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

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

VOLUME VII
SEWERAGE AND DRAINAGE SYSTEM
FEASIBILITY STUDY

< Advance Version >

MARCH 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

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

FINAL REPORT

MARCH 2014

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Abbreviation

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

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

Abbreviation for the Relevant Studies

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

Unit

1 Gallon (British Gallon) = 4.546 liter

1 Acre = 4,047 m^2

Foreign Exchange Rate

1 USD = 101.1 JPY

1 Kyat = 0.114 JPY

1 UAD = 885 Kyat

(as of June 2013)

CHAPTER 1. SUMMARY OF MASTER PLAN AND PROJECT FOR FEASIBITY STUDY

1.1 Summary of Master Plan

A total of 13 sewerage zones in 2040 which is the target year of the planning, has been formulated taking into consideration urbanization conditions, topography and situation of wastewater-receiving water bodies. Among 13 sewerage zones, 6 zones were selected as sewerage planning areas and planning of sewerage facilities was carried out. In the sewerage planning area, 4.21 million persons which accounts for 49 % of the total 8.52 million persons in YCDC in 2040 was estimated to be served by sewerage system in 2040. The rest of the population, which is approximately a half of the total population cannot avail sewerage service. Also, even in the sewerage planning area, it takes a long time to provide sewerage system. Therefore, improvement of the existing wastewater treatment systems and/or introduction of new systems is proposed other than provision of sewerage system. In addition, possibility of adoption of interceptor sewerage system was examined to reduce initial investment.

Priority of 6 sewerage zones as regards sewerage system provision was evaluated based on progress of urbanization, physical conditions of the zone and impact on water pollution. As a result, C1 Sewerage Zone is considered to have the highest priority. Thus, feasibility study was determined to be carried out for sewerage system in C1 Sewerage Zone.

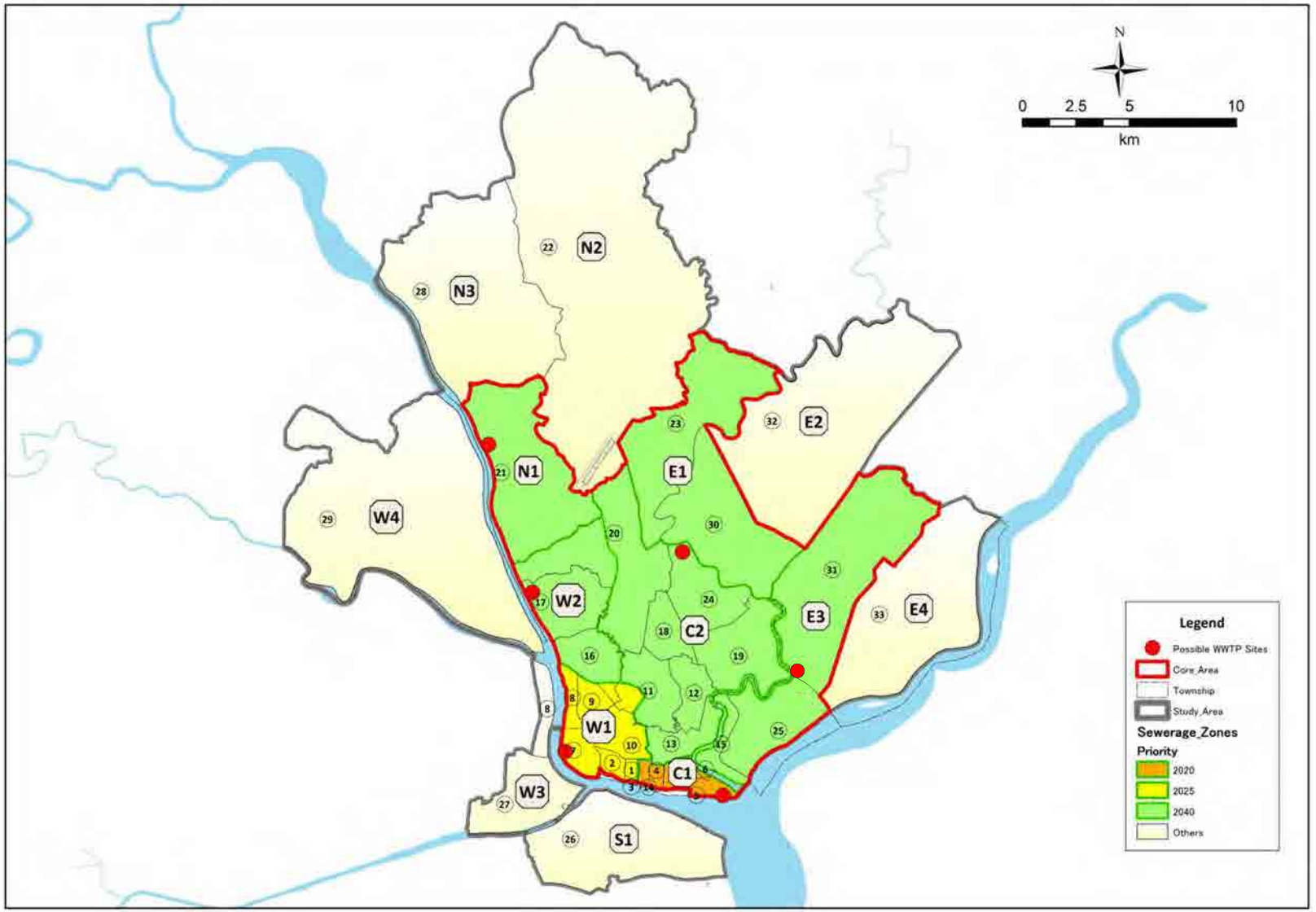
All 13 sewerage zones and 6 of them for sewerage planning are shown in Table 1.1 and Figure 1.1.

Table 1.1 Sewerage Zones

Sewerage Zone	Population (person)	W. Flow (m^3/day)		Area (ha)	Township	Remark
		Daily Ave.	Daily Max.			
C 1	178,127	64,276	70,213	499	Pazundaung, Botahtaung, Kyauktada, Pabedan	
C 2	1,191,499	452,548	492,264	6,102	a part of Bahan, Mingalar Taung Nyunt, Tamwe, South Okkalapa, Thingangyun, Yankin, a part of Mayangone	
W 1	483,058	169,214	184,247	1,654	Lanmadaw, Latha, Dagon, a part of Bahan, a part of Kyee Myin Daing, Ahlone, Sanchaung, a part of Kamaryut	
W 2	349,512	116,999	126,410	2,356	Hlaing, a part of Kamaryut, a part of Mayangon	
W 3	74,419	14,512	15,628	1,485	A part of Kyee Myin Daing, Seikgyikhanaungto	
W 4	737,724	191,809	206,563	7,761	Hlaing Tharyar	
N 1	377,188	129,633	139,691	3,163	Insein	
N 2	906,748	294,693	317,362	12,783	Mingaladon	
N 3	514,954	100,416	108,140	5,271	Shwe Pyi Thar	
E1	710,656	232,953	252,094	5,184	North Okkalapa, North Dagon	to be combined to C2
E 2	1,183,320	269,207	289,915	17,064	East Dagon	
E 3	920,933	243,849	263,583	5,418	Dawbon, Taketa, South Dagon	
E4	399,111	77,827	83,814	4,202	Dagon Seikkan	
S 1	490,032	127,409	137,210	9,840	Dala	
Out of SZ	2,241	971	1,046	117	Seikkan	
Total	8,519,522	2,486,316	2,688,180	82,899		

Note: [ ] to be implemented by 2040

Source: JICA Study Team



Source: JICA Study Team

Figure 1.1 Thirteen (13) Sewerage Zones and Six (6) of them to be Served by 2040

Objectives of the feasibility study (FS) include sewerage facilities in C1 sewerage zone. Because C1 sewerage zone is the current sewerage service area, improvements and expansion of the existing systems are to be studied. The existing sewerage system collects and treats only toilet wastewater (black water), and gray water is discharged to storm water drain without treatment. In addition wastewater collecting system is unique so called "ejector system" which was introduced by British in 19th century. Original equipment has been used except for driving system which was changed from steam engine to electric motor in 1960s. Ejector system was designed based on the design wastewater flow, 14,775 m^3/day and the capacity of the system will be insufficient for the design wastewater flow in 2040. In addition, force main has been used till now far beyond its useful life time, and inspection on deterioration of pipe interior and sediments in pipe cannot be carried out. Procurement of spare parts becomes difficult currently. Taking into account these conditions, entirely new pipe network is to be planned. As regards house connection, existing pits, which are usually provided as one for black water and one for gray water for each building are determined to be used from observation. Branch sewers and manholes to be connected to these pits will be planned and constructed.

On the other hand, civil works of the existing WWTP, which was designed based on extended aeration process, are determined to be used since the plant has been commissioned recently in 2006, and site investigation confirmed this. Mechanical equipment will be changed entirely, because useful life time of them will be expired at expected commissioning of the plant and treatment process will be changed to conventional activated sludge. Existing structures will be used as much as possible, and expansion is designed to cover insufficient portion.

In addition to the sewerage system in C1 sewerage zone, water quality improvement of Kandawgyi Lake which was requested strongly by YCDC is included in FS. Kandawgyi Lake is a valuable recreation area for citizens of Yangon, which is confirmed in HIS conducted by JICA in 2012. Eutrophication has been progressing in the lake water because of wastewater from households and restaurants in the surrounding areas, and blue-green algae are blooming. Dilution of water cannot be expected even in rainy season, and accumulation of nutrients is progressing. Therefore, to thoroughly improve water quality in the lake, various measures should be taken systematically. Kandawgyi Lake and surrounding areas are included in C2 sewerage zone. C2 sewerage zone is included in sewerage planning area up to 2040, and commissioning of C2+E1 WWTP is planned in 2027. Significant water quality improvement cannot be expected until the provision of the sewerage system, however, temporary measures should be taken to prevent further deterioration of water quality in the lake. Otherwise valuable water resource will be lost. Possible measures, their effects, and costs will be studied here.

1.2 Existing System

As mentioned previously, C1 sewerage zone is currently served with sewerage system. Black water is collected by ejector system and treated at WWTP. Existing sewerage system is described in Section 3.3 of MP. Brief description of the ejector system and WWTP is given in Tables 1.2 and 1.3.

Table 1.2 Outline of Ejector System

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

Source: JICA Study Team

Table 1.3 Outline of Wastewater Treatment Plant

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

Source: JICA Study Team

Surrounding areas of Kandawgyi Lake are not served with sewerage system, and black water is infiltrated into ground after treatment by septic tanks or without any treatment, and gray water is discharged to storm water drains. Large and small size restaurants, and a large hotel exist around the lake, and wastewater from kitchen and the other facilities is discharged to the lake. Simple treatment facilities such as oil trap were installed for kitchen wastewater before, new treatment facilities have been introduced in some restaurants recently in accordance with YCDC guidelines.

CHAPTER 2. WATER QUALITY IMPROVEMENT OF KANDAWGYI LAKE

2.1 Outline of Kandawgyi Lake and Its Basin

Kandawgyi Lake is located in Bahan Township (T/S). Surface area is 647,489m^2 .Surrounding area of Kandawgyi Lake is developed as park area, and this park is a valuable recreation area for residents of Yangon.

Kandawgyi Lake was constructed in 1879 as the water source for Yangon City. In 1884, water transmission facility from Inya Lake (north of Kandawgyi Lake) was constructed to compensate increasing water demand of Yangon City. However, water quality and capacity of Kandawgyi Lake became insufficient because of the development of surrounding area of Kandawgyi Lake. Therefore, after Hlawga Lake was developed as water source, the function of Kandawgyi Lake as water source was finished in 1904.

Because of the geomorphic characteristics around Kandawgyi Lake, catchment basins are located in north and east areas of the lake. Discharges from south and west areas of the lake do not flow into Kandawgyi Lake. Especially, discharge from west area by-passes Kandawgyi Lake, and is discharged directly to downstream of Kandawgyi Lake.

Therefore, Kandawgyi Lake receives discharges from part of Bahan T/S and Tarmwe T/S. In addition, restaurants and small cafes on the north – east lakeside area discharge their wastewater into Kandawgyi Lake.

2.2 Outline of Project

Household Interview Survey (HIS) by JICA in 2012 showed that Kandawgyi Lake and its surrounding area is a valuable recreation area for Yangon citizens.

However, water quality of Kandawgyi Lake is deteriorated by the inflow of domestic wastewater from Bahan T/S and Tarmwe T/S, and wastewater discharge from restaurants and cafes around the lake. At present, Kandawgyi Lake has become eutrophic, and blue-green algae are growing all the year round.

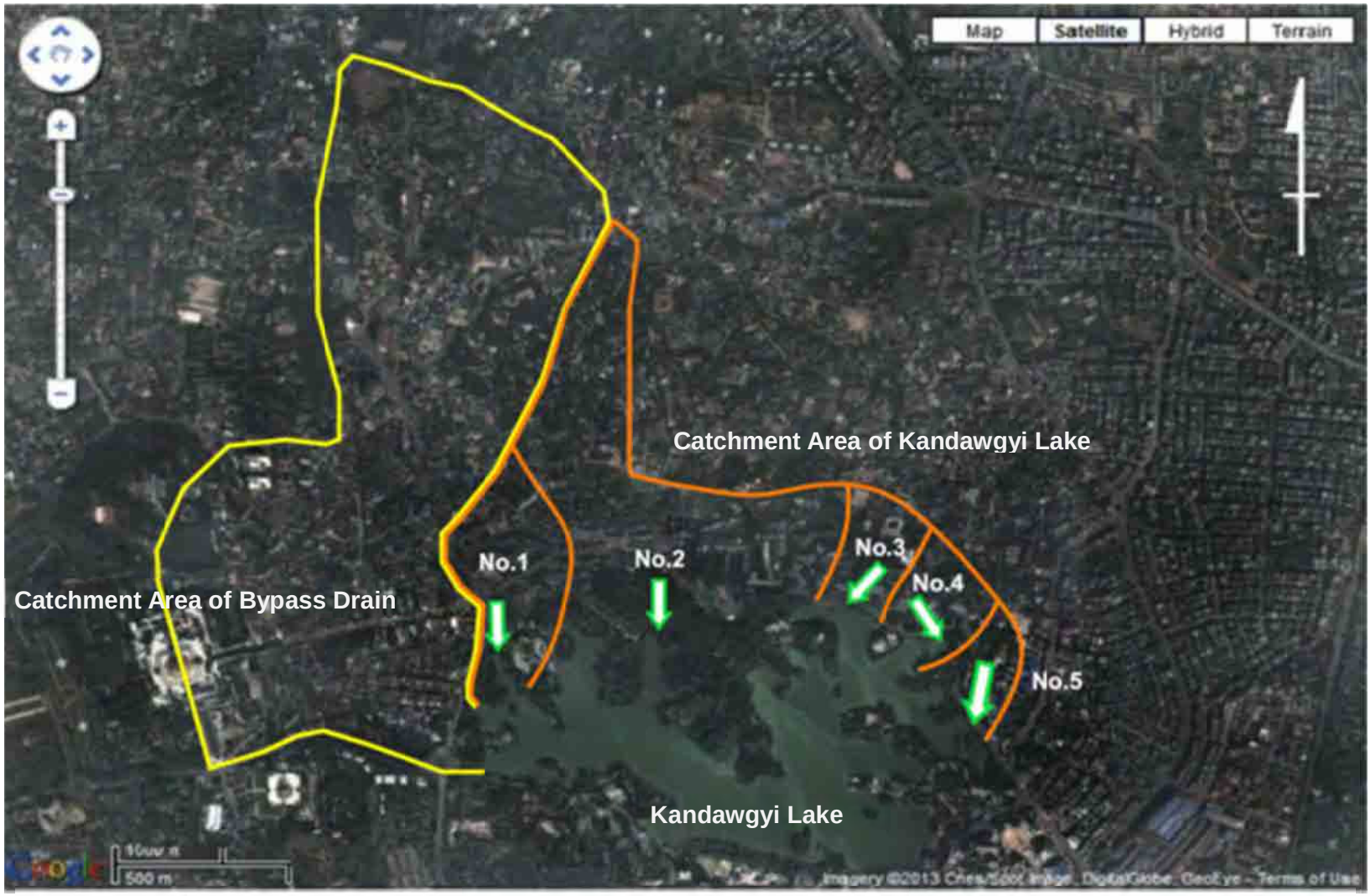
Even in rainy season, extensive lake water exchange of Kandawgyi Lake is not expected, because Kandawgyi Lake is a closed water body. Therefore, accumulation of nutrients is progressing due to the inflow of wastewater.

Therefore, it is necessary to implement comprehensive water quality improvement measures with a number of ways including interception of wastewater inflow from surrounding catchment area and commercial facility near the lake.

Kandawgyi Lake and its catchment area are included in C2 sewerage zone. C2 sewerage zone is included in sewerage system development area up to 2040. However, the priority of development is assessed to be 3rd priority following C1 sewerage zone as 1st priority and 2nd priority going to W1 sewerage zone. Moreover, implementation plan of Master Plan (MP) proposes that commencement of WWTP for C2 + E1 should be in 2027.

Development of sewerage is necessary to achieve fundamental water quality improvement of Kandawgyi Lake. However, implementation of some alternative measure is necessary to prevent degradation of water quality and landscape of Kandawgyi Lake.

In this section, possible alternative measures for Kandawgyi Lake water quality improvement, i.e. construction of interceptor sewer, installation of Johkaso, dredging of sediment and water transmission from Inya Lake are discussed.



Source: JICA Study Team

Figure 2.1 Kandawgyi Lake Catchment Area

2.3 Comparison of Water Quality Improvement Measures

In this Section, four (4) water quality improvement measures, i.e. construction of interceptor sewer, installation of small domestic sewage treatment apparatus (Johkaso), dredging of sediment and water transmission from Inya Lake are discussed.

2.3.1 Construction of Interceptor Sewer

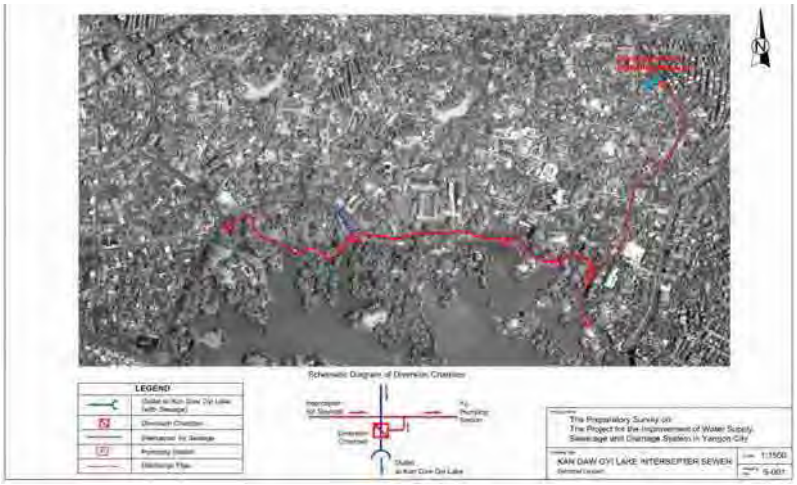
The interceptor sewer intercepts wastewater discharge from Bahan T/S and Tarmwe T/S, and conveys it to the existing drain. Wastewater from Bahan T/S and Tarmwe T/S flows into Kandawgyi Lake through 5 drains (No.1 to No.5, see Figure 2.1). Catchment area and flow of each drain are as follows;

Table 2.1 Drain around Kandawgyi Lake

Drain	Bahan T/S			Tarmwe T/S	
	No.1	No.2	No.3	No.4	No.5
Catchment area (ha)	10.8	49	9.7	11.2	6.6
Daily average flow : m^3/day (2011)	652	1,799	327	829	488
Estimated daily average flow :m^3/day (2025)	768	2,122	386	706	706
Estimated daily average flow :m^3/day (2040)	1,008	2,783	507	935	935

Source：JICA study team

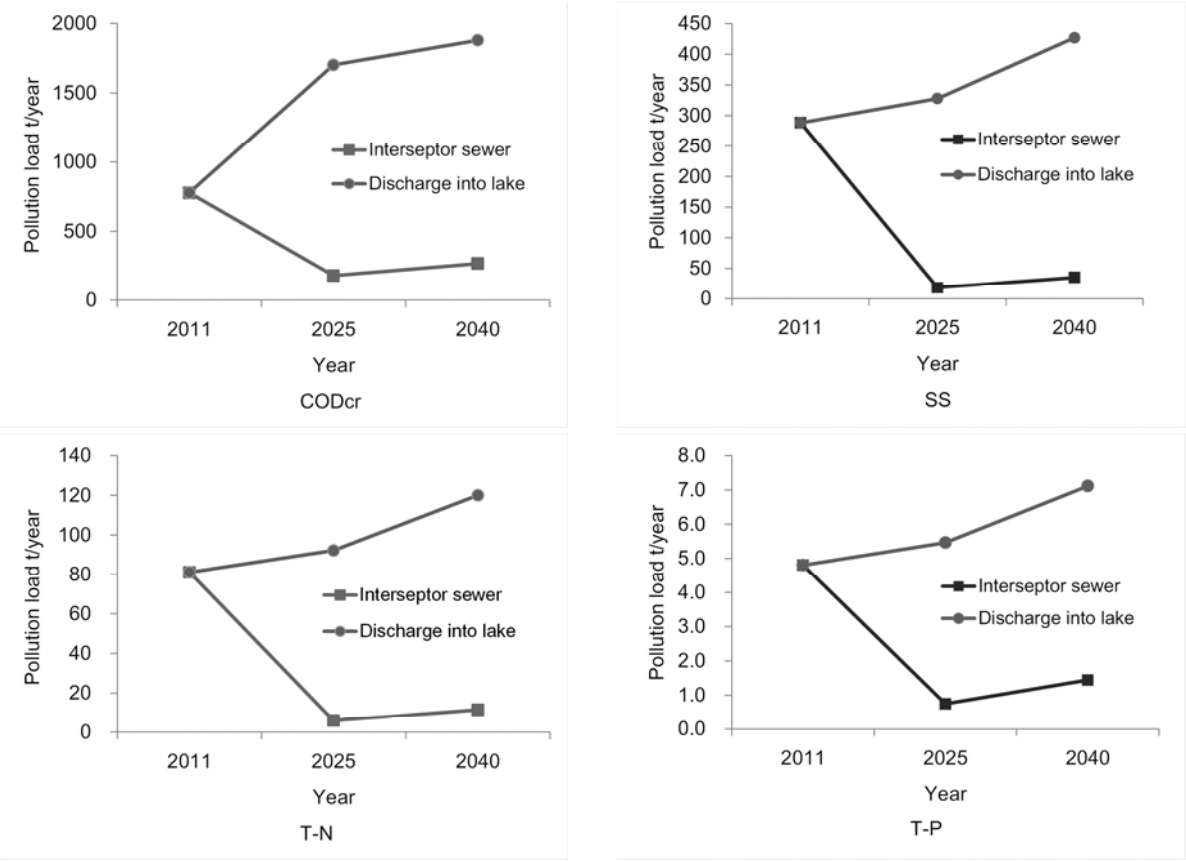
Layout of interceptor sewer is shown below. Interceptor sewer is so constructed that it connects outlets No.1 to No.5, and that wastewater from restaurants around Kandawgyi Lake can be intercepted. Intercepted wastewater is pumped and discharged in existing drain. Design capacity of interceptor sewer is equal to dry weather flow (hourly maximum flow). When it rains, combined sewage flow in excess of hourly maximum flow is discharged into Kandawgyi Lake.



Source：JICA study team

Figure 2.2 Layout of Interceptor Sewer

Following Figures show changes of pollution load with or without interceptor sewer. In these Figures, "Interceptor sewer" means domestic wastewater and restaurant wastewater are intercepted by interceptor sewer and "Discharge into lake" indicates domestic wastewater and restaurant wastewater are discharged directly into Kandawgyi Lake.



Source：JICA study team

Figure 2.3 Variation of Pollution Load Which Flows into Kandawgyi Lake

If interceptor sewer is not constructed (Discharge into lake), pollution load increases year after year due to the increase of population in the catchment area. On the other hand, when interceptor sewer is constructed, large amount of pollution load is intercepted, and pollution load to Kandawgyi Lake decreases drastically. Especially, large portion of pollution load of Nitrogen and Phosphorus are reduced. Therefore, interceptor sewer is an effective measure for eutrophication control.

2.3.2 Installation of Small Domestic Wastewater Treatment Apparatus (Johkaso)

(1) Installation of restaurant wastewater treatment facility by YCDC

In Kandawgyi Lake Park area, 8 restaurants, 1 hotel and 20 small café and shops are existing (See next Table). All of these facilities except 1 restaurant (Karaway Palace) and 1 hotel (Kandawgyi Palace Hotel) are discharging wastewater into Kandawgyi Lake.

Table 2.2 Restaurant and Hotel around Kandawgyi Lake

Type	Name	Water consumption (m^3/day)	Wastewater treatment method and discharge
Restaurant	Dolphin	23	New water treatment facility instructed by YCDC. Treated water is discharged into Kandawgyi Lake.
	Royal Garden	60	
	Bangkok Kitchen	7	
	White Rice	3	
	Signature Garden	11	
	Western Park Royal	31	
	Utopia	30	
	Karaway Palace	64	Septic tank Effluent is discharged into drain.
Hotel	Kandawgyi Palace Hotel	12	New water treatment facility instructed by YCDC. Treated water is discharged into drain.
Café, Small store	Total 20 Café and small store	No Data	Grease trap, Septic tank or untreated

Source：JICA study team

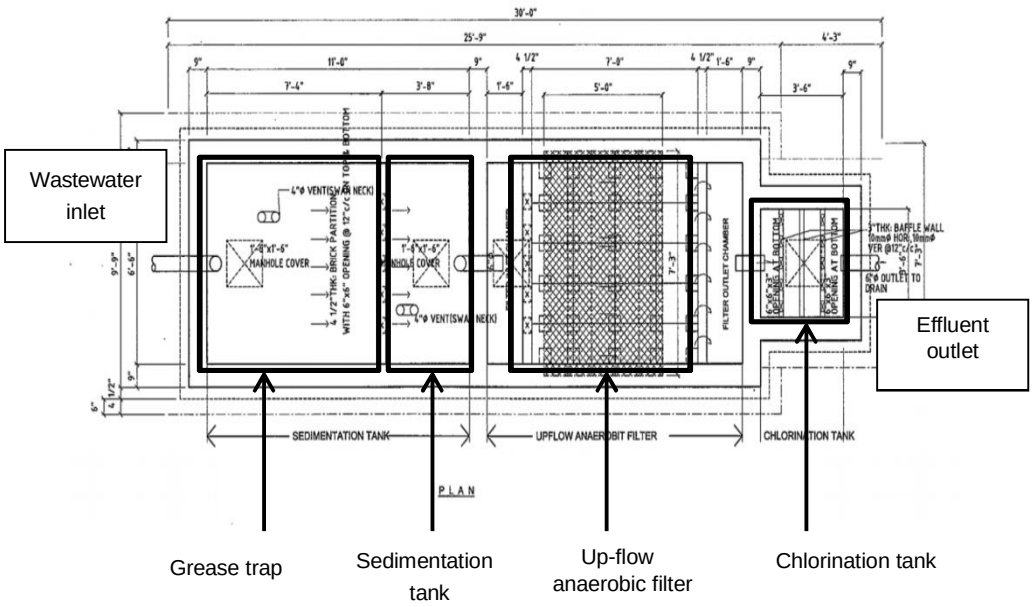
From September 2012, construction of improved wastewater treatment facility was implemented. This improved wastewater treatment facility was constructed in 7 restaurants (Dolphin, Royal garden, Bangkok kitchen, White rice, Signature garden, Western park royal and Utopia) and Kandawgyi Palace Hotel.

Treatment flow of new wastewater treatment facility is as follows;

Grease trap → Sedimentation → Up-flow anaerobic filter → Chlorination

Depending on wastewater volume, few kinds of wastewater treatment facility were designed. Design of this wastewater treatment facility was conducted by local private company (WEG: Water engineering group). Construction of this improved wastewater treatment facility was implemented under the instruction and supervision of YCDC. Construction was commenced in September, 2012, and operation was commenced in March, 2013. Construction cost of this facility was borne by each restaurant. No subsidy was given for this project.

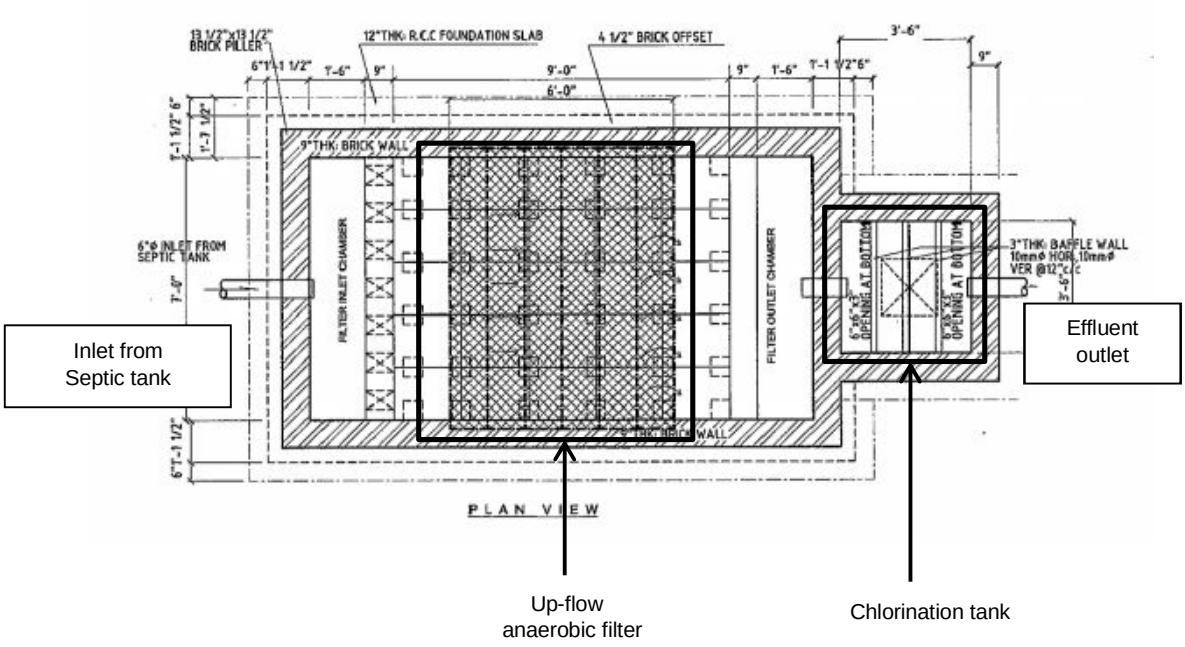
Structure of improved wastewater treatment facility is shown below (Figure 2.4 and 2.5);



Source：JICA Study Team

Figure 2.4 Plan of Improved Wastewater Treatment Facility

(Grease trap → Sedimentation → Up-flow anaerobic filter → Chlorination)



Source：JICA Study Team

Figure 2.5 Plan of Improved Wastewater Treatment Facility

(Additional facility to Septic tank: Up-flow anaerobic filter + Chlorination tank)

Actual performance of these improved water treatment facilities is not clear, because water quality analysis of effluent is not completed (1st water quality test is planned in January, 2014). Using published data, water treatment ability (pollutant removal ratio) of conventional septic tank and improved wastewater treatment facility (Septic tank + up-flow anaerobic filter) are compared.

Table 2.3 Removal of COD, BOD, TSS, T-N and T-P

Wastewater treatment facility	Removal ratio (%)				
	COD	BOD	TSS	T-N	T-P
Conventional septic tank	66.9	57.4	79.3	Not removed	Not removed
Improved wastewater treatment facility	51-86	59-74	66-90	24	30

Source：JICA Study Team

For the improved wastewater treatment facility, removal of T-N and T-P is expected slightly (about 20 to 30 %). Expected restaurant wastewater (effluent) characteristics using this data are shown below;

Table 2.4 Effluent of Improved Wastewater Treatment Facility (Expected value)

Item	Actual wastewater effluent of restaurant (Average)	Improved wastewater treatment facility
BOD	414 mg/L	139 mg/L
COD	796 mg/L	251 mg/L
T-N	37 mg/L	28 mg/L
T-P	3.6 mg/L	2.5 mg/L

Source：JICA Study team

YCDC issued guidance letter to restaurant to do an applicable operation/maintenance of improved wastewater treatment facility (see below).

Table 2.5 Guidance Letter from YCDC

Operation/Management procedure of
Kitchen wastewater treatment facility

Purpose of kitchen wastewater treatment facility is to protect water quality of Kandawgyi Lake. Following articles are necessary operation / management procedure to maintain function of Kitchen wastewater treatment facility.

1. Avoid inflow of solid waste, bush, plastic and other waste into grease trap. Install trap (net) on the inflow port of grease trap. Trap (net) should be cleaned every day.
2. Separated grease in grease trap should be removed every day or every other day. This operation is most important procedure to keep performance of this treatment facility.
3. Deposited sludge of grease trap and sedimentation tank should be withdrawn using vacuum truck every 3 or 6 month.
4. Grease trap and sedimentation tank should be washed annually with clean water.
5. Up-flow anaerobic filter should be backwashed every 6 months or any period.

YCDC advices that implementation of above mentioned operation and maintenance procedure maintain performance of Kitchen wastewater treatment facility.

Source: DEWS, YCDC

In addition, YCDC plans periodical inspection of improved wastewater treatment facility. Frequency and inspection item are as follows;

Visual inspection

Every 3 months

Water quality test

Test item: pH, BOD, CODcr, SS

Frequency: On construction completion (1 time). After that, 1 time / year (in every January)

Note: 1st annual water quality test will be done in January 2014.

As of September 2013, water quality test (at the time of construction completion) and visual inspection (March, June and September) were conducted by YCDC. From the results of visual inspection,

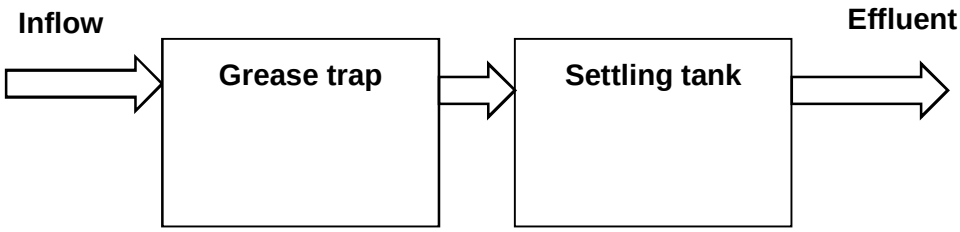
characteristics of effluent from Restaurant A which often cleans grease trap are considered to be satisfactory. YCDC instructs restaurants which do not clean grease trap to improve the maintenance by cleaning of grease trap and sedimentation tank more frequently. Water quality test results are not made public.

Table 2.6 Construction Cost and O&M Cost of Small Scale Wastewater Treatment Facility

Restaurant	Capacity of treatment facility	Construction cost (USD)	Maintenance	Maintenance cost (USD/Month)
Restaurant A	Capacity: 150 to 200 persons	10,000	Cleaning of grease trap and sedimentation tank (Every month)	100
Restaurant B	No information	8,000	No information	No information
Restaurant C	40ft x 9ft x 8 ft (Overall dimension)	8,000	Cleaning of grease trap and sedimentation tank (Every half year)	No information

Source：JICA Study team

For small scale café and shops, YCDC is considering installation of small scale wastewater treatment facility. This small grease trap is designed by WEG. Scheme of this small scale wastewater treatment facility is shown below;



Source：JICA Study team

Figure 2.6 Scheme of Small Scale Wastewater Treatment Facility

Similar to the improvement wastewater treatment facility for restaurant, YCDC plans that installation and maintenance cost are to be borne by each small scale café and shops. Installation of this treatment facility is expected to be implemented from November 2013.

(2) Installation of small domestic sewage treatment apparatus (Johkaso)

Installation of Johkaso for each restaurant is one of the alternatives for improvement of water quality in Kandawgyi Lake. Following Table shows characteristics of effluent of commonly used Johkaso in Japan.

Table 2.7 Effluent Quality of Johkaso

Item	BOD removal type	BOD and N/P removal type	Restaurant effluent (actual, average)
BOD	≤20mg/L	≤10mg/L	414mg/L
T-N	---	≤20mg/L	37mg/L
T-P	---	≤1mg/L	3.6mg/L

Source：JICA Study Team

BOD and N/P removal type Johkaso can reduce BOD and N/P drastically. However, following issues need to be considered to utilize Johkaso as a measure for water quality improvement in Kandawgyi Lake.

- Price of Johkaso is very high (for BOD and N/P removal type: 120 million -300 million Kyats/Johkaso）
- Back up electricity supply source (e.g. generator) in case of power supply failure is necessary
- Periodical maintenance by trained engineer is necessary

Installation of Johkaso poses large cost burden to user (restaurant). Therefore, when Johkaso is selected as the water quality improvement measure, provision of subsidy and ensuring of financial resource are necessary.

2.3.3 Dredging of Sediment

Dredging and removal of nutrients in sediment is to be implemented as the remedial measures of eutrophied lake. For the implementation of dredging, sludge dehydrates method and disposal method have to be considered.

2.3.4 Water Transmission from Inya Lake

Lake water exchange is considered as one of countermeasures against blue-green algae growth. One of the methods is to exchange water in a short time within the generation cycle of blue-green algae (about 3 days), and inhibit reproduction of blue-green algae.

For Kandawgyi Lake, following investigation was carried out;

(1) Water transmission from Inya Lake

In 1884, water transmission pipeline from Inya Lake was constructed. Specification of transmission pipeline is as follows;

- Diameter：75 cm
- Length of pipeline：About 4 km
- Material of pipe：Cast iron
- Capacity of pipeline：3.63 MGD

At present, this transmission pipeline is used only for 2 weeks in a year during water festival. However, maintenance of this pipeline is not done appropriately, actual condition and water transmission capacity are not clear.

Approximate time required to exchange Kandawgyi Lake is calculated as below;

Water volume of Kandawgyi Lake: 1,618,743 m^3
Water transmission capacity: 3.63 MGD = 16,502 m^3/day

Therefore,
1,618,743 m^3 / 16,502 m^3/day = 98.1 day

When Inya Lake water transmission pipeline is used for water exchange of Kandawgyi Lake, necessary time is 98.1 days. Therefore, capacity of transmission pipeline is insufficient to inhibit reproduction of blue-green algae.

(2) Necessary water transmission volume to inhibit reproduction of blue-green algae

For Kandawgyi Lake, necessary water transmission volume to inhibit reproduction of blue-green algae is calculated as follows;

Water volume of Kandawgyi Lake: 1,618,743 m^3
Time needed for water exchange: 3 days

Therefore;
1,618,743m^3 / 3 days = 539,581 m^3/day = 119 MGD

Therefore, necessary water transmission volume to inhibit reproduction of blue-green algae of Kandawgyi Lake is estimated to be 539,581 m^3/day (119 MGD).

Thus, this alternative is not practical because of the difficulty of construction of water transmission facility with 119 MGD capacity and securement of water source.

2.3.5 Conclusion

In this section, construction of interceptor sewer, installation of Johkaso, dredging of sediment and water transmission from Inya Lake was considered. Among these alternatives, installation of Johkaso and water transmission from Inya Lake pose following problems;

Installation of Johkaso

- Johkaso is very expensive (for BOD and N/P removal type: 120 million -300 million Kyats/Johkaso）
- Backup power supply source in case of electricity failure (e.g. generator) is necessary
- Periodical maintenance by trained engineer is necessary
- Establishment of subsidy system and securement of financial resource are necessary

Water transmission from Inya Lake

- Water transmission with 119 MGD capacity is necessary to inhibit reproduction of blue-green algae
- Difficulty in construction of water transmission facility for119 MGD
- Difficulty in securement of water source

On the contrary, interceptor sewer and dredging have following features;

Interceptor sewer

- Small diameter and shallow covering depth
- Construction cost is lower than usual sewer construction
- Construction period is shorter than usual sewer construction

Dredging

- Commonly used construction machinery (backhoe, raft) can be utilized
- Purchasing of new dredging equipment is not necessary
- Implementation cost is small

Considering the above, detail on interceptor sewer and dredging are studied further in the following section.

2.4 Design Condition of Interceptor Sewer

2.4.1 Design Condition

Design conditions of interceptor sewer facility are as follows.

(1) Target facility to be intercepted

Existing drainage channels which discharges wastewater into Kandawgyi Lake are the target of interceptor sewer system. Based on the site survey of existing drains, five (5) drainage channels are selected.

(2) Design flow

Since the interceptor facility will be converted to sewerage system network in future, the facilities are designed by wastewater flow planned in master plan for 2040.

The design flow is shown below.

Table 2.8 Design Flow

Items	Outlet No.1	Outlet No.2	Outlet No.3	Outlet No.4	Outlet No.5	Remarks
Catchment Area (ha)	10.8	48.5	9.7			Bahan T.S. (80.29 m^3/day/ha)
				11.2	6.6	Tarmwe T.S. (227.26 m^3/day/ha)
Design Flow	867	3,894	779	2,545	1,500	
Total (m^3/day)	9,585					Hourly Maximum in 2040

Source: JICA Study Team

(3) Discharge point

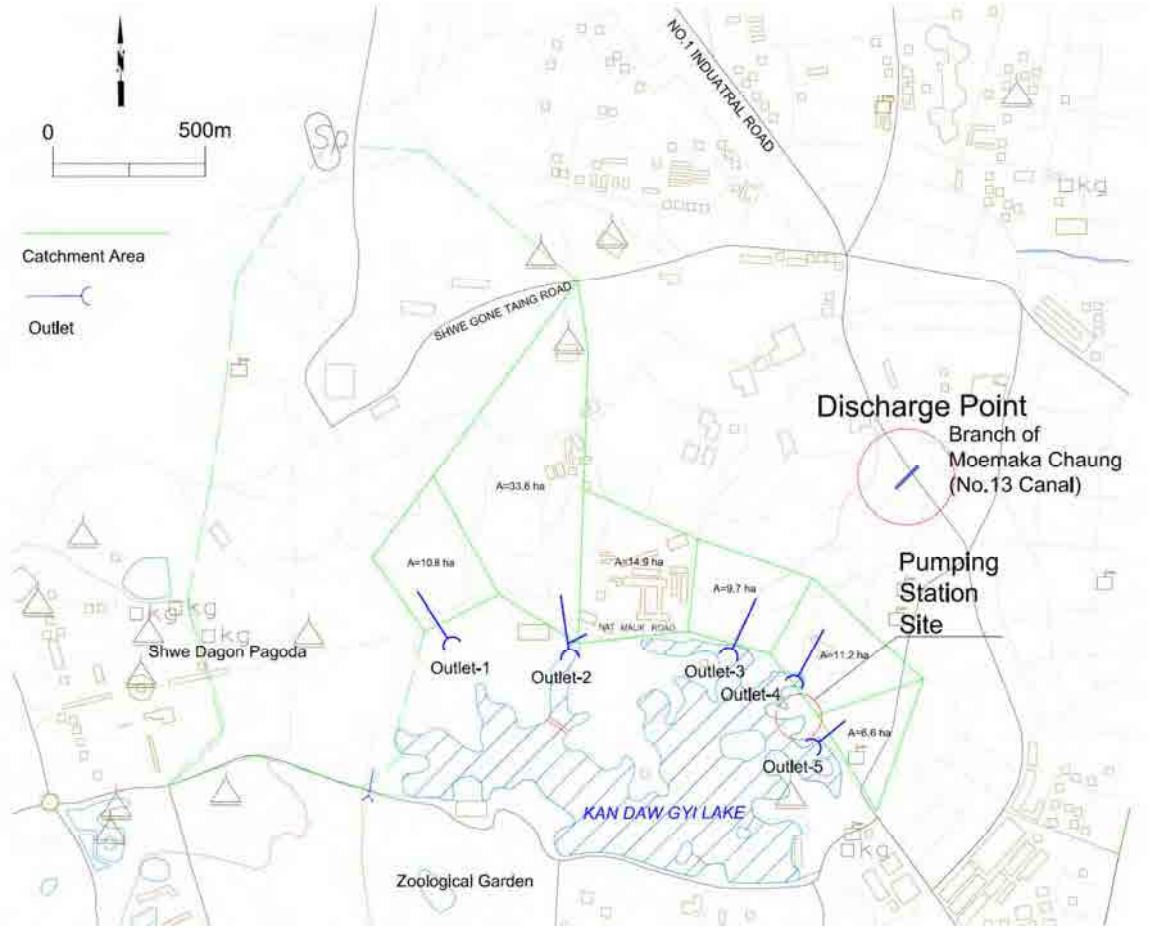
Collected wastewater flows into pumping station and is sent to discharge point by pressure pipe. The discharge point should be selected carefully because it has an effect on operation cost of pumping station and untreated wastewater has to be received safely.

The discharge point has been selected considering the following points upon confirmation with YCDC.

- Length of pressure pipe (To be close to pumping station)
- Current condition of inundation problem near the discharge point (To prevent overflow of untreated wastewater)
- Width of road and traffic condition of the route for pressure pipe (For easy construction and O&M)

The pumping station is planned in Kandawgyi Lake area. Since the area is owned by YCDC, it is easy to acquire necessary land for pumping station.

Locations of target outlets for interception, discharge point and pumping station are shown in Figure 2.7.



Source: JICA Study Team

Figure 2.7 Locations of Outlets for Interception, Discharge Point and Pumping Station

(4) Design criteria

Design criteria for the facilities are shown below.

Table 2.9 Design Criteria for Interceptor Sewer

Items	Adoption	Remarks
(1) Target Year	2040	Matching with Master plan of Sewerage system
(2) Capacity Calculation	Manning Formula $v = \frac{1}{n} \times R^{\frac{2}{3}} \times I^{\frac{1}{2}}$ Where, V: flow velocity (m/s) N: Roughness Coefficient (-) R: Hydraulic Radius (m) I: Gradient(-)	Pressure pipe loss is calculated by Hazen-Williams formula
(3) Flow Velocity	Minimum: 0.6 m/s Maximum: 3.0 m/s	
(4) Minimum Diameter	150mm	
(5) Minimum Earth Covering	1.5m	Depends on the structure of diversion chamber
(6) Interval of Manhole	75m	Assumed pipe dia; less than 600mm

Source: JICA Study Team

2.4.2 Facility Design

Outline of facility design is summarized below.

(1) Interceptor sewer and diversion chamber

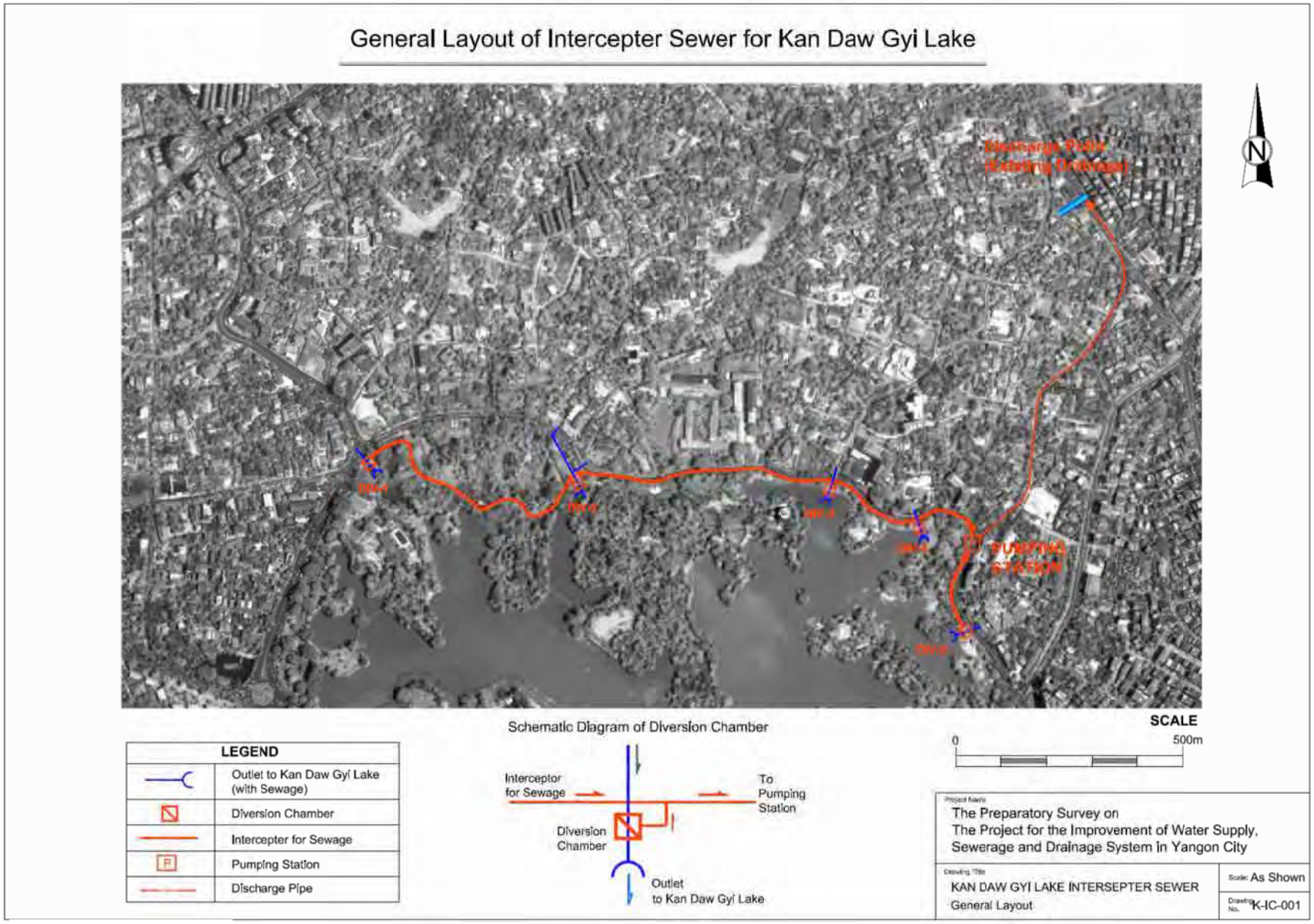
Interceptor sewer is planned based on gravity system connecting with each outlet and installed along the lakeside road which makes the route of interceptor sewer shortest in length. Interceptor sewer from Outlet No.1 to No.2 only is installed inside the lake area for easy construction and O&M. Diameter of Interceptor sewer is 250 to 600 mm. Material of pipe is HDPE which is easy to procure and to use for construction in Myanmar.

Diversion chamber is constructed in front of outlet to Kandawgyi Lake. Invert level of interceptor sewer is set under 30 cm from existing drainage invert level to intercept wastewater efficiently. Sedimentation pit and manual screen are designed in diversion chamber to prevent pipe clogging due to rubbish and sediments. An overflow weir or a flap gate is also designed in diversion chamber to prevent back water from Kandawgyi Lake. Frame for stop log plate is set to control interceptor volume especially during rainy season.

(2) Pumping Station

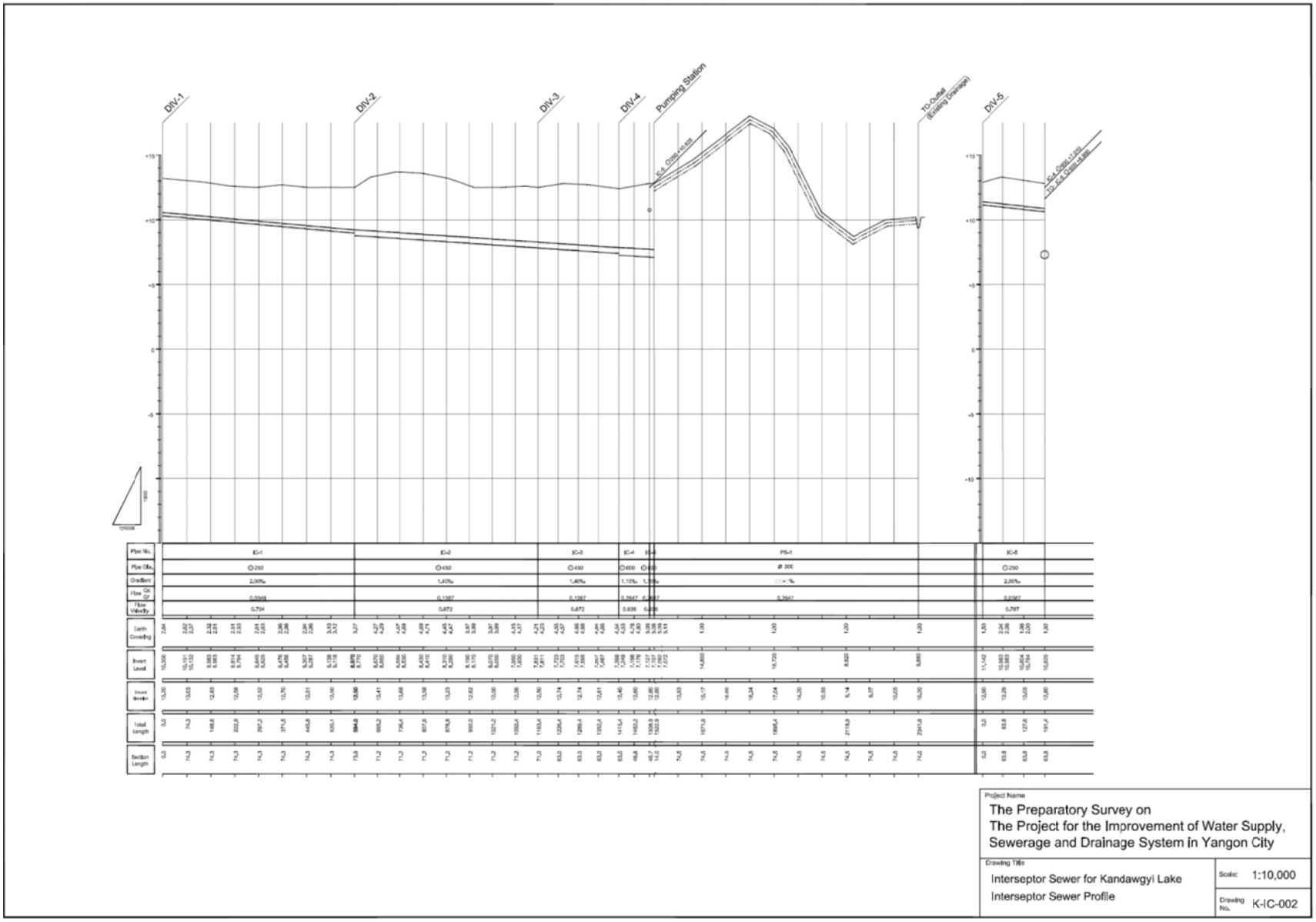
Simple type pumping station with submersible pump is designed taking into consideration capacity scale, easy operation and economic efficiency. Equipment in pumping station includes flow meter, screen for rubbish and hoist for rubbish and equipment for effective operation and generator is installed as emergency power supply in case of power failure. For enhancing of reliability, two pumps are operated regularly. One stand-by pump, which has capacity of pumping daily maximum flow, is also installed as back up for regular pumping even when there is trouble in other pumps.

Design drawings of interceptor sewer are shown in Figures 2.8 to 2.11.



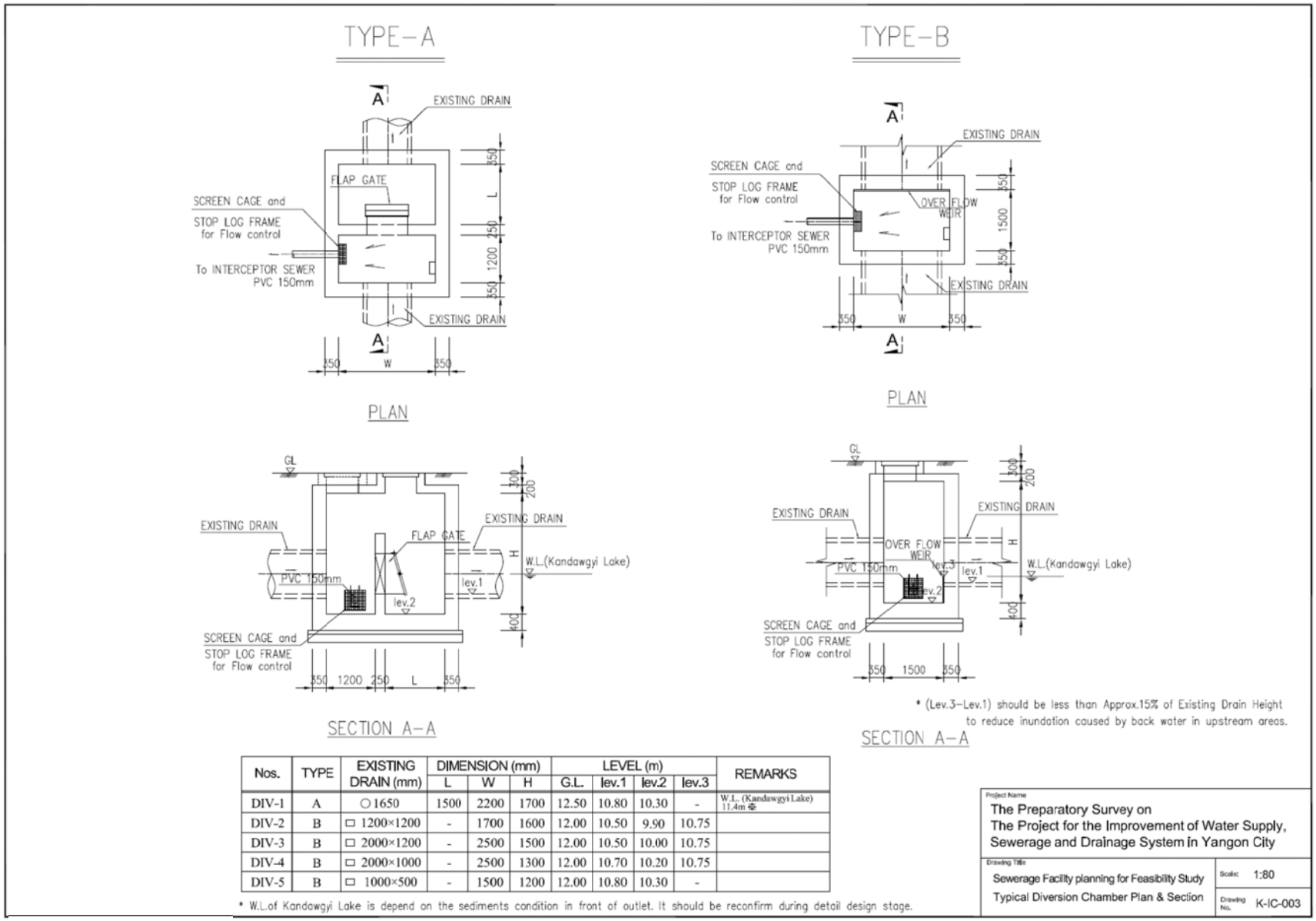
Source: JICA Study Team

Figure 2.8 General Layout of Interceptor Sewer Facility



Source: JICA Study Team

Figure 2.9 Interceptor Sewer Profile



Nos.	TYPE	EXISTING DRAIN (mm)	DIMENSION (mm)			LEVEL (m)				REMARKS
			L	W	H	G.L.	lev.1	lev.2	lev.3	
DIV-1	A	○1650	1500	2200	1700	12.50	10.80	10.30	-	W.L. (Kandawgyi Lake) 11.4m
DIV-2	B	□ 1200×1200	-	1700	1600	12.00	10.50	9.90	10.75	
DIV-3	B	□ 2000×1200	-	2500	1500	12.00	10.50	10.00	10.75	
DIV-4	B	□ 2000×1000	-	2500	1300	12.00	10.70	10.20	10.75	
DIV-5	B	□ 1000×500	-	1500	1200	12.00	10.80	10.30	-	

* W.L.of Kandawgyi Lake is depend on the sediments condition in front of outlet. It should be reconfirm during detail design stage.

Project Name
The Preparatory Survey on
The Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City

Drawing Title
Sewerage Facility planning for Feasibility Study
Typical Diversion Chamber Plan & Section

Scale: 1:80
Drawing No.: K-IC-003

Source: JICA Study Team

Figure 2.10 Typical Diversion Chamber

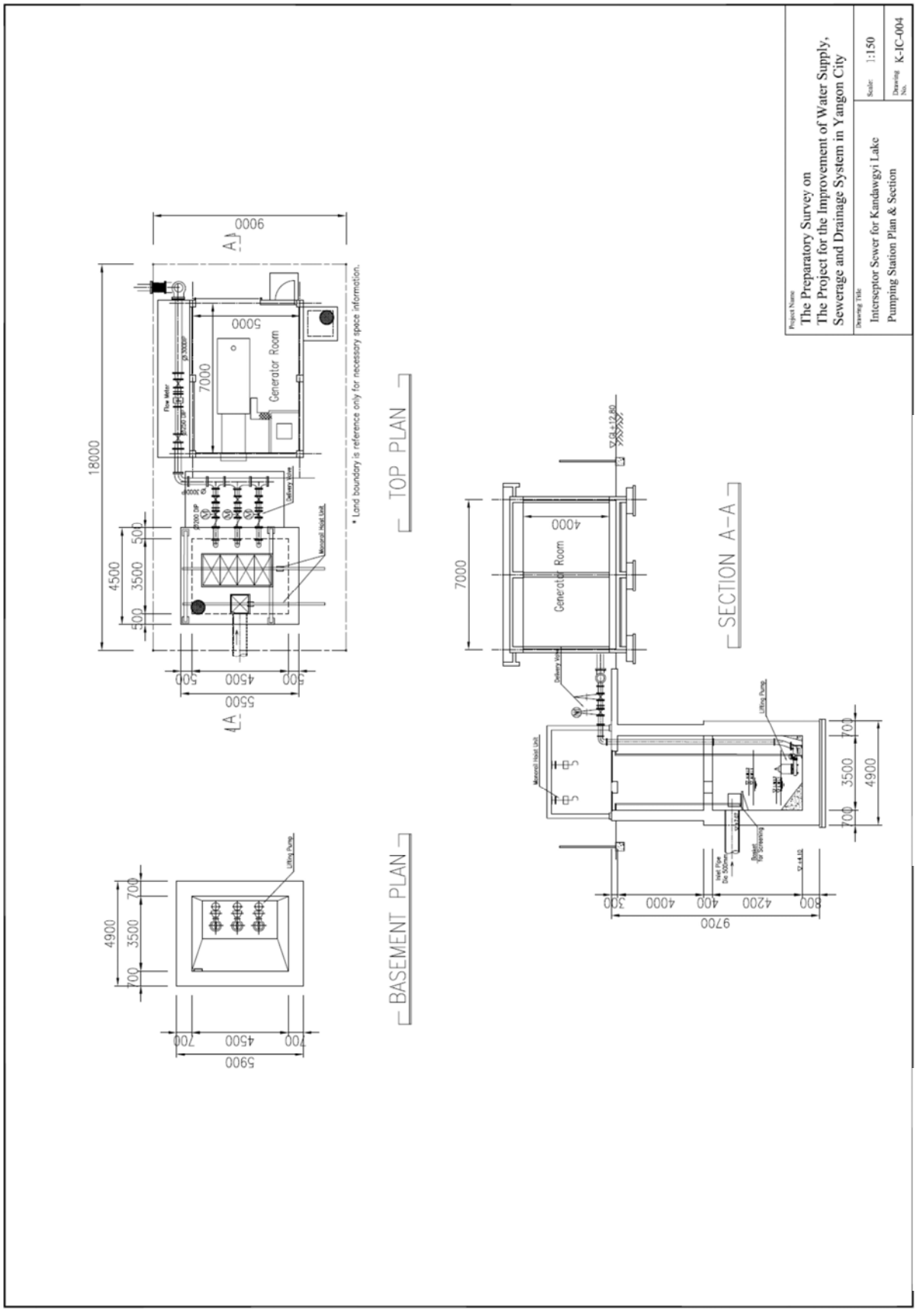


Figure 2.11 Pumping Station

Source: JICA Study Team

(3) Mechanical equipment

Type of pump

Submersible non-clog pump is adopted for the pumping station for easy operation and maintenance. Pump pit is designed for all three pumps including one standby considering the reason below.

