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

THE REPUBLIC OF THE UNION OF MYANMAR
DATA COLLECTION SURVEY FOR SEWERAGE SYSTEM DEVELOPMENT IN YANGON CITY

FINAL REPORT

(SUMMARY)

FEBRUARY 2019

Japan International Cooperation Agency (JICA)

Nippon Koei Co., Ltd. (NK)

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Exchange Rate (May 2018)
JPY/USD = 110
MMK/USD = 1,320
JPY/MMK = 0.0833

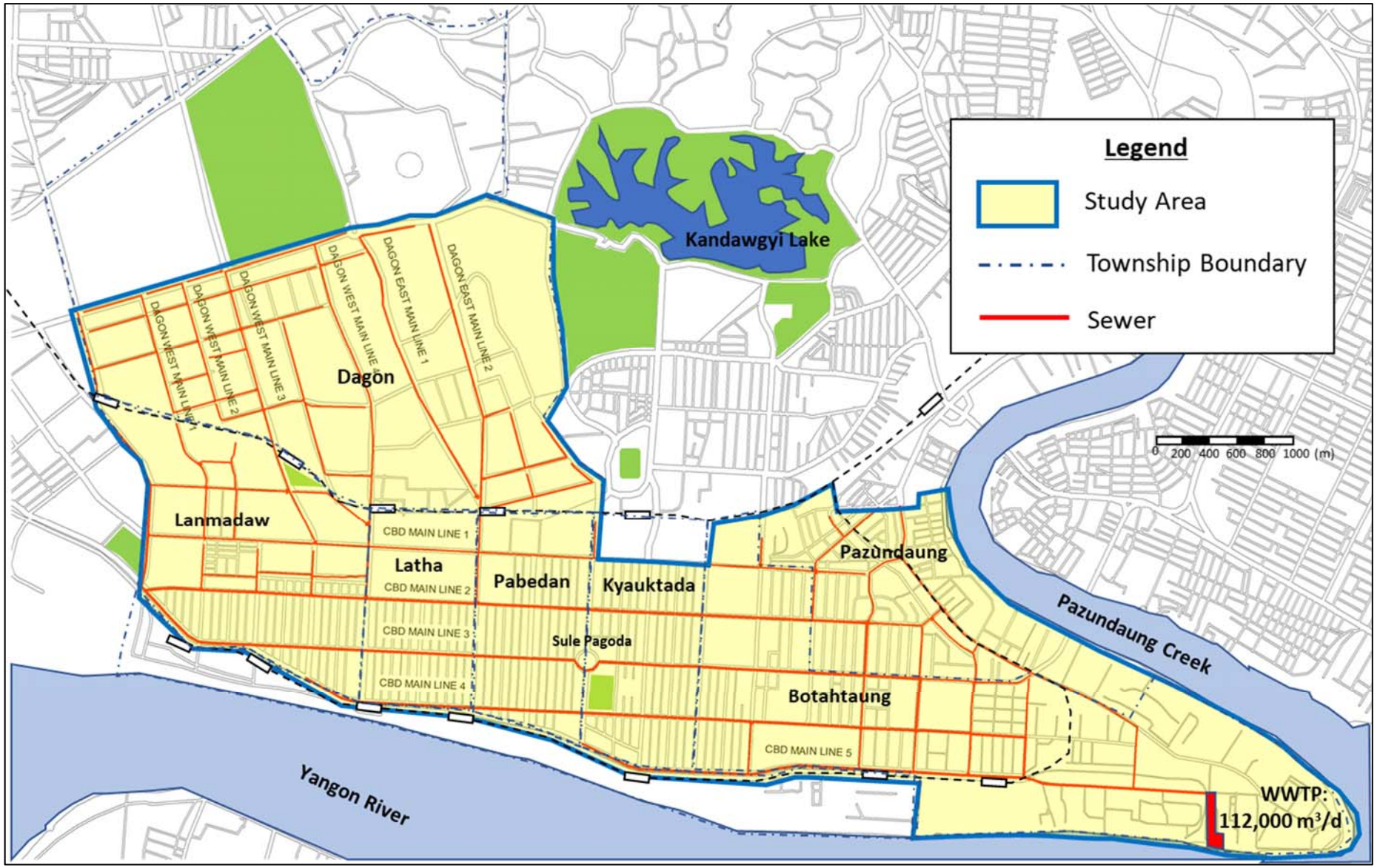
DIFINITION OF THE STUDY AREA

Administrative Boundary		Township Group	Township Name	Sewerage Zone	The Study Area
Yangon Region	Yangon City	CBD	Latha	W1	√
			Lanmadaw	W1	√
			Pabedan	C1	√
			Kyauktada	C1	√
			Botahtaung	C1	√
			Pazundaung	C1	√
		Inner Urban Ring	Ahlone	W1	
			Kyee Myin Daing	W1/W2	
			Sanchaung	W1	
			Dagon	W1	√[1]
			Bahan	C2/W1	
			Tarmwe	C2	
			Mingalar Taung Nyunt	C2	
			Seikkan		
			Dawbon	E3	
		Outer Ring	Kamaryut	W1/W2	
			Hlaing	W2	
			Yankin	C2	
			Thingangyun	C2	
		Northern Suburbs	Mayangone	C2/W2	
			Insein	N1	
			Mingalardon	N2	
		Older Suburbs	North Okkalapa	E1	
			South Okkalapa	C2	
			Thaketa	E3	
		South of CBD	Dala	S1	
			Seikgy ikhanaungto	W3	
		New Suburbs	Shwe Pyi Thar	N3	
			Hlaing Tharyar	W4	
			North Dagon	E1	
			South Dagon	E3	
			East Dagon	E2	
			Dagon Seikkan	E4	
	Outside of Yangon City		Kyauktan		
			Thanlyin		
			Hlegu		
			Hmawbi		
			Htantabin		
			Twantay		
			Taikkyi		
			Kawhmu		
			Kungyangon		
			Kayan		
			Thongwa		

1: Part of Dagon township is included in the study area

Source: JICA Study Team

Source: Myanmar Information Management Unit



Source: JICA Study Team

Sewerage Facility Development Plan for Study Area

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Abbreviations

Abbreviation	English
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
CQHP	Committee for Quality Control of High-Rise Building Construction Project
DDA	Department of Development Affair
DIP	Ductile Iron Pipe
DMA	District Metered Area
E/N	Exchange of Notes
EDWS	Engineering Department of Water and Sanitation
ECC	Environment Conservation Committee
ECC	Environmental Compliance Certificate
EIA	Environmental Impact Assessment
ESC	Environmental and Social Considerations
F/S	Feasibility Study
FC	Foreign Currency
FDS	Final Disposal Site
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
JST	JICA Study Team
Kyat	Myanmar Kyat
LPCD or(Lpcd)	Litters 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 Litters
MLD	Million Litters per Day
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOC	Ministry of Construction
MONREC	Ministry of Natural Resources and Environmental Conservation
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
PCCD	Pollution Control and Cleansing Department
PPP	Public-Private Partnership
PVC	Polyvinyl Chloride
R	Reservoir
RC	Reinforced Concrete
S/R	Service Reservoir
SCADA	Supervisory Control And Data Acquisition
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SHM	Stakeholder Meeting
SS	Suspended Solids
STF	Sludge Treatment facility
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
WTF	Wastewater Treatment Facility
YCDC	Yangon City Development Committee
YRG	Yangon Regional Government

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Yangon City, the former capital city of the Republic of the Union of Myanmar, consists of 33 townships with a population of 5.21 million in 2014. The city is the economic center of the country. A volume of sewerage generation (human waste water, domestic waste water and industrial waste water) in the whole city was estimated to be 500,000 m^3 approximately as of 2011. The Central Business District, hereinafter referred to as CBD area, has a quarter million of people and generates about 55,000 m^3/day of sewage.

Currently the existing sewerage service area is limited within the CBD consisting of six townships out of 33 townships In British colonial era, the existing sewerage pipes for collection and disposal of human waste had been firstly constructed downtown in the 1880s, 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 2005 with a design capacity of 14,775 m^3/day. This existing sewerage service area is called the C1 area in the Study.

However, the sewerage service area has not been expanded yet. In addition, the existing sewerage pipes suffer from the problems such as water leakage due to the deteriorated old pipes, and failures of pressure pumps frequently identified. Therefore, the sewage influent volume to the wastewater treatment plant is currently 630 m^3/day, which is only about 4% of the design capacity of the existing wastewater treatment plant . In remaining 27 townships, 80% of human waste (black water) is treated by septic tanks and 15% is discharged to the existing storm water drainage pipes without any treatment. As domestic wastewater (grey water) and industrial wastewater are also discharged to storm water drainage pipes, water quality of rivers and lakes in the city has consequently deteriorated. Moreover, during the rainy season, the overflow of floodwaters including human waste from storm water drainages makes the sanitary condition worsened. In addition, the water supply system in the CBD will be developed (water supply amount upto 86,000 m^3/day) in the Greater Yangon Water Supply Improvement Project (Phase II) (Yen loan, Loan agreement signed in 2017) financed by the Japanese official development assistance (ODA) with the loan agreement (L/A) dated January 2017. The supply area will be expanded and water supply will improve thus accordingly, sewage volume will also be increased. The current situation of wastewater treatment not only brings forth deteriorating living conditions but also involves potential health risks.

Under the circumstances mentioned above, the development of sewerage systems in Yangon City is urgently required for the improvement of the level of sewerage services and living conditions.

In the past, the Japan International Cooperation Agency (JICA) implemented the development plan titled “Preparatory Survey for the Improvement of Water Supply, Sewerage and Drainage

System in Yangon City" in March 2014 (hereinafter called as "JICA MP 2014"). The study was conducted to prepare a sewerage system development plan targeting the year 2040.

Based on the JICA MP 2014, the Yangon Regional Government (YRG) requested JICA to conduct this data collection study for sewerage system development in Yangon City (hereinafter referred to as the "Study").

1.2 Objectives of the Study

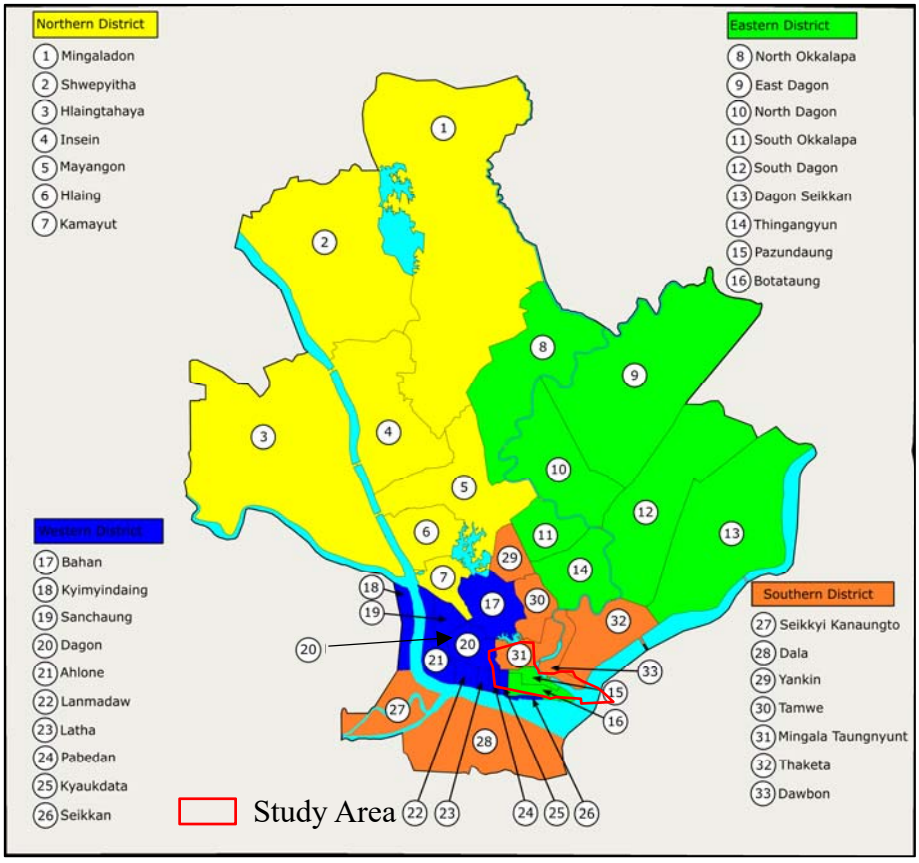
The objectives of the Study is to conduct the preparation of the project for development of the sewerage system in the priority area in Yangon City by the Japanese ODA in order to contribute to economic development and to improvement of living environment of the city.

In the process of the Study, results of the following project studies under the Japanese assistance conducted in the past are referred.

- Project for the Strategic Urban Development Plan of the Greater Yangon, (JICA, 2013)
- Preparatory Survey for the Improvement of Water Supply, Sewerage, and Drainage System in Yangon City (JICA, 2014)
- Study on the Improvement of Wastewater Treatment in Yangon City (Ministry of Economy, Trade and Industry, Japan (METI), 2017)
- Study on Development of Sewerage System in in Yangon City (Ministry of Land Infrastructure, Transport and Tourism, Japan (MLIT), 2017)

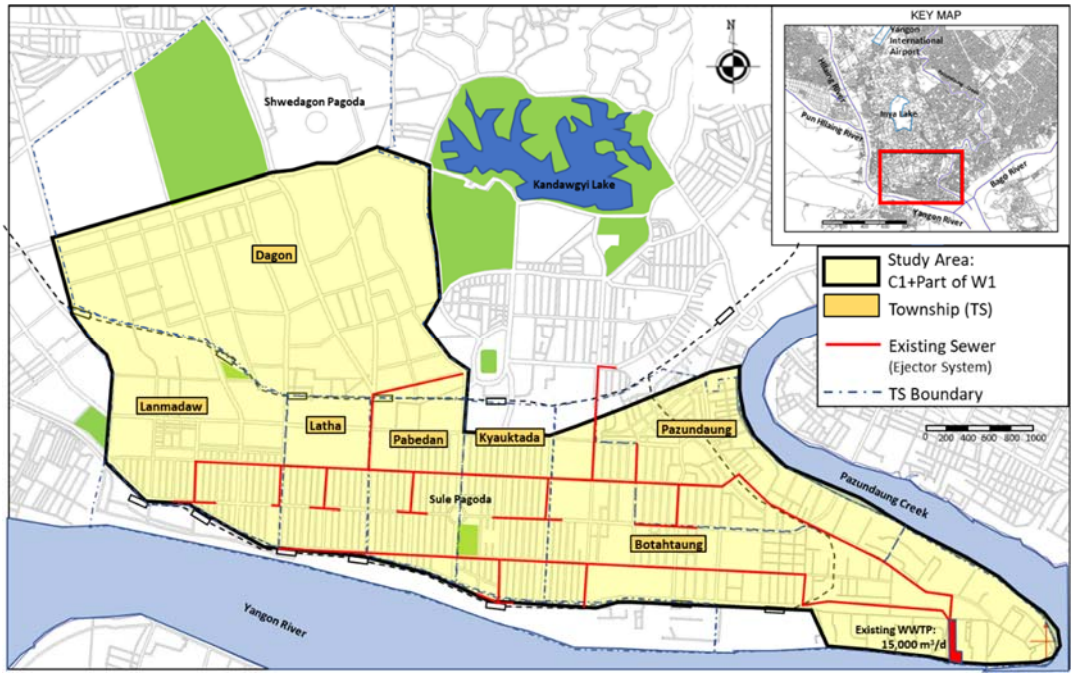
1.3 Study Area

Figure 1.3.1 shows the location of the study area in Yangon City. The study area targeted is C1 area plus part of W1 area (part of Dagon Township) of Yangon City including six townships within the city. Pazundaung, Botahtaung, Kyauktada, Pabedan, Latha, Lanmadaw, and Dagon as shown in Figure 1.3.2 where are the first prioritized to develop the sewerage system agreed with the Yangon City Development Committee (YCDC) before the commencement of the Study.



Source: JICA Study Team

Figure 1.3.1 Location of the Study Area in Yangon City



Source: JICA Study Team

Figure 1.3.2 Study Area

1.4 Target Year

The target year for the Study is set as 2040 based on the master plan.

CHAPTER 2 OUTLINE OF THE STUDY AREA

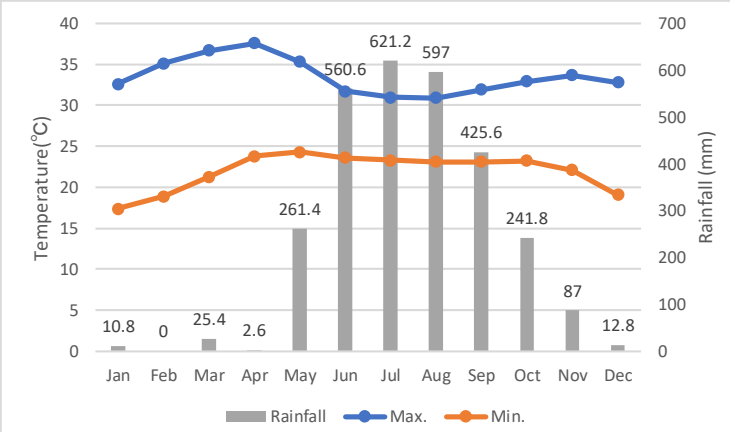
2.1 Natural and Physical Conditions

2.1.1 Climate

Yangon has a tropical monsoon climate which consists of three seasons as listed below.

- Summar seaon: From March to middle of May
- Rainy season: From Middle of May to October
- Dry season: From October to Feburary

It has an annual rainfall of 2,840 mm, an average temperature of 27.4 ºC, a maximum mean temperature of 37.6 ºC, and minimum mean temperature of 17.4 ºC as shown in Figure 2.1.1. The difference between the monthly maximum and monthly minimum temperatures is around 15 degrees from December to April and around 10 degrees from June to August. About 95% of the total annual rainfall occurs during the rainy season from May to October.



Source: YCDC

1) Temperature:

-Data 2011-2017 Meteorology and Hydrology Department, Kaba-aye Station, Yangon

2) Rainfall:

- Data 2010-2014: Data Collection Survey Report for Improvement of Navigation Channel of Yangon Port, 2016, JICA
- Data 2015-2017: Meteorology and Hydrology Department, Kaba-aye Station, Yangon

Figure 2.1.1 Climate Condition in Yangon City

2.1.2 Hydrology

(1) River

Yangon City lies at the confluence of the Bago River and the Hlaing River. The two rivers downstream of the confluence is called the Yangon River, which is connected to the Gulf of Mottama. The Pan Hlaing River and Twantay Canal, which converge and flow downstream the Yangon River, as well as the Kokkowa River, which connects to the Hlaing River, all obtain its water from the Ayeyarwady River.

(2) Tides

The rivers in Yangon City are all tidal rivers. Table 2.1.1 shows available tidal information taken from the Myanmar Port Authority (MPA).

Table 2.1.1 Tidal Information in Yangon Port 2018

Items	Tidal Height (m)	Date Observed
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: Myanmar Port Authority (MPA)

(3) Setting Water Level at Discharge Point of WWTP

The water level above is used for the river and different from the ground BM. Regarding the difference with the ground B.M., it is confirmed from "Myanmar Port Authority Tide Table 2018" as described in the table below.

Table 2.1.2 Chart Datum Level and Ground Elevation

Items	Elephant Point	Monkey Point (Close to Sule Pagoda)
Chart Datum Level (CDL)	+0.00 m	N/A
Ground Elevation at Benchmark (BM)	CDL+2.979 m	CDL+2.814 m

Source: Myanmar Port Authority Tide Table 2018

The above mentioned CDL can be converted to BM, and it is appropriate to set HWL of the water level of Yangon River to which the treated water is discharged to +3.950 m based on the abovementioned basis.

The survey results of the current ground level of the sewage treatment plant is +4.3 m to +4.7 m and this can be considered as appropriate since inundation to the facility site can be prevented with this water level.

2.2 Site Conditions

2.2.1 Administrative Boundary (Township)

The administrative boundaries of YCDC have been gradually expanding, incorporating urbanizing townships in the peripheral area, and 33 townships are included in the YCDC area as of 2018. In the future, parts of the other six townships surrounding the Yangon City might be incorporated with the YCDC administrative area, but at present, it is under the administration of the Yangon Regional Government (YRG).

2.2.2 Population Projection

Population projection has been updated in the Data Collection Survey for the Project for Updating the Strategic Urban Development Plan of the Greater Yangon by JICA in 2017 from the project Preparatory Survey on the Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City, which was formulated by JICA in 2014. It is observed that population growth in the CBD area is not estimated, and the current population in 2017 will be kept until 2040. However, the population in Dagon Township will increase with an average yearly increasing ratio of 3.2%.

Table 2.2.1 Population Projection for the Study Area in 2040

Township	Area (ha)	2017	2020	2025	2030	2035	2040
Latha	61	25,057	25,057	25,057	25,057	25,057	25,057
Lanmadaw	131	47,160	47,160	47,160	47,160	47,160	47,160
Pabedan	62	33,336	33,336	33,336	33,336	33,336	33,336
Kyauktada	70	29,853	29,853	29,853	29,853	29,853	29,853
Botahtaung	260	40,995	40,995	40,995	40,995	40,995	40,995
Pazundaung	107	48,455	48,455	48,455	48,455	48,455	48,455
Dagon	299	28,222	30,999	36,325	41,651	45,201	48,751
Total	990	253,078	255,855	261,181	266,507	270,057	273,607

Source: JICA Study Team based on the Data Collection Survey for the Project for Updating the Strategic Urban Development Plan of the Greater Yangon by JICA in 2017

2.3 Standards for Sewerage Works in Yangon City

2.3.1 Standard for Effluent Water Quality

(1) YCDC Effluent Water Quality

In Myanmar, the Environmental Conservation Department (ECD) of the Ministry of Environmental Conservation and Forestry (MOECAF) has developed the Environmental Impact Assessment Law, the Environmental Preservation Law, and the effluent water quality guideline since 2012 with the support of the Asian Development Bank (ADB). The Environmental Preservation Law and the Environmental Preservation regulations were formulated in 2012 and 2014, respectively, and the guideline for environmental standards and effluent standards for the whole country was established in 2015.

