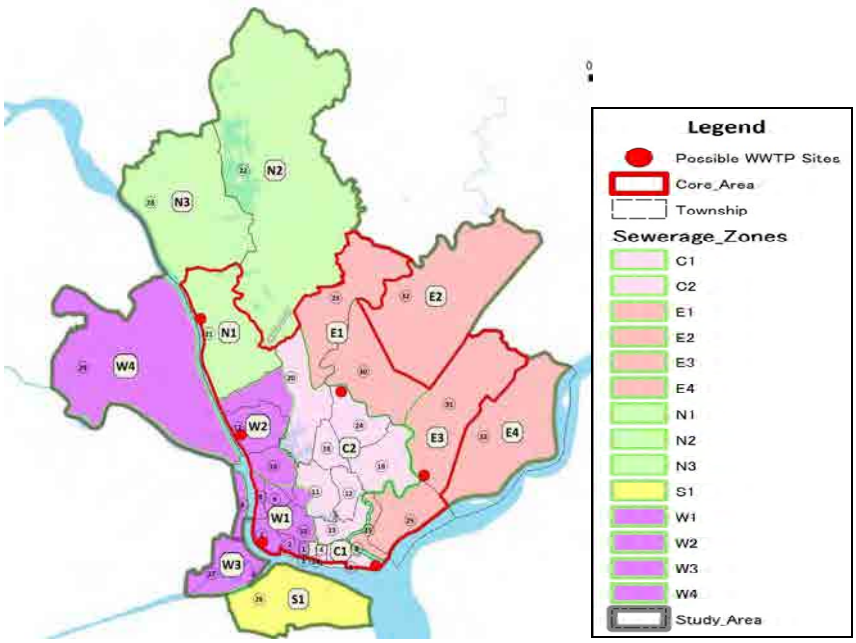
IEE-level environmental and social considerations which introduce the concept of SEA shall be implemented.

12.3 Alternative in the Master Plan

The alternatives in the Master Plan are the wastewater treatment system for 2040.

- Zero option: No new sewer or new treatment plant but construction of septic tank for the increased population.
- Alternative 1: Construction of treatment system (coverage 50 %) and construction of septic tank for the increased population outside of coverage area.
- Alternative 2: Construction of treatment system (coverage 50 %) and construction of community plant or Johkaso for the increased population outside of coverage area.

The coverage area by wastewater treatment plant is shown below.



Source: JICA Study Team

Figure 12.1 Sewerage Treatment Area by 2040

12.4 Selection of Evaluation Items

The environmental and social items to be evaluated are set as shown below to conduct SEA.

Table 12.1 Evaluation Items

Items	Main Impacts
Land acquisition and involuntary resettlement	● Land would be required for construction of sewers and wastewater treatment plant ● Involuntary resettlement due to the land acquisition
Land Use and utilization of local resources	● Change in land use by land acquisition
Living and Livelihood	● Impact on people's living and livelihood by the project ● Impact on water use of downstream
Protected area / cultural heritage	● Impact to the protected area
Landscape	● Impact on the local landscape
Indigenous, or ethnic people	● Impacts on the culture and lifestyle of ethnic minorities and indigenous peoples ● Impacts on the rights of ethnic minorities and indigenous peoples in relation to land and resources
Water pollution	● Impact to water quality of river, canal and drainage
Waste	● Generated sludge disposal
Soil contamination	● Impact on soil by infiltration of untreated wastewater and treated wastewater from septic tank
Biological and eco system	● Impact by the discharge of effluent and untreated wastewater

Source: JICA Study Team

12.5 Baseline Data Related to Evaluation Items

12.5.1 Land Acquisition and Involuntary Resettlement

The price of land is decided based on the past 10 years' market price. According to YCDC, the request for land acquisition is submitted to the Ministry of Home Affair and after the approval, it is announced in the newspaper for one month and notice is sent to the land owners. The responsible department within YCDC is General Administration Department. The detail procedures of land acquisition will be studied during the feasibility study period.

The required area to construct the wastewater treatment plant is given in the Table below.

Table 12.2 Required Area for Wastewater Treatment Plant

Sewerage Zone	Population (person)	W. Flow (m^3/day)		Area (ha)	WWTP Area (ha)	Township
		Daily Ave.	Daily Max.			
C 1	178,127	64,276	70,213	499	6.4	Pazundaung, Botahtaung, Kyauktada, Pabedan
C 2	1,191,499	452,548	492,264	6,102	21.4	a part of Bahan, Mingalar Taung Nyunt, Tamwe, South Okkalapa, Thingangyun, Yankin, a part of Mayangone
W 1	483,058	169,214	184,247	1,654	11.7	Lanmadaw, Latha, Dagon, a part of Bahan, a part of Kyee Myin Daing, Ahlone, Sanchaung, a part of Kamaryut
W 2	349,512	116,999	126,410	2,356	9.2	Hlaing, a part of Kamaryut, a part of Mayangon
W 3	74,419	14,512	15,628	1,485	2.5	A part of Kyee Myin Daing, Seikgyikhanaungto
W 4	737,724	191,809	206,563	7,761	12.5	Hlaing Tharyar
N 1	377,188	129,633	139,691	3,163	9.8	Insein
N 2	906,748	294,693	317,362	12,783	16.3	Mingaladon
N 3	514,954	100,416	108,140	5,271	8.4	Shwe Pyi Thar
E1	710,656	232,953	252,094	5,184	14.2	North Okkalapa, North Dagon
E 2	1,183,320	269,207	289,915	17,064	15.4	East Dagon
E 3	920,933	243,849	263,583	5,418	14.5	Dawbon, Taketa, South Dagon
E4	399,111	77,827	83,814	4,202	7.1	Dagon Seikkan
S 1	490,032	127,409	137,210	9,840	9.7	Dala
Out of SZ	2,241	971	1,046	117		Seikkan
Total	8,519,522	2,486,316	2,688,180	82,899	159.2	

Note: C2and E1 will be united.
Source: JICA Study Team

12.5.2 Land Use and Utilization of Local Resources

To select the location of wastewater treatment plant, the policy to select the area that is not used for any purpose is adopted. The probable locations are identified and the proposal is submitted to the Mayor of YCDC and the location will be finalized after the coordination and negotiation with related organizations.

C1 zone: Expansion of existing facility. The expansion area is used by navy and the negotiation is in progress.

C2+E1 zone: Ministry of Defense and Ministry of Information have the right to use the land.

W1 zone: The area is managed by YCDC.

W2 zone: The land was used by Port Authority and now Ministry of Forestry manages the land.

N1 zone: The proposed area is used by Ceramic Product Factory No (4), Phawkan Marble Factory, Ministry of Industry No (1) and KAASAR.

E3 zone: Ministry of Housing and E.P.C own the right to use.

Source: JICA Study Team

Figure 12.2 Proposed Site for Wastewater Treatment Plant

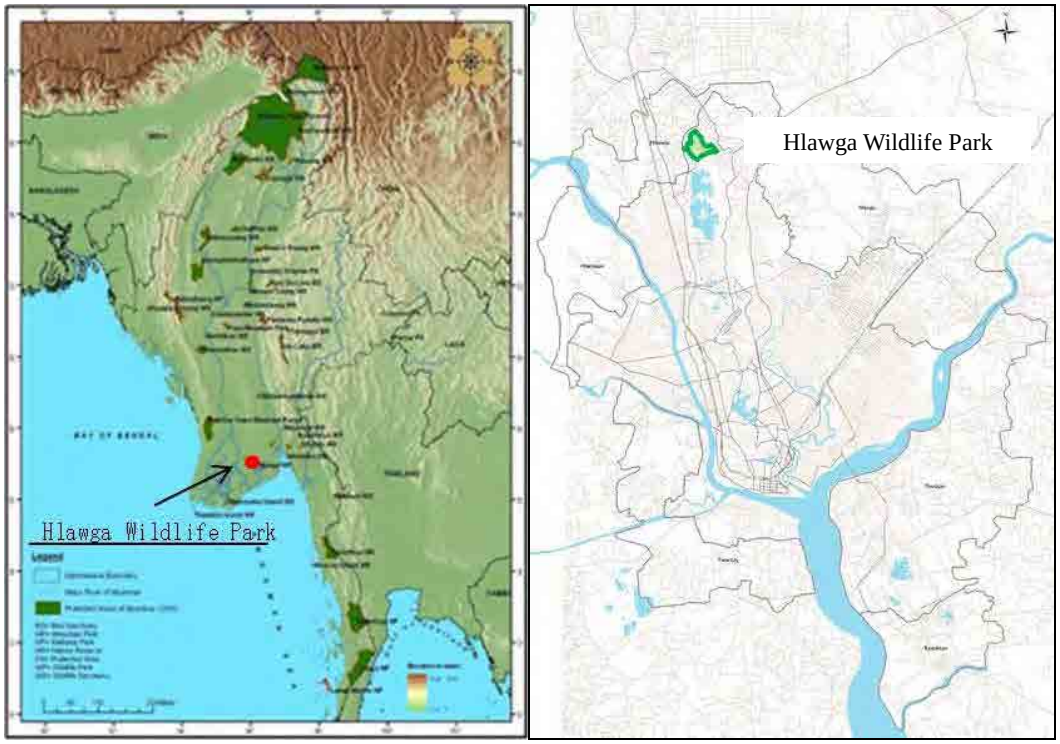
12.5.3 Living and Livelihood

The proposed sites for WWTP are unused land and governmental land so that the impact on living and livelihood by land acquisition is not expected. The treated sewage will be discharged from the WWTPs into the rivers but the river water in the downstream is not used for any purpose.