- Reasonable cost due to compactness of pumping station, though sewage flow is large.
- In the worst case scenario, if one standby pump and one duty pump are out of order, fifty percent of sewer flow can be lifted.

However, adequate maintenance work is necessary.

List of major mechanical equipment is shown in the following table**.**

Table 2.10 Type of Pump

Item	Specification	Unit
Sewage Lift Pump	Submersible non - clog type 3.4 m^3/min x 37 kW	3 units Including 1 standby

Source: JICA Study Team

Installation of basket at inlet sewer mouth

Installation of basket is recommended at inlet sewer mouth of the proposed pumping station in order to protect submersible pumps from clogging by garbage and large solids.

(4) Electrical equipment

Considering the plant load and the location (near the restaurant "White Rice"), the electrical power should be branched from the existing 6.6 kV overhead line nearby. YESB said that the 6.6 kV line is connected to Japanese Embassy and other important facilities and no planned shut-down will be expected.

2.4.3 Construction Plan

Outline of construction plan for interceptor sewer facility is summarized below.

(1) Target Facilities

Interceptor Sewer: Dia. 250 mm（L=785.4 m）, Dia. 450 mm（L=821.4 m）, Dia. 600mm（L=107.5 m）

Discharge Pipe: Dia. 300 mm L=819.0 m

Diversion Chamber: 5 Nos.

Pumping Station: 1 Nos.

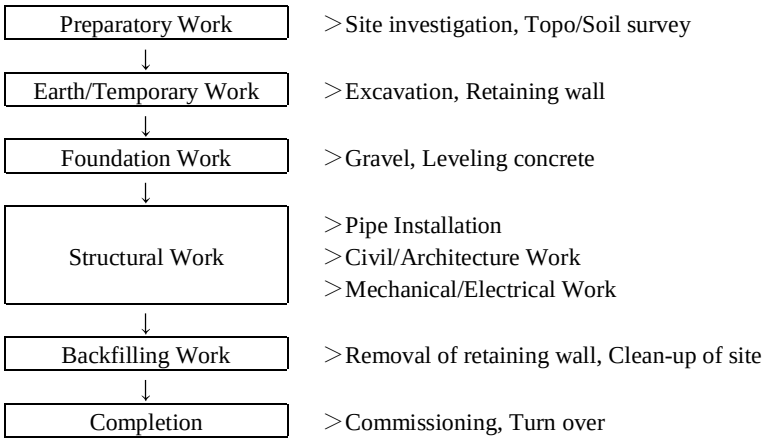
(2) Basic policy and procedure

Construction of interceptor sewer facility except pumping station is conducted on public road. It is important to keep construction site safe for prevention of construction trouble and public hazard.

Construction of diversion chamber includes modification of existing drainage channel. Therefore, construction schedule have to be so managed that the work may be carried out in dry season.

Since construction sites are in public road or flat land area, pre-construction work, such as land reclamation and temporary access road, is unnecessary. Construction work for facilities can start immediately after commencement.

Outline procedure of construction is shown below.



Source: JICA Study Team

Figure 2.12 Procedure Outline for Construction of Interceptor Sewer Facility

(3) Construction Schedule

Construction schedule is summarized below. It is assumed that pre-construction stage such as detailed design and tendering will be completed by 2014 and construction work will start in 2014.

Construction Work	2014（Assumption）				2015				Remarks
1. Preparatory Work									
2. Interceptor Sewer									
3. Discharge Pipe									
4. Diversion Chamber									Except Rainy Season
5. Pumping Station									
6. Commissioning									
7. Start of Operation									

Source: JICA Study Team

Figure 2.13 Construction Schedule of Interceptor Sewer Facility

2.4.4 Operation and Maintenance Plan

After starting operation of interceptor sewer facility, it is important to conduct 1) maintenance/inspections, 2) cleaning/dredging and 3) repair/rehabilitation (if necessary) for sewer and diversion chamber adequately. Additionally, pumping station requires operation control and periodical maintenance of equipment.

Daily maintenance and inspection work required for each facility is summarized below.

(1) Interceptor sewer

Daily maintenance and inspection work for sewer is very important for proper working of interceptor system. Main check points in daily maintenance and inspection are as follows.

- ✓ Condition of sewage flow and sediments
- ✓ Subsidence and cracks of road surface
- ✓ Breakage, crack, and invasion of tree root
- ✓ Infiltration of groundwater
- ✓ Miss connection of storm water
- ✓ Illegal wastewater discharge, generation of hydrogen sulfide

Inspection work is conducted through visual survey from manhole periodically. If some troubles are found, cleaning, repair or rehabilitation work should be carried out immediately.

(2) Diversion Chamber

Diversion chamber is key facility for interceptor system and any trouble in diversion chamber will directly affect the water quality of Kandawgyi Lake. Periodical inspection of diversion chamber is required to keep it in right condition even in rainy season. If some troubles are found, cleaning, repair or rehabilitation work should be carried out immediately. In Yangon city, water level in diversion chamber in dry season and rainy season is quite different because of varied precipitation. In case water level in diversion chamber rises up in rainy season, wastewater volume intercepted will increase

several times of design flow. Flexible operation depending on season, weather and so on is required through flow control by stop log plate, etc.
Inspection items are shown in following table.

Table 2.11 Inspection Items for Diversion Chamber

Category	Check Points
Condition of wastewater flow	① Water level of interceptor sewer ② Wastewater discharge to outfall in dry weather ③ Water level of outfall and top level of weir ④ Rubbish and scum on screen
Condition of structure	① Damage and troubles of weir, flap gate and stop log plate ② Failure of flap gate and stop log

Source: Operation and Maintenance Guideline for Sewerage, Japan Sewage Works Association

(3) Pumping Station

Pumping station is essential facility for interceptor system and trouble in pumping station directly lead to breakdown of the whole system. Pumping station should be operated under adequate condition at all times understanding mechanism, specification and characteristics of pumps. It is important to find troubles as early as possible by thorough implementation of inspection and maintenance. To continue inadequate operation with troubles will cause an increase in operation cost and breakdown of the whole system finally.

Main inspection and maintenance points for pumping station are shown in following table.

Table 2.12 Inspection & Maintenance Points for Pumping Station

Items	Inspection and Maintenance
(1) Regular Inspection	Inspection and record of 1) condition of pump, 2) situation of oil grease, scum and sediments in pump pit Cleaning for screen, water level switches etc.
(2) Periodical Inspection	Pulling-up pumps Lubrication, calibration and detailed inspection of equipment <Reference> 1time per 1year
(3) Overhaul	Implementation of programmed overhaul by economical comparison with replacement <Reference> once per 3-5years
(4) Cleaning	High pressure or vacuum cleaning for removal of sediments, scum and oil grease <Reference> once per 1year

Source: Operation and Maintenance Guideline for Sewerage, Japan Sewage Works Association

2.5 Dredging

2.5.1 Basis for Planning

(1) Estimated sediment volume

Estimated sediment volume of Kandawgyi Lake is calculated as follows;

Surface area of Kandawgyi Lake: 647,497m^2 × Estimated thickness of sediment: 50cm
= 323,749m^3

(2) Dehydration of sediment

Dredged sediment is dumped in adequate dumping site after dehydration. Comparative evaluation of dehydration method is shown below.

Table 2.13 Evaluation of Dehydration Methods

Dehydration method	Evaluation
Drying bed	***Applicable*** − Extensive site is required − Procurement of specific equipment (dewatering equipment, dryer, generator, etc.) is not necessary − Supply of electricity and fuel is not necessary − Special technique is not employed. Therefore, specific training for workers is not necessary − Operation cost can be reduced
Mechanical dehydration	**Not applicable** − Procurement of dewatering equipment is necessary − Installation of dewatering equipment and its ancillary facilities (feeder wire and panel, control apparatus, generator, etc.) is necessary − Supply of electric power and fuel is necessary − Specific training for dewatering equipment operator is necessary
Mechanical dehydration and drying	**Not applicable** − Procurement of dewatering equipment and dryer is necessary − Installation of dewatering equipment and drier, and their ancillary facilities (feeder wire and panel, control apparatus, generator, etc.) is necessary − Supply of electric power and fuel is necessary − Specific training for dewatering equipment and drier operator is necessary

Source: JICA Study Team

In rainy season, operating efficiency of drying bed technique is reduced considerably. Therefore, operation period of drying bed technique is limited within dry season. However, drying bed technic has following advantages.

- Procurement of specific equipment (dewatering equipment, dryer, generator, etc.) is not necessary
- Operation cost can be reduced
- Specific training for workers is not necessary

Therefore, solar drying technique enable prompt launch of dredging work and can reduce initial investment. From these reasons, drying bed technique is suitable technique for this project.

2.5.2 Dredging Work Using YCDC Dredging Equipment

YCDC already owns pump dredging equipment. Estimated work schedule utilizing YCDC dredging equipment and drying bed technique is mentioned in this clause.

(1) Capacity of dredging pump
Capacity of dredging pump is as follows;

- Pump capacity: 140-170m^3/hour
- Pump head: 20-28m

(2) Necessary operation period
Daily amount of dredging sediment

Pump capacity: 140m^3/hour
Operating time: 6 hour /day

i.e. amount of dredging sediment / day is;

Pump capacity: 140m^3/hour × Operating time: 6 hour /day
＝840m^3/day

Required dimensions of drying bed

Daily amount of dredging sediment：840m^3/day

Depth of drying bed is 0.6m. Therefore, required dimension of drying bed for one-day operation is;

840m^3/day / 0.6m = 1,400m^2 (approx. 37m×37m)

Estimated time of drying is 14 days. Therefore, 15 solar drying beds are necessary to operate dredging and drying work continuously.

Dredging and drying work cycle

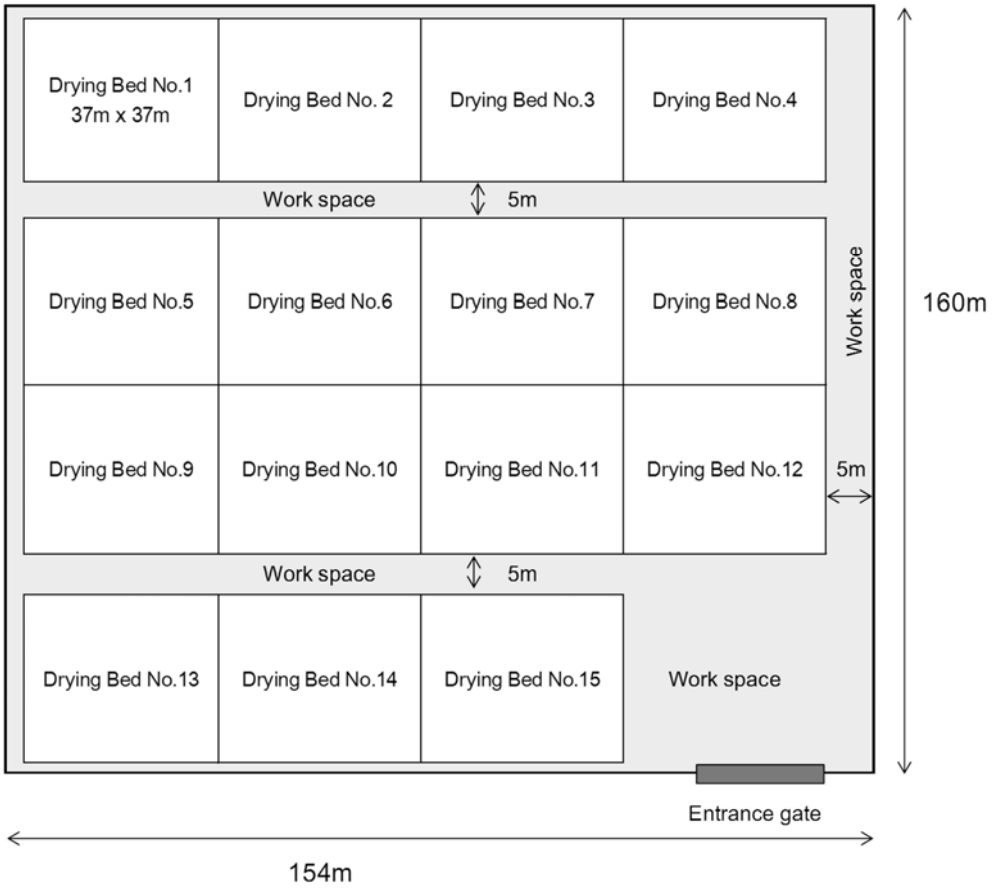
Dredging →Drying → Carrying out of dried sediment

When 15 drying beds are installed, this cycle completes in about 1 month.

Layout of drying bed site with 15 draying beds is shown below.
Required site area is 154 m × 160 m. Estimated processing ability of 1 dredging and drying work cycle (i.e. processing ability / month) with this drying bed site is 12,600m^3 (including water).
Total amount of sludge in Kandawgyi Lake is estimated to be 323,749m^3. Therefore, total work period is estimated 26 work cycles (26 months). Operation period of drying bed is limited within dry season (from November to May, about 6 months). Therefore, 5 years of operation period is required to complete dredging work in Kandawgyi Lake.

Estimation of operation and construction costs of this dredging work is as follows;

- Operation cost of YCDC dredging equipment (Fuel cost): 884,797 USD
- Construction cost of drying bed: 5,996,000 USD



Source: JICA Study Team

Figure 2.14 Site Plan of Drying Bed

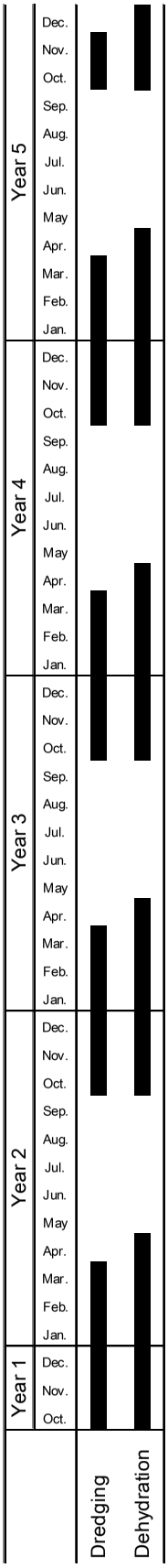


Figure 2.15 Work Schedule of Dredging Work

Source: JICA Study Team

2.6 Cost Estimation and Implementation Schedule

2.6.1 Condition of Cost Estimation

- This Project is assumed not to implement as loan Project from the view of its urgency and its Project scale and it is assumed to be implemented by Myanmar's budget.
- The project cost comprises construction cost, consulting cost and contingency (physical).
- The project cost is composed of the local currency potion (L.C.) and foreign currency portion (F.C.).
- Consulting cost is considered as 7.0 percent of total of construction cost.
- Physical contingency is considered as 10.0 percent of total of construction cost and consulting cost.
- The base period of cost estimation is June in 2013 and the exchange rate considered is 1 Kyat=0.114 Yen, 1 USD=101.1 Yen and 1USD=885 Kyat.

2.6.2 Condition of Construction Cost

- It is possible to procure civil and building material, labour and construction machine within the country and the procurement in local country is set as basic policy for project cost estimation.
- The mechanical and electrical equipment is basically procured from overseas including third country; such as European Union (EU) etc. The equipment will be procured with consideration of quality, performance, economical efficiency and O&M, etc.
- The local contractors have enough experiences and ability for normal civil engineering work. On the other hand, they are not experienced in the specialized project regarding water supply and sewerage. However, Japanese experts and foreign experts are staffed in implementation system of the Project and construction is conducted by the local contractor.
- The local contractors are not experienced in the construction methods of pipe jacking and shield. The unit cost of these construction methods is collected from Thailand where many contractors have relevant experiences.
- The construction plan is established upon the considerations of local natural condition (topographic aspects, geotechnical condition and meteorological condition) and legislation/custom.

2.6.3 Estimation of Project Cost

Non-disclosure Information

Table 2.14 Project Cost (Interceptor)

Non-disclosure Information

2.6.4 Estimation of O&M Cost

The required cost for operation and maintenance of the proposed facilities for interceptor is shown in the following table. The O&M cost comprises labour cost, electrical cost, maintenance cost and cleaning cost for interceptor. The annual total cost of operation and maintenance is approximately 17.6 thousand USD (1.8 million JPY).

Table 2.15 O&M Cost

Items	Amount (thousand USD/Year)
Labour cost	1.1
Electrical cost	11.6
Maintenance cost	4.3
Cleaning cost for interceptor	0.3
Others	0.3
Total	17.6

Source: JICA Study Team

2.6.5 Implementation Schedule of the Project

The construction schedule is planned by accumulation of the required period for each process and it is shown in Table 2.16. The total implementation period of the Project is assumed as 14 months.

Table 2.16 Implementation Schedule for Construction

	1st Year	2nd Year
Kandawgyi Interceptor		
Interceptor		
Discharge Pipe		
Diversion Chamber		
Pumping Station		
Handing over		

Source: JICA Study Team

2.7 Project Evaluation

2.7.1 Project Outline

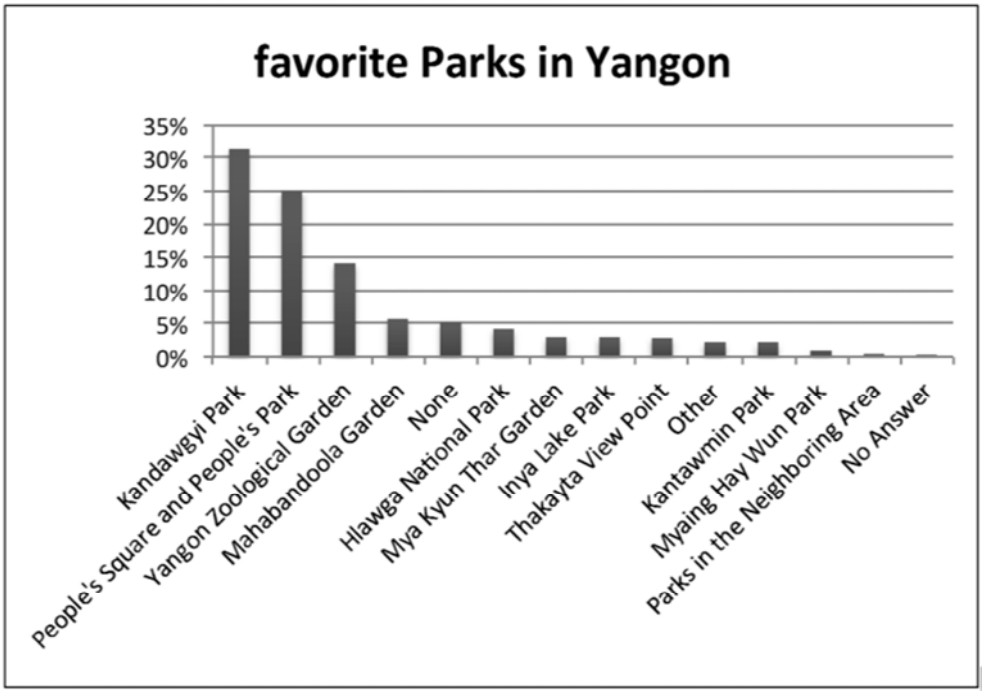
(1) Significance of Kandawgyi Lake

Kandawgyi Lake is one of the most popular places of the citizens of Yangon. Inside the park, there are seven restaurants with proper buildings, one five star hotel and around 30 open air cafes that the visitors can freely visit. In addition, there are souvenir shops and plant pot shops. The visitors to the park include dating couples, joggers, and casual strollers. The Japanese Embassy, high end restaurants and other institutions in the surrounding areas comprise the primary location in the city. Figure 2.15 shows ranking of the parks in the city. The JICA Study Team on "Project for the Strategic Urban Development Plan of the Greater Yangon" had undertaken 10,000 sample household interview survey, which included one question, "Which park do you like the most in Yangon?" By far the majority, 31% of the respondents, favored Kandawgyi Lake as their most favorite lake, indicating the importance of the lake for the Yangon residents.

On the practical side, originally the lake was developed as the raw water source for water supply to the city. Now the water is only used as a water source for Water Festivals held annually. During the festival in April, the whole city turns into a game of indiscriminately water bashing on anyone on the street. However, there is a widespread concern over the use of Kandawgyi Lake water during the festival for hygienic reasons.

At the time of a large fire, the water in the lake serves as firefighting water to be carried by tank-lorries.

Myanmar is located in an active seismic zone. YCDC is planning to prepare the lake water for emergency water supply source in case of the distribution system breakdown in case of such emergencies. Thus, it is important to improve the lake water quality to be ready for emergency uses.



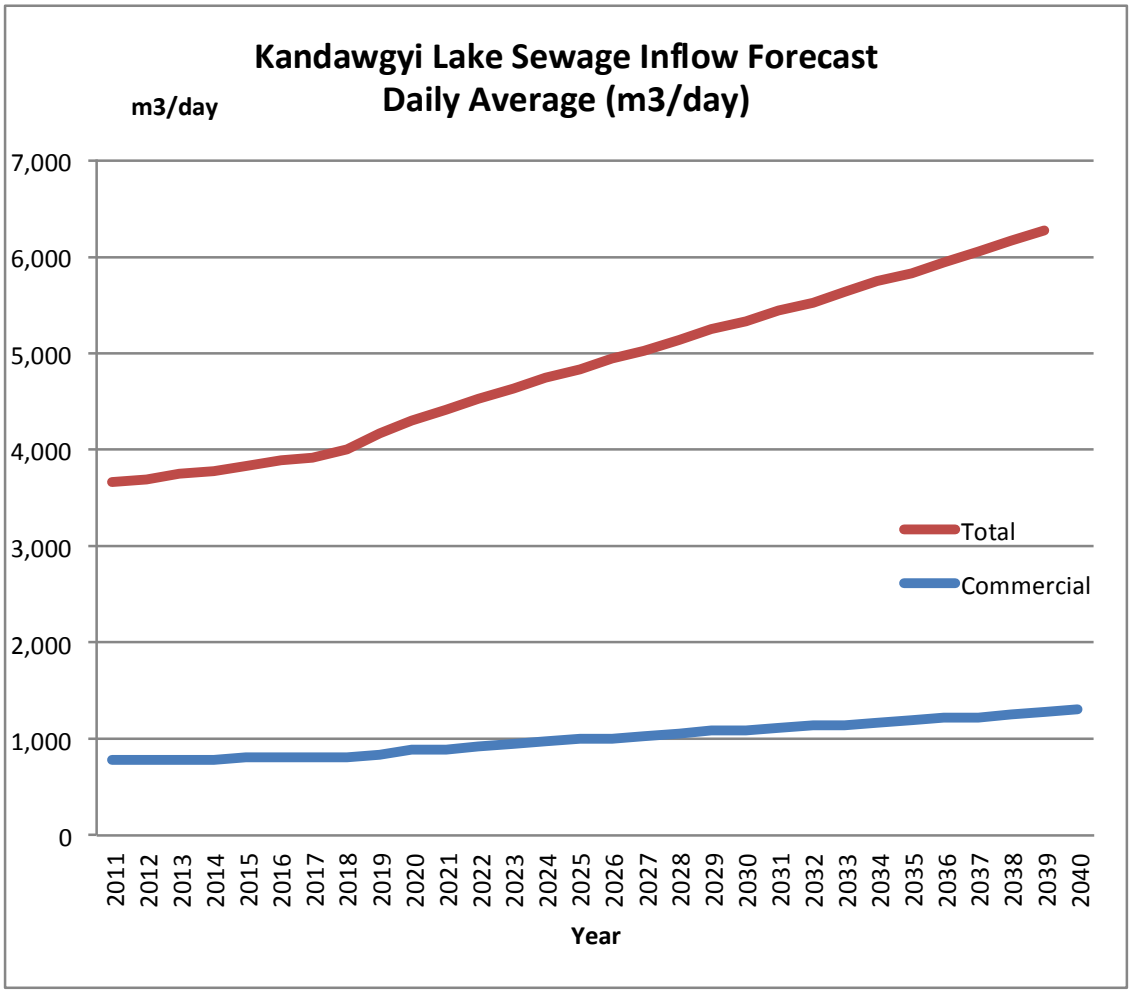
Source: 2012 JICA-HIS

Figure 2.16 Most Favorite Parks in Yangon City

(2) Wastewater Volumes

There are two townships in the north whose wastewater flows into the lake. These townships are Bahan and Tarmwe. Toilet water is treated by septic tanks and only other wastewater from baths, showers, kitchen generated by households and restaurants are discharged into the lake.

Hydrological topography indicates a total 86.8 ha of discharge area to the lake in the north comprised of 69 ha of Bahan (8% of the township area) and 17.8ha of Tarmwe (4% of the township area). The total wastewater generation forecast based on water demands by the townships is shown in Figure 2.16.



Source: JICA Study Team

Figure 2.17 Wastewater Flow Forecast to Kandawgyi Lake

Commercial water demand comprises 28% of the total township water demand in Bahan and 11% in Tarmwe.

According to the construction schedule, the earliest starting year is 2015 when the wastewater generation is estimated as 3827m^3/day.

(3) Investment

As shown in Table 2.17, the investment is composed of interceptor, diversion chamber, pumping station and engineering charges. It is assumed that for each investment, the contingency will add 5% to the total investment, whereas administration costs another 5%, commercial tax 10%, and import duty 5%. Commercial tax and import duty are not actually costs but the transfer of the money from one party to another within the same national economy. These transfer items do not count as costs in economic analysis but only in financial analysis. Furthermore neither economic nor financial analysis includes price escalations into the costs as they only represent nominal and not real changes in values.

Table 2.17 Composition of Investment Costs

Non-disclosure Information

Works involved in the construction of the project for Kandawgyi wastewater diversion are small and simple. Therefore the whole process from engineering to construction should not require more than two years. Table 2.18 shows the disbursement schedule for the project.

Table 2.18 Investment Disbursement Schedule

Year	Interceptor	Diversion Channel	Pumping Station	Engineering
2014	40%	20%	30%	40%
2015	60%	80%	70%	60%

Source: JICA Study Team

It is presumed that electrical and mechanical equipment would require 15% of replacement investment every 15 year after the completion of the project.

(4) Operation and Maintenance Costs

Table 2.19 shows the summary of the operation and maintenance costs for the interceptor system for wastewater diversion.

Table 2.19 Operation and Maintenance Costs Summary

	Quantity	Unit	Price	Unit	Cost	Unit
Salary	1	common worker	1,116	USD/Year	1,116	USD/Year
Spare Parts	269,000	initial investment	1.60%	percentage	4,304	USD/Year
Electricity	0.12	kWh/m^3	0.04	USD/kWh	0.0048	USD/m^3
Pipe Cleaning and Other Costs	1	Set			600	USD/Year

Source: JICA Study Team

2.7.2 Economic Analysis

(1) Economy of Kandawgyi Lake

Table 2.20 shows the current economic activities and estimated revenues within the park of the Kandawgyi Lake. The estimates are based on the information collected by interviewing the managers of the major business entities on the lake.

The visitors to the park need to pay for entrance. The customers to the hotel and restaurants can enjoy the lake environment without entrance fee. The total estimated expenditure by these visitors is 1.3 billion Kyat (approximately USD 15 million) per year. The estimate does not include the economic activities that take place in the vicinity of the lake. Thus the total economic domain of the lake is quite large. Even 10% influence to the estimated economic values would equal to the required investment for the project.

Table 2.20 Estimated Number of Visitors and Economic Impacts

Category	Number of Visitors (No/day)	Unit Expenditure (Kyat)	Value (Kyat/day)	Value (Million Kyat/Year)
Park Visitors	2000	300	600,000	219
（Café Visitors）	(800)	2000	1,600,000	584
Restaurants	1300	5000	6,500,000	2,373
Hotel	200	140000	28,000,000	10,220
total	3500		36,700,000	13,396

Source: JICA Study Team

(2) Economic Benefit Survey

As described above, there is a large economic value associated to the lake environment. Improvements in lake water quality will increase the number of visitors and customers to commercial facilities and generate higher profits. However, it is not possible to quantify the value to be generated by the improvements in water quality by the project due to existence of multiple factors to the valuation of lake environment by the visitor with a large degree of uncertainties. Therefore, the methodology adopted for economic analysis is to inquire the valuation directly to the actual visitors.

A team of interviewers were engaged during June 3 through 7 to ask the perception of the lake environment and willingness-to-pay for the improvement of the lake water quality. The interviewer asked one page questionnaire by stopping the visitors on the pedestrian trails within the park （Appendix F.1）. Appendix F.2 shows the summary of the interview survey. The overall statistics show that the average willingness-to-pay by the visitor is 296 Kyat, （Approximately 300Kyat）. This value is adopted as the average economic benefit for the project by visitors to the lake.

(3) Economic Analysis

The visitor to the lake in 2015 after the completion of the project is assumed to be 3500 visitors per day as is the case at present. However, due to the mid-year completion date, the annual visitors will be halved. Thereafter the number of visitors is assumed to increase at 2% per year. The economic benefit per visitor is assumed to be 300 Kyat, regardless of type of visitors. Those who stay at the lakeside hotel spend prolonged hours and are willing to pay a much higher premium to the improvement. However, taking the lower value indicated by the interview survey conforms to the conservativeness principle of economic analysis.

The project period is assumed as 40 years after the completion of the project. Table 2.21 shows the cash flows for economic analysis to derive an economic return on investment. The Economic Internal Rate of Return, EIRR, is 18% according to the cash flow. The result indicates a good economic viability of the project.

Table 2.21 Cash Flow Table for Economic Analysis of Kandawgyi Lake Water Quality Improvement

Non-disclosure Information

2.7.3 Financial Analysis

Given the fact that there is no tariff for sewerage service in Yangon, it requires thorough discussion among stakeholders whether it is possible to collect some kind of tariff from the residents or entities who discharge wastewater into the lake. The proposed project does not treat the wastewater but only divert it from the lake. Nevertheless, the project will reduce the pollution in the lake that is so close to the heart of the citizens. For financial analysis, the tariff is set at USD 0.02/m^3 to the residents that are currently discharging wastewater into the lake. Table 2.22 shows the financial cash flow developed based on the assumptions of the tariff imposed on the discharge basin customers. The financial return on investment (FIRR) is 1.6%. The return is marginally positive on the investment. Therefore, the

project is feasible as a public project with financing under soft loans such as provided by the Japanese government.

The parties that would benefit most from the improvement of the water quality in Kandawgyi Lake are the business entities providing services to the visitors to the lake such as restaurants. An option in tariff setting is to limit the charge to the commercial entities in and around the lake. A financial simulation with a target of 10% FIRR, the tariff only levied to the commercial sector would be as high as USD 0.57/m^3. The simulated tariff may be too high to be implemented.

Table 2.22 Cash Flow Table for Financial Analysis for Kandawgyi Lake Water Quality Improvement

Non-disclosure Information

Table 2.23 Financial Simulation for Tariff Setting（Wastewater disposal fee from commercial customers with target FIRR 10%）

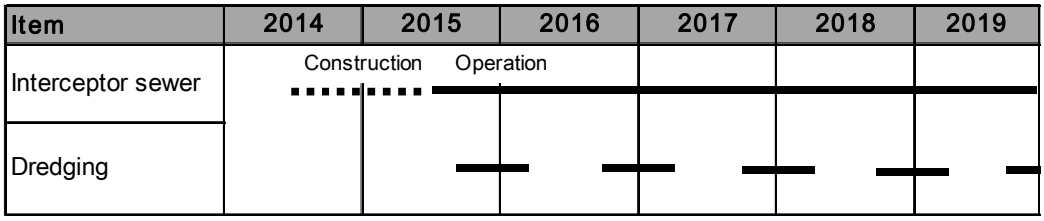
Non-disclosure Information

2.7.4 Improvement of Kandawgyi Lake Water Environment

Following 2 measures are proposed for water quality improvement in Kandawgyi Lake.

- Construction of interceptor sewer
- Dredging

Estimated work schedule of interceptor sewer construction and dredging is shown below.



Source: JICA Study Team

Figure 2.18 Work schedule of Interceptor Sewer Construction and Dredging

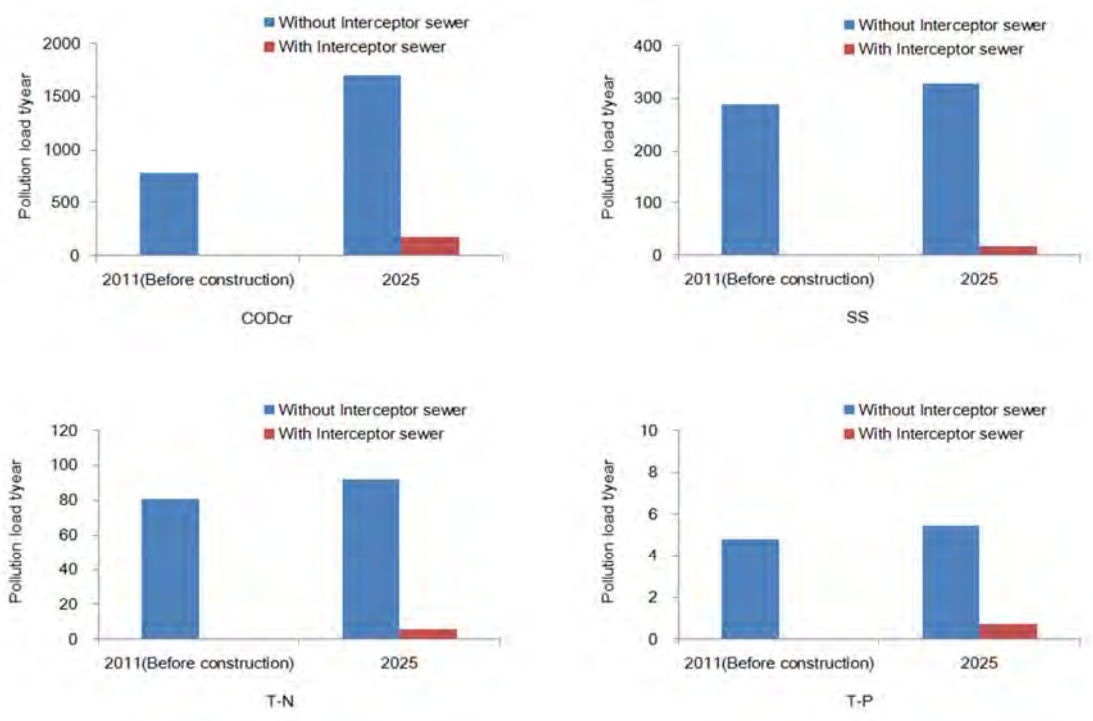
First, interceptor sewer is constructed to prevent wastewater inflow into Kandawgyi Lake. After that, dredging is implemented, and sediment and nutrients in Kandawgyi Lake are removed.

Proposed environmental improvement measure (construction of interceptor sewer and dredging) will finish by 2019. The following describes estimated water quality improvement by the implementation of these measures.

(1) Construction of interceptor sewer

Interceptor sewer is installed to intercept wastewater from Bahan T/S and Tarmwe T/S, and wastewater from restaurant around Kandawgyi Lake. Intercepted wastewater is conveyed to outside of Kandawgyi Lake basin and discharged to the existing drain.

Estimation of pollution load influx until 2040 is already shown in Section 2.3.1 (Figure 2.3). The following figure shows expected pollution load influx (CODcr, SS, T-N and T-P) in 2025. This figure shows comparison of pollution load influx in 2 cases, i.e. with and without interceptor sewer.



Source: JICA Study Team

Figure 2.19 Change of Pollution Influx (2025)

As shown in Figure 2.19, pollution load influx is decreased considerably by construction of interceptor sewer. Especially, decrease of inflow of nutrients (T-N and T-P) contributes prevention of blue-green algae growth. Therefore, construction of interceptor sewer is regarded as an effective remedial measure of eutrophication of Kandawgyi Lake.

(2) Dredging

Dredging is implemented after pollution load influx is decreased by the construction of interceptor sewer. By the implementation of dredging, nutrients accumulated at the bottom of Kandawgyi Lake is removed. Thus, it is expected that the prevention of blue-green algae growth in Kandawgyi Lake is accelerated. Therefore, dredging is regarded as an effective measure to enhance the advantage of interceptor sewer.

(3) Conclusion

For the water environment improvement of Kandawgyi Lake, construction of interceptor sewer and dredging are proposed. Through implementation of these measures, influx of nutrients into Kandawgyi Lake is decreased, and accumulated nutrients in Kandawgyi Lake are removed. Thus, through the implementation of these measures, it is expected that the concentration of nutrients (T-N and T-P) in lake water decreases below assessment criteria of eutrophication (see reference below), and growth of

blue-green algae is prevented.

Reference: Assessment criteria of eutrophication

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

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

CHAPTER 3. C1 SEWERAGE ZONE

3.1 Outline of C1 Sewerage Zone

C1 sewerage zone consists of four townships viz. Pazundaung, Botahtaung, Kyaktada and Pabedan. These four townships are included in CBD which was developed by British in 19th century based on city planning. Main roads are arranged like checkerboard and run in north-south and east-west directions. There are many central and regional government buildings, YCDC offices, many commercial establishments and residences exist and most of them are high- and middle-rise buildings. Among them, some elegant colonial style buildings are included. C1 sewerage zone is the historical and the most bustling area in Yangon. (refer to Photos 3.1 to 3.6)

Population projection of C1 sewerage zone by four townships is shown in Table 3.1. This projection was worked out by JICA Strategic Urban Development Plan. Population densities are as high as 189 persons/ha to 606 persons/ha in 2011 which are considered to be almost saturation population densities. Therefore population in Pazundaung Township is projected to slightly increase, but population of other three townships will remain as they are now.

Table 3.1 Population and Population Densities Projection of C1 Sewerage Zone

Item	Township	Area (ha)	2011	2020	2025	2030	2040
Population (person)	Pabedan	62	37,551	37,551	37,551	37,551	37,551
	Kyauktada	70	34,797	34,797	34,797	34,797	34,797
	Botahtaung	260	49,134	49,134	49,134	49,134	49,134
	Pazundaung	107	53,648	54,353	54,822	55,354	56,647
	C1 Total	499	175,130	175,835	176,304	176,836	178,129
Population Density (person/ha)	Pabedan		606	606	606	606	606
	Kyauktada		497	497	497	497	497
	Botahtaung		189	189	189	189	189
	Pazundaung		501	508	512	517	529
	C1 Total		351	352	353	354	357

Source: JICA Study Team

Photo 3.1 Sule Pagoda, Center of the City

Photo 3.2 YCDC City Hall

Photo 3.3 Sule Pagoda Road, Traders Hotel

Photo 3.4 Anawrahta Road

Photo 3.5 Merchant Road

Photo 3.6 34th Street

Wastewater generation in C1 sewerage zone up to 2040 is estimated as shown in Table 3.2. Current wastewater generation of 30,745 m^3/day is estimated to increase to 64,275 m^3/day (approximately 2 fold). Wastewater generation is estimated to increase due to increment of per capita water consumption and water supply service ratio although population does not increase.

Table 3.2 Estimation of Wastewater Generation in C1 Sewerage Zone

Item	Township	2011	2020	2025	2030	2040
Daily Average (m^3/day)	Pabedan	7,082	8,872	9,998	11,062	13,127
	Kyauktada	6,738	8,325	9,370	10,355	12,268
	Botahtaung	9,512	13,390	14,863	16,255	18,958
	Pazundaung	7,413	12,998	14,745	16,447	19,922
	C1 Total	30,745	43,585	48,976	54,119	64,275
Daily Maximum (m^3/day)	Pabedan	7,729	9,698	10,937	12,107	14,379
	Kyauktada	7,345	9,091	10,240	11,324	13,428
	Botahtaung	10,205	14,471	16,091	17,623	20,596
	Pazundaung	8,050	14,194	16,116	17,988	21,810
	C1 Total	33,330	47,454	53,384	59,041	70,213

Source: JICA Study Team

Current sewerage service area includes Latha and Lanmadaw townships other than C1 sewerage zone. Wastewater from these two townships should be treated at C1 WWTP until the time when sewerage system in W1 sewerage zone will be provided and W1 WWTP be put into operation. According to the implementation schedule worked out under MP, commissioning of W1 WWTP is expected in 2025. Population projection of two townships and wastewater generation are estimated as shown in Tables 3.3 and 3.4 respectively. Wastewater generation is estimated based on 50 lpcd with assumption that residents will use flush toilet.

Table 3.3 Estimation of Population from Outside of C1 Sewerage Zone

	2011	2020	2025	2030	2040
Latha	34,125	34,125	34,125	34,125	34,125
Lanmadaw	43,137	43,137	43,137	43,137	43,137
Total	77,262	77,262	77,262	77,262	77,262

Source: JICA Study Team

Table 3.4 Wastewater Flow from Outside of C1 Sewerage Zone

	2011	2020	2025	2030	2040
Daily Average	3,863	3,863	3,863	3,863	3,863
Daily Maximum	4,249	4,249	4,249	4,249	4,249

Source: JICA Study Team

Most of the buildings in C1 sewerage zone are high- and middle-rise buildings. In between these buildings BDS is provided, and black water and gray water are collected separately to pits installed

in BDS. Black water is discharged to sewer pipes from the pits and collected to the ejector station by gravity, and gray water is discharged to storm water drain and finally flow into Yangon River. Current situation of BDS in the four townships are illustrated in Photos 3.7 to 3.10. As shown in photos, garbage is piled up in some BDS resulting in unhygienic environment.

Photo 3.7 BDS No.1, Pabedan TS

Photo 3.8 BDS No.2, Kyaktada TS

Photo 3.9 BDS No.3, Botahtaung TS

Photo 3.10 BDS No.4, Pazundaung TS

3.2 Design Conditions

Design conditions for sewerage system in C1 sewerage zone are as follows.

(1) Basis for design

Basis for facility design is shown below.

Table 3.5 Basis for Facility Design

Items	Basis
(1) Target Year	2040
(2) Service Area	499 ha
(3) System	Separate system
(4) Service population	178,129 person
(5) Design flow	64,300 m^3/d (Daily Average) 70,200 m^3/d (Daily Maximum) 102,900 m^3/d (Hourly Maximum)
(6) Design Sewage Characteristics	BOD_5 200 mg/L SS 180 mg/L

Source: JICA Study Team

(2) Disuse of existing sewerage system

Existing sewer network has been operated for 120 years and is obviously overrunning its life period. Although having repair and rehabilitation many times, it shows marked deterioration and operation troubles due to difficulty of repair parts procurement. Moreover, since existing sewer network is only for black water from toilet, its overall renovation is necessary to match with planned sewerage system capacity. Thus, existing sewerage system will be stopped to use in future. Meanwhile, existing wastewater treatment plant (here after "WWTP") started its operation in 2005. Facility condition is comparatively good and it is possible to use in future. For effective utilization of existing facility as much as possible, the facility only covering capacity shortage will be newly constructed after evaluation of existing capacity.

(3) Receiving of sludge from septic tank

Existing WWTP is receiving septic tank sludge which is collected by vacuum truck from outside. New WWTP have to continue receiving septic tank sludge until completion of night soil treatment plant in future.

Assumed BOD concentration of septic tank sludge is about 4000 mg/L (Refer below). It shows that receiving sludge doesn't affect WWTP operation because BOD concentration increase by receiving septic tank sludge is approximately 10% and is within the range of design value even in initial stage of WWTP construction.

Therefore, septic tank sludge will be received at pumping station directly without receiving facility.

Estimation for BOD concentration of septic tank sludge

Based on the operation record and water quality test,
Total inflow: 2,300 m^3/d, Septic tank sludge: 150 m^3/d, Combined inflow water quality: 600 mg/l

Assuming the BOD concentration of black water is approx.400 mg/l [=pollution load per person 13 g/d÷30 l/d],
BOD concentration of septic tank sludge :X
{(150 m^3/d×X mg/l)＋(2150 m^3/d×400 mg/l)}/2300 m^3/d=600 mg/l ⇒ X=4000 mg/l

Note) This BOD concentration shows that digestion and stabilization of septic tank sludge is proceeding.

Impact to inflow water quality at initial stage of WWTP construction with capacity of 24,800 m^3/d
{(150 m^3/d×4000 mg/l)＋(24800 m^3/d×200 mg/l)}/24800 m^3/d= 224 mg/l
⇒ Approx. 10% increase of design water quality of 200 mg/l

(4) Expansion of WWTP site

Construction site for C1 WWTP is shown below. The existing WWTP site will be expanded to 3.9 ha. Yangon city mayor is now requesting acquisition of expansion area to government.

Source: JICA Study Team

Figure 3.1 Construction Site for C1 WWTP

3.3 Sewer System Design

(1) Design criteria

Design criteria for sewer system are shown below.

Table 3.6 Design Criteria for Sewer System

Items	Adoption	Remarks
(1) Capacity Calculation	Manning Formula $v = \frac{1}{n} \times R^{\frac{2}{3}} \times I^{\frac{1}{2}}$ Where, V: flow velocity (m/s) N: Roughness Coefficient (-) R: Hydraulic Radius (m) I: Gradient(-)	
(2) Flow Velocity	Minimum: 0.6 m/s Maximum: 3.0 m/s	
(3) Minimum Diameter	150 mm	
(4) Minimum Earth Covering	1.5 m	
(5) Interval of Manhole	75 m（Branch sewer） 150 m（Trunk main）	>for small dia. pipe jacking, open cut method >for Middle/large dia. pipe jacking

Source: JICA Study Team

(2) Sewer network design

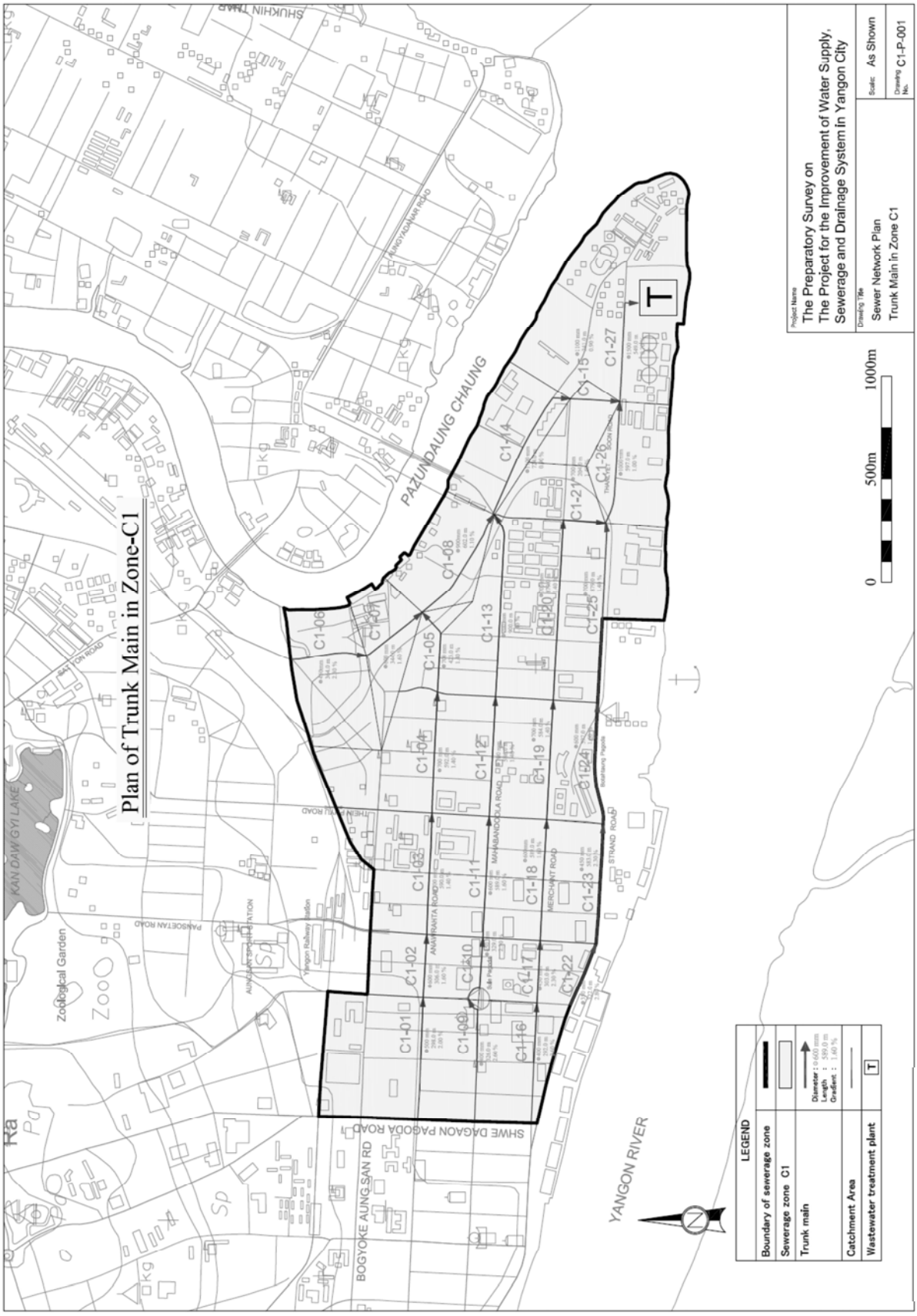
- Trunk Main

  Trunk mains are installed in main road in C1 sewerage zone such as Anawramta Road, Maha Bandoola Road, Merchant Road, Strand Road and Lower Pazundaung Road. Each road has enough width for pipe installation with over 20m. Diameter of trunk main is 500 to 1500 mm. Since pipe jacking method is adopted for trunk main due to heavy traffic condition, pipe material is RC (Reinforced concrete) for pipe jacking. Trunk main sewer is designed by gravity system without pumping station because C1 sewerage zone is generally flat area and has no significant low area.

- Branch sewer and house connection

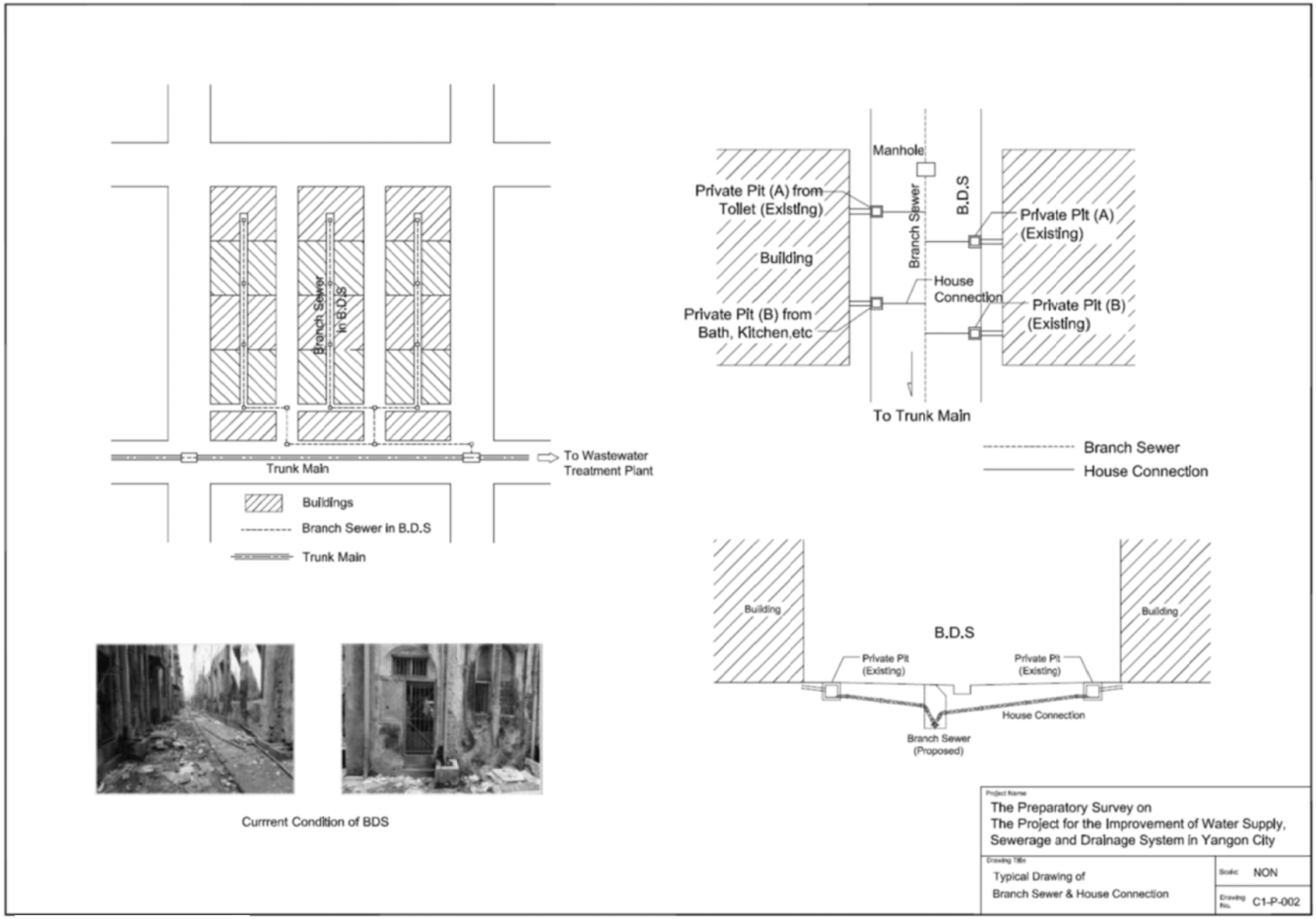
  Most residence in C1 sewerage zone is complex housing and has back yard space so called BDS (Back Drainage Space). Black and grey water discharged from each house flow into existing pits in BDS. Branch sewer is designed to collect wastewater from existing pit and connect to trunk main through BDS.

Figures 3.2 to 3.8 show general layout of trunk main, typical drawings of branch sewer and house connection and trunk main profile in C1 sewerage zone. Flow calculation of trunk main is attached in Appendix A.