While the guideline for environmental standards and effluent standards for the whole country was established, the Pollution Control and Cleaning Department (PCCD) of YCDC has set out the effluent standard for public waters, which is practically applied to the areas under control of YCDC. (Refer to Table 2.3.1)

Table 2.3.1 YCDC Standard for Effluent Water Quality

Parameter	Standard Value
pH	6~9
BOD	Less than 60 mg/L
COD_{Cr}	Less than 200 mg/L
TSS	Less than 2,000 mg/L
SS	Less than 500 mg/L

Source: YCDC

The YCDC Water and Sanitation Department requires properties in the YCDC areas to install a septic tank or equivalent, setting the standard for sewer discharged from nine-storey buildings or higher (excluding industrial buildings such as a factory or a plant). (Refer to Table 2.3.2)

The treated wastewater is discharged to public waters in the area where the sewage treatment system has not yet been improved, while it is instructed that the treated wastewater can be released to either a sewer or public waters in the area where the sewage treatment system has been improved.

The YCDC Water and Sanitation Department provides guidance for improvement when the effluent quality exceeds the standard, and in some cases, it requests operators to transport the sludge to a sewage treatment plant using a vacuum truck at the operators' cost as part of the improvement steps. They seem to be selectively monitoring the CBD and the areas around Lake Kandawgyi and Lake Inya.

Table 2.3.2 YCDC Standard for Effluent to Sewer

Parameter	Standard Value
BOD	Less than 20 mg/L
COD_{Cr}	Less than 60 mg/L
SS	Less than 30 mg/L

Source: YCDC

Note: Applies only to buildings with more than nine stories

(2) CQHP Effluent Standard for Treated Raw Sewage (Black Water)

As for the four to eight-storey buildings, YCDC is guided to treat only raw sewage (black water) in a septic tank and to set the guideline parameters for the biochemical oxygen demand (BOD) of 200 to 250 mg/L for discharging to a sewer. However, it is not strictly implemented.

In the CQHP guideline (sanitation) created by the Committee for Quality Control of High-rise Building Construction Projects (CQHP), the effluent standard for raw sewage (black water) is defined as indicated below. Appendix 14 shows the CQHP guideline. This standard is less restrictive than the YCDC standards (Table 2.3.3).

Table 2.3.3 CQHP Effluent Standard for Raw Sewage (Black Water)

Parameter	Standard for Discharge to Public Water	YCDC Standard for Discharge to Sewer
BOD	Less than 50 mg/L	Less than 150 mg/L
COD_{Cr}	Less than 100 mg/L	Less than 200 mg/L
SS	Less than 50 mg/L	Less than 150 mg/L

Source: Guidelines for high-rise building construction projects (water supply and sanitation), CQHP

CHAPTER 3 INSTITUTIONAL ASPECTS RELATED TO WATER AND SEWERAGE SECTOR

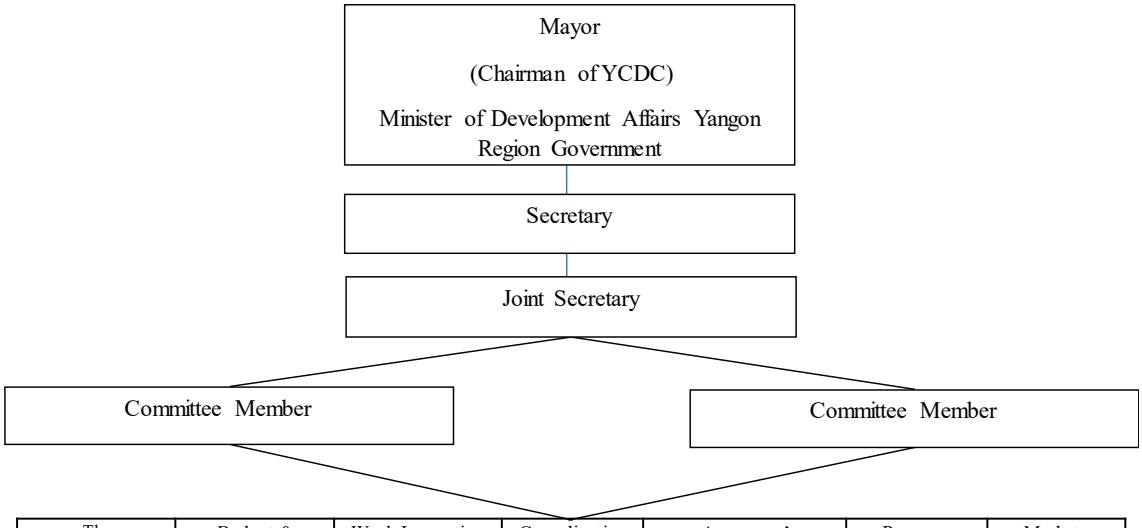
3.1 Yangon City Development Committee (YCDC)

YCDC was established in accordance with the City of Yangon Development Law with the aim of self-motivated promotion of development of Yangon City. A similar law has been introduced to the second largest city, Mandalay, and the capital, Naypyidaw. The City of Yangon Development Law authorizes YCDC to execute their own projects with self-financing. However, it does not necessarily mean that the authority can be fully exercised since regulatory approval from the regional government is required for such projects, and the objectives and contents of the projects need to match with the administrative activities planned in the national budgetary framework.

The organization of YCDC is shown in Figure 3.1.1. With the Mayor as the head of YCDC (serving concurrently as the minister of development of the regional government), there are the positions of secretary and joint secretary under the head. The committee consists of the mayor, the secretary, the joint secretary, and two committee members.

The water, sewage, sanitation, and rainwater drainage works for 33 out of 45 townships in the area under the jurisdiction of YRG are included in the roles of YCDC. The law defines the responsibilities to create plans, execute, and manage these water-related works. The Water and Sanitation Department is the responsible party for water/sewage and sanitation works, and it is the role of the Roads and Bridges Department to control the rainwater drainage works.

Although the individual budget for YCDC is reserved, it is included in the budget of the YRG, and the decision-making regarding budgeting requires approval from the regional government and the federal government. YCDC does not receive any subsidy from the regional government and the federal government, and its operating expenditures are fully born by its own financial sources. It is operated with revenues from the services and taxes in Yangon City. More specifically, it gains income from the tolls of roads and bridges, parking fees, real estate development business with private companies, water service, waste disposal, real estate tax, and stamp tax. However, these revenues (including income from the water services) are included in the budget of the YRG, and these cannot be used at the discretion of YCDC.



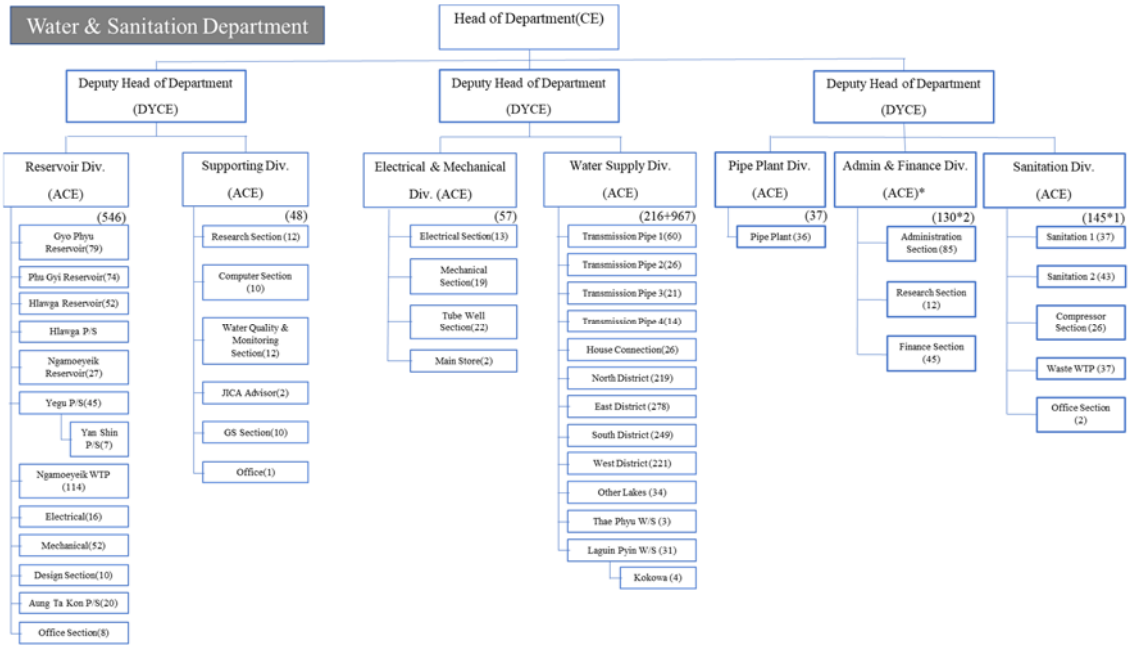
The Administration Department	Budget & Accounts Department	Work Inspection Department	Co-ordination Department	Assessors' Department	Revenue Department	Markets Department
Veterinary & Slaughter House Department	Pollution Control & Cleansing Department	Engineering Department (Roads &Bridges)	Engineering Department (Buildings)	Engineering Department (Water & Sanitation)	Motor Transport & Workshop Department	Central Stores Department
Playgrounds, Parks & Gardens Department	Security & Disciplinary Department	City Planning and Land Administration Department	Health Department	Public Relations and Information Department	Production Department	Committee Office

Source: YCDC

Figure 3.1.1 Organization of YCDC

3.2 Water and Sanitation Department in YCDC

The organizational chart of the Water and Sanitation Department is shown in Figure 3.2.1. It is comprised of one head of the department and three deputy heads of the department, and under which there are seven divisions. The total number of staff members is 2,152 as of December 2017. Currently, they are considering reorganization with the support of the ongoing Japan International Cooperation Agency (JICA) technical cooperation project The Project for Improvement of Water Supply Management of Yangon City Development Committee (YCDC).



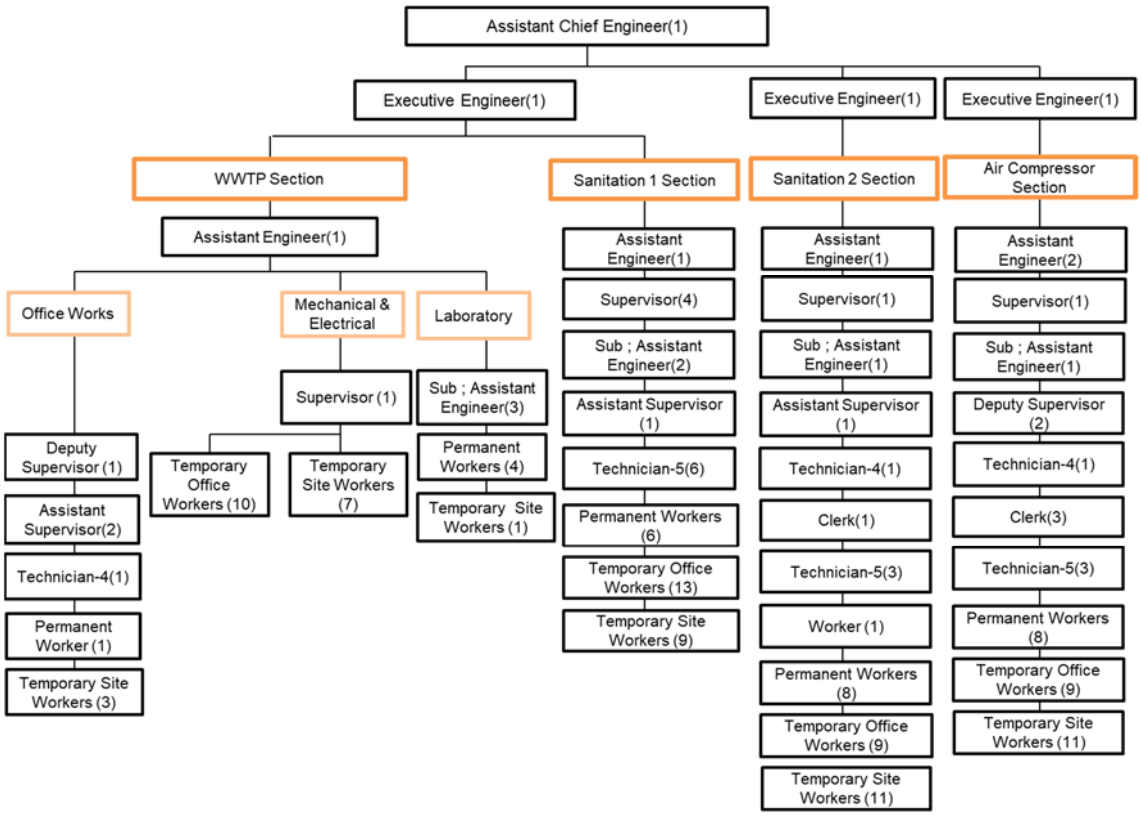
Source: YCDC

Figure 3.2.1 Organization of YCDC Water and Sanitation Department

The organizational chart of the Sanitation Division is shown in Figure 3.2.2. The party in-charge of sewers and sewage treatment in YCDC is the sanitation division, which has 145 staff members, and its main responsibilities are as follows:

1) Cleaning of sewers
2) Operation and maintenance of compressors, ejectors, and sewage treatment plants
3) Creation of expansion plan for sewer pipes and operation plan
4) Radical improvement of sewage treatment system
5) Purchase of facilities, equipment, and modern machinery

According to YCDC, it was scheduled that a new organization structure would be established in April 2018. However, the schedule is still tentative since the detailed structure is still being considered by YRG.



Source: YCDC

Figure 3.2.2 Organization of Sanitation Division in YCDC Water and Sanitation Department

3.3 Road and Bridge Department in YCDC

While the drainage sector is closely related to the Water and Sanitation Department of YCDC, the sector actually belongs to the Road and Bridge Department.

The improvement work of the back drainage space (BDS), which mainly aims to improve the surface pavement of BDS, is being conducted by the Administration Department.

According to the information from YCDC, the Sanitation Division of the Water and Sanitation Department and the Drainage sector of the Road and Bridge Department will be merged into one department in the near future.

CHAPTER 4 CURRENT CONDITION OF SEWERAGE AND SANITATION SYSTEM IN THE STUDY AREA

4.1 Outline of Current Sewerage System and Sanitation System

4.1.1 Current Condition of Sewerage Systems

(1) Existing Ejector System

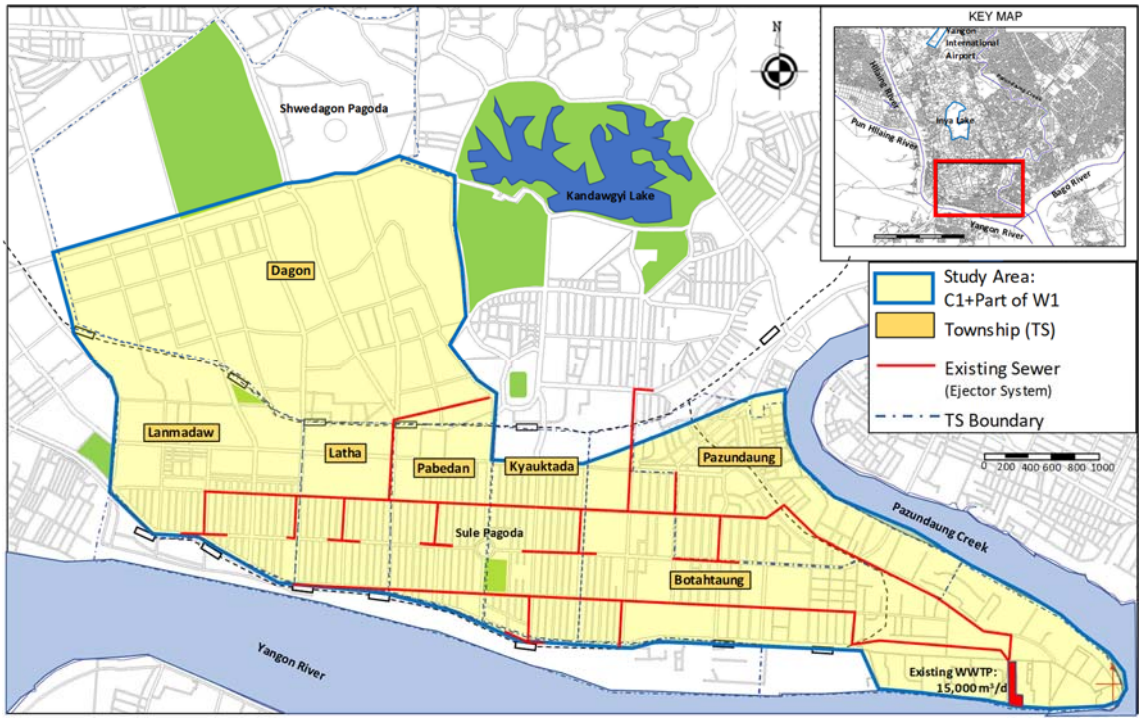
The existing sewerage system in Yangon City is an ejector system introduced in 1888 under the British sovereignty. It collects wastewater (i.e., only raw sewage) coming from eight townships which are in the central business district (CBD). Miscellaneous wastewater is discharged to the Yangon River without treatment through the storm water drains.

This system is unique in that wastewater is conveyed by the air pressure from an ejector station (ES) to one of the two sewage ejector pipes running east and west. Initially, 40 ESs were installed in the treatment zone, and 35 of those are currently in service. This system has been used for 120 years by continuously making improvements and modifications. Table 4.1.1 describes the outline of the existing system, and Figure 4.1.1 shows the ejector system.

Table 4.1.1 Existing Sewerage System in the CBD Area

Item	Description
Completion	1888
Planned population	40,000 persons
Planned service area	8 townships Lanmadaw, Latha ,Panbedan, Kyauktada, Botadaung, Puzondaung(part), Dagon (part), Mingalataungnyunt (part)
Contractor	Hughes & Lancaster
Manufacturer	Shone Hydro-Pneumatic Ejector
Construction cost	INR 2.3 million (loan from the Indian Government)
Length of force main	North: 5.55 km, South: 5.03 km, Total: 10.58 km
Diameter of force main	North: 300 to ~1,200 mm, South: 300 to ~600 mm
Material of force main	Cast iron
Number of ejector stations	40 stations; out of which, 35 are currently in operation
Number of manholes	2,114

Source: JICA Study Team based on Information from YCDC



Source: JICA Study Team

Figure 4.1.1 Ejector System in the CBD Area

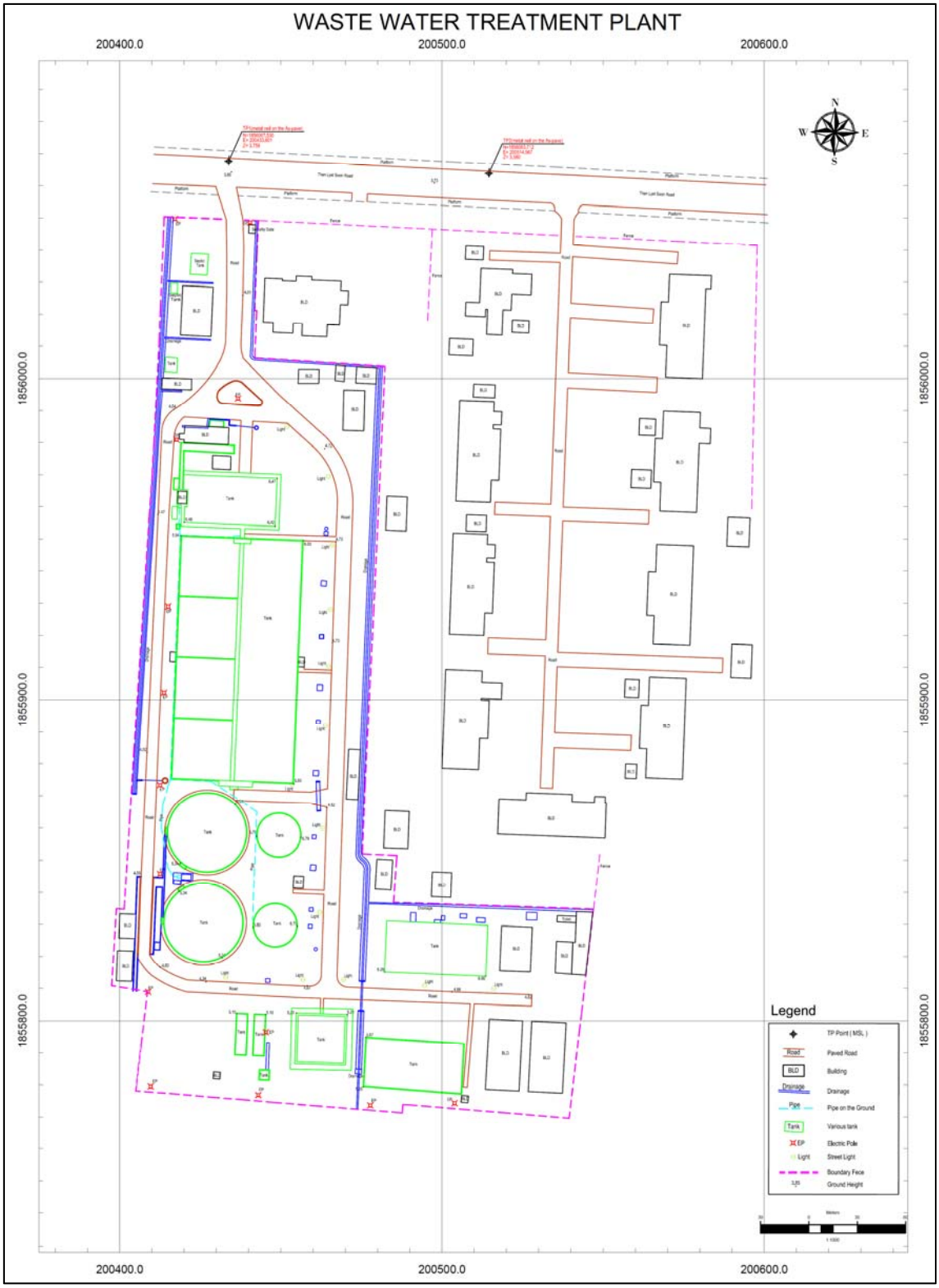
(2) Existing Wastewater Treatment Plant (WWTP)

The design served population is 300,000 people. Since only raw sewage is collected, the sewage quantity per person/day is 50 litters, and the design treatment capacity of the WWTP is 15,000 m^3/day (maximum daily capacity). Long-term aeration method is used for sewage treatment, and effluent is discharged to the Yangon River. Air-drying (sun-drying) after gravity thickening is used for sludge treatment. The plant receives 150 m^3/day of septage from households as well. This septage is thrown into equalization tank. Supernatant liquid and solid are respectively transported to grit chamber and drying bed. Table 4.1.2 describes the outline of the sewage treatment plant, and Figure 4.1.2 shows the layout of the sewage treatment plant.