12.5.4 Protected Area / Cultural Heritage

The protected area of Myanmar (wildlife park, wildlife sanctuary, bird sanctuary, etc.) are shown in the Figure below. The protected area within the Study Area is Hlawga Wildlife Park. The Hlawga Wildlife Park is located 35 km north of Yangon and the area is 6.2 km^2 including a wildlife park (3.1 km^2), a mini-zoo (0.3km^2) and a buffer zone (2.7 km^2). The park was established in 1982 to establish an environmental education center near Yangon, to protect the forests and vegetative cover in the catchment of Hlawga Lake, to establish a representative collection of Myanmar indigenous wildlife species of mammals, reptiles and birds, and kept under as near as possible natural conditions in such a

way that they can be readily viewed by visitor. The location is far from the area of wastewater treatment system development and the impact is not expected.



Source: (Left) Fourth National Report to the United Nations Convention on Biological Diversity, Ministry of Forestry, 2009

Figure 12.3 Protected Area

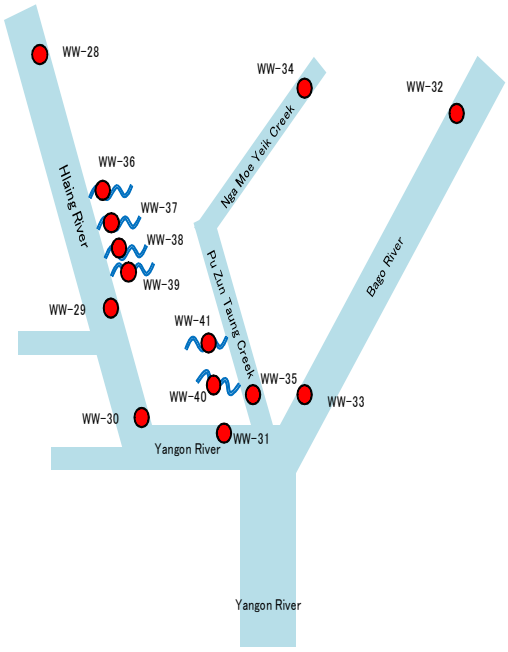
189 buildings which were constructed before 1950 are registered as cultural heritage buildings by YCDC in 1996. Most of the heritage buildings are located in the southern part of the Yangon City and the impact may be expected by the development of the central wastewater treatment system.

12.5.5 Landscape

The proposed WWTP sites are selected considering vacant area and off site of residential area. There is no special landscape to be considered.

12.5.6 Water Pollution

At present, only 5.8 % of population receives the sewerage service, only black water from toilet is collected and treated, the rest gray water is discharged into the drain directly. The population that has no access to sewerage service owns septic tank to treat the black water or discharges into the drain without treatment. The water quality of the river and the drain is shown in the Table below.



Sample No.	Location of Sampling Point
WW - 28	River -1 (Hlaing River, Wartayar Village, upstream)
WW - 29	River -2 (Hlaing River, midstream)
WW - 30	River -3 (Hlaing River, downstream, Myanmar Industrial Port)
WW - 31	River -4 (Yangon River, Near Bo Ta Htaung Pagoda)
WW - 32	River -5 (Bago River, upstream)
WW - 33	River -6 (Bago River, downstream, Near Thanlyin - Yangon Bridge)
WW - 34	River -7 (Nga Moe Yeik Creek)
WW - 35	River -8 (Pu Zun Taung Creek)
WW - 36	Drainage Canal -1 (Pauk Tar Chaung)
WW - 37	Drainage Canal -2 (Yoe Gyi Chaung)
WW - 38	Drainage Canal -3 (Thamaing Chaung)
WW - 39	Drainage Canal -4 (Padauk Chaung)
WW - 40	Drainage Canal -5 (Tbebyu Chaung)
WW - 41	Drainage Canal -6 (Nat Chaung)

Source: JICA Study Team

Figure 12.4 Sampling Locations (River and Drain)

The results are as follows:

- The major drain in the urban area is contaminated by the wastewater from the houses. The level of COD in drain is 2.4 times of the level in river water, BOD level in drain is 1.0 time the level in river water, T-N level in drain is 12.2 times of that in river water, and T-P level in drain is 4.4 times of river water.
- The river water flow (Hlaing, Yangon and Bago Rivers) is huge in rainy season and the condition of water quality in river is minor compared to that of the drain. However, the results show that the COD is 72 mg/l (48～128 mg/l), and BOD is 36 mg/l (27～50 mg/l) and river water quality cannot be judged as good.

Table 12.3 Water Quality of River and Drain

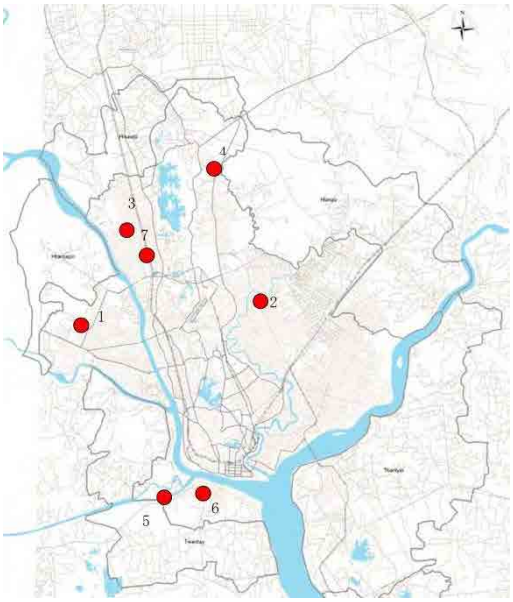
	COD_{Cr} (mg/l)		BOD (mg/l)		T-N (mg/l)		T-P (mg/l)	
	Range	Average	Range	Average	Range	Average	Range	Average
River	48～128	72	27～50	36	0.84～1.49	1.15	0.05～0.59	0.24
Drain	96～224	171	6～62	36	5.42～22.5	14.09	0.30～1.78	1.05
Drain/River	-	2.4 times	-	1.0 time	-	12.2 times	-	4.4 times

Source: JICA Study Team

12.5.7 Waste

Department of Pollution Control and Cleansing (DPCC) of YCDC is responsible for waste management in Yangon City. DPCC implemented the waste generation survey from 2011 to 2012 and it identified that the waste generation is 0.396 kg per person per day. Among the waste, 76 % is organic, 10% plastic, and 4 % is paper and textile. Waste collected is (1,550 ton per day), around 92 % of total generation. 62 % of collected waste comes from household, 35 % from commercial and market and 0.1% from the hospital. The amount of disposed waste at the dumping site is 1,250 – 1,400 ton per day in the past 5 years. The amount decreased from 2007 to 2010, but increased from 2010 to 2011.

There are two main final disposal sites and five temporary sites in Yangon City. These two disposal sites are open and receive waste for 24 hour/day, operated by DPCC. The temporary sites are supervised by DPCC.



Source: JICA Urban Plan Study, 2012

Figure 12.5 Location of Existing Landfill Sites

Table 12.4 Existing Final Disposal Site

No.	Name	TSP/District	Area (ha)	Planned service period	Present condition
	Disposal site				
1	Htein Bin	Hlaing Tha Yar / West	61	2002-2021	28 ha has been occupied with disposed waste
2	Htawe Chaung	North Dagon / East	60	2004-2015	19 ha has been occupied with disposed waste
	Temporary sites				
3	Shwe Phi Thar [Kyun Chaung]	Shwe Pyi Thar / West	1	1998-2015	There are two separate sites in operation within the area for rainy and dry season
4	Mingalar Done	Mingalar Done / North	1	2003-2012	Fence is set along the main road, A candidate site for future landfill
5	Seikkyi Khanaung	Seikkyi Khanaung / South	0.1	1962-?	
6	Dala	Dala / South	1	1950-?	A candidate site for future landfill
7	Damyingone Train Station, vegetable Market	Shwe Pyi Thar / North	5	2009-2012	Dumping is accepted for land reclamation. No fence at the site. This site is used in dry season.

Source: JICA Urban Plan Study, 2012

12.5.8 Soil Pollution

The data regarding soil pollution cannot be obtained. It is expected that the soil quality is deteriorated

by the infiltration of the untreated wastewater and leachate from septic tank.