Source: JICA Study Team

Figure 3.2 General Layout of Trunk Main in C1 Sewerage Zone



Source: JICA Study Team

Figure 3.3 Typical Drawing of Branch Sewer and House Connection in C1 Sewerage Zone

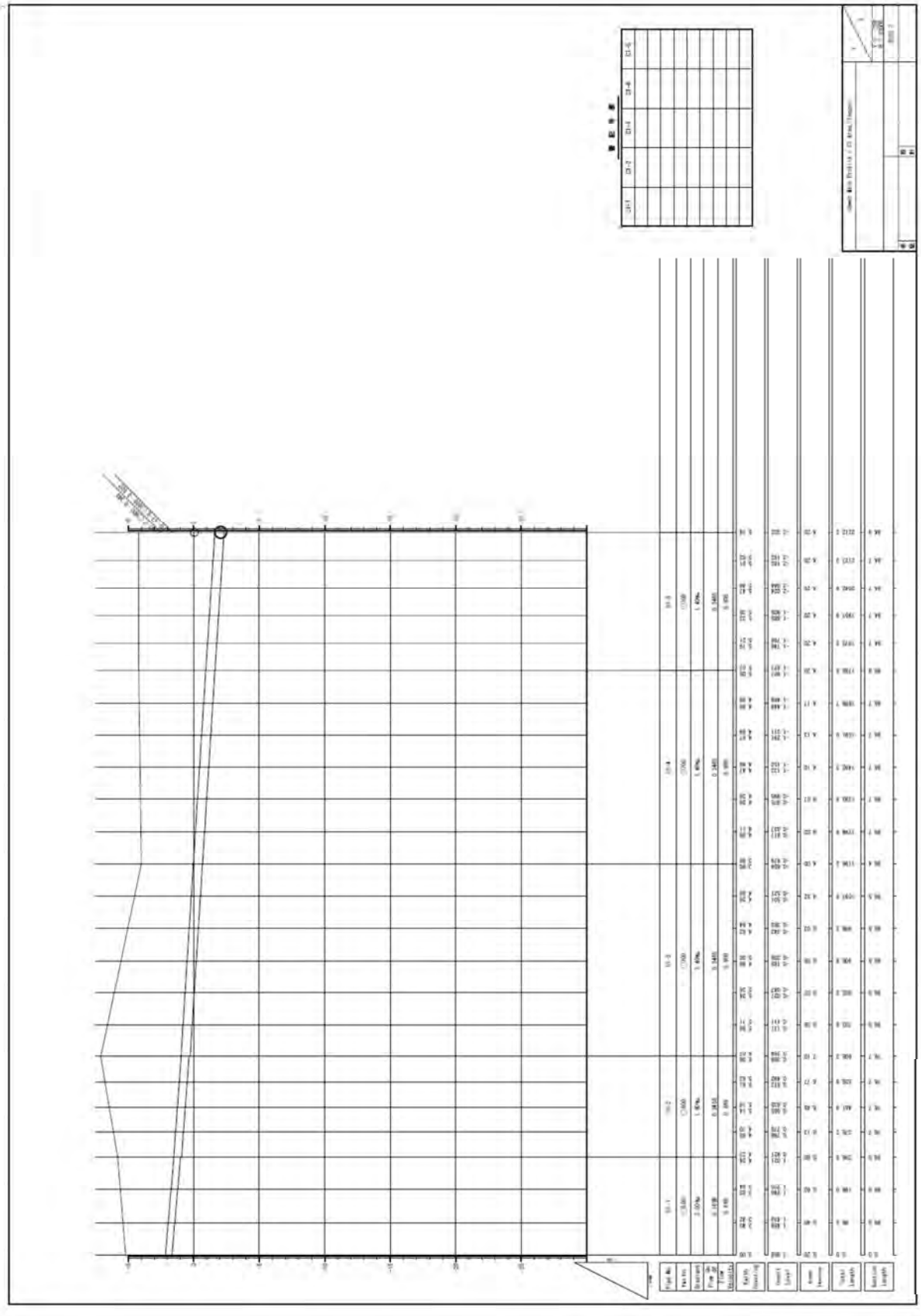


Figure 3.4 Trunk Main Profile in C1 Sewerage Zone (1/5)

Source: JICA Study Team

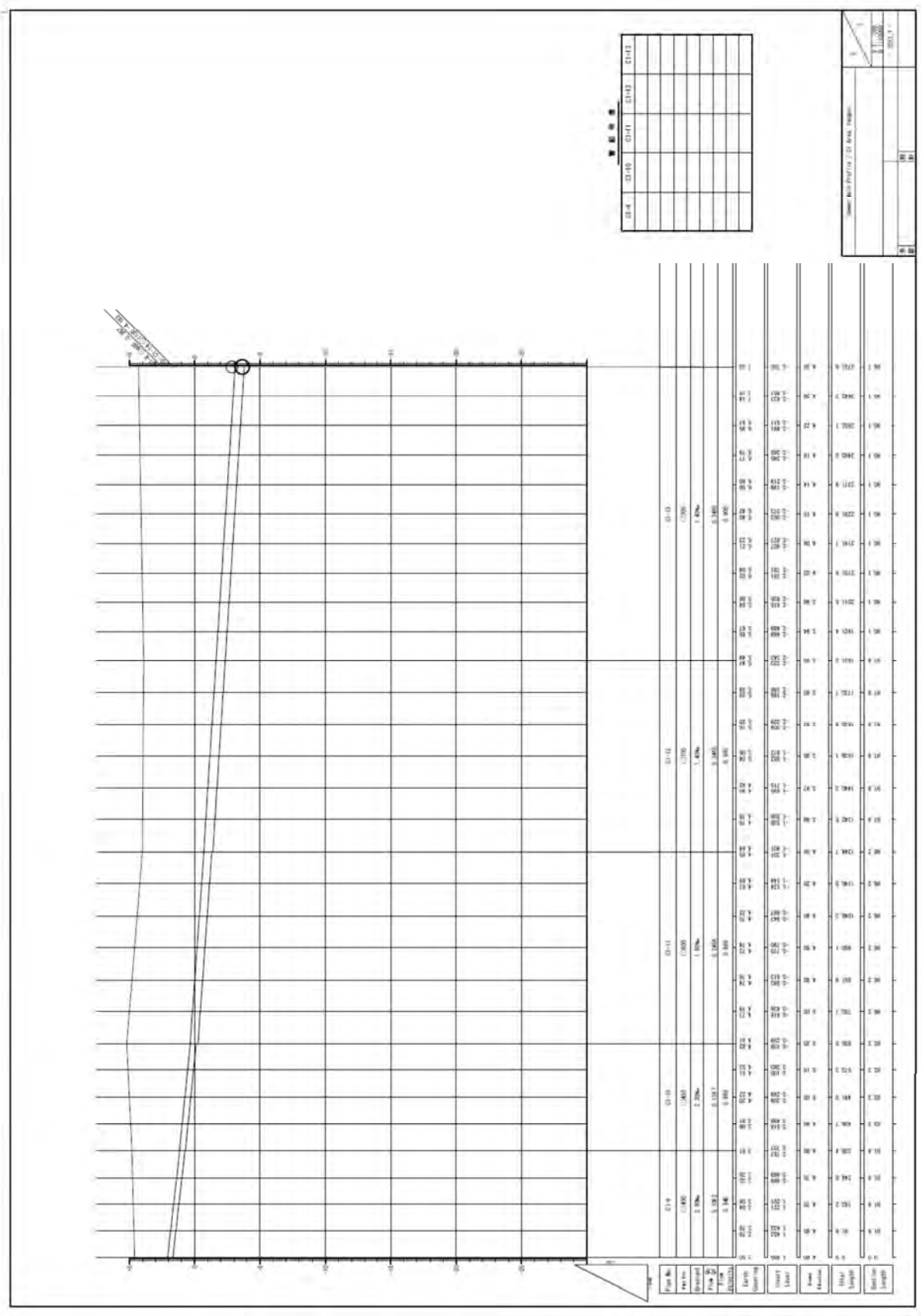


Figure 3.5 Trunk Main Profile in C1 Sewerage Zone (2/5)

Source: JICA Study Team

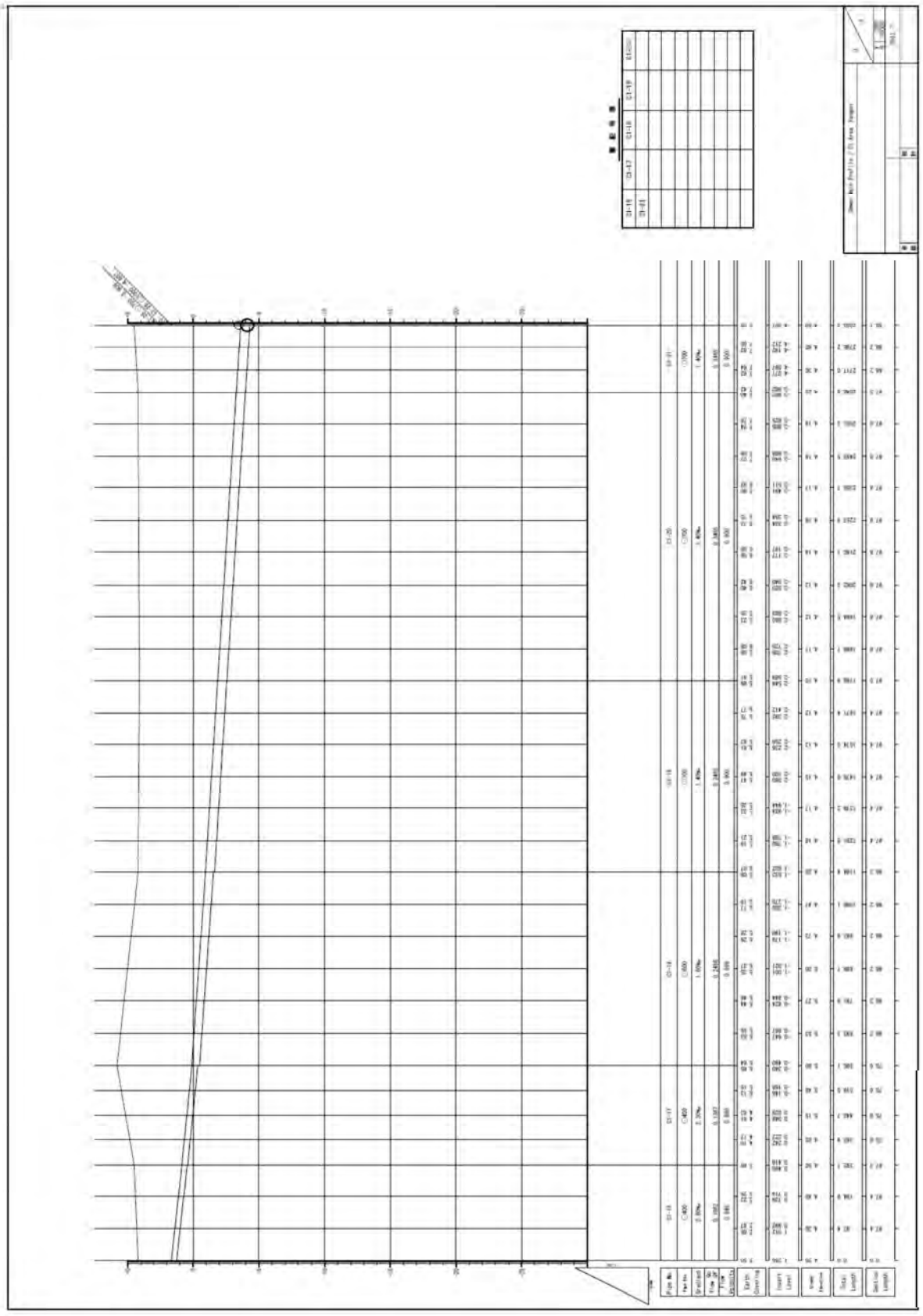


Figure 3.6 Trunk Main Profile in C1 Sewerage Zone (3/5)

Source: JICA Study Team

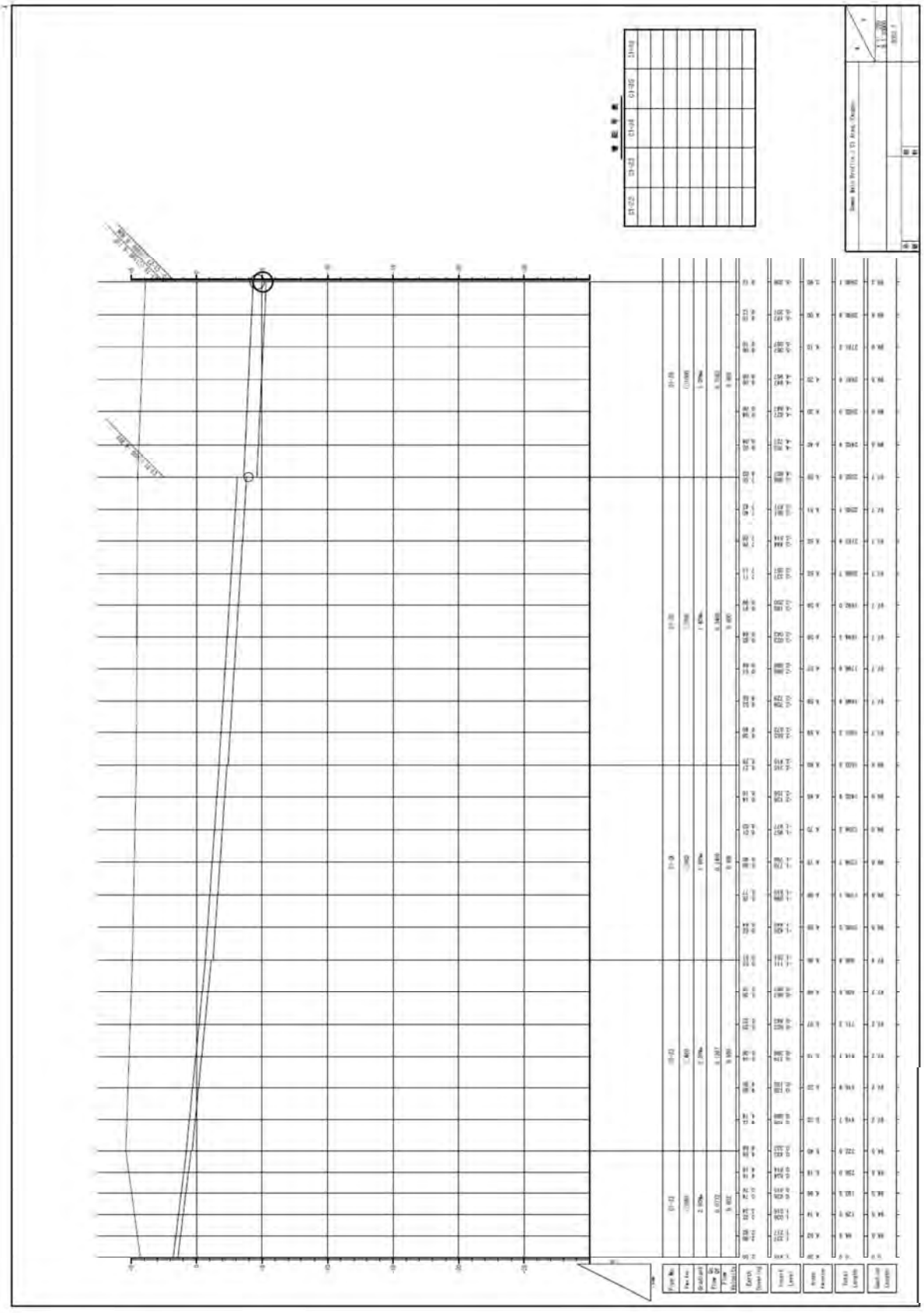


Figure 3.7 Trunk Main Profile in C1 Sewerage Zone (4/5)

Source: JICA Study Team

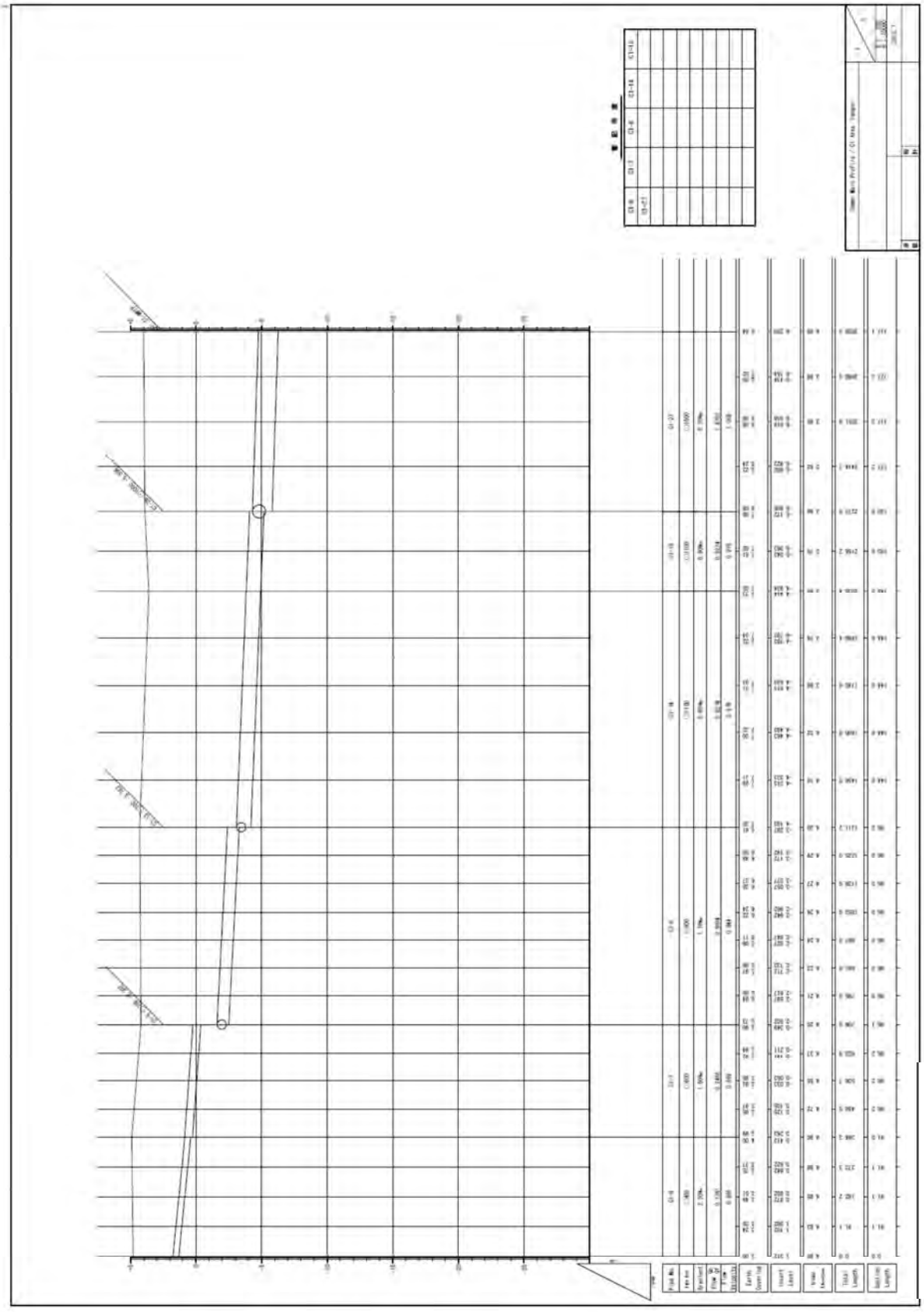


Figure 3.8 Trunk Main Profile in C1 Sewerage Zone (5/5)

Source: JICA Study Team

3.4 WWTP Design

3.4.1 Basis for Design

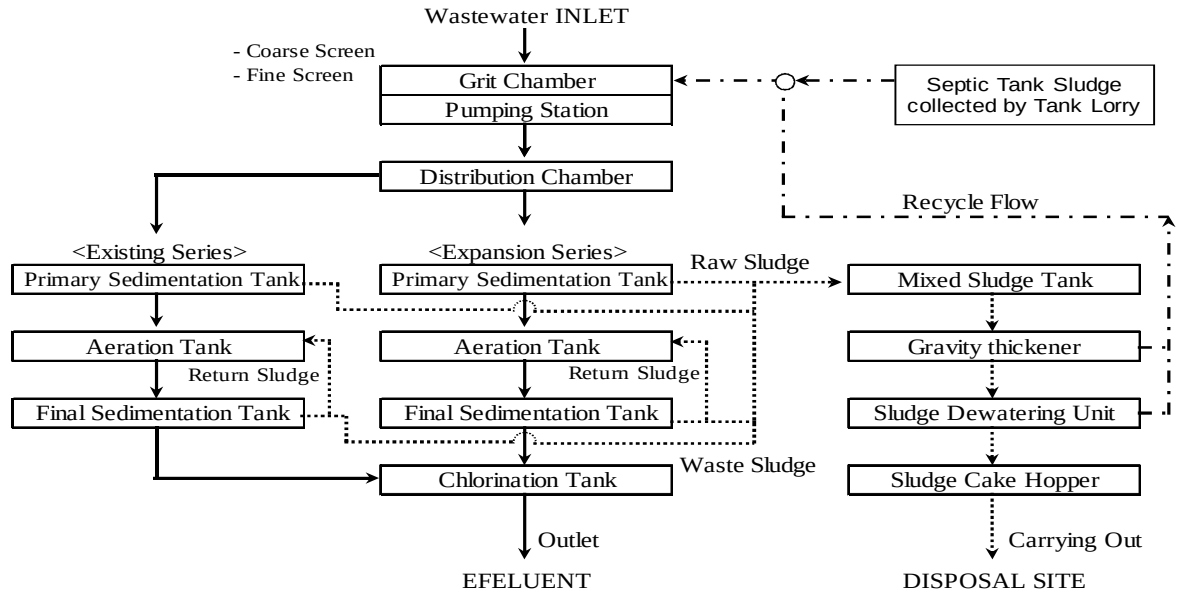
(1) Treatment method

Conventional activated sludge process is adopted for treatment of wastewater considering the following points.

- ✓ Sufficient function for target effluent standard with enough experience around the world
- ✓ Flexibility of facility layout for site conditions
- ✓ Effective utilization of existing facility without overall renovation
- ✓ Ease in operation by O&M staff who has knowledge and experience of activated sludge process adopted in the existing WWTP

For existing WWTP, treatment process will be changed from extended aeration process to conventional activated sludge process. By changing treatment process, existing WWTP capacity can be increased and effective operation by unification of whole WWTP process should be realized.

Regarding sludge treatment, "thickening-dewatering-carrying out" process, in which easy operation is relatively possible, is adopted since construction space is limited and O&M staff has not enough experience for sludge treatment. In the future, it is desirable to build up experience, knowledge and skills for sludge treatment for promotion of sludge reuse and recycling in Yangon city. Flow diagram of C1 WWTP is shown below.



Source: JICA Study Team

Figure 3.9 Flow Diagram of C1 WWTP

(2) Design Flow

Design flow up to 2040 is shown below. Daily maximum flow is used for WWTP facility design.

Conduit and pumping station in WWTP design are based on hourly maximum flow. Daily average flow is used for O&M cost estimation.

Table 3.7 Design Flow in C1 Sewerage Zone

C1 Sewerage Zone		2011	2018	2020	2025	2030	2035	2040
Population (person)		175,130	175,664	175,835	176,304	176,836	177,441	178,129
Wastewater Flow (m3/day)	Daily Average	30,745	41,498	43,585	48,976	54,119	59,020	64,275
	Daily Maximum	33,330	45,158	47,454	53,384	59,041	64,432	70,213
	Houry Maximum	47,544	65,287	68,730	77,625	86,111	94,198	102,869

Source: JICA Study Team

(3) Design characteristics of wastewater

Design water quality of influent and effluent is shown in following table. Effluent quality target, as BOD 20mg/l, SS 30mg/l, is decided considering MOI (Ministry of Industry) regulation and international standards.

Table 3.8 Design Water Quality for C1 WWTP

Items	Value	Remarks
(1) Influent	BOD_5 200 mg/L SS 180 mg/L	Water temp. 29℃
(2) Effluent （Target water quality）	BOD_5 20 mg/L SS 30 mg/L	MOI regulation （N0.1 Directive 1/95） Max BOD_5 20～60 mg/L Max SS 30 mg/L

Source: JICA Study Team

(4) Site Condition

Condition of site for C1 WWTP construction is shown below.

Table 3.9 Site Condition for C1 WWTP

Items	Condition	Remarks
Area	3.9 ha	Expansion area is now under application to the government
Ground Elevation	+4.5 m	
Discharge Point	Yangon River （H.H.W.L. + 3.619）	Tidal River
Land use of surroundings	East: Government Land West: Governmental Company South: Yangon River North: Land for military	＞Official residence ＞Myanmar Oil and Gas Co. ＞Ministry of Defense
Wind Direction	NW (Summer and Rainy season) SE (Dry season)	
Temperature	Yearly Ave. 27 ℃	
Relevant Law/regulation	-	
Geological condition	- From surface, Clay with silt and clay with sand layer is dominant - Ground Water Level: GL-2.0m - Supporting Layer Sand with silt layer (GL-20m)	

Source: JICA Study Team

3.4.2 WWTP Facility Design

Basic policy for WWTP design is that additional facility will be constructed for covering lack of design capacity after evaluation of the capacity of the existing WWTP. Regarding the existing WWTP, primary and final sedimentation tank will be expanded to utilize existing aeration tank capacity as much as possible. Breakdown of WWTP design capacity, i.e. 70,200 m^3/d, is that a) existing line 45,400 m^3/d and b) expansion line 24,800 m^3/d.

Facility level is designed to make gravity flow possible after lifting up at pumping station. In facility layout planning, water treatment facilities and sludge treatment facilities are consolidated for effective and energy saving O&M.

Outlines of WWTP facility are shown in the following table.

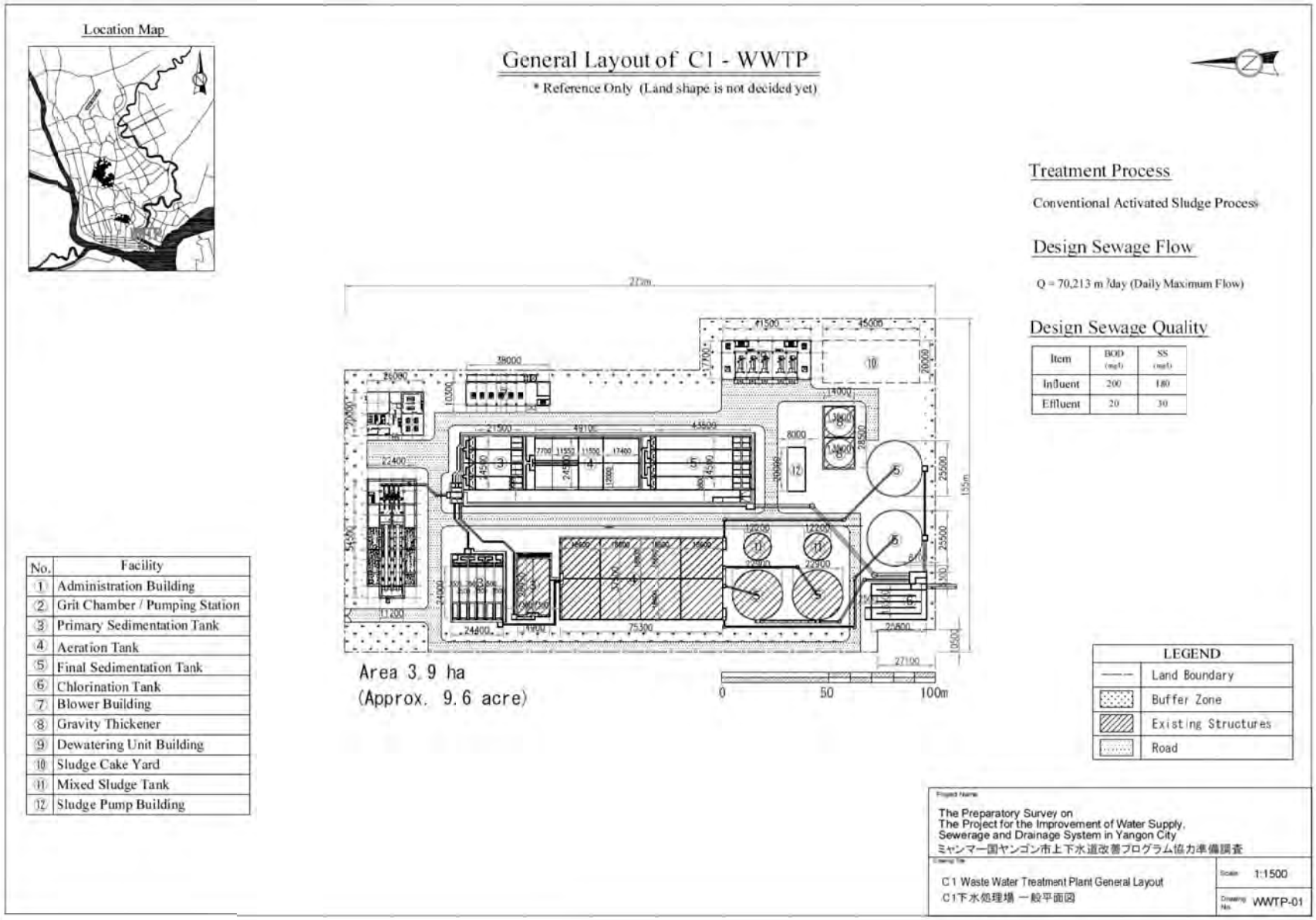
Table 3.10 Outline of C1 WWTP Facilities

Name	Category		Outline of Facility	Dimension
	New construction	Remodeling		
Pumping Station	○		Pumping station is planned for lifting up sewage incoming from inflow pipe, Dia 1500 mm, with earth covering of 8.6 m. Pumping station includes grit chamber and screen for removal of rubbish and sand. ＜Design criteria＞ For Grit chamber, Water surface load 1800 m^3/m^2/d, Average velocity 0.3 m/s	Grit chamber： Width 1.1m×Length 13m×Depth 0.9m×4 Basin Pump Unit：4 Nos (incl.1 Stand-by)
Primary Sedimentation Tank (PST)	○	○	PST is planned for removal of sediment in sewage. PST is planned both in existing line and expansion line. PST of existing line is designed with rectangular parallel flow type same as existing facility and PST of expansion line is designed also by rectangular parallel flow type due to limited site area. ＜Design criteria＞ Water surface load 50 m^3/m^2/d, Hydraulic retention time 1.5 hr.	Existing Line Width7.3m×Length27.4m×Depth3.65m×2tanks(Existing) ,Width 3.5m×Length24.0m×Depth3.0m ×6tanks (New construction of Existing Line) Expansion Line Width3.85m×Length21.5m×Depth3.0m×6tanks
Aeration Tank	○	○	Aeration tank is planned to treat organic matter in sewage biologically. Aeration method is designed as spiral flow type aeration. Aeration unit of existing line will be changed from mechanical aeration to diffused air aeration. Although effluent standards of Yangon city don't include regulation of ammonia and nitrogen, partition wall is designed in aeration tank for nitrification process operation for future. ＜Design criteria＞ Hydraulic retention time more than 6hr., MLSS concentration 2000 mg/l	Existing Line Width18.6m×Length4.4m×Depth4.1m×2tanks (Remodeling of Existing Line） Expansion Line Width12.0m×Length48.2m×Depth5.5m×2Tanks
Final Sedimentation Tank (FST)	○	○	FST is planned for separation of treated water and sludge generated by biological treatment. FST is planned both in existing line and expansion line. FST of existing line is designed with radial flow circular type same as existing facility and FST of expansion line is designed with rectangular parallel flow type due to limited	Existing Line Dia22.9m×Depth3.5m×2tanks(Existing), Dia25.5m×Depth4.0m×2Tanks(New construction of Existing Line)

Name	Category		Outline of Facility	Dimension
	New construction	Remodeling		
			site area. ＜Design criteria＞ Water surface load 25 $m^3/m^2/d$	Expansion Line Width3.85m×Length43.5m×Depth3.5m×6tanks
Disinfection Facility	○		Disinfection facility is planned for securement of sanitary safety in effluent. Disinfection facility is planned with full design capacity due to big lack of existing capacity. Disinfection facility is designed with chlorine disinfection, for which easy operation with low cost is expected, and coliform group count of less than 3000 Nos./cm^3 is adopted for indicator of effluent quality target. ＜Design criteria＞Chlorination time 15 min	Expansion Line Width2.5m×Length147.0m×Depth2.0m
Sludge Mixing Tank/Sludge Pump Room	○	○	Sludge mixing tank is planned for mixing sludge withdrawn from PST and FST. Existing gravity thickener will be remodeled to sludge mixing tank for effective utilization of existing facility. Mixed sludge will be sent to gravity thickener by sludge pump. For effective operation, sludge pump room is planned to put together all sludge pumps such as return sludge pump, excess sludge pump and thickened sludge pump.	Sludge Mixing Tank: Dia12.3m×Depth4.0m×2Tanks (Remodeling of existing gravity thickener) Sludge Pump Room： Width9.0m×Length20.0m ×1 Basement
Gravity Thickener		○	Gravity thickener is planned for effective operation of following dewatering process. Thickening process is designed by gravity thickener, which takes easy operation with low cost. Existing digestion tank will be remodeled to gravity thickener for effective utilization of existing facility. ＜Design criteria＞ Solids Loading 75 kgds/m^2d, Solids capture rate 90%, Water content of thickened sludge 98%	Dia10.5m×Depth4.1m×2Tanks （Remodeling of existing digestion tank）
Sludge Dewatering Unit Building	○		Sludge dewatering process is planned with mechanical dewatering considering odor control and limited site area. Sludge treatment facility is consolidated in layout plan for effective and energy saving O&M. ＜Design criteria＞ Solids capture rate 95%, Water content of sludge cake 80%	Width17.7m×Length41.5m ×2 Storey with 1 Basement
Blower Building	○		Blower building is planned as independent building because blower unit is main source of noise and vibration in WWTP.	Width10.3m×Length38.0m ×1 Storey with 1 Basement
Administration Building	○		Administration building is planned for putting in staff room, monitoring room, electrical room and laboratory, etc.	Width20.0m×Length26.0m×2 Storey

Source: JICA Study Team

Figures 3.10 to 3.12 show General layout, hydraulic profile and flow diagram of C1 WWTP. Structure drawings of each facility and capacity calculation are attached in Appendices B and C respectively.



Source: JICA Study Team

Figure 3.10 General Layout of C1 WWTP

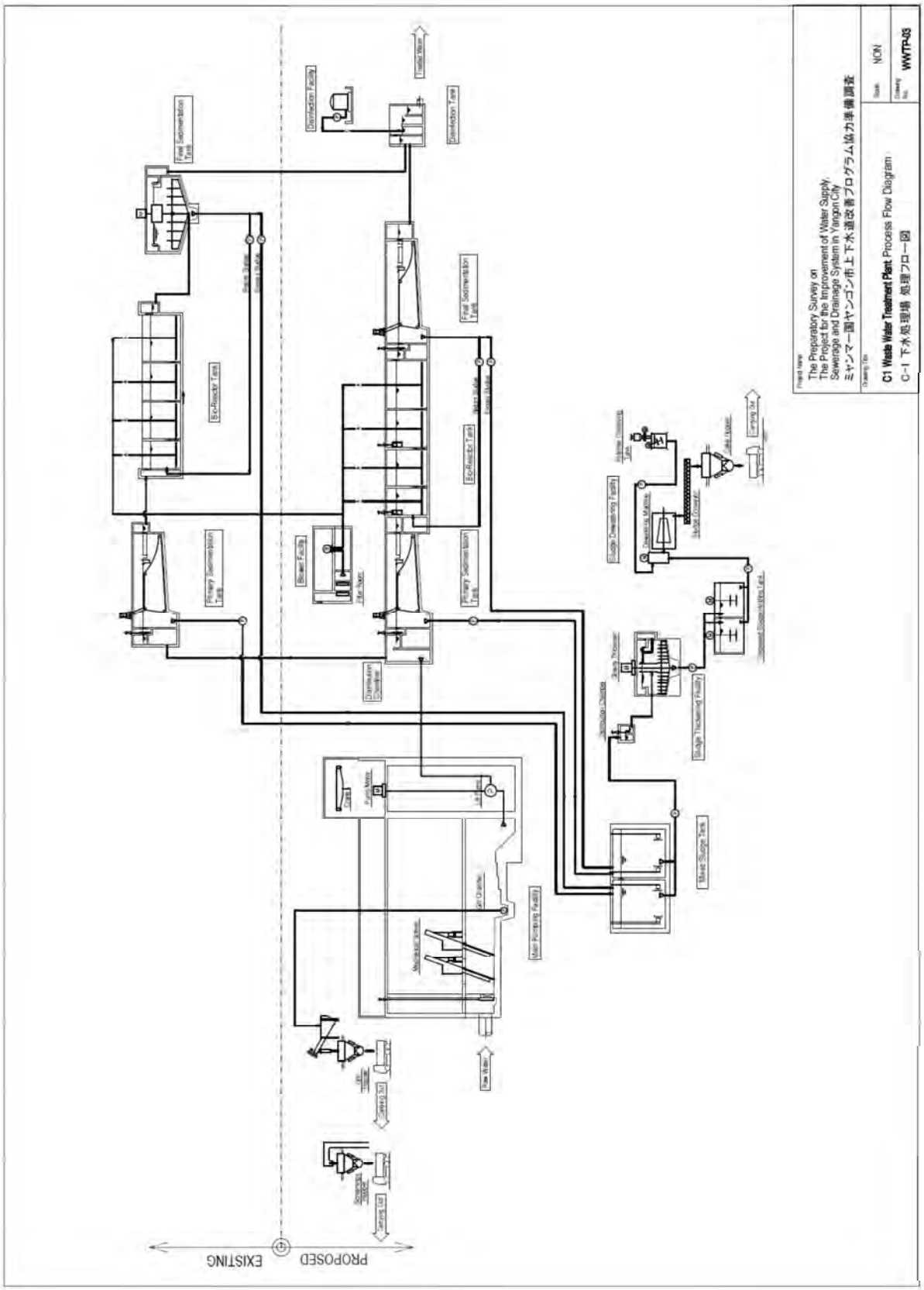
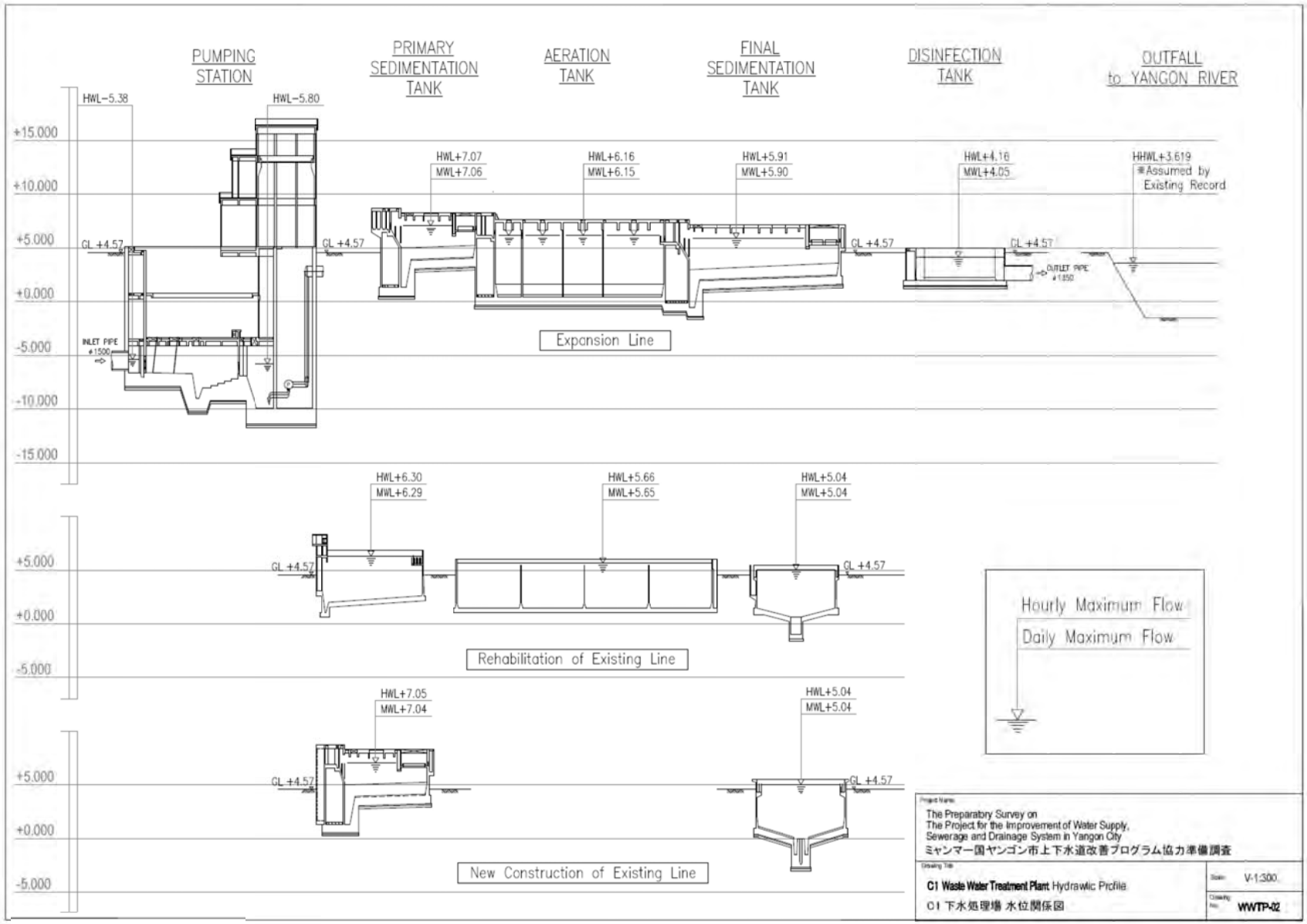


Figure 3.11 Flow Diagram of C1 WWTP

Source: JICA Study Team



Source: JICA Study Team

Figure 3.12 Hydraulic Profile of C1 WWTP

3.4.3 Mechanical Equipment Design

(1) Basic policy for design

According to policy for facility plan under MP, ejector stations and compressor facilities are planned to be abandoned. Thus, generated wastewater will be collected by gravity up to the proposed pumping station which is constructed within the existing WWTP site. New screen facility and grit chamber are proposed to meet design flow instead of the existing ineffective facility. Vertical non clog type in dry well as sewage lift pump is recommended. Treatment process will be changed from current extended aeration process to conventional activated sludge process, and design capacity will increase from about 15,000 m^3/d up to about 70,300 m^3/d. The existing mechanical equipment will be abandoned because different process is adopted and existing facilities are in deteriorated conditions.

The existing gravity sludge thickener will be converted to sludge mixing tank, and the existing aerobic digester will be converted to gravity sludge thickener to meet increased design wastewater flow. The sludge treatment process, i.e. gravity thickening plus mechanical dewatering same as the existing process is adopted. The existing belt press dewatering equipment which has not been used since commissioning of the plant will be abandoned and new screw press for which Japan has advantages is adopted because the existing machine has not been used until now and large scale machine is required.

Mechanical facilities are designed in view of economy and ease of operation. Current status of mechanical equipment and their problems are also taken into account. Key points for mechanical equipment design are described below.

- Type of sewage lift pump in pump station – Current submersible type is prone to frequent failure and is difficult in maintenance. Dry well centrifugal non-clog type is recommended.
- Aeration type – Super fine membrane diffusers with the latest technology are recommended due to reduction of electrical power cost.
- Dewatering unit type – Screw press type is recommended for easy maintenance. The existing belt press type is difficult in maintenance.
- Installation of odor control system – Two sets of biological scrubber are designed for pump station and for sludge treatment facility.

(2) Design basis

Design basis for mechanical equipment is shown in Table 3.11.

Table 3.11 Design Basis for Mechanical Equipment

Facility Name	Design basis	Reference
Pump Station	103,000 m^3/ day	(Hourly maximum)
Grit chamber Facility	103,000 m^3/ day	(Hourly maximum)
Primary Clarifier Facility	70,300 m^3/ day	(Daily maximum)
Aeration Tank Facility	70,300 m^3/ day HRT Approx. 6.0 hr. MLSS Ave. 2,010 mg/ l Temperature of water 20℃ Water depth 4.1 m (the existing) Water depth 5.5 m (the proposed)	(Daily maximum)
Secondary Clarifier Facility	70,300 m^3/ day	(Daily maximum)
Disinfection Facility	103,000 m^3/ day	(Hourly maximum)
Gravity Thickener	Inlet Sludge Solids Load 7,215 kg/d (primary sludge) Inlet Sludge Solids Load 5,109 kg/d (waste sludge) Thickened Solids Content 2.0 %	(Daily maximum)
Sludge dewatering Unit	Inlet Sludge Solids Load 11,203 kg/ day Sludge Water content Approx. 85% Operation time 10 hr/ day x 5 days/ week	(Daily maximum)

Source: JICA Study Team

(3) Preliminary treatment facility

Preliminary treatment facility is composed of grit chamber and pumping station. Both facilities have very important role, which make treatment process reliable and effective.

1) Grit chamber

Grit chamber is designed in front of sewage lift pump facility, which is composed of four channels. Mechanical facilities are composed of gates, coarse screens, and medium screens. The principal role of screens is to remove coarse and medium materials from the flow stream, such as leaves, paper, and rags. These materials are lifted up by screen automatically, which are transferred to screenings hopper by screens conveyors and skip hoist.

Sand is settled by gravity at grit chamber, because grit, consisting of sand, or other heavy solid materials have specific gravities greater than organic solids. Settled sand is collected at bottom of sand pit by grit collector, and transferred to grit separator by grit pump. Jet nozzle grit collector and screw type grit separator are applied for its compactness and easy operation.

Since the FRP sealing plate and sealing cover of mechanical equipment prevent odor from spreading into surrounding atmosphere effectively, air is transferred to odor control system by deodorization fan.

Mechanical equipment in preliminary treatment facility (grit chamber) is shown below.

Table 3.12 Mechanical Equipment for Preliminary Treatment (Grit Chamber)

Item	Specification	Unit
Inlet Gate	Motorized driven cast iron gate W 0.5m x H 0.75 m	2 units
Mechanical Coarse Screen	Bar Screen W 1.2 m x H 3.0 m x Opening 100mm	2 units
Mechanical Medium Screen	Motorized driven intermittent screen W 1.2 m x H 3.0 m x Opening 25 mm	2 units
Grit Collector	Pressured jet water type W 1.1 m x H 13 m	2 lot
Grit Pump	1.0 m^3/min x 5.5 kW	2 units
Scrubber	70 m^3/min	1 unit

Source: JICA Study Team

2) Pumping station

Pumping station is composed of two wet wells and one dry well for sewage lift pumps. Effluent flow is transferred to distribution chamber installed upstream of primary sedimentation tank by sewage lift pump. Vertical submersible non-clog type pump in dry well type is recommended due to the following reasons.

- Easy operation and maintenance because the pumps are installed in a dry well, and operators have thus easy access to monitor pumps.
- Strong against water immersion in flood.

Table 3.13 Mechanical Equipment for Preliminary Treatment (Pumping Station)

Item	Specification	Units
Sewage Lift Pump	Vertical submersible non - clog type 23.9 m^3/min x 140 kW	4 units Including 1 standby

Source: JICA Study Team

(4) Primary Treatment Facility

Solid-liquid separation occurs in primary sedimentation tank by gravity, and settled solids (primary sludge) are collected to sludge pit by sludge collector, and transferred to the mixed sludge tank by primary sludge pumps.

Notch chain flight type is recommended. Floating scum is separated by scum skimmer and sent to scum screen by scum pump. Scum pit is covered and deodorization is provided. Mechanical equipment for primary sedimentation tank is shown below.

Table 3.14 Mechanical Equipment in Primary Sedimentation Tank

Item	Specification	Unit
Primary Sludge Collector (Existing train)	Notch chain flight type 7.2 m W x 27.4 m L x 0.75 kW	2 units
Primary Sludge Collector (Proposed train 1)	Notch chain flight type 3.5 m W x 24 m L x 0.75 kW	6 units
Primary Sludge Collector (Proposed train 2)	Notch chain flight type 5.8 m W x 21.5 m L	4 units
Primary Sludge Pump (Existing train)	Non – clog centrifugal 1.2 m^3/ min x 5.5 kW	2 units including 1 standby
Primary Sludge Pump (Proposed train 1)	Non – clog centrifugal 1.2 m^3/ min x 5.5 kW	2 units including 1 standby
Primary Sludge Pump (Proposed train 2)	Non – clog centrifugal 1.2 m^3/ min x 5.5 kW	2 units including 1 standby
Primary De-sludge Valve	Motorized driven eccentric Dia. 150 mm x 0.2 kW	7 units

Source: JICA Study Team

(5) Secondary treatment facility

1) Aeration Tank

Effluent from primary sedimentation tank flows to the gates installed in front of aeration tanks by gravity. Aeration tank is divided into four trains. Mixed liquor is biologically treated in each of four aeration tanks when it flows by plug flow, and discharged to secondary sedimentation tank by gravity. Super fine diffuser with blower is recommended because of the reasons below instead of mechanical aerator of which efficiency is inferior.

- Energy saving
- Easy maintenance because of nonexistence of complex devices
- Most popular and latest technology for conventional activated sludge process

Air is supplied by combination of blower and diffuser, and oxygen required for treatment dissolves in wastewater. Diameter of fine bubble is approximately 1mm which realizes efficient dissolution. Air volume is efficiently controlled by outlet valve operation and DO measuring. Mechanical equipment for aeration tank is shown below.

Table 3.15 Mechanical Equipment for Aeration Tank

Item	Specification	Unit
Aeration Diffuser (Existing train)	Super fine membrane diffuser SOR 69.5 kg/O_2/d/tank 18.6 m W x 18.6 m L x 4.05 m WD	4 tanks/ train x 2 trains
Aeration Diffuser 1 (Proposed train)	Super fine membrane diffuser SOR 24.4 kg/O_2/d/tank 12.0 m W x 7.7 m L x 5.5 m WD	1 tank/ train x 2 trains
Aeration Diffuser 2 (Proposed train)	Super fine membrane diffuser SOR 36.6 kg/O_2/d/tank 12.0 m W x 11.5 m L x 5.5 m WD	1 tank/ train x 2 trains
Aeration Diffuser 3 (Proposed train)	Super fine membrane diffuser SOR 36.6 kg/O_2/d/tank 12.0 m W x 11.5 m L x 5.5 m WD	1 tank/ train x 2 trains
Aeration Diffuser 4 (Proposed train)	Super fine membrane diffuser SOR 54.9 kg/O_2/d/tank 12.0 m W x 17.4 m L x 5.5 m WD	1 tank/ train x 2 trains
Blower 2 (Existing train)	Rotary type 87 m^3/ min x 120 kW	3 units including 1 standby
Blower 1 (Proposed train)	Rotary type 33 m^3/ min x 75 kW	3 units including 1 standby

Source: JICA Study Team

2) Final sedimentation tank

Sludge separated by solid-liquid separation in the tank is collected in the sludge pit by sludge collector and sent to sludge mixing tank by waste sludge pump which is operated intermittently by timer control. On the other hand, return sludge is circulated to the front part of aeration tank by return sludge pump for keeping MLSS concentration.

Generated scum is removed by scum skimmer and discharged to scum pit by gravity. Scum pit is covered and deodorized. Mechanical equipment is shown below.

Table 3.16 Mechanical Equipment for Final Sedimentation Tank

Item	Specification	Unit
Secondary Sludge Collector (Existing train)	Central driven type Dia. 22.9 m x 2.2 kW	2 units
Secondary Sludge Collector (Proposed train 1)	Central driven column type Dia. 25.5 m x 2.2 kW	2 units
Secondary Sludge Collector (Proposed train 2)	Notch chain flight type 5.8 m W x 43.5 m L	4 units
Waste Sludge Pump (Existing train)	Non – clog submersible 2.6 m^3/ min x 15 kW	2 units including 1 standby
Waste Sludge Pump (Proposed train 1)	Non – clog centrifugal 1.2 m^3/ min x 15 kW	2 units including 1 standby
Waste Sludge Pump (Proposed train 2)	Non – clog centrifugal 1.2 m^3/ min x 15 kW	2 units including 1 standby
Return Sludge Pump (Existing train)	Non – clog submersible 7.2 m^3/ min x 18.5 kW	2 units
Return Sludge Pump (Proposed train 1)	Non – clog centrifugal 8.7 m^3/ min x 22 kW	2 units
Return Sludge Pump (Proposed train 2)	Non – clog centrifugal 8.7 m^3/ min x 22 kW	2 units
Waste De-sludge Valve	Motorized driven eccentric Dia.200 mm x 0.2 kW	4 units

Source: JICA Study Team

(6) Disinfection and Reuse Facility

Hypochlorite solution is injected to effluent from the final sedimentation tank by chemical pumps. Treated effluent before disinfection is used as de-foaming water to aeration tank. Treated effluent after disinfection is used as washing water for mechanical equipment.

Table 3.17 Mechanical Equipment for Disinfection and Reuse Facility

Item	Specification	Unit
Chlorine Storage Tank	20 m^3	2 units
Chlorine Dosing pump	Diaphragm Pump 0.5 – 1.5 L/min x 0.2 kW	3 units including 1 standby

Source: JICA Study Team

(7) Sludge treatment facility

1) Sludge thickening facility

Primary sludge and waste sludge are transferred to the gravity thickener by sludge feed pumps via the mixed sludge tank. Thickened sludge is transferred to the thickened sludge holding tank for dewatering by thickened sludge pumps. Separated liquid in gravity thickener is returned to grit chamber by gravity. FRP sealing plate and sealing cover of mechanical equipment are provided to prevent odor from spreading into surrounding air and air is transferred to odor control system by deodorization fan. Mechanical equipment for sludge thickening is shown below.

Table 3.18 Mechanical Equipment for Sludge Thickening

Item	Specification	Unit
Sludge Feed Pump to Thickener	Non – clog centrifugal 0.6 m^3/ min x 3.7 kW	3 units including 1 standby
Gravity Thickener	Centre driven type Dia. 10.5 m x 0.4 kW	2 units
Thickened Sludge Pump	Non – clog centrifugal 0.6 m^3/ min x 3.7 kW	3 units including 1 standby
Thickened Sludge Pump for Dewatering Unit	Non – clog centrifugal 0.36 m^3/ min x 3.7 kW	5 units including 2 standby

Source: JICA Study Team

2) Sludge dewatering facility

Thickened sludge is transferred to dewatering unit by sludge pump. Screw press or multi-disk plate screw press is recommended for its compactness, low-speed rotation, low energy consumption, and easy operation. Further, polymer solution work is needed for dewatering every day. Separated liquid from dewatering machine is returned to grit chamber by gravity. FRP sealing plate and duct are provided for odor control and air is suctioned by fan to deodorization device. Mechanical equipment for sludge dewatering is shown below.

Table 3.19 Mechanical Equipment for Sludge Dewatering

Item	Specification	Unit
Sludge Dewatering Unit	Screw press type 400 ds-kg/ hr. x 5.2 kW	4 units including 1 standby
Polymer Dissolving Tank Set	40 m^3	3 units
Polymer feed pump	Progressive cavity pump 1.5 – 5 m^3/ hr. x 2.2 kW	4 units including 1 standby
Sludge Cake Hopper	Motor driven cut gate 1.5 kW	2 units

Source: JICA Study Team

3.4.4 Electrical Equipment Design

(1) General

The electrical facilities in the existing wastewater treatment plant were built in 2004 and the rated capacities are small against the required load demand of the new wastewater treatment plant. Therefore, a new electrical substation will be provided to cover both new and existing facilities.

Electrical facilities should be designed to achieve their continuous function and protection for the mechanical facilities of the plant. They should be optimized to achieve economical requirements and to have the best practical maintainability of the plant. Design parameters of the electrical facilities are shown in Table 3.20.

Table 3.20 Design Parameters of Electrical Facilities

Facility	Design Parameter	
1. Wastewater Treatment Plant (WWTP)		
	1) Receiving Voltage	33kV, 50Hz, 1 circuit
	2) Receiving Transformer	3,000 kVA
	3) Installed Capacity	2,800 kW
	4) Operating Capacity	2,100 kW

Source: JICA Study Team

(2) Electricity Supply in the Area

YESB (Yangon Electrical Service Board) governs the electricity transmission and distribution in the area of the plant located in Yangon city. Their main transmission network is 230kV and the sub network is 66kV and 33kV. YESB Electricity Network Diagram is attached in Appendix D. The town distribution for industry and home is 6.6 kV and 400 V, and there are planned or accidental power shutdowns very often. Electricity is made available during working hours in the day time in some industrial areas, and the main receiving switches have been opened for several months in some other industrial areas.

The plant should receive electricity from 33 kV sub network transmission line which corresponds to the YESB regulation for the plant with the receiving transformer capacity of 1 MVA and above but less than 10 MVA. There are existing YESB 33 kV overhead lines dedicated for public utilities such as existing YCDC water treatment plants, and they are supplying electricity for 24 hours.

The Study Team collected a table of electricity bill for YCDC water and wastewater plants in the fiscal years 2011 and 2012. (attached in Appendix D). Electricity unit price is as low as 25 Kyats/kWh. Average electricity bill is 1.6 million kWh per month and 45 million Kyats per month in the case of Nyaunghnapin water treatment plant with 33 kV supply, and it is 14,000 kWh per month

and 450,000 Kyats per month in case of existing wastewater treatment plant with 6.6kV supply. The table shows the unit rate was increased as 35 Kyats/kWh from year 2012, but the recorded price figures indicate the original 25 Kyats/kWh. This inexpensive electricity and the supply from 33 kV sub transmission network do not require the large size power generation facility in the Plant in view of economic feasibility of the project.

(3) Power Receiving Circuit

The receiving voltage is 33kV according to YESB regulation. The existing 6.6kV power receiving facility will be dismantled and a new 33 kV cable shall be installed underground from the nearest YESB substation along the street. It is cost beneficial if the 33kV overhead line will be allowed in this town area after negotiation. The estimated length of the cable is around 2 km.

Source: JICA Study Team

Figure 3.13 Wastewater Treatment Plant (WWTP) and 33 kV Underground Cable Route

(4) Power receiving substation

The existing 6.6 kV power receiving facilities (a 6.6 kV ring-main circuit breaker unit and two 6.6 kV/400V transformers) have been located in an open shelter and minimum maintenance and cleaning have been made. The equipment will not be able to reuse in the new plant. A new 33 kV substation will be provided to supply electrical power to whole area of the new wastewater treatment plant.

The 33 kV receiving substation shall consist of metal-enclosed switchgear in the electrical room, as popular in most South-East Asian countries. However, some electrical manufacturers in Yangon said that outdoor switchyard is more popular in Myanmar not only because of cost but also because the indoor switchgears of this high voltage level often caused troubles due to dews produced therein when opening doors or in rainy season in general. Selection of outdoor switchgears should be evaluated during the basic design stage of the project. Outdoor switchyard is less expensive but requires more space as 10 m x 20 m (typical).

Table 3.21 Power Receiving Equipment

Item	Specification	Unit
Receiving Panel	Metal-enclosed Switchgears VCB (Vacuum Circuit Breaker), 36 kV	1 set
Main Power Transformer	Oil-insulated, Naturally Oil-cooled Transformer 33 kV / 6.9 kV	1 set

Source: JICA Study Team

(5) Power Distribution System

Voltage application of the power distribution system in the plant is as follows;-

Motors 132 kW and above : 6.6 kV

Motors below 132 kW : 400 V

Motors should be direct-on-line starting on condition that the voltage drop study proves it during the detail design stage. An emergency generator should be provided in the plant so that it covers plant control and monitoring system for minimum and safe plant operation. Plant equipment will not be supported by the emergency generator in principle except ones required for safe condition of the plant and personnel. The emergency generator should not be larger than 1 MVA as a maximum case.

Table 3.22 Power Distribution Equipment

Item	Specification	Unit
6.6 kV High Voltage Switchgear	Metal-enclosed Switchgears VCB (Vacuum Circuit Breaker), 7.2 kV Vacuum Contactor, 7.2 kV	1 lot
Distribution Transformer	Oil-insulated, Naturally Oil-cooled Transformer 6.6 kV / 400 V	1 set
400 V Low Voltage Switchgear	Metal-enclosed Switchgears and Motor Control Centre Main Circuit Breaker : ACB Outgoing Feeder Circuit Breaker : MCCB Motor Starting : DOL (except in high voltage drop circuit)	1 lot
Uninterruptible Power Supply (UPS) for Control	Solid-state Rectifier-Inverter with Bypass Switch Battery Back-up : 60 minutes	1 lot
Emergency Diesel Engine Generator	Diesel Engine Driven Generator Continuous Rating 400 V, 50 Hz	1 set

Source: JICA Study Team

Single line diagrams are attached in the Appendix D.

(6) Basic Policy for Electrical Facilities

It is strongly advisable to adopt electrical equipment conforming to IEC standards and/or Japanese standards (JIS, JEC & JEM) with the type test records, in order to assure the quality and personnel safety.

On the other hand, electrical products of manufacturers in Myanmar were adopted in the existing YCDC plants and the local manufacturers give large benefit to YCDC personnel in operation, maintenance and upgrading. As the results of survey in June, 2013 by JICA Study Team, the type-tested electrical equipment is limited to low capacity transformers only, and therefore there is lower probability to apply those until they will proceed with the type tests and pass them. The plant does not have any critically unsafe facilities in the system, electrical facilities should have very basic fundamental protection only, and does not require any special devices.

Electrical cables have large impact on the plant operation by their product quality. Cables, from India, China, etc., stocked in Myanmar companies are, and have been, normally used in electrical construction, but for many of these the factory inspection records for quality control cannot be traced. The cables provided with individual test records in accordance with IEC standards and/or Japanese standards shall be used in the plant.

As for the electrical construction, there are several companies that joined the existing YCDC plant constructions. They should participate in this wastewater treatment plant construction so that they will help YCDC to proceed with proper maintenance and upgrading after start-up. However, those construction companies should be strictly evaluated in view of construction safety control.

3.5 Construction Plan

Outlines of construction plan for sewerage facility in C1 sewerage zone are summarized below.

(1) Components of construction

Components of construction are shown below. Sewer system consists of trunk sewer, branch sewer and house connection pipes. Construction work for WWTP includes remodeling of existing facility and new construction of expansion facility.

Table 3.23 Components of Construction of C1 Sewerage System

Facility	Component	Remarks
(1) Sewer system	Trunk Main（HP） Dia 1500mm: 550m Dia 1100mm: 970m Dia 1000mm: 600m Dia 900mm: 600m Dia 700mm: 5,650m Dia 600mm: 2,430m Dia 500mm: 2,820m	Pipe Jacking Method
	Branch sewer（HDPE） Dia < 500mm: 45,000m	Open Cut Method
	House Connection（HDPE） Dia 100mm: 9000 Nos	Open Cut Method
(2) WWTP	＞Remodeling of existing facility ＞New construction of expansion facility	Total Capacity： Q=70,200m^3/day

Source: JICA Study Team

(2) Basis for construction and procedure

Construction of sewer is conducted on public road. It is important to keep construction site safe for prevention of construction trouble and public hazard. Especially, since vertical shaft of pipe jacking method for trunk main occupy public road space for long duration, it is important to consider location of vertical shaft and construction schedule for minimization of traffic interruption.

Construction site for WWTP is flat land area. Pre-construction work, such as land reclamation and temporary access road, is unnecessary and construction work for facilities can start immediately after commencement.

In C1 sewerage zone, there is existing sewerage system and existing sewerage system has to continue its operation during construction work. Therefore, construction procedure for completion of new sewerage system in C1 sewerage zone requires three steps as follows.

Step 1： New construction of expansion facility in WWTP and trunk main
⇒Operation of existing system

Step 2： Remodeling of existing facility in WWTP and construction of trunk main (continued), branch sewer and house connection
⇒Operation of newly constructed facility with existing sewer network, switch-over from existing sewer network to new sewer network sequentially

Step 3： Construction of branch sewer and house connection (continued)
⇒Operation of new WWTP with new sewer network, Switch-over from existing sewer network to new sewer network sequentially

Summary of construction procedure for C1 sewerage system is shown below.

Table 3.24 Construction Procedure for C1 Sewerage System

Step	WWTP		Sewer system		
	Existing Facility	Expansion Facility	Existing System	New Trunk Main	New Branch sewer/House connection
Present	Operation ↓	—	Operation ↓	—	—
Step 1	Operation ↓	(Construction) ↓	Operation ↓	(Construction) ↓	—
Step 2	(Remodeling) ↓	Operation ↓	Operation (Inflow to Expansion Facility) ↓	(Construction) ↓	(Construction) (Switch-over from existing system sequentially after completion of trunk main) ↓
Step 3	Operation	Operation	(Switch-over to new system) ↓ Disuse	Operation	(Switch-over from existing system) ↓ Operation

Source: JICA Study Team

(3) Construction Schedule

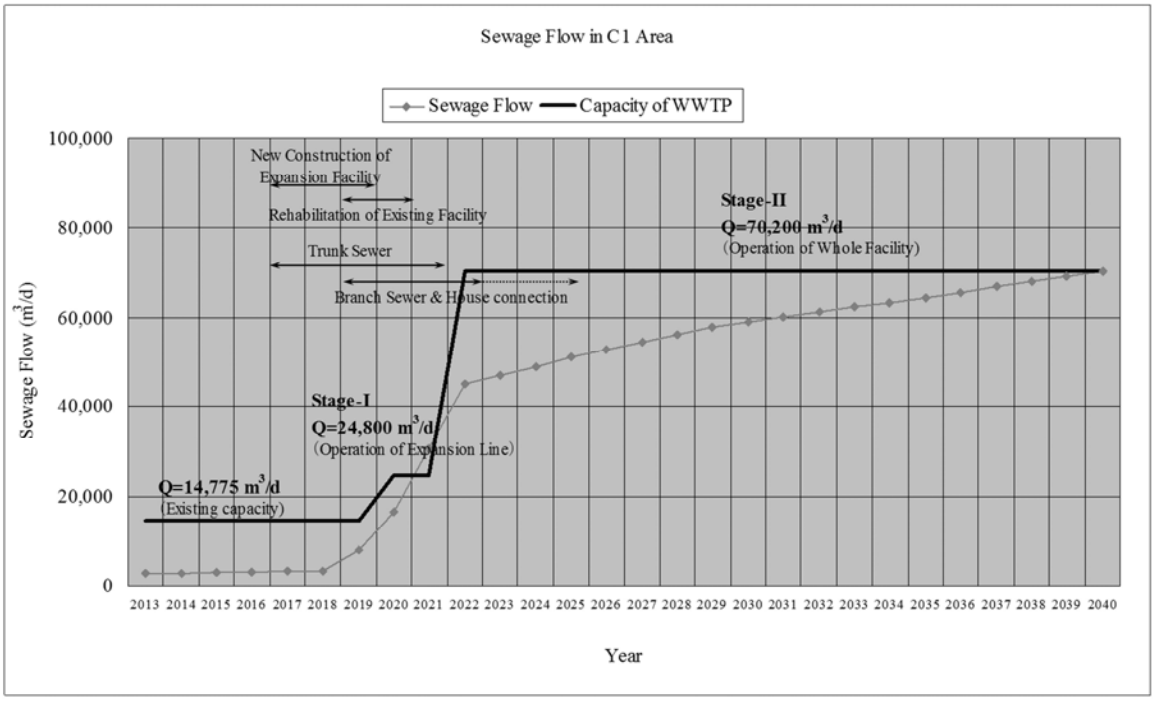
Based on the construction procedure, outline of construction schedule is worked out and summarized below. It is assumed that pre-construction stage such as detailed design and tendering will be completed by 2016 and construction work will start in 2017.

Construction Work	Year								
	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. New construction for expansion facility of WWTP	━━	━━	━━	━━					
2. Remodeling of existing facility of WWTP			━━	━━					
3. Trunk Main	━━	━━	━━	━━	━━				
4. Branch Sewer/House Connection			━━	━━	━━	━━	┅┅	┅┅▶	

Source: JICA Study Team

Figure 3.14 Construction Schedule for C1 Sewerage System

Construction of branch sewer and house connection will start after completion of expansion facility of WWTP. It is assumed that house connection will increase up to 90% in 4 years from 2019 and reach 100% in 2030 finally. Wastewater flow up to 2040 considering progress of house connection is shown in Figure 3.15 and phased construction plan of WWTP is shown in Figure 3.16.



	Year	2020	2021	2022	2023	2024	2025	2030	2035	2040
Design Sewage Flow	(m^3/d)	47,454	48,640	49,826	51,012	52,198	53,384	59,041	64,432	70,213
Sewered Ratio	%	30%	60%	90%	92%	94%	96%	100%	100%	100%
Sewage Flow	(m^3/d)	16,734	30,611	45,200	47,109	49,066	51,249	59,041	64,432	70,213

Note) Sewage flow includes flow volume coming from exisiting network system.

Source: JICA Study Team

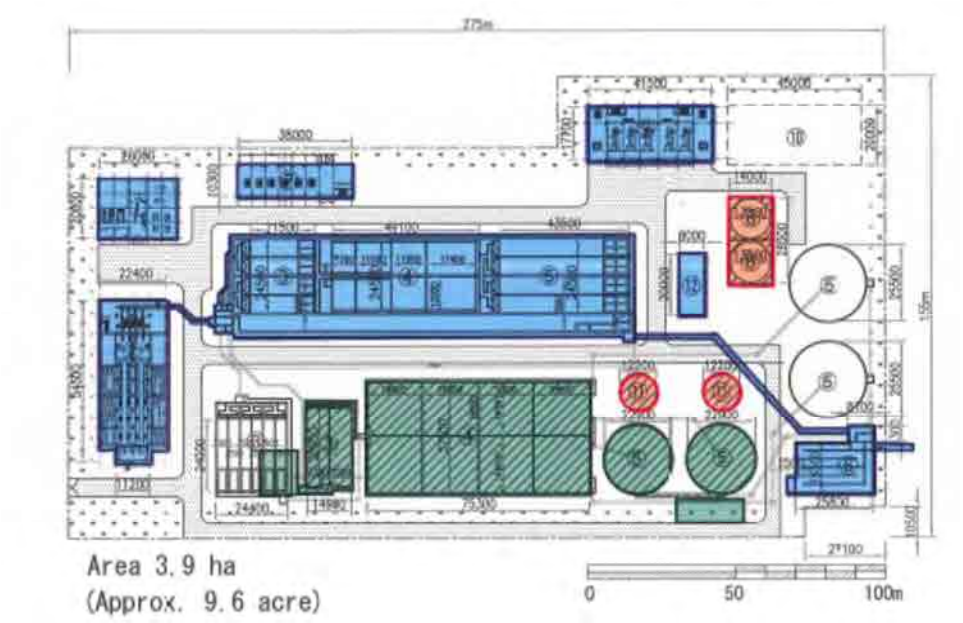
Figure 3.15 Wastewater Flow Considering Progress of House Connection in C1 Sewerage Zone

(4) Recommendation

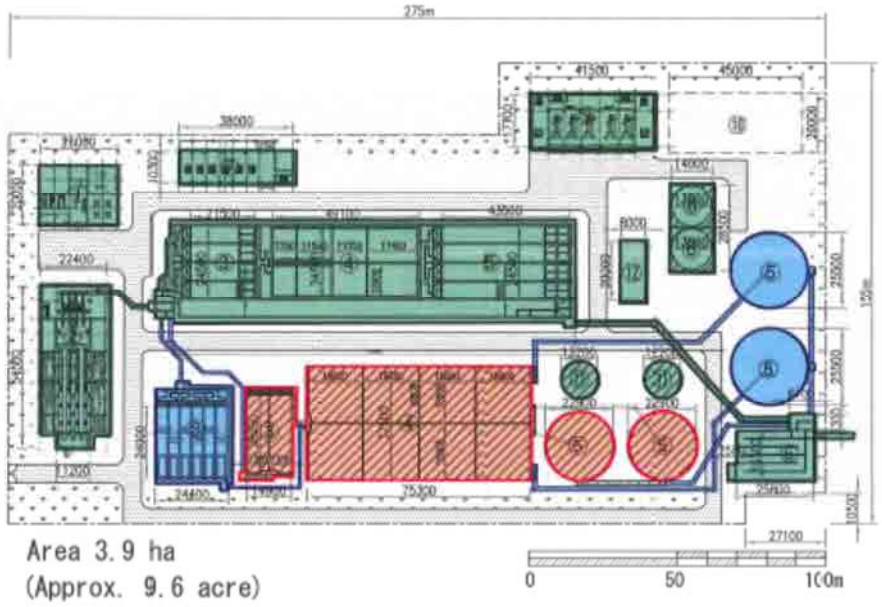
Although Latha Township and Lanmadaw Township are situated next to C1 sewerage zone, both townships are planned in W1 sewerage zone due to limited area for C1 WWTP. Latha township and Lanmadaw township should be included in C1 sewerage zone originally because both townships have existing sewerage system and high population density same as in case of C1 sewerage zone.