Table 4.1.2 Outline of Wastewater Treatment Plant

Items	Description
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 (3.25 MGD)
Construction cost	USD 1.96 million（MMK 2,065.7 M）
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: JICA Study Team based on the information from YCDC



Source: JICA Study Team

Figure 4.1.2 Existing Wastewater Treatment Plant (C1 WWTP)

(3) Septic Tank

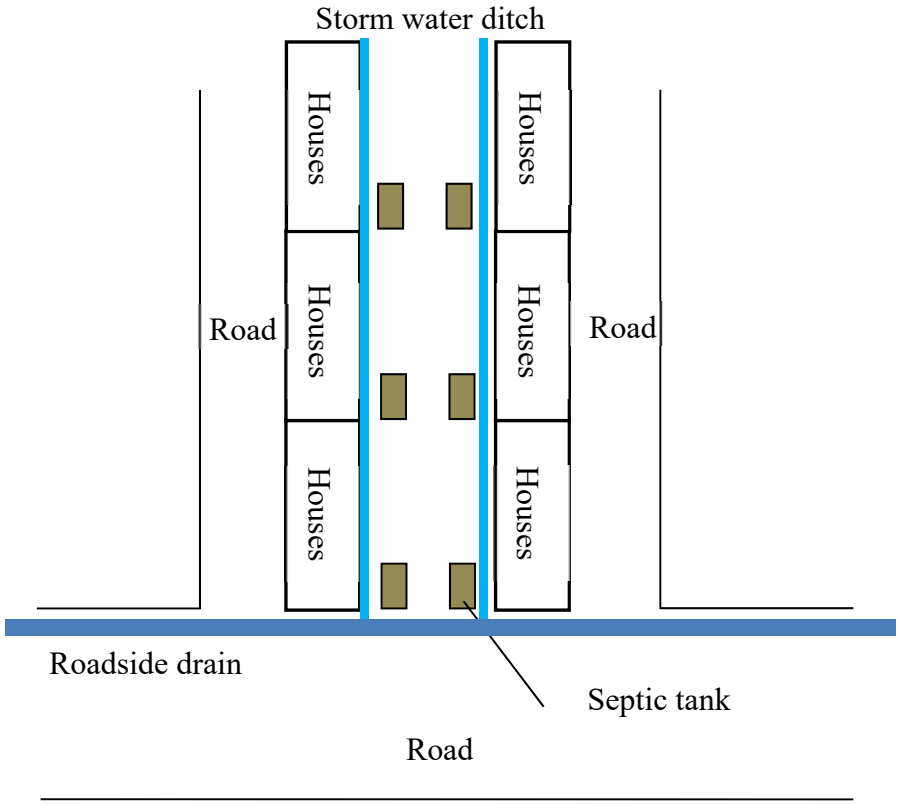
YCDC prescribes a utilization of septic tank system as a wastewater treatment except for the catchment area where wastewater collection system is available. The septic tank treats only toilet wastewater (black water), while grey water from kitchen, laundry, and so on is discharged directly to storm water drains without treatment. The owner of a house or a building requires to submit an application to the Sanitation Division, Engineering Department of Water and Sanitation (EDWS) and must obtain a permission before the construction. YCDC has the authority to approve applications for up to 8-story buildings. In case of high buildings with more than 9-story, approval from the Committee for Quality Control of High-Rise Building under the Ministry of Construction is required. A type of septic tank to be installed is depending on the story of the house or the building as below.

- Up to three-storey: soak pit type
- More than four-storey: up-flow filter type

The CBD covered by the existing sewerage system is prohibited to be installed septic tank. However, the large-scale building, e.g. hotel and shopping mall, has its own septic tank due to lack of the capacity of the existing sewerage system.

In the CBD and the Inner Urban Ring areas, back drainage space (BDS) is mostly provided in the backyard of buildings. BDS is classified into two types: 1) sewer for collection of black water exists and it is connected to the existing sewerage system, and 2) septic tank is installed. The BDS is not only space, it includes storm water drains, buried pipe and pavement in the space. The width of the 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. The typical arrangement of septic tanks in the BDS is shown in Figure 4.1.3. Usually, storm water drains with a width of 1.0 to 1.5 ft (30 to 45 cm) are provided on both sides or center of the BDS into which storm water is discharged. YCDC owns the BDS and bear O&M cost for the BDS. The building owner should pay the construction cost of the septic tank.

For detached houses, gray water together with storm water is discharged through small drains in the building owner's property (mostly open drain made of brick structure, rarely pipes) to roadside drains. The septic tank is installed in the area where the BDS does not exist and the existing sewerage system does not cover in the CBD.



Source: JICA Study Team

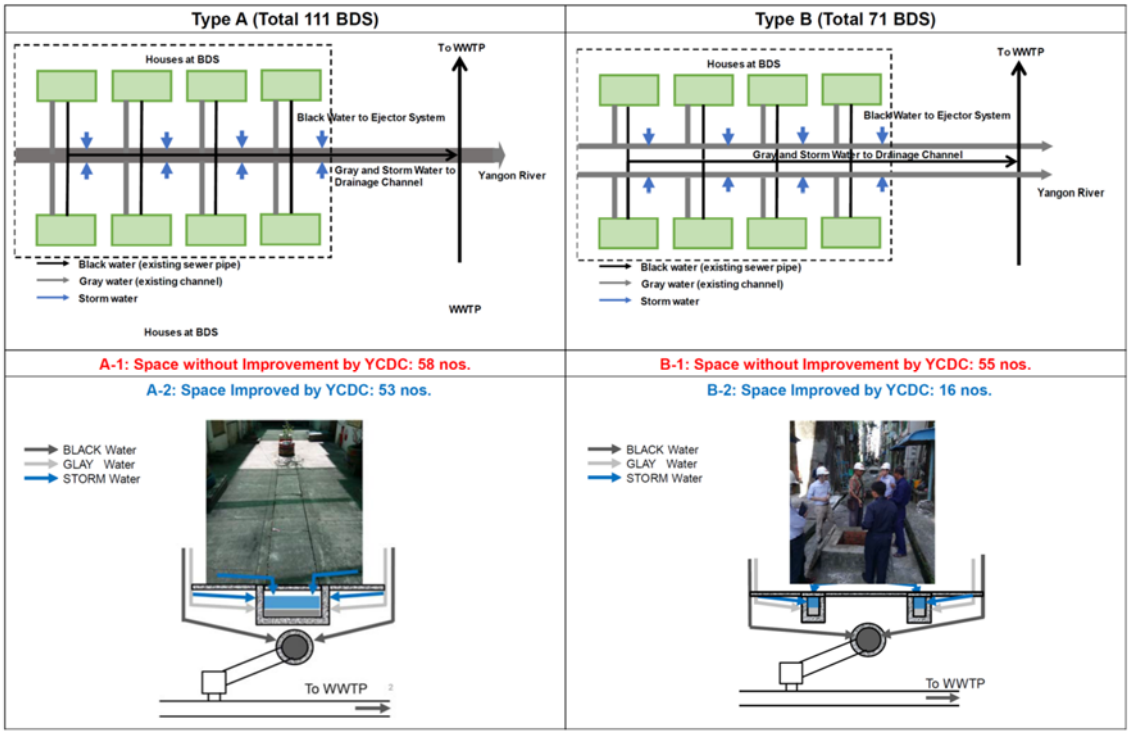
Figure 4.1.3 Typical Layout of Septic Tanks in BDS Area

In Yangon City, the Department of Motor Transportation Workshop collects septage in septic tanks upon request of the household owner and transports the collected septage to the existing WWTP. Frequency of the septage collection service is once or twice a year in each household. The department has 45 operational vacuum trucks (1,200 gallons: 10 trucks, 800 gallons: 20 trucks, 400 gallons: 15 trucks), and 6 trucks are damaged and out of service. There was a total of 23,133 collection times in 2017 (Jan. 2017 to Dec. 2017) according to the department.

(4) Type of BDS in the CBD

There is no BDS that has the septic tanks in the CBD. The BDS is classified into two types: 1) one drainage channel exists at the center, and 2) drainage channels exist at both sides, as shown below.

Table 4.1.3 Type of BDS



Source: JICA Study Team

At present, YCDC is conducting the improvement work of the BDS in the manner of additional concrete pavement on the existing one. It means that no improvement work for the drainage, sewer, etc. is carried out.

4.1.2 Disposal for Generated Sludge after Wastewater Treatment

The amount of sludge produced from wastewater treatment has not been recorded by YCDC. The amount is not big because only the drying bed has been operated among the sludge treatment facilities. Currently, sludge is dried at the drying bed, and a portion of the dried sludge is irregularly used for some purposes such as fertilizer for street plants outside of the WWTP.

4.2 Issues on Current Sewerage and Sanitation Works

4.2.1 Wastewater Treatment Plant (WWTP)

The following issues on the existing WWTP have been observed through site surveys and interviews with YCDC:

- Unexpected inflow of septage at the preparation of design for the existing WWTP and operation of the ejectors have affected the operation and management of the C1 wastewater treatment plant causing huge load fluctuation.
- Septage, which was not expected at the time of planning, has been dumped by a vacuum truck, and the load has significantly exceeded the planned load of wastewater inflow. As a result, some untreated wastewater is being discharged into the public water body and affects

the environmental condition.

- Wastewater inflow depends on the operation of the ejectors (only daytime), and the inflow of septage takes place only during daytime, which causes the big fluctuation of the load onto the treatment plant.
- For sludge treatment, the thickener tank, the aerobic digestion tank, and the belt press type dehydrator have been out of service. As a result, the sludge cannot be removed from the final sedimentation tank, and the MLSS concentration in the reactor tank has been very high.

4.2.2 Sewerage System (Sewer and Ejector System)

The following issues on the existing sewer system (pipe network system) have been observed through site surveys and interviews with YCDC:

- The inflow to the sewage treatment plant is around 4% or less of the design wastewater flow, which is extremely low because of following reasons:
  1) The large-scale building, e.g. hotel and shopping mall, has its own septic tank and does not connect to the existing sewerage system even in the CBD covered by the system.
  2) Sewage is discharged to the ditch due to misconnection in the BDS
  3) Clogging of the existing sewer reduces the flow area

  According to YCDC, there was an accident due to the bursting of the force main at Marchant Road in 2014, and it was repaired after digging out the road.
- Since the existing sewers are used only for collecting black water, grey water is discharged without treatment, and the environment in the city gets deteriorated consequently.
- The ejector system has been deteriorating since the operation started from March 1890, and necessary spare parts for repair are not available. So, special orders for the spare parts have been placed to a local company.
- According to YCDC, out of the 40 ejector stations, 2 have become unnecessary, 3 were broken and replaced with another system, and 35 are operating. Even the ejector stations in service frequently fail due to the inflow of plastics or rubber products.
- Also, the air tube, which sends pressure from the compressor station to each ejector station, has deteriorated, and an individual small-sized air compressor has been newly installed at 7 ejector stations.

4.2.3 Disposal for Generated Sludge after Wastewater Treatment

(1) Necessity of disposal site

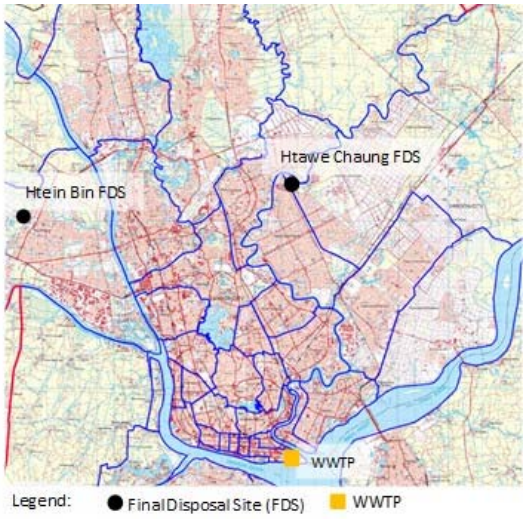
The EDWS envisages that they would, as much as possible, utilize sludge generated from the new WWTP enhanced by the project instead of simply disposing of it as solid waste. The amount of dried sludge generated from the new WWTP is preliminarily estimated at about 46 t/day (moisture content: 35%) in its full operation years, which is equivalent to more than 60 times the volume utilized in 2006. While the JICA Study Team respects their idea, it's much difficult to utilize sludge effectively because the estimated amount of sludge utilized decreased sharply after 2007.

Therefore, it is necessary to find and secure such facility to prepare for sludge generation in the future since EDWS has not disposed of the sludge of the WWTP to the disposal facility.

(2) Possible site for sludge disposal

Currently, solid waste generated in the target area is transported and disposed of into the existing final disposal sites (FDSs). YCDC operates two FDSs, namely Htein Bin FDS, located in Hlaingthaya Township, and Htawe Chaung FDS, located in East Dagon Township. Htein Bin FDS has been operating for 17 years since 2002. The location and the existing conditions of both FDSs are shown in Figure 4.2.1 and Figure 4.2.2. Disposal of the sludge from WWTP to FDS is practiced and commonly observed in other countries.

It is said, and it is obvious that Htawe Chaung FDS is already full and should be closed soon. The piled solid waste forms a hill, even in Htein Bin FDS. The remaining area of the Htein Bin FDS is estimated to be about 60 ha against 120 ha of the total area. According to PCCD, more than 800 tons of solid waste is being hauled and disposed of at the FDS every day, while the amount of solid waste generation in Yangon increases in accordance with the city development.



Source: YCDC

Figure 4.2.1 Location of Studied Final Disposal Site

(Htein Bin FDS)

(Htawe Chaung FDS)

Source: JICA Study Team

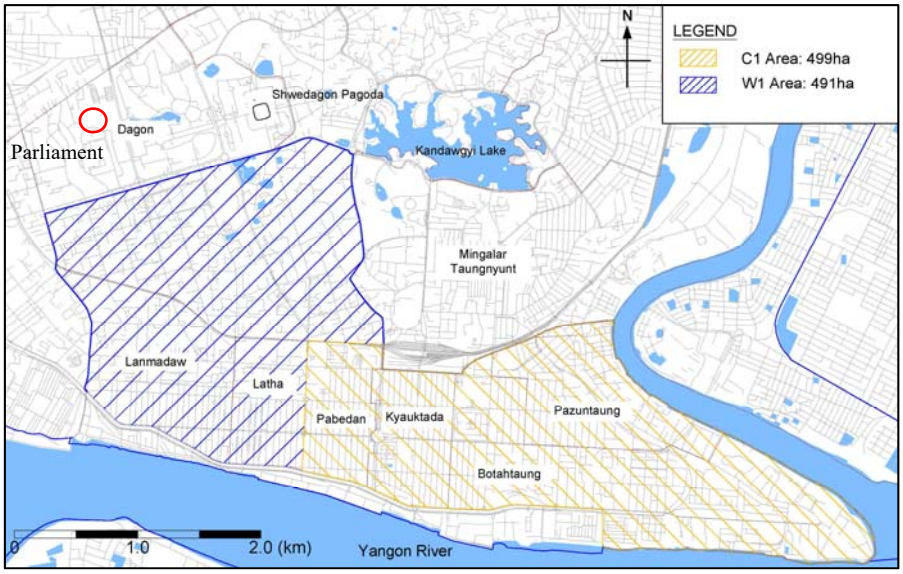
Figure 4.2.2 Conditions of the Existing Final Disposal Sites in Yangon City

CHAPTER 5 DEVELOPMENT POLICIES FOR SEWERAGE SYSTEMS

5.1 Sewerage Collection System

5.1.1 Catchment Boundary for the Study

The JICA MP 2014 defined the catchment boundary for C1 and W1. However, at the beginning of the Study, the C1 Wastewater Treatment Plant (WWTP) was planned to treat wastewater from part of W1 in order to maximize the capacity of the C1 WWTP within the available land for the plant. This was desirable due to the scarcity of available land for the W2 WWTP. The net result was that wastewater from a portion of the W1 area, namely Latha Township, Lanmadaw Township and the southern part of Dagon Township, is to be conveyed to the C1 WWTP. The boundary of C1 and part of W1 is shown in Figure 5.1.1. Therefore, the C1 and part of W1 catchment has been updated with an area of 990 ha.



Source: JICA Study Team

Figure 5.1.1 Boundary of C1 and Part of W1

5.1.2 Type of Sewage Collection System and Characteristics

(1) Comparison of Sewer System

The wastewater collection method is selected after consideration of pros and cons, taking into account the features of both the combined sewer and the separated sewer. As a result of the discussion with YCDC, it was decided that a separated system shall be applied for the Project since it is not desirable for a combined system to discharge wastewater to Yangon River even if it is diluted with storm water.

(2) Sewage conveyance to WWTP

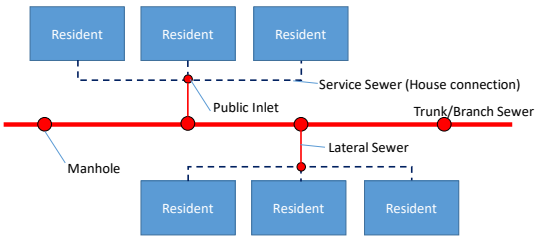
Generally, a sewage conveyance system to a WWTP has either gravity flow or pressure flow. Gravity flow is normally selected for a sewerage plan from the viewpoint of operation and maintenance cost. However, the selection of a sewage transportation system shall also consider the topographic condition of the catchment.

The ground elevation of the CBD is almost flat, and the existing sewer is applied for pressure flow. However, the ground elevation of Dagon, which is located upstream of the CBD, declines toward the CBD area. In addition, it was observed that a pumping station was not required in the middle in case gravity flow is applied because the deepest earth covering was identified as around 14 m at the pumping station in the WWTP. Therefore, it can be said clearly that operation and maintenance are much easier in gravity flow than in pressure flow. Considering the above, gravity flow will be applicable for the sewer system in the CBD and in Dagon, in accordance with the theory.

5.1.3 House Connection in Target Area

A house connection shall be considered separately whether the back drainage space (BDS) is currently available or not since BDS has already been equipped with a sewer, storm water pipe, and grey water pipe from each residence in the apartment building, although grey water and storm water are finally mixed and collected by the ditch. Therefore, for the improvement and new installation of a house connection in the Project, the house connection method shall be different to suit the current available facilities, taking into consideration the construction cost and implementation period.

House owners are obliged normally to connect with the sewage collection system individually through their own service pipe connecting a public inlet in adjacent to the border between public and private. The public sector should provide the public inlet and lateral sewer for collecting sewage into the trunk/branch sewer.



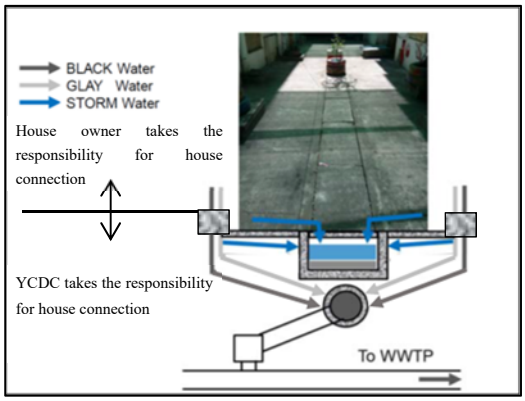
Source: JICA Study Team

Figure 5.1.2 House Connection

A steady implementation of house connection is essential issue because project effectiveness of the sewerage development will not be obtained until sewage reaches the WWTP by the house connections. Therefore, prior to the implementation of the Project, YCDC is required to implement the house connections by making it obligatory, formulating the legal system relating to the sewerage and operating these systems properly.

1) CBD with BDS

House owners currently bear the installation cost of the pipes from the apartment building to the public inlet on the surface of the ground. On the other hand, YCDC bear the installation cost for the inlet and required facilities to connect the inlet with the ejector station, i.e. buried connection pipes, BDS sewer and the manhole. In this study, each responsibility for the house connection will be the same as the current situation.



Source: JICA Study Team based on information from YCDC

Figure 5.1.3 House Connection in BDS

2) CBD with non BDS and Dagon area

House owners will install the service sewer from household to the public inlet. The public inlet and other facilities will be installed under the project as shown in Figure 5.1.2.

5.2 Sewerage System Development Plan

5.2.1 Wastewater Generation Volume

The population projection until 2040 has been updated in the 'Data Collection Survey for the Project for Updating the Strategic Urban Development Plan of the Greater Yangon' by JICA in 2017. Therefore, the updated population projection is used for the Study. To calculate wastewater volume, the water supply service ratio and the served population in each year is estimated.

Wastewater generation volume is mainly composed of domestic wastewater, commercial wastewater, industrial wastewater, and groundwater infiltration. JICA MP 2014 defined the domestic and non-domestic unit water supply consumption until 2040 which categorization was different from the above. There is no industrial park in the target area, therefore, wastewater volume is calculated based on the premise that no industrial wastewater will be generated. It leads that non-domestic wastewater volume is the same volume with commercial wastewater volume in the Study. Domestic water consumption was estimated as 150 lpcd in 2025 and 200 lpcd in 2040. Domestic and non-domestic water supply consumption were estimated with the ratio of 60:40, which is based on the current water consumption in Yangon as mentioned in Section 4.3.7, Chapter 4, Volume III of JICA MP 2014. Therefore, the domestic and non-domestic unit water supply consumption was estimated as 250 lpcd in 2025 and 333 lpcd in 2040.

No industry uses a large volume of water in the target area. Therefore, industrial wastewater volume was not considered in the Study. As for the groundwater infiltration, the Study adopted 10 m^3/ha/day as the groundwater infiltration volume which was estimate with reference to the other southeast Asian Cities defined by the JICA MP 2014.

Daily average wastewater volume was calculated equivalent to 100% of the daily average water

supply consumption plus groundwater infiltration. A peak factor of 1.1 was applied to the daily average wastewater volume to calculate the daily maximum wastewater volume. Hourly maximum wastewater volume is calculated as 1.5 times of daily maximum wastewater volume. The calculated wastewater volume in each township is shown from Table 5.2.1 to Table 5.2.3.