12.5.9 Odor

The odor comes from the drains where the untreated wastewater is discharged. According to the results of HIS, 26 % of the respondents answered the odor is very bad, and 50 % feels the odor to be bad when it is flooded, and 23 % responded rare occurrence of bad odor.

12.5.10Ecology

The biodiversity inventory has not yet been completed in Myanmar, it is officially stated that there are 153 endangered species. In Greater Yangon, it is recorded that four kinds belongs to "Endangered" (No. 1 – 4 of table below) and one "Vulnerable" (No. 5 of table below). The habitat of those species is the forest and the impact is not expected as no activities on forest are included in the Project.

Table 12.5 Endangered Animal Species and Plant

No.	Scientific name	Common name	Family	IUCN, 2011
1	Lissemys punctata 	Indian flap shell turtle	Trionychidae	Endangered
2	Indotestudo elongate 	Yellow tortoise	Testudinidae	Endangered
3	Python molurus bivittatus 	Burmese Python	Boidae	Endangered
4	Dipterocarpus alatus 	Kanyin-phyu	Dipterocarpaceae	Endangered
5	Hopea odorata 	Thin-gan	Dipterocarpaceae	Vulnerable

Source: JICA Urban Plan Study, 2012

12.6 Analysis of Alternatives

The alternatives are analyzed from the view point of environmental and social, financial and technical aspects.

Table 12.6 Evaluation Matrix of Alternatives

Item		Zero Option (no sewerage system)	Alternative 1 (sewerage system + septic tank)	Alternative 2 (sewerage system + community plant)
Environmental and social aspects	Land acquisition and involuntary resettlement	No construction of facilities is required; land acquisition or involuntary resettlement may not happen. New septic tank for increased population will be constructed within the building area so that no land acquisition is required. D	Land acquisition is necessary for the construction of WWTP. The site should be carefully chosen so that the involuntary resettlement can be avoided. New septic tank for increased population will be constructed within the building area so that no land acquisition is required. B-	Land acquisition is necessary for the construction of WWTP. The site should be carefully chosen so that the involuntary resettlement can be avoided. The area for community plant is also needed. A-
	Land use and utilization of local resources	No impact D	Existing land use will be affected by land acquisition B-	Existing land use will be affected by land acquisition B-
	Living and livelihood	No impact D	No impact D	No impact D
	Protected area / cultural heritage	No impact D	No impact on protected area. The heritage buildings are located in the center of the city and impact might be expected due to the excavation of the ground. B-	No impact on protected area. The heritage buildings are located in the center of the city and impact might be expected due to the excavation of the ground. B-
	Landscape	No impact D	There is no special landscape as the proposed WWTPs sites are located off site of the central area. D	There is no special landscape as the proposed WWTPs sites are located off site of the central area. D
	Indigenous, or ethnic people	No impact D	There are no settlements of indigenous and ethnic people near around the project site so that no impact is expected. D	There are no settlements of indigenous and ethnic people near around the project site so that no impact is expected. D
	Water pollution	The discharged amount of BOD load at present is 282 ton /day and it will increase to 434 ton/day in 2040 and the water quality of drain and river will be polluted. The amount of water supply will also increase by 2040. Consequently, the increase in wastewater amount will cause negative impact on water quality of receiving water bodies. A-	In this alternative, the amount of discharge BOD load will be decreased from 282 ton/day to 251 ton /day despite the increased population, thus the water quality will be slightly improved. B+ / B-	In this alternative, the amount of discharge BOD load will be decreased from 282 ton/day to 131 ton /day despite the increased population, thus the water quality will be significantly improved. A+ / B-

Item		Zero Option (no sewerage system)	Alternative 1 (sewerage system + septic tank)	Alternative 2 (sewerage system + community plant)
	Waste	Most of the pollutants will be discharged into the drain and rivers without treatment, the sludge waste at the WWTP and septic tank will be slightly increased but no significant impacts on amount of waste is expected. D	The amount of waste will be increased because of the generated sludge from WWTP and septic tank. The sludge is dried and reused as fertilizer in the parks. In future, the reuse of sludge in the agriculture should be promoted and the rest should be disposed at the final disposal sites. B-	The amount of waste will be increased because of the generated sludge from WWTP and community plant. The sludge is dried and reused as fertilizer in the parks. In future, the reuse of sludge in the agriculture should be promoted and the rest should be disposed at the final disposal sites. B-
	Soil pollution	The soil will be contaminated by infiltration of untreated wastewater and leachate from septic tank. A-	The soil pollution will be improved by the sewerage system and septic tank. B+	The soil pollution will be improved by the sewerage system and community plant. A+
	Odor	The odor problem from drains and rivers will be worsening due to the increased untreated wastewater discharge into the drain and river. The odor might be generated from WWTP but as the operation rate is low against the whole capacity and no residences near WWTP, the impact is not large. B-	As the wastewater discharged into the drains and rivers will be reduced, the odor problems will improve. The temporary impact may occur when the sludge will be drawn from the septic tank. The odor might be generated from WWTP, the impact is not large as the residences are not located near WWTP. B+ / B-	As the wastewater discharged into the drains and rivers will be reduced, the odor problems will improve. The odor might be generated from the community plant. The odor might be generated from WWTP, the impact is not large as the residences are not located near WWTP. B+ / B-
	Ecology	The increased untreated wastewater will flow into the rivers through drains and impact on ecology is expected. A-	The pollution load will be reduced and as a result positive impacts on ecology can be expected. A+	The pollution load will be reduced and positive impacts on ecology can be expected. A+
Financial aspect		No additional investment is required. D	The investment for WWTP construction is necessary and the tariff of water supply and sewerage services shall be increased. B-	The investment for WWTP construction is necessary and the tariff of water supply and sewerage services shall be increased. Construction cost of community plant is almost same as that of sewerage system. Construction of Johkaso costs three or four times the cost of septic tank, and electricity is needed for operation. B-
Technical aspect		-	The removal rate of BOD of septic tank is 16 %, very low compared to WWTP of 90 %.	The removal rate of BOD of Johkaso or community plant is same as the sewerage system.

Item	Zero Option (no sewerage system)	Alternative 1 (sewerage system + septic tank)	Alternative 2 (sewerage system + community plant)
		Considering the pollution load reduction, the facility does not have enough capacity. Considering the structure and installed location, it is not possible but very limited to upgrade the septic tank to treat the gray water. B-	No Johkaso manufacture in Myanmar.. A+ / B-
Overall evaluation	The negative impacts on environment due to increased population, increased water use and increased untreated wastewater can be expected. **Not recommended**	By the construction of sewerage system and septic tank, the environmental improvement to some extent can be expected. **Recommended**	By the construction of community plant in the area where sewerage system cannot cover, which has same level of treatment as in case of WWTP, large positive impacts on environment can be expected. **Highly recommended**

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
D: No impact is expected.

Source: JICA Study Team

12.7 Mitigation Measures

The mitigation measures are proposed for the identified optimal alternative.

(1) Land acquisition and involuntary resettlement

The involuntary resettlement may not happen. The locations where WWTP is proposed are the land which is not used at present or does not provide impacts on people's life. The responsible organization for land acquisition is YCDC and close discussion on the procedures and policies are required. If the land should be acquired, the resettlement action plan or abbreviated resettlement plan should be prepared based on JICA Guidelines.

(2) Land use and utilization of local resources

No impact may be expected on land use and utilization of local resources as the proposed site of WWTP are carefully chosen.

(3) Water quality

The effluent from WWTP and community plant which will be discharged into the drains and rivers should meet the effluent standards.

(4) Waste

The sludge will be generated from the WWTP and community plant. The present generated sludge is used in the parks as fertilizer. In 2040, considerable amount of sludge will be generated, the reuse of sludge in agriculture should be promoted considering safety. Unused sludge should be disposed at the final disposal site.

(5) Odor

The odor may be expected from WWTP and community plant. The location of WWTP and community plant should be carefully chosen and should be away from the residential area. If residential area is near the proposed location, the facilities to mitigate the odor should be considered.

12.8 Public Consultation

The information disclosure and transparency are important items in the process of SEA. The results of M/P and SEA were presented in the stakeholder meeting. The objectives of stakeholder meeting are as follows:

- To disclose and share the results of water supply, sewerage and drainage M/P and formulation process
- To exchange the opinions with stakeholders

The stakeholder meeting was organized as follows.

Date and time: 10 April 2013 (Wed), 9:00-13:00

Venue: Traders Hotel

Agenda: 1) Opening Speech

2) Presentation

(i) Water Vision of Yangon City

(ii) Master Plan for Water Supply in Yangon City

(iii) Master Plan for Sewerage and Drainage in Yangon City

3) Questions and Answers

4) Closing Remarks

More than 140 stakeholders participated in the stakeholder meeting. The participants included the representatives of the residents, the parliament members of Yangon Region who were elected by the direct election, professors and advisor, and private companies. To obtain broader opinion from the participants, a comment paper was distributed to the participants for writing their feedback freely. The comments were read aloud and the answers were made by the presenter.