At detailed design stage, it is necessary to reconsider the possibility to include both townships in C1 sewerage zone. Depending on the situation of land acquisition for C1 WWTP and progress of W1 sewerage system development, flexible development of C1 sewerage system, such as adjustment of invert level of trunk main and upgrade of C1 WWTP capacity, should be re-examined for receiving wastewater from both townships.

Step 1：New Construction of Expansion Facility [Operation Capacity Q=14,775 m^3/d]



Step 2：Remodeling of Existing facility [Operation Capacity Q=24,800 m^3/d]



Legend

: Operating Facility

: New Construction

: Remodeling

Source: JICA Study Team

Figure 3.16　Phased Construction Plan of C1 WWTP

3.6 Operation and Maintenance Plan

After start of operation of sewerage system, systematic utilization of sewerage facilities, which include pipelines, pumping stations, and treatment plants, is required to collect wastewater without delay and to treat it adequately to maintain satisfactory final effluent quality. Main points for proper operation and maintenance of sewerage system are summarized below.
(The following description referred to "Tentative Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries" [Infrastructure Development Institute-Japan])

3.6.1 Sewerage Ledgers and Records

In order to ensure adequate operation and maintenance of sewage works, it is essential to grasp the location, scale, and shape of facilities. The inventory or sewerage ledger provides fundamental information necessary for this purpose. A ledger should be developed for pipes, treatment plant, pumping station, and other facilities related to sewerage. Development of sewerage ledgers enables clear definition of the sewerage service area and users, which is important to achieve thorough collection of sewage service charges.

Reference materials to be filed and confirmed when developing the ledger are as follows:
a) Sewer system
- Pipe network map
- As-built plans (plan and longitudinal sectional views of the system)
- Flow calculation

b) Pumping station and treatment facilities
- Drawings (general plan, detailed plan, equipment assembly drawing, electrical equipment drawing, connection diagram, elementary wiring diagram, material list, accessories, spare parts list, etc.)
- Various calculations (hydraulic and capacity calculations)
- Operation manual (including the equipment part type, type number and supplier list)

Additionally, it is recommended to prepare and control the following records so that they can be referred any time.
- ✓ Maintenance and inspection records
- ✓ Operation records
- ✓ Water quality control records
- ✓ Accident and complaints records

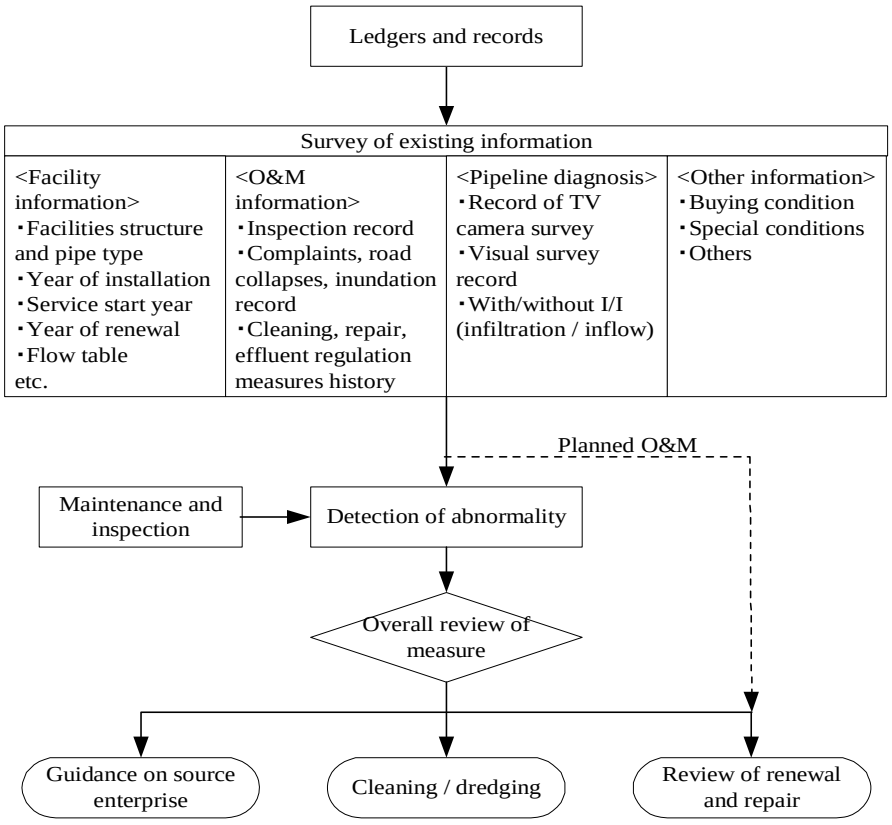
The records retain the operation status and maintenance/inspection history of facilities, and provide

the important information necessary to enhance the subsequent operation and maintenance level, that is, adjust operation or develop the facility improvement plan. In certain cases, findings from operation and maintenance must be fed back to planning and design to achieve fundamental solutions of a problem that has occurred once. For such evaluation, the records are indispensable.

3.6.2 Operation and Maintenance of Sewer Systems

Sewers are the backbone of sewerage facilities. Being mostly underground structures, their abnormalities are more difficult to predict and detect than those at treatment plants or pumping stations. On the other hand, any abnormality in conduits causes accidents directly affecting city activities and civil life, such as inundation of sanitary wastewater, road collapse, etc. Positive promotion of operation and maintenance of sewers contributes to reduce damage caused by accidents, to prevent increases in treatment costs caused by infiltration inflow, and to enhance asset utilization effects through extension of the practical service life of sewers. From the long-term viewpoint, this is advantageous economically.

Figure 3.17 shows O&M flow of sewer system. Operation and maintenance of sewers involves adequate implementation of maintenance inspections, cleaning, dredging, renewal, and repair along a flow series.



Source: Tentative Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries, IDI, Japan

Figure 3.17 O&M Flow for Sewer System

The example of maintenance, inspection and investigation cycle for sewer system is shown below.

Table 3.25 Maintenance and Inspection Cycle for Sewer System (Example)

Items / Elapsed Years after Start of Operation		Manhole, Pipe	Inverted siphon	Manhole type pumping Station	House inlet, Storm-water inlet	Gate
Maintenance and Inspection	0～30years	Every 3 years	Yearly	Monthly	Every 3 years	Every 6 months
	More than 30 years	Yearly				

Source: Tentative Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries, IDI, Japan

Table 3.26 Survey Cycle for Sewer System (Example)

Items	Place	Elapsed Years after Start of Operation	Cycle	Remarks
Visual survey (manhole inspection)	Manhole and connected pipes	0～30 years	Every 5 years	
		More than 30 years	Every 3 years	
TV camera survey	Less than Dia.800mm	0～30 years	Every 10 years	Including Service Lateral
		More than 30 years	Every 7 years	Ditto

Source: Tentative Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries, IDI, Japan

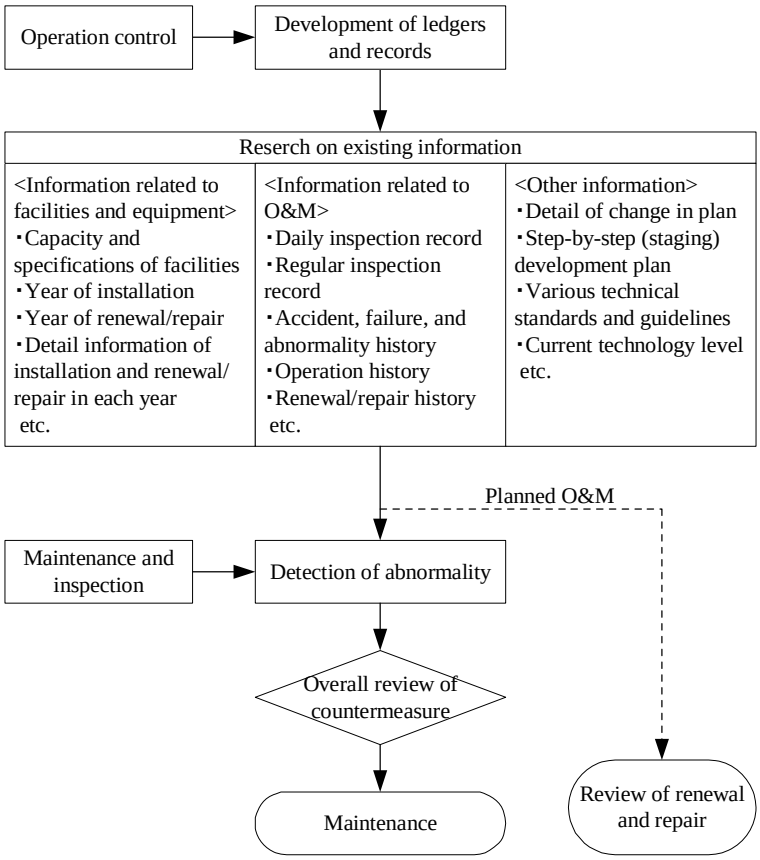
Table 3.27 Cleaning Cycle for Sewer System (Example)

Items	Elapsed Years after Start of Operation	
	0～30 years	More than 30 years
Pipe	Every 5 years	Every 5 years
Manhole	Every 5 years	Every 3 years
Inverted siphon	Yearly	Yearly
Manhole type pumping Station	Every 3 months	Every 3 months
House inlet, Storm- water inlet	Every 5 years	Every 5 years
Service Lateral	Every 15 years	Every 5 years
Gate	Yearly	Yearly

Source: Tentative Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries, IDI, Japan

3.6.3 Operation and Maintenance of the WWTP

The objective of O&M of the WWTP is to meet effluent standards or targeted water quality through full demonstration of wastewater treatment functions, thereby contributing to securing of public hygiene and conservation of the quality of public water bodies. Figure 3.18 shows O&M flow of WWTP. O&M of WWTP should involve adequate implementation of operation control, maintenance and inspection, renewal, and repair according to the work flow. Each work should be coordinated for planned and preventive O&M.



Source: Tentative Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries, IDI, Japan

Figure 3.18 O&M Flow for WWTP

(1) Appropriate number of O&M staff

As the appropriate number of O&M staff to be assigned to WWTP varies depending on the treatment method and scale, degree of automation, etc., it is essential to consider staffing according to the situation. Required number of O&M staff for C1 WWTP is shown below. Before start of operation, YCDC have to recruit necessary staff and establish effective organization utilizing out-sourcing if necessary.

Table 3.28 Number of O&M Staff for C1 WWTP (Draft)

Position/Designation	Number	Remarks
Manager	1	
Process Engineer	1	
Mechanical Engineer	1	
Electrical Engineer	1	
Water Quality Engineer	1	
Mech.& Elec. Technician	6	(2×3shift)
General worker	4	
Administration Clerk	1	
Driver	1	
Guard	3	(1×3shift)
Total	20	

Source: JICA Study Team

(2) Operation record

In order to ensure efficient control of plant operation, it is indispensable to record operating conditions in daily and monthly logs and to evaluate the conditions. The types and contents of operation records are shown below.

Table 3.29 Types and Contents of Operation Records

Type	Contents
Daily operation log	Record of the operating conditions and results of the day on the basis of indicated data of monitoring equipment in the monitoring room and job site. It basically contains the following data: a. Treatment results b. Items directly related to operation costs, including electric power, chemicals, etc. c. Compulsory matters, such as legal regulations, etc. d. Operating conditions of principal facilities and equipment
Daily operation report	Summarizes principal items on the basis of daily operation log to understand and report on operating conditions of the day
Monthly operation report and year book	Used as reference data for operation methods and the facility/equipment improvement plan. The daily operation log is summarized in the monthly report, and the monthly operation report is summarized in the year book.

Source: Tentative Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries, IDI, Japan

The important thing in the WWTP is to check the site every day to get a feel for any changes (abnormalities). If well-experienced, the staff can achieve considerable effects through such simple checks as those outlined below.

Table 3.30 Sensory Inspection

Visual Inspection	Check condition of treatment facilities and activated sludge. Check for equipment failure
Auditory Inspection	Check for any abnormality in equipment
Smell Inspection	Foul odor, scorched odor
Touch Inspection	Feel operation temperature of equipment, check for vibrations

Source: Tentative Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries, IDI, Japan

(3) O&M for equipment

WWTP involves a lot of mechanical and electrical equipment and should be operated under adequate condition at all times with realization of mechanism, specification and characteristics of equipment. For proper operation of equipment, it is important to carry out: 1) Rearrangement and filing of operation manuals and specifications, 2) Development of equipment standard operation procedure, 3) Development of counteraction system during normal, abnormal, and emergency cases etc. In addition to daily maintenance work, periodical repair and overhaul is necessary.

As an example, typical check items and frequency of the pump are shown below

Table 3.31 Typical Check Items and Frequency of the Pump

Check items	Check content	Frequency
Current and pressure check	Ensure current and pressure are normal	Daily
Abnormal sound and vibration check	Check for abnormality	Daily
Leakage check	Check for leakage	Monthly
Inspection and cleaning of float switch	Operation check	Monthly
Appearance check by lifting the pump	Check for abnormality	Every 3 months
Check of lubrication oil condition	Foulness and amount	Every 3 months
Lubrication oil change	—	Yearly
Overhaul	Wear of rotating slide section	Irregular (approximately every 2 years)

Source: Tentative Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries, IDI, Japan

(4) Water quality monitoring

In the WWTP, efforts should be made to maintain treatment functions properly, to observe the regulations related to water quality and to conserve the receiving water body. Water quality monitoring should be undertaken as required to determine the adequacy of the treatment plant and to observe the regulations. Monitoring records should be maintained and stored. Typical examination items and frequency for WWTP are shown below.

Table 3.32 Typical Examination Items and Frequency of Wastewater Treatment

Frequency / Objects	Daily Check	Periodical Check (More than every month)
Wastewater inflow	appearance, odor, water temperature, transparency, pH	BOD, SS
Aeration tank (Activated sludge method)	appearance, odor, SV (sludge volume), water temperature, DO (dissolved oxygen), MLSS (mixed liquor suspended solids)	microorganisms dimension, MLSS
Effluent of Final sedimentation tank	appearance, transparency, pH Nitrate nitrogen*, ammonia nitrogen* (*: simplified test)	BOD, SS, nitrate nitrogen, ammonia nitrogen
Final effluent (refer to legal regulation)	appearance, transparency, pH, residual chlorine	BOD, SS, COD (nitrate nitrogen, ammonia nitrogen)

Source: Guidelines for Planning, Design and O&M of Small Scale Sewerage System, Japan Sewage Works Association

Table 3.33 Typical Examination Items and Frequency for Sludge Treatment

Objects / Frequency		Category		Remarks
		Daily	As appropriate	
Sludge thickening facility	thickened sludge	appearance	water temperature, pH, TS (total solids)	
	supernatant	pH, SS	COD, TN (total nitrogen), TP (total phosphorus)	
Sludge dewatering facility	dewatered sludge	appearance	moisture content, coagulation test※	※in case of moisture content rise
	supernatant	SS	COD, TN (total nitrogen), TP (total phosphorus)	

Source: Guidelines for Planning, Design and O&M of Small Scale Sewerage System, Japan Sewage Works Association

CHAPTER 4. COST ESTIMATION AND IMPLEMENTATION SCHEDULE

Basis for facility design and components of construction of C1 sewerage system are shown in the table below.

Table 4.1 Basis for Facility Design and Components of Construction of C1 Sewerage System

Categories	Items	Details
Basis for Facility Design	(1) Target Year	2040
	(2) Service Area	499 ha
	(3) System	Separate system
	(4) Service population	178,129 person
	(5) Design flow	64,300 m^3/d (Daily Average) 70,200 m^3/d (Daily Maximum) 102,900 m^3/d (Hourly Maximum)
	(6) Design Sewage Characteristics	BOD_5 200 mg/L SS 180 mg/L
Components of Construction of C1 Sewerage System	(1) Sewer system	Trunk Main（HP） Dia 1500mm: 550m Dia 1100mm: 970m Dia 1000mm: 600m Dia 900mm: 600m Dia 700mm: 5,650m Dia 600mm: 2,430m Dia 500mm: 2,820m
		Branch sewer（HDPE） Dia < 500mm: 45,000m House Connection（HDPE） Dia 100mm: 9000 Nos
	(2) WWTP	＞Remodeling of existing facility ＞New construction of expansion facility

Source: JICA Study Team

4.1 Condition of Cost Estimation

Based on condition mentioned below, the Project cost is estimated.

- The project cost comprises construction cost, administration cost, consulting cost, contingency (physical and price escalation), land acquisition and compensation, interest during construction, commitment charge and relevant tax.
- The project cost is composed of the local currency potion (L.C.) and foreign currency portion (F.C.).
- Administration cost in recipient country is assumed to be 5.0 percent of the construction cost.
- Consulting cost is estimated based on man-months of consulting services.
- Physical contingency is considered as 5.0 percent of total of construction cost, consulting cost,

land acquisition and compensation.

- Price escalation of 6.1 percent per annum for the local currency portion and 1.2 percent per annum for the foreign currency portion are applied and estimated based on implementation schedule.
- The base period of cost estimation is June 2013 and the exchange rate considered is 1 Kyat=0.114 Yen, 1 USD=101.1 Yen and 1USD=885 Kyat.
- Interest during construction is estimated taking into consideration that Project cost is financed by Japanese ODA loan. (Loan condition: Preferential terms / Standard, Interest rate of main components=0.01%, Interest rate of consulting services=0.01%, Repayment period=40year, Grace period=10year)
- Commitment charge is not added.
- Instead of VAT, commercial tax rate is added in Myanmar and rate is 10%. Import tax is 2.0%.
- Construction cost, consulting cost, contingency (physical and price escalation) are eligible portions while interest during construction, administration cost, land acquisition and compensation, and relevant tax are non-eligible portions taking into consideration that Project cost is financed by Japanese ODA loan.
- Project cost will be determined based on JICA's guideline at the time of loan and it has possibility to change.

4.2 Condition of Construction Cost

- It is possible to procure civil and building material, labour and construction machine within the country and the procurement in local country is set as basic policy for project cost estimation.
- The mechanical and electrical equipment is basically procured from overseas including third country; such as European Union (EU) etc. The equipment will be procured with consideration of quality, performance, economical efficiency and O&M, etc.
- The local contractors have enough experiences and ability for normal civil engineering work. On the other hand, they are not experienced in the specialized project regarding water supply and sewerage. However, Japanese experts and foreign experts are staffed in implementation system of the Project and construction is conducted by the local contractor.
- The local contractors don't have any experiences in the construction methods of pipe jacking and shield. The unit cost of these construction methods is collected from Thailand where many contractors have relevant experiences.
- The construction plan is established with the considerations of local natural condition (topographic aspects, geotechnical condition and meteorological condition) and legislation/custom.

4.3 Cost Estimation of the Project

Non-disclosure Information

Table 4.2 Project Cost

Non-disclosure Information

Table 4.3 Construction Cost

Non-disclosure Information

Non-disclosure Information

4.4 Implementation Schedule

If the Project is financed through Japanese ODA loan, the Government of the Republic of the Union of Myanmar must follow JICA procurement guidelines for the selection of the consultants and contractors to implement the Project.

Implementation schedule starting from signing of Loan Agreement has been developed as shown in Table 4.4. taking into account necessary steps that would be required. Implementation of the project has been estimated to extend over 105 months (8.8 years) in total. Herewith Loan Agreement should be signed in the beginning of 2014 for operation to start in 2022.

Table 4.4 Implementation Schedule

	Period	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Signing of L/A	-									
Selection of Consultant	9 months									
Detailed Design	15 months									
Preparation of Specification & Bidding Documents	11 months									
Selection of Contractor	9 months									
Construction Works	68 months									
Trial Operation Period	12 months									

Source: JICA Study Team

Duration necessary for selection of the consultant and the contractor has been decided considering the JICA's standard procedures and estimated as 9 months for selection of the consultants and 9 months for selection of the contractor, respectively. Detailed implementation schedule are shown in Table 4.5 and Table 4.6

Table 4.5 Detailed Implementation Schedule of Selection of Consultant

Month	Period	1	2	3	4	5	6	7	8	9
Preparation of shortlist and request for proposal	2 months									
Concurrence to request for proposal by JICA	1 month									
Issuing request for proposal to consultant	1.5 months									
Evaluation of proposals	1.5 months									
Concurrence to evaluation by JICA	1 month									
Contact negotiation with candidate	1 month									
Concurrence to contract by JICA	1 month									
Contract award	-									

Source: JICA Study Team

Table 4.6 Detailed Implementation Schedule of Selection of Contractor

Month	Period	1	2	3	4	5	6	7	8	9
Concurrence to bidding documents by JICA	1 month									
Bidding period	2 months									
Technical evaluation and Price evaluation	2 months									
Concurrence to technical evaluation and price evaluation by JICA	1 month									
Contract negotiation with candidate	2 months									
Concurrence to contract by JICA	1 month									
Contract award	-									

Source: JICA Study Team

Duration necessary for construction works has been planned to ensure the proper execution of the

work considering conditions including ability of contractors, procurement of materials and labor force, manner of construction in Myanmar and construction scale. The construction schedule is mainly estimated according to procedure and working volume of construction such as excavation and concrete casting since there is rarely restriction regarding procurement. Implementation schedule of the construction has been estimated to extend over 68 months in total and shown in Table 4.7.

Table 4.7 Detailed Implementation Schedule of Construction Works

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
WWTP						
Term-1 for Expansion						
Civil and Architecture Works						
Mechanical and Electrical Works						
Term-2 for Replacement of the existing facility						
Civil and Architecture Works						
Mechanical and Electrical Works						
Trunk Sewer						
Trunk Main						
Branch sewer and house connection						
Testing and commissioning						

Source: JICA Study Team

One year of trial operation period including on the job training is planned after the construction so that YCDC, which is responsible for operation and maintenance, takes over operation of the constructed facilities smoothly.

4.5 Consulting Service

If this Project is financed through Japanese ODA loan, the procurement procedure of Design-Bid-Build contract applying "FIDIC Conditions of Contract for Construction Multilateral Development Bank (MDB) Harmonized Edition for Building and Engineering Works Designed by the Employer" is a common practice for the construction project. In the procurement of Design-Bid-Build contract, detailed design and supervision of the construction works is done by the consultants. Consulting services including the followings will be required for smooth implementation of the Project by assisting YCDC, the executing agency.

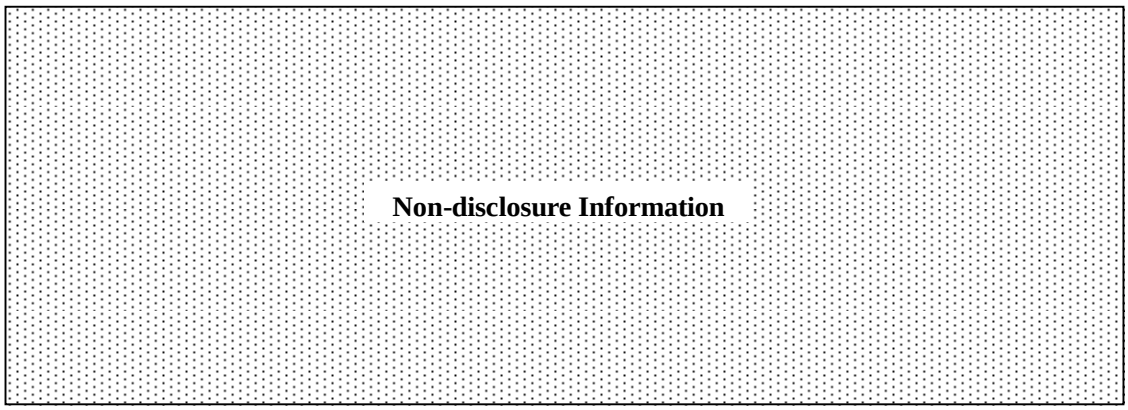
- Implementation of detailed design
- Preparation of tender documents for the contract
- Assistance in tender/qualification evaluation and contract negotiation
- Supervision of the construction works
- Technical assistance of management, operation and maintenance

The consultants are composed of international and local experts. The local experts should support international experts in all the activities of the Project. The proposed work schedule of the consultants should accord with the implementation schedule. Required international and local experts along with man-months for consulting services for the implementation of the Project are presented in Table 4.8. Based on the estimation of required man-months, [redacted] of international experts and [redacted] of local experts would be required for assisting the executing agency for implementing the Project.

Table 4.8 Man-Months for Consulting Service

[redacted]

Non-disclosure Information



4.6 Estimation of O&M Cost

The required operation and maintenance cost for sewerage works is shown below. The O&M cost comprises labour cost, electrical cost, maintenance cost (check and repair), sludge cake disposal cost, consumable supplies cost and other cost. The annual total cost of operation and maintenance is approximately 1,118 thousand USD (110 million JPY).

Table 4.9 O&M Cost

Items	Amount（thousand USD/Year）
Labour cost	40.9
Electrical cost	281.6
Maintenance cost	543.6
Sludge cake disposal cost	89.2
Chemical cost	100.5
Cleaning cost for sewer	41.4
Others	21.1
Total	1,118.3

Source: JICA Study Team

4.7 Operation and Index Indicators

Under the Yen ODA loan, post project monitoring is a requirement for any project. JICA will carry out a post evaluation based on pre-determined indicators that measure the effectiveness and efficiency of implementation and performance of the project. JICA adopts these so-called operation and effect indicators tailored for each project at the time of loan negotiation. For the operation and effect indicators, the project owner is required to carry out the baseline survey prior to the implementation of the project. In two to three years after the completion of the project, the JICA will undertake the post-evaluation to compare the impacts realized by the project. Usually operation indicators measure the realized capacity of the project in relation to the planned design, while effect indicators measure

the performance of the project in relation to the original objectives of the project.

The proposed project for C1 sewerage zone covers around 5% of the entire population of the city. Therefore the impact of the project to the overall riparian environment of the city is not substantial. The importance of the project is rather to set the standard for the future similar projects to be implemented. The proposed operation and effect indicators are shown in Table 4.9 and 4.10 respectively. The first four operation indicators of Treatment Capacity, Plant Utilization, Pollutant Removal Ratio (BOD5, COD, TSS), and Service Population Coverage measure the achievement of project implementation in relation to the planned capacity and operation targets. The first three targets are related to the operations of the treatment plant. The fourth indicator of population coverage measures the achievement in the sewer network construction. The fifth indicator of Tariff Recovery is an indicator for operation achievement of the project.

Table 4.10 Operation Indicators

Operation Indicator	Definition	Planned Target	Note
Treatment Capacity	Achieved Treatment Capacity / Planned Treatment Capacity	100%	
Plant Utilization	Average Treated Volume / Planned Treatment Capacity	70%	
Pollutant Removal Ratio (BOD_5, COD, TSS)	Effluent Measurement / Influent Measurement	BOD_5: 90% COD: 75% TSS: 90% (Lower Limit Value)	
Service Population Coverage	Service Population / Planned Service Population	90%	The target value for service connection is set at 90%.
Tariff Recovery		At least 90%	Tariff recovery can be regarded as public support for wastewater treatment system.

Source：JICA Study Team

The proposed project is small in its scale. It is not possible to expect for the citywide impacts. Therefore the main effect indicators are limited to the project scope itself such as FIRR and EIRR. Nevertheless, the realization of tariff system for the first full sewerage treatment system with separate sewer network in Yangon needs to be regarded as a model case for the future. In this regard, the realization of tariff system is set as an effect indicator.

Table 4.11 Effect Indicators

Effect Indicator	Definition	Baseline Value	Note
Introduction of Sewerage Tariff	Currently free sewerage service will be reformed as fee based service	Minimum Target USD0.1/m^3	Public awareness is generated to support fee-based sustainable service in the future.
Returns on Investment	Financial and Economic Internal Rates of Return on Investment	FIRR: 0.98% EIRR: 6.2%	The baseline FIRR is based on the assumed tariff thus readjustment is required for actual tariff realized.

Source：JICA Study Team

4.8 Organizational Structure for Implementing the Project

4.8.1 Organizational Structure for Implementing the Project

An organizational structure for the Project consists of Project Executing Agency (PEA), Project Management Unit (PMU), Project Coordination Committee (PCC).

Table 4.12 Organizational Structure, Role and Responsibility

Project organization	Institutions responsible	Role and responsibility
Project Executing Agency: PEA	YCDC DEWS	• Comprehensive management of project implementation according to a loan contract • Allocation of budget • Guidance to project management unit
Project Management Unit: PMU	YCDC DEWS	• Project management • Supervision • Monitoring and coordination • Budgetary management
Project Coordination Committee：PCC	Regional government, YCDC, Ministry of Environment, Ministry of Construction	• Project coordination for planning and implementation

Source：JICA Study Team

(1) Project Executing Agency（PEA）

YCDC shall be the PEA and responsible for overall supervision and execution of the Project. DEWS will be responsible for water, sewerage and sanitation works. Main role and duty is to supervise overall activities during the project implementation. In addition, DEWS will be responsible for management and monitoring of the project activities by their expertise and specialized knowledge from the technical view point.

The main functions of PEA will be as follows;

- To be comprehensively responsible for the project implementation in accordance with a loan contract
- To coordinate and manage the Project activities
- To establish a monitoring and evaluation system that would track the progress of the Project
- To support the PMU for planning and implementation of project activities technically and financially
- To Provide timely feedback on project planning and implementation to PMU
- To report to the government on the overall progress of the Project
- To call regular meetings for the duration of the Project, and special meetings should the need arise

(2) Project Management Unit (PMU）

A PMU shall be established within DEWS and shall be created in the DEWS as a principal entity for the project implementation. PMU is an ad hoc entity to be established for the project implementation. PMU is aimed at enhancing management and monitoring of the project, and be an independent organization to implement the specified project during the limited period. It will be headed and staffed by a full-time Project Director (PD), probably by the Chief Engineer, and creates the project office consisting of the staff members of technical section, management section, and administration section in the DEWS of YCDC.

PMU shall be tasked with managing and monitoring the day-to-day activities of the project at the field level. The Project Director has a responsibility and authority for overall activities including coordination between sections and construction companies to ensure the progress of the project within the implementation period. PMU will be managed under PEA and PCC.

The technical section supervises reduction of NRW and water quality management etc. The management of waterworks section is responsible for improvement of water tariff, operational works by using performance indicators, revenue collection. It is recommended that administration section includes the function of finance and accounting for ensuring financial resources and smooth payment works, of legal and contract management.
Main functions of PMU are shown as follows.

- Supervising and monitoring the day-to-day project activities
- Preparing project implementation and work plan and reporting the progress of the project with the assistance of the consultant;
- Arranging and supervising construction works
- Arranging procurement of goods, works and services for the project
- Organizing monitoring and evaluation activities;
- Receiving and distributing funds for project activities
- Maintaining accounts of the project and arrange audit

(3) Project Coordination Committee（PCC）

Project Coordination Committee: PCC is a supreme organization on project implementation. The committee will be held regularly, for instance quarterly in addition to at the beginning of the project, the terminal occasion. PCC shall be co-chaired by the project director and development affairs of regional government. PCC coordinates the necessary issues for agreement, discussion and cooperation on the project activities. It regularly reviews the progress of project activities and gives instruction and

guidance for project implementation.

The main composition member of PCC will be development affairs of regional government, department of finance, accounting, road and bridge of YCDC, and township offices and so on.

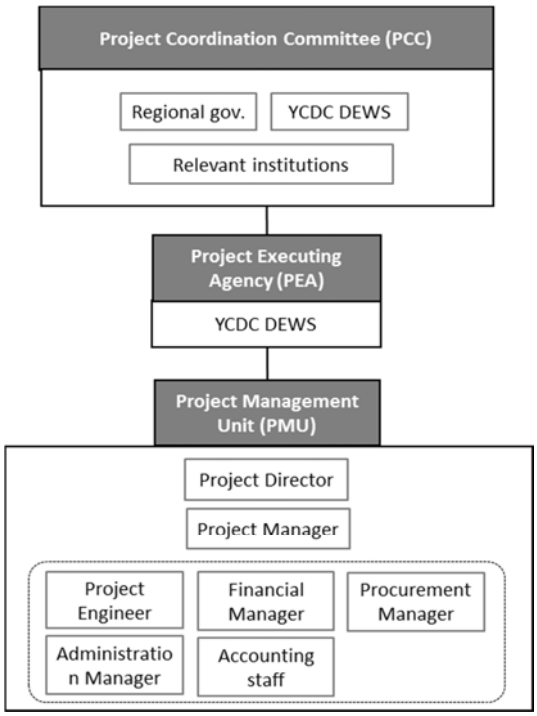
The main functions of PCC will be as follows:

- Approving work plans and budgets for the project
- Monitoring and reviewing progress of activities of various concerned agencies
- Opening of regular meetings for committee
- Coordinating stakeholders relevant to the project activities of other institutions, dispute settlement, enhancing a smooth project implementation
- Monitoring and reviewing the activity progress by the relevant institutions
- Identifying problems and bottlenecks in course of implementing various activities by the concerned agencies and suggest ways and means to solve those.
- Identifying issues which need to be considered, discussed, coordinated
- Coordinating follow-up actions

4.8.2 Division of Duties for PIA and Organizational Arrangement

(1) Organizational arrangement of project management unit

An organizational arrangement of PEA, PCC, PMU is assumed to be established as follows.



Source：JICA Study Team

Figure 4.1 Organizational Arrangement for Project Implementation

PMU should be created in order to ensure a smooth works for ODA loan and project implementation. The composition of PMU likely consists of administration, financial and technical sections. It will be effective to employ expert or specialized consultants in order to enhance the ODA procedure smoothly.

PMU generally consists of project manager, engineering manager, technical engineers, procurement manager, financial manager, administration manager, accountants and so on.

Project director should have responsibility and authority of all activities such as planning, coordination between sections, its management and so on. Also PD should have an authority to coordinate private companies and supervise financial and accounting section of PMU as well in order to secure sufficient financial resources and appropriate payment for smooth construction works.

(2) Staffing of Project Management Unit (PMU)

The following staffing for PMU is recommended. The duty of PD may be taken by Chief Engineer and that of project manager may be played by Deputy Engineer or Assistant Chief Engineer. It is desirable that these personnels is appointed from DEWS of YCDC from the viewpoint of capacity development of staff members and synergy effects. The number of persons are not necessarily limited to this table, and are just for indication.

Table 4.13 Staffing for PMU

Areas	Position	Section	No.
Management			
1	Project Director	Chief Engineer	1
2	Project Manager	Deputy Chief Engineer, or Assistant Chief Engineer	1
Technical section（including manager）			
3	Engineer	Distribution division（Civil 1）, Water quality section 1	3
4	Assistant Engineer	Distribution division（Civil 1）, Water quality section 1	3
Waterworks management（including manager）			
5	Sewerage tariff/ Revenue collection	Financial division	2
6	Plan for waterworks management	Planning and monitoring division	1
Administration and Finance（including manager）			
7	Finance and accounting	Financial division	2
8	Administration	Administration division	1
9	Procurement	Administration division	1
Total			15

Source：JICA Study Team

(3) Technical level of executing agency and relevant experiences

DEWS has no experience to establish PMU for a development project before.

There are no engineers who know facility designing of ejector system well because the ejector system was constructed in 1890. However the system has been utilized with improvements for long years, the expertise and knowledge are taken over by YCDC staffs. Also the existing operational wastewater treatment plant is designed and constructed by YCDC.

Therefore it is fair to say that expertise and knowledge on wastewater treatment including sewerage has been accumulated for YCDC staffs. Meanwhile, the staffs in charge of designing water and sewerage infrastructure in DEWS are very limited if available human resources in DEWS are considered.

In terms of construction work experience, DEWS has contracted out to external local consulting firm for design of Nyaunghnapin WTP (phase 2) and Lagunbyin WTP, even these are experience of water infrastructure. The local consulting firm has a resource person who is an executive and is used to work at DEWS of YCDC and he also designed water treatment plant in phase 1. The pile driving works of Lagunbyin WTP has been carried out by contracting out to a local construction firm. DEWS has despatched some engineers for supervising the construction works of Nyaunghnapin WTP (phase 1and 2) and pile driving works of Lagunbyin WTP and employ many daily labours.

In this sense, DEWS has experiences of the construction of water infrastructure and the supervising works, it can be said that DEWS has some experience of project management at a certain level.

4.9 Remarks for Project Implementation

In this section, issues on procurement methods to be necessarily considered is described and proposed in case of implementation of a water supply/ sewerage development project financed by ODA Loan.

4.9.1 Procurement Environment of Relevant Experiences of the Myanmar Side

(1) General environment of local construction companies.

In Myanmar, after the democratization, local companies who have experience in civil construction works mainly in Yangon city has increased and it can be said that their technical level reached to a certain level. In that civil and construction works, local engineers and skilled workers are engaged.

Meanwhile, it can be recognized that local private firms who have experiences of construction works in water and sewerage sector are very limited according to the interview survey etc. One of the reasons is that YCDC has directly conducted the construction works of water and sewerage infrastructures in Yangon city managed by YCDC, by appointing some YCDC engineers and employing daily contract

labours. There are, however, some local companies engaged in construction works of water and sewerage facilities in other cities such as Mandalay.

Thus, a joint venture with these local firms having experiences of water and sewerage sector construction works or utilization of local subcontractors of civil construction firms could be effective ways for Japanese construction firms to implement the project smoothly and reduce the costs efficiently. In addition, domestic pipe manufacturing firms can be seen in Myanmar, even though the number is very limited.

Information on local construction firms and local materials manufacturing firms are indicated in the following table.

Table 4.14 Information on Local Construction Firms and Local Materials Manufacturing Firms

Company	Outline	
[Design and Construction Works]		
Authentic Group of Companies	Establishment : Field : Experience : Size : Others :	2010 Design of water, sewerage and drainage system, construction, trading, import and sales, water and sewerage, since 2012. 3 years' experience in the above fields Small and medium The firm has an executive who designed Nyaunghnapin WTP and pumping stations Water treatment plant in Naypyidaw and private wastewater treatment.
Waterworks Engineering Group Services Company Limited (WEG)	Establishment : Field : Experience : Size : Others :	2004 Design of water and wastewater system, construction, water quality test The main activity is water quality test, others are import and sales of wastewater treatment facilities, borehole drilling for well. The firm has experiences in groundwater development and water supply facilities for private firms. Small and medium The firm has a laboratory, namely ISOTECH, which was utilized by JICAs activity.
Supreme Group, water doctor related to water activities	Establishment : Field : Size : Others :	1990s Water related activity (water and sewerage treatment, water treatment plant), construction, trading, fertilizer, pesticide Small and medium The firms started import and sales of small water filtration equipment and currently expands to sell various types of water filtration machines. A subsidiary company, water doctor, was established in 1994 aiming water treatment, plumbing, construction works etc.
Dagon International Company Limited	Field : Experience : Others :	Estate development, land development, construction, woods selling business, agriculture and plantation, hotel, hospitality and second hand vehicles sales, etc. The firm was started as estate developer, currently civil works is one of their activities. The firm is one of the largest Burmese

Company	Outline
	conglomerates
Chan Tha Construction	Establishment： 1990s Field： Estate development, construction Experience： Experience of civil works Size： Large construction contractor
Royal Gandamar Construction Co., Ltd	Establishment： 2006 Field： Civil works, mainly railway construction works Experience： Many experiences such as civil works of station and railway construction Size： Middle-size construction contractor Others： The firm has a concrete block factory for railway construction works except for construction works
[Manufacturing and sales of Materials]	
Tokyo Pipe Co., Ltd	Field： Pipe sales and manufacturing Experience： Only one HDPE pipe manufacturing firm in Myanmar Size： Large pipe manufacturing firm Others： The firm has the largest factory in Myanmar, and produces pipe products by using machineries made in China and Germany. HDPE pipe manufactured in Tokyo Pipe has been applied for Nga Moe Yeik (Phase 2) construction works. Their activities focus on only pipe manufacturing and sales, not construction works.
Po Seng Pipe Co., Ltd	Field： Manufacturing pipe, construction Experience： Pipe installation works in Naypyidaw Size： Large manufacturing company Others： Company size is smaller than Tokyo Pipe co., Ltd but is famous in Myanmar. The strong point in comparison to Tokyo Pipe co., Ltd is that they can provide services with construction works as well.
Han Sein Thant Engineering and Trading Co., Ltd	Field： Import and sales, and installation works of pump Size： Small and medium Others： Providing services of only installation of machineries. Sales agency of KSB pump.

Source：JICA Study Team

(2) Local Procurement Environment

Materials and equipment for sewerage system construction are basically procured from Myanmar, however in case of difficulty of domestic procurement, procurement from third countries and Japan may be assumed. The procurement environment of main materials and equipment, and construction machineries are shown in the following table.

Table 4.15 Procurement Environment of Main Materials and Equipment, and Construction Machineries

	Myanmar	Japan	Third Country
Cement	○		
Aggregate	○		
Reinforcing bars	○		
Fuel (gasoline/diesel)	○		
Form work materials	○		
Ductile cast iron pipe		○	○
u-PVC pipe	○		
HDPE pipe	○		
Painted Steel pipe		○	○
Valves		○	○
Water meter		○	○
Screw steel pipe pile with toe wing		○	
Base course	○		
Asphalt	○		
Scaffolding and support materials	○		
Sheet pile and earth retaining materials		○	○
Mechanical equipment (pump)		○	○
Electrical equipment (panel)		○	○
Monitoring and instrumentation		○	○

Construction machineries	Myanmar	Third countries	Japan
Backhoe	○		
Track crane	○		
Track equipped with crane	○		
Dump truck	○		
Automobile sprinkler	○		
Grader	○		
Roller mobile for compaction	○		
Asphalt finisher	○		
Concrete pumper truck	○		
Vibration roller	○		
Tamping machine	○		
Pavement cutter machine	○		
Cutter machine for reinforcing steel bar	○		
Processing machine for reinforcing steel bar	○		
Generator	○		
Air compressor	○		
Submersible pump	○		
Drilling machine（Non-suspension）			○
Vibrohammer pile-driver	○		

Source：JICA Study Team

4.9.2 Bidding Methods and Setting of Contract Conditions

The project requires a high technical level, and the procurement by international bidding is appropriate. A general procedure of international bidding is indicated as follows.

1.	Publicly advertisement is done to construction firms for prequalification through newspapers, etc.
2.	Tender documents is distributed to the prequalified firms
3.	A proposal is submitted by firms who received tender documents according to the contents of tender documents on the determined date and venue
4.	A successful bidder that is eligible for contractual negotiation among all the bidders is decided through the bidding procedure such as confirmation of bidder documents, opening, contents evaluation, etc.
5.	A successful bidder has a contractual negotiation with the executing agency of Myanmar as a client.
6.	A successful bidder make contract with the executing agency of Myanmar
7.	The construction works is started
8.	The necessary investigation are conducted at each stages of the works
9.	Preliminary operation of completed facilities is implemented, and the firm obtains consensus from the Myanmar side.
10.	Water/ sewerage facilities are handed over to Myanmar side
11.	The firm needs to respond any actions during the warranty period
12.	The final investigation is conducted at the end of warranty period
13.	The firm obtains a final consensus from Myanmar side then finally hands over the facilities.

4.9.3 Selection Policy for Consulting Firms

Quality and Cost Based Selection (QCBS) is recognized appropriate for selection of consulting firms. QCBS is a selection method considering quality of a proposal and cost of service, so it is recommended for the selection of consulting firms particularly for the project, which requires a high technical level.

For instance, the first step is to select 3-5 consulting firms that meet the following criteria, and to make a short list.

① To have consulting experiences of overseas projects in the relevant sector
② To have experiences on acceptance of order for consulting in south-east or south Asian countries
③ To have experiences of the Japanese ODA projects

The invitation letter for the project will be sent to all short-listed consulting firms. In case of QCBS, a submission of technical and cost proposals are required. At first, evaluation of the technical proposal will be implemented in accordance with the following criteria.

① General experiences of consulting firms in the relevant areas which is indicated in Terms of

Reference (TOR)

② Appropriateness of the proposed approach, methodology and a work plan

③ Staff's experiences and achievements

The cost proposal will not be opened and sent back to a consulting firm in case that; 1) the evaluation result of technical proposal of a consulting firm does not reach to the minimum scores required for passing, or 2) a consulting firm does not meet the requirements indicated in the invitation letter for the submission of proposal.

The cost proposal will be opened only if a consulting firm meets the minimum scores of technical proposal. Total scores will be calculated by considering weighted value of both technical and cost scores, then the final rank will be determined based on the total scores.

4.9.4 Selection Policy for Contractors

(1) Pre-Qualification（P/Q）

This project requires high technical level, so that invitation for bids should be targeted on the technically and financially capable contractors. Prior to the bidding, pre-qualification procedure is necessary. Prequalification needs to consider the following issues in order to judge on whether candidate bidders are capable for meeting the specified contract or not.

① Experience and achievement in the similar contracts

② Capability of staffing and equipment

③ Financial situation

(2) Bidding System

Two Envelop Bidding could be appropriate for the selection of contractors. The bidding system requires submission of technical and cost proposals separately and simultaneously. At first, technical proposals are opened and considered to check whether the engineers meet TOR or not. After the consideration, the cost proposals from only the successful bidders who meet the minimum requirement is opened.

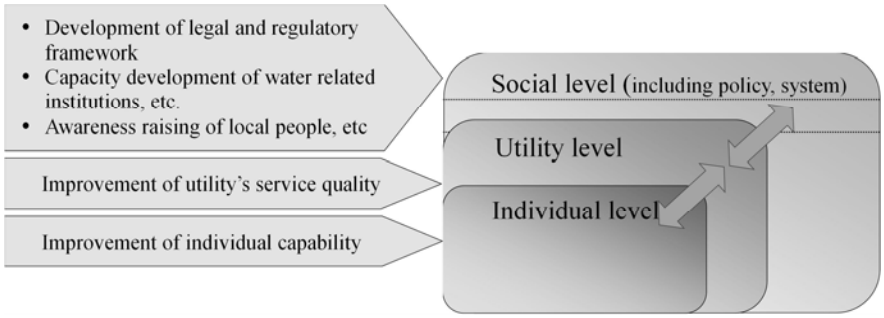
If technical proposal does not meet the minimum requirement, the cost proposal is returned to the bidders. Two Envelop Bidding is desirable for enhancing cost competition between only qualified bidders and for securing the quality.

CHAPTER 5. Capacity Development Plan

5.1 Outline of Capacity Development

5.1.1 Concept of Capacity Development

Capacity development is defined as “the process by which individuals, organizations, institutions, and societies develop abilities to perform functions, solve problems and set and achieve objectives” by JICA. Capacity development not only in technical aspects but also in overall organizational aspects including management and financial issues is essential for water and sewerage utilities to operate their organization and infrastructure facilities on sustainable basis. In order to support this, capacity development at individual and social level also plays a crucial role.



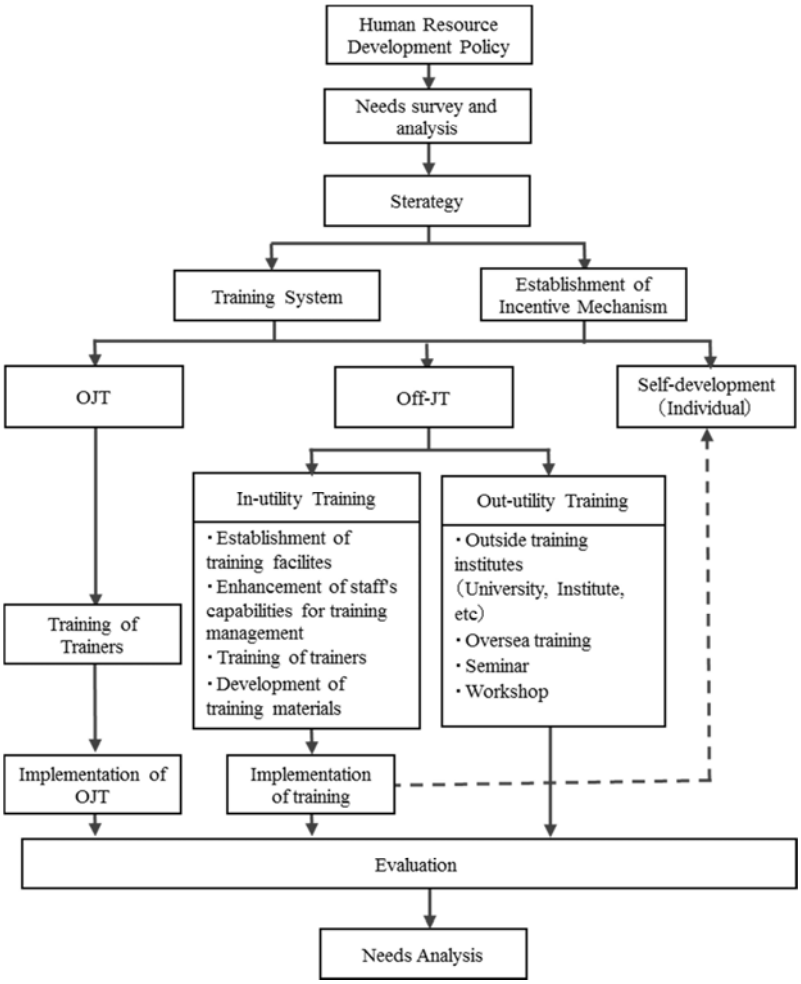
Source: JICA（2008）Capacity Assessment Handbook

Figure 5.1 Concept of Capacity Development

5.1.2 Capacity Development Methods

A training mechanism and capacity development methods are indicated as the following figure.
Capacity development should follow a utility’s basic policy for human resource development and a result of needs assessment. Main methods of capacity development are the following three: (1) OJT, (2) Off-JT, (3) self-development.

OJT enhances capacity development of necessary technology and capability through a form of training on practical works and trial and error in a normal working situation. Off-JT is a form of training receiving external lectures or education either inside or outside of utility. Self-development is a form of training to develop own capability by individual learning.



Source: JICA (2008) Capacity Assessment Handbook

Figure 5.2 Capacity Development Mechanism and Methods

For effective capacity development of YCDC, a combination of all types such as OJT, Off-JT and self-training is essential. Currently the training subjects of YCDC central training center is limited to general engineering and accounting etc., so that a training opportunity on wastewater treatment including sewerage and sewerage works management is very few. Since the development of wastewater treatment is still in the initial stage particularly in Yangon city, cultivation of experienced trainers capable of giving guidance and acquisition of broader and deeper knowledge and technology by trainers are necessary. From the long-term view, it is expected to nourish resource persons effectively, and it is needed to ensure that they teach obtained knowledge and experiences to the next middle or young staff members. At the same time, creation of incentive mechanism and awareness rising, and development of surrounding environment where the obtained lessons learnt by training are effectively utilized are necessary.

At the initial stage, it is considered that the assistance of dispatch of external experts by aid agencies etc. and a technical cooperation project are useful for entire capacity development.

5.2 Necessity of Capacity Development

Currently, development of wastewater treatment in Yangon city remain at low level in overall, capacity development at all level such as individual, organizational and society are essential for improvement of wastewater treatment situation. Sanitation division should put the priority on institutional development, development of legal and regulatory frameworks, IEC activities for local people aiming at enhancement of developing wastewater facilities including improved septic-tank. In addition, development of business management basis, improvement of operation and maintenance, and strengthening financial management are important in order to shift the utility's constitution to customer-focus "service provider" before entire development of sewerage system.

Considering these situation and succeeding 5 or 10 years after, there are various areas in technical, managerial and financial for capacity development of staff members in Sanitation division.
In sewerage and drainage sector, the main areas for capacity development of Sanitation division for short-term up to 2025 are summarized as following table. Priority is given to the training areas in the range of high and low.

Table 5.1 Necessary Training Areas for Capacity Development of YCDC

Large	Small	Training Subjects for Capacity Development	Priority		
			High		Low
Technical Capacity (Technical Aspect)	General	1. Sewerage treatment basic	●		
		2. Development of assets database of sewerage facilities	●		
		3. Information management system （SCADA）			●
	Design	4. Design of sewage pipeline facilities			●
		5. Design of sewage treatment facilities			●
		6. Design of electrical and mechanical equipment			●
		7. Design of improved septic tank			
	O&M	*O&M of treatment and pumping facilities*			
		8. - Development of water treatment and sludge treatment plan	●		
		9. - Development of an operational plan for equipment	●		
		10. - Recording and management of operation (daily, monthly, yearly)		●	
		11. - Development of repair and maintenance of mechanical and electrical equipment		●	
		12. O&M of mechanical and electrical equipment		●	
		13. Development of rehabilitation and renovation work plan		●	
		14. Continuous and efficient management of treatment facilities			●
		O&M of pipeline facilities			
		15. - Inspection and survey of pipeline infrastructure		●	
		16. - Cleaning and dredging of pipeline facilities		●	
		17 - Rehabilitation and repair of pipeline facilities		●	
		18. - Recording and management of O&M		●	
		19. - Continuous and efficient management of pipeline facilities			●
		20 Development of O&M manuals	●		
		21. Operation and maintenance of septic tank, and collection of sludge	●		
	Water quality management	22. Development of water quality management plan	●		
		23. Usage and O&M of water quality analysis equipment		●	
		24. Implementation of water quality test		●	
		25. Implementation of water quality test of industrial effluent		●	
		26. Recording and analysis of water quality data and reporting			●
Core-Capacity （Non-technic	Institutional issues	27. Organizational arrangement and expansion	●		
		28. Definition of duties and responsibilities	●		
		29. Human resource management		●	

Large	Small	Training Subjects for Capacity Development	Priority		
			High		Low
al Aspect）		30. Human resource development plan		●	
		31. Good governance and prevention of corruption			●
	Management / Business efficiency	32. Development of plan and strategy for short-, middle- and long-term.	●		
		33. Setting of performance indicators (PIs) and waterworks management	●		
		34. Performance monitoring and evaluation	●		
		35. Computerization of business operation, and processing and editing of data		●	
		36. Quality management（ISO9001, ISO14001）			●
		37. Public procurement management and construction supervision			●
		38. Industrial health and safety			●
	Financial performance	39. Budgetary planning for wastewater treatment	●		
		40. Consideration of sewerage tariff policy	●		
		41 Socio-economic situation of local people and sewerage tariff	●		
		42. Setting of sewerage tariff and cost analysis, projection of profit and loss		●	
		43. Billing and collection of sewerage tariff			●
		44. Assets management			●
	Public & Society	45. Social responsibility and accountability	●		
		46. Customer service and public relation	●		
		47. Household awareness survey (public health, development of sewerage facilities, existing sewerage work service)	●		
		48. IEC activities to residents on public health and environmental conservation	●		
		49. Development of IEC materials	●		
		50. Public awareness of improved septic tank/ on-site compact treatment facilities (Johkaso) and PR activities of a funding subsidy system		●	
		51. Public awareness on development of sewerage system			●
		52. Guidance on installation of small-scale wastewater treatment facilities (e.g. community plant) (large scaled development area)		●	
		53. Guidance on installation of wastewater treatment facilities for high rise building		●	
		54. Participatory development and gender			●
Surrounding Environment	Law & regulator system	55. Establishment of policy, laws and regulatory framework on sewerage and drainage sector	●		
		56. Law and regulatory framework of planning, construction, operation, management and supervision for wastewater treatment facilities (including sewerage)	●		
		57. Standards and institutions of improved septic-tank/ on-site compact treatment facilities (Johkaso)	●		
		58. Establishment of by-law/ ordinance on sewerage		●	
		59. Regulation on water quality standards for public water bodies and effluent standards		●	
		60. Regulation on development activities		●	
		61. Laws and regulations related to solid waste treatment and on environmental pollution （Air pollution prevention, noise regulation, vibration regulations, hazardous odor prevention, etc.）		●	
		62. Establishment of by-law/ ordinance on sewerage tariff setting		●	
	Enhancement of monitoring & regulation	63. Enhancement of monitoring and regulation of water quality standards for public water bodies and effluent standards			●
		64. Enhancement of monitoring and regulation of development activities			●

Source: JICA Study Team

Six priority areas, out of the above overall areas, for capacity development are described in the following section.

5.2.1 Development of Institutional Arrangement

- Division of duty and responsibility should be clearly defined. Every staffs needs to understand their own duty and responsibility, and self-awareness and self-reliance of employees should be encouraged more than ever before.
- Department (for instance: planning and monitoring department) should be set up for preparing high level policies and plans, strategies, business plans and so on. During the initial stage before development of entire sewerage system, a planning and monitoring division needs to be established in the sewerage division.
- A water quality laboratory should be created in WWTP, and then establish water quality monitoring system for regular testing by themselves.
- A section in charge of customer services and public relations should be set up in the DEWS and each township offices. Up to 2025, main tasks of this section could be to reinforce the functions of IEC activities and public health education both in water and wastewater sectors.

5.2.2 Development of Legal and Regulatory Framework

- Yangon City Development Law and the rules describe the duty and the responsibility of YCDC on sewerage and sanitation works, however further consideration and development of the contents are necessary as an ordinance.
- In Myanmar, sewerage law is not yet formulated, so that sewerage ordinance may play an advanced role prior to the law. In this sense, basic policies on position, planning, construction, operation, management and supervision of wastewater treatment facilities need to be included in sewerage ordinance.
- Ambient water quality standards for public water bodies need to be considered and be institutionally established.
- In order to enhance shifting from the current facility to and introduction of improved septic tank or on-site compact treatment facility, consideration and development of standards and institution are necessary.

5.2.3 Development of Business Management Bases

- The high level policies and development plans in short-, mid- and long-term of the sewerage division need to be formulated in gradual stages hence forth.
- Key performance indicators should be considered and set up in order to understand the current situation of management and achievement visually. This action does not only focus on sewerage works but also on IEC activities and development of improved septic-tank/ On-site compact treatment facilities (Johkaso) which are necessary for large areas in Yangon city in order to know the current situation and the progress on an as needed-basis.
- Monitoring and evaluation by PIs should be launched and utilized for identification of improvement points and challenges to be tackled.

5.2.4 Enhancement of Financial Management

- A customer database to exactly understand and record the current situation of IEC activities and dissemination of septic-tank in the stage until 2025 need to be established. Billing and sewerage tariff collection functions should be included in the database regarding the planned treatment areas of C1 and W1.
- A tariff setting policy of DEWS for sewerage tariff collection is necessarily considered especially in the area of C1 and W1 that will be developed first.
- Financial projection should be established considering cost analysis of sewerage works and cross-subsidy including water tariff in the process of sewerage tariff setting.

5.2.5 Strengthening of Hygiene Education and Awareness Activities

- Household awareness survey on public health, environmental conservation, development of sewerage system, sewerage tariff and cost sharing, willingness to pay need to be planned and conducted before starting IEC activities for public health and education.
- A customer service and public relation section newly established needs to establish activity policies and plans. An efficient activity plan should be prepared in cooperation with the regional department of health that has deployed IEC activity on public health.
- Based on the abovementioned plan, IEC materials on necessary issues such as public health, improved septic tank, funding subsidy system for dissemination, development of sewerage system and an beneficiaries-pay principle needs to be developed.
- IEC activities should be launched in cooperation with NGOs as a partner. Also capacity development NGOs at individual and organizational level need to be enhanced in order to intend a systematic deployment of IEC activities in future.

5.2.6 Improvement of Operation and Maintenance Capability

- Current sewerage infrastructure facilities need to be precisely recorded through research and a sewerage assets database should be established.
- Standard operation procedure for operation and maintenance is not unified. At wastewater treatment plant, the operation is differentiated by operators due to the trouble of automatic control system of sewage pumps. Therefore an operation and maintenance manual should be developed for standardization of operation and maintenance works.
- Training for capacity development is necessary in order to respond corrosion and pipe blockage of the aged ejector system, no record on water temperature and water quality in wastewater treatment plant, inappropriate operation and maintenance due to the lack of procurement of repair parts and chemicals.
- Currently operation hours, operational status, maintenance status, influent wastewater, water temperature and quality etc. are not recorded, thereby it is difficult to understand the operation and maintenance situation exactly. Recording of operation and maintenance, and regular

preparation and submission of reports are required to formulate a system to know operation and maintenance situation on a steady basis.

5.3 Activity Targets for Improvement

Short-term activity targets for FY 2025 in the aforementioned 6 areas are summarized in the following table.

Table 5.2 Activity Targets of Capacity Development

Areas for Capacity Development	Activity Targets
Development of Institutional Arrangement	• Clear division of duties in each section • Formulation of planning and monitoring sections in the sewerage division • Establishment of a laboratory in wastewater treatment plant, installation of materials and equipment for water quality testing • Formulation of customer service and public relation section in DEWS • Formulation of customer service and public relation section in each township office • Securing human resources for new sections（new recruitment, transfer）
Development of Management Bases	• Formulation of the orientation of sewerage section, development plans in short-, middle-, and long-term based on the master plan • Selection and setting targets for short-, middle- and long-term by using key performance indicators (PIs) • Starting regular monitoring and reporting based on key PIs (monthly, annually)
Enhancement of Financial Management	• Formulation of database of customer information management（information management on IEC activities, coverage of septic-tank at the initial stage） • Consideration on tariff setting policy toward sewerage tariff collection • Cost analysis of sewerage works and financial projection combined with waterworks
Strengthening of Hygiene Education and Awareness Activities	• Formulation of policy for IEC activities and action plan by customer service and public relation section • Development of IEC materials regarding public awareness on public health, necessity of improved septic-tank and funding subsidy system for dissemination, development of sewerage system and beneficiary-pay principle. • Starting systematic IEC activities in collaboration with NGOs • Implementation of household awareness survey
Improvement of Operation and Maintenance Capability	• Research and establishment of sewerage assets database (treatment plant, pumping station, pipeline etc.) • Development of O&M manual • Training on improvement of O&M works of sewerage facilities • Recording and management of operational record
Development of Legal and Regulatory Framework	• Formulation of sewerage ordinance • Formulation of law and regulation on planning, construction, operation, management and supervision for wastewater treatment facilities • Formulation of ambient water quality standards for public bodies, effluent standards • Formulation of standards and institutional arrangement on installation of improved septic tank or on-site compact treatment facilities

Source：JICA Study Team

CHAPTER 6. PROJECT EVALUATION

6.1 Economic/Financial Analysis Assumptions

6.1.1 Wastewater Treatment Volume and Water Consumption

The wastewater treatment volumes and water demand for C1 Zone for each year will be interpolated between the years that the Master Plan makes the forecast for. C1 Zone is located in the heart of the business district with vibrant commercial activities and is the most international area of the city. Though the population growth of this area is set at zero for the forecast, the per capita consumption is expected to grow rapidly. Table 6.1 shows the share of commercial demand for water. There are four townships within C1 Zone, i.e., Pabedan, Kyauktada, Botahtang, Pazundaung. The shares of commercial demand range between 18% to 41% with an average of 34%, much higher rate than the city-wide average of 24%. The two township of Latha and Lanmadaw, which are planned to be connected to W1 Sewerage Zone, are currently connected to the existing treatment plant. Therefore as an interim measure, these two townships will be connected to the C1 WWTP. However, only toilet water, assumed at 50 liters per day per person, will be collected just as is the case in the current practice. Table 6.2 shows the projected volumes of household and commercial water and sewerage. The differentiation between household and commercial uses is to follow the current tariff system which charges 88Kyat/ m^3 to household and 110Kyat/ m^3 to commercial customers.