Table 5.2.1 Wastewater Generation Volume (Daily Average Maximum)

Unit: m^3/d

Township	2017	2020	2025	2030	2035	2040
Latha	5,222	5,952	6,869	7,565	8,261	8,957
Lanmadaw	8,568	9,818	12,157	14,411	15,721	17,031
Pabedan	6,964	7,953	8,953	9,879	10,805	11,731
Kyauktada	6,626	7,270	8,165	8,994	9,824	10,653
Botahtaung	10,820	11,621	12,851	13,989	15,128	16,267
Pazundaung	10,831	11,728	13,181	14,527	15,873	17,219
Dagon	6,023	7,018	9,260	12,134	15,287	19,245
Total	**55,056**	**61,359**	**71,437**	**81,500**	**90,898**	**101,102**

Source: JICA Study Team

Table 5.2.2 Wastewater Generation Volume (Daily Maximum)

Unit: m^3/d

Township	2017	2020	2025	2030	2035	2040
Latha	5,744	6,547	7,556	8,322	9,087	9,853
Lanmadaw	9,425	10,800	13,373	15,852	17,293	18,734
Pabedan	7,661	8,748	9,848	10,867	11,885	12,904
Kyauktada	7,289	7,996	8,982	9,894	10,806	11,718
Botahtaung	11,902	12,783	14,136	15,388	16,641	17,894
Pazundaung	11,914	12,900	14,499	15,980	17,461	18,941
Dagon	6,626	7,720	10,186	13,348	16,815	21,169
Total	**60,561**	**67,495**	**78,581**	**89,650**	**99,988**	**111,213**

Source: JICA Study Team

Table 5.2.3 Wastewater Generation Volume (Hourly Maximum)

Unit: m^3/d

Township	2017	2020	2025	2030	2035	2040
Latha	8,617	9,821	11,334	12,482	13,631	14,779
Lanmadaw	14,138	16,200	20,060	23,777	25,939	28,100
Pabedan	11,491	13,122	14,772	16,300	17,828	19,356
Kyauktada	10,933	11,995	13,472	14,841	16,209	17,577
Botahtaung	17,854	19,174	21,204	23,083	24,961	26,840
Pazundaung	17,870	19,351	21,749	23,970	26,191	28,412
Dagon	9,938	11,580	15,280	20,022	25,223	31,754
Total	**90,842**	**101,243**	**117,871**	**134,475**	**149,982**	**166,819**

Source: JICA Study Team

5.2.2 Sewerage Development Plan for 2040

The general planning conditions of the sewerage developments are summarized as follows:

a) The target year is 2040;
b) The covered area is 990 ha, including 499 ha of the C1 area and 491 ha of the Dagon Township;
c) The sewerage-served population in 2040 is 273,607 people;
d) The daily average wastewater volume is estimated at 102,000 m^3/d;
e) The daily maximum wastewater volume is estimated at 112,000 m^3/d;
f) The hourly maximum wastewater volume is estimated at 167,000 m^3/d;
g) Separated system is applied; and
h) The current ejector system including sewer pipes, the ejector station, and an air pipe should be switched to the new sewerage system after the completion of the Project.

The JICA Study Team has discussed a scenario of the development of the WWTP based on the improvement steps of the sewers and house connections. It is tentatively set in two step-wise development plans, first with the new WWTP construction followed by the upgrading of the existing WWTP because of continuous wastewater treatment service.

In consideration of Loan Agreement, procurement of consultant, detailed design, and bidding period, the timing of the commencement of construction is set to the middle of 2021. The sewerage development plan was formulated taking into account the progress of each construction work such as improvement of sewer, wastewater treatment plant, and BDS improvement.

Development plan for the installation of sewer was divided into the three area where the BDS is available in CBD, not available in CBD, and the Dagon area. In the area where the BDS is available in CBD, it was considered that it is possible to collect wastewater relatively quickly by installation of the trunk sewer by the Project since there is a certain level of sewer system available in BDS. Also, in the area without BDS in CBD and the Dagon area, it is planned to take into account the period of each house connection since stepwise house connection after installation of the trunk sewer is required.

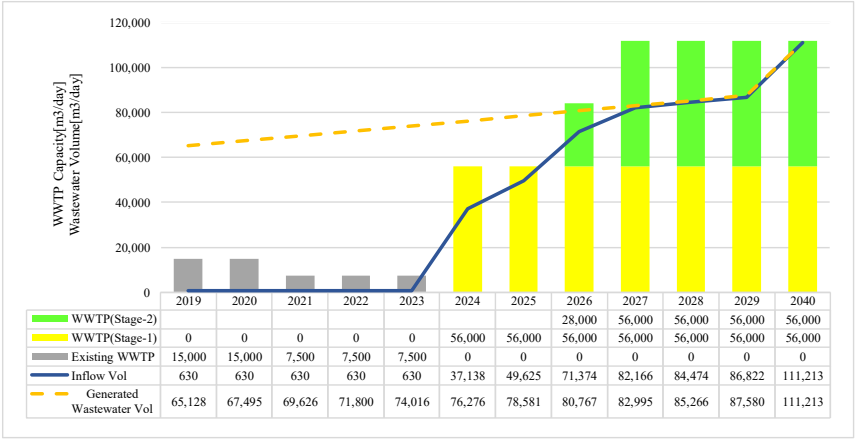
Sewage, which will be collected from the CBD area, where BDS is currently available will be conveyed and treated at the WWTP. The construction of the sewer and the WWTP with a capacity of 56,000 m^3/d will take three years. After the WWTP with the capacity of 56,000 m^3/d starts operation in 2024, sewer collection system will be replaced by new system instead of existing ejector system. To fill the gap between the generated wastewater volume and the sewage volume to be treated at the WWTP, further construction of sewers where BDS is currently not available and Dagon area, increasing the number of house connections, and expansion of the WWTP from 56,000 m^3/d to 84,000 m^3/d and 112,000 m^3/d will be required by 2026 and 2027 respectively. It should be noted that house connections in the future development areas, where no utilization takes place for the time being, have to be implemented by the house owner or the developer after 2027

in order to accomplish 100% service coverage. Sustained implementation of house connections will be required until 2040 in Dagon area because house connection ratio in 2029 will be 77%. The reason why house connection ratio in the area is lower than the other are is that the house connection will increase together with increase of the water supply coverage ratio.

The blueprint of the project implementation schedule is shown in Figure 5.2.1.

Period		Year											-	
		1	2	3	4	5	6	7	8	9	10	11	-	22
		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	-	2040
		Pre-con. Stage		Construction Stage (6years)						DNP				
CP-1 (Sewer)														
a) CBD (BDS)		Procure Consultant, D/D and BID		Pipe installation										
b) CBD (No BDS)						Pipe installation		House connection						
c) Dagon (Part of W1)				Pipe installation				House connection						
CP-2 (WWTP)														
a) WWTP (New: 56,000m^3/d x 2)		Procure Consultant, D/D and BID		56,000m^3/d (half)				56,000m^3/d (half)						
				Existing under Operation										
		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	-	2040
a) CBD (BDS)	Sewer Inst. Ratio (%)	0%	0%	17%	50%	83%	100%	100%	100%	100%	100%	100%	-	100%
	House Connection (%)	95%	97%	97%	97%	98%	98%	99%	99%	99%	100%	100%	-	100%
	Collection Vol (m^3/d)※1	630	630	630	630	630	34,289	35,185	35,997	36,812	37,633	38,458	-	46,151
	Served Pop.	109,064	110,431	110,927	111,423	111,918	112,414	112,910	113,292	113,673	114,055	114,436	-	114,436
	Total Pop.	114,436	114,436	114,436	114,436	114,436	114,436	114,436	114,436	114,436	114,436	114,436	-	114,436
b) CBD (No BDS)	Sewer Inst. Ratio (%)	0%	0%	0%	0%	25%	75%	100%	100%	100%	100%	100%	-	100%
	House Connection (%)	0%	0%	0%	0%	0%	0%	25%	74%	99%	100%	100%	-	100%
	Collection Vol (m^3/d)※1	0	0	0	0	0	0	8,330	25,576	34,887	35,676	36,470	-	43,893
	Served Pop.	0	0	0	0	0	0	27,237	81,987	109,684	110,052	110,420	-	110,420
	Total Pop.	110,420	110,420	110,420	110,420	110,420	110,420	110,420	110,420	110,420	110,420	110,420	-	110,420
c) Dagon	Sewer Inst. Ratio (%)	0%	0%	17%	50%	83%	100%	100%	100%	100%	100%	100%	-	100%
	House Connection (%)	0%	0%	0%	0%	0%	22%	46%	71%	73%	75%	77%	-	100%
	Collection Vol (m^3/d)※1	0	0	0	0	0	2,849	6,110	9,801	10,467	11,165	11,894	-	21,169
	Served Pop.	0	0	0	0	0	7,875	16,709	26,547	28,072	29,640	31,251	-	48,751
	Total Pop.	30,074	30,999	32,064	33,130	34,195	35,260	36,325	37,390	38,455	39,520	40,585	-	48,751
Inflow Volume to WWTP(m3/d):Daily Max		630	630	630	630	630	37,138	49,625	71,374	82,166	84,474	86,822	-	111,213
WWTP Capacity (m3/d):Daily Max		15,000	15,000	7,500	7,500	7,500	56,000	56,000	84,000	112,000	112,000	112,000	-	112,000
Total Served Population		109,064	110,431	110,927	111,423	111,918	120,289	156,856	221,826	251,429	253,747	256,107	-	273,607
Total Population		254,930	255,855	256,920	257,986	259,051	260,116	261,181	262,246	263,311	264,376	265,441	-	273,607
Sewerage Service Ratio	Total Served Pop./Total Pop. x 100	43%	43%	43%	43%	43%	46%	60%	85%	95%	96%	96%	-	100%

※1 : Sewage Vol. from 2019 to 2023 was observed volume including sewage transported by Vacuum Truck



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2040
WWTP(Stage-2)								28,000	56,000	56,000	56,000	56,000
WWTP(Stage-1)	0	0	0	0	0	56,000	56,000	56,000	56,000	56,000	56,000	56,000
Existing WWTP	15,000	15,000	7,500	7,500	7,500	0	0	0	0	0	0	0
Inflow Vol	630	630	630	630	630	37,138	49,625	71,374	82,166	84,474	86,822	111,213
Generated Wastewater Vol	65,128	67,495	69,626	71,800	74,016	76,276	78,581	80,767	82,995	85,266	87,580	111,213

Source: JICA Study Team

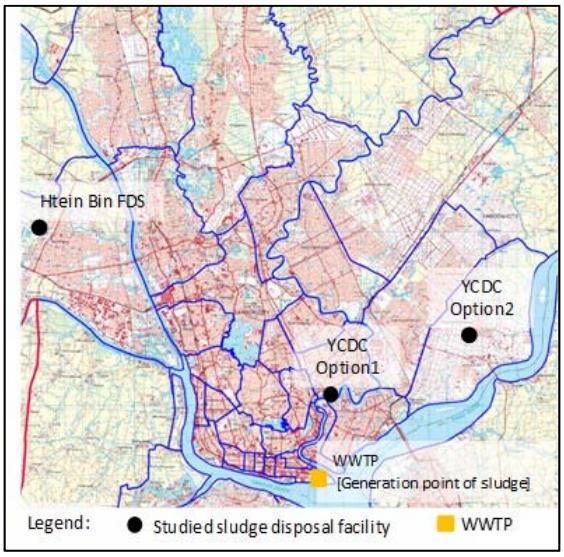
Figure 5.2.1 Development Plan for Construction of Sewer and WWTP by 2040

5.3 Precondition on Planning of Wastewater Treatment Plant Requested by YCDC

5.3.1 Background of the Request

(1) Lack of Disposal Site in Yangon City

Upon query of the JICA Study Team about the possible location of the sludge disposal facility, YCDC considered and proposed two lands owned by YCDC. However, both lands are evaluated as inappropriate by the JICA Study Team because it is surrounded by residential areas. It is difficult to make a consensus among stakeholders because they may complain about the development of the disposal facility and the offensive odour from the sludge.



Source: JICA Study Team

Figure 5.3.1 Location of the Proposed Sites for Sludge Disposal

The JICA Study Team suggested EDWS to confirm the possibility of disposing of the sludge to the final disposal site (FDS) of solid waste, Htein Bin FDS, managed by PCCD because it is practiced and commonly observed in other countries.

It is estimated that 60 ha is available for the Htein Bin FDS, assuming a layer thickness of 5.0 m, the remaining capacity of the site is estimated as about 3 million m^3 and it is not sufficient for the rapidly increasing amount of solid waste generated from the city. It is an urgent issue for YCDC to immediately find and secure a new site for solid waste disposal.

(2) Fire Incident at Htein Bin FDS

In the field survey, the fire at the sprawling Htein Bin FDS, located in the outer northwest of the Hlaing Tharyar Township, began on 21 April and spread quickly until it consumed more than half of the site. According to the Pollution Control and Cleansing Department (PCCD) of YCDC, the blaze was fuelled by the methane produced from decaying biodegradable organic waste. The fire was not under the complete control until 14 May. (Source: information from YCDC and Myanmar Times)

Source: YCDC

Figure 5.3.2 Fire Incident at Htein Bin FDS (April 2018)

In response to this incident, YCDC decided to consider carefully disposal of waste to this site in

the future. Initially, PCCD, the department of YCDC in charge of solid waste management, concluded that the dewatered sewage sludge generated in the wastewater treatment plant of this project shall be disposed in Htein Bin FDS. However, after this incident, PCCD did not agree to dispose dried sludge containing organic component into Htein Bin FSD and strongly requested the JICA Study Team to conduct a technical study on further treatment options in the wastewater treatment plant in order to reduce the volume of generated sewage sludge and to convert sludge into a form which would not produce methane gas, consequently reducing the risk of occurrence of a similar incident in the future. In addition, there is no vacant capacity in the other YCDC's FDS currently, so the Yangon Regional Government (YRG) intend to improve and develop the FDS in order for YCDC to appropriately and safely dispose and manage solid waste and sewage sludge generated from Yangon City, including this study area.

5.3.2 Preconditions for Study on Wastewater Treatment Plant

From the aforementioned situation, YCDC requested the JICA Study Team the following preconditions for planning of the wastewater treatment plant:

(1) Sludge Treatment Process and Facilities

- The sludge treatment process shall be i) thickening, ii) dewatering, and iii) drying.
- A mechanical drying method shall be implemented, but not a sun-drying method because this method needs a huge space and may affect the environmental condition around the sewage treatment plant due to odours, etc.
- The sludge treatment facility should be designed as compact as possible so that sludge incineration facilities and other components can be installed and so that an appropriate facility layout plan can be prepared in the future.
- The above requests from YCDC were made based on the consideration of the limitation of the area for sludge disposal site in Yangon city, but not only in the target study area. The sludge will be generated more with the increase of population from entire Yangon city. Therefore, currently, YCDC has a plan to construct sludge incineration facility in the existing WWTP area in order for minimizing the sludge volume and reducing the environmental impact.

(2) Utilization of the Existing Sewage Treatment Plant during Construction Works

- The existing sewage treatment plant shall be utilized until the operation of the new treatment facilities.
- The existing sewage treatment plant shall be demolished after the construction of new treatment facilities to secure space for future facilities including incineration facility.

The JICA Study Team conducted the study in accordance with the preconditions given by YCDC after confirming their validity in Chapter 6.

CHAPTER 6 PLANNING OF IMPROVEMENT AND DEVELOPMENT OF SEWERAGE SYSTEMS

6.1 Planning of Sewage Treatment Plant

6.1.1 Design Water Quality

(1) Design Influent Water Quality

The design influent water quality is shown in Table 6.1.1. Values were set based on the discussion with Yangon City Development Committee (YCDC) experts, considering the process of modification from the current sewer collection system.

Table 6.1.1 Design Influent Water Quality

Items	Design Value (mg/L)
BOD	250
SS	250

Source: YCDC

(2) Design Effluent Water Quality

The design effluent water quality, which was set based on the value confirmed with YCDC in the past study (MLIT's Study in 2016), is shown in Table 6.1.2. The following limits are commonly used for treated effluent by the activated sludge process.

Table 6.1.2 Design Effluent Water Quality (YCDC Internal Guideline)

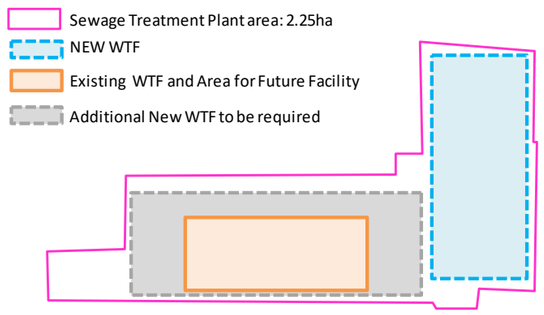
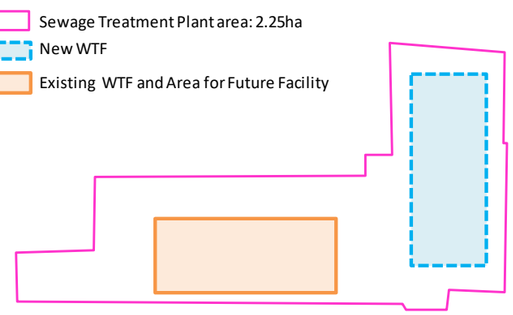
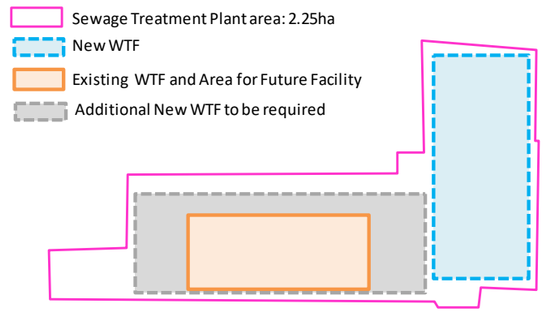
Items	Design Value (mg/L)
BOD	Less than 20
SS	Less than 30

Source: YCDC

6.2 Study for Wastewater Treatment Facility (WTF)

MBR process was selected after the comparative study as shown in Table 6.2.1. which satisfies the conditions under which the existing treatment facilities shall be operated during the construction work.

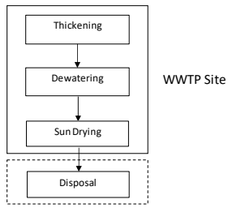
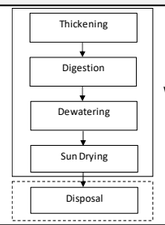
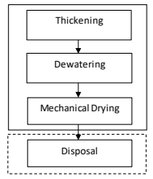
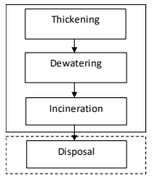
Table 6.2.1 Secondary Comparative Study on Wastewater Treatment Process

Subject		General Facility Layout Plan of Wastewater Treatment Facilitiy (WTF)		
		Option 1 : CAS (Deep Type)	**Option 2 : MBR**	**Option 3 : IFAS (Deep Type)**
General Facility Layout				
Features		**Dimension**	**Dimension**	**Dimension**
		Appcable Treatment Capacity (South) / **Less than 56,000m3/day**	**Appcable Treatment Capacity** / **112,000m3/day**	**Appcable Treatment Capacity** / **Less than 56,000m3/day**
		Primary Sedimentation Tank (2 Stories) / L=23m, B=55m(25*2), H=8m(4*2)	Primary Sedimentation Tank (2 Stories) / L=35m, B=55m(25*2), H=4m	Primary Sedimentation Tank (2 Stories) / L=23m, B=55m(25*2), H=8m(4*2)
		Reactor (Deep Type) / L=46m, B=55m(25*2), H=10m	Reactor / L=35m, B=55m(25*2), H=4m	Reactor (Deep Type) / L=40m, B=55m(25*2), H=10m
		Final Sedimentation Tank (2 Stories) / L=42m, B=55m(25*2), H=8m(4*2)	Final Sedimentation Tank (2 Stories) / -	Final Sedimentation Tank (2 Stories) / L=42m, B=55m(25*2), H=8m(4*2)
		Additional New STP / **Cannot be placed**		**Additional New STP** / **Cannot be placed**
		Not satisfied the design capacity	**Satisfied the design capacity**	**Not satisfied the design capacity**
Adaptability of Precondition required by YCDC	**WTF**	Need to demolish the existing WTF	**New WTF can be placed without demolition of the existing WTF**	Need to demolish the existing WTF
	STF	No space is available for sludge treatment facility (STF)	**Spece is available for sludge treatment facility (STF)**	No space is available for sludge treatment facility (STF)
	Existing WTF	Existing WTF cannot be operated during the constrcution work	**Existing WTF can be operated during the constrcution work and the area can be used for future facilities**	Existing WTF cannot be operated during the constrcution work
	Area for Future Facilities	Cannot be secured because the area of existing WTF will be required for an additional WTF	**Can be sedured because an additional WTF is not required**	Cannot be secured because the area of existing WTF will be required for an additional WTF
Maintenance		Maintenance road is difficult to place	**Maintenance road can be placed**	Maintenance road is difficult to place
Evaluation		**Area is insufficient for complete WWTP**	**Only MBR Method can be applicable with satisfaction of the technical conditions and the requirement of YCDC**	**Area is insufficient for complete WWTP**
		Not Applicable	**Applicable**	**Not Applicable**