The main comments/suggestions are as follows. The details are shown in the minutes in Appendix G.

- The immediate program will be seriously taken into considerations: replacement of pumps and aging pipe to control water leakage, replacement of pumps and sewerage (existing pipe), and provision of transmission mains from Ngomoyeik Reservoir to Nyaunghnapin water treatment station (at present water is taken by open channel) to improve water quality (especially with turbidity and pesticides) and to reduce cost.
- To provide safe and clean water, the improvement of water supply system must be implemented as soon as possible.
- Can citizen pay the increased water tariff suggested by the Project?
- Special Economic Zone, Industrial Zones and urban areas need to share limited water resources. It is advisable that Yangon Water Vision should be part and parcel of the overall "Yangon City Development Plan".
- The decentralized wastewater treatment system known as DEWAS should be studied, which provides clean water for domestic use except for drinking.
- In the sewerage presentation, improvement of the existing system and zone is proposed as the highest prioritized project. I think that the improvement of existing septic tanks must also be done at first.
- For the development of legal system such as effluent standard for wastewater from the factories to sewerage system, It is very helpful if the JICA study team can propose or show us the example of the standards or regulation laws of this kind since this kind of laws are currently being studied in the Union Government and some of them are expected to be

promulgated next year.

- Myanmar Water Professionals are currently drafting the Myanmar Water Law. That needs JICA's support.
- If the Water Law is drafted with the support of JICA through the YCDC, the future implementation, monitoring and law enforcement activities would be more effective and efficient. Yangon City would also become pioneer in such systematic approach.

CHAPTER 13. SELECTION OF PRIORITY PROJECT FOR FEASIBILITY STUDY

Sewerage system is proposed to be developed to improve living conditions and water quality in river and drains. Living conditions are not so bad because of existence of large number of septic tanks in Yangon. On the other hand, water quality in drains has already worsened and water quality in the rivers has started deteriorating. So, necessity of sewerage system development is regarded to have high priority.

On the other hand, fund requirements for sewerage system development are huge, particularly in Yangon where only a small percentage of population is served with the sewerage system. Although, the water supply coverage ratio is higher than sewerage, it is still only 38%. Usually needs for water supply system development is higher than those for sewerage system development. In most of the cities, water supply system development proceeds first and, when economic situation allows, sewerage development follows.

Accordingly, expansion of the sewerage system is not selected as priority project. Alternatively, renewal of the existing sewerage system which is more than 100 years old is selected as priority project.

Water quality improvement of the Kandawgyi Lake is also selected as priority project. The lake is regarded as the most important lake according to 2012 JICA Household Surveys.

Table 13.1 Priority Project

No.	Project Name	Facility	Remark	Urgency/ Effectiveness
SW-1	Project for rehabilitation and expansion of sewerage facilities in the CBD	Improvement of the existing separate sewer system and expansion of WWTP in the CBD area • Trunk sewer and branch sewer （61.8 ㎞） • Improvement and expansion of the existing WWTP （70,200m^3/day, of which, expansion is of 35,000m^3/day）	Currently only toilet wastewater is collected by ejector system. In addition, the sludge from septic tank is transported to WWTP and treated. The system will be changed to separate sewer system which treats both toilet wastewater and gray water.	CBD is the highest density area indicating the highest cost-benefits performance of sewerage project
SW-2	Project for Water quality improvement of the Kandawgyi lake	To intercept wastewater inflow from drainage channels in the northern area of the Kandawgyi lake • Interceptor sewer（2.0km） • Discharge pump station • Diversion chamber（7 points） Countermeasures on wastewater discharge from the restaurants surrounding the Kandawgyi lake	- To intercept wastewater inflow from 7 drainage channels in the northern area of the Kandawgyi lake - In addition, to intercept wastewater discharge from restaurants surrounding the Kandawgyi lake	- Urgency is high - The Kandawgyi lake is a symbolic lake and recreation place for the Yangon citizens - JICA HIS shows that the lake is the most important place.

CHAPTER 14. TARGET OF IMPROVEMENT OF INUNDATION

As mentioned in the previous sections, small inundation occurs in Yangon city frequently but YCDC and many residents have no sense of crisis for inundation. Even though its damages are not serious at present, economic damage by inundation will increase in future because of urbanization of Yangon city. Furthermore, it is important to prevent flooding due to wastewater from the aspects of hygiene and appearance. Thus, early development of drainage facilities is required to solve inundation problems, and its target is set as follows.

Target Year : 2040

Goals : Elimination of inundation in Yangon city
Inundation in Yangon city central area will be eliminated gradually by target year.

Target Area : Twenty two (22) drainage districts in the central area and CBD
Target areas for inundation improvement are twenty two (22) drainage districts in the central area and CBD. YCDC manages drainage facilities in these areas and should promote drainage system developments mainly.

CHAPTER 15. PLANNING CONDITIONS AND BASIC POLICIES

15.1 Basic Policies

Table 15.1 shows general methods for development of drainage system. It is important to consider combination of these methods and coordination with related river plan for effective drainage system planning. For this purpose, coordination with relevant organizations, such as MOAI and DDA, is necessary for confirmation about planning conditions, etc. However, in relevant organizations, the design policies and conditions are not decided clearly yet . Therefore, in this study, drainage system planning is conducted based on conventional drainage system in order to confirm the project scale.
In the future, it is also required to develop related rules and regulations, by which for instance land development is controlled based on land use plan, installation of run off control facilities by private developers is obligated and ground water pumping causing ground subsidence is controlled to prevent inundation with high tide, for formulation of comprehensive drainage plan.

Table 15.1 Methods of Drainage System Developments

Categories	Methods
Conventional Drainage System	・Pipe/Channel ・Pumping Facility
Run-off Control System	・Storage Facility ・Infiltration Facility
Others	・Development of rules and regulations ・Land use control ・Rainfall information System

Source: JICA Study Team

15.2 Planning Conditions

Table 15.2 shows planning conditions for drainage system which is decided based on present conditions of drainage and results of discussions with YCDC.

Since project implementation takes long period, for the time being, it is important to conduct practical measures such as modification of bottleneck channels, dredging sand/sediments and educational campaign for quitting illegal dumping.

Table 15.2 Drainage System Planning Conditions

Items	Adoption	Remarks
(1) Target Year	2040	Coordination with Water Supply and Sewerage Master Plan
(2) Return Period	5 Year	Coordination with MOAI planning conditions (Source: "Study on Drainage System of Mingalar Taung Nyunt Area", Fukken Co., LTD, Nov 2002) Note: It is desirable to adopt long return period for safe drainage system. However, excessive project scale requires too much cost and long project implementation period. Therefore, 5-year is adopted as appropriate return period.
(3) Runoff Analysis	Rational Formula $Q = \frac{1}{360} C \cdot I \cdot A$ Here Q: Peak Runoff (m^3/s) C: Runoff Coefficient I: Rainfall Intensity (mm/hr) A: Catchments area (ha) < Rainfall Intensity formula> $I = 1{,}115/t^{0.7}$ t: Concentration time	
(4) Runoff Coefficient	CBD: 0.8 Other area: 0.4～0.6	Assumption based on population density in 2040
(5) Level of Receiving Water	+3.619 above mean sea level	Highest high water level

Source: JICA Study Team

CHAPTER 16. DRAINAGE SYSTEM PLAN

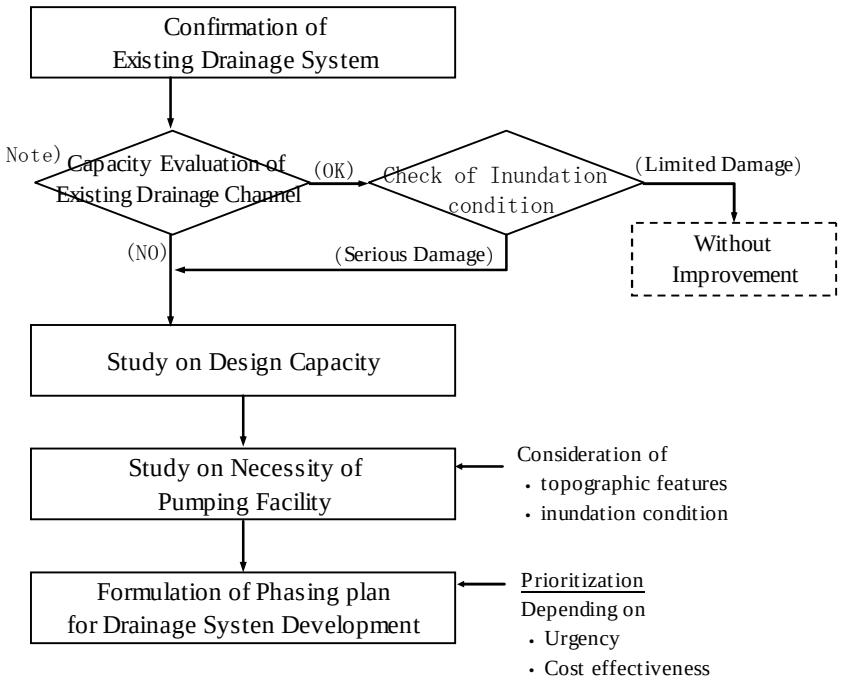
16.1 Flow Diagram of Drainage System Planning

Figure 16.1 shows a flow diagram of drainage system planning. The planning work starts from capacity checking of existing drainage channels and confirmations of inundation damages. Based on the result of that, necessity and design capacity of drainage facilities are evaluated.