Table 6.1 Share of Commercial Demand for Water by Towns

	Township	Commercial Demand Ratio
C1	Pabedan	34%
	Kyauktada	38%
	Botahtaung	41%
	Pazundaung	18%
	Total	33%
W1	Latha	29%
	Lanmadaw	39%
	Total	34%

Source: JICA Study Team

It is presumed that sewerage tariff will be collected together with water tariff. This internationally practiced method of sewerage tariff collection stems from the fact that the volume of sewerage water disposal can be metered only by water meters and also promote efficiency in bill collection. The costs for operation and maintenance are based on forecasted volume of wastewater treatment while the revenue for sewerage service is based on the forecasted volumes of water consumption.

Table 6.2 C1 Sewerage Zone Wastewater Treatment Volume and Water Demand Forecast by Customer

Year	C1 Planned Wastewater Volume (m3/day)	W1 Planned Wastewater Volume (m3/day)	Total Planned Wastewater Volume (m3/day)	Treatment Capacit (m3/day)	Connection Coverage Rate	Treated Volume (m3/day)	Water Demand (m3/day)				Water Supplied with Sewerage Connection (m3/day)	
							C1 Domestic	C1 Commercial	W1 Domestic	W1 Commercial	Domestic	Commerical
2014												
2015												
2016												
2017												
2018												
2019												
2020	43,585	3,863	47,448	24,800	54%	24,800	26,441	12,244	2,303	1,209	15,598	7,300
2021	44,663	3,863	48,526	24,800	70%	24,800	27,181	12,582	2,303	1,209	20,682	9,674
2022	45,741	3,863	49,604	24,800	84%	24,800	27,921	12,920	2,303	1,209	25,401	11,875
2023	46,820	3,863	50,683	70,200	90%	45,755	28,662	13,258	2,303	1,209	27,954	13,061
2024	47,898	3,863	51,761	70,200	91%	47,016	29,402	13,596	2,303	1,209	28,798	13,448
2025	48,976	3,863	52,839	70,200	91%	48,289	30,142	13,934	2,303	1,209	29,651	13,839
2026	50,004	3,863	53,867	70,200	92%	49,528	30,849	14,255	2,303	1,209	30,481	14,219
2027	51,032	3,863	54,895	70,200	93%	50,778	31,556	14,576	2,303	1,209	31,319	14,601
2028	52,060	3,863	55,923	70,200	93%	52,039	32,263	14,897	2,303	1,209	32,165	14,988
2029	53,088	3,863	56,951	70,200	94%	53,312	32,970	15,218	2,303	1,209	33,019	15,378
2030	54,119	3,863	57,982	70,200	94%	54,600	33,679	15,540	2,303	1,209	33,883	15,772
2031	55,099	3,863	58,962	70,200	95%	55,850	34,355	15,844	2,303	1,209	34,723	16,153
2032	56,079	3,863	59,942	70,200	95%	57,111	35,030	16,149	2,303	1,209	35,570	16,538
2033	57,059	3,863	60,922	70,200	96%	58,384	35,706	16,453	2,303	1,209	36,425	16,926
2034	58,039	3,863	61,902	70,200	96%	59,667	36,381	16,758	2,303	1,209	37,287	17,318
2035	59,020	3,863	62,883	70,200	97%	60,962	37,058	17,062	2,303	1,209	38,158	17,713
2036	60,071	3,863	63,934	70,200	98%	62,336	37,783	17,388	2,303	1,209	39,084	18,132
2037	61,122	3,863	64,985	70,200	98%	63,721	38,509	17,713	2,303	1,209	40,019	18,554
2038	62,173	3,863	66,036	70,200	99%	65,119	39,235	18,038	2,303	1,209	40,961	18,979
2039	63,224	3,863	67,087	70,200	99%	66,528	39,961	18,363	2,303	1,209	41,912	19,409
2040	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2041	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2042	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2043	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2044	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2045	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2046	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2047	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2048	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2049	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2050	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2051	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2052	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2053	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2054	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2055	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2056	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2057	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2058	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2059	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842
2060	64,275	3,863	68,138	70,200	100%	67,949	40,687	18,688	2,303	1,209	42,870	19,842

Source: JICA Study Team

6.1.2 Investment

The cost breakdown for investment is shown in Table 6.3. Whereas financial costs include tax payments such as commercial tax and import duties, economic costs do not include the payment of taxes. From macroeconomic viewpoints, tax payments are nothing but transfer of money within the same national economy. The investment costs include the consulting fee to prepare the tender document and construction supervision and costs for house connection as well as the construction costs of wastewater treatment plant and sewer network. Switching to a separate sewer system will require the installation of wastewater chamber and connection pipes for each customer. For each cost item, the project cost needs to add contingency, administration cost, commercial tax and import tax.

Table 6.3 Economic/Financial Investment Costs

Non-disclosure Information

The work is now assumed to start in 2014 and to be completed by 2022. The construction work for phase I and phase II will continue without any break. The service connection work will achieve 90% of the target connections by 2022 and will continue till 2040 by adding 0.56% every year to meet the new applications for connection. The expenditure disbursement schedule for each investment item is shown in Table 6.4.

Table 6.4 Investment Schedule by Item

Year	Wastewater Treatment Plant Phase1	Wastewater Treatment Plant Phase2	Sewer Network	Consultancy	Connection
2014	0%	0%	0%	3%	0%
2015	0%	0%	0%	19%	0%
2016	0%	0%	0%	9%	0%
2017	31%	0%	16%	13%	14.6%
2018	34%	13%	18%	15%	15.9%
2019	34%	50%	18%	15%	15.9%
2020	0%	38%	18%	12%	15.9%
2021	0%	0%	18%	8%	15.9%
2022	0%	0%	13%	6%	11.9%
2023	0%	0%	0%	0%	0.56%
2024-2040	0%	0%	0%	0%	0.56%

Source: JICA Study Team

The reinvestment will cover only electro-mechanical investments. The reinvestment will take place 15 years after commissioning with 15% of the original investment costs.

6.1.3 Operation and Maintenance Costs

(1) Salary

Worker categories assumed for the project are engineers, technicians and common workers and corresponding numbers and salary levels are shown in Table 6.5.

Table 6.5 Salary Assumptions

		person	unit cost	Salary
Phase I	Engineer	5	203	1,015 USD/Month
	Technician	3	106	318 USD/Month
	Common Worker	10	93	930 USD/Month
	sum	18		2,263 USD/Month
	Annual			27156 USD/Year
phase II	Engineer	0	203	0 USD/Month
	Technician	2	106	212 USD/Month
	Common Worker	10	93	930 USD/Month
	sum	12		1,142 USD/Month
	Annual			13,704 USD/Year

Source: JICA Study Team

(2) Spare Parts

Electro-mechanical equipment requires spare parts to continue normal operations. The annual requirement for spare parts is assumed at 1.6% of the original investments as shown in Table 6.6.

Table 6.6 Spare Parts Requirements

Non-disclosure Information

(3) Sewer Maintenance

Sewerage system requires regular proper maintenance of sewer network including pipes and manholes. In addition to the deployment of high pressure water jet machines and vacuum vehicles, a large manpower will be engaged for cleaning work. The estimation of sewer maintenance costs is based on an empirical formula used in Japan with price level adjustment to Myanmar.

368 x total pipe length（km） + 19,782 (USD/Year)

The annual maintenance cost is estimated to be USD 41,352.

(4) Variable Cost

There are several types of variable costs that increase in proportion to the volume of sewerage treatment. These variable costs include electricity, chlorine, coagulants, and disposal of sludge. The assumed unit costs per treatment volume for the variable costs are listed in Table 6.7.

Table 6.7 Variable Cost Item Requirement and Unit Cost

	Quantity	Unit	Price	Unit
Electricity	0.3	kWh/ m^3	0.04	USD/kWh
Chlorine	0.30	%	0.5	USD/ m^3
Polymer	0.0018	ton/ m^3	5.1	USD/ m^3
Sludge Cake	0.0007600	m^3/ m^3	5	USD/ m^3

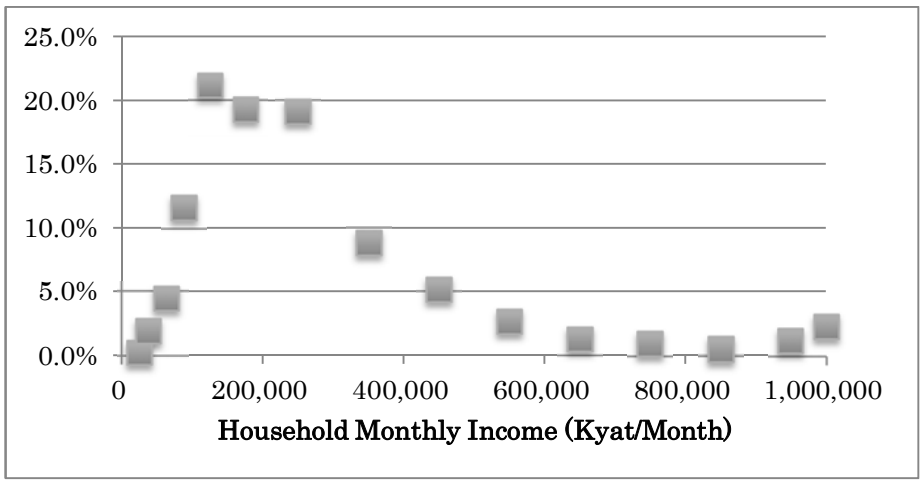
Source: JICA Study Team

6.2 Economic Analysis

6.2.1 Economic Benefit

The economic benefit used for economic analysis is based on the value of willingness-to-pay (WTP) following standard economic welfare theories. JICA HIS has asked the questions regarding WTP. However the answers show only low values. Interviewing residents with simple questions does not reveal true valuation or appreciation of sewage treatment benefits since the respondents tend to indicate lower values in most cases. It is suspected that there is a psychological anchoring on the present tariff and payment.

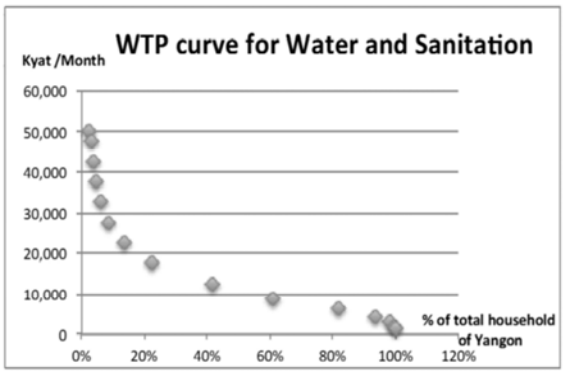
APPENDIX F-3 shows the methodological background to derive WTP using the demand curve. Accordingly the social welfare for water and sewerage services is equal to the area of the demand curve. HIS has asked the question on monthly income and responses are summarized as shown in Figure 6.1.



Source: The original data is obtained by 2012 JICA-HIS

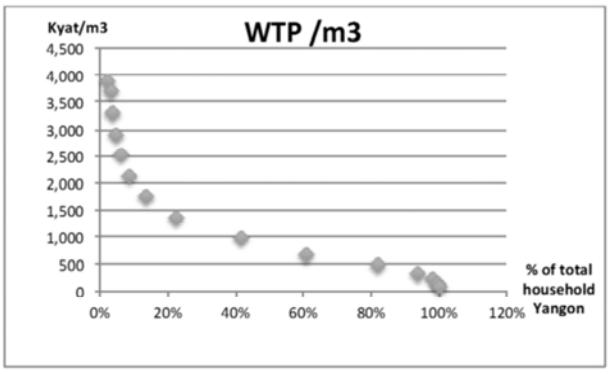
Figure 6.1 Monthly Income Distribution of Yangon Households

A general rule of thumb in analyzing affordability-to-pay for water and sewerage tariffs is the expenditure of 3-5% of income. It is assumed that the economic willingness-to-pay will be close to the upper value of 5% of income. Figure 6.2 shows the monthly budgetary limit (monthly WTP) for water and sewerage service from higher income groups in descending order. In economic theory, the plotted WTP is synonymous with demand curve. As described in Appendix F3, the social welfare or economic benefits are the total area below the demand curve. For economic analysis, the demand for water changes every year, thus the fixed monthly value needs to be converted to a unit volumetric value. According to the HIS, the average size of the household is 4.3. Using the current water consumption of 100 liters per person per day, the demand curve to the volumetric tariff is derived as shown in Figure 6.3. The average tariff WTP for water and sewerage is 937Kyat/ m^3 by dividing the average WTP for water and sewerage of 12,950 Kyat/household/month by the household size of 4.3, 100 liter consumption per day per person, and 30 days. The tariff is then divided by 1:0.8 between water and sewerage to arrive at 418 Kyat/ m^3 or USD 0.47/ m^3 for sewerage economic benefit in 2013. At present the tariff for household is set at 88 Kyat/ m^3 while that for commercial customer is 110 Kyat/ m^3. Applying the same price differential of 1.25 to the household value, the commercial benefit value in 2013 is USD 0.59/ m^3.



Source: The original data is obtained by 2012 JICA-HIS

Figure 6.2 Monthly WTP for Water and Sewerage Service



Source: The original data is obtained by2012 JICA-HIS

Figure 6.3 Volumetric WTP for Water and Sewerage Service

6.2.2 Economic Analysis

Economic analysis requires the development of cash flow table over the project period of 40 years, comprising of cash inflow from tariff revenue, the cash outflow by investment and OM expenditures. The net cash flows are calculated by taking the difference between the cash inflow and cash outflow. The evaluation indicator of Economic Internal Rate of Return is the discount rate that equates the net present value of the net cash flows to zero.

First, the operation costs are calculated based on the treatment volume of wastewater. The cash outflow is calculated by adding OM costs to the investment costs. The tariff revenue, cash inflow, is calculated by tabulating the revenues from household and commercial customers by multiplying each tariff to the corresponding forecast water demands.

The above tabulations are summarized in Table 6.8. The EIRR is calculated to be 6.3%. In comparison to a standard benchmark of 12% for public projects, the return is half the level of the benchmark. One important reservation is that the evaluation is based on the WTP benefit of individuals and does not include economic external benefits of environmental protection or public health improvements. Also the WTP is predicated on the current income level. At a low income level, the people will place higher priorities for economic development over environmental protection. In many cases, environmental degradation is irreversible and it would be too late to wait for economic development in the future. It is important to embody environmental policy early for cities such as Yangon which expect rapid urbanization and economic development.

Table 6.8 Economic Cash Flow Table

Non-disclosure Information

6.3 Financial Analysis

6.3.1 Financial Affordability To Pay

The financial analysis must start with the examination of tariff affordability by the residents to see if the project is viable in financial terms. Currently there is no sewerage charge levied on the customer. Therefore it is not possible to base the analysis on the current level of payment. So-called affordability-to-pay analysis is conducted. As is the case for economic analysis, the basis for financial affordability is the income data from HIS.

In case of assuming affordability, the benchmark will be set at 80% of the residents who can afford the payment for water and sewerage. The tariff set affordable for the bottom 20% income group is affordable for 80% of the city. The income level of bottom 20% of the respondents from HIS is 105,000 Kyat/month as shown in Figure 6.1. If 4% of income is expendable for water and sewerage, the limit would be 4,200 Kyat/month in total. The average household size is 4.3 and assuming 100 liter per day per person consumption, the volumetric tariff limit would be 326Kyat/m^3. Allocating the tariff between water and sewerage with 1: 0.8 allocation ratio, the maximum limit for sewerage tariff would be 145 Kyat/m^3, equivalent to USD 0.16/m^3. Since the commercial tariff is set at 1.25 times higher than household tariff, the same ratio is applied for the commercial tariff. The tariffs[1] adopted for financial analysis are USD 0.16/m^3 for household and USD 0.20/m^3 for commercial customers on the basis of the year 2013.

6.3.2 Financial Evaluation

In order to derive financial return on investment, the financial cash outflow, inflow, net inflow are tabulated over the project period of 40 years after commissioning as shown in Table 6.9. The financial internal rate of return on investment (FIRR) is -1.2%. The evaluation result indicates that it is difficult to recover the investment and operation costs solely with tariff revenue of USD 0.16/m^3. As the column for the net cash inflow suggests, the sustained operation is quite possible solely with the tariff revenue as it shows surplus in regular years.

[1] Financial simulations undertaken in the Master Plan are based on the initial tariff of US 0.08/m^3 and constant annual rate of increase. The framework is based on the notion that there are a series of projects that are scheduled in later stages, thus the future income growth has to be incorporated over the time. The evaluation for C1 district is based on the assumption that the project will be undertaken immediately, thus the prices are fixed at the prevailing prices of 2013 and income levels of the customers without incorporating the future income growth.

Table 6.9 Financial Cash Flow Table

Non-disclosure Information

6.3.3 Sustainable Tariff Setting

The first target to be achieved by water supply and sewerage service is to acquire the revenue sufficient to cover the costs of operation and maintenance. The target year for balancing revenue and OM costs is assumed as the year 2025. The target tariff would be USD 0.07/m^3 for household and USD 0.09/m^3 for commercial customers.

The most ambitious target for the project financially is to recover both investment and OM costs solely with tariff revenues. This target is translated as having complete payoff of all the liabilities without leaving any surplus from operations. Table 6.11 shows the financial cash flow table for the financial

simulation with the borrowing Yen ODA loan with an interest of 0.01%, a 10 year grace period, and repayment period of 40 years. For some initial years, the operating surplus is not sufficient to meet the loan repayment obligation. For these period, the project owner, YCDC, needs to borrow money from the government to meet these obligations. It is assumed that the interest for inter-governmental lending would be free of interest. However, at the end of period, the project owner pays off all the accumulated borrowings from the government as well. The investment expenditure is shown in the column, "1.Investment" which will be accumulated in the column, "2.JICA Debt Outstanding", with an interest. After the grace period expires, the cash in "10.Operation Cash Flow", is used to pay out the debt repayment. If the available cash is not sufficient, the project owner will borrow from the government. The deficiency appears as a negative figure in the column "5.Repayment to Additional Lenders", and the borrowed amount will be accumulated in the column "3.Additional Borrowing Outstanding". This format can be utilized in the case of borrowing from the private sector instead of the government. Then it would be necessary to add an interest charge for the borrowings.

The financial simulation result shows that full cost recovery requires USD 0.23/m^3 for household and USD 0.29/m^3 for commercial customers and it is possible to pay off all the government borrowings as well as ODA Yen Loan by the year 2053.

The required charge above appears to be slightly expensive for an average household as the affordability to pay analysis indicates. Also, it is prudent to take into account the economic externality of sewerage projects in relation to environment. Therefore it is assumed that 50% of the investment costs are covered by the government subsidy. The same simulation model is run with 50% investment subsidy as shown in Table 6.12. The values in the column "2.JICA Debt Outstanding" is the amount which the project owner has to repay. Comparison of the values between the column, "1.Investment", and the column, "2.JICA Debt Outstanding" shows that only half of the investment value is added to the "2.JICA Debt Outstanding". The difference indicates that the balance, 50% of the investment costs, is covered by the government. Under this additional condition, the required tariffs for the payment of the Yen Loan and inter-governmental borrowing obligations are USD 0.14/ m^3 for household and USD 0.18/ m^3 for commercial customers.

Table 6.10 summarizes the above results of the required tariffs under the three scenarios above.

Table 6.10 Financial Goals and Required Tariffs

Financial Goals	Target Year	Capital Subsidy	Tariff (USD/ m^3)	
			Household	Commerce
Revenue/OM Cost Balance	2025	0%	0.07	0.09
Zero Liability	2053	0%	0.23	0.29
Zero Liability	2053	50%	0.14	0.18

Source: JICA Study Team

Table 6.11 Financial Simulation for Tariff Setting (0% Subsidy)

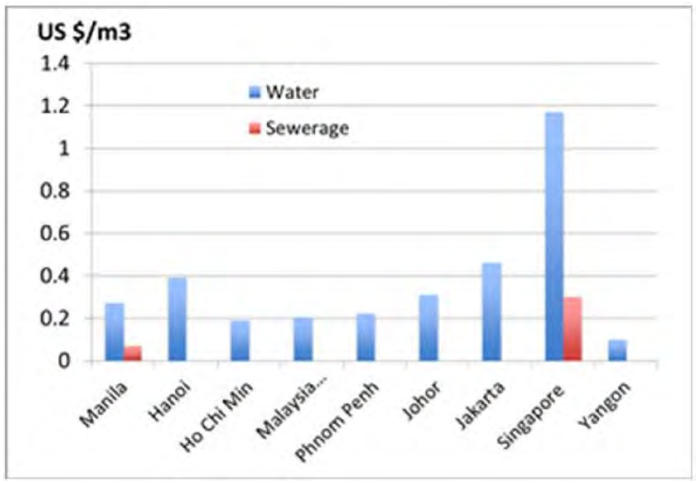
Non-disclosure Information

Table 6.12 Financial Simulation for Tariff Setting (50% Subsidy)

Non-disclosure Information

6.3.4 Tariff Setting Strategy

Currently YCDC charges 88 Kyat for water and nothing for sewerage services. Small population coverage of less than 6% of the population of the whole city of Yangon makes it possible to offer free service. In the case of Thailand, there are only three municipalities that charged sewerage tariff by the year 2010. These are Patong, Pattaya and Saensuk. Of these, only Pattaya charges some substantial tariff at about 150 Kyat per cubic meters. Pattaya is a beach resort with heavy water contamination. Bangkok has not introduced sewerage charge yet even though it had announced to do so since 2000.



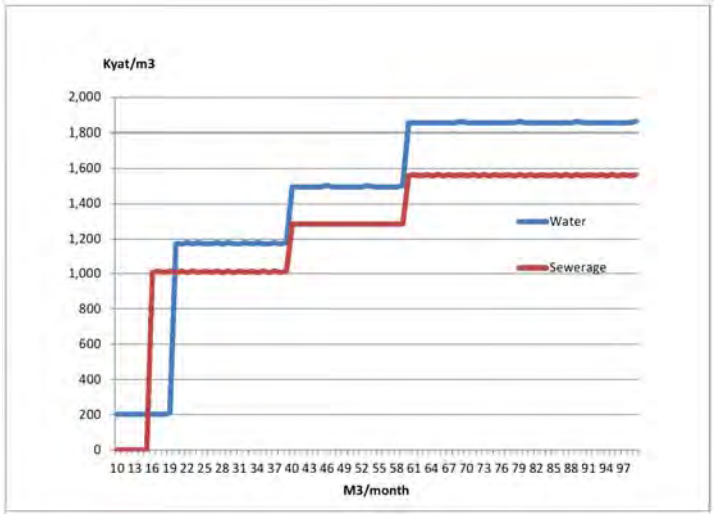
Source: International Benchmark Networking, Phnom Penh Water

Figure 6.4 Water and Sewerage Tariff in Asian Cities

The comparison of water and sewerage tariffs in Asian cities is summarized in Figure 6.4. The highest tariffs is levied by Singapore followed by Jakarta. The third is Hanoi. Only Manila and Singapore have tariff for sewerage services. Malaysian cities imposes wastewater treatment tariff but is not proportional to consumption.

Figure 6.5 shows the case of water and sewerage tariffs in Tokyo. There are two prominent differences from tariff system compared to Yangon's. Yangon offers only a flat rate per volume of water consumed. In the case of Tokyo, the rates increases in steps at 20 cubic meters of consumption, then 40 cubic meters and finally at 60 for water and in the case of sewerage at first increase at 15 cubic meters and then 40 cubic meters and 60. This system of progressive tariff basically penalizes wasteful consumption of water. Another difference is the charge imposed on sewerage. Though sewerage rate is slightly lower than water rates, the levels for water and sewerage are similar.

The reasons why the developing countries fail to impose sewerage tariff are that people are willing to pay for water but throwing out wastewater is someone else's problem. However, water pollution accumulates, as sedimentation of polluted sludge at the bottom of sea or river.



Source: City of Tokyo

Figure 6.5 Progressive Tariff System of Tokyo

There are four elements of sewerage tariff strategies. The first is to introduce something small in the beginning without full cost recovery. As implemented in every city in the world, the second tip is to charge sewerage tariff together with water bill for collection. The third tip is to create public awareness on importance of sewage treatment to avoid long term water pollution. The fourth element is to increase sewerage tariff in accordance with increased public awareness as well as rise in economic living standard of the citizens. In summary:

- Introduce Small Fee Immediately
- Charge it with Water Bill Together
- Create Public Awareness for Environmental Protection
- Increase Sewerage Tariff Keeping Pace with Economic Development

6.4 Project Evaluation

6.4.1 Summary of Economic and Financial Analyses

In summarizing the above project evaluations, the Economic Internal Rate of Return on Investment of the project is 6.2% while the Financial Internal Rate of Return on Investment is 0.98%. The value for the EIRR is relatively high for a sewerage project. However amongst other public investment projects in the country it is less than the standard level of EIRR. However, there is a large economic externality to a sewerage project. Therefore the evaluation by WTP alone may not even cover the half of the social benefits that the project may generate. The following discussion will add these extra dimensions to the project evaluation on less quantifiable merits. These benefits include environmental protection benefits, improvements in public health and boosting of location values of the areas with access to sewerage.

6.4.2 Economic Externality of Environment Protection

A large portion of an environmental project's benefits accrues to the society as a whole beyond each customer. Individuals can enjoy life so long as solid waste and wastewater is disposed. However as seen above, it is difficult to cover the full cost of the project through tariff revenues. Therefore, delays in implementation may lead to the deterioration of environment. Viewed from an overall social well-being, there may be more negative effects. In fact, the histories of advanced countries demonstrate the tragedy of inaction to environmental protection. Often true WTP for environmental protection reveal itself after the destruction of environment becomes evident. It is no more than hindsight. However, it is difficult to impose high tariffs to individuals when income levels are still low without clear perception of risks in the future. In Japan, for example, the government has provided a subsidy of approximately 50% to the investment costs to provide incentives for early implementation of sewerage projects.

6.4.3 Public Health

Table 6.13 shows the patient statistics and estimated medical costs for water-borne diseases in Yangon.

Table 6.13 Water-Borne Disease Patients and Estimated Medical Costs

		2008	2009	2010	2011	2012	Average
Diarrhea	No of Patients	17,462	13,166	11,851	10,969	15,713	13,832
	Treatment Cost (Kyat million)	363.2	273.9	246.5	228.2	326.8	287.7
Dysentery	No of Patients	9489	6135	6361	4436	4099	6,104
	Treatment Cost (Kyat million)	128.1	82.8	85.9	59.9	55.3	82.4
Cholera	No of Patients	49	191	22	37	134	87
	Treatment Cost (Kyat million)						
nectious Hipatitu	No of Patients	251	14	271	205	212	191
	Treatment Cost (Kyat million)	9.4	0.5	10.2	7.7	8.0	7.1
hoid/Para Typoi	No of Patients	71	55	98	47	27	60
	Treatment Cost (Kyat million)	3.6	2.8	4.9	2.4	1.4	3.0
Total	No of Patients	27,322	19,561	18,603	15,694	20,185	20,273
	Treatment Cost (Kyat million)	504.3	360.0	347.4	298.1	391.5	380.2

Source: Ministry of Health, Yangon Regional Health Department, Estimation by JICA Study Team

The average medical costs per year for water-borne diseases total to 380 million Kyats (USD 0.43 million). Given the size of the population of C1 Zone, around 5% of the city, the total eradication of water borne disease in the C1 Zone reduces the medical bills by USD 20,000. Naturally, the sick patient with light symptoms will not enter into the statistics as they may cure themselves by resting or purchasing over-the-counter drugs. Therefore the statistics and the corresponding medical costs only show the tip of an iceberg of public health implication.

6.4.4 Rise in Land Values and Fundamentals for International City

Yangon is now witnessing once in a century land speculation period. With international attention focused on Myanmar as the last frontier in Asia, expectation for the future rental values of land in Yangon has increased by a large degree. Faced with rising land prices, the existing owners will withhold their land for future price gains. Speculators try to purchase land also for future gains. Once speculative motives start to prevail, the prices embark on an upward spiral. Though the project may affect increases in land values, but it is difficult to forecast the land prices impacted by the project under the present volatile market.

From the perspective of economic development policy, it should be noted that lack of access to sewerage in the international district of the capital city deprives the investors of fundamental urban amenities. Foreign investors and businesses catering to foreigners may be forced to make an extra investment for sewage treatment and disposal. Such an extra investment may reduce the investment incentives. Promotion of foreign investment is one of key economic development policies in Myanmar at present. Provision of modern sewerage service to foreign investors will not only provide the amenities but will also present a great showcase to display the societal capacities of Myanmar.

CHAPTER 7. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

7.1 Framework Related to Environmental and Social Considerations

The laws, regulation and administrative framework are described in the Chapter 2.8 of Volume II "Water Supply Master Plan". The details identified during the Feasibility Study are described in the Appendix G of Volume IV "Water Supply Feasibility Study". The baseline data are described in the Appendix G of this report.

7.2 Components Which Affect the Environment and Society

The components which may affect the environment and society are shown in the table below. See more details in Chapter 2 and 3.

No.	Name of the Project	Facilities	Note
SW-1	Modernization of Sewerage System in Central Business District	Improvement of existing sewer system into separate sewerage system and expansion of WWTP • Trunk main (13.6 km, dia. 500 ~ 1,500 mm) • Branch sewer(45 km, dia. less than 500 mm) • Connection pipe (9,000 locations, dia. 100mm) • Rehabilitation and expansion of WWTP (70,200m^3/day, expansion 24,800 m^3/day)	The black water is collected by ejector system at present. The system is separate system and black and gray water will be collected and treated. The sludge from the septic tank will be transported and treated at WWTP.
SW-2	Improvement of Water Quality of Kandawgyi Lake	Construction of interceptor for drainages located in the north side of Kandawgyi Lake • Interceptor (total 2.5 km) • Pumping station • Rainwater outlet (5 locations) Dredging of the bottom sediment of the lake	Five drains on north side of Kandawgyi will be intercepted. The bottom sediment will be dredged. The wastewater from the restaurants will be treated by them or collected by interceptor.

7.3 Improvement of C1 Sewerage Zone

7.3.1 Analysis of Alternatives

(1) With/Without Project

At present, the black water is treated in C1 sewerage zone but the amount treated is 2,300 m^3/day, smaller comparing with the design capacity, i.e. 15,000 m^3/day. The gray water is not treated and discharged into the drains without treatment. If the project is implemented, both black and gray water will be treated, the pollution load to the river will be decreased and water quality of Yangon River will

be slightly improved.

(2) Construction / Rehabilitation of the Trunk Main

The following cases were examined as alternatives. The plan using the existing trunk main is abandoned as the capacity is not enough for the year 2040.

Case 1: To change the existing mechanical valves to electromagnetic valves as necessary. All force main pipes should be replaced.
Case 2: To convert ejector system to ordinary pumping system. A new trunk sewer by gravity is to be constructed.
Case 3: To abandon all existing ejector stations. A new trunk sewer to collect wastewater from lateral sewers by gravity is to be constructed.

For the Case 1, the forty ejector stations exist and this is rare system and the procurement of the necessary equipment is difficult. For the Case 2, the necessary pumps are forty and it is not considered to be efficient to provide such a high number of pump sets. It is not only uneconomical but also problematic in terms of maintenance. The Case 3 is the best considering the operation and maintenance. From the environmental and social considerations, the energy consumption is lower than the other alternatives, and the construction of trunk sewer may be implemented by the pipe-jacking method so that the disruption of the social life will be less. Considering the above, the alternative 3 was selected.

7.3.2 Scoping and TOR for Environmental and Social Survey

Table 7.1 Scoping and TOR for Environmental and Social Survey

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
Involuntary resettlement and land acquisition	C	D	The right to use the land of WWTP expansion area is governmental organization but the right should be cleared.	• Confirmation of right • Procedures of land acquisition	• Hearing survey of related organizations • Site survey
Local economies, such as employment, livelihood, etc.	B+	D	The increase of employment by the construction can be expected.	-	-
Land use and utilization of local resources	C	D	As the trunk main will be installed under the road, no impact is expected on land use and utilization of local resources. The land acquisition may affect the land use.	• Confirmation of land use	• Hearing survey of related organizations • Site survey
Social institutions	D	D	The impact on social institution and local decision-making institutions is not expected.	-	-

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
Existing social infrastructures and services	B-	D	The trunk main will be installed by pipe-jacking method and the impact may be low. The branch sewers will be constructed by open cut method and the traffic disturbance may be expected.	• Situation of infrastructure service	• Hearing survey of related organizations • Site survey
The poor, indigenous & ethnic people, gender and children's right	D	D	No indigenous and ethnic people exist in and around the project site. No impact is expected on gender and children's right.	-	-
Misdistribution of benefits and damages	D	D	The construction and operation of sewerage system may not cause any misdistribution of benefits and damages.	-	-
Cultural heritage	B-	D	The historical buildings may exist in CBD area.	• Location of cultural heritage in project area	• Hearing survey of related organizations • Site survey
Local conflicts of interest	D	D	The construction and operation of sewerage facilities may not cause the local conflicts of interest.	-	-
Water usage or water rights and rights of common	D	D	The construction and operation of sewerage system may not cause any impact on water usage, water rights and rights of common.	-	-
Hazards (Risk) infectious diseases	B-	D	Influx of construction worker may affect to inhabitants during construction.	• Data of infectious diseases	• Hearing survey of related organizations
Accidents	B-	D	The construction may cause the accidents.	• Confirmation of the traffic along the route	• Site survey
Topography and geographical features	D	D	The scale of facility is not large and no impact is expected.	-	-
Soil erosion	D	D	No impact is expected.	-	-
Groundwater	C	D	The impacts on groundwater by the construction of sewers and WWTP may be expected.	• Location of well, depth	• Hearing survey of related organizations
Hydrological situation	D	D	The effluent from WWTP will join into the Yangon River. The Yangon Rive has huge water flow and joins with Bago River just after the WWTP. The impacts on hydrological situation by WWTP may not be expected.	-	-
Coastal zone	D	D	No impact is expected.	-	-
Protected area	D	D	No protected area in the project site.	-	-
Flora, fauna and biodiversity	D	D	The plants and animals included in the Red List of IUCN habits in the forest so that the impact is not expected.	-	-
Meteorology	D	D	No impact is expected as the scale of facility is not large.	-	-
Landscape	B-	D	The landscape gets worse due to the dig up of the road and storage of excavated soil during construction. No	• Situation of the project site	• Site survey

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
			impact is expected during operation.		
Air pollution	B-	D	The operation of construction machines and other equipment will cause dust to rise and spread throughout the surrounding area during construction. The impact is temporary.	• Air quality standards • Air quality of the site	• Hearing from the related organization
Water pollution	B-	A+	The water may be affected by the construction of sewers and WWTP. The collection and treatment of wastewater will improve the river water quality where the wastewater is currently discharged directly.	• River water quality • Water use near around the project site	• Hearing survey of related organizations • Site survey
Soil pollution	B-	B-	Due to excavation and earthwork, soil erosion, loss of top soil and silting might be expected. The compaction of soil due to vehicle movement, and ground contamination from the spillage of materials such as vehicle fuel, sewage sludge, chemicals might be expected. The soil might be contaminated if the sludge is not properly treated and disposed.	• Prevention measures	• Collection of the related project information
Waste	B-	A-	The spoil will be generated during installation of pipelines and construction of WWTP. The sludge will be generated from WWTP during operation.	• Waste management regulations • Disposal method of construction waste • Situation of waste disposal sites	• Hearing survey of related organizations • Site survey
Noise and vibrations	B-	B-	Construction machines will cause noise and vibration during construction. The facilities which create noise will be installed inside the building of WWTP site. No impact is expected during operation.	• Noise standards	• Hearing from the related organization
Ground subsidence	D	D	No intake of groundwater is planned so that no ground subsidence.	-	-
Offensive odors	D	B-	The odor might be expected from WWTP	• Wind speed, direction	• Hearing from the related organization
Bottom sediment	D	D	No impact is expected.	-	-
Global warming	D	D	No impact is expected.	-	-

P: Planning, C: Construction, O: Operation

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/Negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the study progresses).

D: No impact is expected.

Source: JICA Study Team

7.3.3 Results of the Environmental and Social Surveys

(1) Involuntary Resettlement / Land Acquisition

A land of 1.35 ha area is required for the expansion of WWTP of C1 sewerage zone. At present, the two-storey buildings exist in this area. The right to use the land belongs to the Ministry of Construction and YCDC made the request to transfer the right to YCDC. The transfer of the right to use the land may not require the compensation. But for the buildings, the compensation might be required and this will be decided by the governmental negotiation.

Source: JICA Study Team

Figure 7.1 Proposed Expansion Area of WWTP

(2) Land use and utilization of local resources

There is the two-storey building in the area which is used by the Navy. The issue will be settled among the governmental agencies.

(3) Existing social infrastructures and services

The trunk sewer will be installed in the main road, such as Anawrahta Road, Mahabondoola Road, Merchant Road and Strand Road by pipe-jacking method.

Table 7.2 Information of Major Road

Name	No. of Lane	Direction	Dia. Of trunk main (mm)
Anawrahta Road	4	One way from east to west	500～700
Mahabondoola Road	4	One way from west to east	400～700
Merchant Road	4	One way from east to west	400～700
Strand Road	6 (+2)	Three lanes for each way (there are roads only for truck transportation)	350～1,500
Lower Pazundaung	4	Two lanes for each way	450～1,100

Source: JICA Study Team

(4) Cultural Heritage

Many heritage buildings within C1 sewerage zone and the routes of trunk main and the buildings are shown in the figure below.

Table 7.3 Heritage Buildings

Pabedan		22	Yangon Division Office Complex
1	Headquarters of Myanmar Oil and Gas Enterprise	23	Yangon Division Court (Civil)
2	Cholia Jamah Temple	24	Office of Port Authority
3	Account Department, Myanmar Posts and Telecommunications	25	Strand Hotel
Kyauktada		26	Embassy of Australia
4	Central Fire Station	27	Embassy of United Kingdom
5	The Headquarters of Fire Services Dept. (Yangon Division)	28	Central Post Office
6	City Hall	29	Custom House
7	Myanmar Insurance	30	Central Naval Hydrographic Depot
8	Immigration and Registration Department	31	Telegu Methodist Church
9	Department of Labor	32	Myanmar Agriculture & Village Tract Development Bank
10	Ministry of Hotels and Tourism	33	Sule Pagoda
11	Emmanuel Baptist Church	34	Bengali Sunni Jamah Mosque
12	Office of the Myanmar Post and Telecommunications	Botahtaung	
13	Myanmar Economic Bank (Department of Industrial Loans)	35	Printing and Publishing Enterprise
14	Stationary, Printing & Photographic Enterprise	36	Minister's Office
15	Myanmar Economic Bank Branch (3)	37	No. (6) Basic Education High School
16	Central Bank of Myanmar	38	Compressor Station, YCDC
17	Embassy of United States of America	39	Botahtaung Pagoda
18	Myanmar Export-Import Enterprise	Pazundaung	
19	Indian Embassy	40	Shwe Phone Pwint Pagoda
20	Office of Internal Revenue Department	41	Maha Vishnu Temple
21	Myanmar Insurance (Fire & Engineering)	42	Sunni Mosque (Yangon, Eastern)

Source: YCDC

Source: JICA Study Team

Figure 7.2 Route of Trunk Main and Location of Heritage Buildings

(5) Hazards (Risk) infectious diseases

The HIV/AIDS is becoming serious problem recently in Myanmar. According to UNAIDS, the disease rate of HIV among adult is 1.3 % in 2005. The infection is spread among the drug-addicted people and sex workers. The rate in Yangon Region is 0.25 % in 2010, 0.15 % in 2011 and it shows the decreasing trend comparing 0.55 % in 2005. The number of HIV patients who receive the ART treatment is shown in the table below.

Table 7.4 Number of AIDS Case in Yangon Region

		2013 January						2013 February						2013 March					
		AIDS Case (on ART, alive)			AIDS Death (on ART)			AIDS Case (on ART, alive)			AIDS Case (on ART)			AIDS Case (on ART, alive)			AIDS Case (on ART)		
		M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
1	Specialist Hospital by NAP	2,146	1,627	3,773	14	3	17	2,143	1,651	3,794	6	1	7	2,166	1,675	3,841	5	4	9
2	Specialist Hospital by UNION-NAP	807	633	1,440	5	5	10	841	609	1,450	4	3	7	877	645	1,522	10	6	16
3	Specialist Hospital by NAP	10	10	20	0	0	0	10	10	20	0	0	0	10	10	20	0	0	0
4	Specialist Hospital by NAP	16	10	26	1	0	1	15	12	27	0	0	0	17	14	31	0	0	0
5	AMI	372	323	695				372	326	698				376	327	703			
6	Alliance	432	375	807				437	376	813				485	401	886			
7	MSF (Holland)/AZG	8,040	5,893	13,933				8,040	5,893	13,933				8,040	5,893	13,933			
8	MSF (Swiss)	147	102	249				154	110	264				161	111	272			
9	PSI	79	27	106				87	29	116				88	29	117	0	1	1
	Total	12,049	9,000	21,049	20	8	28	12,099	9,016	21,115	10	4	14	12,220	9,105	21,325	15	11	26

M: male, F: Female, T: Total

Source: Yangon Regional Health Department, Ministry of Health

The situation of other infectious diseases is shown in the table below. The data is for Yangon Region.

Table 7.5 Number of Cases and Death of the Diseases

Diseases	2007		2008		2009		2010		2011	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Cholera	4	-	49	0	191	7	22	1	37	0
DHF (Dengue Haemorrhagic Fever)	4,759	54	3,604	31	3,333	38	3,162	21	552	4
Plague	0	0	0	0	0	0	0	0	0	0
Dysentery	8,507	0	9,489	-	6,135	0	6,361	0	4,436	0
Typhoid & Para Typhoid	103	1	71	1	55	0	98	0	47	0
Meningitis/ Encephalitis	32	5	24	2	1	4	9	4	10	2
Viral Hepatitis	188	6	251	1	14	4	271	3	205	2
Malaria	5,155	36	5,741	26	4,605	27	4,374	16	2,226	3

Source: Yangon Regional Health Department, Ministry of Health

The regulations related to working condition are not yet established in Myanmar. To prevent the infectious diseases among the construction workers, the contractor should implement the awareness training to them.

(6) Accidents

The traffic situation is described in (3) Existing social infrastructures and services. The contractor is responsible for the prevention of the accidents and the awareness and education to the construction workers should be implemented. The safety measures for the workers should be prepared and implemented by the contractor. For the preparation, ILO standards shall be applied.

(7) Groundwater

The main water source of YCDC water supply is the surface water, but YCDC has 414 operational tube well pumps and around 8 MGD is used as water source. The figure shows the location of the wells in YCDC area. The wells are mostly located in CBD and east area of South Dagon. There is no data on the private wells but it is estimated that 71 MGD is used by the private users. The development potential of groundwater is 83 MGD and the amount currently used is almost approaching this potential (see detail in chapter 3.4.2 of Volume II "Water Supply Master Plan"). The depth of the wells is from 24 to 146 m. The intake of groundwater will be zero from 2025.

Source: 2002 JICA-M/P

Figure 7.3 Location of Wells

(8) Landscape

The landscape will be temporally worsening due to the dig up of the road, storage of excavated soil and construction materials. To mitigate, the fence to cover the construction site should be considered.

(9) Air Pollution

YCDC is not monitoring the air quality regularly. The existing data of air quality is the results of the measurements of April 2007 and January 2008 by NCEA (Appendix G). The air quality standards are not established yet in Myanmar. Comparing the WHO standards, the values of PM10 and TSP are higher than the standards.

To mitigate the impact during construction, the measures such as proper maintenance of construction vehicles, machinery and equipment, idling off, installation of muffler should be taken not to exceed the WHO standards.

(10) Water Pollution

The river water around the project site is not used for any purpose. The sea water intrusion comes around this area so that the water is not used for agriculture. The water pollution might be expected during the construction, but the impact can be negligible.

(11) Soil Contamination

The regulations related to EIA are still developing in Myanmar so that the EIA reports of similar project are not found. Therefore, the EIA reports of other countries were examined.

A silt fence and/or staked hay bales can be installed along the boundary of the work before construction begins to prevent sediment and debris being transported towards downward sloping areas. The silt fence/hay bale barrier should be inspected weekly and after all larger storm events, and repaired if needed.

(12) Waste

The excavated soil will be generated and need to be disposed of properly. The regulations about solid waste management are not yet established so that the excavated soil and construction waste is disposed of at the municipal waste dumping site. Yangon City has two dumping sites (see Section 12.5.7, Volume VI) and the excavated soil will be disposed of at these landfill sites.

The sludge will be generated from WWTP. The average daily amount of wastewater is 49,000 m^3/day and 37 m^3/day of sludge will be generated. This is equivalent to 0.4 % of the total amount of solid waste generated in Yangon City. Till the regulation of sludge disposal is developed, the waste will be disposed at the waste treatment site. The dried sludge can be utilized as fertilizer for agriculture as the heavy metal may not be included in the sludge.

(13) Noise and Vibration

The standards of noise and vibration are not fixed yet in Myanmar. The measurement of the noise and vibration has not been monitored. JICA Urban Plan Study 2012 measured the noise at two locations and it shows the equivalent noise level for one hour was 50 dB(A), the max varied from 47.7 dB(A) to 96.8 dB(A). The route of trunk main has a lot of traffic. The installation of trunk main is done by pipe-jacking method so that the generation of noise is limited to the construction of the shaft. As there are no standards in Myanmar, the standards of IFC are used to regulate the noise generation. Temporary noise pollution due to construction works should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers.

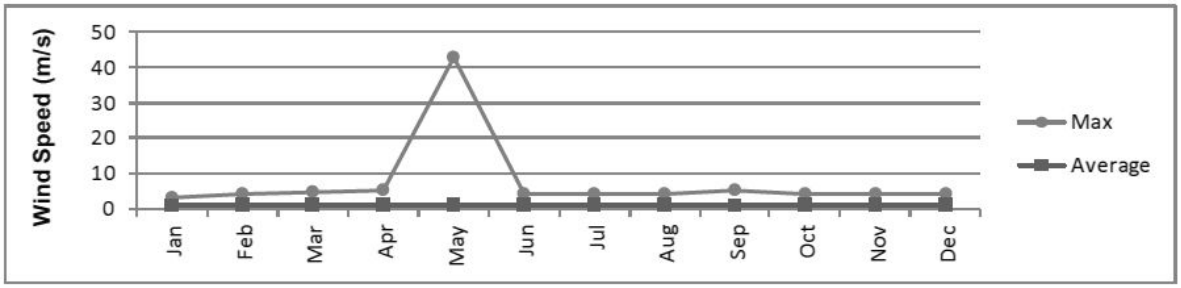
Table 7.6 Noise Level (One hour LA_{eq} (dBA))

Receptor	Daytime (7:00 – 22:00)	Nighttime: (22:00 – 7:00)
Residential / Institutional / Educational	55	45
Industrial / commercial	70	70

Source: FC General Health, and Safety (EHS) Guidelines, April 2007

(14) Odor

The generation of odor may be expected from WWTP if the WWTP is not properly operated. The data on the wind speed and direction in Yangon City was collected. The meteorological data are measured at the Kabayaee Station and according to the data the average wind speed at the station is 1.1 m/s, and the maximum wind speed, 42.8 m/s was observed when the Cyclone Nargis occurred in May 2008. The major wind direction is southwest during summer and rainy season and northeast during the winter.



Source: JICA Urban Plan Study, 2012

Figure 7.4 Wind Speed

The location of WWTP is the southernmost point of Yangon City and the surroundings are occupied by the factories (gas and oil), a freightliner terminal for the car and not the residential area. The residential area is located 700 m away by passing the Pazundaung Creek. The odor may not cause big problems but if necessary, the ventilation and use of deodorant equipment shall be examined during the design stage.

7.3.4 Environmental Evaluation, Mitigation Measures and Cost

Table 7.7 Environmental Evaluation, Mitigation Measures and Cost

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
Social Environment	Involuntary resettlement and land acquisition	C	D	D	D	A land with 1.3 ha for expansion of WWTP is required. The right to use the land belongs to the government and YCDC has requested to transfer the right to YCDC. There is two-storey building in the area. The compensation for the land may not be required and compensation amount for building will be decided by the discussion among the governments.	-	-	-
	Local economies, such as employment, livelihood, etc.	B+	D	B+	D	The increase of employment by the construction can be expected.	-	-	-
	Land use and utilization of local resources	C	D	D	D	As the trunk main will be installed under the road, no impact is expected on land use and utilization of local resources. The expansion area of WWTP is used by the Navy. There is no impact to the general public by land acquisition	-	-	-
	Existing social infrastructures and services	B-	D	B-	D	The trunk main will be constructed by pipe-jacking method so that the impact might be low. The construction of branch sewer will be done by open-cut method and the impacts on traffic might be expected.	The construction schedule should be prepared considering the traffic volume to minimize the impacts on traffic. The traffic authorities should be notified of the planned works in a timely manner so that alternative traffic routes can be formed and the public alerted. The rules of construction work and transportation of the construction materials should be established and the compliance by the driver and workers	Contractor YCDC Traffic police	Contractor

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
							should be controlled by the contractor. Traffic accidents can be avoided by collaborating with the traffic police and posting warning signs and directions to alternative routes. The office which accepts the complaints and demand from the citizens should be established.		
	Cultural heritage	B-	D	D	D	There are heritage buildings in the zone 1. Based on the discussion with Building Department of YCDC and Yangon Heritage Trust, the mitigation measures are not required.	-	-	-
	Hazards (Risk) infectious diseases	B-	D	B-	D	The infectious diseases may increase by the influx of construction worker.	The educational plan to reduce the risk of infectious diseases by influx of the construction workers should be prepared and implemented by the contractor.	Contractor	Contractor
	Accidents	B-	D	B-	D	The increase of traffic may lead the increase of the accidents during construction.	The measures to protect the citizens are described in the item “Existing social infrastructures and services”. The safety considerations to the construction workers should be prepared by the contractor which should meet the requirement of ILO standards to secure the safety of working conditions. The safety training such as wearing working clothes and work shoes, use of temporary toilet, traffic safety and public health should be provided by the contractor.	Contractor YCDC Traffic police	Contractor
Natural Environment	Groundwater	C-	D	D	D	There are 414 wells which are used as the water source and many private wells exist in CDB area. The depth of well is 24 to 146 m. The trunk main will be installed under the road and deepest point of sewers	-	-	-

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
						is 11.7m, so that there is no direct damage on the wells.			
	Landscape	B-	D	B-	D	The landscape gets worse due to the dig up of the road and storage of excavated soil during construction. No impact is expected during operation.	The landscape will be worsening due to the dig up of the road, storage of excavated soil and construction materials. To mitigate, the fence to cover the construction site should be considered. The excavated solid should be removed quickly from the site.	Contractor YCDC	Contractor
Pollution	Air pollution	B-	D	B-	D	The operation of construction machines and other equipment will cause dust to rise and spread throughout the surrounding area during construction. The impact is temporary.	Construction vehicles, machinery and equipment should be in good working condition and well maintained. Dust emissions from piles of soil or any other material during earthwork, excavation and transportation should be controlled by wetting surfaces, using temporary wind breaks and covering truck loads. The office which accepts the complaints and demand from the citizens should be established.	Contractor YCDC	Contractor
	Water pollution	B-	A+	B-	A+	There are 414 wells which are used as the water source and many private wells exist in CDB area. The depth of well is 24 to 146 m. The trunk main will be installed under the road and deepest point of sewers is 11.7m, so that there is no direct damage on the wells. But due to the vibration of construction, the turbid water can be expected during construction period. The wastewater currently discharged into the river will be treated so that the river water quality may be improved.	Prior notice should be sent to the residents near the construction site to inform the temporal impact on turbid water.	Contractor YCDC	Contractor
	Soil pollution	B-	B-	B-	B-	Due to excavation and earthwork, soil erosion, loss of top soil and silting might	A silt fence and/or staked hay bales can be installed at the boundaries of work	Contractor YCDC	Cost of generator is

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
						be expected. The compaction of soil due to vehicle movement, and ground contamination from the spillage of materials such as vehicle fuel, sewage sludge, chemicals might be expected.	before construction begins, to prevent sediment and debris being transported to downward sloping areas. The silt fence/hay bale barrier should be inspected weekly and after all larger storm events, and repaired when needed. During the expansion of WWTP, the existing WWTP shall continue operation so that there will be no discharge of wastewater from the WWTP. The sludge treatment and storage facilities should be provided with the prevention measures for soil contamination and the details will be considered during the detail design. The generator will be installed to be used in case of the power failure.		included in the cost estimation.
	Waste	B-	A-	B-	A-	The excavated soil will be generated. Other construction waste during the construction of pumping station may not be generated. The sludge will be generated from WWTP during operation.	The excavated soil should be disposed of at the waste dumping site and the discussion with DPCC is necessary. The sludge can be utilized as fertilizer in parks and agriculture.	Contractor YCDC (DEWS, DPCC)	Disposal cost of sludge is included in the cost estimation.
	Noise and vibrations	B-	B-	B-	D	Construction machines will cause noise and vibration during construction.	The standards for noise and vibration are not yet established in Myanmar. The standards of IFC (70 dB) shall be applied till the standards will be established. The noise level should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers to keep the ELV set by the regulations. The selection of construction machinery will be examined during detailed design. Before the construction	Contractor YCDC	The detail will be examined in the detail design. Contractor

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
							of distribution pipeline, the notice of the construction schedule should be issued to the houses and buildings along the route to request for the cooperation and understanding. The office which accepts the complaints and demand from the citizens should be established.		
	Offensive odors	D	B-	D	B-	The offensive odor can be expected if the WWTP is not operated properly. If WWTP is operated properly, the odor problem may not occur. The residential area is more than 700 m away from the WWTP so that the impact may not be expected.	WWTP should be operated and maintained properly. If necessary, use of ventilation and deodorant equipment can be examined during design stage.	YCDC Design Consultant	-

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the study progresses).
D: No impact is expected.
Source: JICA Study Team

7.3.5 Monitoring Plan

The monitoring during construction and operational period is necessary. The monitoring form is attached in Appendix G.

Table 7.8 Monitoring Program

Item	Monitoring location	Monitoring item	Frequency	Responsible organization	Budget*
[Construction]					
Noise	− Trunk main route − WWTP	Noise level (max)	Whenever necessary (especially after the complaint and high value)	Contractor	- (contractor should arrange)
Air quality	− Trunk main route − WWTP	NOx、SOx、TSP	Whenever necessary (especially after the complaint and high value)	Contractor	- (contractor should arrange)
Water quality	− Trunk main route	Water level and turbidity of well of each township	Once a month	Contractor	-
Soil quality	− Trunk main route − WWTP	Spilt of oil and wastewater by visual check	Once a month	Contractor	-
Complaints and demand from citizens	− WWTP − YCDC office	Number and contents of complaints/ demand	As needed during construction period.	Contractor YCDC	-
[Operation]					
Noise	− Boundary of WWTP	Noise level (max)	Four times/year	YCDC (DEWS)	Included in O&M cost
Water Quality	− Inlet and outlet	BOD, COD, TSS, T-P, T-N, pH, temperature	Once a week (if necessary, daily)	YCDC (DEWS)	Included in O&M cost
Soil quality	− Trunk main route − WWTP	Spilt of oil and wastewater by visual check	Once a month	YCDC (DEWS)	-

*: personal expenses are not included.

Source: JICA Study Team

7.4 Improvement of Water Quality of Kandawgyi Lake

7.4.1 Analysis of Alternatives

(1) With/Without Project

The wastewater is discharged into the Kandawgyi Lake without treatment, a lot of blue-green algae are generated in the Kandawgyi Lake and the water color and quality is deteriorated. The Kandawgyi Lake is the most famous lake in Yangon City and on average 3,000 people visit the Kandawgyi Lake daily. If any countermeasures are not taken, the water quality and landscape will be worsened and the place for recreation and relaxation of the people will be lost. The details are described in Section 2.3.1.

(2) Alternatives of Treatment

To consider the water quality improvement of Kandawgyi Lake, the alternatives of the treatment method were examined. The methods are (i) intercept the wastewater and treat them in the septic tank near the interceptor, (ii) intercept the wastewater and divert it to drain till the WWTP of this area will be constructed. The detail analysis was conducted in Chapter 2.3.

The phosphorus and nitrogen which cause the eutrophication cannot be removed by the septic tank so the effluent from the septic tank cannot be discharged into Kandawgyi Lake and it should be diverted to the drain. The septic tank to treat the intercepted wastewater (4,100 m^3/day in the dry season in 2011, 4,700 m^3/day in 2025, and 9,600 m^3/day in rainy season) will be the large scale and the large area of land needs to be acquired. The cost for installation of the septic tank will be high.

To intercept and divert the wastewater to the drain will not require the additional land and investment. However, the water quality deterioration may be expected to the discharged drain. The WWTP for Tarmwe and Bahan Townships which are the catchment area of the intercepted drains will be constructed and operated from the year 2028 (see the Table 10.2 of Sewerage and Drainage Master Plan). The intercepted and discharged amount of wastewater is equivalent to 10 % of the capacity of the Drain No.11 to which the wastewater will be discharged and the significant impact may not be expected in terms of water quality and quantity and the impact will be limited till the WWTP will be operated.

(3) Alternatives of drains to which wastewater is discharged.

The intercepted wastewater will be diverted to the drain till the WWTP in C2 sewerage zone will start operating. The drains to which wastewater is discharged was examined from the following view point.

- Discharge by the gravity

- The length of pressure transmission
- Flood occurrence of the drain to which collected wastewater is to be discharged
- The easiness of the construction of the interceptor pipes (width of the road and transportation)

The drain which discharges the lake water by gravity is located in the southwest point and collected wastewater cannot be sent to this point by gravity due to the topographic condition. The drains near the interceptor are No. 11, 12 and 13 and considering the flood situation and route of construction of the pressure transmission, the drain No. 13 was selected.

7.4.2 Scoping and TOR for Environmental and Social Survey

Table 7.9 Scoping and TOR for Environmental and Social Survey

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
Involuntary resettlement and land acquisition	C	D	The area for pumping station is required.	• Confirmation of right • Procedures of land acquisition	• Hearing survey of related organizations • Site survey
Local economies, such as employment, livelihood, etc.	B+	D	The increase of employment by the construction can be expected.	-	-
Land use and utilization of local resources	C	D	The land acquisition for pumping station may affect the land use.	• Confirmation of land use	• Hearing survey of related organizations • Site survey
Social institutions	D	D	The impact on social institution and local decision-making institutions is not expected.	-	-
Existing social infrastructures and services	B-	C	The interceptor will be constructed by open cut method and the traffic disturbance may be expected. The water level might be expected due to the interceptor of the wastewater.	• Situation of infrastructure service • Estimation of the water level	• Hearing survey of related organizations • Site survey
The poor, indigenous & ethnic people, gender and children's right	D	D	No indigenous and ethnic people exist in and around the project site. No impact is expected on gender and children's right.	-	-
Misdistribution of benefits and damages	D	D	The improvement of water quality of Kandawgyi Lake will be beneficial for all citizens.	-	-
Cultural heritage	D	D	There are no heritage buildings near around the Kandawgyi Lake.	-	-
Local conflicts of interest	D	D	The construction and operation of interceptor may not cause the local conflicts of interest.	-	-
Water usage or water rights and	D	D	The construction and operation of interceptor may not cause any	-	-

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
rights of common			impact on water usage, water rights and rights of common.		
Hazards (Risk) infectious diseases	D	D	The impact by the influx of construction worker is not expected as the construction scale is not large.	-	-
Accidents	B-	D	The construction may cause the accidents.	• Confirmation of the traffic along the route	• Site survey
Topography and geographical features	D	D	The scale of facility is not large and no impact is expected.	-	-
Soil erosion	D	D	No impact is expected.	-	-
Groundwater	D	D	The impact on groundwater is not expected by construction and operation of interceptor.	-	-
Hydrological situation	D	C	The wastewater will be diverted to the drain so that the impact might be expected. The drain will be discharged into the river but the amount is small compared with the amount of river water.	• Confirmation of drain	• Site survey
Coastal zone	D	D	No impact is expected.	-	-
Protected area	D	D	No protected area in the project site.	-	-
Flora, fauna and biodiversity	D	D	The plants and animals included in the Red List of IUCN habits in the forest so that the impact is not expected.	-	-
Meteorology	D	D	No impact is expected as the scale of facility is not large.	-	-
Landscape	B-	C	The landscape gets worse due to the dig up of the road and storage of excavated soil during construction. The wastewater discharged into the Kandawgyi Lake will be intercepted so that the water level of the Lake will be decreased and the landscape will be worsened.	• Change of the water level	• Analysis of the water level
Air pollution	B-	D	The operation of construction machines and other equipment will cause dust to rise and spread throughout the surrounding area during construction. The impact is temporary.	• Air quality standards • Air quality of the site	• Hearing from the related organization
Water pollution	D	A+ C	The water quality of the lake will be improved by interceptor. The wastewater diverted to the drain might worsen the water quality of drain.	• Water quality of drain	• Site visit
Soil pollution	D	D	The soil contamination may not be expected.	-	-
Waste	B-	D	The spoil will be generated during installation of pipelines.	• Waste management regulations	• Hearing survey of related organizations

Item	Evaluation		Reason	Survey Item	Survey Method
	P/C	O			
				• Disposal method of construction waste • Situation of waste disposal sites	• Site survey
Noise and vibrations	B-	D	Construction machines will cause noise and vibration during construction. The noise and vibration may not be expected from facilities during operation.	• Noise standards	• Hearing from the related organization
Ground subsidence	D	D	No intake of groundwater is planned so that no ground subsidence.	-	-
Offensive odors	D	B-/ B+	The odor may occur at the location where the diverted wastewater will be discharged. The odor may be decreased by the Kandawgyi Lake.	• Situation of the discharged point	• Site survey
Bottom sediment	D	D	No impact is expected.	-	-
Global warming	D	D	No impact is expected.	-	-

P: Planning, C: Construction, O: Operation
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the study progresses).
D: No impact is expected.
Source: JICA Study Team

7.4.3 Results of the Environmental and Social Surveys

(1) Involuntary Resettlement / Land Acquisition

The location for pumping station is required to send the intercepted wastewater to the drain. The required area is around 160 m^2 and the area is selected within the YCDC area (see the figure below). The location belongs to the YCDC and no land acquisition is required.

Source: JICA Study Team

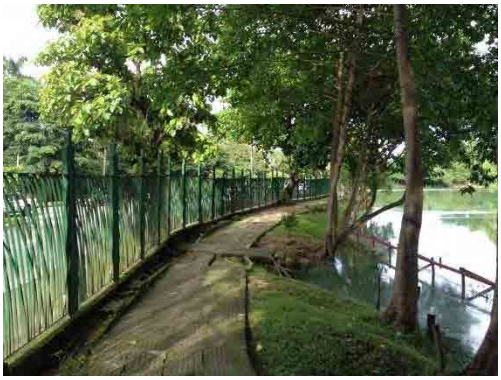
Figure 7.5 Proposed Site for Pumping Station

(2) Land use and utilization of local resources

As mentioned above, the proposed site for pumping station belongs to YCDC and the land acquisition is not required.