6.3 Study for Sludge Treatment Facility (STF)

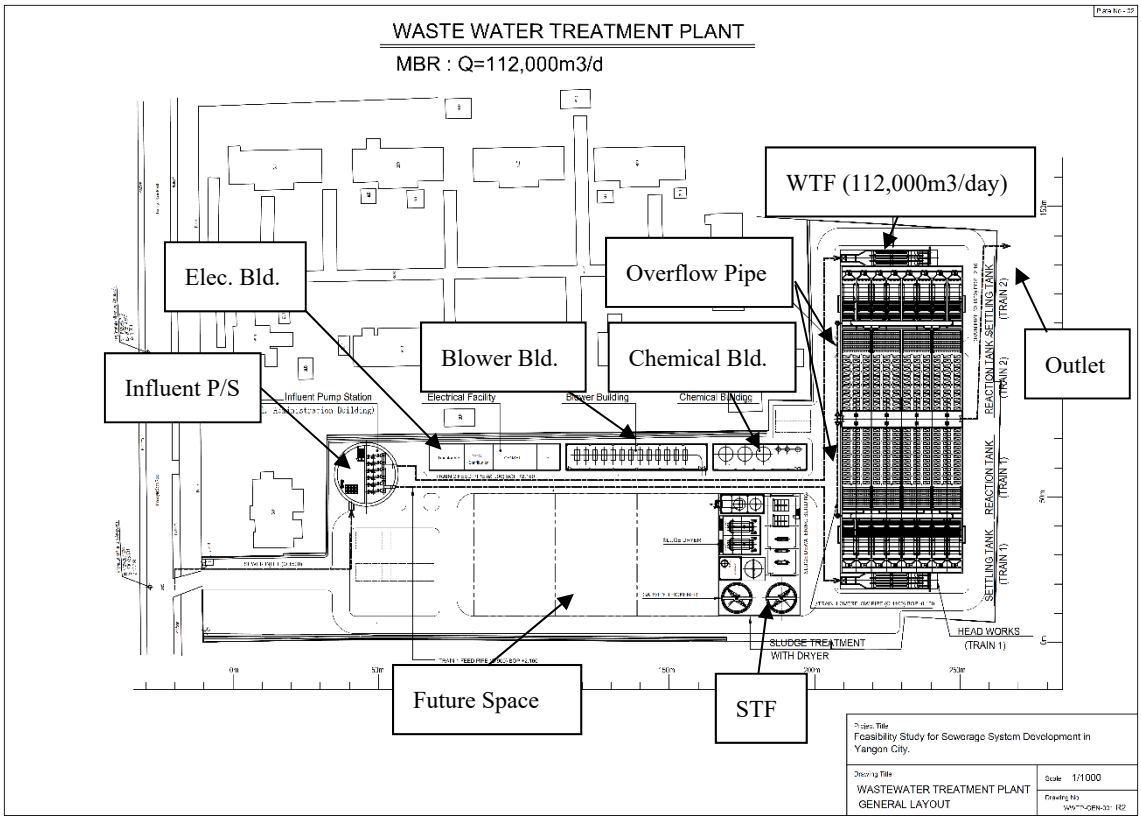
"Thickening + Dewatering + Mechanical Drying" process was selected after the comparative study as shown in Table 6.3.1. On the other hand, the installation of incinerators, is planned by YCDC in the future after conducting the study of integration of sludge management with efficient construction and operational plan for whole Yangon city. Therefore, YCDC has the idea of constructing the incineration facility within the area of the existing WTF in the future as one of the additional facilities if it is required

Table 6.3.1 Comparative Study on Sludge Treatment Facility

		Option 1	Option 2	Option 3	Option 4
		Thickening + Dewatering +Sun Drying	**Thickening + Digestion + Dewatering + Sun Drying**	**Thickening + Dewatering + Mechanical Drying**	**Thickening + Dewatering + Incineration**
Process Flow					
Overview	**Thickening** *Outputted sludge Moisture* (97.5 %)	Raw sludge of about 2% concentration and excess sludge of about 0.8% concentration are mixed and fed as mixed sludge into the gravity thickener. After being thickened to a concentration of 2.5% in a gravity thickener, sludge is loaded into the Dewatering Equipment.	Raw sludge of about 2% concentration and excess sludge of about 0.8% concentration are mixed and fed as mixed sludge into the gravity thickener. After being thickened to a concentration of 2.5% in a gravity thickener, sludge is loaded into the digester.	Same as Option 1	Same as Option 1
	Digestion *Outputted sludge Moisture* (99%)	No digestion process applicable to Option 1	The organic content in sludge is reduced and the volume of sludge is stabilized in the digester. The odour from sludge is also reduced in this process and the digested sludge of about 2.5% concentration is loaded into the sludge dewatering machine.	No digestion process applicable to Option 3	No digestion process applicable to Option 4
	Dewatering *Outputted sludge Moisture* (82%)	Being dewatered, sludge cake with about 82% water content by using mechanical dewatering equipment, sludge is disposed offsite.	Same as Option 1	Same as Option 1	Same as Option 1
	Drying (Natural or Mechanical) Sludge Moisture (60%)	Being delivered to the existing dumping site (Htein Bin Fial Disposal Site), then being dried for about 30 days on the sludge drying bed, sludge reaches down to 40 % of water content approximately. Sludge Drying time is 30 days.	Same as Option 1	Mechanical Drying inside the territory of existing WWTP reduces the dewatered sludge volume.	No Drying process applicable to Option 4
	Incineration	No incenertion process applicable to Option 1	No incenertion process applicable to Option 1	No incenertion process applicable to Option 3	To reduce drastically the dewatered sludge volume by introducing incineration process to the other process
General Features of Process		- Since the dewatered sludge contains a large quantity of undissolved organic, it is volatile and generates odor. - Sludge drying is a process with the objective of further enhancing handling of sludge so that the moisture content in sludge can be further reduced and stabilized and it can be used in agricultural land applications.	- Possible to reduce solid waste volume in digested sludge by drying bed and improve the volatility - Large space for the premises is necessary - Sludge drying is a process with the objective of further enhancing handling of sludge so that the moisture content in sludge can be further reduced and stabilized and it can be used in agricultural land applications.	- Possible to reduce sludge volume - Space for the premises is necessary	- Possible to extremely reduce solid waste volume - Large space for the premises is necessary
Required Space in WWTP		N/A (7,200m2 (Drying bed cannot be placed))	N/A (9,500m2 (Drying bed cannot be placed))	1,500m2	2,800m2
Sludge Volume		After Dewatering: 200t/day, Drying: 46m3/day	After Dewatering: 100t/day, Drying: 46t/day	After Dewatering: 200t/day, Mechanical Drying: 46t/day	After Incineration: 9t/day
Initial Cost		**N/A**	**N/A**	32 million USD (42,800 million MMK)	62 million USD (83,000 million MMK)
Running Cost		**N/A**	**N/A**	3.5 million USD (4,600 million MMK)	4.0 million USD (5,200 million MMK)
Advantages		**N/A**	**N/A**	- As YCDC requested, drying process can be placed within WWTP site, so, the sludge generation volume can be reduced. - Duration for mechanical drying process is much shorter than sun-drying process. - Odor impact is much less than sun-drying process.	- The generated sludge volume will be much less than Option 3. - Transportation cost to dumping site will be reduced less than Option 3.
Disadvantages		**N/A**	**N/A**	- Running cost is higher than sun-drying process.	- Running cost is higher than Option 3 because fuel will be necessary for incineration. - Moisture content should be reduced for efficient incineration. (i.e. to add drying process, however, sun-drying process cannot be placed due to land limitation as mentioned in Option 1 and 2.)
Selection		- As YCDC's given condition, sludge drying process will be accommodated in WWTP site. However, the sun drying bed cannot be placed because the huge area is required. - The sun dring process is not recommended considering the environmental impact surround the area.	- As YCDC's given condition, sludge drying process will be accommodated in WWTP site. However, the sun drying bed and digestion facility cannot be placed because the huge area is required. - The sun dring process is not recommended considering the environmental impact surround the area.	- As YCDC requested, the sludge drying process can be accommodated in WWTP site. - The drying machine can be used for a part of incinerator if it is inslatted in the future by YCDC.	- YCDC would like to install an integrated incineration facility in future. (A study on the integrated sludge management plan for the entire Yangon city will be conducted separately from this study for future installation of incineration process.) - Therefore, incineration facilities will be installed in future by YCDC after the study.
		NOT APPLICABLE	**NOT APPLICABLE**	**SELECTED**	-

6.4 General Facility Layout Plan of Wastewater Treatment Plant (WWTP)

The general facility layout plan of the WWTP is shown in Figure 6.4.1.



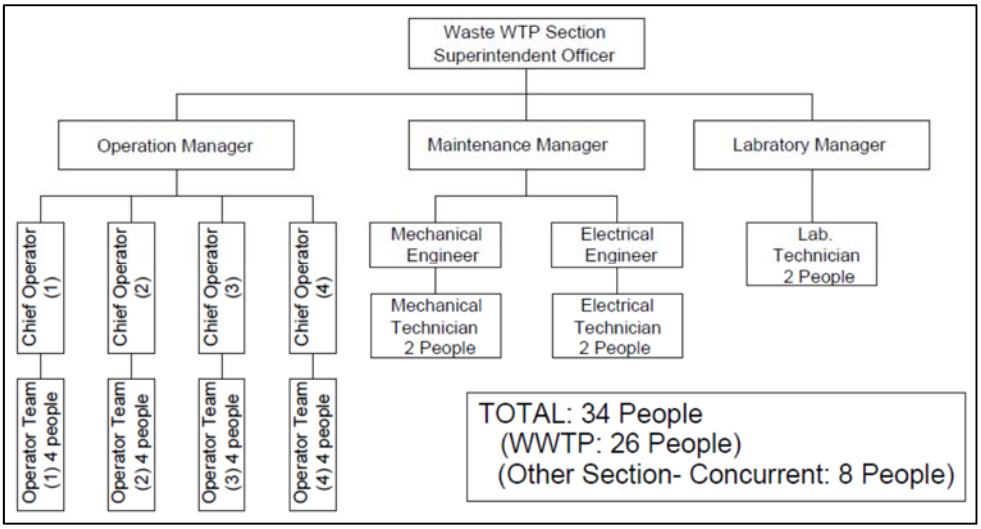
*The new electrical transmission line will be installed from THIDA substation (33 kV) to the WWTP

Source: JICA Study Team

Figure 6.4.1 General Facility Layout Plan of the WWTP

6.5 Operation and Maintenance of the WWTP

Organization requirements for O&M works for the new WWTP is shown in Figure 6.5.1.



Source: YCDC

Figure 6.5.1 Recommended O&M Structure

6.6 Study on Main Sewer

6.6.1 Design Condition

Design conditions for the installation of the sewer are defined in reference to Japanese standards as follows since there is no applicable design standard in Myanmar.

Table 6.6.1 Design Conditions for Installation of Sewer

Items	Parameter	Remarks
Minimum Diameter of Sewer	Trunk sewer and branch sewer: 200 mm Service sewer: 150 mm for CBD where existing sewerage system is available 100 mm for CBD where existing sewerage system is not available, and Dagon township.	Taking into consideration operation and maintenance such as cleaning, inspection, and new connection, each diameter is defined as the minimum diameter of the sewer.
Connection Type	Pipe top connection	Pipe top connection type makes wastewater flow smoothly and maintains hydraulically safety.
Minimum Earth Covering	3.0 m	Minimum earth covering is defined for ensuring enough depth of the sewer to cross underneath the existing drains installed between houses including the BDS and the existing road
Calculation Formula	Manning's Formula $V = \frac{1}{n} R^{\frac{2}{3}} I^{\frac{1}{2}}$ n: friction factor = 0.013 (concrete pipe)	
Velocity	Min=0.6 m/s, Max=3.0 m/s	Minimum velocity for gravity flow is defined to avoid sedimentation inside the sewer. The maximum velocity is defined to avoid damage to the sewer and the manhole
Manhole Interval	$D < 600$[*1] : <75 m (100 m) $600 \leq D < 700$[*1] : 100 m (100 m) $800 \leq D < 1{,}000$[*2] : 100 m (200 m) $1{,}000 \leq D \leq 1{,}500$[*2] : 150 m (200 m) Note: Number in a parenthesis is maximum value	The interval is defined taking into account of construction cost and workability. [*1]: Maximum interval is 100 m considering maximum length of small diameter pipe-jacking with smaller than D700 and O&M. [*2]: Maximum interval is 200 m considering maximum length of medium and large diameter pipe-jacking with bigger than D800 and O&M.

Source: Design Standards for Sewerage Systems, Japan Sewerage Works Association

Hourly maximum wastewater flow was calculated by 1.5 times of daily maximum wastewater flow and was applied for the planning of the sewer system.

6.6.2 Study for the Alignment of Sewers

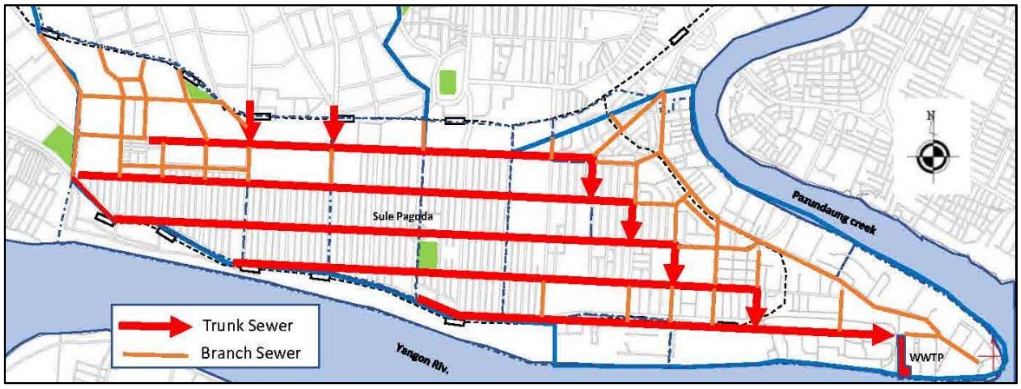
(1) Definition of Sewer

Sewers were classified into 1) trunk sewer, 2) branch sewer, 3) service sewer and 4) BDS sewer in the Study.

- Trunk Sewer: Sewer to be connected into WWTP
- Branch Sewer: Sewer to collect wastewater from service sewers in its catchment and to be connected with the trunk sewer
- Service Sewer: Sewer to connect each household with branch sewer
- BDS Sewer: Sewer installed inside BDS to collect sewage from the CBD covered by the existing sewerage system and to connect the service sewer

(2) Comparison Study for Trunk Sewer Line Route in CBD

The general concept on the trunk sewer line route, especially for the central business district (CBD) area, basically depends on the location of the outlet branch and the service sewer from the back drainage system (BDS). Three alternatives of trunk sewer routes were considered from the viewpoints of pipe length, number of vertical shaft, construction cost, workability, and compatibility with drainage line. The 14 existing drainages flow from north to south and finally discharge storm water into the Yangon River; therefore, the trunk sewer shall cross those drainages since the trunk sewer alignment is from west to east, and the branch sewers also require connection to the trunk sewer. To compare the alternative trunk sewer routes, compatibility with the World Bank project should also be taken into account from the viewpoint of crossing. The number of trunk sewers of two routes, three routes, and five routes were compared. After discussing the pros and cons of both alternatives with YCDC, five routes was selected to be applied as shown in Figure 6.6.1



Source: JICA Study Team

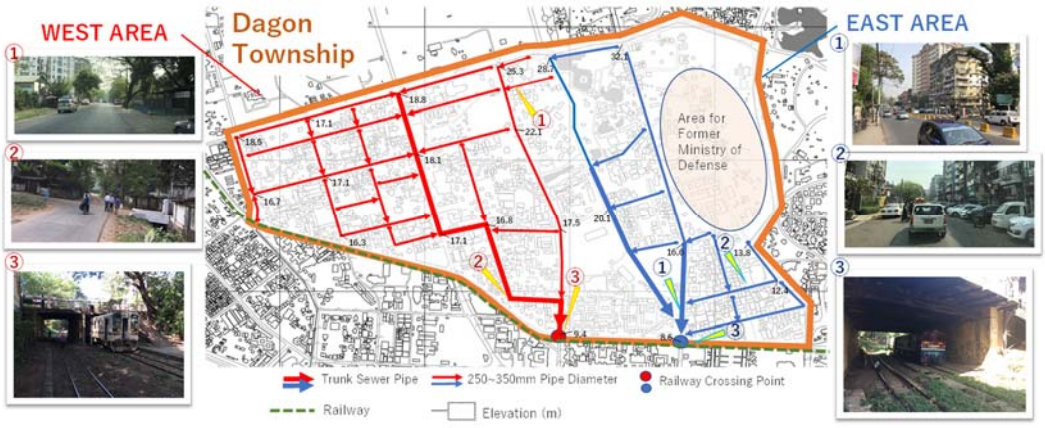
Figure 6.6.1 Trunk Sewer Alignment in CBD Area

(3) Trunk Sewer Alignment for Dagon

The Dagon area is located upstream of the CBD. Ground elevation around the Dagon area is hilly toward the Shwedagon Pagoda and is relatively higher than the CBD area. Most of the sewerage customers in the Dagon area are individual houses or are part of the public sector, such as hospitals,

schools, and embassy. The railway runs on the boundary of the CBD and the Dagon area; therefore, it is necessary to consider how the trunk sewer crosses the railway for minimizing the number of the crossings as much as possible to prevent interruption of the railway operation during the construction. Two locations of the railway crossing were selected taking into consideration the catchment area, the length of pipe, and the topographical condition in order not to install trunk sewer at a very low depth. The catchment in the Dagon area was divided into two sub-catchments, in the east and in the west.

The Ministry of Defence occupies the eastern Dagon with a total area of approximately 50 ha. Entry into the area is restricted. Wastewater from the area is not discharged into the existing drain around the area. According to YCDC, the area will be used for other purposes in the future, although specific uses cannot be defined yet. Therefore, in the Study, no sewer was planned in the area, and the invert elevation of the initial end of the sewer is set deep enough for future connection from the area.



Source: JICA Study Team

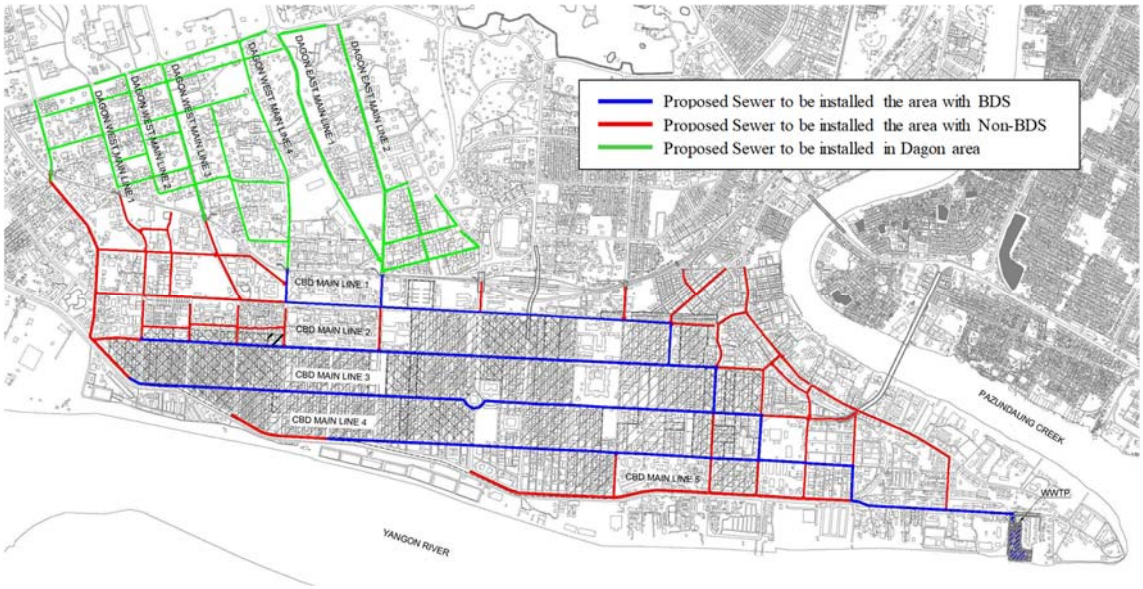
Figure 6.6.2 Trunk Sewer Alignment in Dagon Area

(4) Step-wise Implementation of Sewer

To ensure project effectiveness of the sewerage development as early as possible, sewer construction shall be commenced in the CBD area where BDS is available since the construction period for house connections can be relatively shorter than for the CBD with non BDS.

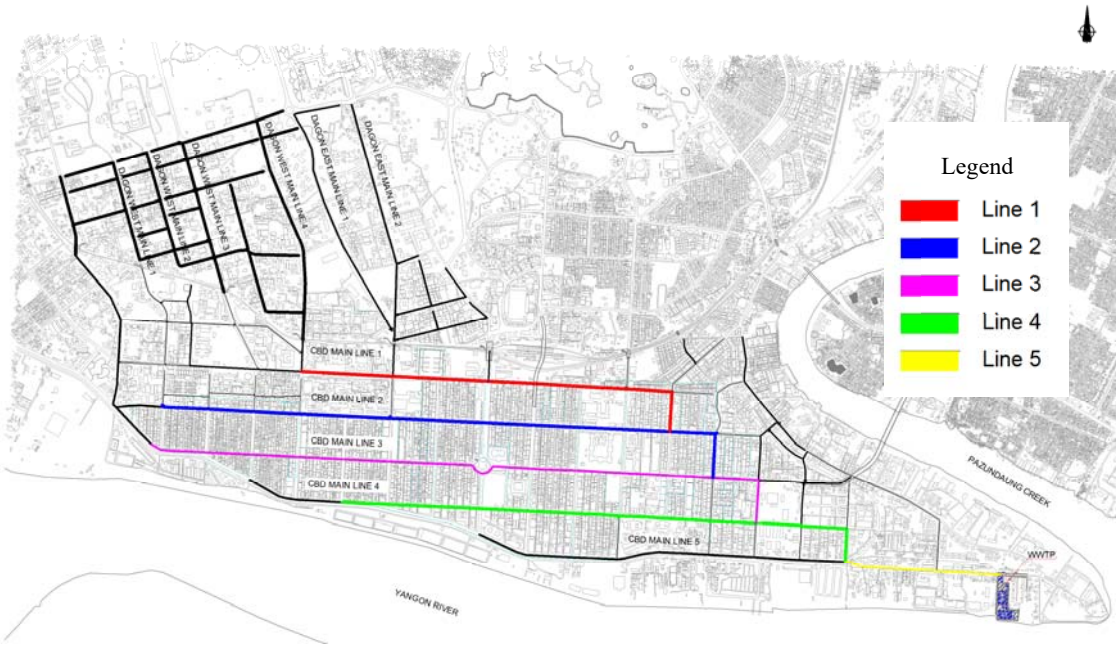
The installation of sewers in the Dagon area can be separately considered from the sewers in the CBD. The sewer construction in the Dagon area and the CBD with BDS will be implemented simultaneously from the beginning of the project because it will take a long time to proceed house connections. However, house connections should be implemented in the Dagon area after completion of the construction for the sewers in the CBD with BDS.

Therefore, it is proposed that sewers to be installed for the area with BDS and the Dagon area shall be the first priority, while sewers in the CBD with non BDS will be installed later on. Figure 6.6.3 shows the proposed sewers in each area. Figure 6.6.4 shows detail of proposed sewer to be installed in the CBD with BDS.