Following aspects are considered in drainage system planning.

- Prioritization
  Each drainage district is prioritized based on severity of inundation problems

- Phased Approach
  Short-term (~2020), Middle-term (~2030) and Long term (~2040) plans are formulated for effective development.



Note) Capacity evaluation based on limited rusult of cross section survey

Source: JICA Study Team

Figure 16.1 Flow Diagram for Drainage System Planning

16.2 Drainage System Plan

Figure 16.2 and Table 16.1 show the drainage system plan. Capacity calculations and evaluation results of existing facilities are attached in Appendix D.

Facility planning takes into consideration the followings.

(1) Capacity evaluation of existing drainage channel and study on design capacity

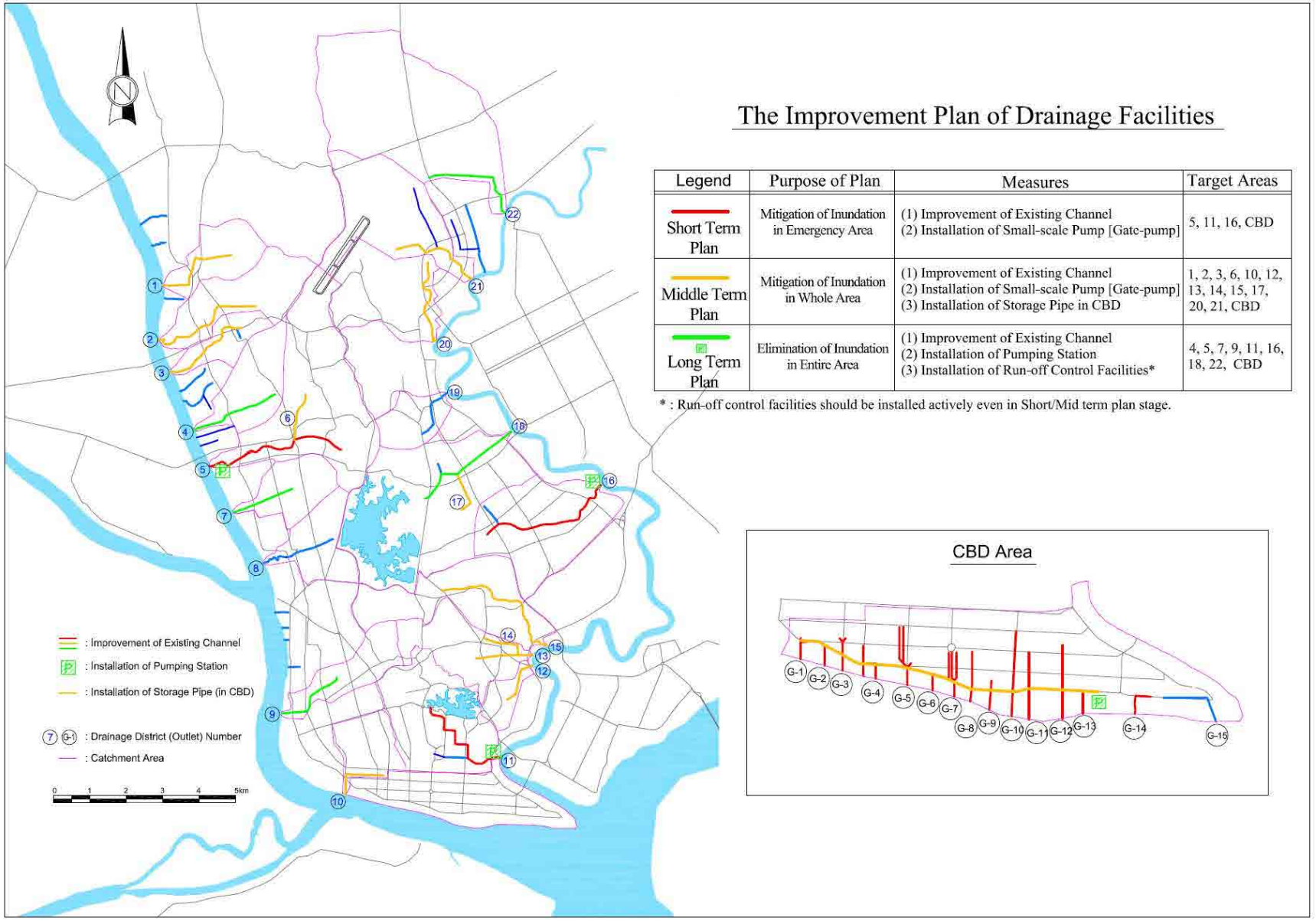
Main trunk drain is required to discharge design flow immediately. Utilizing the existing information about drainage district from ”Yangon Infrastructure and Environmental Services - Pre Feasibility Study, UNCHS/UNDP, Aug 1993”, upgraded design capacity is calculated based on the assumption that existing drains will be improved with same route and length.

(2) Study on necessity of Pumping Facility

Based on the current situation of inundation damage, pumping station is planned in the place where forced drainage system is needed (Refer to Section 4.3 “Current flood status”). Small type pumping stations, say “Gate Pump”, are planned for local inundation. Big scale pumping stations are planned at the end of main trunk channel for the drainage district in which it is difficult to discharge storm water by gravity system, such as drainage district No 5, 11, 16 and CBD.

(3) Formulation of Phasing Plan

For elimination of inundation immediately, Short and Middle-term plan include the drainage district which has inundation damage at present. Especially, drainage district No 5, 11, 16 and CBD ,which has large scale inundation damage and should be improved urgently, are selected for Short-term plan. However, construction of big scale pumping station in these districts is planned for Long-term plan because its construction is impractical in short term period from view point of cost effectiveness. On the other hand, inflow pipe to pumping station in CBD is planned in Middle-term plan as storm water storage pipe for early improvement of inundation problem in CBD.