(3) Existing social infrastructures and services

The route of interceptor is along the Nat Mauk Road. The interceptor will be installed within Kandawgyi Lake but if enough location cannot be secured, the interceptor will be installed under the road. The road has two lanes for both side and the road is surrounding the lake. This road is not connected to the main road so that large impact may not be expected during pipe installation. The road of U Tun Myat has one lane for both sides so the impact might be large. However, the unpaved road is passing along the road and the interruption can be mitigated.



Source: JICA Study Team

Figure 7.6 Road within the Park

The Kandawgyi Lake is the recreation and relaxation place for the citizens. The wastewater discharged into the Lake will be intercepted and the water level in lake might reduce. The level of the impact is analyzed in the chapter (5) landscape.

(4) Accident

Same as Section 7.3.3 (6).

(5) Hydrological Situation

The capacity of drain No. 13 where the wastewater diverted from the Kandawgyi Lake will be discharged is 20 m^3/s (1.67 million m^3/day). The wastewater discharged into the drain is 4,000 m^3/day and it is equivalent to 0.24 % of the capacity of the drain. The impact is very small and not expected.

(6) Landscape

The impact during construction is the same as Section 7.3.3 (8).

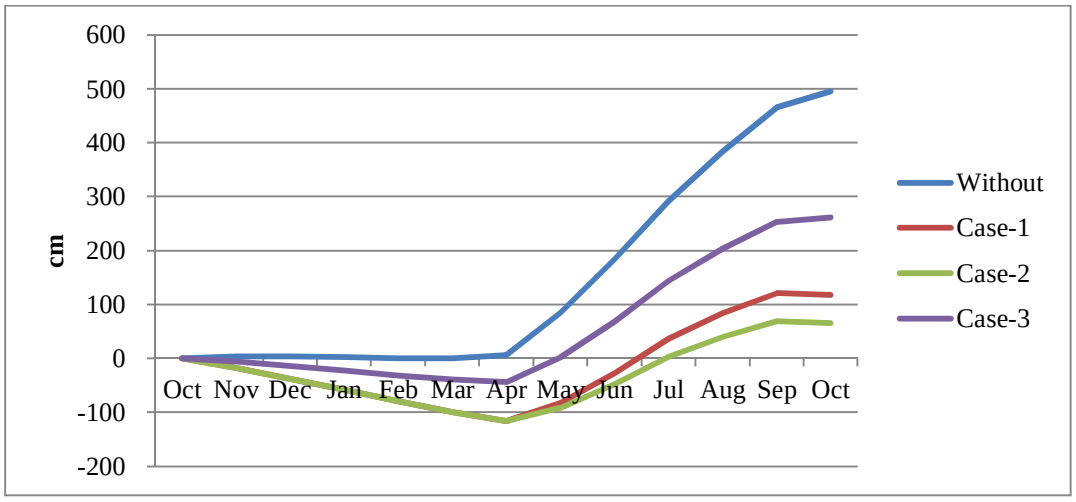
By the implementation of the project, the eutrophication will be decreased and the water quality and landscape will be improved. However, the rainwater and wastewater into the Kandawgyi Lake will be diverted so that the water level of Kandawgyi Lake during the dry season may reduce. The degree of water level decrease was simulated and the result is shown in the figure below.

Table 7.10 Prerequisite of Simulation

	Precipitation*	Runoff coefficient**	Evaporation**	Infiltration**
Without	Average of 2000～2009	0.6	5 mm/day	2mm/day
Case-1	Average of 2000～2009	0.6	5 mm/day	2mm/day
Case-2	Average of 2000～2009	0.45	5 mm/day	2mm/day
Case-3	Average of 2000～2009	0.6	2 mm/day	1mm/day

* Statistical Yearbook 2010, Central Statistical Organization
**The number of runoff coefficient, evaporation and infiltration is used as the figures in the neighborhood countries.
Source: JICA Study Team

Considering the water level to be maximum at the end of the rainy season (October), the increase and decrease in the water level after October is shown in the figure below.



Source: JICA Study Team

Figure 7.7 Simulation Results of the Water Level of Kandawgyi Lake

Without the project, the water level may not decrease but the water quality will be deteriorated. The maximum water level decrease will be in the Case 1 and Case 2 and the water level is decreased to 116 cm at the end of the dry season. The water depth of the Kandawgyi Lake is around three meters so that the impact on landscape might be significant.

The pipeline between Inya Lake to Kandawgyi Lake was installed in the old time and the pipe is used during the water festival in April to improve the water quality of Kandawgyi Lake. To prevent lowering of the water level, the necessity days to transmit the water from the Inya Lake will be eight days in a month on average. The lake area of Inya Lake is around six times of the Kandawgyi Lake so that the transmission of the water from Inya Lake to Kandawgyi Lake will decrease 20 cm of the water level of Inya Lake.

(7) Water Pollution

The water quality might be worsened by the discharge of wastewater and rainwater which is diverted

from Kandawgyi Lake. The water quality of the drain No. 13 is 224 mg/l of COD and this is almost same with the domestic wastewater. By this reason, the flow of the drain No. 13 will be increased but the water quality will be the same.

(8) Air Pollution

Same as the Section 7.3.3 (9).

(9) Waste

The excavated soil will be generated and need to be disposed of properly. The regulations about solid waste management are not yet established so that the excavated soil and construction waste is disposed of at the municipal waste dumping site. Yangon City has two dumping sites (see Section 12.5.7, Volume VI) and the excavated soil will be disposed of at these landfill sites. The waste generated from the dredging of the bottom sediment will be disposed of at the existing waste disposal site.

(10) Noise and Vibration

The standards for noise and vibration are not fixed yet in Myanmar. The measurement of the noise and vibration has not been monitored. Interceptor will be constructed along Nat Mauk, U Tun Myat and Ba Nyar Dala Roads. Nat Mauk Road is located in an area where embassies, hotels and residents are located. This Road has two lanes on both sides. Tun Myat Road has one lane on each side, and is located in an area where a hospital and residents are located. Ba Nyar Dala Road has three lanes on both sides, and is located in a commercial area. As there are no standards in Myanmar, the standards of IFC are used to regulate the noise generation. Temporary noise pollution due to construction works should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers.

Table 7.11 Noise Level (One hour LAeq (dBA))

Receptor	Daytime (7:00 – 22:00)	Nighttime: (22:00 – 7:00)
Residential / Institutional / Educational	55	45
Industrial / commercial	70	70

Source: FC General Health, and Safety (EHS) Guidelines, April 2007

7.4.4 Environmental Evaluation, Mitigation Measures and Cost

Table 7.12 Environmental Evaluation, Mitigation Measures and Cost

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
Social Environment	Involuntary resettlement and land acquisition	C	D	D	D	The area for pumping station is necessary but the land belongs to YCDC and no land acquisition is required.	-	-	-
	Local economies, such as employment, livelihood, etc.	B+	D	B+	D	The required land belongs to YCDC and the land is used for park. The increase of employment by the construction can be expected.	-	-	-
	Land use and utilization of local resources	C	D	D	D	As the interceptor will be installed under the road, no impact is expected on land use and utilization of local resources.	-	-	-
	Existing social infrastructures and services	B-	C	B-	B-	The construction of interceptor along the Kandawgyi Lake may cause the traffic interruption. The impact on water level of Kandawgyi Lake is expected. The impact and mitigation measures are described in "Landscape".	The construction schedule should be prepared considering the traffic volume to minimize the impacts on traffic. The traffic authorities should be notified of the planned works in a timely manner so that alternative traffic routes can be formed and the public alerted. The rules of construction work and transportation of the construction materials should be established and the compliance by the driver and workers should be controlled by the contractor. Traffic accidents can be avoided by collaborating with the traffic police and posting warning signs and directions to alternative routes. The office which accepts the	Contractor YCDC Traffic police	Contractor

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
							complaints and demand from the citizens should be established.		
	Accidents	B-	D	B-	D	The increase of traffic may lead the increase of the accidents during construction.	The measures to protect the citizens are described in the item "Existing social infrastructures and services". The safety considerations to the construction workers should be prepared by the contractor which should meet the requirement of ILO standards to secure the safety of working conditions. The safety training such as wearing working clothes and work shoes, use of temporary toilet, traffic safety and public health should be provided by the contractor.	Contractor YCDC Traffic police	Contractor
Natural Environment	Hydrological situation	D	C	D	D	The capacity of drain No. 13 where the wastewater diverted from the Kandawgyi Lake will be discharged is 20 m^3/s (1.67 million m^3/day). The wastewater discharged into the drain is 4,000 m^3/day and it is equivalent to 0.24 % of the capacity of the drain. The impact is very small and not expected.	-	-	-

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
	Landscape	B-	C	B-	B-	The landscape gets worse due to the dig up of the road and storage of excavated soil during construction. No impact is expected during operation. By the interception of the wastewater flowing into the Kandawgyi Lake, the water level of the Lake will decrease during the dry seasons.	The landscape will be worsening due to the dig up of the road, storage of excavated soil and construction materials. To mitigate, the fence to cover the construction site should be considered. The excavated solid should be removed quickly from the site. To mitigate the lowering of water level in Kandawgyi Lake, the water can be transmitted from Inya Lake for seven or eight days in a month during the dry season. This may not cause the impact on Inya Lake.	Contractor YCDC	Contractor
Pollution	Air pollution	B-	D	B-	D	The operation of construction machines and other equipment will cause dust to rise and spread throughout the surrounding area during construction. The impact is temporary.	Construction vehicles, machinery and equipment should be in good working condition and well maintained. Dust emissions from piles of soil or any other material during earthwork, excavation and transportation should be controlled by wetting surfaces, using temporary wind breaks and covering truck loads. The office which accepts the complaints and demand from the citizens should be established.	Contractor YCDC	Contractor
	Waste	B-	D	B-	D	The excavated soil will be generated. Other construction waste by the construction of pumping station may not be generated.	The excavated soil should be disposed of at the waste dumping site.	Contractor YCDC	Disposal cost is included in the cost estimation.
	Noise and vibrations	B-	D	B-	D	Construction machines will cause noise and vibration during construction.	The standards for noise and vibration are not yet established in Myanmar. The standards of IFC (70 dB) shall be applied till the standards will be	Contractor YCDC	The detail will be examined in the

Category	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization	Cost
		P/C	O	P/C	O				
							established. The noise level should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers to keep the ELV set by the regulations. The selection of construction machinery will be examined during detailed design. Before the construction of distribution pipeline, the notice of the construction schedule should be issued to the houses and buildings along the route to request their cooperation and understanding. The office which accepts the complaints and demand from the citizens should be established.		Detail design. Contractor
	Offensive odors	D	B-/ B+	D	B-/ B+	The wastewater intercepted may not generate the odor because the interceptor is installed underground. The drainage to which the intercepted wastewater is discharged may emit increased odor as the amount of wastewater is increased by 10 %, However, the drain become underground soon after the discharge point so that the impact is not large. The odor from the Kandawgyi Lake will be improved.	The dredging of the drain should be implemented regularly not to keep the wastewater stagnant for long period.	YCDC	YCDC

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the study progresses).
D: No impact is expected.
Source: JICA Study Team

7.4.5 Monitoring Plan

The monitoring during construction and operation period is necessary. The monitoring form is attached in Appendix G.

Table 7.13 Monitoring Program

Item	Monitoring location	Monitoring item	Frequency	Responsible organization	Budget*
[Construction]					
Noise	− Route of interceptor	Noise level (max)	Whenever necessary (especially after the complaint and high value)	Contractor	- (contractor should arrange)
Air quality	− Route of interceptor	NOx、SOx、PM10	Whenever necessary (especially after the complaint and high value)	Contractor	- (contractor should arrange)
Complaints and demand from citizens	− Route of interceptor	Number and contents of complaints/ demand	As needed during construction period.	Contractor YCDC	-
[Operation]					
Water level of Kandawgyi Lake	− Kandawgyi Lake	Water level	Once a month during dry season	YCDC (Playground, Park & Garden Dept.)	-

*: personal expenses are not included.

Source: JICA Study Team

7.5 Stakeholder Meeting

The public consultation seminar was organized on 17 July 2013. The objectives are as follows.

- To incorporate stakeholder opinions into decision-making processes regarding environmental and social considerations (basic principles of JICA Guidelines)
- To disclose the results of the project including facility planning, tariff setting, and environmental and social impacts
- To obtain the comments and opinions from stakeholders

The agenda of the public consultation seminar is as follows.

Date: 17 July (Wednesday), 2013

Time: 14:00 p.m. to 16:30 p.m.

Venue: Kandawgyi Palace Hotel

Time	Agenda
13:45 – 14:00	Registration
(1) Opening Session	
14:00- 14:10	Opening Speech (Secretary of YCDC) Opening Remarks (Senior Representative of JICA Myanmar Office)
14:10- 14:30	Photo session Coffee Break
(2) Presentation on the Priority Projects for Water Supply, Sewerage and Drainage System	
14:30- 14:50	Outline of the JICA Project Components of Priority Projects for Water Supply
14:50-15:00	Priority Project for Sewerage System and Improvement of Kandawgyi Lake
15:00- 15:20	Tariff Setting
15:20- 16:00	Results of Environmental and Social Impacts and mitigation measures
16:00- 16:30	Questions and Answers
(3) Closing Session	
16:30	Closing Remarks (YCDC)
	Announcement for closing seminar

More than 130 participants attended the meeting comprising the following. The project affected people from each townships of zone 1, 7 and 8 were invited.

- Yangon regional government: 2
- Professors and advisors: 3
- Donors: 7
- Representatives of townships: 47
- NGO: 6
- Media: 25
- YCDC: 34
- JICA Study Team: 12

There were a few questions and comments.

- The explanation about the tariff should be announced to the public by YCDC and discussions should be held in future.
- The tariff for sewerage system on public is a little bit early. It is better to start from hotel, restaurant, condominium, industrial zone, etc. as a test case.

The Minutes of Meeting is attached in Appendix G.

CHAPTER 8. CONCLUSION AND RECOMMENDATIONS

Feasibility study was conducted on the first priority sewerage project, i.e. improvement of the sewerage system in C1 sewerage zone, and on the water quality improvement in Kandawgyi Lake project which was requested by YCDC. C1 sewerage zone is included in CBD, and bustling area of Yangon city where central and local government buildings and high rise commercial buildings such as high class hotels and shopping centers exist. On the other hand, Kandawgyi Lake is a small lake located in the center of the city and provides citizens of Yangon with valuable recreation area together with surrounding park and restaurants.

Kandawgyi Lake has been eutrophicated due to wastewater inflow from surrounding areas and restaurants and the blue-green algae bloom in lake has resulted in emission of foul smell. Water quality in the lake will be worsened unless countermeasures are taken resulting in loss of valuable asset. In order to control eutrophication of the lake, interception of wastewater inflow and at the same time removal of nutrients already accumulated in the lake is essentially required. Provision of sewerage system is the ultimate solution for purification of lake water. However, it requires large amount of investment and several years to provide sewerage system. Therefore, temporary measures such as interceptor sewer facility and dredging are planned in the study. It takes a few years to realize effects of the project, nutrients level will be lowered causing reduction in eutrophication level and blooming of blue-green algae will be prevented.

Interceptor sewer facility is proposed for improvement of water quality in Kandawgyi Lake. However, it is clarified that water level in the lake would be lowered in dry season when this system is in operation. Transmission of water from Inya Lake and/or keeping higher water level in rainy season should be considered. In case interceptor sewer facility is constructed, water level control plan should be considered in advance.

C1 sewerage zone is included in the existing sewerage service area. However, the existing system has serious problems and does not function properly. Firstly, the existing system collects only black water and gray water is discharged to drains and finally to the river without any treatment. Ejector system which collects wastewater was constructed in 19th century and has been used until now with occasional minor repairs. Corrosion of the force main is about a matter of concern, but investigation is difficult to find real conditions. Procurement of spare parts is difficult because of obsolete system. Taking into account increased future wastewater flow, it is determined that the existing ejector system is abandoned and new sewer network is to be constructed because rehabilitation of the existing system is uneconomical. On the other hand, the existing wastewater treatment plant is relatively new, completed in 2005, and investigation revealed that most of civil structures can be utilized in future. Therefore, existing facilities should be used as much as possible and new facility which meets

shortage in the capacity is to be constructed. When entire planned sewerage facilities are completed all wastewater generated in C1 sewerage zone is collected and treated resulting in improvement of citizens living conditions and water quality in the river.

Construction cost of sewerage facilities in C1 sewerage zone is estimated to be 95 million USD, and total project cost is 151 million USD. This estimation was made based on introduction of low interest loan and includes tax and duty levied in Myanmar. The site for WWTP is to be expanded, however land acquisition cost is not included because the site for expansion is government property. Operation and maintenance cost is estimated to be 1.1 million USD/year. It takes 68 months (5 years and 8 months) for construction of the sewerage system, and total project period including detailed design, selections of consultant and contractor, technology transfer and so on is estimated to be 117 months (9 years and 9 months). Total cost of Kandawgyi Lake water quality improvement is estimated to be 1.4 million USD which is only for interceptor sewer facility since dredging is carried out by YCDC. Operation and maintenance cost is estimated to be 1.8000 USD/year. It takes 1.5 year from commencement of detailed design to complete construction.

Project evaluation for C1 sewerage zone shows that EIRR is 6.25% and FIRR 0.98%. The EIRR for Kandawgyi Lake Project is 18% and the FIRR is 1.6%. The tariff for sewerage is not levied to the customer. However, it is highly desired to introduce the tariff at the earliest point in view of long-term sustainability of sewerage operation. If the government is willing to cover the investment cost for C1 sewerage zone, the required tariffs to pay off the operation and maintenance costs are USD 0.07/m^3 for household and USD 0.09/m^3 for commercial customers. On the other hand, if all the investment is to be recovered by tariff itself over 40 years after commissioning, the required tariffs are USD 0.23/m^3 for household and USD 0.29/m^3 for commercial customers. Given the economic externality that sewerage projects impart to the maintenance of social environment, advanced countries also provide subsidies to the development of sewerage system. If the government provides money for half of the investment and the rest is left for the tariff to recover over 40 years, the required tariffs are USD 0.15/m^3 for household and USD 0.18/m^3 for the commercial customers.

Sanitation division of DEWS is in charge of operation and maintenance of the existing sewerage system and approval of on-site treatment systems. However the division does not have any experience of planning and implementation of full scale sewerage system development. Further, legal and institutional system for sewerage system development is not provided sufficiently. Therefore, institutional strengthening of YCDC together with cooperation with the central government for development of legal system should be carried out. Low interest loan such as Japanese Yen Loan should be introduced for development of sewerage system in C1 sewerage zone taking into account magnitude of required amount of investment. Consultation with the central government in this regard is recommended and necessary actions should be taken. It takes some time to realize loan proceedings,

earliest action is desirable. Moreover, for development of sewerage system, at early stage of development in particular, subsidy from the central government is considered to be indispensable. YCDC should appeal to the central government to establish subsidy system. In addition, appropriateness of sewerage tariff from beneficiary should be confirmed, its collection system should be investigated and policy for these should be determined. It is recommended that YCDC should request JICA's assistance for establishment of legal system, institutional strengthening and introduction of sewerage tariff.

Project for the Improvement of
Water Supply, Sewerage and Drainage System
in Yangon City

Final Report

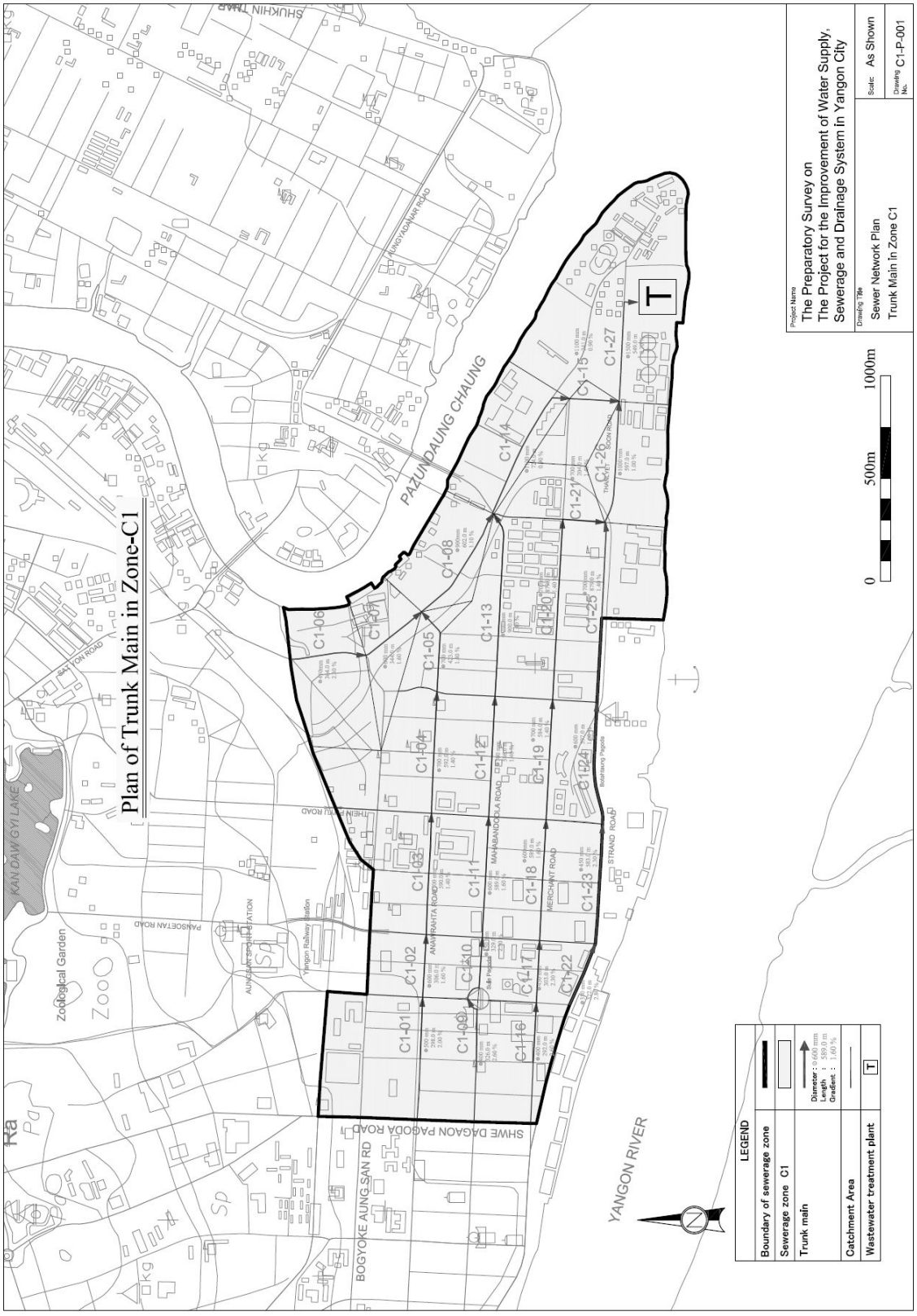
Volume VII
Sewerage and Drainage System Feasibility Study

Appendix

Appendix

Table of Contents

A FLOW CALCULATION OF TRUNK MAIN IN C1 SEWERAGE ZONE



Source: JICA Study Team

Figure A.1 General Layout Plan of Trunk Mains in C1Sewerage Zone

Flow Calculation C1

p 1

Wastewater unit flow per ha: 0.00238672m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff					Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha		Coversion Area		Stormwater		Population		Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
								Each	Total			Each	Total												
		ha	ha	m	m	m3/sec/ha		ha	ha	m3/sec				m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
C1-1		2880	2880	298	299									00688			00688	⊙ 500	200	0860	01689	520 580	1658 1021	300 424	
C1-2		840	3720	306	605									00888			00888	⊙ 600	160	0869	02456	580 710	0921 0369	423 608	
C1-3		1960	5680	590	1196									01356			01356	⊙ 700	140	0900	03465	710 400	0269 -0659	607 390	
C1-4		2240	7920	592	1789									01891			01891	⊙ 700	140	0900	03465	400 420	-0679 -1607	392 305	
C1-5	C1-8	630	8550	423	2212									02041			02041	⊙ 700	140	0900	03465	420 420	-1627 -2502	307 574	
C1-6		2450	2450	364	364									00585			00585	⊙ 450	230	0860	01367	480 490	1312 0413	300 400	
C1-7		1430	3880	344	709									00926			00926	⊙ 600	160	0869	02456	490 420	0263 -0349	399 390	
C1-8	C 1-14	1820	14250	602	2814									03402			03402	⊙ 900	110	0944	06004	420 430	-2502 -3287	573 661	
C1-9		1620	1620	326	326									00387			00387	⊙ 400	260	0845	01062	460 480	1665 0757	250 361	
C 1-10		830	2450	329	656									00585			00585	⊙ 450	230	0860	01367	480 520	0707 -0109	361 482	
C 1-11		1640	4090	589	1245									00976			00976	⊙ 600	160	0869	02456	520 400	-0259 -1301	481 465	
C 1-12		1660	5750	586	1831									01373			01373	⊙ 700	140	0900	03465	400 390	-1401 -2323	464 347	
C 1-13		1570	7320	900	2732									01747			01747	⊙ 700	140	0900	03465	390 430	-2343 -3783	349 733	
C 1-14		2160	23730	724	3539									05665			05665	⊙ 1100	090	0976	09274	430 360	-4183 -4914	730 733	

Table A.1 Flow Calculation of Trunk Mains in C1 Sewerage zone (1/2)

Flow Calculation C1

P 2

Wastewater unit flow per ha: 0.00238672m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater			Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
C 1-15	C 1-27	970	24700	241	3780							06896			06896	⊙ 1100	090	0976	09274	360 390	-4934 -5172	735 788	
C 1-16		1660	1660	292	292							00396			00396	⊙ 400	260	0845	01062	420 450	1265 0466	250 360	
C 1-17		850	2510	303	595							00599			00599	⊙ 450	230	0860	01367	450 580	0116 -0340	360 565	
C 1-18		1650	4160	589	1184							00993			00993	⊙ 600	160	0869	02456	580 420	-0490 -1532	564 508	
C 1-19		1650	5810	584	1769							01387			01387	⊙ 700	140	0900	03465	420 410	-1632 -2549	307 389	
C 1-20		2500	8310	879	2649							01984			01984	⊙ 700	140	0900	03465	410 420	-2569 -3962	591 740	
C 1-21	C 1-26	1120	9430	204	2853							02251			02251	⊙ 700	140	0900	03465	420 450	-3982 -4507	742 805	
C 1-22		1200	1200	322	323							00286			00286	⊙ 350	280	0802	00772	430 540	1418 0433	250 459	
C 1-23		1630	2830	583	906							00676			00676	⊙ 450	230	0860	01367	540 490	0333 -0111	458 352	
C 1-24		1370	4200	597	1504							01003			01003	⊙ 600	160	0869	02456	490 460	-1261 -2315	551 627	
C 1-25		3280	7480	879	2383							01786			01786	⊙ 700	140	0900	03465	460 450	-2415 -3808	626 755	
C 1-26		1980	18890	597	3451							04509			04509	⊙ 1000	100	0965	07582	450 390	-4607 -5806	803 812	
C 1-27		6310	49900	549	4329							11912			11912	⊙ 1500	070	1058	18702	390 400	-5806 -6250	809 864	

Table A.1 Flow Calculation of Trunk Mains in C1 Sewerage zone (2/2)

B DESIGN CALCULATION OF C1 WWTP

Table B.1 Design Calculation of C1 WWTP (1/16)

1 BASIC CONDITIONS

1-1 Basic Items

(1) Name : **C1 WWTP**

(2) Land Area : Approximately xxxx ha

(3) Ground Level (Elevatio : + 4.50 m

(4) Inlet Pipe Invert Level : - 6.80 m

(5) Pipe Diameter : 1,500 mm

(6) Land Use : —

(7) Collection System : ~~Combined System~~ Separate System

(8) Treatment Process : Conventional Activated Sludge Process

(9) Effluent Point : Yangon River

(10) Water Level at the Effluent Poir :
High water leve = 3.70 m
Low water level = — m

(11) Target Year : 2020 (F/S Stage)
2040 (M/P Stage)

1-2 Service Area and Design Population

(1) Service Area : 499 ha

(2) Design Population

Item		Year 2020	Year 2040
Design Population	person	-	178,000

Table B.1 Design Calculation of C1 WWTP (2/16)

1-3 Design Sewage Flow

(Year 2020)

Item	m^3/day	m^3/hr	m^3/min	m^3/sec
Maximum Daily Flow		0.0	0.00	0.000
Maximum Hourly Flow	0	0.0	0.00	0.000

(Year 2040)

Item	m^3/day	m^3/hr	m^3/min	m^3/sec
Maximum Daily Flow	70,200	2,925.0	48.75	0.813
Maximum Hourly Flow	102,900	4,287.5	71.46	1.191

1-4 Design Sewage Quality

Item	BOD	SS	T-N	Coli-group	Oil&Greese
	(mg/l)	(mg/l)	(mg/l)	(MPN/cm^3)	(mg/l)
Influent	200	180	-	-	-
Effluent	20	30	-	3,000	5

1-5 Process Flow Diagram

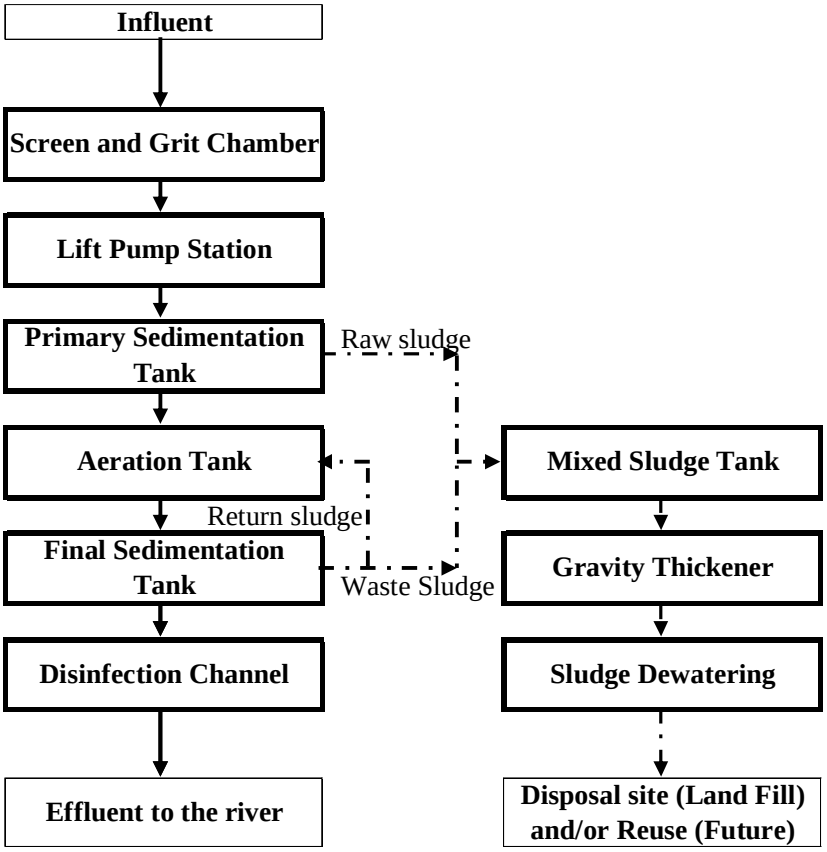


Table B.1 Design Calculation of C1 WWTP (3/16)

1.6 Design Criteria

ITEMS		UNIT	Formula or Value	Application
1	Grit Chamber (For Maximum Hourly Flow)			
(1)	Hydraulic Load	$m^3/m^2/day$	1,800	1,800
(2)	Average Velocity	m/sec	0.3	0.3
2	Primary Sedimentation Tank (For Maximum Daily Flow)			
(1)	Hydraulic Load	$m^3/m^2/day$	35.0-70.0	50
(2)	Settling Time (Ref.)	hour	1.5	1.5
(3)	Water Depth	m	2.5-4.0	3.5
(4)	Weir Loading	$m^3/m/day$	250	250
3	Aeration Tank (For Maximum Daily Flow)			
(1)	Hydraulic Retention Time (HRT)	hour	6 - 8	6.0
(2)	MLSS Concentration	mg/l	1,500 -2,000	2,000
(3)	BOD-SS Load (Reference only)	kg/kg/day	0.2 - 0.4	-
4	Final Sedimentation Tank (For Maximum Daily Flow)			
(1)	Hydraulic Load	$m^3/m^2/day$	20.0-30.0	25
(2)	Settling Time (Ref.)	hour	3.0-4.0	-
(3)	Water Depth	m	2.5-4.0	3.5
(4)	Weir Loading	$m^3/m/day$	150	150
5	Disinfection Tank (For Maximum Daily Flow)			
(1)	Retention (Chlorination) Time	min	15	15
6	Gravity Thickener (For Maximum Daily Flow)			
(1)	Solids Loading	$kg/m^2/day$	60-90	75
(2)	Water Depth	m		4.0

Table B.1 Design Calculation of C1 WWTP (4/16)

2 CAPACITY CALCULATION

2-1 Grit Chamber

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Parallel Flow Type		
Design Sewage Flow	Q1	m^3/day			102,900
(Maximum Hourly Flow)	Q2	m^3/sec			1.191
Water Surface Load	WSL	m^3/m^2/day			1,800
Required Surface Area	RSA	m^2	Q1/WSL		57.17
Basin Number	BN	basin			4
Average Velocity	AV	m/sec			0.3
Depth	H	m			0.9
Width	W1	m	Q2/(AV×H×BN)		1.10
Therefore	W2	m			1.1
Length	L1	m	RSA/(W2×BN)		12.99
Therefore	L2	m			13.0
Dimension (Width)	W	m			**1.1**
(Jength)	L	m	L2		**13.0**
(Depth)	H	m	H		**0.90**
(Basin Number)	N	basin			**4**
(Check)					
Water Surface Load		m^3/m^2/day	Q1/(W×L×N)		1,799
Average Velocity		m/sec	Q2/(W×H×N)		0.301

2-2 Lift Pump Station

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Vertical shaft Volute type mixed flow pump		
Design Sewage Flow	Q1	m^3/min	Peak Flow		71.46
Pump Unit -1 Number	UN1	unit	including 1 stand-by		4
Discharge per Unit	DU1	m^3/min	Q1/UN1		23.82
Pump Diameter(V=1.5~3.0m/s	D1	mm	$146\times(DU1/1.5\sim3.0)^{0.5}$		411 ～582
Therefore	D1	mm			500

Table B.1 Design Calculation of C1 WWTP (5/16)

2-3 Primary Sedimentation Tank

(1) Existing

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Parallel Flow Type		
Design Sewage Flow	Q1	m^3/day			20,000
(Maximum Daily Flow)	Q2	m^3/hr			833.3
Basin Number	BN	basin			2
Hydraulic Load	HL	m^3/m^2/day			50.0
Required Surface Area	A1	m^2	Q1/HL		400
	A2	m^2/basin	A1/BN		200
Width	W1	m	3.0m~4.0m, Max5.0m		7.3
Length	L1	m	A2/W1		27.40
Therefore	L2	m			27.4
Water Depth	WD	m			3.7
Overflow Weir Load	OWL	m^3/m/day			250
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		40.00
Therefore	WL2	m/basin			40.0
Dimension (Width)	W	m			**7.3**
(Depth)	D	m			**3.7**
(Length)	L	m			**27.4**
(Basin Number)	N	basin			**2**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	Q1/(N×W×L)		50.00
Retention(Settling) Time	T	hour	(N×W×D×L)/Q2		1.75
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		250.00

Table B.1 Design Calculation of C1 WWTP (6/16)

Continuing Primary Sedimentation Tank
(2) Proposed-1

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Parallel Flow Type		
Design Sewage Flow	Q1	m^3/day			25,400
(Maximum Daily Flow)	Q2	m^3/hr			1,058.3
Basin Number	BN	basin			6
Hydraulic Load	HL	m^3/m^2/day			50.0
Required Surface Area	A1	m^2	Q1/HL		508
	A2	m^2/basin	A1/BN		85
Width	W1	m	3.0m~4.0m, Max5.0m		3.5
Length	L1	m	A2/W1		24.19
Therefore	L2	m			24.0
Water Depth	WD	m			3.0
Overflow Weir Load	OWL	m^3/m/day			250
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		16.93
Therefore	WL2	m/basin			17.0
Dimension (Width)	W	m			**3.5**
(Depth)	D	m			**3.0**
(Length)	L	m			**24.0**
(Basin Number)	N	basin			**6**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	Q1/(N×W×L)		50.40
Retention(Settling) Time	T	hour	(N×W×D×L)/Q2		1.43
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		249.02

Table B.1 Design Calculation of C1 WWTP (7/16)

Continuing Primary Sedimentation Tank
(3) Proposed-2

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Parallel Flow Type		
Design Sewage Flow	Q1	m^3/day			24,800
(Maximum Daily Flow)	Q2	m^3/hr			1,033.3
Basin Number	BN	basin			4
Hydraulic Load	HL	m^3/m^2/day			50.0
Required Surface Area	A1	m^2	Q1/HL		496
	A2	m^2/basin	A1/BN		124
Width	W1	m	3.0m~4.0m, Max5.0m		5.8
Length	L1	m	A2/W1		21.38
Therefore	L2	m			21.5
Water Depth	WD	m			3.0
Overflow Weir Load	OWL	m^3/m/day			250
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		24.80
Therefore	WL2	m/basin			25.0
Dimension (Width)	W	m			**5.8**
(Depth)	D	m			**3.0**
(Length)	L	m			**21.5**
(Basin Number)	N	basin			**4**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	Q1/(N×W×L)		49.72
Retention(Settling) Time	T	hour	(N×W×D×L)/Q2		1.45
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		248.00

Table B.1 Design Calculation of C1 WWTP (8/16)

2-4 Aeration Tank

(1) Existing

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Multi-tank Complete mixing Type		
Design Sewage Flow	Q1	m^3/day			45,400
(Maximum Daily Flow)	Q2	m^3/hr			1,891.7
Hydraulic Retention Time	HRT	hr			6.0
Basin Number	BN	basin			2
Required Volume per basin	RV	m^3/basin	Q2×RT/BN		5,675
Width	W	m	1~2H		18.6
Water Depth	H	m	4.0m~6.0m		4.1
Length	L1	m	RV/(W×H)		74.4
Therefore	L2	m			74.4
Dimension (Width)	W	m			**18.6**
(Depth)	H	m			**4.1**
(Length)	L	m			**74.4**
(Basin Number)	N	basin			**2**
(Check)					
Hydraulic Retention Time	HRT	hour	W×H×L×N/Q2		6.0
BOD-SS load	BSS_L	kgBOD/kgSS/d	(Q1×BODin)/(W×H×L×N×Xa)		0.24
BOD_{in} : Inflow BOD Concentration			120 mg/L (Removal Rate in PST : 40%)		
Xa : MLSS Concentration			2,000 mg/L		
Aerobic Sludge Retention Time	ASRT	day	HRT/24×Xa / (a×S-BODin + b×SSin - c×HRT/24×Xa) =		4.738
$S\text{-}BOD_{in}$: Inflow S-BOD Concentration			80 mg/L (S-BOD[Solved BOD]=BODin×0.67		
SS_{in} : Inflow SS Concentration			90 mg/L (Removal Rate in PST : 50%)		
a : Sludge converting ratio of solved BOI			0.5 mgMLSS/mgBOD (0.4~0.6)		
b : Sludge converting ratio of SS			0.95 mgMLSS/mgSS (0.9~1.0)		
c : Sludge reduction ratio caused by endogenous respiration			0.04 (1/day)(0.03~0.05)		
Effluent Quality (C-BOD)	EQ	mg/L	$10.42\times A\text{-}SRT^{(-0.519)}$ (15~20℃)		4.648
Water Temperature			20 ℃		
Effluent Water Quality (C=BOD Maximum)			EQ×3 20mg/l >		14
					-OK-

Table B.1 Design Calculation of C1 WWTP (9/16)

Continuing Aeration Tank
(2) Proposed

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Multi-tank Complete mixing Type		
Design Sewage Flow	Q1	m^3/day			24,800
(Maximum Daily Flow)	Q2	m^3/hr			1,033.3
Hydraulic Retention Time	HRT	hr			6.0
Basin Number	BN	basin			2
Required Volume per basin	RV	m^3/basin	Q2×RT/BN		3,100
Width	W	m	1~2H		12.0
Water Depth	H	m	4.0m~6.0m		5.5
Length	L1	m	RV/(W×H)		47.0
Therefore	L2	m			48.2
Dimension (Width)	W	m			**12.0**
(Depth)	H	m			**5.5**
(Length)	L	m			**48.2**
(Basin Number)	N	basin			**2**
(Check)					
Hydraulic Retention Time	HRT	hour	W×H×L×N/Q2		6.2
BOD-SS load	BSS_L	kgBOD/kgSS/d	(Q1×BODin)/(W×H×L×N×Xa)		0.23
BOD_{in} : Inflow BOD Concentration			120 mg/L (Removal Rate in PST : 40%)		
Xa : MLSS Concentration			2,000 mg/L		
Aerobic Sludge Retention Time	ASRT	day	HRT/24×Xa / (a×S-BODin + b×SSin - c×HRT/24×Xa) =		4.888
$S\text{-}BOD_{in}$: Inflow S-BOD Concentration			80 mg/L (S-BOD[Solved BOD]=BODin×0.67		
SS_{in} : Inflow SS Concentration			90 mg/L (Removal Rate in PST : 50%)		
a : Sludge converting ratio of solved BOI			0.5 mgMLSS/mgBOD (0.4~0.6)		
b : Sludge converting ratio of SS			0.95 mgMLSS/mgSS (0.9~1.0)		
c : Sludge reduction ratio caused by endogenous respiration			0.04 (1/day)(0.03~0.05)		
Effluent Quality (C-BOD)	EQ	mg/L	$10.42\times A\text{-}SRT^{(-0.519)}$ (15~20℃)		4.573
Water Temperature			20 ℃		
Effluent Water Quality (C=BOD Maximum)			EQ×3 20mg/l >		14
					-OK-
			1 : 1.5 : 1.5 : 2.25		
Partition of Aeration Tank			No.1 | No.2 | No.3 | No.4		
Total Length of Tank	TL	m			48.2
No.1 Tank Length	L1	m	TL×1/(1+1.5+1.5+2.25)		7.7
No.2 Tank Length	L2	m	TL×1.5/(1+1.5+1.5+2.25)		11.6
No.3 Tank Length	L3	m	TL×1.5/(1+1.5+1.5+2.25)		11.6
No.4 Tank Length	L4	m	TL×2.25/(1+1.5+1.5+2.25)		17.4
			Total		**48.3**

Table B.1 Design Calculation of C1 WWTP (10/16)

5 Final Sedimentation Tank

(1) Existing

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Radial flow circular type		
Design Sewage Flow	Q1	m^3/day			20,600
(Maximum Daily Flow)	Q2	m^3/hr			858.3
Basin Number	BN	basin			2
Hydraulic Load	HL	m^3/m^2/day			25.0
Required Surface Area	A1	m^2	Q1/HL		824
	A2	m^2/basin	A1/BN		412
Water Depth	WD	m			3.5
Diameter	D1	m	$(4\times A2/3.14)^{0.5}$		22.91
Therefore	D2	m			22.9
Overflow Weir Load	OWL	m^3/m/day			150
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		68.67
Therefore	WL2	m/basin			69.0
Dimension (Diameter)	D	m	D2		**22.9**
(Depth)	H	m	WD		**3.5**
(Basin Number)	N	basin	BN		**2**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	$4\times Q1/(D^2\times 3.14\times N)$		25.02
Retention(Settling) Time	T	hour	$D^2\times\pi\times H\times N/(4\times Q2)$		3.36
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		149.28

Table B.1 Design Calculation of C1 WWTP (11/16)

Continuing Final Sedimentation Tank
(2) Proposed-1

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Radial flow circular type		
Design Sewage Flow	Q1	m^3/day			24,800
(Maximum Daily Flow)	Q2	m^3/hr			1,033.3
Basin Number	BN	basin			2
Hydraulic Load	HL	m^3/m^2/day			25.0
Required Surface Area	A1	m^2	Q1/HL		992
	A2	m^2/basin	A1/BN		496
Water Depth	WD	m			4
Diameter	D1	m	$(4\times A2/3.14)^{0.5}$		25.14
Therefore	D2	m			25.5
Overflow Weir Load	OWL	m^3/m/day			150
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		82.67
Therefore	WL2	m/basin			83.0
Dimension (Diameter)	D	m	D2		**25.5**
(Depth)	H	m	WD		**4.0**
(Basin Number)	N	basin	BN		**2**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	$4\times Q1/(D^2\times 3.14\times N)$		24.29
Retention(Settling) Time	T	hour	$D^2\times\pi\times H\times N/(4\times Q2)$		3.95
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		149.40

Table B.1 Design Calculation of C1 WWTP (12/16)

Continuing Final Sedimentation Tank
(3) Proposed-2

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Parallel Flow Type		
Design Sewage Flow	Q1	m^3/day			24,800
(Maximum Daily Flow)	Q2	m^3/hr			1,033.3
Basin Number	BN	basin			4
Hydraulic Load	HL	m^3/m^2/day			25.0
Required Surface Area	A1	m^2	Q1/HL		992
	A2	m^2/basin	A1/BN		248
Width	W1	m	3.0m~4.0m, Max5.0m		5.8
Length	L1	m	A2/W1		42.76
Therefore	L2	m			43.5
Water Depth	WD	m			3.5
Overflow Weir Load	OWL	m^3/m/day			150
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		41.33
Therefore	WL2	m/basin			41.5
Dimension (Width)	W	m			**5.8**
(Depth)	D	m			**3.5**
(Length)	L	m			**43.5**
(Basin Number)	N	basin			**4**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	Q1/(N×W×L)		24.57
Retention(Settling) Time	T	hour	(N×W×D×L)/Q2		3.42
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		149.40

Table B.1 Design Calculation of C1 WWTP (13/16)

2-6 Disinfection Channel

(1) Proposed

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Chlorination		
Design Sewage Flow	Q1	m^3/day			70,200
(Maximum Daily Flow)	Q2	m^3/min			48.75
Retention(Chlorination) Time	RT	min			15.0
Required Volume	RV	m^3	Q2×RT		731
Width of channel	W	m			2.5
Depth of channel	H	m			2.0
Pass Number	PN	pass			6
Length of channel	L1	m/pass	RV/(W×H×PN)		24.4
Therefore	L2	m/pass			24.5
Dimension (Width)	W	m			**2.5**
(Depth)	H	m			**2.0**
(Length)	L	m/pass			**24.5**
(Pass Number)	N	pass			**6**
(Check)					
Retention(Chlorination) Time	RT	min	(W×H×L×PN)/Q2		15.1

Table B.1 Design Calculation of C1 WWTP (14/16)

2-7 Sludge Thickening Tank

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Gravity Thickener (Radial Flow Circular Type)		
Generated Sludge Solids	GS	t-DS/day	Refer to Mass Balance Cal.		12.32
Generated Sludge Volume	GSV	m^3/day	Refer to Mass Balance Cal.		1,503
Solid Matter Load	SML	kg/m^2/day			75
Required Surface Area	SA	m^2	$(GS\times10^3)/SML$		164.3
Water Depth	H	m			4.1
Basin Number	BN	basin			2
Required Tank Diameter	TD1	m	$(SA\times4/(3.14\times BN))^{0.5}$		10.23
Therefore	TD2	m			10.5
Dimension (Diameter)	D	m/basin			**10.5**
(Depth)	H	m			**4.1**
(Basin Number)	BN	basin			**2**
(Check)					
Solid Matter Load	SML	kg/m^2/day	$GS\times10^3/(3.14\times D^2/4)\times BN$		71.2
Sludge Thickened Time	T	hr	$(3.14\times D^2/4)\times H\times BN\times24/GSV$		11.3

2-8 Sludge Dewatering

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Mechanical Dewatering (Screw Press Type)		
Thickened Sludge Solids	TS	t-DS/day	Refer to Material Balance		11.201
Unit Number	UN	Unit			4
Operating Day	OD	day(/week)			5.0
Operating Time	OT	hr/day			10.0
Required Dewatering Capacity	DC	kg/hr/unit	$TS\times10^3\times7/(OD\times OT\times UN)$		392.0
Solids Loading	Q_{100}	kg-ds/hr/φ100			3.0
Screnn Diameter	SD1	mm	$100\times(DC/Q_{100})$^(1/2.2)		916.0
Therefore	SD2	mm			800
Dimension (unit)	UN	Unit			**4**
(Screen Diameter)	SD	mm			**800**
(Check)					
Dewatering Capacity	DC	kg/hr/unit	$(SD/100)$^2.2$\times Q_{100}$		291.0
Operating Time	OT	hour/day	$TS\times10^3/(DC\times(UN-1))$*(7/OT		13.5

Table B.1 Design Calculation of C1 WWTP (15/16)

Material Balance Calculation (Primary and Secondary Sedimentation Tank + Thickening Tank + Mechanical Dewatering)

Table-1 Input Data

1. Calculation Manner		1	1:Premise that the quality of supernatants are same level removed with inlet sewage 2:Premise that the entire supernatants are removed at treatment process
2. Selection of Treatment Efficiency		2	1:Total Removal Ratio 2:Outlet Water Quality (input 1or2)
In case of 1 : input data		90	(%)
In case of 2 : input data		30	(mg/l)
3. Excess Sludge Generation		1	1:Consideration of Solid Matter Only 2:Consideration of Converting of Solved BOD (input 1or2)
In case of 1:Input data (Sludge generation)		100	Sludge generation ratio per removal SS(%)
In case of 2:Input data	a		T2=Q2･S2=(a･S_{BOD}+b･S1-c･θ･XA)･Q1/10^6･･(Excess sludge generation formula)
	b		a:Converting ratio of solved BOD(mgMLSS/mgBOD)
	c		b:Converting ratio of SS(mgMLSS/mgSS)
	SBOD		c:Sludge reduction ratio caused by endogenous respiration of activated sludge(1/day)
	XA		S_{BOD}:Solved BOD quality at inlet to reactor
	θ		XA:MLSS concentration(mg/l)
			θ:Hydraulic retention time(day)

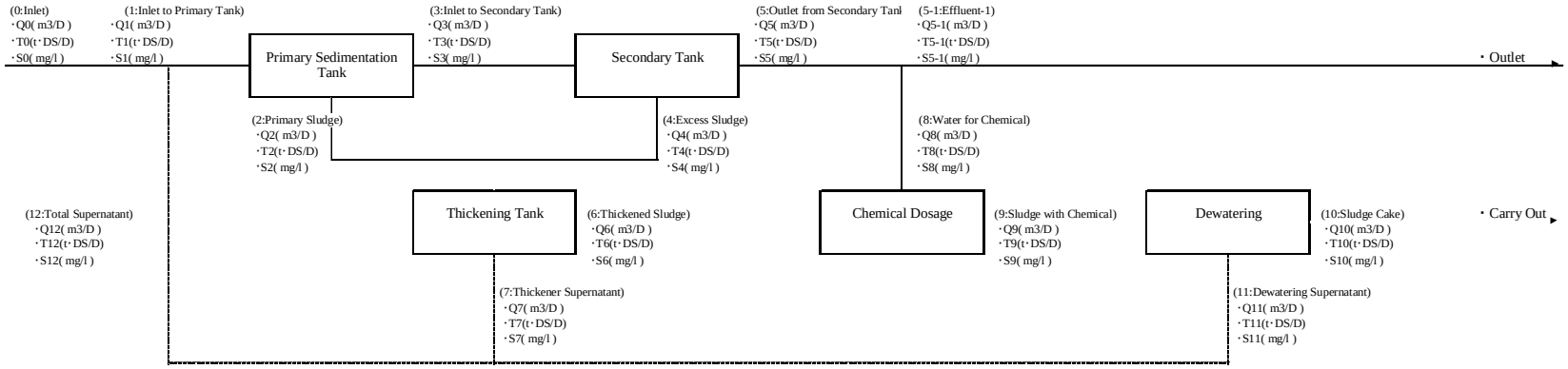
Table-2 Basic Conditions

Water Flow and Quality		Sludge Moisture and Recovery Ratio				Chemical Conditions for Dewatering	
･Inlet flow : Q0(m3/D)	70200	･Primary sludge moisture ratio : W1(%)	98.5	･Removal ratio in primary tank : A2(%)	50.0	･Chemical dosage : A5(%)	1.0
･Inlet quality : S0(mg/l)	180	･Excess sludge moisture ratio : W2(%)	99.5	･Recovery ratio in sludge thickener : A3(%)	90.0	･Chemical dissolve concentration : A6(%)	0.2
･Total removal ratio : A1(%)	-	･Thickened sludge moisture ratio : W3(%)	98.0	･Recovery ratio in dewatering : A4(%)	95.0		
･Effluent quality : St(mg/l)	30.0	･Dewatered sludge moisture ratio : W4(%)	80.0				
･Sludge generation ratio per removal SS : Si(%)	100.0						

Table-3 Material Balance Calculation

	0	1	2	3	4	5	6	7	8	9	10	11	12			5-1		
Q (m3/day)	70,200	71,705	481	71,224	1,022	70,202	554	948	55	610	53	557	1,505			70,147		
T (t･DS/day)	12.636	14.428	7.214	7.214	5.108	2.106	11.090	1.232	0.111	11.201	10.641	0.560	1.792			1.995		
S (mg/l)	180	201	15,000	101	5,000	30	20,000	1,300	2,000	18,364	200,000	1,006	1,191			30		
X (Ti/T0*100)	100	114.2	57.1	57.1	40.4	16.7	87.8	9.8	0.9	88.6	84.2	4.4	14.2			15.8		

Figure-1 Material Balance Model

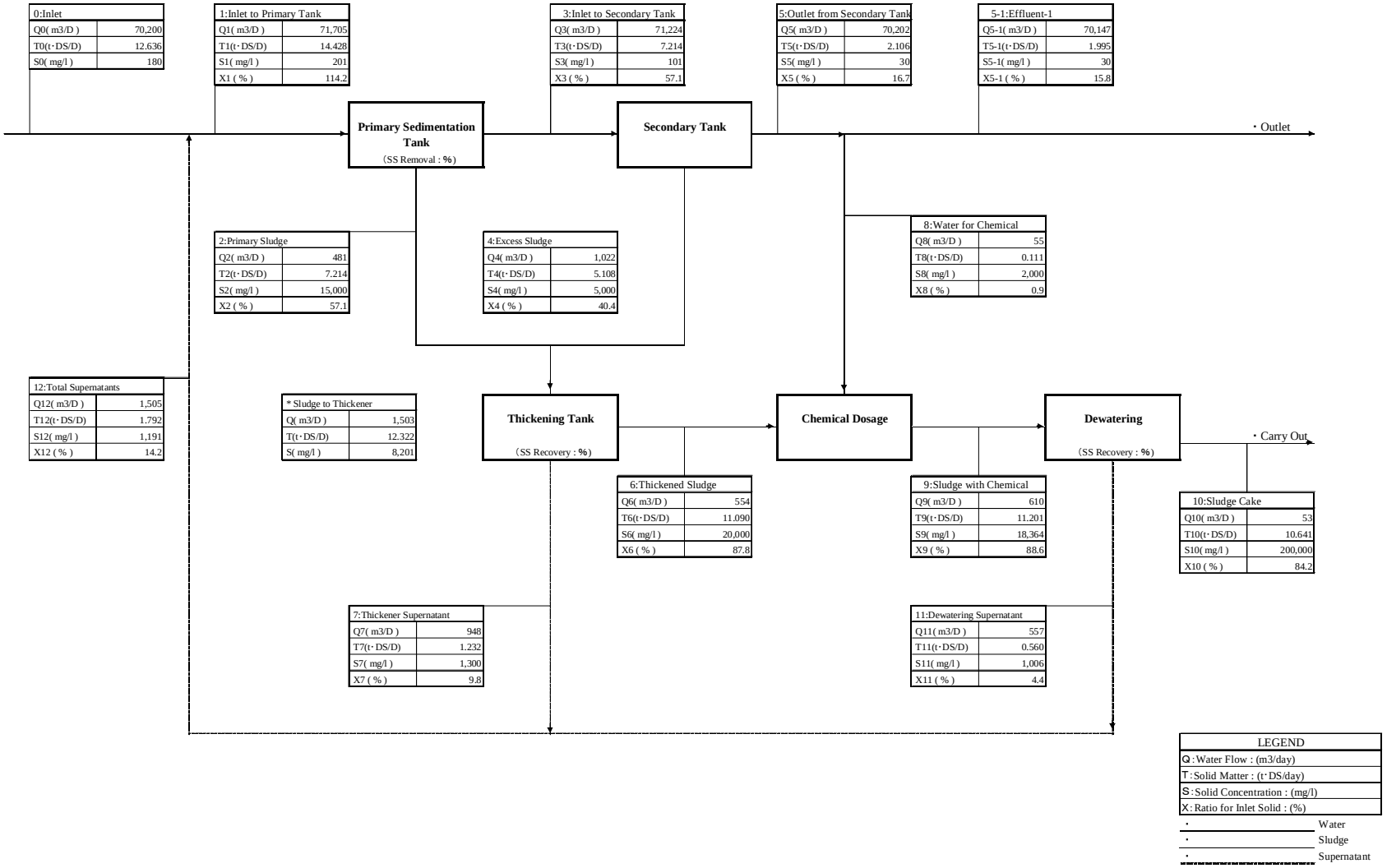


Calculation Formula

･Q0=Input Data	･Q3=Q1-Q2	･Q6=T4*100/(100-W3)	･Q9=Q6+Q8	･Q12=Q7+Q11	･Q5-1=Q5-Q8
･T0=Q0*S0*10^(-6)	･T3=T1*(100-A2)/100	･T6=(T2+T4)*A3/100	･T9=T6+T8	･T12=T7+T11	･T5-1=T5-T8
･S0=Input Data	･S3=T3*10^6/Q3	･S6=10^6*(100-W3)/100	･S9=T9*10^6/Q9	･S11=T11*10^6/Q11	･S5-1=S5
･Q1=Q0+Q13	･Q4=(Q3*ST-T3*10^6)/(ST-S4)*T4/(T3-T5)	･Q7=(Q2+Q4)-Q6	･Q10=T10*100/(100-W4)		
･T1=T0+T13	･T4={(T1-T5)*Si/100}-T2	･T7=(T2+T4)-T6	･T10=T9*A4/100		
･S1=T1*10^6/Q1	･S4=10^6*(100-W2)/100	･S7=T7*10^6/Q7	･S10=10^6*(100-W4)/100		
･Q2=T2*100/(100-W1)	･Q5=(T3*10^6-Q3*S4)/(ST-S4)	･Q8=T6*A5/A6	･Q11=Q9-Q10		
･T2=T1-T3	･T5=Q5*ST/10^6	･T8=Q8*S8/10^6	･T11=T9-T10		
･S2=10^6*(100-W1)/100	･S5=St	･S8=10^4*A6	･S11=T11*10^6/Q11		

Table B.1 Design Calculation of C1 WWTP (16/16)

Material Balance Sheet



C DRAWINGS OF C1 WWTP

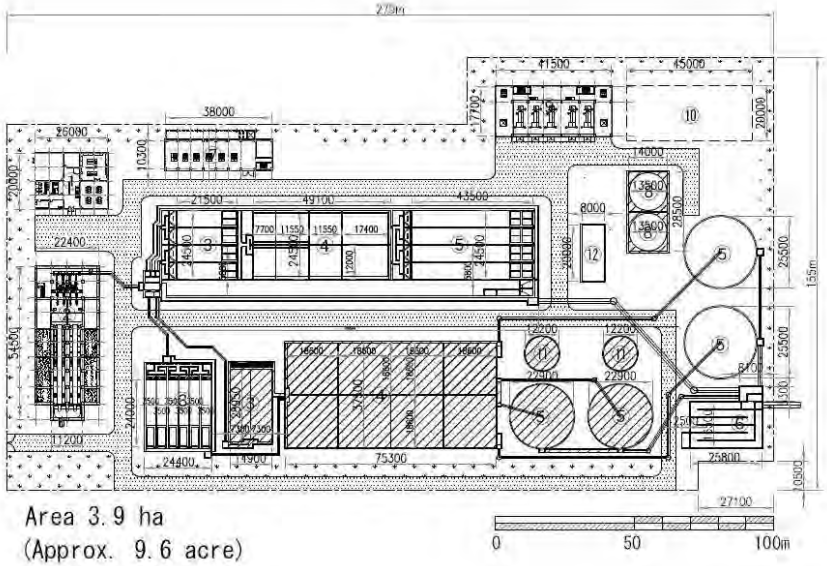
Drawing List

Drawing No.		Title of Drawing	Scale
1	WWTP-001	General Layout Plan of C1 WWTP	1:1500
2	WWTP-002	Hydraulic Profile of C1 WWTP	V-1:300
3	WWTP-003	Process Flow of C1 WWTP	Non
4	WWTP-004	Administration Building, Plan & Section	1:300
5	WWTP-005	Pumping Station, Plan & Section (1/2)	1:400
6	WWTP-006	Pumping Station, Plan & Section (2/2)	1:400
7	WWTP-007	Primary Sedimentation Tank, Plan & Section (New Construction of Existing Line)	1:500
8	WWTP-008	Final Sedimentation Tank, Plan & Section (New Construction of Existing Line)	1:500
9	WWTP-009	Primary/Final Sedimentation Tank & Aeration Tanks, Plan (Expansion Line)	1:500
10	WWTP-010	Primary/Final Sedimentation Tank & Aeration Tanks, Section (Expansion Line)	1:500
11	WWTP-011	Chlorination Facility, Plan & Section	1:400
12	WWTP-012	Sludge Pump Room, Plan & Section	1:300
13	WWTP-013	Blower Building, Plan & Section	1:400
14	WWTP-014	Sludge Dewatering Unit Building, Plan & Section	1:400

Location Map

General Layout of C1 - WWTP

* Reference Only (Land shape is not decided yet)



Treatment Process

Conventional Activated Sludge Process

Design Sewage Flow

Q = 70,213 m³/day (Daily Maximum Flow)

Design Sewage Quality

Item	BOD (mg/l)	SS (mg/l)
Influent	200	180
Effluent	20	30

No.	Facility
①	Administration Building
②	Grit Chamber / Pumping Station
③	Primary Sedimentation Tank
④	Aeration Tank
⑤	Final Sedimentation Tank
⑥	Chlorination Tank
⑦	Blower Building
⑧	Gravity Thickener
⑨	Dewatering Unit Building
⑩	Sludge Cake Yard
⑪	Mixed Sludge Tank
⑫	Sludge Pump Building

LEGEND	
	Land Boundary
	Buffer Zone
	Existing Structures
	Road

Project Name:
The Preparatory Survey on
The Project for the Improvement of Water Supply,
Sewerage and Drainage System in Yangon City
ミャンマー国ヤンゴン市上下水道改善プログラム協力準備調査