Source: JICA Study Team

Figure 6.6.3 Step-wise Implementation of Sewer



Source: JICA Study Team

Figure 6.6.4 Detail of Proposed Sewer to Be Installed in CBD with BDS

6.6.3 Related Sewerage Facilities

(1) Pipe Material

The proper material should be selected considering the sewer type and the laying environment of sewers. Reinforced concrete pipe (RCP) is applied for the planning of the sewerage system in the Study. However, HDPE pipe may also be acceptable since the material cost has been getting lower

recently.

(2) Manhole

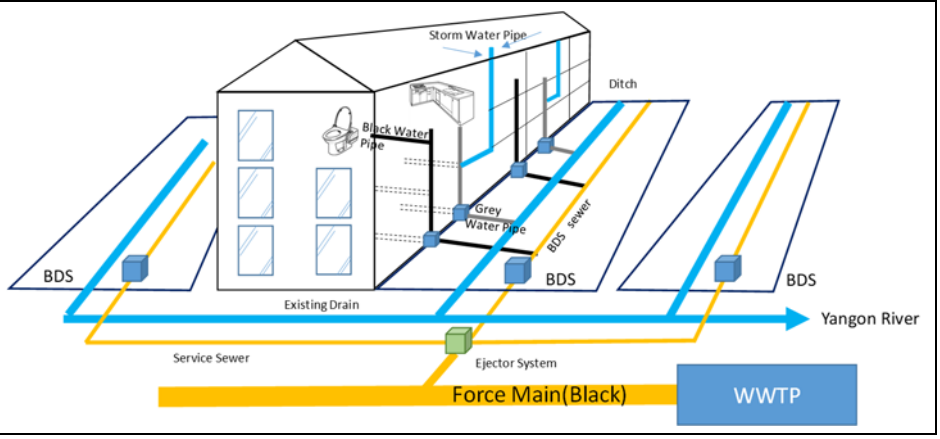
Manholes are constructed in a sewer system as a means of access to sewers for inspection, cleaning, and repairs. They are also employed as transition structures for changes in shape, size, grade, or alignment of sewers and as junction chambers for two or more sewers.

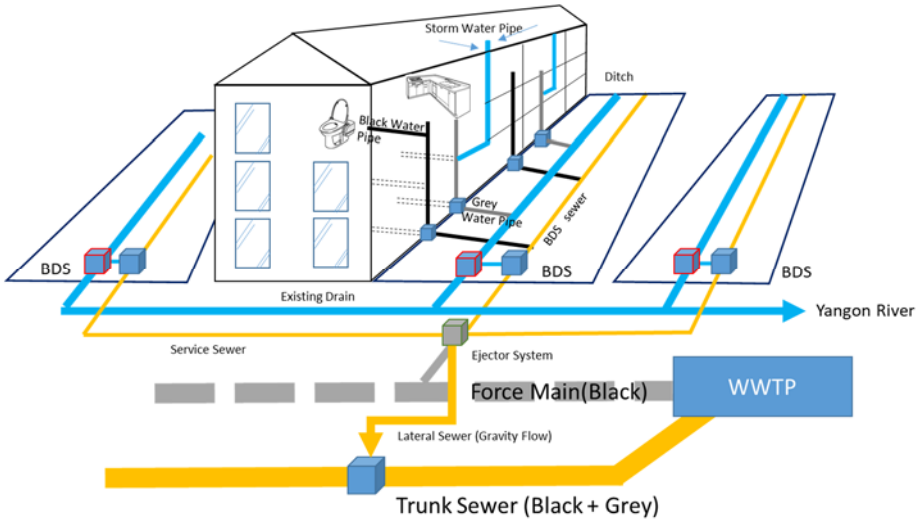
6.6.4 Construction Concept of Wastewater Collection

(1) CBD (BDS)

It is suggested that the existing sewer for black water in BDS is kept as it is since it will take time to replace all existing sewers at the 182 BDSs. Therefore, reconnection at the new trunk sewer shall be prioritized in order to achieve project effectiveness as early as possible. Then, the replacement of the existing sewer in BDS will be the next priority.

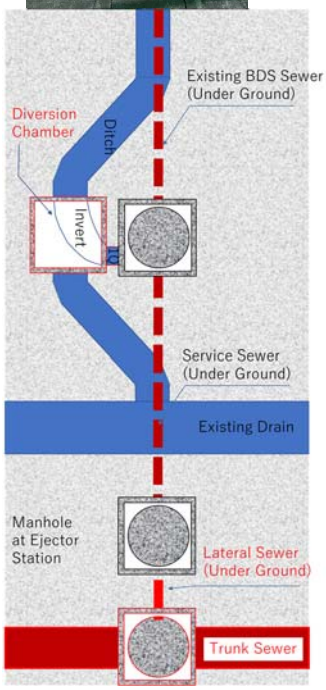
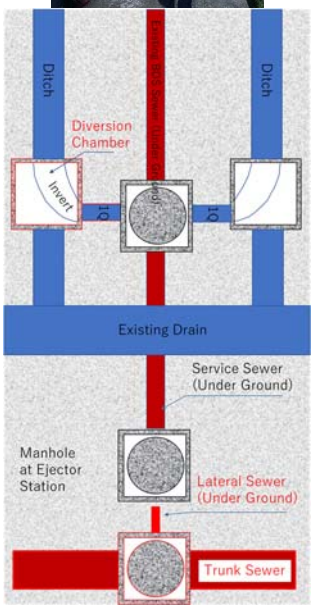
In the sewerage development, it is suggested that some extent of the replacement of the existing sewer in BDS should be implemented as a pilot project. Six locations of BDS will be selected by YCDC during the implementation stage. For the rest of the 176 BDSs, a diversion chamber which collects grey water at the exit of BDS will be temporarily installed at the end of the existing ditch to separate grey water and storm water as shown in Figure 6.6.5. Grey water collected in the diversion chamber will go to the manhole in the ejector station using this BDS sewer and service sewer and then go to the trunk sewer. Black water from each household will also go to the trunk sewer through the existing BDS sewer and conveyed into the manhole of the ejector station. In addition, YCDC will bear the construction cost for the diversion chamber and the lateral sewer in the project. Storm water, which is over the flow capacity of the connecting pipe of the diversion chamber and the existing sewer in BDS, will discharge into the existing drain eventually pouring into the Yangon River. The installation of the diversion chamber is a temporary measure and will not separate grey and storm water completely during the rainy season. Therefore, the replacement of the existing sewer with the reconnection of black and grey water for the rest of the 176 BDSs should be implemented in the latter stage accordingly.

Current Situation	

After Improvement (Separated System)	

Source: JICA Study Team

Figure 6.6.5 Current Situation and Concept of Sewage Collection in BDS

Type A (Total 111 BDS)	Type B (Total 71 BDS)
A-1: Space without improvement by YCDC: 58 nos	B-1: Space without improvement by YCDC: 55 nos
A-2: Space improved by YCDC: 53 nos	B-2: Space improved by YCDC: 16 nos
 	 

Note: Red colour is to be implemented by under JICA ODA loan.

Source: JICA Study Team

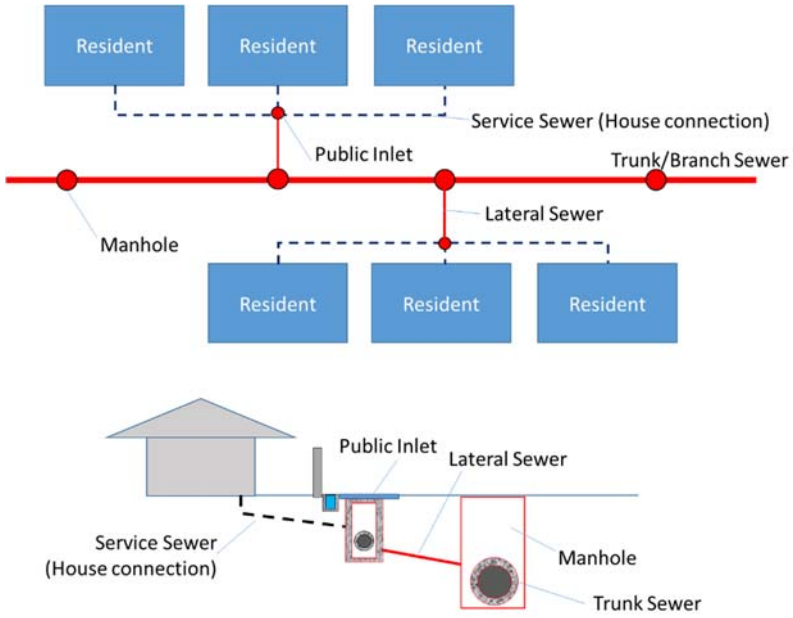
Figure 6.6.6 Improvement of Back Drainage Space

(2) Rest of CBD area and Dagon area

In the CBD area except the sewered area and the Dagon area, a septic tank is receiving wastewater from each household. Public inlets connected to the trunk sewer in the vicinity of each household shall be installed in the Project. However, resident shall connect sewer pipes from each house to the manhole.

Figure 6.6.7 shows the demarcation of sewer installation and sewage collection system in the Dagon area. There are individual houses and public compounds such as hospitals, schools, and embassies so that generated wastewater, i.e., black and grey water, from each house or compound will be brought to the public inlet through the service sewer. The public inlet has to receive the wastewater from several houses or compounds in order to convey the collected wastewater to the trunk sewer through the branch sewer. The trunk sewer, branch sewer, and public inlet will be implemented under Japanese ODA Loan. The resident will install and maintain the service sewer

and also bear these cost. The soak pit type septic tank is used for wastewater treatment up to three-storey building. Therefore, counter measure work (e.g. blockage of the bottom of the septic tank) is required to prevent effluent from infiltrating into the ground when house connection will be conducted in this kind of building. This demarcation is basically derived from the border of public and private lands.



Red color is to be implemented under JICA ODA Loan

Source: JICA Study Team

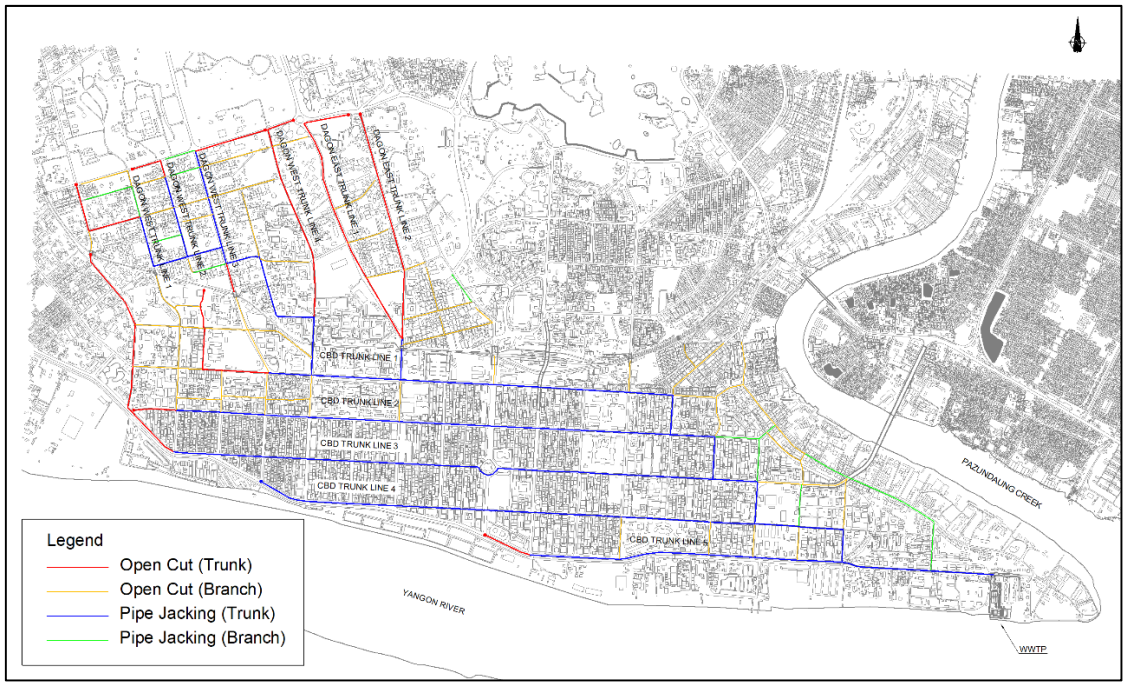
Figure 6.6.7 Concept of House Connection in the Rest of CBD area and Dagon Area

6.6.5 Installation Method

Pipe installation methods for the Project, with inner sewer diameter ranging from D200 mm to D1500 mm, are examined. The types of pipe installation methods are generally listed as follows:

- Open Cut Method
- Trenchless Method
  - Pipe Jacking Method (small pipe diameter and large to medium pipe diameter)
  - Shield Tunnelling Method

The two methods for the installation of new sewer pipelines are the open cut method and the trenchless construction method. The selection of method to be used depends on a number of factors including pipe diameter, installation depth, type of soil, depth of water table, available construction space on the surface, conflict with other underground utilities, and the volume of traffic. Figure 6.6.8 the sewer alignment section where the open-cut or trenchless method is proposed to be applied.



Source: JICA Study Team

Figure 6.6.8 Proposed Installation Method (Trunk Sewer and Branch Sewer)

CHAPTER 7 APPLICABLE JAPANESE SEWERAGE TECHNOLOGIES FOR YANGON CITY

7.1 Overview of Japanese Sewerage Technologies

The technologies, which is applicable for Yangon city, have been selected as reported in the previous Chapters considering the several issues for the development of sewerage system in the target area. The main two issues are that pipeline will be constructed under the busy main street in central business district, and the space for wastewater treatment plant is very limited. Also, energy saving system is preferable for the equipment installed in the plant. The Japanese sewerage technologies, which are applicable in this study, are shown in Table 7.1.1. Details of technologies are also described as follows.

Table 7.1.1 Categories of Japanese Sewerage Technologies Selected for the Project

Category	Facility	Japanese technology
Sewer	Sewage pipeline in congestion area	Long-distance Pipe-jacking Method
Wastewater Treatment Facility (WTF)	Reactor	Membrane Bio Reactor
Sludge Treatment Facility (STF)	Dewatering	Energy-saving Dehydrator
	Dryer	Inclined Disc Dryer

7.2 Sewer

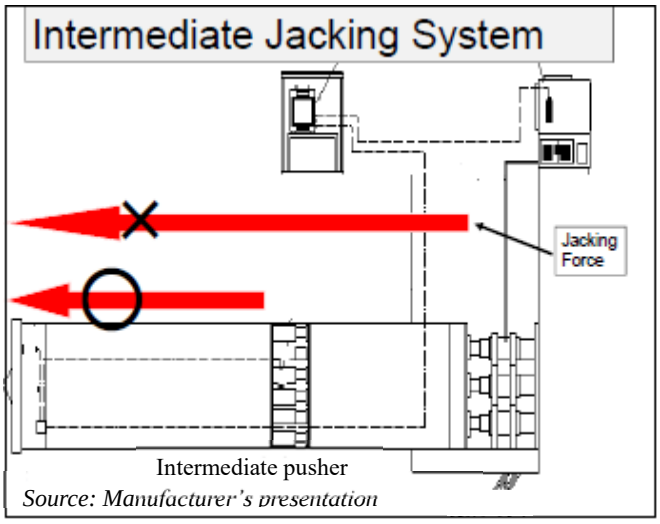
7.2.1 Long-distance Pipe-jacking Method

Pipe jacking method will be applied to the pipe installation to minimize large scale road occupation, which causes heavy traffic congestion, and construction noise, dust and vibration.

One of the key factors to minimize adverse influences and risks caused by the pipe installation construction as mentioned above is reducing the number of shafts. Installing the intermediate pusher in the middle of pipes as shown in the figure below will make it possible. This method is called long-distance pipe-jacking method which Japan has expertise. One span can be over a couple of hundreds of meters, and it is able to be jacked by a propulsion force provided the intermediate pusher. This technology enables the number of shafts to be possibly reduced half, moreover the construction cost can be saved because construction period is shortened as a result compared with the ordinal pipe-jacking method. However, this method requires technologies

which Japan has sufficient successful experiences as described below.

Lubrication is used to push a pipe without damage, which has to appropriately be applied to the surface of a pipe. As countermeasure against it, automated lubricant injection system is installed to effectively control injection amount, points and time. Also, propulsion at a curve is possible by using curve formulation unit and gyrocompass attached to boring machine.



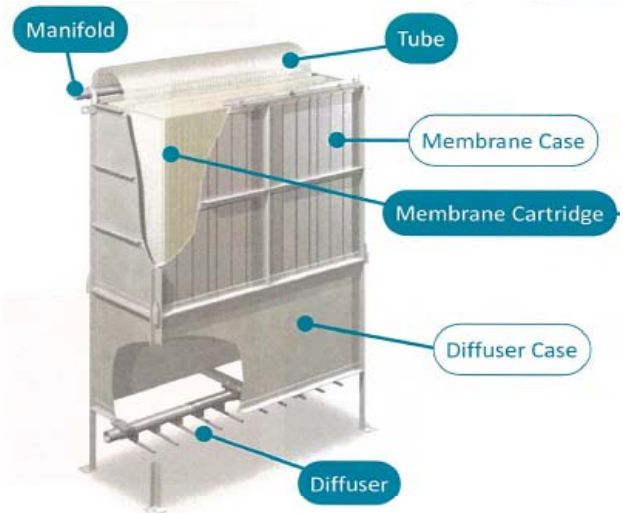
Source: Manufacturer's presentation

Figure 7.2.1 Image of Intermediate Pusher of Long-distance Pipe-jacking Method

7.3 Wastewater Treatment Facility (WTF)

7.3.1 Membrane Bio Reactor

Membrane Bio Reactor method is selected as the wastewater treatment because of the space limitation. MBR system does not require a final sedimentation tank, while having a reduced size of reactor which has membranes. It makes it possible to operate MBR processes at higher MLSS compared to conventional activated sludge process, therefore, reactor capacity can be reduced.



Source: Manufacturer's presentation material

Figure 7.3.1 Overview of Flat Sheet Membrane Unit

It is also possible not to install a disinfection facility theoretically because coliform bacillus cannot pass through a membrane, but it is usually installed for emergency purposes such as power supply down. Japan is strong on the market of membrane, and accounts for about 40 % share in the international market of membranes used for the MBR method (as of 2009) because of its high quality. Also, after the sales service provided by manufacture is important factor as selection criteria since MBR is composed of a lot of mechanical and electric equipment that need maintenance. For example, membrane requires cleaning for the removal of fouling about once everyone to two years per unit, that is, after sales service is crucial and it is even better that a brunch of manufacture that has sufficient experiences is located in the same country for the prompt action.

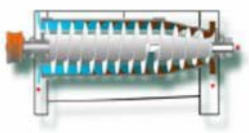
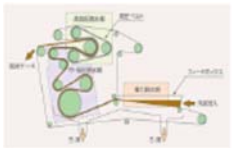
7.4 Sludge Treatment Facility (STF)

7.4.1 Dewatering/ Energy-Saving Dehydrator

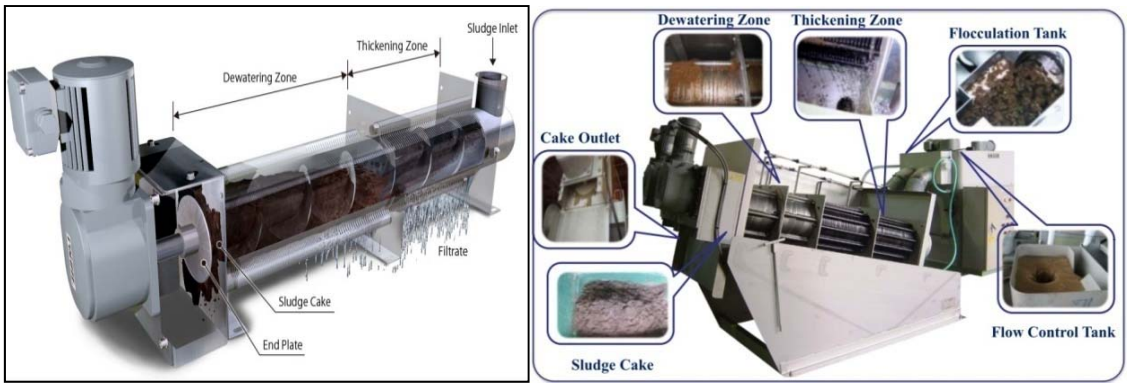
Sludge treatment is one of the most significant processes in this project because sludge disposal is the critical point. The amount of water that is dewatered by a dehydration machine has a large effect on the following sludge treatment process such as drying and incineration.

There are 4 types of dewatering equipment; screw press with multiple layered rings, centrifugal, screw press and belt press as shown in the following figure.

Table 7.4.1 Dewatering Equipment

	Screw press with multiple layered rings	Centrifugal	Screw press	Belt press
				
Foot print	Small	Large	Smallest	Largest
Energy consumption	Smallest	Largest	Small	Small
Initial cost	Smallest	Largest	Small	Largest
O&M cost	Smallest	Largest	Small	Largest
Ease of O&M	Easy	Not easy	Easy	Not easy

As a result of the comparison, screw press with multiple layered rings, which Japanese manufacture developed, would be the most suitable type for this project. Sludge feed is regulated with the overflow pipe, returning excess volume to the sludge storage tank. Next, sludge is instantly thickened at the thickening zone, and dewatered at the dewatering zone in the subsequent stage under increasing inner pressure. Further pressure is applied from the outlet side with the end plate, discharging dewatered cake with 20±5%solides content.



Source: Manufacturer's presentation material

Figure 7.4.1 Energy-Saving Dehydrator (Screw Press with Multiple Layered Rings)

In summary Japanese screw press with multiple layered rings is compact, high performance and has the following characteristics; No clogging, Easy maintenance, Energy saving (low running cost), No thickened sludge storage tank required, Continuous 24-hour unmanned operations.

Japanese screw press with multiple layered rings has already been installed 3200 units in 70 countries; which shows the excellence of the product.