Source: JICA Study Team

Figure 16.2 General Plan of Drainage System

Table 16.1 Summary of Planned Drainage System

No.	Drainage District		Outfall No.	Phasing Plan									Remarks						
				Short Term Plan (～2020) 【Mitigation of Inundation in Emergency Area】		Middle Term Plan (～2030) 【Mitigation of Inundation in Whole Area】			Long Term Plan (～2040) 【Elimination of Inundation in Entire Area】			Pipe/Channel		Pumping Facility				Storage Facility
				Pipe/Channel	Pumping Facility	Pipe/Channel	Pumping Facility	Storage Facility	Pipe/Channel	Pumping Facility	Storage Facility	Dimension (m)	Length (m)	Gate Pump		Pumping Station		
				・Improvement of Existing Channel	・Installation of Gate Pump	・Improvement of Existing Channel	・Installation of Gate Pump	・Installation of Trunk Sewer	・Improvement of Existing Channel	・Construction of Pumping Station	・Installation of On-site Run-off control facility			Design Flow (m3/min)	Nos.	Design Flow (m3/min)	Nos.	Design Capacity (m3)
1	Out of CBD	Ywa ma Chaung Area	①			○	○				On-site Run-off control facilities should be installed actively together with redevelopment of existing urban area and urbanization of suburbs.	4.50×2.25 ～6.50×3.25	2,770	200	2			
2		Ka thwe Chaung Area	②			○						6.50×3.25 ～8.00×4.00	2,610					
3		Pauk taw Chaung Area	③			○	○					4.50×2.25 ～5.50×2.75	2,460	200	2			
4		Yoe gyi Chaung Area	④						○			6.00×3.00 ～7.00×3.50	2,050					
5		Tha maing Chaung Area	⑤	○	○					○		5.00×2.50 ～10.00×5.00	4,410	200	4	5,370	1	
6		Aung theik Chaung Area	⑥			○						8.50×4.25 ～9.50×4.75	1,250					
7		Pa dauk Chaung Area	⑦						○			5.50×2.75 ～7.50×3.75	1,490					
8		Kamayut Chaung Area	⑧						△			4.50×2.25 ～7.00×3.50	2,360					
9		Kwin Chaung Area	⑨						○			5.50×2.75 ～6.00×3.00	1,840					
10		Ywa thit Chaung Area	⑩			○						4.00×2.00 ～7.00×3.50	1,630					
11		Thebyu Chaung Area	⑪	○	○					○		8.50×4.25 ～9.50×4.75	3,420	200	5	4,470	1	
12		Aung mingalar myopat Chaung Are	⑫						○			3.50×1.75 ～5.00×2.50	1,330					
13		Moemaka Chaung Area	⑬			○	○					5.00×2.50 ～8.00×4.00	1,800	200	1			
14		Nat Chaung Area	⑭			○	○					5.50×2.75 ～6.50×3.25	1,340	200	2			
15		Kunitpinlain Chaung Area	⑮			○	○					7.00×3.50 ～8.50×4.25	4,740	200	3			
16		Kyaiksan Chaung Area	⑯	○	○					○		6.00×3.00 ～9.50×4.75	4,370	200	3	5,300	1	
17		Semyaung Chaung Area	⑰			○	○					8.00×4.00	1,120	200	2			
18		Yeipauk-kyi Chaung Area	⑱						○			8.00×4.00 ～12.00×6.00	3,230					
19		Zwezon Chaung Area	⑲						△			3.50×1.75 ～5.50×2.75	1,320					
20		Shwehle Chaung Area	⑳			○	○					4.00×2.00 ～7.50×3.75	1,990	200	4			
21		Thunandar Chaung Area	21			○	○					5.00×2.50 ～7.50×3.75	4,480	200	4			
22		Danityoe	22						○			6.50×3.25 ～8.50×4.25	9,010					
23	CBD	War Dan St. Area	G-1	○				○ (φ6250mm) (L=4450m) Utilization of Trunk Sewer to PS as Storage Pipe		○	On-site Run-off control facilities should be installed actively together with redevelopment of existing urban area and urbanization of suburbs.	□2.20×2.20	295			2,280	1	136,500m3 (Mid term Plan) 68,000m3 (Long term Plan)
24		Lanthit St. Area	G-2	○								□2.40×2.40	348					
25		Phone Gyi St. Area	G-3	○								□2.60×2.60	386					
26		Lanmadaw St. Area	G-4	○	○							□3.20×3.20	637	200	1			
27		Bo Ywe St. Area	G-5	○	○							□3.20×3.20	889	200	1			
28		Sule Pagoda Rd. Area	G-6	○	○							□3.20×3.20	1,220	200	1			
29		Maha Bandoola Garden St. Area	G-7	○	○							□2.20×2.20	984	200	1			
30		Pansodan St. Area	G-8	○								□2.80×2.80	1,009					
31		Bo Aung Kyaw St. Area	G-9	○								□2.60×2.60	1,164					
32		Thein Phyu Rd. Area	G-10	○	○							□3.40×3.40	1,223	200	1			
33		Bo Myat Tun St. Area	G-11	○	○							□3.00×3.00	1,134	200	1			
34		Botahtaung Pagoda Rd. Area	G-12	○								□3.00×3.00	1,209					
35		Botahtaung Rd. Area	G-13	○								□4.40×4.40	1,033					
35		Mya Nandar Yeik Thar St. Area	G-14	○								□4.40×4.40	520					
36		Mya Nandar Yeik Thar St. Area	G-14	○								□3.20×3.20	632					

Note1：“○” means inplementation of each measure

Note2：“△” means implementation if necessary, based on the status of urbanization

Source: JICA Study Team

16.3 Recommendations from the Environmental and Social Considerations

Most of the drains are clogged by the solid waste dumped into the drain illegally and when the rain starts, the flooding situation gets worse. The houses / huts / buildings are constructed along the drains and it will disturb the cleaning of the drains and expansion of the drains in the future. Thus, for the smooth implementation of the M/P, the following actions should be taken by YCDC.

- Awareness activities to make the people understand the impacts on drains by the illegal dumping, and enhance the changes of attitudes towards the solid waste management, etc.
- Establishment of the laws and regulations to tackle the illegal inhabitants (squatters) and the illegal buildings,
- Compensation payment based on the laws and regulations when the involuntary resettlement may be caused by the expansion of the drains.

16.4 Recommendations for Drainage System Development

Urbanization in Yangon city is spreading. Especially it is remarkable in suburban townships. Since storm water runoff will increase with urbanization, appropriate development of drainage system is required in these areas.

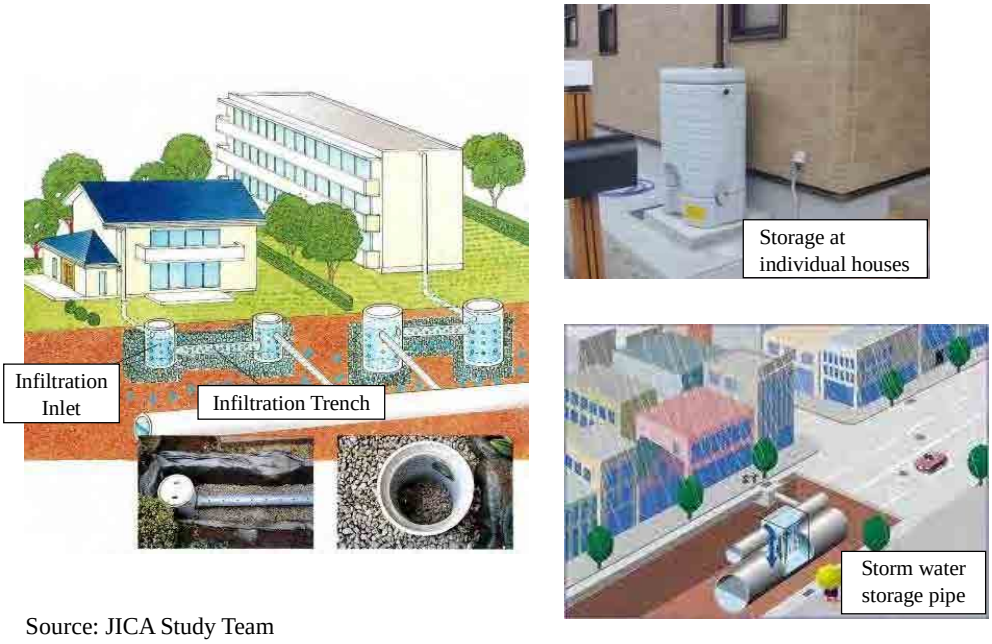
For drainage system development in future, it is effective to employ not only the conventional drainage system, which drains storm water immediately through drainage facilities, but also the runoff control system, which reduces storm water runoff by infiltration and storage.

The runoff control system includes land use management such as control of urbanization based on land use plan and conservation of paddy/green fields for flood control areas. Land development should be controlled by government instructions and regulations to reduce the storm water runoff by appropriate land use. For that purpose, it is important to coordinate with relevant organizations such as river, road and land development departments for formulation of comprehensive drainage system.

Table 16.2 and Figure 16.3 show categories and examples of runoff control facilities.

Table 16.2 Categories of Runoff Control Facilities

Categories		Methods
Storage System	On-site Storage	・Storage at park, schoolyard ・Storage at parking area, open space ・Storage at individual house ・Storage at public land
	Off-site Storage	・Storm water storage pipe ・Storm water reservoir ・Green space for flood control
Infiltration System		・Infiltration trench, street gutter ・Infiltration inlet ・Infiltration pavement, etc.