Drawing Title:
C1 Waste Water Treatment Plant General Layout
C1下水処理場 一般平面図

Scale: 1:1500

Drawing No: WWTP-01

Figure C.1 General Layout Plan of C1 WWTP

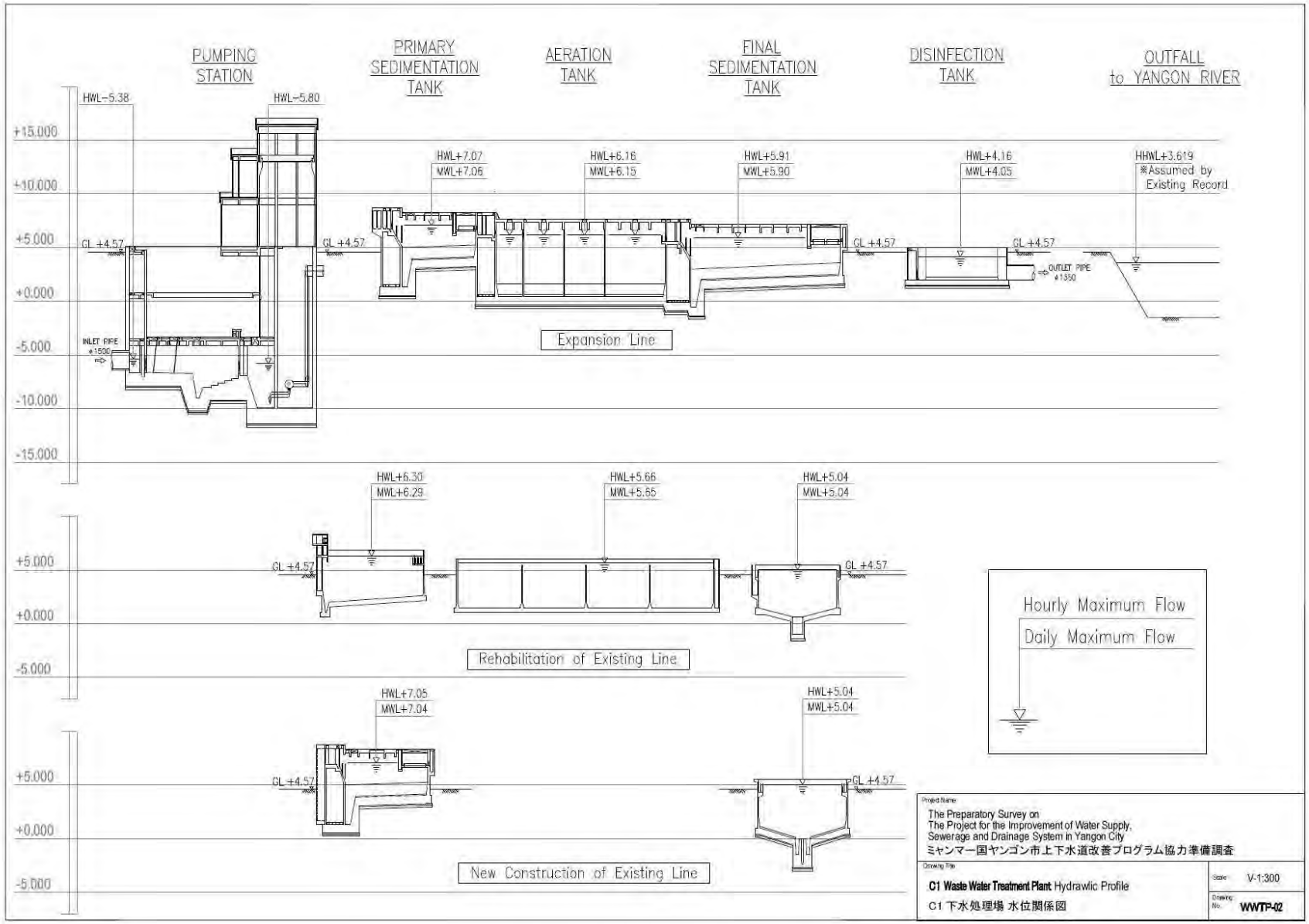


Figure C.2 Hydraulic Profile of C1 WWTP

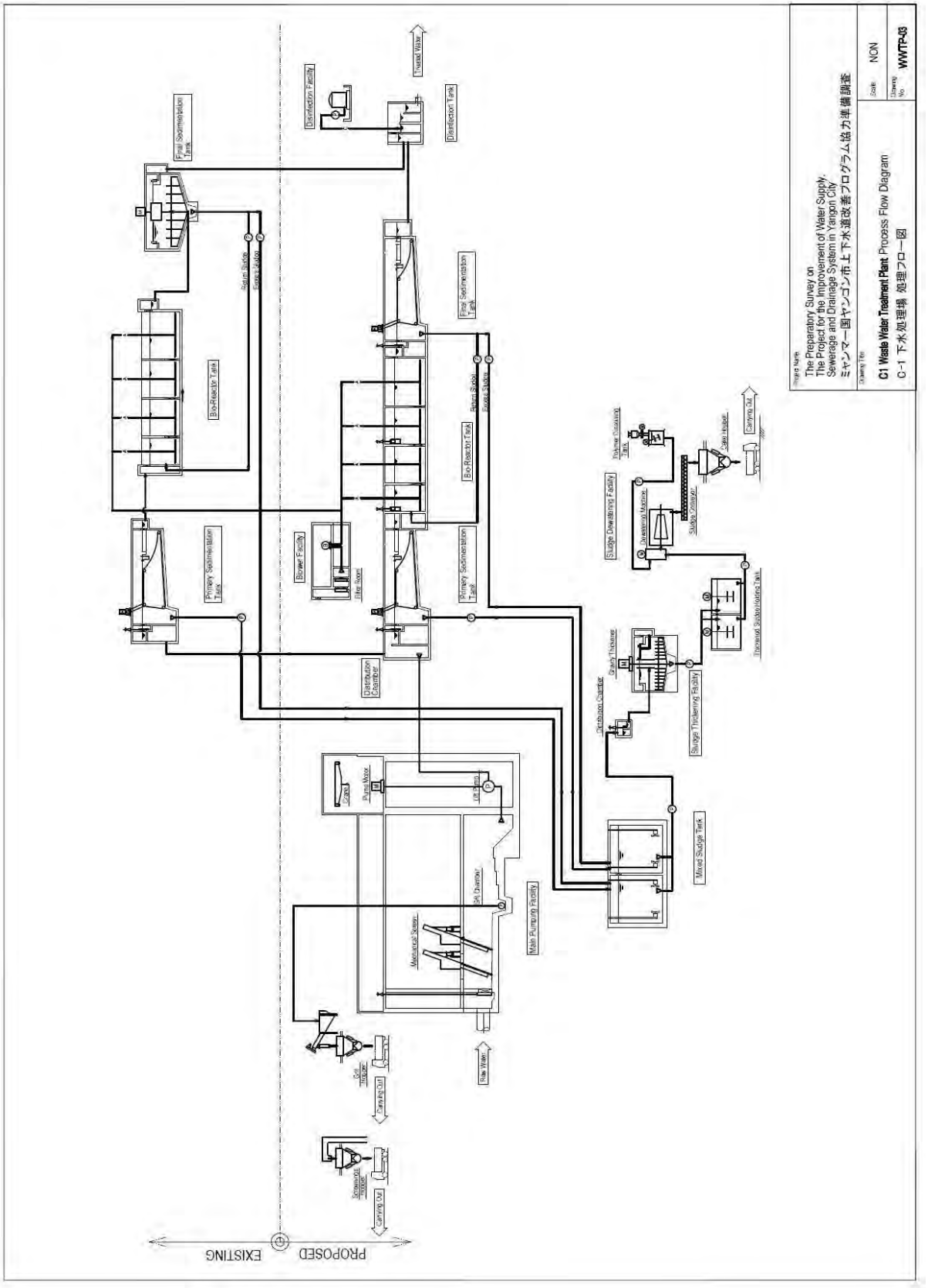


Figure C.3 Process Flow Diagram of C1 WWTP

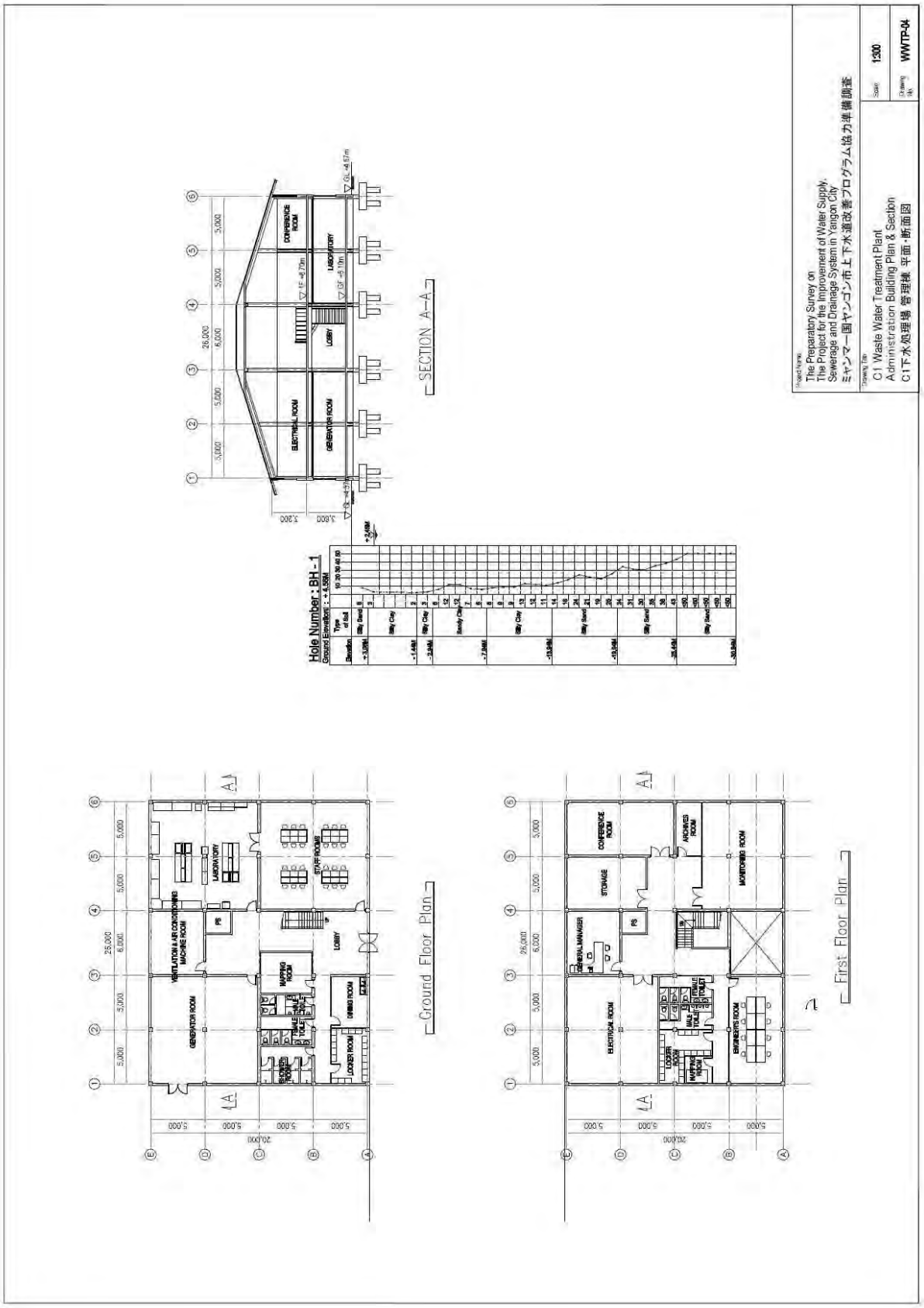


Figure C.4 Administration Building, Plan & Section

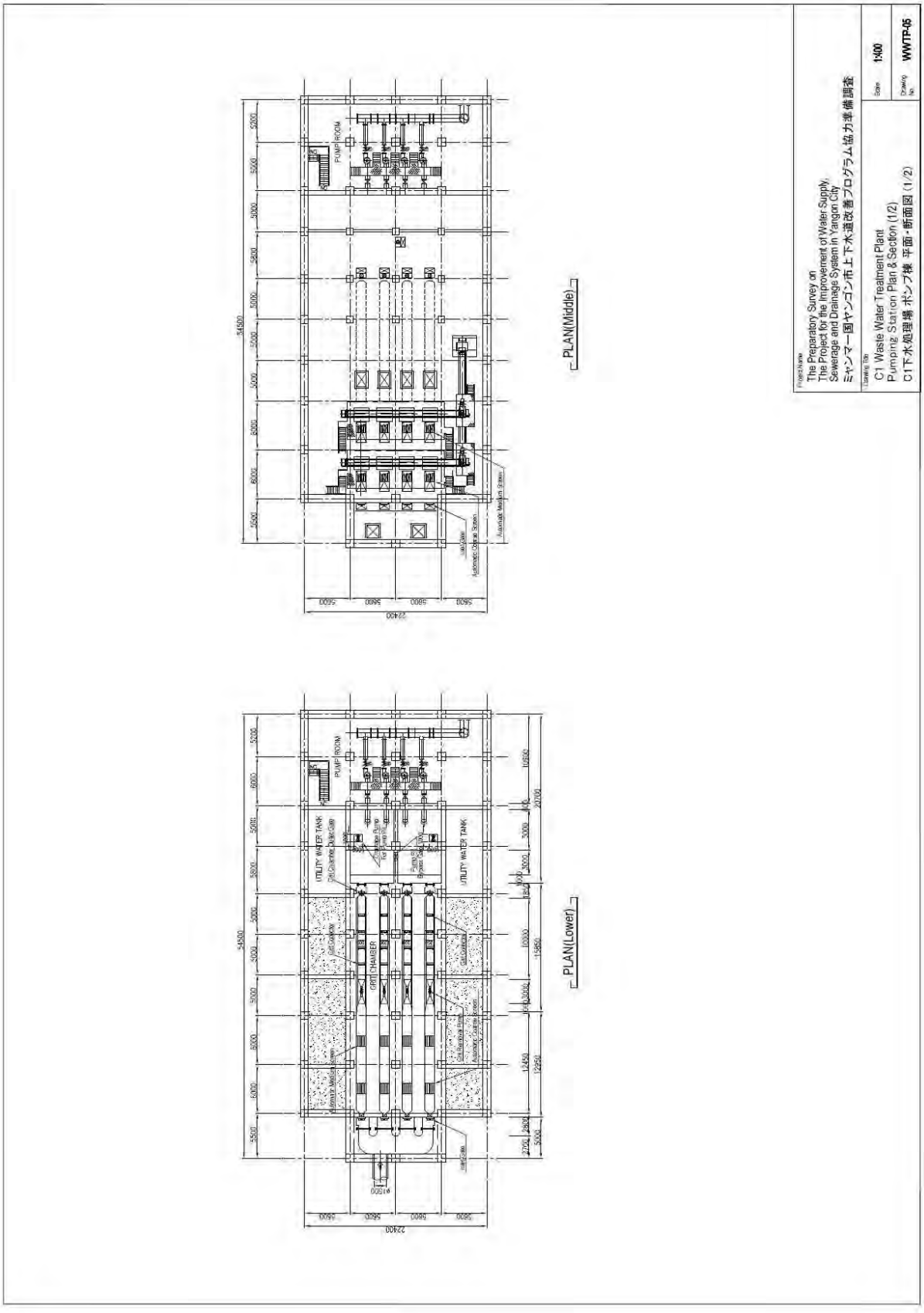


Figure C.5 Pumping Station, Plan & Section (1/2)

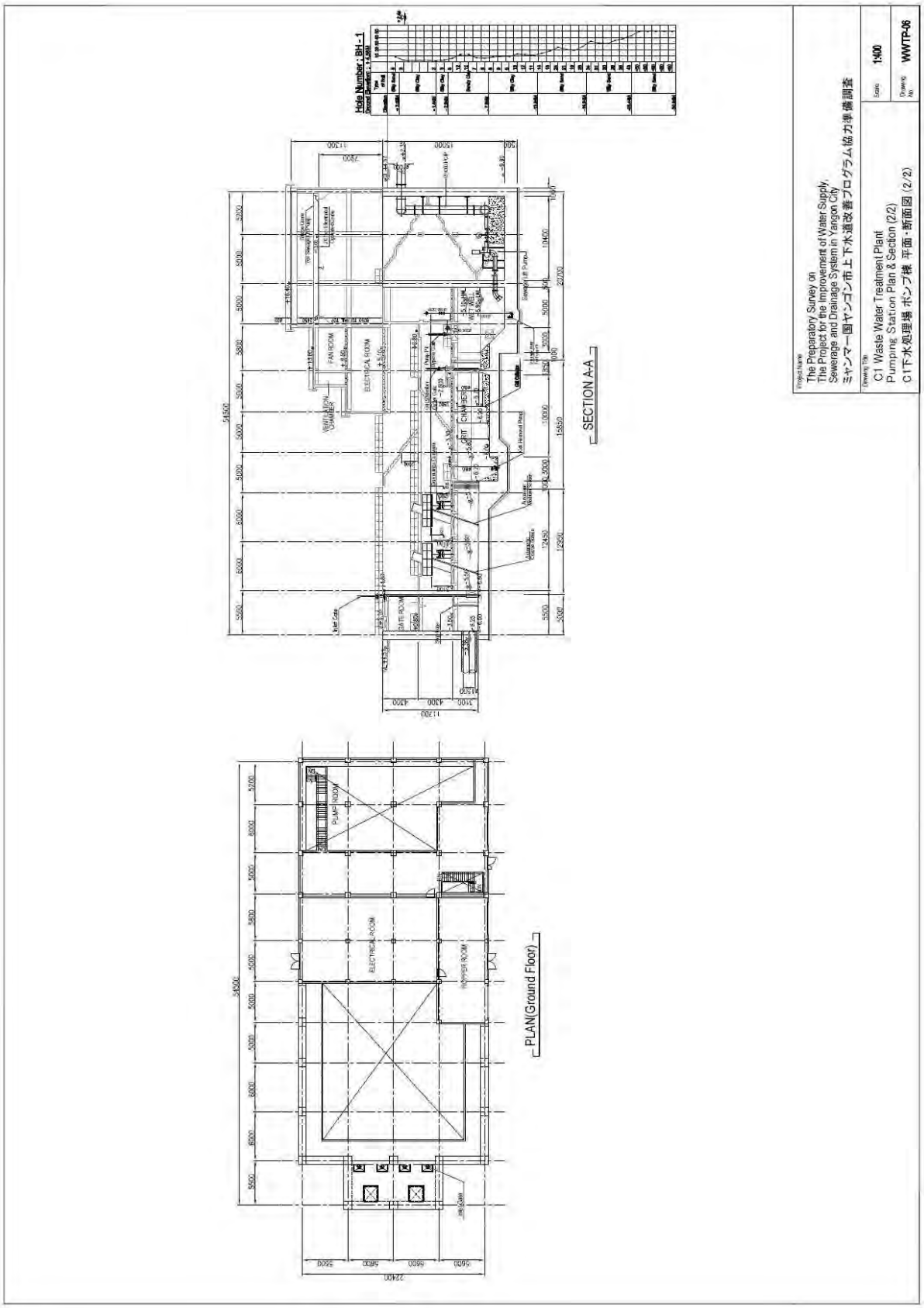


Figure C.6 Pumping Station, Plan & Section (2/2)

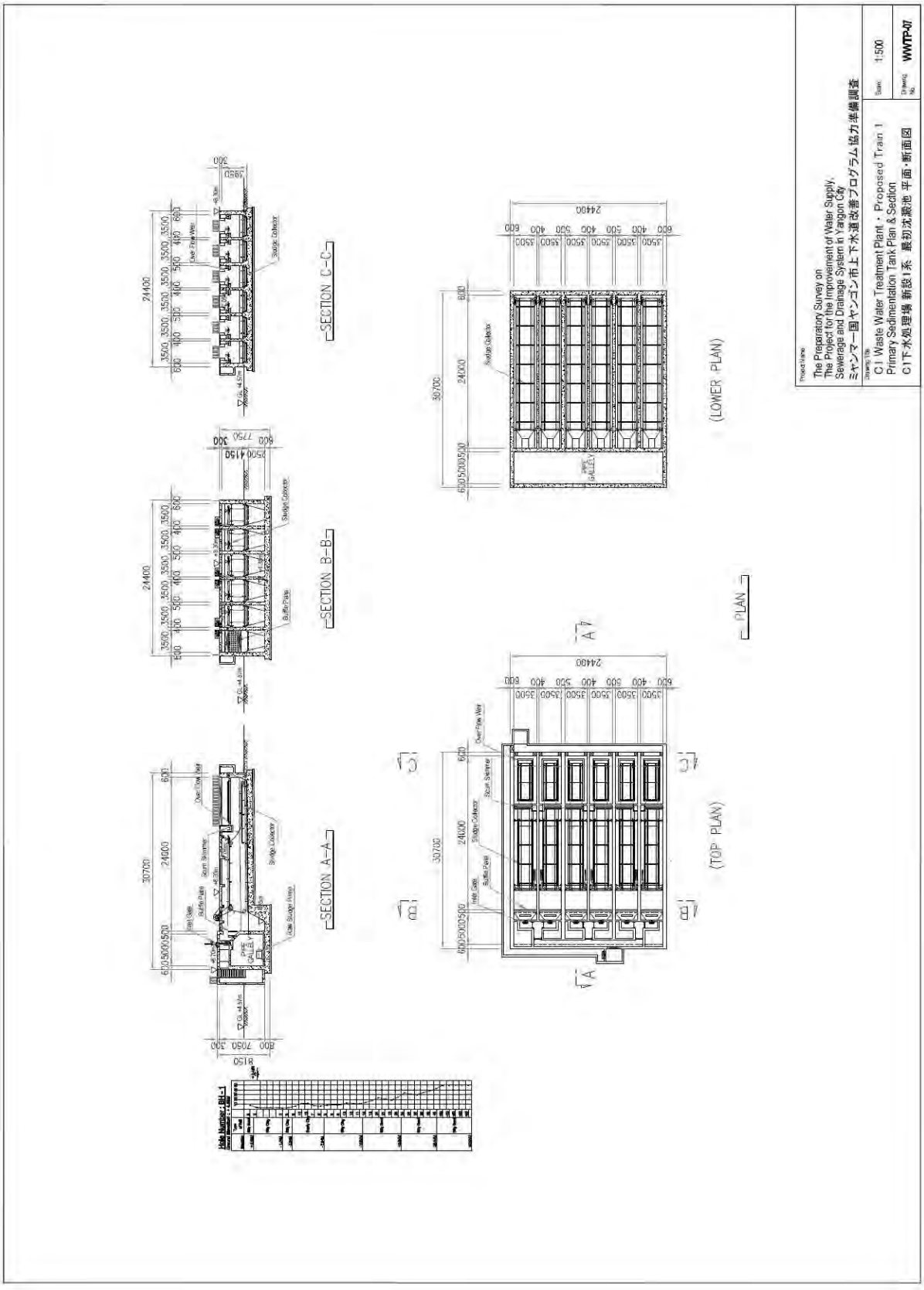


Figure C.7 Primary Sedimentation Tank, Plan & Section (New Construction of Existing Line)

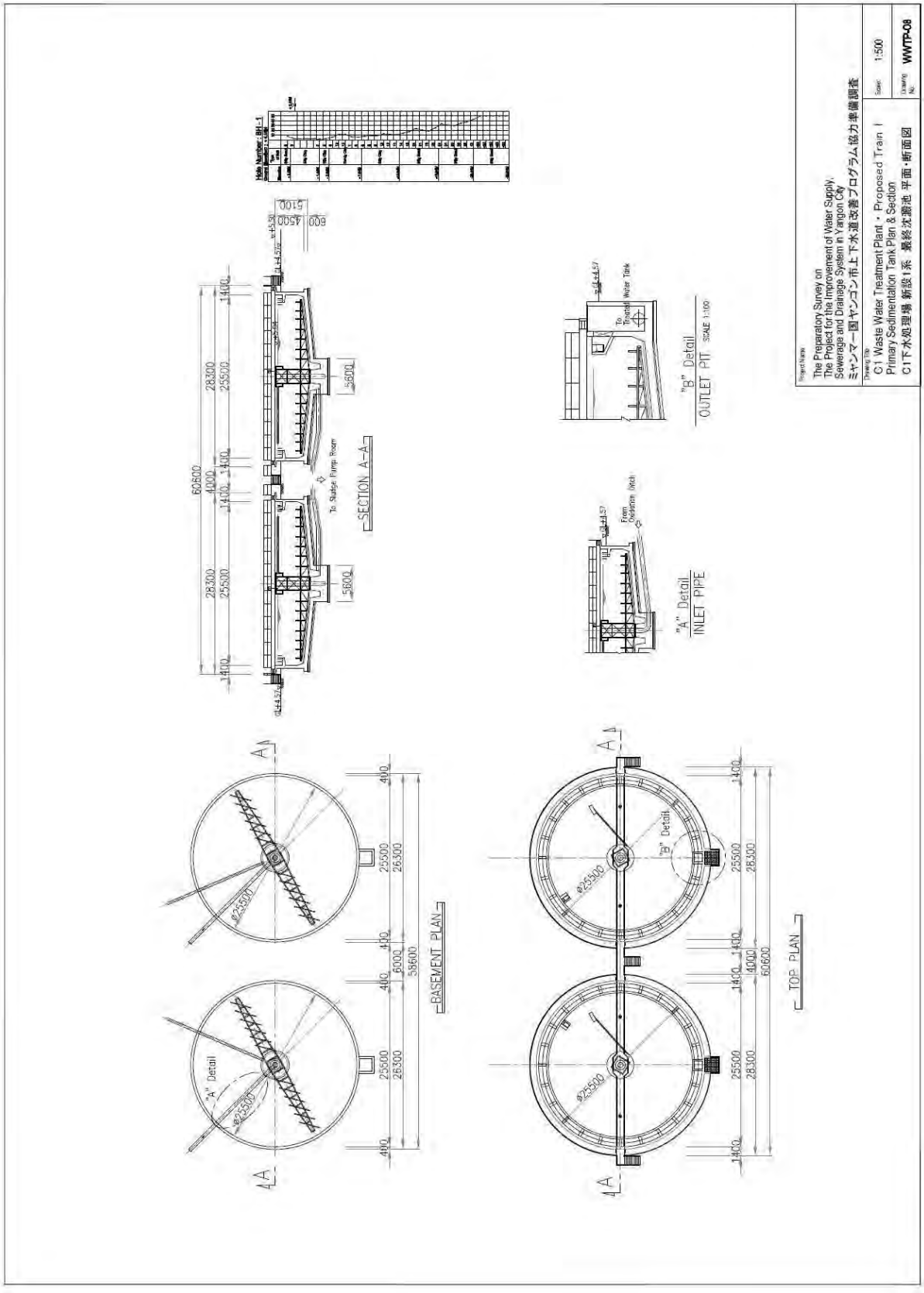


Figure C.8 Final Sedimentation Tank, Plan & Section (New Construction of Existing Line)

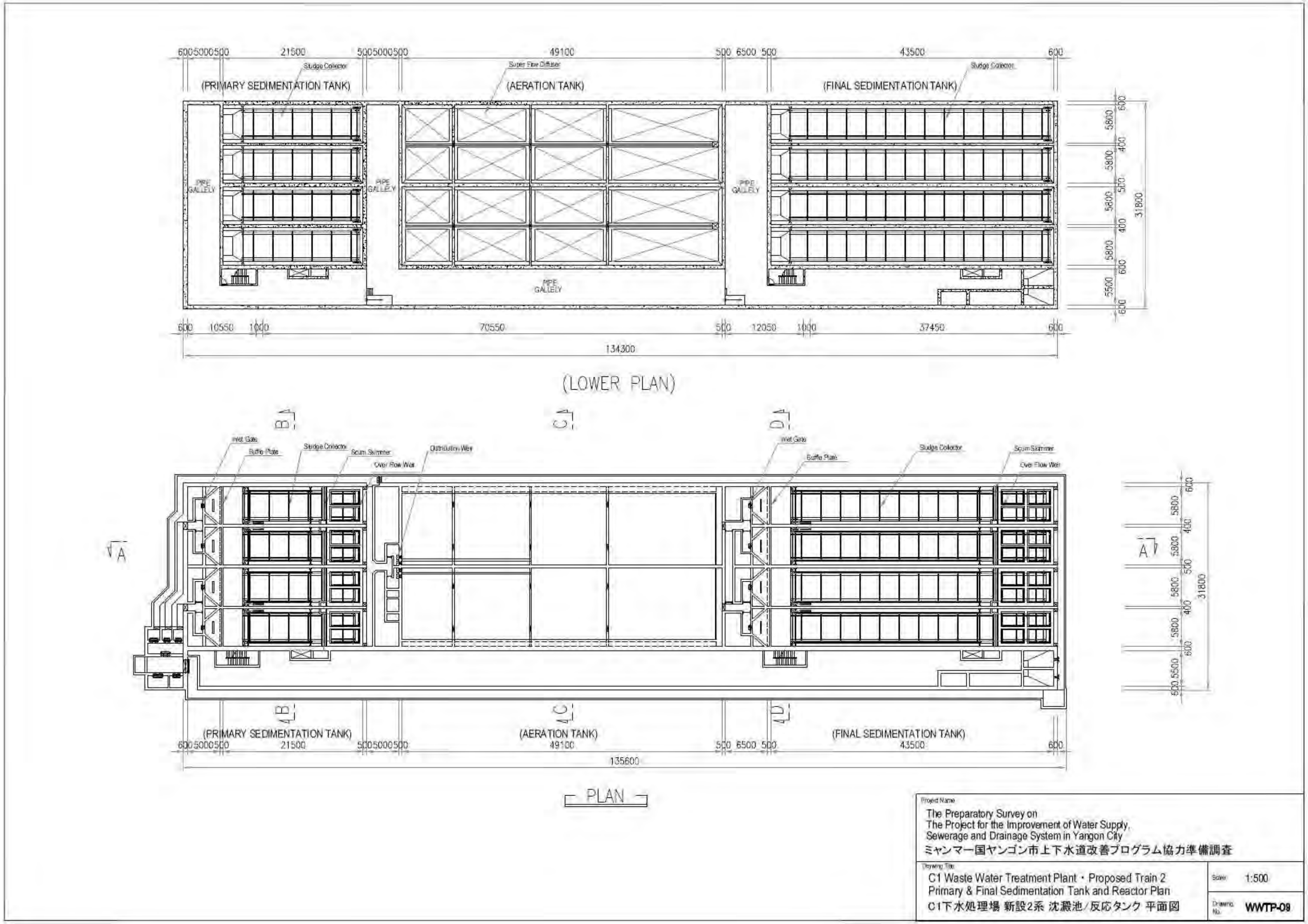


Figure C.9 Primary/Final Sedimentation & Aeration Tanks, Plan (Expansion Line)

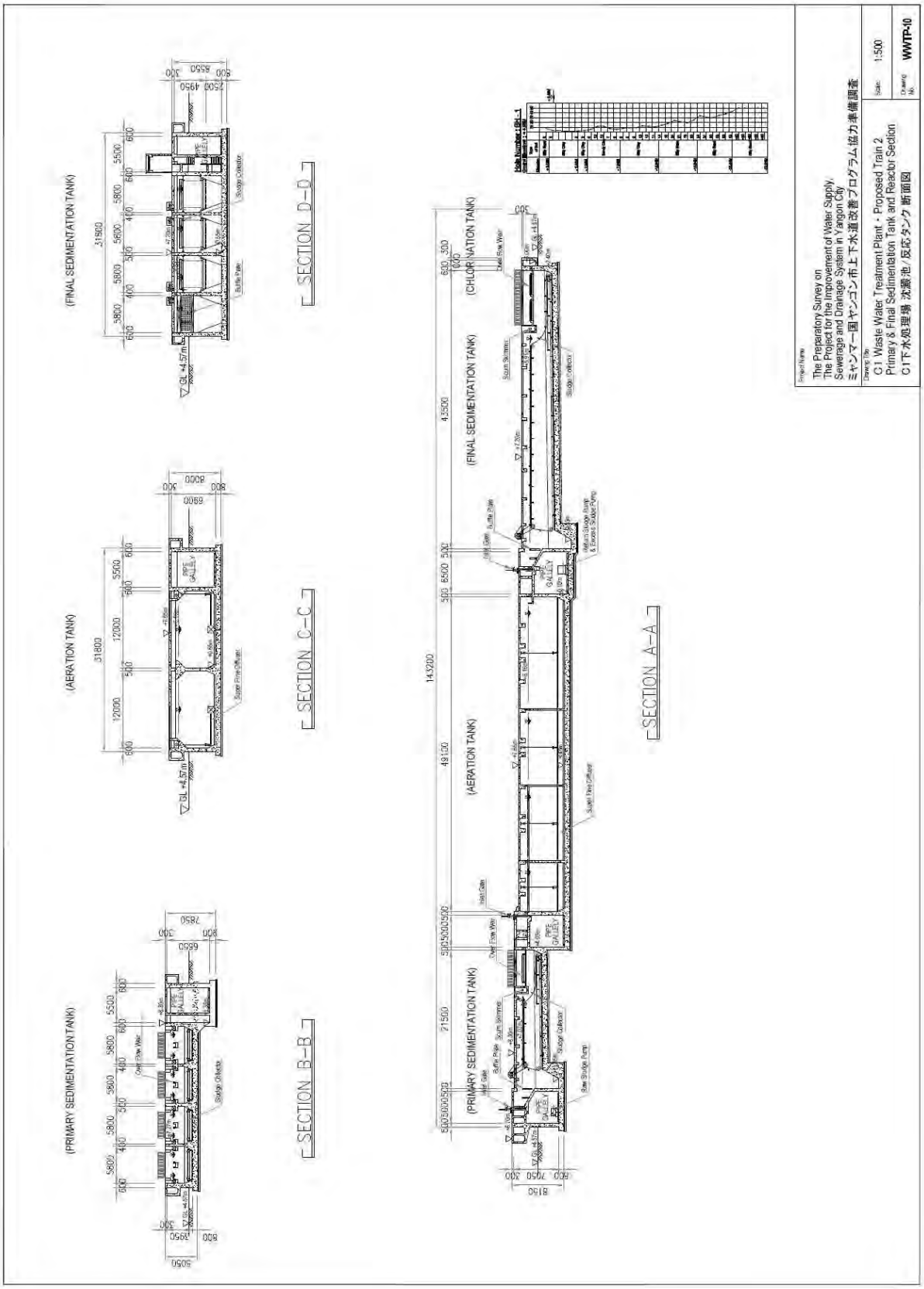


Figure C.10 Primary/Final Sedimentation & Aeration Tanks, Section (Expansion Line)

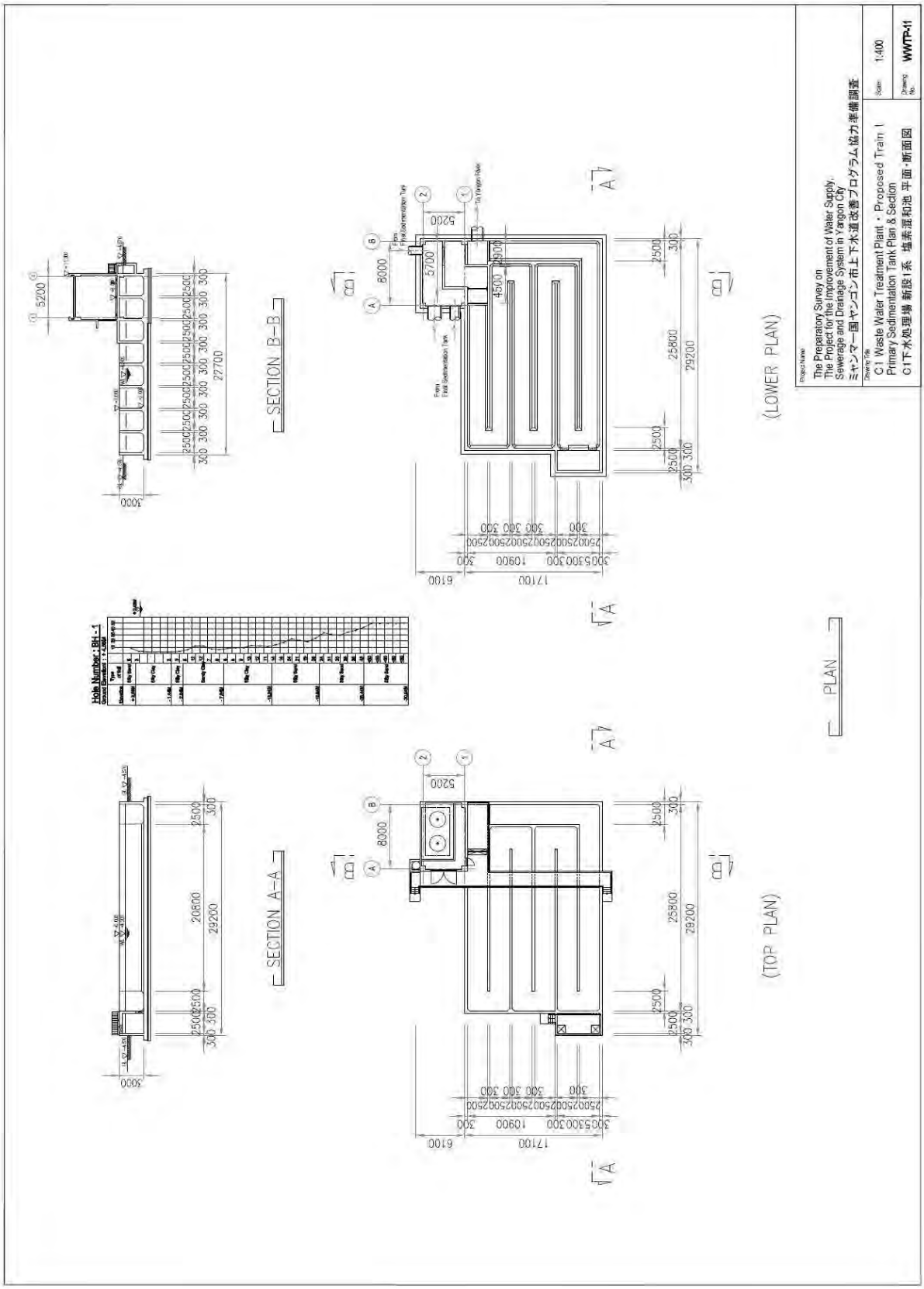


Figure C.11 Chlorination Facility, Plan & Section

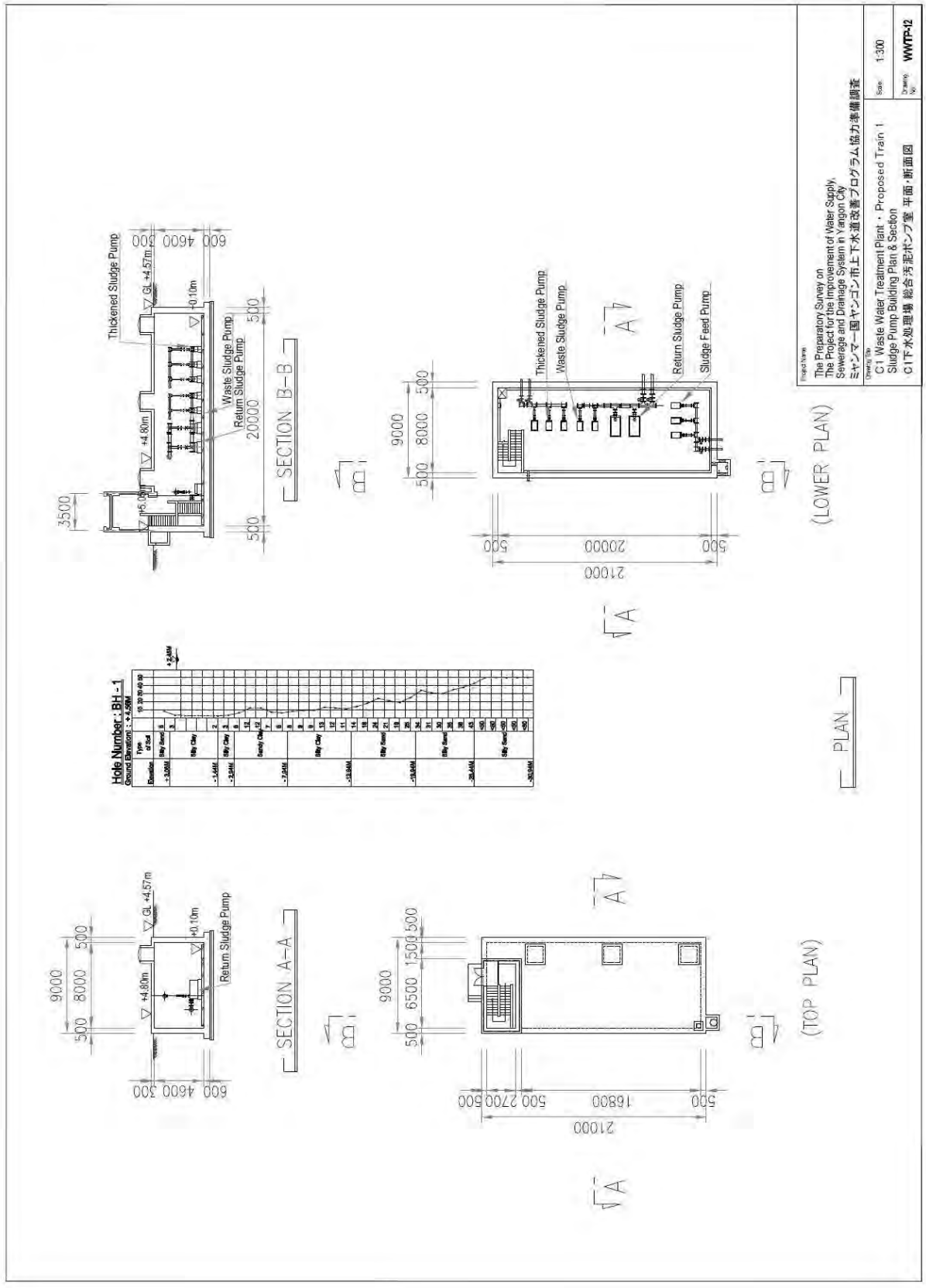


Figure C.12 Sludge Pump Room, Plan & Section

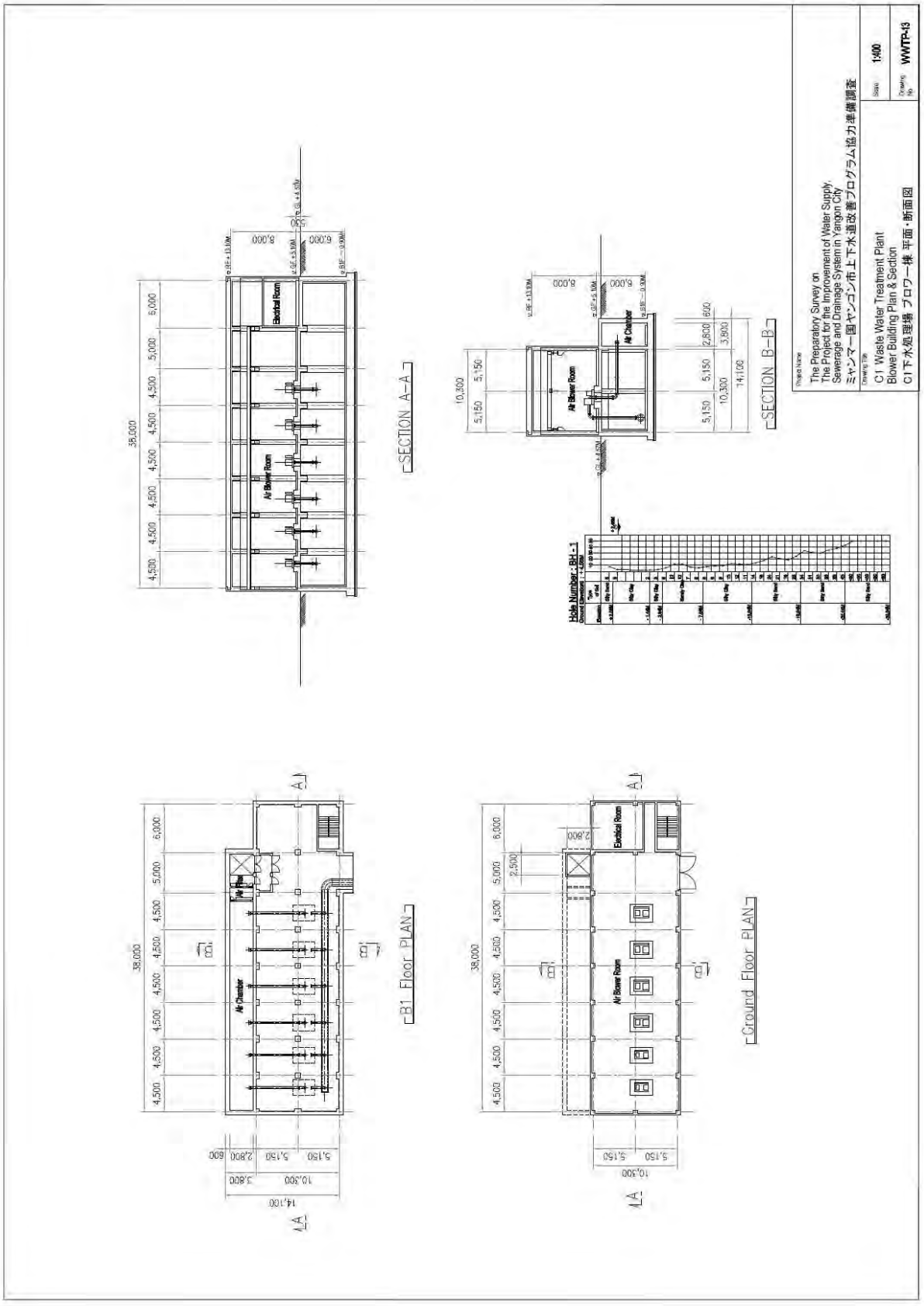


Figure C.13 Blower Building, Plan & Section

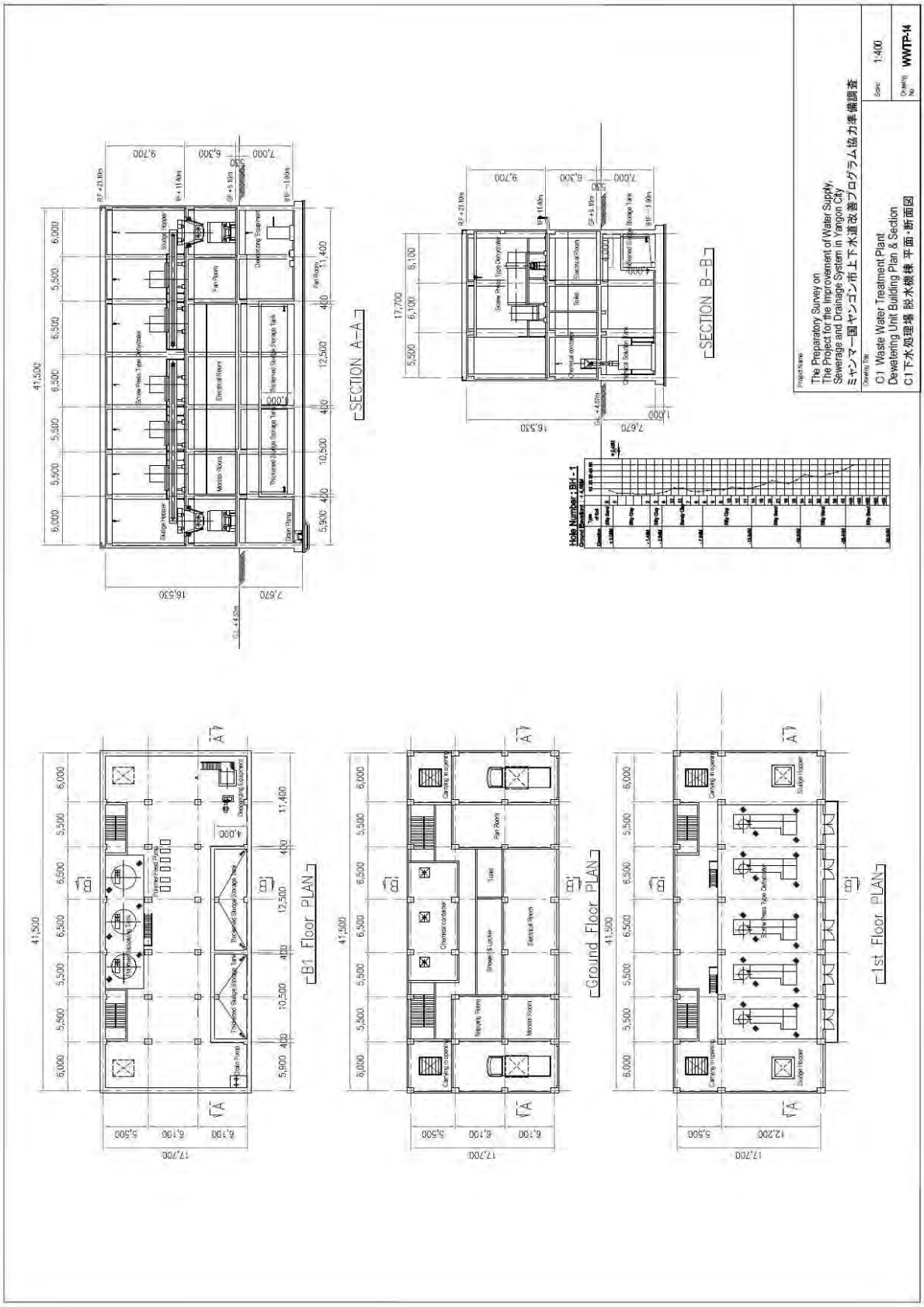
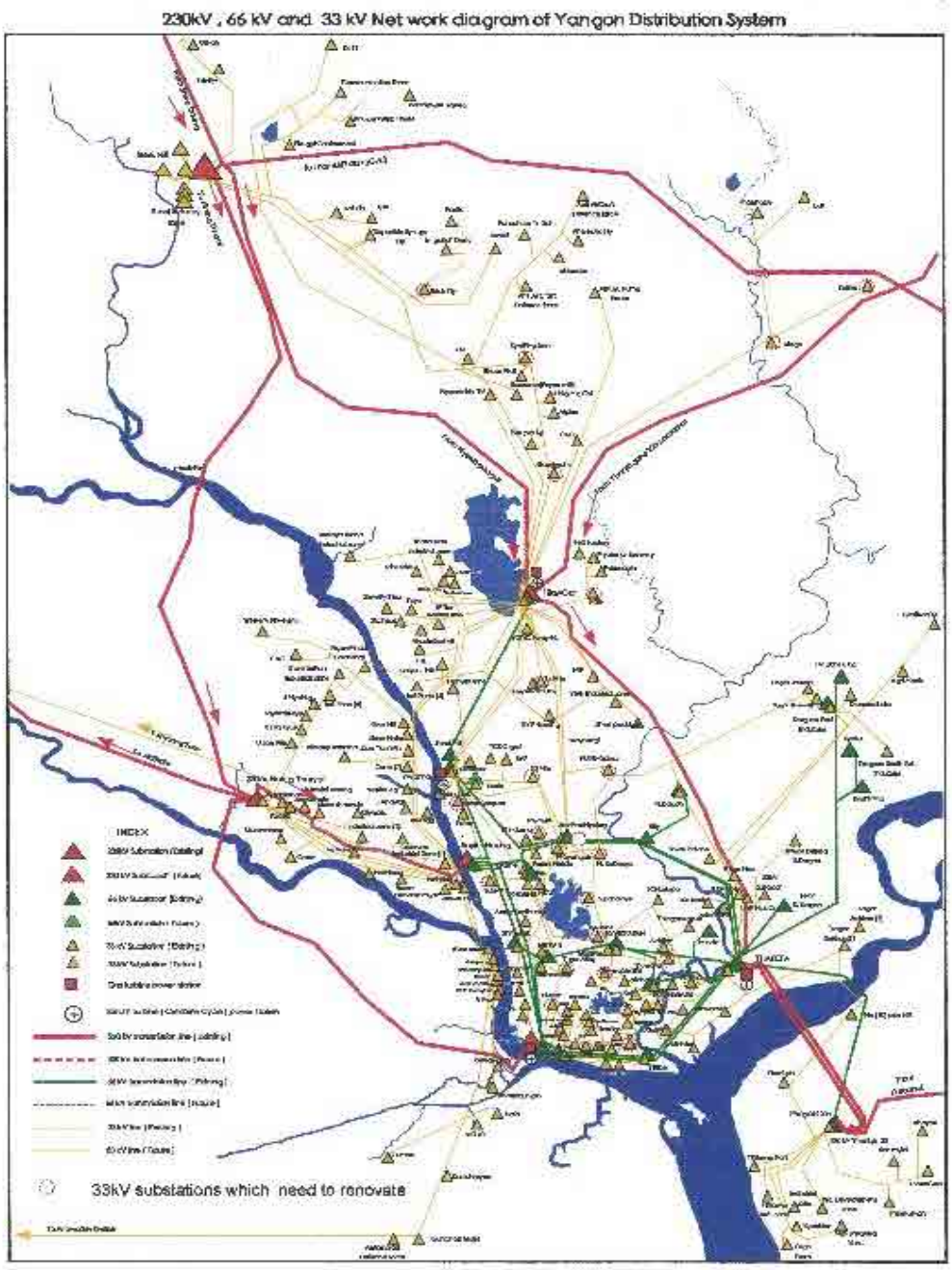


Figure C.14 Sludge Dewatering Unit Building, Plan & Section

D FIGURES AND TABLES RELATED TO ELECTRICAL FACILITY



Source：YESB

Figure D.1　YESB Network

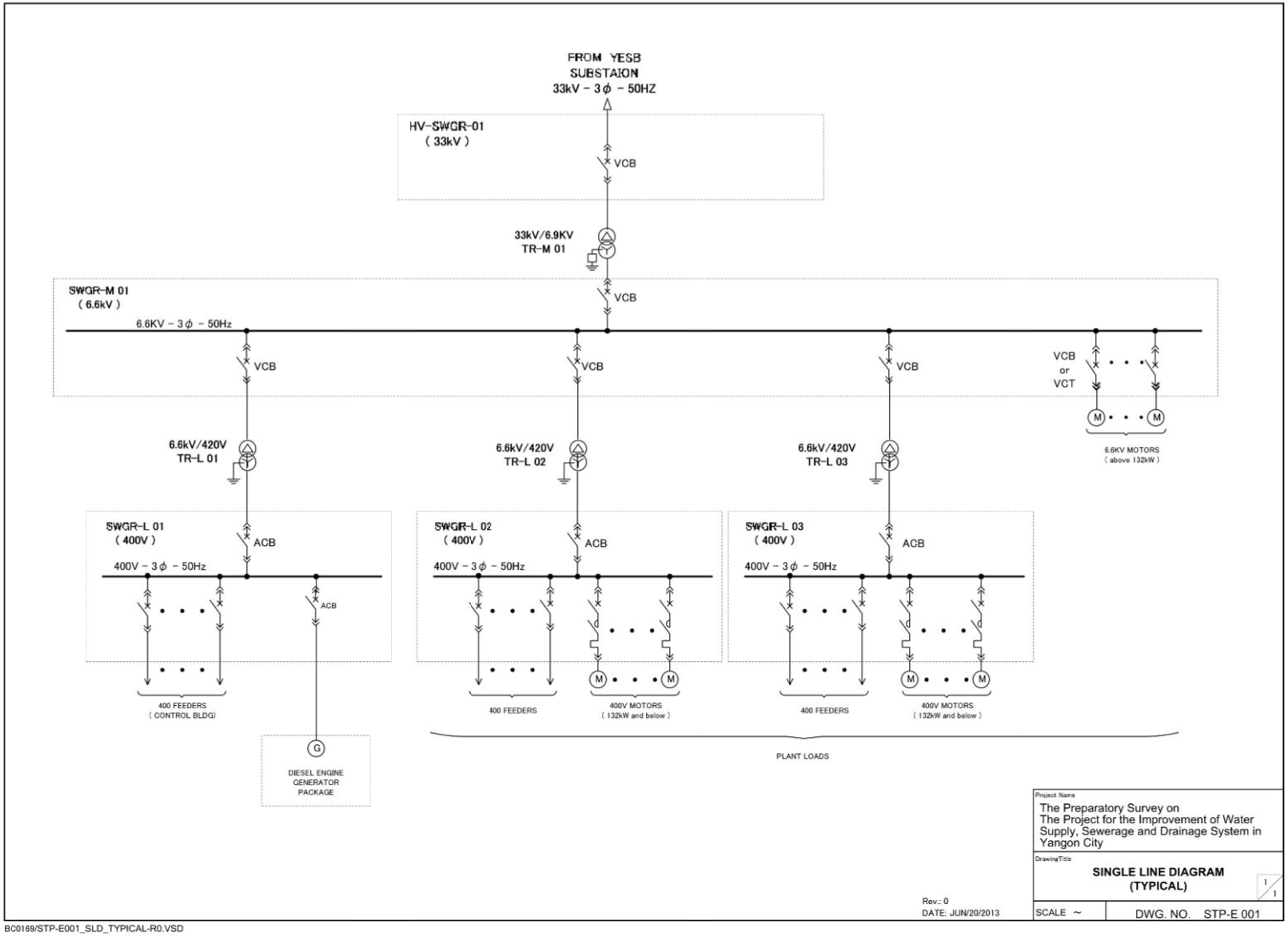
Table D.1 Electricity Consumption by Water Supply System in Yangon

Electricity Consumption and Cost of Yangon Resion Water Systems

	Month	Apr. 2011	May. 2011	Jun. 2011	Jul. 2011	Aug. 2011	Sep. 2011	Oct. 2011	Nov. 2011	Dec. 2011	Jan. 2012	Feb. 2012	Mar. 2012	Fixed Charge Kyats	Variable Charge (Up to 2011) Kyats/kWh	Variable Charge (2012) Kyats/kWh
Nyaunghanpin Water Treatment	kWh	1,784,782	1,490,528	1,989,077	2,186,628	1,637,828	1,464,337	1,750,586	1,549,806	1,352,806	1,549,333	1,432,826	1,496,277	1,720,800	25	35
	Kyat	46,340,350	38,984,000	51,447,725	56,386,500	42,666,500	38,329,225	45,485,400	40,465,950	35,540,950	55,772,495	51,869,710	54,090,495			
Gyobyu Water Treatment	kWh	888	528	1,515	1,172	1,314	1,181	1,294	1,210	2,429	1,786	2,098	1,816	15,800	25	35
	Kyat	38,000	26,600	53,675	45,100	48,650	45,325	48,150	46,050	76,525	78,310	89,230	102,960			
North Dagon (South Dagon No.1) Water Treatment	kWh	706	551	551	66	60	50	60	100	2,178	651	414	607	5,400	25	35
	Kyat	23,050	19,175	19,175	7,050	6,900	6,650	6,900	7,900	58,850	28,185	19,890	26,645			
South Dagon (South Dagon No.2) Water Treatment	kWh	52,008	48,736	51,040	49,896	47,344	45,232	44,000	49,984	44,088	56,936	62,040	58,784	72,600	25	35
	Kyat	1,372,800	1,166,000	1,348,600	1,320,000	1,256,200	1,203,400	1,172,600	1,322,200	1,174,800	2,065,360	2,244,000	2,130,040			
Theaphyu Water Treatment	kWh	34,848	28,952	24,112	28,160	37,576	28,078	31,680	37,312	43,384	43,120	40,392	33,792	72,600	25	35
	Kyat	943,800	796,400	675,400	776,600	1,012,000	774,550	864,600	1,005,400	1,157,200	1,581,800	1,486,320	1,255,320			
Yangonpauk Water Treatment	kWh	35,024	97,944	60,720	47,520	29,040	39,952	60,984	66,088	58,256	61,160	58,960	50,248	72,600	25	35
	Kyat	948,200	2,521,200	1,590,600	1,260,600	798,600	1,071,400	1,597,200	1,724,800	1,529,000	7,213,200	7,136,200	1,831,280			
Aungtagon Pump Station	kWh	1,164,583	969,258	1,133,384	1,055,106	1,012,898	1,078,467	1,012,023	730,498	1,364,838	2,026,561	1,023,728	1,067,665	1,140,400	25	35
	Kyat	30,254,975	25,371,850	29,475,000	27,518,050	26,458,650	28,097,875	26,436,775	19,398,650	35,237,150	72,065,835	36,966,680	38,504,475			
Hlawga Pump Station	kWh	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	33,255	36,020	40,800	58,800	25	35
	Kyat	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	1,322,775	1,319,500	1,486,800			
Phugyi Pump Station	kWh	685,300	527,210	941,490	739,310	217,580	315,480	341,770	375,980	505,120	489,500	664,840	864,710	863,000	25	35
	Kyat	17,995,500	14,041,000	24,400,250	19,345,750	6,302,500	8,750,000	9,407,250	10,262,500	13,490,000	17,995,500	24,132,400	31,127,850			
Yegu Pump Station	kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	35
	Kyat	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400			
Gyobyu Pump Station -> Jointed in Gyobyu WT	kWh															
	Kyat															
Waste Water Treatment	kWh	15,576	13,552	13,992	15,048	14,960	14,784	15,488	15,400	13,904	15,312	13,640	13,258	72,600	25	35
	Kyat	462,000	411,400	422,400	448,800	446,600	442,200	459,800	457,600	420,200	608,520	550,000	537,680			

	Month	Apr. 2010	May. 2010	Jun. 2010	Jul. 2010	Aug. 2010	Sep. 2010	Oct. 2010	Nov. 2010	Dec. 2010	Jan. 2011	Feb. 2011	Mar. 2011
Nyaunghanpin Water Treatment	kWh	1,651,057	1,501,798	1,471,814	1,685,196	1,709,906	1,598,181	1,634,303	1,531,458	1,325,033	1,624,999	1,797,648	1,798,764
	Kyat	42,997,225	39,265,750	38,516,150	43,850,700	44,468,450	41,674,076	42,578,376	40,007,250	34,846,625	42,345,277	46,662,080	46,662,000
Gyobyu Water Treatment	kWh	998	998	998	998	998	998	6,336	971	1,068	2,060	1,768	1,768
	Kyat	40,750	40,750	40,750	40,750	40,750	40,750	174,200	40,075	42,500	67,300	60,000	60,000
North Dagon (South Dagon No.1) Water Treatment	kWh	450	477	450	221	422	1,127	540	577	309	635	538	538
	Kyat	16,650	17,325	16,650	10,925	15,950	33,575	18,900	19,825	13,125	21,275	18,850	18,850
South Dagon (South Dagon No.2) Water Treatment	kWh	40,832	33,616	46,200	36,520	45,760	45,496	43,472	48,664	46,288	55,704	45,408	45,408
	Kyat	1,093,400	913,000	1,227,600	985,600	1,216,600	1,210,000	1,159,400	1,289,200	1,229,800	1,465,200	1,207,800	1,207,800
Theaphyu Water Treatment	kWh	21,648	22,176	24,112	32,208	29,128	25,608	33,352	32,120	32,208	37,336	40,216	39,600
	Kyat	613,800	627,000	675,400	877,800	800,800	712,800	906,400	875,600	877,800	1,056,000	1,078,000	1,062,600
Yangonpauk Water Treatment	kWh	41,712	11,352	24,904	19,360	2,112	39,360	41,536	41,096	34,056	57,024	37,048	37,048
	Kyat	1,115,400	356,400	965,200	556,600	92,200	996,600	1,111,000	1,100,000	924,000	1,498,200	998,800	998,800
Aungtagon Pump Station	kWh	70,301	1,201,218	1,272,322	1,300,861	714,254	1,085,774	1,122,264	969,517	991,322	882,457	1,007,202	969,800
	Kyat	18,722,925	31,170,850	32,948,450	33,661,925	18,996,750	28,284,750	29,197,000	25,378,325	23,923,450	23,201,825	26,320,450	25,385,400
Hlawga Pump Station	kWh	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000
	Kyat	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800	608,800
Phugyi Pump Station	kWh	1,048,850	772,640	806,300	766,700	877,800	662,640	684,200	704,990	872,820	617,430	573,210	573,210
	Kyat	26,869,850	19,964,600	20,806,100	19,816,100	22,593,600	17,214,600	17,753,600	18,273,350	22,461,600	16,084,350	14,978,850	14,978,850
Yegu Pump Station	kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Kyat	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400	691,400
Gyobyu Pump Station -> Jointed in Gyobyu WT	kWh												
	Kyat												
Waste Water Treatment	kWh	19,008	15,400	12,408	14,520	13,992	13,464	13,376	13,288	13,640	14,080	12,760	12,760
	Kyat	547,800	457,600	382,800	435,600	422,400	409,200	407,000	404,800	413,600	424,600	391,600	391,600

Source: JICA Study Team



Source: JICA Study Team

Figure D.2 Single Line Diagram

E COST ESTIMATION

(1) The Result of Cost Estimation for Kandawgyi Interceptor Facility

Non-disclosure Information

Non-disclosure Information

Non-disclosure Information

Non-disclosure Information

(2) The Result of Cost Estimation for STP Term-I

Non-disclosure Information

Non-disclosure Information

Non-disclosure Information

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(3) The Result of Cost Estimation for STP Term-II

Non-disclosure Information

Non-disclosure Information

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Non-disclosure Information

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Non-disclosure Information

Non-disclosure Information

Non-disclosure Information

(4) The Result of Cost Estimation for Sewer Network

Non-disclosure Information

Non-disclosure Information

Non-disclosure Information

(5) Operation and Maintenance Cost

Kandawgyi Interceptor Facility

O&M Cost of Kan Daw Gyi 5,809 m3/day

(USD)

Item	Cost
Salary	1,116
Electricity	11,615
Maintenance(Spare parts)	4,304
Sludge cake	0
Chemical	0
Sewer	279
Other cost	341
Total	17,655

0.84

(USD)

Item	Unit Price
Salary (engineer: month)	203
(technitian:month)	106
(common :month)	93
Electricity (/kWh)	0.040
Sludge Cake (/m3)	5
Choline (/kg)	1.7
Polymer (/kg)	5.1
Coagulant (/kg)	1.0
% of Maitenance	1.60

(1) Salary

	person	unit cost	(USD)
No. of worker (engineer)		203	= 0
No. of worker (technitian)		106	= 0
No. of worker (common)	1	93	= 1,116
sum	1		1,116

(2) Electeicity

	kWh	kWh/year		
Amount of kWh	723	263,975	0.040	= 10,559
sum				11,615

(3) Maintenance(Spare parts)

Non-disclosure Information

(4) Sludge cake

	m3/day	m3/year		
Amount of Sludge Cake		0	5.0	= 0
sum				

(5) Chemical

	kg/day	kg/year		
Amount of Chlorine		0	1.7	= 0
Amount of Polymer		0	5.1	= 0
Amount of Coagulant		0	1.0	= 0
sum				

(6) Sewer Total length (m)

= 279

279

C1 Sewerage System

O&M Cost of C1 64,300 m3/day

(USD)

Item	Cost
Salary	40,860
Electricity	281,634
Maintenance(Spare parts)	543,600
Sludge cake	89,184
Chemical	100,543
Sewer	41,352
Other cost	21,116
Total	1,118,290
	4.82

(USD)

Item	Unit Price
Salary (engineer: month)	203
(technitian:month)	106
(common :month)	93
Electricity (/kWh)	0.040
Sludge Cake (/m3)	5
Choline (/kg)	0.51
Polymer (/kg)	1.5
Coagulant (/kg)	1.0
% of Maitenance	1.60

(1) Salary

	person	unit cost	(USD)
No. of worker (engineer)	5	203	= 12,180
No. of worker (technitian)	5	106	= 6,360
No. of worker (common)	20	93	= 22,320
sum	30		40,860

(2) Electeicity

	kWh	kWh/year		
Amount of kWh	19,290	7,040,850	0.040	= 281,634
sum				281,634

(3) Maintenance(Spare parts)

Non-disclosure Information

(4) Sludge cake

	m3/day	m3/year		
Amount of Sludge Cake	49	17,837	5.0	= 89,184
sum				89,184

(5) Chemical

	kg/day	kg/year		
Amount of Chlorine	193	70,409	0.5	= 35,908
Amount of Polymer	116	42,245	1.5	= 64,635
Amount of Coagulant		0	1.0	= 0
sum				100,543

(6) Sewer	Total length (m)		
	58,620	41,352	= 41,352
			41,352

F ECONOMIC AND FINANCIAL ANALYSIS

(1) Questionnaire Survey for Improvement of Lake Water

SI _____

1. How often do you come to the lake?

1) everyday 2) once a week, 3)once a month, 4) 2-3 times a month 5) 2-3 times a year 6) once a year, 7) this is first time?