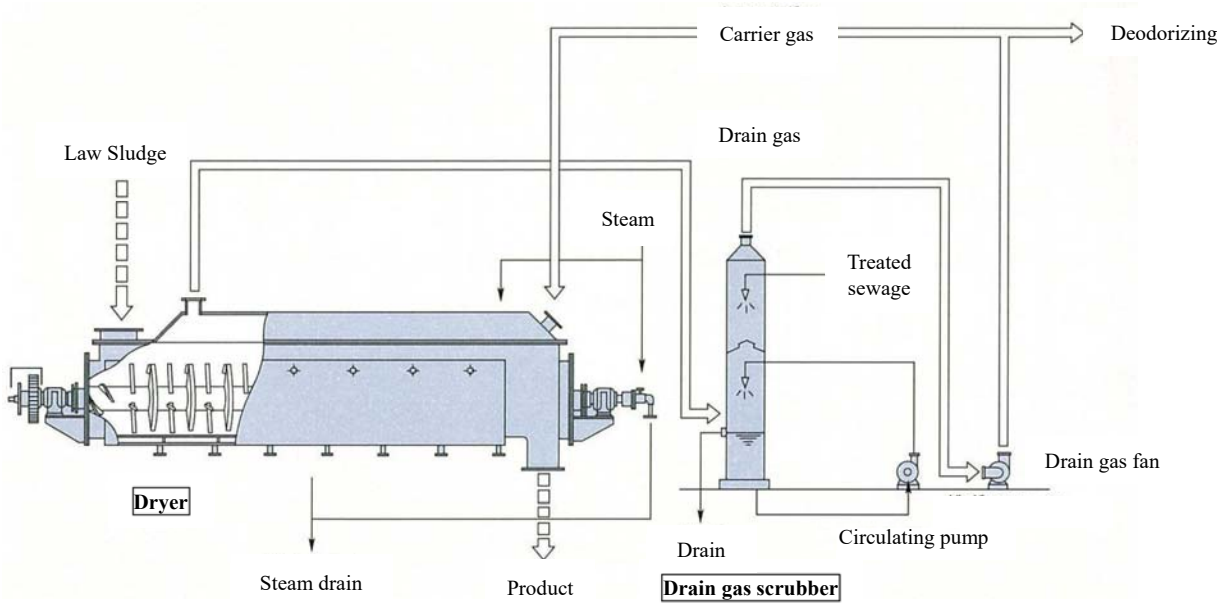
7.4.2 Mechanical Dryer

As described in chapter 6, mechanical dryer was selected for drying process. The overview of inclined disc dryer which is suitable type for this project is described here. Sludge is usually dried until the moisture content reaches about 70 % in case an incinerator is installed on the following process. A large amount of energy as latent heat is required in the drying process regardless of drying method, which means energy saving technology is crucial.

Drying method can be divided into two types; direct heat dryer and indirect heat dryer. Inclined disc dryer is the latter and high heat transfer coefficient is materialized by its disc. Thermal efficiency is extremely high as heat losing area per effective heat transfer surface is small. These characteristics lead to save consumed energy. In addition, Japanese inclined disc dryer has self-cleaning system by the inclined disc for heat transfer surface, so heat transfer efficiency will be kept high, which makes energy-saving property even higher compared to other countries' products.

Also, a small amount of carrier gas is used and it emits only a small volume of exhaust gas.

Japanese inclined disc dryers have been installed in many countries, for example China, and they have been running very well. Lifetime could be 15 years in case proper O&M is conducted.



Source: Manufacturer's presentation material

Figure 7.4.2 Flow of Inclined Disc Dryer

CHAPTER 8 CONSTRUCTION PLAN AND COST ESTIMATE

8.1 Conditions of Project Cost Estimation

8.1.1 Condition of Cost Estimation

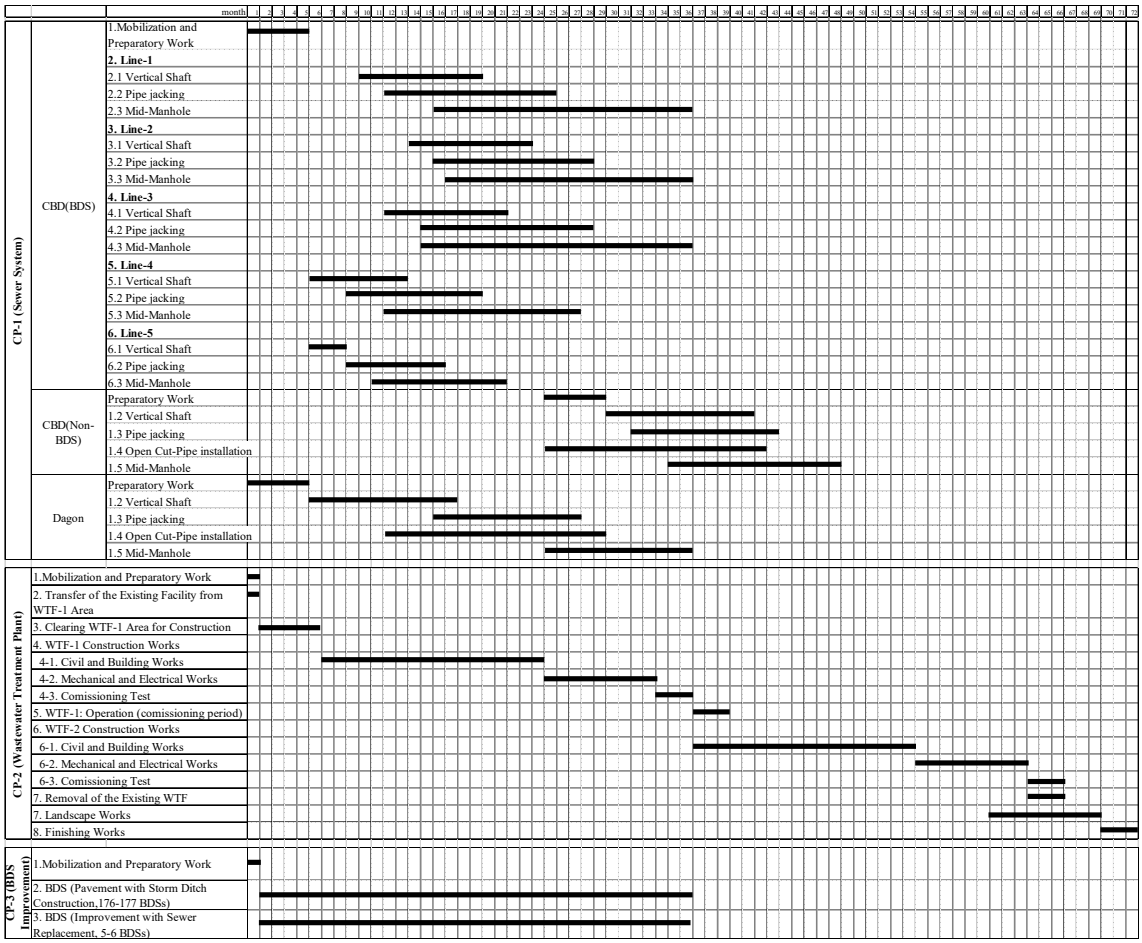
The project cost consists of construction cost, administration cost, consulting service cost, contingency (physical and price escalation), interest during construction, front end fee, and relevant taxes.

The project cost was estimated based on the following conditions:

- The project cost is divided into the local currency portion (LC) and the foreign currency portion (FC).
- Administration cost in the recipient country is assumed to be 5.0% of the construction cost.
- Consulting service cost is estimated based on the man-months of consulting services.
- Physical contingency is assumed to be 10.0% of construction work cost and 5.0% of engineering cost.
- Price escalation is at 1.83% per annum for FC and 5.0% per annum for LC.
- Base year for cost estimation: May 2018
- Exchange rate: USD 1 = JPY 110.0, USD 1 = MMK 1320, MMK 1 = JPY 0.0833
- Interest during construction is estimated considering that the Project is financed through Japanese ODA Loan. (Loan conditions: Interest rate for construction cost = 0.01%, Interest rate for consulting services = 0.01%, Repayment period is 40 years including grace period = 10 years)
- Front end fee is 0% because Myanmar is categorized as 'Least among Less Developed Countries' (LLDC).
- Customs rate of 10%, same as prepaid income taxes, is applied to imported goods in reference to the customs tariff of Myanmar, with customs and trade agreement acceded. Also, sales tax rate of 5% is applied to all imported and domestic goods, considering the value added tax rate of 5% in Myanmar.
- Construction cost, consulting service cost, and contingency (physical and price escalation) are portions eligible for ODA loan, while administration cost, interest during construction, and relevant taxes are portions non-eligible for ODA loan, considering that the Project is to be financed by Japanese ODA Loan.

8.2 Construction Schedule

The construction schedule is shown in Figure 8.2.1. The estimated construction period for three components of the project is shown below.



Note: Alignments of sewer lines in CP-1 are shown in Figure 6.8.5 in main report

Source: JICA Study Team

Figure 8.2.1 Construction Schedule

CHAPTER 9 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

9.1 Purpose of the Considerations

The "environmental and social considerations" (ESC) in the Study examines if the project complies or will comply with all the Japanese and Myanmar requirements.

9.2 General Requirement of the JICA Guidelines

In accordance with the JICA Guidelines for ESC (2014) (herein after referred to as "JICA Guidelines"), the Project proposed by the Study has been classified as "Category B" by JICA. (See Appendix 16 of the Main Report)

9.3 Environmental Management of Myanmar

9.3.1 Major Legislative Framework on Environment

The major laws, regulations and guidelines for the environmental management and EIA are as follows (See Table 9.3.1 of the Main Report).

- Environmental Conservation Law (2012)
- Environmental Conservation Rules (2014)
- Environmental Impact Assessment Procedure (2015) (EIA Notification No. 616 / 2015)
- National Environmental Quality (Emission) Guidelines (2015) (NEQG 2015)

9.3.2 Other Relevant Laws and Regulations on Environment

See Table 9.3.2 of the Main Report.

9.3.3 International Environmental Conventions/ Protocols/ Agreements

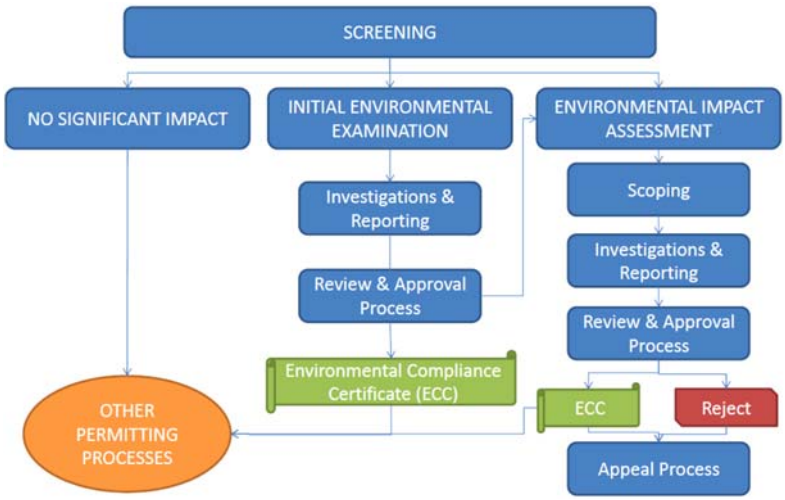
Myanmar as one of the parties signed more than 30 international and regional conventions and protocol on environment. (See Table 9.3.3 of the Main Report)

9.3.4 Institutional Framework on Environmental Management

The Ministry of Natural Resources and Environmental Conservation (MONREC)" is the nodal governmental body. The Environmental Conservation Department (ECD) of the MONREC is to take responsibility for the environmental conservation and management as well as the EIA procedures.

9.3.5 EIA System and Environmental Compliance Certificate (ECC)

As per the EIA Notification No. 616. 2015 (EIA Notification (2015)), the EIA procedure including ECC issuance can be summarized in Figure 9.3.1. (See Section 9.3.6 of the Main Report)



Source: EIA Good Practices in Myanmar Dr. San Oo Director ECD MONREC, 10 May 2016, ASIA EIA Conference Japan

Figure 9.3.1 Overview of Step and Action/Activity by Each Type Project

9.4 All Environmental Requirements for the Project

9.4.1 Requirements for Category B project by the JICA Guidelines

The Project classified as "Category B" shall compliance with requirements stipulated in the JICA Guidelines.

9.4.2 Requirements for the Project by EIA Notification (2015) of Myanmar

In accordance with Annex A (See Appendix 17 of the Main report) of EIA Notification (2015) the Project is subject to an EIA investigation and is required to obtain an ECC from ECD.

9.4.3 All Environmental Requirements for the Project to Satisfy Both Sides

Requirements for the Project to satisfy both sides can be summarized in Table 9.4.1.

Table 9.4.1 All Environmental Requirements for the Project

Requirement	EIA Notification (2015)	The JICA Guidelines	Both Requirement
EIA Report	Yes (Project is categorized as Waste Management)	No	Yes
ECC	Yes (EIA is required for the Project)	Yes (ECC is to be obtained for the Project)	Yes
RAP	Yes (Households in existing WWTP)	Yes (Households in existing WWTP)	Yes
SHMs	Yes	Yes	Yes
IEE level Study	Not specified	Yes	Yes
Environmental Monitoring	Yes	Yes	Yes
Others (such as IPP)	If required	If required	If required

Source: JICA Study Team

9.4.4 Gap between the JICA Guidelines and the Environmental Management System of Myanmar

Gaps (inconsistencies) between the JICA Guidelines and the Environmental Management System of Myanmar were compared. (See Table 9.4.2 of the Main Report)

9.5 Environmental and Social Conditions related to the Project

As base line on the environmental and social conditions relate to the Project, environmental and social items summarized in the Table 9.5.1 were surveyed in the JICA Study. (See Section 9.5 of the Main Report)

Table 9.5.1 Survey Items for Environmental and Social Conditions

Sector	Items			
Pollution	(1) Air Quality	(2) Noise and Vibration	(3) Water Quality	(4) Solid Waste
Natural Environment	(1) Meteorological Condition	(2) Topography	(3) Geology	(4) Soil
	(5) Hydrology	(6) Flora and Fauna	(7) Protected and Green Areas	(8) Landscape
Social Environment	(1) Demography	(2) Economic Activities	(3) Land Use	(4) Transportation
	(5) Infrastructure and Public Facility	(6) Cultural Heritage	(7) Public Health	(8) Risk

Source: JICA Study Team

9.6 EIA Procedure to be done by YCDC

9.6.1 Budgetary Request for EIA Procedure

YCDC has initiated necessary arrangements on a budgetary request of 50 million Kyat in the next fiscal year (2019-2020) for carrying out the EIA procedure. (See Appendix 19 of the Main Report).

9.6.2 Implementation Method for the EIA Procedure

The following shows implementation methods in carrying out the EIA procedure for the Project .

- Utilization of the JICA Study Results for the EIA
- Supervision of the EIA procedure in the Consulting Services for the Project
- Assignment of international and national experts in environmental assessment and social assessment in the Consulting Services for the Project
- Assignment of counterparts (C/Ps) for the EIA from EDWS/YCDC

9.6.3 Draft Schedule for EIA Procedure and Issuance of ECC

A draft schedule for the EIA procedure and ECC issuance for the Project is shown in Table 9.6.1.

Table 9.6.1 Draft Schedule for EIA and ECC for the Project

Action	2018	2019	2020	2021
JICA Study	▬▬▬▬▬▬▬▬			
Budget for EIA Procedure	▲ Request	▲ EIA Budget Allocation		
EIA Investigation and Issuance of ECC	▪▪▪▪▪▪▪▪ Preparation for EIA	▪▪▪▪▪▪▪▪	▬▬▬▬ EIA Investigation ▲ ECC	
Loan Agreement (L/A)	▲▲ FF & AP Missions	▲ L/A		
Consultant Procurement, D/D and BID		▬▬▬▬▬▬▬▬	▲ BID	▬▬▬▬
Construction				▬▬▬▬

Note: ECC; Environmental Compliance Certificate, FF; Fact Finding, AP; Appraisal, D/D; Detailed Design, BID: Bidding
Source: JICA Study Team

9.7 Land Acquisition and Resettlement

9.7.1 Legal Framework on Land Acquisition and Resettlement of Myanmar

Relevant laws and regulations of Myanmar are shown below (See Table 9.7.1 of the Main Report).

- Land Acquisition Act No. 1/1894
- Land Nationalization Act 1953
- Farmland Law 11/2012
- Farmland Rules 62/2012

However, currently there is no law comprehensively stipulating land acquisition and resettlement in Myanmar.

9.7.2 JICA Policies on Involuntary Resentment

JICA has the JICA policies on involuntary resettlement. (See Section 9.7.2 of the Main Report).

9.7.3 Comparison between the JICA Guidelines and the Laws on Land Acquisition and Resettlement of Myanmar

A comparison between the JICA Guidelines and the laws and regulations on land acquisition and resettlement of Myanmar was made. (See Table 9.8.2 of the Main Report)

9.8 Adaptation to Climate Change

The Project will contribute to the climate change adaptation through improvement of the sewer system facilities.

9.9 Recommendations

9.9.1 Pre-Construction Phase

(1) Necessary Assistance for the EIA Procedure and Investigation

It is desirable for YCDC that during the detailed design, international experts in the field of environmental and social considerations shall be hired, and counterpart staff from EDWS shall be assigned.

(2) Preparation of Transfer Work Plan

YCDC shall prepare a practical transfer work plan for the YCDC staff.

(3) Public Consultations and Meetings regarding the Installation of Trunk Sewer Pipes

YCDC shall hold public consultations and explanatory meetings with surrounding communities and business establishments regarding the installation/construction of the trunk sewer pipes.

9.9.2 Construction Phase

YCDC shall supervise the contractor to manage time restrictions and traffic diversions on installation/construction of the trunk sewer pipes.

9.9.3 Operation Phase

It is preferable that those monitoring of the water quality of the new WWTP effluent are reported to JICA as part of the EMoP.

As environmental management for the sludge transportation trucks, it is desirable to carry out similar environmental management activities required for vehicles during the construction phase.

9.9.4 Complaints and Opinions

The following points are recommended.

- As EDWS has taken actions on complaint and opinions, it can be considered that EDWS has the potential to organize a section specialized for handling complaints and opinions for the Project at the EDWS administrative level.
- At the YCDC administrative level, it can be considered that the Administration Department and the Public Relation and Information Department have the potential to organize a grievance redress mechanism for the Project.
- Such a grievance redress mechanism including the specialized section shall be discussed in the EIA investigation.

CHAPTER 10 FINANCIAL AND ECONOMIC ANALYSIS

10.1 Financing Scheme of the Project

The project is executed by YCDC and its initial investment cost is financed by the Japan International Cooperation Agency Official Development Assistance (JICA ODA) loan (eligible portion) and the Yangon City Development Committee (YCDC) own fund (non-eligible portion). The JICA loan is lent to the Ministry of Planning and Finance (MoPF) based on the Loan Agreement (L/A), and then on-lent to YCDC. The previous on-lending agreement between MoPF and YCDC (for the Greater Yangon Water Supply Improvement project) states that the interest rate and repayment schedule are the same as the L/A, and YCDC will pay it back to MoPF in the local currency. This project expects the same terms and conditions regarding the subsidiary loan agreement.

10.2 Financial Situation of YCDC

YCDC has wide range of responsibilities and has the ability to raise its own revenue through tax collection, fees, license, and property development. Under YCDC, there are 20 departments[1], and the fiscal deficit of a department has been covered by a surplus of other departments. Although its budget is a part of Yangon Region Government (YRG), YCDC does not regularly receive subsidy from YRG nor from the union government.

10.2.1 Financial status of Water and Sanitation

Table 10.2.1 shows the cash inflow and outflow of the department.