Source: JICA Study Team

Figure 16.3 Examples of Runoff Control Facilities

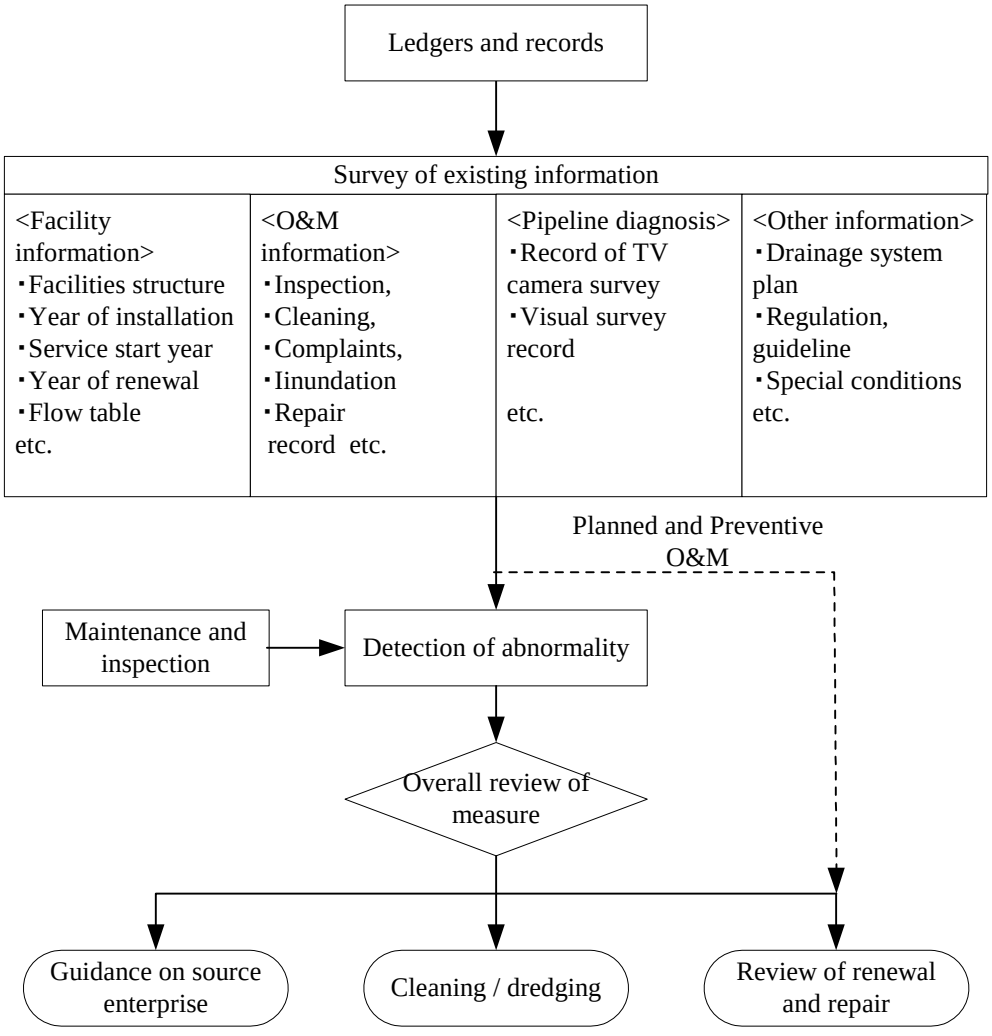
CHAPTER 17. OPERATION & MAINTENANCE AND CAPACITY DEVELOPMENT OF DRAINAGE SYSTEM

17.1 Flow Diagram of O&M Work

Main O&M works for drainage facilities are; 1) inspection, 2) cleaning/dredging, 3) repair of damaged facility, 4) detailed investigation, and 5) management of ledger and records.

For pumping stations which will be constructed in future, 1) operation of pumping station, 2) removal of sand and screenings, 3) inspection and maintenance of equipment, etc., will be required additionally.

For preventive O&M works, it is important to carry out these works appropriately and to make connection among each work, such as through returning feedback to each other.



Source: JICA Study Team

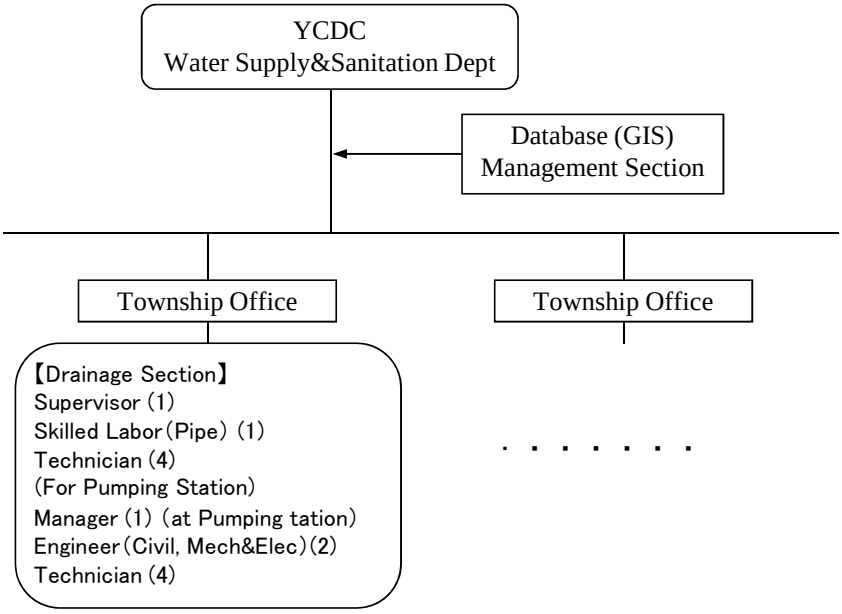
Figure 17.1 Flow Diagram of O&M Work for Drainage Systems

17.2 Organization for O&M of Drainage System

Figure 17.2 shows a tentative organization chart for O&M of drainage system.

Drainage sections are organized under each YCDC township office or district office since drainage facilities are located in each township. Water Supply & Sanitation Department in YCDC head office manages database/information of drainage facilities in all townships through a GIS section.

YCDC and township offices shall hire necessary staffs shown below in conjunction with drainage system development. For an efficient organization, outsourcing of O&M works should also be considered if necessary.



Source: JICA Study Team

Figure 17.2 Proposed Organization for O&M of Drainage System

17.3 Capacity Development

There is no independent section for drainage management in YCDC at present. To establish the O&M organization for drainage system, YCDC shall hire new staff members in addition to existing staff members coming from water supply & sanitation department. Since newly employed staff members have no skill and experience in O&M works of drainage system, capacity development of new staff members is essential to conduct appropriate O&M works continuously.

A capacity development program will be implemented with following steps.

- Assessment of training needs for target staff members
- Implementation of classroom and/or on the job trainings by experts

- Monitoring and evaluation of results of capacity development program

Table 17.1 shows examples of capacity development program for drainage system management.

Table 17.1 Examples of Capacity Development Program

Fields	Contents
General Management Skills	- Training in project management, including foreign-funded projects - Training in human resource development - Training in financial management, accounting, budgeting - Training in relevant IT applications - Development of drainage system management manuals and handbooks
Drainage System Operation	- Development of O&M manuals - Training on operation and maintenance of the drainage system (1)O&M trainings for Pipe/Channels □Inspection, cleaning/dredging and rehabilitation of pipes □Inspection, repair/maintenance and renewal of tide gate □Ledgers and maintenance record, etc. (2)O&M trainings for pumping station □Removal/disposal of sediments and screenings □Operation of pumps □Inspection, repair/maintenance and renewal of equipment □Operation & maintenance record, etc.
Database and GIS	- Development of database of drainage system in GIS - Training on using the database
Environmental Management	- Development on environmental management plan - Training on environmental management including environmental monitoring
Public Relations	- Training on public announcement such as brochure distribution, hold a briefing, etc. - Training on public hearing such as questionnaire, hold a conference, etc.

Source: JICA Study Team

CHAPTER 18. PROJECT COST OF IMPROVEMENT OF DRAINAGE SYSTEM

18.1 Condition of Cost Estimation

The price level and exchange rate are defined below.

Price level: Average in December 2012

Exchange rate: 1USD=84.64JPY

Based on the condition shown below, the construction cost is calculated.

- It is possible to procure civil and building material, labor and construction machine within the country and the procurement in local country is set as basic policy for project cost estimation.
- The mechanical and electrical equipment is basically procured from overseas including third country; such as European Union (EU), etc. The equipment will be procured with consideration of quality, performance, economic efficiency and O&M, etc.
- The utilization of local contractor is prioritized for construction implementation of the project.
- The construction plan is established with the considerations of local natural condition (topographic aspects, geotechnical condition and meteorological condition) and legislation/custom.

18.2 Project Cost Estimation

18.2.1 Capital Cost

Non-disclosure Information

Table 18.1 The Result of Cost Estimation of Drainage Project

Non-disclosure Information

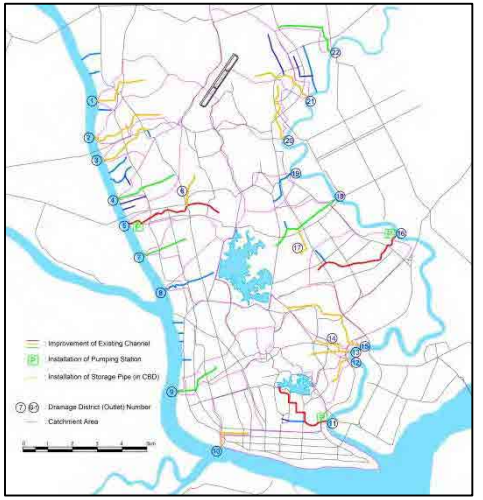
Additionally, Table 18.2 shows location of drainage facilities, specifications and project cost.