If The answer is 7) then

2. Have you experienced environmental deterioration of lake last few years?

3. What do you think of the lake water?

4. Are you aware that the lake's green color is reflection of algae growth?

YES NO

5. Are you aware of the JICA working on this problem with a test plant?

YES NO

6. How much have you paid to enter the park today?

_____

7. How much in addition would you be willing to pay per your visit i for entrance fee if lake water quality is improved?

1) +100 2) +200, 3)+300, 4)+400 5)+500, 6)MORE THEN +600 %? How much

8. Your profile

Place of Residence:

AGE:

PROFESSION:

DATE _____ INTERVIEWER _____

Instructions for Interview Survey

1. Finding a respondent:

We would like to have answers from all kinds of background including age, purpose of visits, income, sex etc. So please try to approach different type of visitors each time, such as young one after old person, woman after man. Please do not include children. Look for someone above 20.

During daytime there are only few visitors so that the interviews are not efficient. It is more efficient during early evening and morning or holidays.

2. Starting questions

-First introduce yourself as a surveyor working for a project undertaken by Japanese Government and city of Yangon to improve environment.

- The interview would only take 5 minutes of easy questions. Only start asking after receiving the OK from the respondent.

- For numerical questions you can ask the upper side and lower side such as visiting the park once a week or one a year and then can narrow down to more specific zone.

- If the visitor is the first timer, you can skip the question 2, because it is not possible to answer this.

3. Filling answers

After you finished asking, please thank the respondent and make sure the answers you write are clearly readable. Make corrections on the spot immediately. Do not depend on your memory for later corrections.

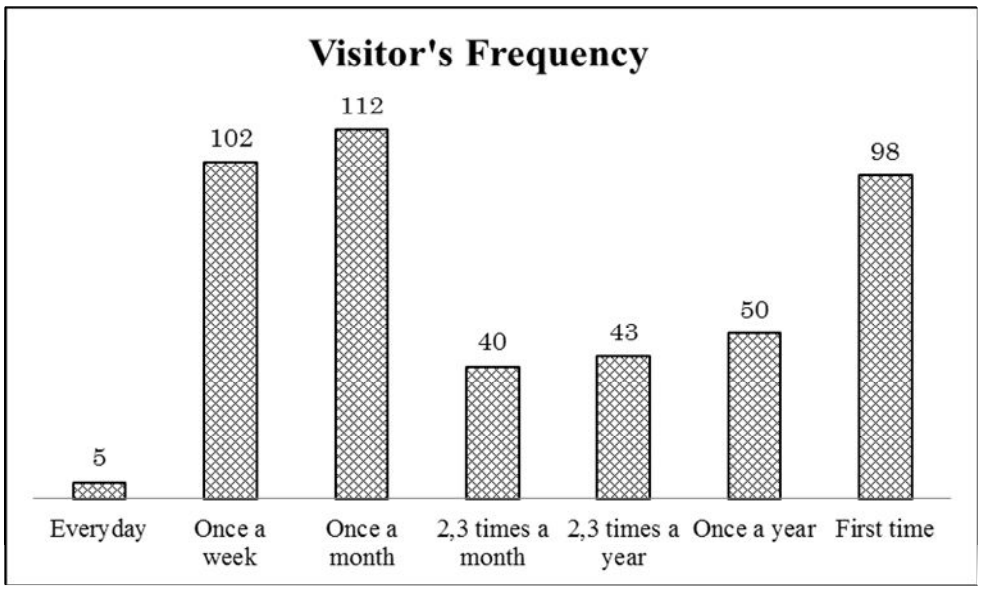
(2) Kandawgyi Lake Survey Report

JICA Study Team had undertaken an interview survey regarding the improvement of water quality in the Kandawgyi Lake. The survey period was June 3 to 10. The Survey included 4 weekdays and 2 weekend days. Recruited and trained three interviewers asked the visitors to the park by randomly selecting the respondents. They obtained answers from 451 persons, approximately 150 persons by each interviewer.

The questions are as follows;

1. How often does the respondent come to the lake?
2. Have the respondent experienced environmental deterioration of lake last few years?
3. What do the respondent think of the lake water?
4. Are the respondents aware that the lake's green color is reflection of algae growth?
5. How is the respondent aware of the JICA working on this problem with a test plant?
6. How much have the respondent paid to enter the park today?
7. How much in addition would the respondent be willing to pay per respondent's visit for entrance fee if lake water quality is improved?
8. The respondent profile: Place of residence, Age, Profession
   (For the detail please refer to Appendix F1.)

Question No.1, visitor's frequency is shown by Figure F.1. Everyday visitors were 5 persons among 451 persons, comprising 1 %. Visitors responding once a week and once a month are the largest groups, comprising 23%, and 25% respectively of the total. The third largest group is the first time visitors, 22%. Two or three times a month and two or three times a year visitors is almost same, approximately 10%.



Source: JICA Study Team

Figure F.1 Visitor's Frequency

Question number 2 asked about the environmental deterioration experience of lake in last few years. The answer was addressed to the groups except for the first time visitors. It is Yes and No answer. The respondents also added their comments such as (Before, it's not dirty like that.) (It's a lot of rubbish.) (May be it is because of Nargis cyclone.).

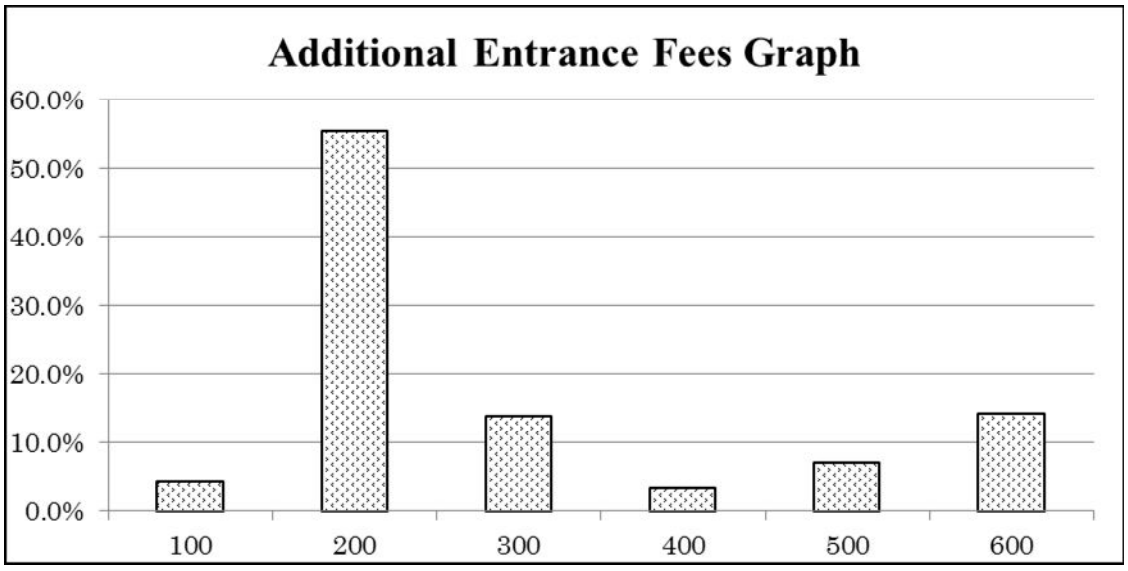
Question number 3 asked about what the respondent thinks of lake's color. After classification, the answers are almost identical. The lake is dirty and smelly, thus it needs improvements.

Question number 4 asked whether the respondent is aware that the lake's green color is reflection of algae growth? Among 451 persons, 446 persons answered YES i.e., 99%, and NO were only 1%.

Question number 5 asked whether the respondent is aware of the JICA working on the lake water problem with a test plant. Those who answered YES were 56%, and NO were 44%.

Question number 6 asked how much the respondent paid to enter the park on that day. Most of visitors paid 300 Kyats. But, there were some variations in the entrance fee and some foreigners paid in dollars.

Question number 7 asked how much more the respondent would be willing to pay per visit as entrance fee if lake water quality is improved. The distribution of answers is shown in Figure F.2. The largest group chose additional fees of 200 Kyats, i.e., 55%. The groups of additional fee of 300 and 600 Kyats both comprise 14% of the total. The groups with additional fees of 100 and 400 Kyats comprise 4% and 3% respectively. 500 Kyats group is comprised of 32 persons, 7% of the total. The average additional amount that visitors can pay (as per survey) for improved lake water quality is 296 Kyats.

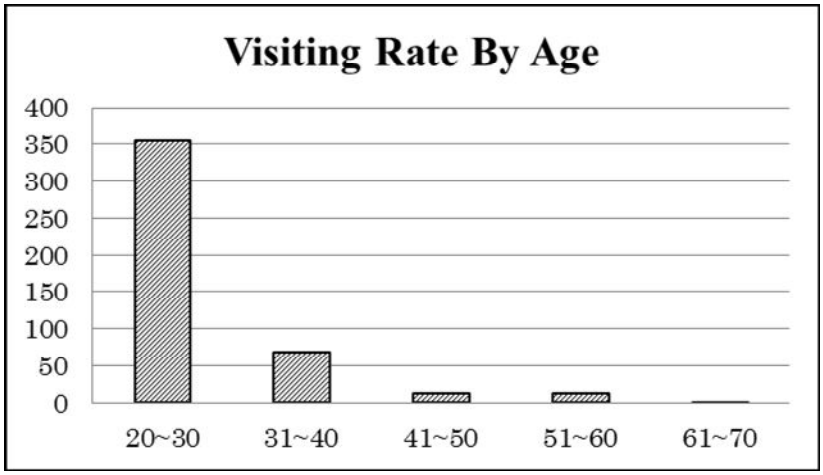


Source: JICA Study Team

Figure F.2 Additional Entrance Fees

The age profile of the respondents shows that the age group of twenties is the largest, 79%. The respondent in the age group of thirties was 15%, in the forties was 3%, and in the fifties was 3%. Only

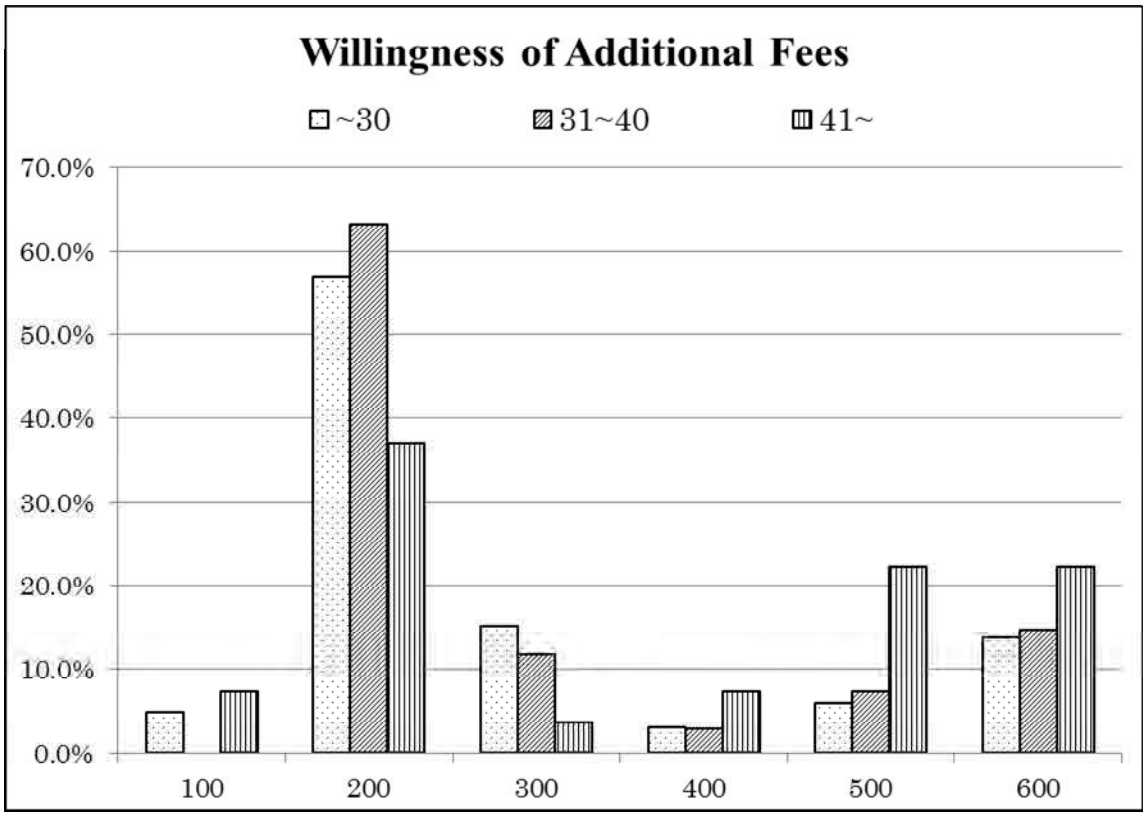
1% of the respondents were in the age group of sixties.



Source: JICA Study Team

Figure F.3 Respondent Age Group

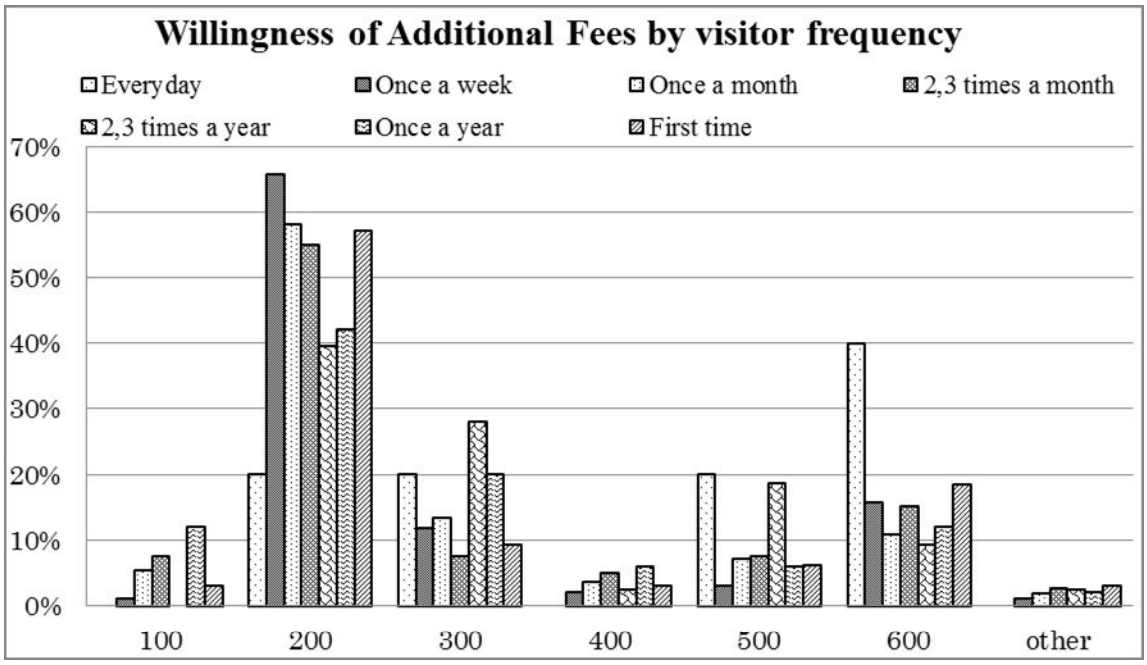
Figure F.4 shows the analysis of willingness to pay for lake water improvements by age group. 57% of the age group 20-30 is willing to pay additional 200 Kyats and 15% is willing to pay additional 300 Kyats. There are substantial number of respondents within the age group of over 40 willing to pay additional 500 Kyats and 600 Kyats reflecting larger paying capacities of the group.



Source: JICA Study Team

Figure F.4 Willingness of Additional Fees by Age Group

Figure F.5 shows the additional fees by frequency of visits. Naturally all groups are concentrated in the 200 Kyat bracket. The willingness to pay of the group of everyday visit is concentrated in the top category of additional 600 Kyat, reflecting their strong attachment to the lake. The group of once a year visit are more evenly distributed reflecting the minimal financial impacts due to less frequency.



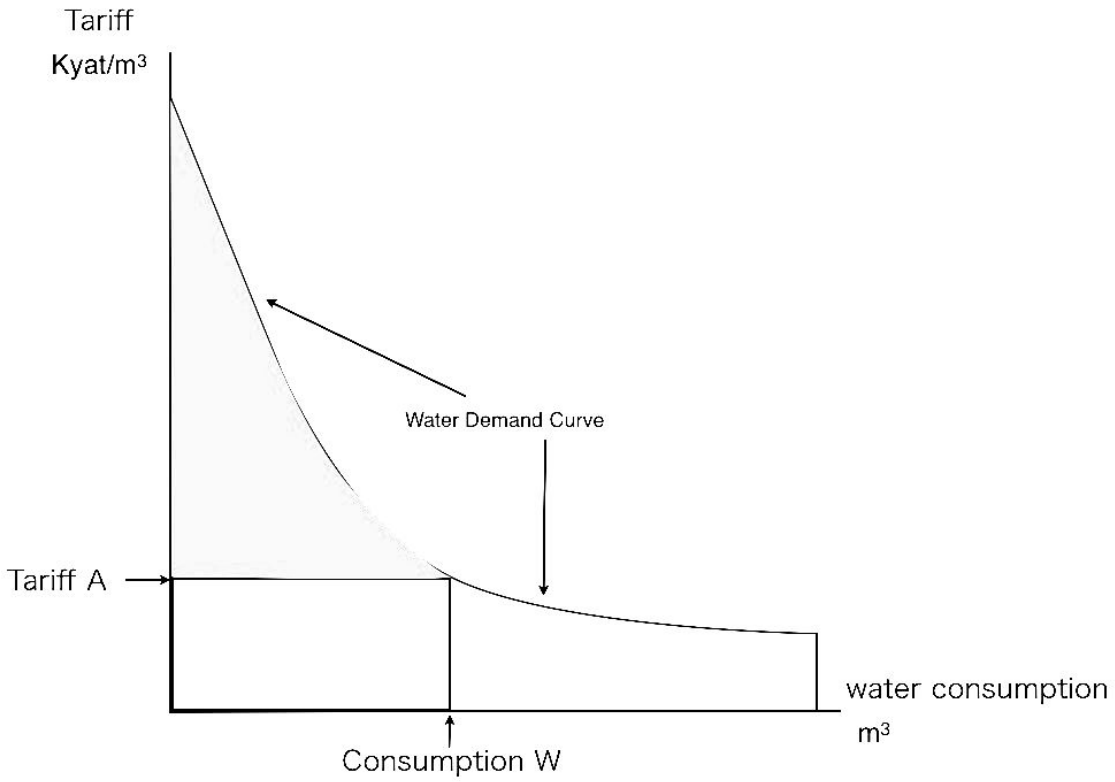
Source: JICA Study Team

Figure F.5 Willingness of Additional Fees by Visitor Frequency

Almost all respondents understood the problem of the lake water quality and expressed a need for improvement. The average willingness to pay for improvement was 296 Kyat.

(3) Methodology for Economic Benefits Deriviation

Here, an attempt is made to explain a basic theory on willingness-to-pay, and economic benefit in water supply and sanitation. For easy exposition of the case, the demand for both water and sanitation is considered simultaneously. When citizens face a question on how much willing to pay for three liters of drinking water a day, they would be willing to pay as much as they are paying for bottles of mineral water now. For example, the ongoing prices for mineral water delivery in Yangon range from 60 thousand to 100 thousand Kyats per cubic meter of water. The prices are close to one thousand times more expensive than the current municipal water service. It is quite natural to pay more for bodily intake of water for the sake of safety. Willingness to pay would rapidly decline for the use of water for washing dishes or taking showers. Still the willingness may be higher than the current price of 88 Kyat per cubic meter for municipal water service. Going down the list of water use, the water usage for cleaning floors and flushing toilets will fetch even lower prices in normal circumstances. If the demand for water is accumulated from high valued uses to lower valued uses horizontally with corresponding unit-wise willingness to pay vertically, the graph would appear as shown in Figure F.6.



Source: JICA Study Team

Figure F.6 WTP Curve for Water and Sanitation Service

If a water supply corporation set the tariff at the point A, the customer will only consume water up to the point W in the graph. In this case the customer spends the payment for water represented by the blue rectangle. On the other hand, the value of customer benefit would be equal to the combined red and blue areas. The marginal benefit starting the very first liter of consumption represented by the

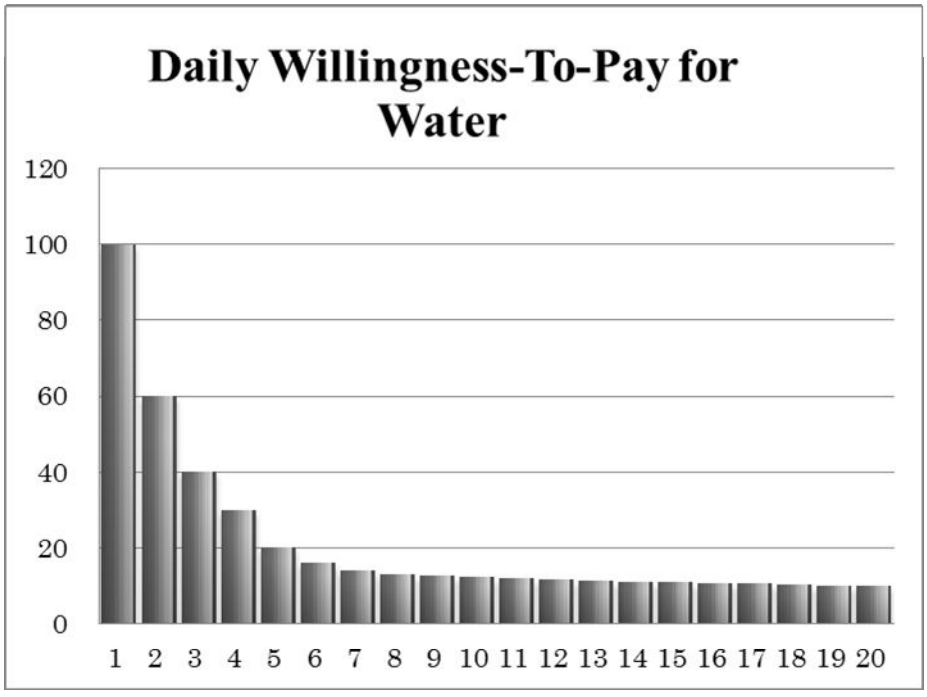
origin and the consecutive liters will gradually decline along the slope of the water demand curve in the graph. Therefore the cumulative benefit is equal to the areas represented by red and blue shapes.

From the social perspective, the most influential determinant for willingness to pay for water is the level of income of each individual. Naturally, higher income customers are willing to pay more for the same quantity of consumption due to the higher paying capacities. Let us assume that the society consisting of twenty consumers as shown in Table F.1. The customers are rearranged from higher income customers to lower with corresponding willingness to pay for one cubic meter of water as shown in the graph depicted in Figure F.7. As is the case with Figure F.6, the curve in F.7 shows a downward slope. The downward slope can be considered as the societal demand curve for water, consisting of different income groups. More precisely, the real societal demand is derived by adding individual downward sloped demand curves to create a societal demand curve which is more gradual but equally downward sloped demand curve. Obviously, when a water supply sets an equal tariff for any consumption, a higher income person would benefit more than lower income person. As the demand curve is followed down to the tariff level the corresponding income customer has less and less extra benefit beyond the price of water. The accumulated values from highest to the tariff level and supplied quantity is equal to the societal total benefit for the particular quantity and tariff according to the standard economic theory.

Table F.1 Income Level and Corresponding Demand for Fictitious 20 Person Society

Daily Water Supply	Income	WTP for 1m3/day
1	5,000	100
2	3,000	60
3	2,000	40
4	1,500	30
5	1,000	20
6	800	16
7	700	14
8	650	13
9	630	13
10	610	12
11	590	12
12	570	11
13	560	11
14	550	11
15	540	11
16	530	11
17	520	10
18	510	10
19	500	10
20	490	10

Source: JICA Study Team



Source: JICA Study Team

Figure F.7 Water Demand Curve Created from the 20 Person Willingness-To-Pay Model

G ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

1. Environmental and Social Baseline Data.

1.1 Population and Area

The population and area of four townships in C1 zone are shown in the Table below.

Table G1 Population and Area of C1 Sewerage Zone

Township	Area (ha)	Population			Household	Density (pop/ha)
		2011	2025	2040	2011	2011
Pabedan	62	37,551	37,551	37,551	5,366	606
Kyauktada	70	34,797	34,797	34,797	6,078	497
Botahtaung	260	49,134	49,134	49,134	8,148	189
Pazundaung	107	53,648	54,822	56,647	8,258	501
Total	499	175,130	176,304	178,129	27,850	351

Source: JICA Study Team

1.2 Existing Infrastructure and Services

The existing infrastructure and services of four townships are shown in the table below. The CBD district is old and developed so that there is no significant difference among four townships.

Table G2 Infrastructure Services in C1 Zone

Township	Electricity		Piped Water Supply		Sewage		Sludge Removal from Septic Tank		Telephone (Fixed)		Solid Waste Collection	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Pabedan	100%	0%	86%	14%	91%	9%	70%	30%	71%	29%	95%	5%
Kyauktada	100%	0%	82%	18%	82%	18%	65%	35%	74%	26%	92%	8%
Botahtaung	100%	0%	84%	16%	74%	26%	71%	29%	63%	37%	91%	9%
Pazundaung	100%	0%	89%	11%	82%	18%	79%	21%	73%	27%	94%	6%
Yangon	*88%*	*12%*	*40%*	*60%*	*44%*	*56%*	*49%*	*51%*	*26%*	*74%*	*72%*	*28%*

Source: JICA Study Team

The access to the toilet facilities is shown in the table below. The sewerage system in CBD district is developed so that most of the household own the pour-flush and flush toilet.

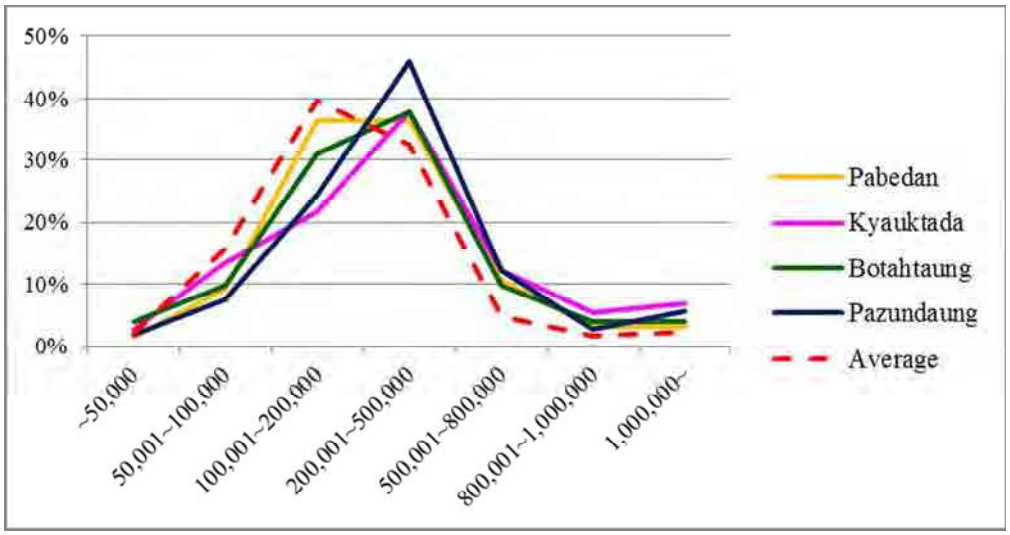
Table G3 Access to Toilet Facility

Township	No Toilet	Pit Latrine	Pour-flush Toilet	Flush Toilet
Pabedan	1.5%	0.0%	83.3%	15.2%
Kyauktada	0.0%	0.0%	74.3%	25.7%
Botahtaung	0.0%	1.9%	82.5%	15.5%
Pazundaung	0.0%	2.8%	81.3%	15.9%
Yangon	*0.6%*	*11.1%*	*82.6%*	*5.8%*

Source: JICA Study Team

1.3 Socio-Economic Situation

The monthly income distribution by township is shown in the figure below. Compared with the average, the high income distribution is above the average in the townships in C1 zone so these areas are relatively wealthy area.



Source: JICA Study Team

Figure G1 Income Distribution in C1 Zone

The education level of each township is shown in the table below. The level of income and education is correlative.

Table G4 Education Level in C1 Zone

Township	Master Degree/ Doctoral Degree	University	Diploma	High School	Middle School	Primary School	Lower Primary
Pabedan	3%	36%	3%	23%	9%	18%	8%
Kyauktada	0%	32%	4%	24%	27%	5%	7%
Botahtaung	3%	32%	1%	17%	27%	14%	6%
Pazundaung	1%	49%	3%	21%	20%	2%	5%
Yangon	*1%*	*19%*	*0%*	*12%*	*29%*	*24%*	*15%*

Source: JICA Study Team

1.4 Air Quality

YCDC is not monitoring the air quality regularly. The existing data of air quality is the results of the measurements of April 2007 and January 2008 by NCEA. The air quality standards are not established yet in Myanmar. Comparing the WHO standards, the values of PM10 and TSP are higher than the standards.

Source: JICA Study Team

Figure G2 Measurement Location of Air Quality

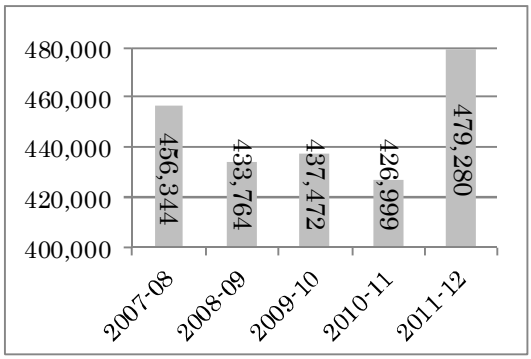
Table G5 Results of Air Quality

Site	Date	TSP (ug/m^3)	PM10 (ug/m^3)	SO2 (ug/m^3)	NO2 (ug/m^3)
1. Commercial site (Traders Hotel)	April, 2007	342.58	177.69	-	-
	Jan, 2008	143.21	71.75	-	-
2. Residential site (IBC)	April, 2007	168.61	68.59	1.14	23.22
	Jan, 2008	118.70	65.30	1.24	22.28
3. Surrounding site near to industrial zone (Forest Department Head Quarter)	April, 2007	127.37	66.95	0.37	28.36
	Jan, 2008	188.66	136.92	0.25	25.42
WHO (2005 updated)		100	50.00	20.00	40.00

Source: DPCC, YCDC

1.5 Waste

Department of Pollution Control and Cleansing (DPCC) of YCDC is responsible for waste management in Yangon City. DPCC implemented the waste generation survey from 2011 to 2012 and it identified that the waste generation is 0.396 kg per person per day. Among the waste, 76 % is organic, 10% plastic, and 4 % is paper and textile. Waste collected is (1,550 ton per day), around 92 % of total generation. 62 % of collected waste comes from household waste, 35 % from commercial and market waste and 0.1% from the hospital. The amount of disposed waste at the dumping site is 1,250 – 1,400 ton per day in the past 5 years. The amount decreased from 2007 to 2010, but increased from 2010 to 2011. The considerable reasons for decrease are: illegal dumping, recycling activities and capital relocation. The recent increase may be caused by the increase of economic activity and reduction of illegal dumping by control. The amount of waste generation from 2012 to 2013 is 1,690 ton/day.



Source: DPCC, YCDC

Figure G3 Solid Waste Amount

There are two main final disposal sites and five temporary sites in Yangon City. These two disposal sites are open and receive waste for 24 hour/day, operated by DPCC. The temporary sites are supervised by DPCC.

Figure G4 Location of Waste Disposal Site

The Htein Bin landfill site is located at 30 km north-west of center of Yangon City. The area is 150 acre (60 ha) and 847 ton /day of solid waste is disposed. The landfill is divided into 16 blocks and one block is 150 m on a side and 3 m depth. The measure to prevent the infiltration to ground is not taken. 10 blocks among 16 blocks are occupied with the solid waste. The Htein Bin landfill accepts the industrial and construction waste and the disposal fee is 5,000 Kyat for first one ton and 2,000 Kyat /ton for the rest of the weight. The medical waste is incinerated at the incinerator located near the Htein Bin landfill. The project is under preparation to generate the electricity and 92% biogas by using the methane gas which will be generated from the solid waste. The construction of the facility may start in November 2013 at the earliest.

The Htawe Chaung landfill is located at 26 km north of Yangon City. The area is 150 acre (60 ha) and 612 ton /day of solid waste is disposed. The landfill is open dumping and no measurement to prevent the pollution of soil and groundwater is taken. There is plan to generate electricity by incinerator.

The recycle activities are implemented by YCDC and the private agencies. The DPCC of YCDC implements the awareness activities to the public and students to enhance recycling. The amount of recycle waste is 86 ton/day.

Table G6 Recycled Waste

Item	Ton/day
Plastic	5.1
Paper	8.94
Carton	11
Leather	0.1
Iron	0.5
Metal	0.3
Copper	0.3
Lead	0.1
Glass	40.5
Can	5.1

Source: DPCC, YCDC

1.6 Cultural Heritage

189 buildings which were constructed before 1950 are registered as cultural heritage buildings by YCDC in 1996. The buildings are located in twenty-one townships and 25 % of the buildings (forty-eight) are located in the Kyauktada and Botahtaung Townships, center of the Yangon City. 49 % of the heritage buildings are religious buildings such as Pagoda, temple and mosque, and 28 % is used as office buildings.

1.7 Fauna, Flora and Biodiversity

The biodiversity inventory has not yet been completed in Myanmar, it is officially stated that there are 153 endangered species. In Greater Yangon, it is recorded that three are threatened animal species and two threatened plant species as shown in the Table below.

Table G7 Endangered Animal Species and Plant

No.	Scientific name	Common name	Family	IUCN, 2011
1	Lissemys punctata 	Indian flap shell turtle	Trionychidae	Endangered (EN) 絶滅危惧IB類
2	Indotestudo elongate 	Yellow tortoise	Testudinidae	Endangered (EN) 絶滅危惧IB類
3	Python molurus divittatus 	Burmese Python	Boidae	Endangered (EN) 絶滅危惧IB類
4	Dipterocarpus alatus 	Kanyin-phyu	Dipterocarpaceae	Endangered (EN) 絶滅危惧IB類
5	Hopea Odorata 	Thin-Gan	Dipterocarpaceae	Vulnerable (VU) 絶滅危惧II類

Source: JICA Urban Plan Study, 2012

1.8 Kandawgyi Lake

The Kandawgyi Lake is located in the center of Yangon City, this is the artificial lake used as the water source constructed in 1879. The water of Inya Lake was transmitted in 1884 as the demand of water increased due to the population increase. However, as the development of the City, the amount and quality of lake water was not appropriate for drinking water and finished its role in 1904. The lake surrounding is 8 km, the lake area is 64.7 ha and depth is around 3 m. 44.5 ha of park surrounds the lake and 28 ha of Yangon Zoological Garden is located next to the park. Many citizens visit the Kandawgyi Park and 31 % of the respondents of HIS answered the Kandawgyi Park is their favorite park. Around twelve commercial facilities such as restaurants and hotel are located in the vicinity and the wastewater is treated by the simple treatment system (grease trap, septic tank etc.) and the effluent is discharged into the Lake. There is no water flow from the south and east by the geographic features. The five drains in the catchment area of Bahan and Tarmwe, flow into the Lake, and the water quality of the Lake is deteriorated due to the inflow of the wastewater.

2. Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) - (c) - (d) -	(a) The laws and regulations related to EIA are under preparation in Myanmar. Environmental and social considerations at IEE level was implemented in F/S stage according to JICA Guidelines. (b) (c) (d)
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) Y (b) -	(a) The stakeholder meeting related to the M/P and selection of priority project was implemented in April 2013. The stakeholder meeting to inform the results of IEE study was organized on 17 July 2013. (b) The comments raised by the participants in the first stakeholder meeting were covered by the Study. The questions in the second stakeholders were answered and there is no comments to be reflected to the project design.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) The project is the rehabilitation of the existing WWTP so that there are not many alternatives. Related to the trunk main, alternatives for the rehabilitation or replacement or re-construction were considered and the traffic disturbance, generation of waste and water pollution were examined for the alternatives.
2 Pollution Control	(1) Water Quality	(a) Do pollutants, such as SS, BOD, COD, pH contained in treated effluent from a sewage treatment plant comply with the country's effluent standards? (b) Does untreated water contain heavy metals?	(a)- (b) N	(a) There are no effluent standards in Myanmar. The standards as BOD 20mg/l and SS 30 mg/l are adopted for the project. (b) No factories or industries are operated in the CBD area so that the heavy metals may not be included in the wastewater.
	(2) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed of in accordance with the country's standards?	(a) -	(a) There are no standards for disposal of the sludge in Myanmar. The heavy metals are not included in the wastewater so that the sludge can be reused for the parks and agriculture and the rest should be treated at the waste dumping site.
	(3) Soil Contamination	(a) If wastes, such as sludge are suspected to contain heavy metals, are adequate measures taken to prevent contamination of soil and groundwater by leachates from the wastes?	(a) -	(a) As the sludge does not contain the heavy metal, the measures are not required. The sludge treatment and storage facilities should be provided as the prevention measures for soil contamination and the details will be considered during the detail design.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as sludge treatment facilities and pumping stations comply with the country's standards?	(a) -	(a) The standards for noise and vibration are not yet established in Myanmar. The standards of IFC (70 dB) shall be applied till the standards will be established. To keep the standards, control is necessary such as proper maintenance of equipment and vehicles, turning off the engines and mufflers. The equipment which creates noise and vibration should be installed in the properly acoustically lined building and low-noise equipment should be adopted. There is no regulation for vibrations in Myanmar and it is proposed to follow the international standards, DIN 4150-3: Effects of vibration on structures. The equipment which causes the vibration should be carefully selected to keep the vibration level under DIA 4150-3.
	(5) Odor	(a) Are adequate control measures taken for odor sources, such as sludge treatment facilities?	(a) Y	(a) The process equipment for these operations is usually housed in buildings that are ventilated and sometimes have exhaust air odor treatment. Odors can be reduced or prevented through normal housekeeping and improved operation and maintenance design procedures.
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a)N	(a) There are no protected area in and near around the project site.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	(a)N (b)N (c)- (d)-	(a) Not included in the Project (b) Not included in the Project (c) (d)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensations going to be paid prior to the resettlement? (e) Is the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a)N (b)- (c)- (d)- (e)- (f)- (g)- (h)- (i)- (j)-	(a) 1.35 ha of land is required for the expansion of the WWTP and right to use the land belongs to the government so that there is no involuntary resettlement. (b)-(j) There is two-story buildings in the area used by the Navy. The necessity of compensation and the amount of compensation will be decided by the negotiation among the governmental agencies.
	(2) Living and Livelihood	(a) Is there a possibility that changes in land uses and water uses due to the project will adversely affect the living conditions of inhabitants? (b) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	(a)N (b)N	(a) The required land is not private land so that no impact is expected. (b) The construction will be implemented in the area of government, YCDC and public area (road). The traffic disturbance may be expected during construction (the mitigation measures are described in "5. Other, (1) Impact during construction").
4 Social Environment	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a)N	(a) There are heritage buildings within the project site. The discussion with Building department of YCDC and Yangon Heritage trust (NGO) was held and it was concluded no consideration is required.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a)N	(a) The expansion of the existing WWTP may not change any landscape and the trunk sewers are underground so that there is no impact expected.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to lands and resources respected?	(a)N (b)-	(a) There are no ethnic minorities and indigenous peoples within the Project site and no impact is expected. (b)
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a)- (b)Y (c)Y (d)Y	(a) Laws and regulations related to working conditions are not yet established. (b) The safety considerations should be prepared by the contractor which should meet the requirement of ILO standards to secure the safety of working conditions. (c) The safety training such as wearing working clothes and work shoes, use of temporary toilet, traffic safety and public health should be provided by the contractor. (d) The education such as behavior and manner of speaking to the citizen, the action to the complaint etc. should be provided to the security guard by the contractor.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? (d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?	(a)Y (b)- (c)Y (d)Y	(a) For the noise, vibration, dust and exhaust gases, the measures such as consideration of construction time, proper maintenance of construction vehicle, idling off and installation of mufflers should be taken. The excavated soil should be disposed of at the existing landfill. (b) No impact is expected. (c) No impact is expected. (d) During construction, the traffic disturbance may be expected. The mitigation measures such as prior notice of construction, provision of proper notice at site and alternative routes should be taken in cooperation with traffic police.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring	(a)Y (b)- (c)Y (d)-	(a) The monitoring system is not yet developed in Myanmar so that the proposed monitoring shall be implemented according to the JICA Guidelines. (b) No items, methods nor frequencies are stipulated. The monitoring of the complaints and actions to the complaint, noise and air quality shall be implemented. (c) The monitoring will be implemented during construction period and the responsible

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?		organization is the contractor under the supervision of YCDC. During operation period, the water quality analysis for influent and effluent should be implemented in the laboratory of WWTP and the necessary capacity development is proposed in the study. (d) The monitoring system is not yet developed, the report is sent to YCDC only.
6 Note	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a)-	(a)
1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.				
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).				
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which the project is located.				

3. Monitoring Form

3.1 IMPROVEMENT OF C1 SEWERAGE ZONE

In Myanmar, as the monitoring system is not yet established, the monitoring results should be reported to YCDC. The draft monitoring form is proposed.

(1) Construction

1. Response/Actions to the comments and guidance from the Governmental Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
Number and contents of formal comments made by the public	
Number and contents of responses from YCDC	

2. Pollution

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Noise level at WWTP	dB				70	
Noise level Merchant Road	dB				70	
Noise level Strand Road	dB				70	

* IFC General Health, and Safety (EHS) Guidelines, April 2007

- Air Pollution

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards*	Remarks (Measurement Point, Frequency, Method, etc.)
NO_2	$\mu g/m^3$				$40\mu g/m^3$:Annual mean $200\mu g/m^3$ 1-hour mean	
SO_2	$\mu g/m^3$				$20\mu g/m^3$:24 hour mean	
PM_{10}	$\mu g/m^3$				$50\mu g/m^3$ 24-hour mean	

***** Air Quality Guidelines Global Update 2005, WHO

- Water quality of groundwater

Item	Monitoring result	Mitigation measure
Turbidity		
Water level		

- Soil Quality

Item	Monitoring result	Mitigation measure
Spillage of oil		
Spillage of wastewater		

(2) Operation

1. Response/Actions to the comments and guidance from the Governmental Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
Number and contents of formal comments made by the public	
Number and contents of responses from YCDC	

2. Pollution

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Noise level at WWTP	dB				70	

* IFC General Health, and Safety (EHS) Guidelines, April 2007

- Water Quality of Inflow

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
BOD	mg/l				200	
SS	mg/l				180	

- Water Quality of Effluent

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
BOD	mg/l				20	
SS	mg/l				30	

- Soil quality

Item	Monitoring result	Mitigation measure
Spillage of wastewater		

3.2 IMPROVEMENT OF WATER QUALITY OF KANDAWGYI LAKE

In Myanmar, as the monitoring system is not yet established, the monitoring results should be reported to YCDC. The draft monitoring form is proposed.

(1) Construction

1. Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
Number and contents of formal comments made by the public	
Number and contents of responses from YCDC	

2. Pollution

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Interceptor along Kandawgyi Lake	dB				70	

* IFC General Health, and Safety (EHS) Guidelines, April 2007

- Air Pollution

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
NO_2	ug/m^3				40μg/m^3:Annual mean 200μg/m^3 1-hour mean	
SO_2	ug/m^3				20μg/m^3:24 hour mean	
PM_{10}	ug/m^3				50μg/m^3 24-hour mean	

***** Air Quality Guidelines Global Update 2005, WHO

4. Minutes of Public Consultation Seminar

Minutes of Public Consultation Seminar on
The Project for the Improvement of Water Supply,
Sewerage and Drainage System in Yangon City

Venue: Kandawgyi Palace Hotel (Yangon)
Date: 17 July 2013 (Wednesday)
Time: 14:00 am – 16:30 pm
Attendance:
As attached.
Agenda:
1) Opening Session
2) Presentation on the Priority Projects for Water Supply, Sewerage and Drainage System
3) Questions and Answers
4) Closing Session

Minutes:

1. Master announced the opening of the Public Consultation Seminar on the Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City at 14:00 am.
2. Master called for Opening Speech of H. E. U Kyaw Soe, Secretary of Yangon City. U Kyaw Soe gave an opening speech.
3. Master called for Opening Remark of Mr. Akihito Sanjo, Senior Representative of JICA Myanmar Office. Mr. Sanjo gave an opening remark.
4. Master called for the explanation. Mr. Sato of JICA Study Team made a presentation for “Outline of the JICA Project and Components of priority projects for water supply”, with the introduction of seminar agendas and the explanation of study schedule at the beginning.
5. Master called for the explanation and Mr. Miyamoto of JICA Study Team made a presentation for Priority Project for Sewerage System and Improvement of Kandawgyi Lake.
6. Master called for the explanation and Mr. Ohno of JICA Study Team made a presentation for Tariff Setting for Water Supply System.
7. Master called for the explanation and Mr. Nishimaki of JICA Study Team made a presentation for Tariff Setting for Sewerage System.
8. Master called for the explanation and Ms. Yamada of JICA Study Team made a presentation for Environmental and Social Considerations.

9. Master called for questions from audience for agenda 3).

a) Mr. Than Myint, Myanmar Engineering Society asked the questions:

- ✓ The drainage system was not explained in the presentation though the drainage system is included in the study name. Is it included in the study?
- ✓ The drainage plan was made for whole Yangon City?

  Mr. Miyamoto answered the question that:
- ✓ The drainage system was included in the Master Plan, which was presented in the previous public consultation seminar.
- ✓ The master plan for drainage system covers whole Yangon City.

b) Prof. Dr. Khin Ni Ni Thein, WRTC Myanmar made a comment to wrap up the seminar and questions.

- ✓ She gave the good rating to the presentation as well as the study contents and she appreciated that the questions she made in the previous public consultation seminar (financial analysis, environmental and social considerations etc.) were covered by this presentation.
- ✓ She requested YCDC to follow the suggestions of JICA Study Team related to the tariff setting and environmental and social consideration, and suggested translating the presentation of tariff into Myanmar and announcing to the public.
- ✓ She asked that the transmission pipe from Inya Lake to Kandawgyi Lake costs too much and is not good idea. She suggested that to educate the people not to discharge the waste is better way to improve the water quality.

  Ms. Yamada answered the question that the transmission pipe exists already so there is no need for additional cost. Mr. Momose thanked for her suggestions.

c) Dr. Tha Kyan, Botahtaung Township Development & Support Committee made suggestions as follows:

- ✓ Tariff setting for sewerage system is quite interesting but a little early for the citizens. So let us start from hotels, restaurant and industrial.

  Mr. Momose thanked for his suggestions.

d) Ms. Than Than Soe, Director (Rtd), Department of Human Settlement & Housing development, Min. of Construction raised the questions and comments that:

- ✓ Ngamoyeik Plan is considered in the Master plan?
- ✓ The water from Lagunbyin system will be serviced to the Thilawa SEZ?

  Mr. Momose answered that the Ngamoyeik plan is incorporated into the master plan and the water can be distributed to Thilawa SEZ.

10. Master announced the closing of the consultation seminar, the seminar adjourned at 16:30 pm.

Attachment 1

List of Participants

Name	Title	Organization
U Min Swe	Regional Chief Administrator	Irrigation Department
U Kyi Tin	Director	Department of Development Affairs
U Maung Maung Khin	Advisor	YCDC
Dr. Khin Ni Ni Thein	Chairman	Water Resource Training Centre
U Than Myint	Patron	Myanmar Engineering Society
U Percy Lao	Advisor	Myanmar Engineering Society
Dr. Khin Maung Lwin	Advisor	Asia Development Bank
Daw Than Than Soe	Director (Retired)	Department of Human Settlement and Housing
U Kyaw Soe	Secretary	YCDC
U Soe Si	Committee Member (7)	YCDC
U Myat Thet	Head of Department	Department of City Planning & Land Admin
U Maung Maung Zaw	Head of Department	Department of Engineering (Building)
Dr. Myat Mon Aye	Head of Department	Health Department
U Yi Win	Head of Department	Department of Co-ordination
U Aung San Win	Deputy Head of Dept	Department of Engineering (Water & Sanitation)
U Toe Aung	Deputy Head of Dept	Department of City Planning & Land Admin
U Win Hlaing Htun	Assistant Head of Dept;	Department of City Planning & Land Admin
U Khin Maung Phue	Assistant Head of Dept;	Department of Engineering (Water & Sanitation)
U Aung Khin Zaw	Assistant Head of Dept;	Department of Engineering (Water & Sanitation)
U Myo Thein	Assistant Head of Dept;	Department of Engineering (Water & Sanitation)
U Thein Min	Assistant Head of Dept;	Department of Engineering (Water & Sanitation)
Dr. Myint Than Tun	Head of Sub-Dept;	Department of Engineering (Water & Sanitation)
U Maung Maung Htay	Head of Sub-Dept;	Department of Engineering (Water & Sanitation)
U Htin Lin Kha	Head of Sub-Dept;	Department of Engineering (Water & Sanitation)
Daw Thwet Naing Oo	Head of Sub-Dept;	Department of Engineering (Water & Sanitation)
Daw Wai Wai Myint	Head of Sub-Dept;	Department of Engineering (Water & Sanitation)
Daw Khin Aye Myint	Head of Sub-Dept;	Department of Engineering (Water & Sanitation)
Daw Aye Aye Mar	Assistant Engineer	YCDC Water and Sanitation Dept;
Daw Pyae Pyae Phyoe	Flat	YCDC, Urban Planning Dept;
Daw New Thazin	Sub Assistant Engineer	YCDC, Urban Planning Dept;
Daw Thiri Ko Ko	Flat	YCDC, Urban Planning Dept;
U Khaing Zaw Win	Assistant Chief Engineer	YCDC
U Moe Htein Linn	Assistant Engineer	YCDC
U Myint Win	Sub Assistant Engineer	YCDC
U Than Htay	Assistant Engineer	YCDC
U Zaw Naing Oo	Sub Assistant Engineer	YCDC
U Win Htway	Assistant Engineer	YCDC
U Kyaw Kyaw Oo	Assistant Engineer	YCDC
U Nay Lin	Assistant Engineer	YCDC
Daw Nandar Lin	Assistant Engineer	YCDC
Daw Moe Nilar Aung	Assistant Engineer	YCDC (Road and Bridge Dept;)
Daw Moe Moe	Assistant Engineer	YCDC (Road and Bridge Dept;)
U Lwin Min	Regional Chief administrator	Latha Township Management Department
U Min Aung Lynn	Regional Chief administrator	Latha Township YCDC
U Kyi Win	Chairman	Latha Township Development & Support Committee
U Kyaw Zin	Regional Chief administrator	Lanmadaw Township Management Department

U Khin Maung Gyi	Regional Chief administrator	Lanmadaw Township YCDC
U Htay Aung	Chairman	Lanmadaw Township Development & Support Committee
	Regional Chief administrator	Pabedan Township Management Department
U Than Win	Regional Chief administrator	Pabedan Township YCDC
U Ba Than	Chairman	Pabedan Township Development & Support Committee
U Myo Naing	Regional Chief administrator	Kyauktada Township Management Department
U Aung Zaw Moe	Regional Chief administrator	Kyauktada Township YCDC
U Thant Zaw Oo	Regional Chief administrator	Botahtaung Township Management Department
U Yei Myint	Regional Chief administrator	Botahtaung Township YCDC
Dr. Tha Nyan	Chairman	Botahtaung Township Development & Support Committee
U Kyaw Zay Ya	Regional Chief administrator	Pazuntaung Township Management Department
U Zaw Myint	Regional Chief administrator	Pazuntaung Township YCDC
U Nyan Win	Chairman	Pazuntaung Township Development & Support Committee
U Than Naing	Regional Chief administrator	Alone Township Management Department
U Thein Zaw	Regional Chief administrator	Alone Township YCDC
U Own Myint	Chairman	Alone Township Development & Support Committee
U Than Hlaing	Regional Chief administrator	Dagon Township YCDC
U Kyaw Ye Thway	Regional Chief administrator	Kyee Myint Daing Township Management Department
U Nyo Thin Aung	Regional Chief administrator	Kyee Myint Daing Township YCDC
U Kar Si/ U Win Zaw	Chairman	Kyee Myint Daing Township Development & Support Committee
U Tin Oo	Regional Chief administrator	Sanchaung Township YCDC
U Aung Lin	Chairman	Sanchaung Township Development & Support Committee
U Zaw Lwin Aung	Regional Chief administrator	Bahan Township YCDC
U Aung Kyaw Soe	Regional Chief administrator	Tarmwe Township YCDC
U Zaya Own	Regional Chief administrator	Mingalar Taungnyut Township Management Department
U Kyaw Soe	Regional Chief administrator	Mingalar Taungnyut Township YCDC
U Khin Maung Kyway/ U Than Hote	President	Mingalar Taungnyut Township Development & Support Committee
U Tun Win	President	Seitkan Township Development & Support Committee
U Thein Htay	Regional Chief administrator	New-Dagon (East) Township YCDC
U Win Naing/ U Soe Min	President	New-Dagon (East) Township Development & Support Committee
U Hla Thein	Regional Chief administrator	New-Dagon(South) Township YCDC
U Tin Maung Nyein	President	New-Dagon (South) Township Development & Support Committee
U Tin Nyunt	Regional Chief administrator	New-Dagon (North)Township Management Department
U Myat Maw Oo	Regional Chief administrator	New-Dagon(North) Township YCDC
U Ko Ko Lay	President	New-Dagon (North) Township Development & Support Committee
U Myo Soe Moe	Regional Chief administrator	Dagon Seitkan Township Management Department
U Kyaw Sein	Regional Chief administrator	Dagon Seitkan Township YCDC
U Soe Maung	President	Dagon Seitkan Township Development & Support Committee
U Kyaw Aye	Regional Chief administrator	Tharketa Township YCDC
U Aung Ko Zaw	President	Tharketa Township Development & Support Committee
U Myint Wai	Regional Chief administrator	Dawbon Township Management Department
	Regional Chief administrator	Dawbon Township YCDC
U Aung Myint	President	Dawbon Township Development & Support Committee
MRTV	Daw Mar Lwin Oo/ Daw War War Min	MRTV- News

MRTV-4	Daw Ei Theingi Myint	
Skynet	U Zaw Ye Aung	
City News		
MWD	U Soe Min Aung/ U Zin Ko Ko	
Weekly Eleven		
Snap Shot		
Popular News		
Shwe Naing Ngan Thit		
Union Daily		
Myanmar Freedom Daily		
Pe Tin Than Journal		
Myanmar Freedom Daily	Dennis Aung Aung	
The Messenger	Tin Maung Oo	
7 Day News		
The Farmer		
7 Day News	Senior Reporter	Ei Phyu Mar
Myanmar Freedom Daily	Senior Reporter	Soe Sandi Oo
Win Thet Maw	Senior Reporter	Unity
Wai Wai Hnin	Reporter	Flower News
Zayar Myat Khaing	Deputy CE	Monitor News Irr.
Reporter Journal		Moe Lwin Thet
Mr. Park Keon-Soo	1st Secretary	Embassy of the Republic of Korea
Mr. Bae Hyun-Jin	Engineer	K-water
Emilie Röell	Trainee Operations Section	Office of the European Union in Myanmar
Henrice Stöbesand	Research Assistant	German Embassy of Yangon
Ms. Winnie	Cetral Secretary	International Enterprise of Singapore
Mr. Aung Khine Tun	Senior External Relation Coordinator	CESVI- Myanmar
Dr. Maung Maung		M.Y Associates Co., Ltd.
Mr. Akihito SANJO	Senior Representative	JICA Myanmar Office
Ms. Noriko SAKURAI	Project Formulation Adviser	JICA Myanmar Office
Ms. Myat Thuzar		JICA Myanmar Office
Mr. Masaru MATSUOKA	JICA Expert	JICA Expert
Mr. Kazufumi Momose		JICA Study Team
Mr. Hirotaka Sato		JICA Study Team
Mr. Masafumi Miyamoto		JICA Study Team
Mr. Atsuo Ohno		JICA Study Team
Mr. Hiroshi Nishimaki		JICA Study Team
Mr. Kaoru Kariya		JICA Study Team
Mr. Yasuhiko Morita		JICA Study Team
Ms. Shoko Yamada		JICA Study Team
Ms. Khin Latt Cho		JICA Study Team
Ms. Hsu Mon Win		JICA Study Team
Ms. May The Phyu		JICA Study Team

Attachment 2

Comments from the Participants

1. Prof. Dr. Khin Ni Ni Thein, Founder and President, Water, Research and Training Center (WRTC) Myanmar, IWRM Expert, Sustainable Water Resources Development Standing Committee

1) Study schedule and area: well organized. Good

2) Water Supply: very good

3) Sewerage system: also very good but we still need to consider the appropriate use of treated water before its disposal

4) Tariff: the definition of non-domestic use need to expand.

Suggestions: *we need to take drainage study.

1) YCDC should follow up the recommendations from tariff setting principles. the presentation is "S".

2) YCDC should translate presentation 3 and 4 into Myanmar language and invite all NGOs and Cos and make public relation event ASAP.

3) Public consultation to limited invitees only need to expand to NGOs. To seek public acceptance. Need more stakeholders' participation. Water transfer from Inya Lake to Kandawgyi is going to cause a major problem. We need to seriously reconsider.

4) Water allocation 30 MGD to Yangon City and 10 MGD to SEZ is reasonable.

5) Can we get soft-copy of all presentation and calculations behind the last presentation? Result of EIA, SIA and mitigation measures.

2. Dr. Tha Nyan, Botataung Township

Tariff setting for sewerage system quite interesting. If we start tariff for sewerage we can help to get full cost recovery.

But it may be a little early for country wise. Shall we start from hotels, restaurant, condominium, industrial zone, etc. as a test case.

3. Dr. Than Than Soe, Director (Rtd), Department of Human Settlement & Housing Development, Ministry of Construction

- Nyamoyeik Phase 2 has now been operating. By the year 2015, how will YCDC be implemented of plans for transmission main, distribution system to become true for the Master Plan (JICA dream)?
- Will the Lagyunpin water supply system fully served for Thilawa SEZ. If not, what proposed plans to meet the demand of Thilawa SEZ?
- For the modernization of water supply zone 1 is JICA ODA will take into account on implementation, by means of financial support?

- My opinion. Master Plan for the improvement of Yangon City is important. Implementation works (short, mid, long term programme) will also important.

4. Dr. Khin Maung Lwin, National Consultant, ADB

Tariff setting is a necessity but it needs a series of public consultation meetings involving every actor/stakeholder/consumer.

People's behavior play critical role in sustainability of the system.

It is very interesting to see the sewerage tariff set in Manila and Singapore. Their experiences need to be shared with YCDC to adopt this innovation by all citizens of Yangon.