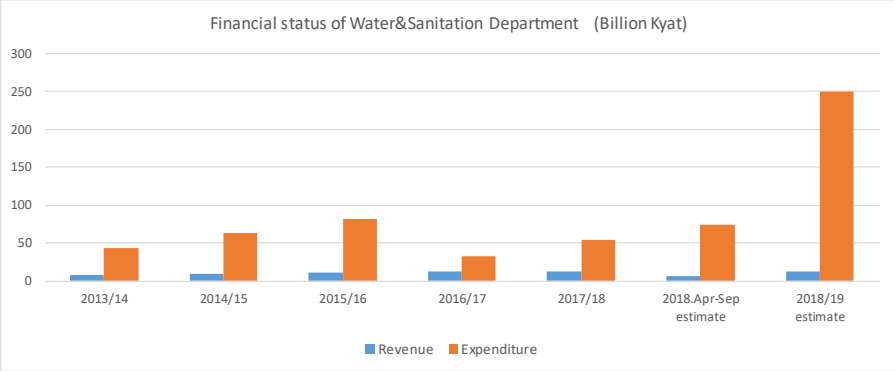
[1] It will be reorganized under the new YCDC law which was approved in June 2018

Table 10.2.1 Revenue and Expenditure of the Water and Sanitation Department

Water & Sanitation Department Fiscal Status (Unit: million Kyat)	Actual 2013/14	Actual 2014/15	Actual 2015/16	Actual 2016/17	Actual 2017/18	Interim period Estimaetd 2018.Apr-Sep	Estimated 2018/19
I. Revenue	**7,599**	**9,288**	**11,753**	**12,104**	**13,323**	**5,961**	**12,519**
1. Water Tariff Revenue	7,084	8,515	10,193	10,908	12,102	5,350	11,419
(1) Government	1,111	1,608	1,697	1,620	1,677	500	1600
(2) Public	5,973	6,906	8,497	9,288	10,425	4850	9818.7
2. House Connection Fees	218	296	536	416	456	282	450
3. Water Meter Sales	130	280	732	549	580	261	519
4. Others	167	197	292	232	186	68	131
II. Operational Expenditure	**-9,377**	**-13,624**	**-16,496**	**-18,153**	**-18,143**	**-10,864**	**-22,439**
1. Salary and allowance	-1,512	-1,729	-2,233	-2,186	-2,146	-1,144	-2,287
2. Materials and service expenses	-5,631	-9,552	-11,474	-13,006	-13,110	-7,989	-15,975
(1) Labor expenses	-951	-1,055	-1,192	-1,407	-1,448	-797	-1,602
(2) Transportation	-27	-28	-30	-11	-16	-15	-20
(3) Fuel and lubricant	-121	-72	-45	-33	-50	-50	-100
(4) Electricity	-2,865	-6,374	-8,964	-10,111	-9,838	-5,400	-10,800
(5) Equipment	-1,603	-1,943	-1,192	-1,381	-1,688	-1,672	-3,339
(6) Others	-63	-80	-50	-63	-69	-55	-114
3. Maintenance expenses	-2,234	-2,343	-2,789	-2,961	-2,886	-1,731	-4,178
(1) Machinery and accessories	-240	-290	-143	-150	-237	-220	-451
(2) Buildings	-340	-340	-337	-314	-200	-185	-524
(3) Roads	-59	-60	-95	-147	-86	-150	-550
(4) Vehicles	-20	-18	-19	-19	-25	-25	-50
(5) Watercrafts	-10	-9	-3	-3	-3	-3	-3
(6) Others	-1,566	-1,626	-2,192	-2,328	-2,335	-1,149	-2,600
Operational Margin	**-1,779**	**-4,336**	**-4,743**	**-6,049**	**-4,820**	**-4,902**	**-9,920**
(% to Revenue)	-23%	-47%	-40%	-50%	-36%	-82%	-79%
III. Capital Expenditure	**-34,402**	**-49,362**	**-65,461**	**-14,920**	**-36,733**	**-63,943**	**-226,942**
1. Expansion of piping	-190	-2,243	-5,146	-1,277	-3,626	-718	-5,198
2. Water supply projects	-32,153	-38,860	-56,055	-11,863	-29,375	-60,741	-211,236
(1) Ngamoeyeik-Hlawga	-13,299	-11,571	-31,766	-3,987		-4,603	-8,595
Ngamoeyeik-Hlawga (YCDC)	-12,665	-9,185	-19,227	-2,814			
Ngamoeyeik-Hlawga (ODA Grant)	-634	-2,385	-12,539	-1,172			
(2) Lagunbyin	-12,834	-22,328	-15,913	-6,580	-26,404	-46,436	-98,518
Lagunbyin (YCDC)	-12,834	-22,328	-13,098	-3,554	-4,741	-5,011	-20,925
Lagunbyin (ODA Loan)	0	0	-2,815	-3,026	-21,663	-41,425	-77,593
(3) Greater Yangon Water Supply	-3,350	-930	-282	-204	-202	-1,677	-4,445
(4) Reservoirs and tube wells	-2,556	-3,527	-5,231	-821	-2,629	-2,515	-2,990
(5) Hlawga-Yangon	-115	-5	-80	0	0	0	0
(6) Kokkowa	0	-498	-2,783	-271	-140	-5,510	-96,688
3. Sanitation works	-167	-241	-208	-55	-389	-352	-3,693
4. Water supply facility expansion	-1,843	-7,950	-4,013	-1,725	-3,344	-2,132	-6,815
(1) Water supply facility expansion (Downtown)	-732	-4,922	-2,990	-510	-3,344	-2,132	-6,815
(2) Myo Daw purified water production	-784	-3,028	-1,024	-1,215	0	0	0
(3) Pipe production factory	-327	0	0	0	0	0	0
5. Sewerage treatment plant	-49	-69	-39	0	0	0	0
Total Revenue	**7,599**	**9,288**	**11,753**	**12,104**	**13,323**	**5,961**	**12,519**
Total Expenditure	**-43,779**	**-62,986**	**-81,957**	**-33,073**	**-54,876**	**-74,807**	**-249,381**
IV. Surplus (Deficit)	**-36,181**	**-53,698**	**-70,205**	**-20,969**	**-41,553**	**-68,845**	**-236,862**

Source: JICA Study Team based on Water and Sanitation Department
Note: In 2018, fiscal year calendar of Myanmar has been changed to October-September, from April to March. Government sets April to September 2018 as interim period.

About 90% of the revenue comes from the water tariff, and the rest comes from house connection fees and water meter sales. The only revenue from the sewerage service is the one-time permit grant fee of septic tanks, which is negligible. The operational expenditure alone exceeds the total revenue where the electricity bill being the largest portion. As the two ODA loan projects (Greater Yangon Water Supply Improvement Projects) proceed, deficit of the department is expected to be larger (Figure 10.2.1). Water tariff increase and introduction of wastewater tariff are critical steps to improve the status and will be discussed later in this chapter.

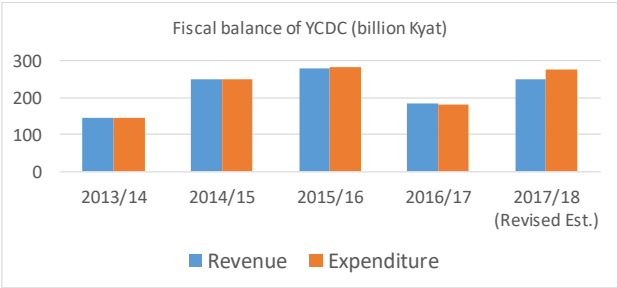


Source: JICA Study Team based on Water and Sanitation Department

Figure 10.2.1 Fiscal Balance of Water Supply and Sanitation Department

10.2.2 Financial status of YCDC

Figure 10.2.2 below shows YCDC's fiscal scale and balance. The city has been keeping its balance by adjusting its capital expenditure to revenue fluctuation, except for 2015/16 when the union government decided to raise the officials' salaries and YCDC made a deficit, which was later covered by the union government.



Source: JICA Study Team based on YCDC

Figure 10.2.2 Fiscal Scale and Balance of YCDC

Looking into the breakdown (Table 10.2.2), current revenue keeps surplus over operational expenditure throughout 2013/14 to 2017/18. Capital revenue is deeply affected by the real estate market: 70-80% of which comes from the Engineering Department (building) plus the City Planning and Land Administration Department through land lease and housing activities. Therefore, capital revenue dropped in 2016/17 due to the government's introduction of relevant regulations and following the market stagnation. Capital expenditure grows rapidly from 2013/14 to 2015/16, majority of which is spent on roads and bridges (40%), water and sanitation (31%), and building (17%) projects. Then it was cut by 61% in 2016/15 to make balance with decreasing revenue, but quickly increased next year, and 48% of it was spent on water and sanitation projects.

Table 10.2.2 YCDC Revenue and Expenditure

	YCDC revenue and expenditure		Actual 2012/13	Actual 2013/14	Actual 2014/15	Actual 2015/16	Actual 2016/17	Revised Est. 2017/18
I.	**Revenue**		**103,167**	**145,768**	**252,179**	**279,359**	**184,888**	**250,579**
		(Growth %)		*41%*	*73%*	*11%*	*-34%*	*36%*
	1.	Current revenue	95,311	92,180	134,232	141,795	140,821	145,146
	2.	Capital revenue	7,856	52,953	115,562	122,210	39,870	46,516
	3.	Foreign Grant		634	2,385	12,539	1,172	0
	4.	Loan				2,815	3,026	58,917
II.	**Expenditure**		**100,198**	**145,727**	**252,141**	**284,826**	**181,761**	**278,563**
	1.	Current expenditure	48,273	50,410	67,693	79,779	101,337	103,370
	2.	Capital expenditure	51,926	95,317	184,448	205,047	80,424	175,192
III.	**Surplus (Deficit)**		**2,969**	**41**	**38**	**(5,467)**	**3,127**	**(27,984)**

Source: JICA Study Team based on YCDC

CHAPTER 11 ORGANIZATION DEVELOPMENT AND INSTITUTIONAL ARRANGEMENT

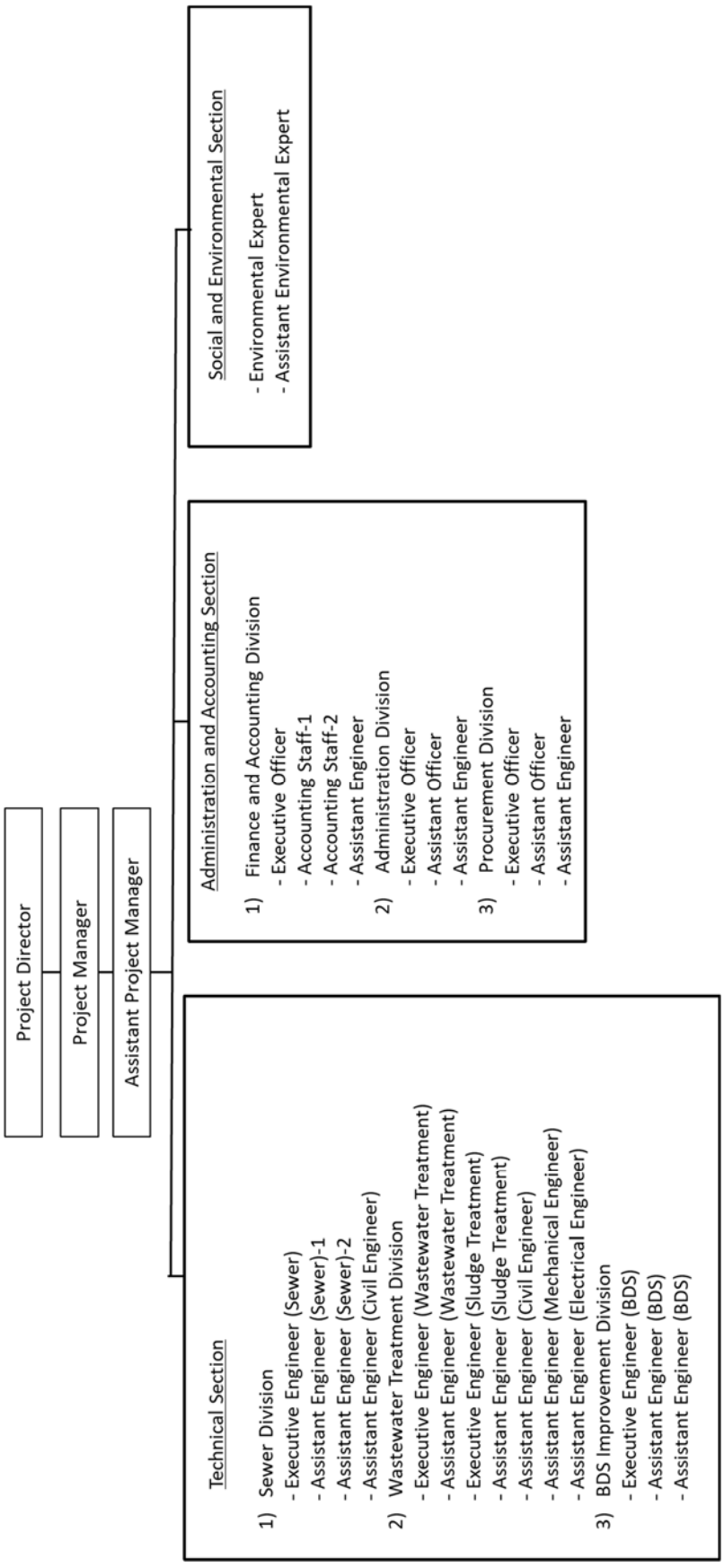
11.1 Required Capacity Development

The implementation of the Project includes “detailed design”, “tender assistance”, and “construction”, which includes the selection of the consultant and contractor for implementation. The Yangon City Development Committee (YCDC) shall provide a project management unit and selection committee for management of the implementation procedures.

11.2 Capacity Development for Project Implementation

For the Project, the project management unit (PMU) is proposed as shown in Figure 11.2.1. The PMU shall be established before the commencement of the consulting service for the project.

As for the selection of the consultant and contractor working for the Project, a “selection committee” will be established. The secretary of the YCDC will be the head of the committee.



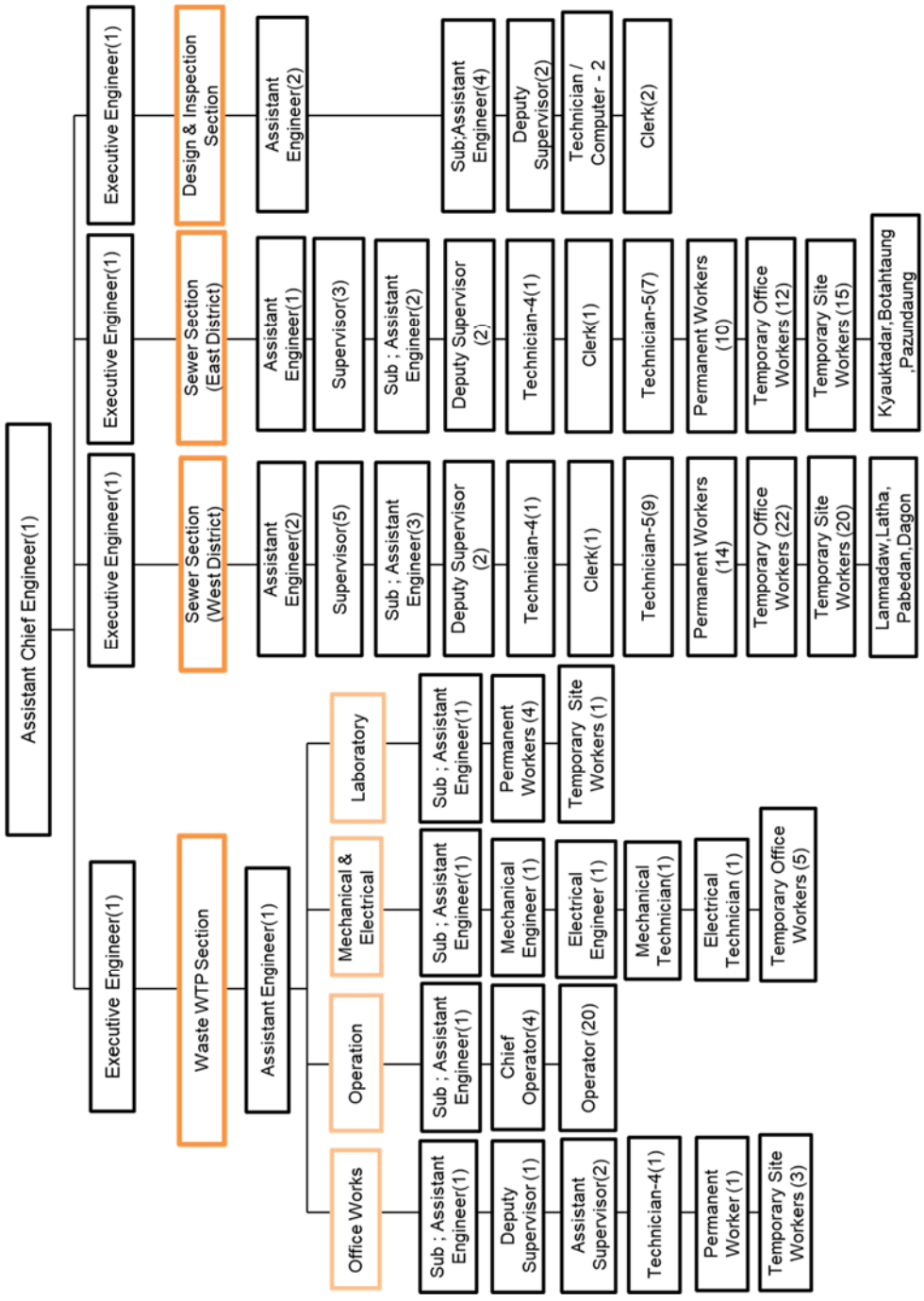
Source: JICA Study Team

Figure 11.2.1 Proposed Organization Chart of the Project Management Unit

11.2.1 Capacity Development for Operation and Maintenance

After discussion with the Water and Sanitation Department, the JICA Study Team proposed the development of O&M organization, considering adoption of advanced technologies (MBR and Sludge Drying Process) and changing sewer pipe network, considering demolishment of ejection system and expansion of the network. Source: JICA Study Team based on the information from YCDC

Figure 11.2.2 shows the proposed organization chart of the Sanitation Division for O&M of the new sewerage system.



Source: JICA Study Team based on the information from YCDC

Figure 11.2.2 Proposed Organization Chart of the Sanitation Division in YCDC

11.3 Institutional Arrangement

For successful O&M of the new sewerage system, capacity development shall be proposed considering the following points:

1) Organization Development

Development of an organization for the O&M of the new wastewater treatment plant using advanced technologies, such as Membrane Bioreactor (MBR) and Sludge Drying Process

Change of the organization for the O&M of the new sewer pipe networks due to the demolishment of the existing ejector system and the expansion of the pipe networks

2) Establishment of a Law and Standard for Construction and Operation

The service population is required to complete house connections to the sewer network on their own cost, under the Sewerage Law. The Sewerage Law requires to complete the sewerage system, hopefully before the commencement of the construction of the Project.

For suitable operation of the system, various standards and regulations are required such as effluent water quality standards of the public water body, regulation for emergency case, standard and regulation on discharging to the sewerage system, regulations on sludge disposal and reuse, regulation for setting the sewerage tariff and collection.

3) Finding a Financial Source

After completion of the Project, a certain amount of annual budget will be required for operation and maintenance of the new sewerage system to be established by the Project.

The sewerage tariff and government subsidy are possible and essential financial sources. Before commencement of the operation of the new wastewater treatment plant in 2023, setting the sewerage tariff and governmental subsidy rules should be established for preparation of enough budget.

CHAPTER 12 CONCLUSIONS AND RECOMMENDATIONS

12.1 Conclusions of the Study

The three packages, CP-1: Sewer, CP-2: WWTP and CP-3: BDS sewer connection, have been proposed in this study.

As reported, there is an existing sewerage system established for a part of the target area. However, the existing system has serious problems and does not function properly. Firstly, the existing system collects only black water, and grey water is discharged to drains and finally to the river without any treatment. The ejector system which collects black water was constructed in 1888 and has been used until now with only occasional minor repairs. Procurement of spare parts is also difficult due to the obsolete system. The corrosion of the force main is very concerning, and the investigation for the whole existing sewer system is difficult.

Considering increased future wastewater, it is decided that the existing ejector system is to be abandoned, and a new sewer is to be constructed because the rehabilitation of the existing system is difficult from the technical and economical point of view.

On the other hand, the Membrane Bioreactor (MBR) process for wastewater treatment has been selected mainly because of the land limitation and the mechanical sludge drying process that has been adopted for minimizing the sludge volume from the WWTP. In the future, the YCDC will further study the possibility of installing incineration facilities in the area.

When the entire planned sewerage facilities are completed, all wastewater generated in the target area will be collected and treated. Thus, it would lead to the improvement of the citizen's living conditions and water quality in the public water receiving body.

12.2 Summary of Project Scope

The following project scope in Table 12.2.1 has been proposed and concluded throughout the study.

Table 12.2.1 Project Scope

	Work Item	Description
1	**Sewer (CP-1: ICB)**	**[Sewer (open-cut)]** 26,320 m (Central Business District (CBD): 13,113 m, Dagon: 13,207 m) Diameter: 200 mm - 450 mm **[Sewer (pipe-jacking)]** 26,319 m (Central Business District (CBD): 21,263 m, Dagon: 5,056 m) Diameter: 200 mm - 1,500 mm

		Vertical shaft: H = 4.00 m – 14.90 m, 210 Nos. **[Manhole]** 732 Nos.
2	**Wastewater Treatment Plant (WWTP) (CP-2: ICB)**	Capacity: 112,000 m^3/day (The 1st phase construction (the first three years of the construction period): 56,000 m^3/day. The 2nd phase construction (the last three years of the construction period): 56,000 m^3/day Wastewater Treatment Facility: Membrane Bioreactor (MBR) Influent Pumping Station: Q = 30 m^3/min x 6 Nos. (4: duty, 2: stand-by) Sludge Treatment Facility: Thickener, Dewatering machine, Mechanical Dryer (100 t/day x 2 Nos.) Administration Building: Administration Office, Operation Room (SCADA), Laboratory, PR Facility Electrical Room: (capacity) 4,000 KVA Effluent Pipeline (outlet): Diameter: 1,000 mm x 2 Nos., L = 20 m
3	**BDS Sewer Connection (CP-3: LCB)**	BDS sewer connection with chamber to collect graywater: 176 Nos. Pilot BDS sewer replacement: 6 Nos. Connection from ejector chamber to the main sewers: 40 Nos.

12.3 Operation Indicator and Effect Indicator

Operation and Effect Indicators for the project is shown in Appendix 21.

12.4 Required Additional Study in Detailed Design Stage

The following additional studies will be required during the detailed design stage:

12.4.1 Environmental Impact Assessment (EIA) Assistance

Further study on the environmental and social considerations is required for the assistance of the EIA which will be obtained by the YCDC.

12.4.2 Investigation of Sewage Sludge Characteristics

During the detailed design of the sludge treatment facilities, detailed investigation of the sewage sludge characteristics is required in order to fix the scale of the facilities.

12.4.3 Soil Investigation

Soil investigation along the alignment of the sewer will be required in order to select the pipe installation method. Especially, the type of pipe-jacking machine is determined through the result of the investigation.

12.5 Recommended Further Assistance

12.5.1 Technical Transfer

In order to operate the new sewerage facilities such as MBR, dewatering machine and sludge drying machine properly, special training for the YCDC staff by an operation specialist who is dispatched by the supplier will be necessary. Also, the daily operation and maintenance status of the WWTP are not recorded at present, therefore, it is an obstacle to establish an appropriate maintenance plan. This issue should be addressed by a specialist, accordingly.

In addition, the sewerage assets database should be introduced for planning of maintenance works and stock management for the future.

12.5.2 Capacity Development

As reported in Chapter 4 and Chapter 11, at present the development of wastewater treatment in Yangon City remains at an overall low level, therefore, the skills for sewerage works including operation and maintenance are at a low level too. Capacity development in the individual, organizational and societal level is required for improvement of wastewater treatment in new facilities.

Institutional development, development of legal and regulatory frameworks, social and environmental activities for local people aiming at enhancement of developing wastewater facilities should be considered a priority.

In order to appropriately operate new sewerage systems in the near future, cultivation of experienced trainers capable of giving guidance and acquisition of broader and deeper understanding and technology by the trainers are essential. From the long-term point of view, it is expected to nourish resource persons effectively, and it is required to ensure that they teach the knowledge and experiences that they obtained to the younger staff. Furthermore, it is necessary to develop an environment for individuals to improve their motivation for learning.

At the initial stage, a technical assistance project carried out by foreign experts who have enough knowledge and skills is necessary for the entire capacity development of the YCDC staff.

12.5.3 Formulation of a Master Plan for Sludge Treatment

YCDC is interested in the introduction of an incinerator for the generated sludge in the future. In connection to this, the generated sludge from the several locations of WWTPs that are to be developed in the future has to be disposed after a certain treatment. It is recommended to formulate a master plan for sludge treatment to grasp the sludge treatment policy as a long-term plan of Yangon City, including the scope of works such as projection of generated sludge volume, treatment method, disposal site, and reuse of the sludge.