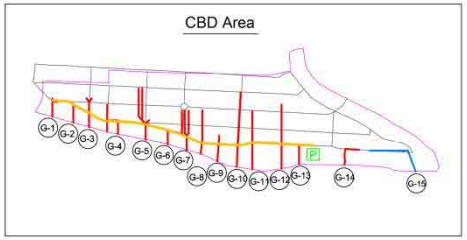
Table 18.2 Location of Drainage Facilities, Specifications and Project Cost

No.		Drainage District	Outfall No.	Phasing Plan: Short Term Plan (～2020) Pipe/Channel Improvement of Existing Channel	Short Term Plan (～2020) Pumping Facility Installation of Gate Pump	Middle Term Plan (～2030) Pipe/Channel Improvement of Existing Channel	Middle Term Plan (～2030) Pumping Facility Installation of Gate Pump	Middle Term Plan (～2030) Storage Facility Installation of Trunk Sewer	Long Term Plan (～2040) Pipe/Channel Improvement of Existing Channel	Long Term Plan (～2040) Pumping Facility Construction og Pumping Station	Long Term Plan (～2040) Storage Facility Installation of On-site Run-off control facility	Remarks: Pipe/Channel Dimension (m)	Pipe/Channel Length (m)	Pumping Facility: Gate Pump Design Flow (m3/min)	Gate Pump Nos.	Pumping Station Design Flow (m3/min)	Pumping Station Nos.	Storage Facility Design Capacity (m3/min)	Construction Cost (Mil. JPY): Pipe/Channel	Storage Facility	Pumping Facility: Gate Pump	Pumping Station	Total	Project Cost (Mil. JPY)
1	CBD&IPA	Ywa ma Chaung Area	①			○	○					4.50×2.25 ～6.50×3.25	2,770	200	2				1,772	0	283	0	2,055	2,419
2		Ka thwe Chaung Area	②			○						6.50×3.25 ～8.00×4.00	2,610						2,767	0	0	0	2,767	3,257
3		Pauk taw Chaung Area	③			○	○					4.50×2.25 ～5.50×2.75	2,460	200	2				1,416	0	283	0	1,699	2,000
4		Yoe gyi Chaung Area	④						○			6.00×3.00 ～7.00×3.50	2,050						1,649	0	0	0	1,649	1,940
5		Tha maing Chaung Area	⑤	○	○					○		5.00×2.50 ～10.00×5.00	4,410		4	5,370	1		5,605	0	566	12,383	18,554	21,838
6		Aung theik Chaung Area	⑥			○						8.50×4.25 ～9.50×4.75	1,250						1,781	0	0	0	1,781	2,097
7		Pa dauk Chaung Area	⑦						○			5.50×2.75 ～7.50×3.75	1,490						1,266	0	0	0	1,266	1,491
8		Kamayut Chaung Area	⑧						△			4.50×2.25 ～7.00×3.50	2,360						1,533	0	0	0	1,533	1,804
9		Kwin Chaung Area	⑨						○		On-site Run-off control facilities should be installed actively together with rdevelopment of existing urban area and urbanization of suburbs.	5.50×2.75 ～6.00×3.00	1,840						1,229	0	0	0	1,229	1,447
10		Ywa thit Chaung Area	⑩			○						4.00×2.00 ～7.00×3.50	1,630						1,046	0	0	0	1,046	1,231
11		Thebyu Chaung Area	⑪	○	○					○		8.50×4.25 ～9.50×4.75	3,420		5	4,470	1		4,986	0	707	11,894	17,587	20,700
12		Aung mingalar myopat Chaung Area	⑫						○			3.50×1.75 ～5.00×2.50	1,330						488	0	0	0	488	574
13		Moemaka Chaung Area	⑬			○	○					5.00×2.50 ～8.00×4.00	1,800	200	1				1,350	0	141	0	1,491	1,755
14		Nat Chaung Area	⑭			○	○					5.50×2.75 ～6.50×3.25	1,340	200	2				925	0	283	0	1,208	1,422
15		Kunitpinlain Chaung Area	⑮			○	○					7.00×3.50 ～8.50×4.25	4,740	200	3				5,738	0	424	0	6,162	7,252
16		Kyaiksan Chaung Area	⑯	○	○					○		6.00×3.00 ～9.50×4.75	4,370		3	5,300	1		5,446	0	424	11,814	17,684	20,814
17		Semyaung Chaung Area	⑰			○	○					8.00×4.00	1,120	200	2				1,385	0	283	0	1,668	1,964
18		Yeipauk-kyi Chaung Area	⑱						○			8.00×4.00 ～12.00×6.00	3,230						5,275	0	0	0	5,275	6,208
19		Zwezon Chaung Area	⑲						△			3.50×1.75 ～5.50×2.75	1,320						541	0	0	0	541	637
20		Shwehle Chaung Area	⑳			○	○					4.00×2.00 ～7.50×3.75	1,990	200	4				1,432	0	566	0	1,998	2,352
21		Thunandar Chaung Area	㉑			○	○					5.00×2.50 ～7.50×3.75	4,480	200	4				2,895	0	566	0	3,461	4,073
22		Danityoe	㉒						○			6.50×3.25 ～8.50×4.25	9,010						7,399	0	0	0	7,399	8,709
23	CBD	War Dan St. Area	G-1	○				○ (φ6,250mm) (L=4450m) Utilization of Trunk Sewer to PS as Storage Pipe		○	On-site Run-off control facilities should be installed actively together with rdevelopment of existing urban area and urbanization of suburbs.	□2.20×2.20	295			2,280	1	147,370	20,438	19,811	707	7124	48,080	56591
24		Lanthit St. Area	G-2	○								□2.40×2.40	348											
25		Phone Gyi St. Area	G-3	○								□2.60×2.60	386											
26		Lanmadaw St. Area	G-4	○	○							□3.20×3.20	637	200	1									
27		Bo Ywe St. Area	G-5	○	○							□3.20×3.20	889	200	1									
28		Sule Pagoda Rd. Area	G-6	○	○							□3.20×3.20	1,220	200	1									
29		Maha Bandoola Garden St. Area	G-7	○	○							□2.20×2.20	984	200	1									
30		Pansodan St. Area	G-8	○								□2.80×2.80	1,009											
31		Bo Aung Kyaw St. Area	G-9	○								□2.60×2.60	1,164											
32		Thein Phyu Rd. Area	G-10	○	○							□3.40×3.40	1,223	200	1									
33		Bo Myat Tun St. Area	G-11	○	○							□3.00×3.00	1,134	200	1									
34		Botahtaung Pagoda Rd. Area	G-12	○								□3.00×3.00	1,209											
35		Botahtaung Rd. Area	G-13	○								□4.40×4.40	1,033											
36		Mya Nandar Yeik Thar St. Area	G-14	○								□4.40×4.40	520											
		Mya Nandar Yeik Thar St. Area	G-14	○								□3.20×3.20	632											
												Total	12,683						78,362	19,811	5,233	43,215	146,621	172,575

Note1: "○" means implementation of each measure

Note2: "△" means implementation if necessary, based on the status of urbanization





Source: JICA Study Team

18.2.2 Operation and Maintenance Cost

The required operation and maintenance cost for drainage works is shown below. In the field of drainage works, the annual cost of operation and maintenance except for electricity cost is approximately 4.6 hundred million JPY. This cost consists of annual labor cost and spare parts cost. Electricity cost will be added depending on the operational status of storm water pump and pump gate. The daily electricity cost is 201.5 million JPY, when all proposed pumps are operated full day.

Table 18.3 Annual Operation and Maintenance Cost for Drainage Works

(Unit: Million JPY/Year)

Category	Cost
Labour cost	23.4 (0.3)
Spare parts cost	436.0 (5.2)
Sludge disposal cost	0 (0)
Chemical cost	0 (0)
Others	13.2 (0.2)
Total	459.4 (5.7)

* The daily electricity cost is 201.5 million JPY, when all proposed pumps are operated.
( ): Million USD
Source: JICA Study Team

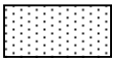
18.3 Financing Plan

The total project investment cost for drainage system development sums to [redacted] million. The total cost is too large to be financed by local funding and external financing at low interest rates needs to be sought out. Moreover there is no operation revenue as is the case of sewerage service. The first priority areas recommended in this plan include drainage No.5, No.11, No.16 as wells as those within CBD. Since the drainage areas covered by these drainage systems are hydraulically defined, the other parts of the city would not benefit from these projects, indicating geographical bias. One way to address the issue of gaps between beneficiaries and contributors is to define flood-prone areas such as 'Flood Zones' in a clear geographic manner and then impose a special-purpose tax for flood control. Such a geographical distinction will help align the beneficiaries and tax contributors. The amount of tax, its affordability, taxation methodology all need further studies when there is a political interest in such system.

Table 18.4 Investment Cost by Priorities

[redacted]
Non-disclosure Information

As analyzed in the macro-framework for the funding for sewerage services, the per capita GDP for the

city of Yangon is projected as USD 5600 in 2040. It is assumed that appropriate level of infrastructure stock for drainage is 5% and the total borrowing debt against the GDP is 50%. The target level is USD 140 per capita. Thus the total cost estimate of  million for the first priority, though close to this per capita limitation, is presumed to be beyond the limit of the economic affordability. In addition, as discussed above, the benefited areas are limited to flood prone areas and its hinterland.